Social Value Creation in Decentralized Energy Models: A Case from Vienna

Submitted to Central European University Department of Environmental Sciences and Policy

In partial fulfilment of the requirements for the degree of Master of Science

Thesis Supervisor: Michael LaBelle

Ecem GUVERCIN

June, 2025

Vienna, Austria

COPYRIGHT NOTICE

For bibliographic and reference purposes, this thesis/dissertation should be referred to as: Guvercin, E. 2025. *Social Value Creation in Decentralized Energy Models: A Case from Vienna.* MS thesis, Department of Environmental Sciences and Policy, Central European University, Vienna.

[1] Icon by Font Awesome.

AUTHOR'S DECLARATION

I, the undersigned, **Ecem Guvercin**, candidate for the MS degree in Environmental Sciences and Policy, declare herewith that the present thesis titled "Social Value Creation in Decentralized Energy Models: A Case from Vienna" is exclusively my work, based on my research and only such external information as properly credited in notes and bibliography.
I declare that no unidentified and illegitimate use was made of the work of others, and no part of the thesis infringes on any person's or institution's copyright.

I also declare that no part of the thesis has been submitted in this form to any other institution of higher education for an academic degree.

Vienna, 25 June 2025

X

ECEM GUVERCIN

CENTRAL EUROPEAN UNIVERSITY

ABSTRACT OF THE THESIS submitted by:

Ecem GUVERCIN

For the degree of Master of Science and entitled: Social Value Creation in Decentralized Energy Models: A Case from Vienna

Month and Year of Submission: June 2025

Transition towards renewable energy is a holistic process: It requires the cooperation of the public sector, industries, research centers, and households. Active participation of households in the renewable energy transition is crucial to prevent energy vulnerability and to increase energy efficiency. Increasing the number of alternatives in energy supply for the households could contribute to reducing energy poverty. Decentralization of energy systems makes the energy systems more complex, but also involves people directly in the energy trade.

This study explores how to make decentralized energy systems more accessible to all the socioeconomic backgrounds. The thesis analyzes the market dynamics and business models of decentralized energy systems, how energy costs are being perceived by households, and what influences people to join an energy community. Furthermore, the study focuses on Turkish communities in Vienna as a case study to understand the intersection of social, cultural, and economic factors in energy transition. The results of the thesis indicate that districts with low income inequality and high CO2 emissions per capita would more likely prefer to join an energy community. Similarly, energy communities have long-term benefits for a just energy policy and decarbonization. However, the study concludes that the short-term challenges should be addressed while increasing public awareness for energy communities to make decentralized energy systems an alternative to preexisting energy systems.

Keywords: energy systems, decentralized energy systems, energy community, price perception, just transition, local participation, energy policy, demand forecasting

ACKNOWLEDGEMENTS

I feel very happy to research the thesis topic, and I am truly grateful to everyone who supported me during the preparation of this thesis. I highly appreciate my thesis supervisor, Michael LaBelle, for his insightful feedback, time, and all the lectures about energy studies. I also would like to express my gratitude towards Tamara Schwarzmayr and Yuki Seidler, who ignited my interest in the topic and community-based research.

I learned a lot from every expert who took their time for consultation to my research, and were very bright in their respective fields. Your kindness, professionalism and deep knowledge truly motivated me for an interdisciplinary study, where every approach was unique.

I am thankful to the Department of Environmental Sciences and Policy, faculty and staff for an intellectually enriching environment; MESP'25 and MESPOM'26 for a fun thesis year with lots of events and memories. Special thanks to Şahran, Lulin and Shazma for their friendship and support in both good and bad days.

Thank you Adéla for your kindness, your creativity and all the common hobbies we have: We became good friends in Vienna!

I want to take a moment to appreciate my friends, Begüm, Güneş and Zeynep, who have supported me since my undergraduate studies! Everything started with a student society, and everyone has carved their own paths since then.

Last but certainly not least, I would like to extend my deepest gratitude to my dear parents, Bergil and Kamil; to my brother Eldem and my sister in-law Ezgi, for your endless love and encouragement.

Thank you.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

LIST OF FIGURES

LIST OF TABLES

1. Introduction

1.1 Background and Problem Definition

Demand for electricity is expected to grow in the future. The anticipated growth in electricity demand is due to heating/cooling of the buildings, power source for green sectors and data centers in the information sector (EMBER 2024). Increasing usage of electricity while shifting towards renewable energy sources in the industries create a further need for sustainable electricity sources. However, one may question the feasibility of reaching the 1.5°C target of the Paris Agreement until 2050 if innovation for green technology leads to high energy usage. IRENA reports that the 1.5°C target is achievable with current technical capacities and financial sources, on the other hand, energy efficiency should be increased for more sustainable energy consumption (2024, 5-6). Energy efficiency itself can take up to %25 of all CO2 emissions reduction measures until 2050, equal to the prioritization of renewable energy investments (Al-Shetwi et al. 2024, 10).

The significance of energy efficiency becomes more evident when it is expected that power and transport will increase its percentage of overall energy consumption until 2050 (Hassan et al. 2024, 6). However, fossil fuels received unconditional funding after COVID-19 pandemic for a fast economic recovery (Tian et al. 2022). Moreover, the tax return of green bonds for regional sustainable initiatives occurs in mid-to long term, which creates disincentive for government funding (Taghizadeh-Hesary and Yoshino 2020, 7). It could be stated that the renewable energy projects with a high budget receive more hesitation for funding due to financial risk.

Supporting a high number of micro-projects for energy transition can contribute to energy efficiency, which may also increase the financial support for clean energy sources. Power and transportation being primary sources for CO2 emission yet having a high potential for switching towards renewable electricity (Hassan et al. 2024) indicate that the energy transition initiatives should include the initiatives which have immediate impacts to the society. Energy communities, which were defined as the energy systems where the citizens are active on decision making of services such a supply and distribution while self-governing with the purpose of environmental benefits (Caramizaru and Uihlein 2020, 7), can support energy efficiency due to high renewable energy consumption in the households of energy communities and impact with micro budgets compared to larger scale renewable energy projects. Energy communities also may reduce social inequalities caused by energy crises times due to them diversifying energy sources and create a buffer for increasing energy prices (REScoop 2025).

Even though energy communities seem as a valuable opportunity which fosters renewable energy transition, joining an energy community includes the risk of a financially unstable process and a high amount of bureaucratic steps (Dioba et al. 2024, 5). Financial uncertainties and necessity for possible legal support decrease the affordability of energy communities, which may hinder the social benefits of energy communities. Energy communities are still an emerging energy system, and energy communities have been becoming an increasingly popular topic in energy literature. Regardless, the papers covering energy communities mostly focus on the profitability of energy communities or the legislative framework in Europe (Gianaroli et al. 2024). In contrast, there seem to be fewer studies that include cultural perspectives in energy communities research, and a research gap in combining societal determinants with economic factors for energy communities.

1.2. Research Question and Aims of the Thesis

The thesis aims to contribute to how energy communities can address energy poverty. To achieve this goal, energy communities should be equally accessible by every resident in the society, regardless of their purchase power. Thus, how the barriers of joining towards energy communities can be overcome in socially disadvantaged groups will be the main focus of the thesis. Furthermore, there will be a case study, Turkish communities in Vienna, in order to fill the research gap of the energy research literature about the role of culture.

As a concept, decentralized energy systems will be analyzed, in order to adopt a more systemic approach. Energy communities are a part of, but not the sole example of decentralized energy systems. The thesis will not use those two terms interchangeably, but energy communities as a subtopic of decentralized energy systems. Considering the aims of the thesis and pre existing literature, the following research questions may help to reach to the aims of the thesis:

Main Research Question:

1) How Decentralized Energy Models can be More Accessible to Socially Disadvantaged Groups in a Society?

Secondary Research Questions:

1) How the cost of electricity consumption is being perceived by socially disadvantaged groups in different energy models?
2) What are the determinants that may affect the preferability of energy communities in the future?
3) How to increase the possible benefits of energy communities for Turkish communities in Vienna?

1.3 Thesis Structure

Literature review covers the preexisting research to provide the knowledge on decentralized energy markets and business models, why people join to the energy communities, and the recent development in energy communities. It also discusses the energy communities in Austria as a background for the case study. Theoretical framework examines the assumptions and theories which guide the research while methodology frames the research. The results section depict and visualize the research findings. Discussion concludes the findings by answering the research question and evaluates the findings in the context of the case study. Discussion section also prepares recommendations for energy policy and decentralized energy models.

2. Literature Review

2.1 Current and Future Trends in Energy Decentralization

Energy decentralization could be stated as the process where there are a larger number of energy suppliers who sell the energy to a smaller number of energy buyers. Decentralization occurs by replacement of old energy firms with newer firms which prioritize decentral energy networks, the preexisting firms adopting the recent market trends either with first mover advantage or with smaller steps leading to new norms in energy markets, or replacement of market gap caused by large sellers withdrawing from the market due to lack of adaptation (Judson et al. 2020, 3). However, the definition proposed by Judson et al. solely focuses on how market sellers, who were considered as powerful, are reacting towards market penetration of a number of competitors. The degree of complexity of links between buyers and sellers, number of consumers of each energy production unit, the proximity between each energy consumer determine what extent an energy landscape is decentralized (Alanne and Saari 2006, 546)

Centralized vs. Decentralized Energy Models. Adapted from Di Silvestre et al. 2018; Gui and MacGill 2018; Cali and Fifield 2019. Diagram created using Canva.

Figure 1 Central Energy Systems

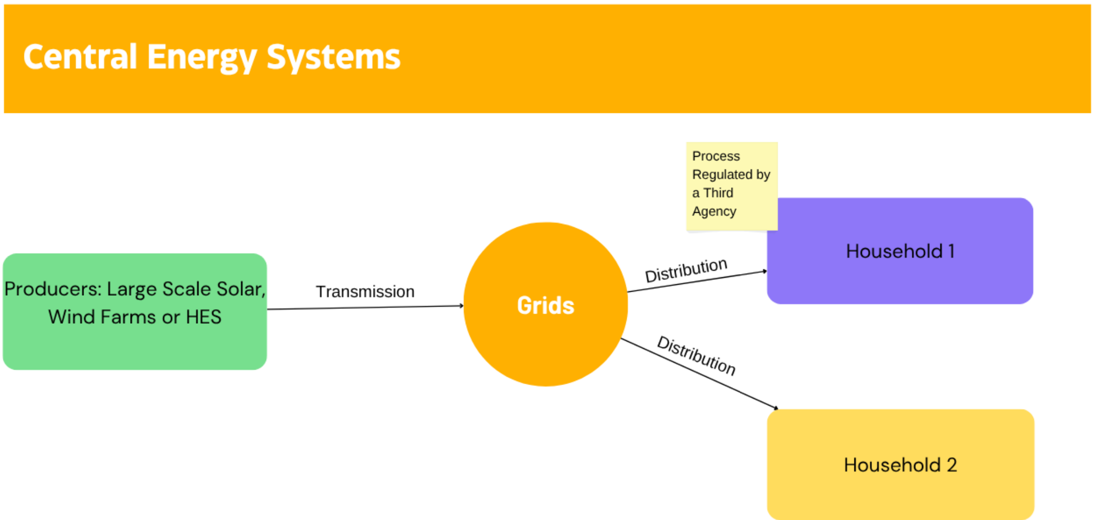


Figure 2 Decentralized Energy Systems

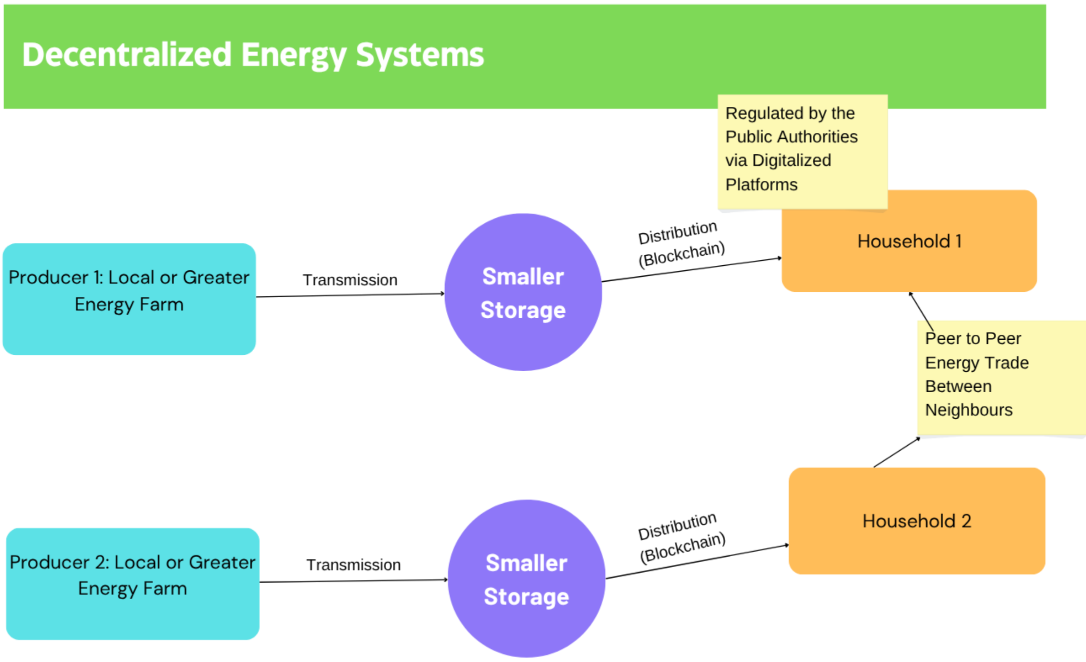


Figure 1 and Figure 2 display the differences between the producer and storage types, the transactions between seller-intermediate (if available)-buyer in the context of transmission and distributions, and the networks between the final consumers.Increasing number of alternatives in both producer and the intermediary side may indicate that not only the energy systems but also the market is decentralizing. Greater bids for renewable investments may be replaced by the renewable energy suppliers, by subsidiaries of large companies, or cheaply available technologies after the technology has matured. Transformation towards small storage centers or microgrids from larger grids could create both opportunities and challenges. Higher number of microgrids could make the energy systems more resilient, causing less disruption on the supply chain if one grid is out of working. Nevertheless, using microgrids in energy systems instead of larger grids shifts the responsibility to keep energy secure and reliable from big private companies or central governments into communities or local governments. In other words, change in energy infrastructure would likewise lead to a shift in governance.

At the first glance, decentral energy systems seem to reduce the authority of central governments, as controlling energy infrastructure could be easier in central energy systems, and there are less actors in energy systems to negotiate. Moreover, tariffs and buy-back rates are being used to regulate and manage energy consumption of the household, with the financial instruments incentivizing savings by offering an overall reduction of energy bills if it does not exceed the upper limit of consumption (IRENA 2020, 7). On the other hand, regulation of energy systems is done by the government agencies in decentral energy systems, compared to private third parties in the central energy systems. The P2P trading model removes the intermediaries in energy distribution, resulting in bargaining is mostly being done by the consumers and energy producers, while the government is regulating the market. Digitalization of the energy markets in P2P trading and blockchain would provide flexibility to sellers, buyers and the regulators.

P2P trading with blockchain codifies each user to the microgrid networks, where the system is vulnerable to privacy concerns. Energy consumers who produces their own energy from the renewable sources by their own households, or "prosumers", were registered with a unique ID, while their energy consumption rates and the amount of price they paid per time intervals were stored under their unique IDs (Tkachuk et al. 2023, 13). However, the data storage should be protected from possible hacking attempts or information leakage. Furthermore, stored data should be managed by a representative, who should be trusted and respected in the community (Mehdinejad et al. 2022, 7). One may argue that the increased number of energy communities would actually prevent larger data breach, as there would be smaller data sets stored in higher amounts of storage. While it can be accurate to some extent, hiring cybersecurity experts for each community can increase the costs of operating an energy community. Electricity sharing between the different households, in addition to possible security concerns can increase the necessity of a tighter-knit community in RECs. Dong et al., evaluate the cooperation between sellers and buyers in local energy markets. According to them, both sellers and buyers have certain price intervals they perceive acceptable for the energy trade (2022, 8). A higher agreement between the buyers can lead to a stronger bargaining from the purchasers' side. Cooperation/non-cooperation dynamics provide further incentives for more established contacts between community members.

2.2 Structure of Decentralized Business Models

Decentralized energy systems have the primary structures of an energy system in general: Energy generation, transmission systems, energy storage, logistics for distribution, and the final consumers. However, decentralized energy systems require a higher level of public support, a smaller scale of control, which results in a higher level of bargaining compared to central energy markets, and provides a greater flexibility for the energy markets, which can create both higher autonomy and less energy supply security (McKenna 2018, 748). The less energy security supply can be caused by the higher flexibility creating challenges in the energy forecasting. Ambiguity of energy demand, the "non-linearity" of relations between external factors such as weather and time of the day (Dudek et al. 2023, 3). Although these concerns are prevalent for all energy systems, the personalization of energy consumption amplifies them. On the other hand, it should be also considered that there are still strong relationship between central and decentral energy systems, where large grids gather data from energy communities, using the data for increasing accuracy rate for energy forecasting, and large scale energy storage for preventing possible energy shortages (Kyriakopoulos 2022, 4). In other words, the systems are still interacting with each other to integrate the decentralized markets to a larger market scheme.

Table 1 Types of Decentralized Business Models (Adapted from Koirala et al. 2016 and Barabino et al. 2023)

Type of Business Model	Community Networks for Energy Trade	Who Owns the Primary Energy Sources?	Value Generation	Degree of Integration
Prosumer	Moderate Cooperation	Community (Individuals)	Low	Low
Collective Generation	Low Cooperation	Community	High	High
Aggregator	Moderate Cooperation	Mixed (Community+Third Parties)	High	Low
Third Party Sponsored	Low Cooperation	Third Party	High	Low
Local Energy Market	High Cooperation	Community	Low	Low
Cooperative	High Cooperation	Mixed (Community+Third Parties)	High	High

In Table 1, the decentralized business models were categorized according to their networks with the other members of the community and the owner of the energy networks, with the scale of integration and value generations. The business models were modeled in Barabino et al. (2023), whereas the "value generation" and "degree of integration" parameters were previously classified by Koirala et al. (2016), across different energy systems. Value generation was described as how much additional economic or social benefits the energy system produces linked to the other energy systems, while the degree of integration indicates the fulfillment goals and actualization of values such as autonomy or active involvement in the energy trading (Koirala et al. 2016, 727). I matched the community energy systems of each business models with Koirala et al. (2016)'s matrix, where they divided the community energy systems as: "Virtual power plants", "Prosumer community groups", "Community energy systems", "Integrated community energy systems", "Community Micro Grids", "Energy Hubs".

Despite the high emphasis on individuality on the prosumer model, or community ownership of the grids in local energy markets, degree of integration remained low. Due to the strong linkage between values such as agency and self sufficiency, and civil society control, degree of integration should have been high according to the prevalent knowledge on the literature. Community ownership of energy sources was associated with a high level of agency, whereas using common resources but operating households' energy consumption individually was regarded as self-sufficiency (Ceglia at al. 2020, 7-8; Wieczorek et al. 2024, 8-9). Although the table did not indicate that there is an adverse relation, the results indicate a gap in the literature: It could be inferred from the table by Koirala et al. (2016, 728) that degree of indication remains low if the decentralized energy models do not include collaboration between different actors, or the systems remain too localized that isolate the households from a larger network of transmission systems. In order to identify social and economic benefits of energy communities, a community based approach should be adopted, where stakeholder engagement is not only regarded as policymaking, but also how each stakeholder is related to and influence the needs of the communities.

"Energy community" refers to the energy systems where the citizens are active in decision making of services such as supply and distribution while self-governing with the purpose of environmental benefits (Caramizaru and Uihlein 2020, 7). Hence, it could be stated that energy communities can coexist with any of the six decentralized business models. On the other hand, energy communities were classified by their purpose and place in the literature. "Place" refers to what extent the communities are forming their own neighbourhoods, and "purpose" classifies the energy communities according to if the energy communities were formed by the sole reason of energy management, or if they have any other common goals which were defined in the community charter (Moroni et al. 2019, 47; de Sao Jose et al. 2021, 5). Categorization of energy communities differ from decentralized business models, as categorization of the business models are based upon their energy operation systems and the political questions of who owns the power by controlling the investment, whereas the role of energy communities and their geographical aspects are the main priority on their classification. Regardless, social relations and impact to the community are the common parameters for both the business models and energy communities. Prioritization of social aspects of business models is rather my choice. There is a high focus on locality of the energy communities in all steps in energy management, public participation in planning and distribution of energy and environmental benefits of smart energy communities (Savelli and Morstyn 2021, 2-3; Bukovzszki et al. 2020, 21). Thus, I decided to adapt the "purpose" of energy community classification as the social relationships between the residents even though the literature does not particularly mean "purpose" as "network" or "social capita" in energy community classification. Societal dynamics is a crucial, but often overlooked factor in decentralized energy systems.

2.3 Pricing Mechanisms and Market Drivers in Energy Communities

Sharing created monetary value relies on in which steps of energy trade it was being created, and in which steps they should be shared. In RECs where the market is operated as a whole, the monetary value is shared by the communities; while in internal markets where every transaction is individually priced, every member is responsible by their own trade activities; and in a hybrid market approach, there is a consensus on a price equilibrium by the buying prices and price compensation (Mello et al. 2023, 6). This approach suggests that market dynamics are affected by the organizational structures of energy communities, such as between individual based- prosumer business models or community-oriented collective generations. However, it would be an oversimplification to focus on market tools solely by the type of operation models. "Licensed suppliers" is a powerful actor in price determination of produced energy, where it implements retail or feed in tariffs to energy cooperative or local grid controllers, where they distributes energy to households; use-of system charges to distribution and transmission system operators and regional system operators (Reis et al. 2021, 10). The influence of licensed suppliers may be caused by the necessity of adapting decentralized energy systems into a legal framework, and licensed suppliers connecting energy producers, consumers and operators. It could be argued that removal of licensed suppliers in the energy trading process can reduce the costs significantly, due to no tariffs. However, it should be also considered that the decentral business models are highly dependent on regulatory framework, market structure and technology (Botelho et al 2021, 11). P2P trading, where the licensed suppliers is not available, the dependence on regulatory framework and technology increases drastically, while dependence on market structure decreases moderately. In other words, a licensed suppliers provides services on legal and technical operations in exchange of market flexibility, which is a tradeoff that can be either preferable or too costly depending on each community.

The issues in decentralized energy schemes reflect that there is a gap in understanding the social and behavioral factors of energy consumers while considering the external risks. Decision of investments for improvement of energy infrastructure and network opportunities prolongs a just value creation process (Burger et al. 2019,4), whereas set tariff prices raise questions on if low-income residents shoulder the burden of increased energy costs (Schittekatte and Meeus 2018, 12-13). Moreover, energy prices are affected by the overall consumption rate and the time of energy demand (Iazzolino el al. 2022, 8). These challenges may indicate that the gap may be stemmed from the underrepresentation of the role of networks, pricing tools and environmental aspects in measurement of energy costs.

Social and behavioral factors in energy consumption can be challenging to measure, especially when the external factors were also considered. However, the "perceived cost" of energy consumption in the households can be measured. In order to measure "perceived cost", the perception of energy prices over the time, and one's individual perception by their relative income level in the society should be included. To do so, a formula where it includes the overlooked factors was developed. The formula was adapted from a household cost optimization formula (Elkazaz et al. 2021); but new variations, price shocks and income sensitivity index were added while the old coefficient of "house sell" was replaced with selling the excess energy to the neighbour, (renamed as "neighbour_sell") to include the role of community relationships and P2P trade in energy communities. Two variations of the same formula were developed to compare different energy systems: Central energy systems where there would be no P2P trade and decentralized energy systems where neighbours can trade energy.

Perceived Household Energy Costs in Central vs. Decentralized Energy Systems Formula: (adapted from Elkazaz et al. 2021)

$$C\_house\_centralized \; = \; C\_energy\_bought\_centralized \; \times (1 + \; (\sigma \; / \; \varphi(H))$$

The first variation depicts the perceived household cost for central energy systems, or the centralized scenario. As there is no P2P trading between neighbours or no self energy production, C_neighbour_sell = 0. "$C_{energy\_bought\_centralized\_}$" here represents the cost of energy purchased from local energy sources in a particular given time:

$$C_{energy\_bought\_centralized=} \text{E\_avg} \times \text{f\_grid}$$

Here (and in the other coefficients), E_avg resembles the average household electricity demand per year. It should be underlined that the "average demand" is used in the hypothetical scenarios where the demand is estimated by the energy consumption statistics. On the other hand, f_grid is the average price of electricity per kwh.

Price shock, or σ is the cost of external factors, such as market regulations, political developments, or shocks in the markets. What "shock" is intentionally left ambigious so that the coefficient can be adapted to the unique dynamics. $\sigma\ (t)$ is the shock coefficient between 0-1, according to severity of the issue. On the other hand, it should be stated that the shock coefficient may not be truly equal to everyone. The risk of energy poverty for lower income groups are higher. Hence, income sensitivity index considers the energy vulnerability in the perceived cost formula:

$$\Phi(H)\ =\frac{\bar{I}}{I_H}$$

"Φ(H)" is the proportion of median household income to the particular household income: a higher proportion would indicate a higher vulnerability to shocks.

$$C\_house\_community\ =\ [C\_energy\_bought\_decentralized\ \times\ (1\ +\ (\sigma\ /\ \varphi(H)))]\ +\ C\_neighbour\_sell$$

The second variation for the perceived household cost in decentralized energy systems is quite similar to the first one. C_house_community is the perceived household cost for the decentralized energy systems. In the second variation, C_neighbour_sell is calculated as it resembles the traded electricity between the neighbours. If a household received electricity from a neighbour, C_neighbour_sell is a negative value as it would decrease the perceived household costs.

$$C\_energy\_bought\_decentralized = \ ((E\_avg - E\_pv)/\ E\_avg)\ \times\ f\_micro$$

C_energy_bought_decentralized is quite similar to C_energy_bought_centralized. E_avg indicates the annual average electricity demand as well, however, in this scenario self produced electricity is being calculated as well, and being subtracted from the demand. f_micro here, represents the electricity cost from the microgrid, similar to f_grid from the centralized scenario.

2.4 Motivations and Policymaking in Energy Decentralization

Policy of energy systems are being shaped by the actors with various interests, and the power dynamics on energy management, on practice and interaction between different groups. The community is the core of decentral energy systems due to increasing public demand towards localism and the role of communities in transition towards renewable energy (Creamer et al. 2018, 3; Olawuyi 2021, 106-110). Regardless, the "traditional" stakeholders are still influential. Public sector and local authorities, private sector and research institutes contribute to the market development and distribution of energy. The fundamental question, however, remains: How the different stakeholders remain or enlarge their influence and how they may react towards new technologies in energy markets that can challenge preexisting power dynamics? Brisbois introduces "powershifts theoretical framework" which covers these questions under three categories: Instrumental, where the institutional power is exercised and the policy goals are being defined; structural, where the decisions and actions are being justified in legal/political narrative and participation and informational access are being managed; and discursive, where the formed narrative for energy policy is being communicated (2020, 51). In other words, a policy proposal should tell a coherent and plausible story to whom or whichever actor being concerned to reach a consensus. However, Brisbois' framework also suggests that the power practices are not always being peaceful, and consensus is not always built upon public participation, but rather coerces people to accept a certain status-quo.

Current policy tools and international energy law suggest that the rights of communities are being formally acknowledged, but a fairer practice and interpretation are needed. While the theories for energy in the context of international political economy seem to be at odds on the question of who would (or should) benefit from applied energy policy, all these theories are not mutually exclusive. Market liberalism prioritized the economy and freedom of innovation, whereas neo-mercantilists emphasized the interests of states and domestic policy, environmentalists underlined the significance of sustainable ecosystems and social greens approached the energy as a social issue which reinforces pre-existing social inequalities (van de Graaf and Zelli 2016, 52). One may argue that each theory represents the interests of one particular area, and due to resource constraints, one perspective would be prioritized no matter what. On the other hand, the disagreements on the energy policy may be rather stemmed from whose interest would be sacrificed in case two or more approaches would clash on a political framework. Principles of International Energy Law also supports the idea that fundamentally protecting the interests of all actors is possible. A resilient and reliant energy system which respects national sovereignty, justice and equity of people, preventing unconscious resource consumption and facilitating modern energy infrastructure was encouraged under seven principles (Heffron et al. 2018, 40). In decentralized energy systems, political instruments focus on adoption of technology in a socially just manner while providing alternative economic policies for green finance and application of regulations for the benefits of the public (Burke and Stephens 2017, 43).

Rethinking financial models and energy networks would require a substantial amount of resources, political discussions and planned projects. In order to implement policies which address the needs of the society, values of the communities and to what extent the public truly participates should be identified. The values of community consist of the values of each member of the society, by the interaction of different agencies and different social groups; while the attitudes, experiences and social changes affect the values (Melnyk et al. 2023). In other words, the values of communities are constantly evolving. It should be further underlined that the societal values are highly versatile, and each local community should be considered as a unique case in the projects, although there are common themes and points. On the other hand, evaluation of community projects should be done both in project planning and implementation process, and the result of the project. Goedkoop and Devine-Wright argue that the spectrum of high community involvement vs. exclusive to project initiators can be applied to both dimensions of a same matrix on the process vs. aftermath (2016, 139). The matrix can be also linked to the powershifts framework by Brisbois, as the matrix itself directly questions who is holding the power in the project, to what extent the project is being inclusive, and if the knowledge of political ecology is shaped by collaborative efforts.

Figure 3 Values and Motivations of Communities on Decentralized Energy Systems (Adapted from van der Wel et al. 2024, Adams et al. 2021, Soeiro and Ferreira Dias 2020 and Hicks and Ison 2018)

The literature suggests that although every community has their own values, they have common motivations to form energy communities. Figure 3 depicts five main drivers to adapt decentralized energy systems, based on research covering a wide geography, from Europe to North America to Australia. The social benefits are being highly prioritized in energy community formation. "Social acceptance" and emphasis on consumption may infer that people are held responsible for their actions, and responsibility for environmental issues are shifted towards attitude on energy consumption. In other words, *agency* could be stated as a key concept on motivation, which could be related to pursuit of energy independence and autonomy.

2.5 Energy Consumption and Energy Decentralization in Austria

Energy poverty in Austrian households was defined as a loop where buildings with energy inefficiency, high percentage of energy bills per monthly income lead to higher amount of energy consumption thus an even higher energy spending in the household income (Berger 2012, 59).

Berger's analysis also included a low amount of energy investment towards increasing efficiency, however, concentration on energy efficiency increased in energy literature in Austria since the article was published in 2012. Hence, it could be stated that one component of the loop is decreased. Furthermore, the progress towards increasing investment to innovation in energy is supported by the legal framework in Austria. Renewable energy communities and citizen energy communities are clearly defined in Austrian laws, whereas implementation of smart meters for energy consumption is being done widespread, and community based microgrid formation is recognized as a right under the Austrian laws (Biresselioğlu et al. 2021, 19).

Despite all the positive steps for investment towards renewable energy and the innovation in Austria, there are still challenges on energy efficiency, distribution, and the positive impact on the society. To begin with, the density of available solar panels is not even in Austria. Northern and Western parts of Austria are 4-5 times denser compared to Lower and Easter parts of Austria (Burgstaller et al., 2022, 12). The geographical difference in availability of solar energy is not creating spatial inequality, but also imply the presence of inefficient energy investments in urban-rural areas. While optimal PV capacity does not matter significantly geographically in the urban areas, Southern areas of Austria has a much higher optimal PV in the rural areas (Fina et al. 2020, 25). In other words, rural areas of Lower Austria can benefit from higher investments for solar energy. On the other hand, the temperature of the districts operated should be calculated more precisely to predict energy demand in the households. Daily temperatures are calculated with the constant which is being set by the researchers from the empirical data (Mascherbauer et al. 2022, 5). If the actual daily temperature is too different than the predicted temperature, there can be a gap between estimated energy consumption vs. real energy consumption. Climate change and heatwaves could increase the hardships for predicting energy demand. Related to the "Pricing Mechanisms and Market Drivers in Energy Communities" section of the literature review, the energy vulnerability index can create larger divisions, as the climate change and heatwaves can create a higher demand in energy inefficient households.

Business contracts for energy communities and policies implemented for energy compensation could offer solutions for the predictability of energy demand in Austria, while some key issues about social policy remain unaddressed. For the business models in decentralized energy systems, there are three components: the type of contract, the duration of contract and the interest rate (Monsberger et al. 2021, 6-7). The classification by Monsberger et al.. (2021) suggests that while the business model for energy communities can be done both community based or external, the interest rate is 4 times higher than a community based contract, with a shorter duration. Highest durability with a low interest rate can be done with energy cooperatives, however, it is for the financial matters only, hence does not create further measures for energy efficiency. With the involvement of a coordinator, additional measures to increase house efficiency can be taken, furthermore, the coordinator can handle the operation and management. While the most appropriate contract type varies from community to community, involvement of the residents in the business models result in overall lower interest rate in local energy generation. A longer durability could indicate a more predictable and stable energy system.

On the other hand, energy compensation measures in Austria seem to have no measure that has a positive contribution to both social effectiveness or energy efficiency. Policies which protect the households from the price increase due to inflation provide great social benefits, whereas it has no significant impact towards energy efficiency (Kettner and Wretschitsch 2025, 7). Meanwhile, subsidy for payment of energy costs benefitted the lower income households significantly, but did not decrease overall energy consumption rate in Austria crucially, due to it would not incentivize energy savings for higher income households, where the energy consumption has a positive correlation with household income (Kettner and Wretschitsch, 2025 7-8). Energy communities can make identification of households who face energy vulnerability easier due to its micromanagement, and policies that can support the communities can be implemented.

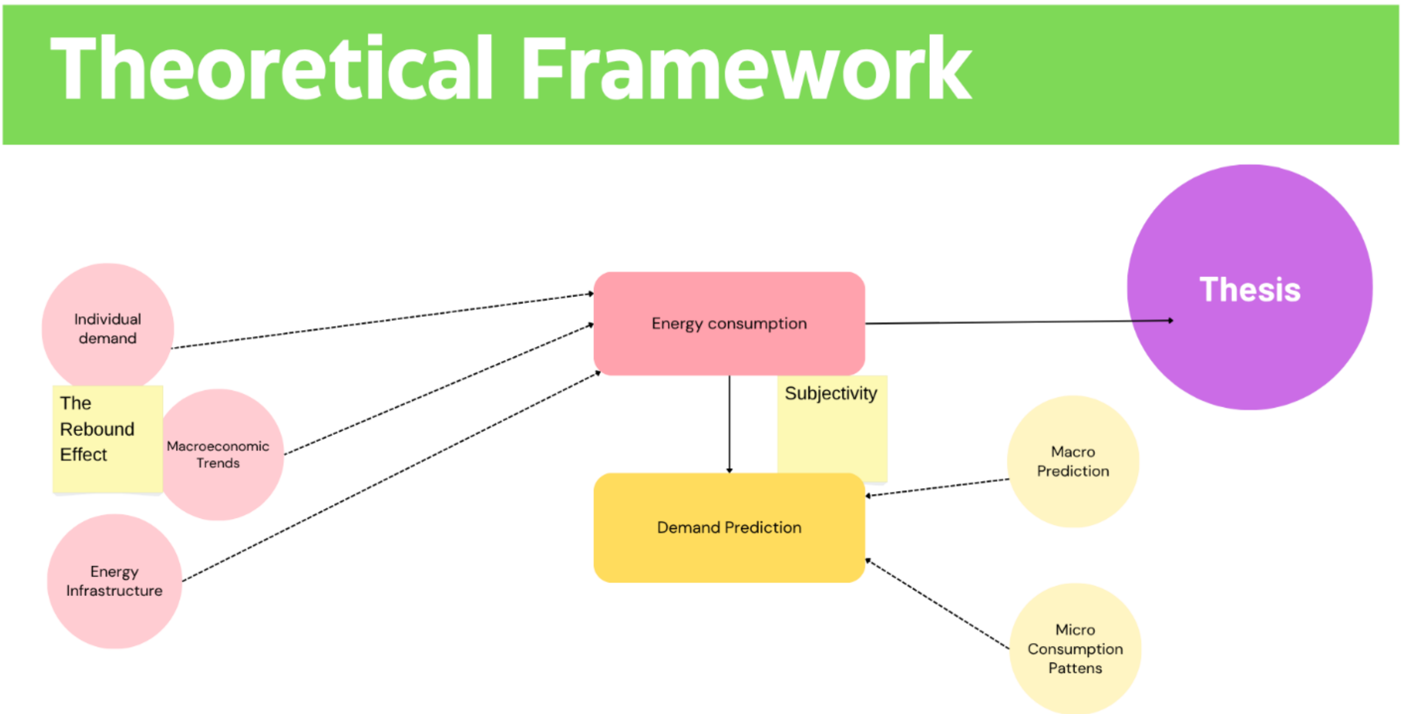
3. Theoretical Framework

The thesis intends to touch upon social, cultural, economic, and technical concepts for its research methodology. On the other hand, like every study, the thesis has its pre-assumptions. To begin with, the thesis assumes that a household income level directly affects their energy consumption habits, with a macroeconomic development leading to higher energy demand in a society; as described in The Rebound Effect (Stern 2011, 41). It could be stated that energy and economic development fuel each other, hence prioritization of green electricity in consumption is significant. Furthermore, the relation between income and energy consumption influences the preference of inclusion of household income in cost calculation scenarios.

The hardships of embracing consumer perspective in economic models have been acknowledged by the researchers. Consumer demand became "identical" for projecting demand in the demand functions, however, multiple data sets may compensate for the "homotheticity" in the functions by providing a greater perspective in consumption trends (Jorgenson and Wilcoxen 1993, 1276-1277). Even though Jorgenson and Wilcoxen's arguments were written for aggregate demand functions, the principles could be adapted to energy consumption forecasting as well. While the scenarios and surveys focused on micro-level cost prediction, the regression analysis for demand forecasting towards decentralized energy models provides a macro-level perspective. Complementary perspectives are significant in order to connect the energy systems and people.

Another key assumption of the thesis is that the perspective of people can be subjective, and the experiences of people about energy may vary from person to person. However, the subjectivity is perceived as an aspect which would enrich the models and formulas. Shapin noted that although the academic literature considered subjectivity as scientific, it is more considered on humanities and focused on the particular subject only (2011, 171). Indeed, deciding on when subjectivity could be scientific is a debate of epistemology. This study does not aim to resolve the ambiguity, rather to embed subjectivity of people to the energy models. *Figure 3* of the literature review covers the multiple motivations to join decentralized energy models. The positive and negative aspects of joining an energy community are normative, the experiences and motivations of people play a crucial role with the economic systems and technical feasibility to decide on what is "positive" or "negative" for energy models. In summary, Figure 4 describes the theoretical framework of the study:

Figure 4 Summary of the Theoretical Framework



4. Methodology

4.1 Research Design and Positionality

Decentralized energy models have the potential to address energy poverty, especially in the areas that have been historically neglected, however, the lack of focus of literature review on the tangible results of energy communities to address energy poverty, instead, rather framing energy communities as a promising project, implies that overcoming energy inequality with the help of decentralized energy systems have been a slow process. Acknowledging and respecting that every society and community has their own unique dynamics, I chose *Turkish communities in Vienna* as the case study on my thesis. "Vienna" as a location of the study, and "Turkish communities" as the community were chosen due to the researcher's personal and research background. I am a 24 years old female, who is studying in Austria for my Master's degree, born to Turkish parents and having Turkish as a mother language. Furthermore, I had been a project intern in Caritas Austria, in the project titled "Betriebsmodelle für sozial gerechte Energiegemeinschaften". (Operating Socially Just Energy Communities) during my thesis research. The project was aligned to my thesis research focus, where my research during the project focused on the possible obstacles a person from a socially disadvantaged household in Vienna may face if they want to join or form an energy community.

Mixed methods are the research methods for this study. Mixed methods are appropriate to use in the research where a specific case is studied for a broad research question, both quantitative data and a narrative should be used to answer the research question, and the generalizability should be enhanced in a study (Johnson and Onwuegbuzie 2004, 21; Doyle et al. 2009, 178-179). For this thesis, using quantitative research alone would have missed the market insights, theoretical concepts about justice and cultural aspects that would impact the interactions between decentralized energy markets and communities significantly. Meanwhile, using qualitative research only would result in the absence of analyzing societal trends of interest and attention towards the concepts of renewable energy, and the pricing mechanisms and behaviours. "Generalizability" is also a particular question for my research. The research question can be too broad to reach conclusions by studying Turkish communities in Vienna alone, hence, mixed methods can help the thesis to reach out more generalizable conclusions and policy recommendations, but flexible enough to be adapted to different societal and cultural contexts.

4.2 Research Methods in the Thesis

Three research methods were applied for the thesis: The expert consultations, scenario building with the survey results and Google Trends Analysis.

4.2.1. The Expert Consultations

The topics of literature review indicate that there are four main research categories for energy decentralization related to the thesis research: Social/Political, Cultural, Economic and Technical. The four subtopics were determined solely for searching experts to consult. Energy research, however, is too interdisciplinary to categorize its topics into single categories. Under the four main categories, keywords were chosen to look for projects or articles. Experts, who worked on the projects, articles, or conferences were contacted by their email addresses. It was considered that each expert's expertise areas should complement each other, in order to have more comprehensive views with higher variety.

Each consultation lasted approximately between 40 minutes to 1 hour, either by online meetings or in the offices the expert is working in. Before each consultation, 3-4 questions were prepared for each expert, tailored according to the expert's focus of work. However, the consultations were semi-structured and the experts shared their additional insights which they perceived relevant for the thesis research. Notes were taken during the expert consultations, and the notes for each expert were cross-compared with each other to understand the discussion areas and the views in energy research after the consultations. Qualitative analysis tools were not preferred to analyze the consultations, as the analysis is more knowledge-based on each sector, and each question was specific to each expert. The difference of the questions, and the lack of narratives in consultations made the thematic codings impractical to the thesis research.

Table 2 Expert Consultation Information

Expert Number	Profession of the Expert	Country the Expert is Working on	Expert Consultation Time (in CET (GMT +2))
Expert 1	Researcher	Italy	01.04.2025 14.00
Expert 2	Expert on Arts and Culture	Austria	03.04.2025 15.00
Expert 3	Researcher	Germany	04.04.2025 16.00
Expert 4	Senior Lecturer	Republic of Ireland	08.04.2025 11.00
Expert 5	Scientist	Austria	08.04.2025 13.00
Expert 6	Consultant	The Netherlands	08.04.2025 14.00
Expert 7	Private Sector Official	Austria	15.04.2025 09.00
Expert 8	Private Sector Official	Austria	15.04.2025 10.00
Expert 9	Consultant	Austria	22.04.2025 14.00
Expert 10	Researcher	Austria	23.04.2025 16.30
Expert 11	Private Sector Official	Austria	24.04.2025 09.00

To protect the anonymity of the experts, each expert was labeled with the numbers, according to the chronology of the expert consultation. Professions of the experts were stated in the table in general terms to demonstrate the sectoral diversity of the experts. Due to the case study of the thesis being in Vienna, Austria is heavily represented in the geographical distribution. While the cultural background of each expert is not shared in the table, it has a higher variety, including experts whose mother language being Turkish and growing in Turkish households. Consulting experts whose parents were from Turkey was significant, as my thesis focused on Turkish communities.

4.2.2. Scenario Building and Survey

The formulas for the perceived household energy costs for different energy systems depicted in the literature review were used in order to compare the perceived energy costs in central and decentralized energy systems. For the scenario building, the formulas were adapted to the energy regulations, taxes and energy tariffs in Austria. The scenario focuses on the case study of Turkish communities in Vienna. The values for household income level and annual energy demand of Turkish communities were according to the energy consumption and demographic statistics of Statistics Austria. Afterwards, the scenarios were compared with the survey results conducted with Turkish communities.

The survey was prepared for the Turkish people living in Vienna, in order to evaluate their attitudes towards renewable energy and energy decentralization; energy vulnerability, and questions to understand their proximity with the people in their districts. The questions were in scales, in multiple choices, and short answers. Towards the end of the survey, they were provided a space to write their reflections if they wished to. All the questions were based on self-evaluation. The questions ask both objective information (such as their duration of stay in Austria) or subjective statements (such as if they struggle to pay their energy bills). The questions of the survey do not have any question that is guiding the participants or imply that joining an energy community is a "better" option. For the same reason, the questions intentionally include less mention of energy communities.

The survey was shared in the online groups for Turkish people living/studying in Vienna, to Turkish people who would be interested in filling the survey. The number of respondents is low in the survey (n=13), which creates a concern for the reliability of the survey. The low response rate may have been caused by the survey being reached out from the mediums which had no issue public. In the studies which distributed surveys about energy communities with high respondents, (Soeiro and Ferreira Dias 2020; Koirala et al. 2018), the surveys were distributed to a target audience, either by choosing individuals by their involvement in energy communities, or with institutional research for possible respondents. The number reliability for the survey may particularly affect the percentage of people who face energy vulnerability in the Turkish communities. The subjectivity of the survey can be a further advantage to mitigate some of the limitations of the low number of respondents, where the subjectivity may enable the researcher to understand the various perspectives, regardless of the number of respondents.

4.2.3 Linear Regression Forecasting with Google Trends

Google Trends Analysis demonstrates popularity of a term over the time and in geographical distributions, where assigning scores in each geographical area according to their popularity. Moreover, Google Trends Analysis is crucial to compare the case study to general societal trends in Austria. Comparison between the case study and general societal trends on decentralized energy systems helps to differentiate the factors which are context-specific, or affecting the society as a whole.

The study conducted linear regression forecasting in order to identify possible factors which can affect future popularity of energy communities in Austria. First, keywords related to decentralized energy systems, and energy communities were being searched for Austria in Google Trends. The terms were searched in German, in order to get clearer results. Popularity of the keywords across the times and federal states in Austria were compared, and Google Trends popularity score formulas were formed in Microsoft Excel. Then, Google Trends popularity score for the energy communities were predicted in the year 2030 in each districts in Austria. The reliability of each regression formula was considered in the study. Then, the predicted scores were visualized with a map in QGIS. The map and possible popularity scores in 2030 were compared with the demographical data and maps of country briefings of intergovernmental or research organizations to determine which factors of demography or environment can be related with the popularity scores. On the other hand, it should be emphasized that there are 10 year gaps between different datas. The popularity scores forecasting is for 2030, whereas the datas for relative poverty in Austria, CO_2 emissions per capita and PV installments per person are from 2018-2022. The different datas and figures are being compared with the assumption that economic and environmental factors have a delayed impact on the popularity of decentralized energy systems.

4.3 Research Ethics

The research does not have any question that discloses any sensitive information or identity. The purpose of the research is shared in detail with both the experts consulted and participants in the survey before the start of the survey. The experts consulted and participants of the survey were informed that they can withdraw from the study whenever they want to without any consequences. Furthermore, if an expert stated that an information/personal anecdote should not be written in the thesis, these parts were not taken down as notes. The information about the scope of the study, the anonymity and withdrawal consent were shared as a briefing before the survey itself. Furthermore, there is not any risk or danger towards the researcher (me) or any participants involved in the study. The data collected from the study was stored in the personal computer and personal Google Drive account of the researcher, where they were protected with password. The research adheres to the research ethics and standards of CEU: Checklist on Ethical Issues in Research had been filled and signed by the researcher, and had been approved by the thesis supervisor before the researcher started her thesis research.

4.4 Limitations

I acknowledge that there are several limitations towards the study: The thesis focuses on Turkish communities in Vienna in the survey, and the scenario was built according to the Turkish communities in Vienna. The methodology itself can be applied to different communities, however, the results would likely be different. The culture varies between societies, hence the outcomes of the study can be only related to the cultural context of Turkish communities of Vienna. Furthermore, although explained in more details in *Scenario Building and Survey* section, the low number of participants to the survey remains as a significant limitation. While the geographical distribution varied between the respondents, the low number of participants in the survey creates challenges on reliability and induction for the survey. The usage of mixed research methods mitigates those concerns, where the expert consultations approach towards the research question in different disciplines, whereas scenario building and Google Trends Analysis provide economic and environmental insights.

5. Results

5.1 Expert Consultations

Consultations with the 11 experts reveal that energy decentralization has both challenges for growth and opportunities which can increase the amount of energy users. The experts' insights revealed four main debate areas about energy communities: technical innovations in decentralized energy systems, market challenges, social attitudes towards energy and justice in energy policy.

5.1.1. Real Time Data: Forecasting and Privacy

The real time electricity consumption data is not being provided by grid operators in Austria to the applications which track overall daily/monthly electricity consumption. According to the Expert 5, the household electricity consumption data can be uploaded only after 1 day, in 15 min/kwh metrics. Expert 5 further stated that it is due to the requirements of Renewable Energy Expansion Act (ErneuerbarenAusbau-Gesetz, EAG), which aim to protect the user data on energy communities. Renewable Energy Expansion Act could address some of the doubts of the potential energy community members, as Expert 1 argued that potential invasion of privacy is a primary deterrent for residents towards decentralized energy models. Peer-to peer trading require a high amount of communication and trust between energy community members, and the community operator (Expert 1). Delaying data entry and dividing the data into smaller bits can make the data more anonymous, while operating the data.

Increasing the accuracy of data forecasting and protecting privacy seem to be at odds, hence one aspect is sacrificed for the another. In Austria, rights of privacy is prioritized, and the data metrics in the uploading time seems to be a suitable method for energy management. Regardless, providing the data not in real time also reduces the accuracy of the forecast. According to Expert 5, the energy consumption forecasting is done by data projection annually in comparison with the previous consumption rates. He further states that for one household, the accuracy rate would be close to real consumption rate, but margin of error increases with more households being connected due to the gap between intervals. Expert 7 further notes that real time energy consumption should not differ from the projected usage, as the data forecasting is not only done to match energy supply with demand, but also the frequency between the grid operators. The smaller data controllers are, the higher risk for a mismatch of frequencies (Expert 7). Expert 7 argued that in the most severe scenarios of disparity between frequencies, blackouts can happen. On the other hand, an alternative approach is proposed by Expert 6. Expert 6 stated that while a data projection which perfectly predicts energy consumption is not possible unless real time energy consumption is being provided, the reliability of energy supplied can be still achieved. With multi-supplier model, a household can have higher number of alternatives for energy supply, ranging from independent energy suppliers to trading with neighbours (Expert 6). In other words, a more complex web of energy suppliers can compensate a shortage in energy demand forecast. In other words, while decentralized energy systems are even more sensitive for the data forecasting for energy security, complex networks with decentralized energy systems can mitigate the consequences of the absence of real time data the without sacrificing privacy.

5.1.2. Market Challenges

5.1.2.1. Entrance Cost

The thesis is built upon the presumption of central energy markets being the preexisting market model for electricity, and decentralized energy market being an emerging market with being an alternative to old market structure, as covered in the literature review. The experts commented that although markets seem favorable for decentralized business models breaking into energy markets, the initial process is not encouraging. Expert 5 argued that there is a paradox in the energy markets: Due to high service expenses, the introduction phase of the product (or service) life cycle for energy management systems (EMS) is very high, and it would be unlikely to decrease before the maturity phase. He further stated that cheaper and more accessible alternatives such as smart meters can be more preferable for energy communities. Expert 7 attributed the entrance costs into a very high return on investment, such as 10-15 years, which makes energy market very slow to mature. The paradox here, could be interpreted as: If the costs for EMS would not slow down before maturity, and the introduction-growth phases would take 10-15 years, then EMS can lose its competitiveness. Of course, one may argue that EMS is not the only necessary solution for decentralized energy markets. Regardless, unfavorable conditions for EMS may also lead to energy communities being more individualized as smart meters directly transmit the data into e-controller, commenting upon Expert 8' and Expert 11's insights on the relations towards user-data transmission. It would not directly make energy communities less attractive, however, it can be a disadvantage for communities which prefer higher social interaction or more complex networks.

5.1.2.2. Market Being "Too Niche"

Traditional definitions of a "Market Nicher" focuses on a product or service targeting a small segment of a society, hence larger market players would not be interested to promote niche products/services (Monash Business School 2025). On the other hand, the nicheness of decentralized energy markets is more likely to be related by its adaptation and ability to penetrate into the preexisting market. Expert 7 argued that even though current market regulations encourage decentralized energy markets, the measures for energy security such as balancing the frequencies of the grids, should be borne by central energy systems, which could be a significant additional cost for central energy markets. In other words, decentral energy market infrastructure is still a hybrid energy system not fully independent from central energy networks. Expert 9 further noted on the profitability and the market expectations for decentral energy markets. He argued that decentralized energy markets gained a larger market share since 2022, hence there is an anticipation for energy community to be more profitable. With the positive market outlook, the number of suppliers for decentralized business models increased. However, Expert 9 stated the profitability remains unchanged, due to only energy communities with larger number of members being profitable.

It should be underlined that there is not a consensus between the opinions of the experts for the market nichery of energy communities. When asked for the potential of market growth of energy communities of Austria, Expert 11 provided a more optimistic answer. She noted that the number of people who express interest to join a prevalent energy community or form their own energy communities have been increased in recent years. Furthermore, she argued that if early adopters state their interest first, then more initially skeptical people would be more likely to be convinced to join later as a snowball effect. Her remarks can be interpreted as marketing with social dynamics, such as word of mouth marketing can play a larger role to increase the number of energy community members. In other words, from the consumer's perspective, the profitability of the market or the service can be secondary to the social benefits provided if the initial phase of energy services is not very profitable.

5.1.2.3. Lack of Market Competition

Expert consultations indicated that while the market competition among the energy market is supported by the legal framework, market competition targeting similar geographical areas and the slow changes in infrastructure reduces competition in decentralized energy markets. Expert 6 emphasized the risk of lock-in with a single supplier. Hence, she further argued that prevention of possible lock-ins is the main motivation for shorter term energy contracts (1-3 years), which is fostered by the European Commission in the European energy markets. The preexisting framework further supports that why the market for energy communities has growth expectations. On the other hand, as indicated in "entrance costs", a transformation in fiscal/technological level is a slower process. Expert 1 argued that market competition for independent suppliers is not as high as the academic literature claimed. He gave the example of Italy, where the number of suppliers is too small for larger areas, which creates challenges for smaller energy communities for supply chain formation. It can be related to the argument of energy communities being more profitable with larger members, and the market itself may mobilize towards keeping the "potential energy communities members/number of suppliers" ratio high. Regardless, Expert 11 stated that there can be too many power sources for each individual in Austria for the future if more consumers apply for energy communities in wide geographical areas in comparison, which may infer that there is no single market supply/demand match in Europe for energy community markets.

Expert 7 and Expert 11 pointed out the lack of alternatives for the energy infrastructure in Austria, decreasing the incentive for market competition. Expert 7 argued that consumers are largely undifferentiated for energy utilities, and the demand being largely inelastic. In other words, not only the number of competitors would be affected, but also price competition would be lessened for energy utilities, such as heating. Expert 11 further commented that data operator systems are monopolistic and prevalent grid operators have little motivation to be user friendly, as there is a high dependence on them in energy transmission. However, she also stated that the electricity prices from the energy communities can be less dependent on the centralized energy prices, which can make energy communities more immune to the external price shocks. In other words, despite the infrastructural challenges, independent pricing can be a positive indicator for decentralized business models, which may alleviate the pricing factors for energy utilities.

5.1.3. Social Attitudes Towards Energy Communities

Social relations between the members affect the likelihood of joining an energy community. The expert insights support the preexisting academic literature of motivations for being interested in energy communities, however, they further commented on how the motivations differ from rural areas vs. urban areas. Expert 1 argued that there are two benefits for joining an energy community: Economic incentives or social benefits. He stated that social incentives are much more influential motivators, due to social networks can carry information towards the members fastly, meaning that if some members think about energy communities positively, the other members would be more likely to join. Expert 2's comments towards a different question can also support Expert 1's argument. When asked about how socially disadvantaged groups can be more included in sustainability initiatives, she answered that the socially disadvantaged groups need to build trust towards the institutions or initiatives and their friends/relatives are being trusted in decision-making process. She further claimed that people who took part in community projects were generally convinced by a friend. However, it should be noted that she answered the question in scope of Turkish migrant communities in Vienna and it may not be the same situation for all communities. Regardless, the theoretical knowledge about social behaviours about energy communities and the case study for Turkish communities in Vienna seem to be aligned with each other.

Expert 8 stated that social relations are not only significant for the opinion towards energy communities, but also for infrastructural networks as well. She argued that energy communities can be beneficial to households with families or villages as they can be one connected solar grid. Expert 1 argued that in more centralized energy communities, the prevalence of intermediaries for energy contracts and frequent contact with the intermediator incentivizes tighter relations between the energy community members. Expert 9 further commented on frequent interactions occur not only between the community members but also between resident-local political institutions in the rural areas. He gave the example of a community center in a rural area being an energy community-friendly building, where the residents would be more invested to support interconnected grids for a community building, and the local politicians can support the solar energy grids for the building to increase public approval.

On the other hand, many experts also emphasized that public attitudes towards energy communities tend to be indifferent, due to lack of familiarity towards the concept. Expert 1 and Expert 7 stated that if a person is not an energy expert, it is unlikely that they heard about the concept of energy communities, with Expert 7 arguing details of one's energy bills are not a primary concern of the energy consumers due to process being standardized. Their arguments can be inferred as central energy systems turning into a consumption habit, related to the *lack of competition* section. However, some experts argued otherwise. When asked about the social acceptance of the energy projects in Austria, Expert 9 argued that the social acceptance of renewable energy projects was increased by the public in Austria, but there is still some initial resistance towards the projects. In a related question, where Expert 10 was asked about the factors that influence social acceptance towards renewable energy projects, she argued that there were various environmental movements in Austria, and the public attitudes shaped from the political debates, cautious attitude of whether the energy project would be sustainable or if the project would minimize economic harm in labor transition. It could be stated that transparency and inclusion of the public can positively impact social acceptance towards renewable energy projects, or lead to revision of the energy projects.

5.1.4. Energy Vulnerability and Poverty in Energy Research

5.1.4.1. Narrow Definition of Energy Justice

When the experts were being asked about what they thought about the preexistent definitions about energy poverty and justice, they argued that the definitions for energy justice should be expanded beyond the current criterias and definition of energy justice. Expert 3 underlined that the traditional definition of energy poverty had included if one's energy bills consisted more than %10 of their disposable income, then it was regarded as the person was facing energy poverty. However, she argued that energy vulnerability is a subjective term where the energy bills of a person can consist of less than %10 of their disposable income, yet they can still be vulnerable to energy poverty. She supported her point by the perception that inflation can vary from person to person. In other words, dynamics of people's lives such as their daily responsibilities, if they have debts, or lacking informal social safety nets could affect one's energy vulnerability. Expert 2 answered as the support of migrant communities towards sustainable initiatives relies on to what extent sustainable initiatives can improve their life conditions in short-midterms, to a related question. She claimed that the life practices of migrant communities prioritized prevention of poverty in a shorter time span, due to inequalities in social opportunities and accessing societal resources. Projects about energy efficiency and sustainability aim for long term gains to a society, hence inclusive projects should address the needs of migrant communities that the projects would not increase economic vulnerability of the migrants who are in the risk of poverty, in the short run. Expert 4 provided insights about how energy vulnerability can be prevented in the long run. He stated that the injustice in energy is intergenerational and historical: Energy justice is a holistic term where the issue could not be resolved without addressing the social and historical aspects. He provided the example of life stages, where during adulthood (a life phase where people actively a part of the workforce) the likelihood of being a part of an energy efficient building is higher compared to young adults or elderhood.

5.1.4.2. Towards Inclusive and Just Energy Projects

Methods for a just energy research should consider multiple factors for understanding energy poverty, and developing projects to address energy vulnerability. Expert 4 stated that both social and technical sides of a project should be prioritized. He further claimed that during the project development, social participation was treated as a tradeoff towards economic development of energy projects. It was due to communities engaging one with another, resistance towards the projects can be increased. However, he underlined that the negative public opinion towards the project may be reflecting intergenerational injustice, where the communities build distrust towards energy and development projects when the previous projects damage the environment. Hence, building trust and relationship with the communities are key for the engagement (Expert 4).

Even though participation in the decisions of energy projects can be significant to overcome societal challenges and to reduce inequality, one may ask how it can be integrated towards project planning and development processes. Expert 10 noted that Multicriteria Decision-Making Analysis involves both objectivity and subjectivity, which is suitable for the projects to decrease energy vulnerability. Her arguments can be interpreted as being aligned with the argument of energy justice is not only evaluated with objective metrics. She further stated that Multicriteria Decision-Making Analysis is plausible due to the researcher being flexible to decide on the criterias, then they can evaluate and score the criterias on certain metrics, increasing objectivity of the study. Multicriteria Decision-Making Analysis can be adapted to energy research as: Definition of the criteria according to the goals of the study and their relevance, defining the climate and energy scenarios with participatory manner and analysis of these scenarios while evaluation according to criteria, and finally conducting a sensitivity analysis to measure the reliability of the analysis (Expert 10). In other words, the combination of scientific research, community engagement, evaluating the needs of each stakeholder and mitigation of the long term adverse effects are the main components of just energy research.

5.2. Scenarios of Centralized vs Decentralized Perceived Household Cost

The literature review and expert consultations provided crucial insights about energy vulnerability, how central and decentral energy systems work. In order to understand in which conditions decentralized energy systems can be advantageous for households which may be facing energy vulnerability, the perceived household cost formula which was covered in the literature review will be used.

Recalling the perceived household cost formula for the household for both energy models:

$$\text{C\_house\_centralized} = \text{C\_energy\_bought\_centralized} \times (1 + (\sigma / \varphi(H))$$

$$\text{C\_house\_community} = [\text{C\_energy\_bought\_decentralized} \times (1 + (\sigma / \varphi(H)))] + \text{C\_neighbour\_sell}$$

The goal here is to determine when annual energy spending in socially disadvantaged households is smaller in decentralized energy models, compared to central energy systems. In other words, when " C_house_centralized > C_house_community"

Rewriting the statement " C_house_centralized > C_house_community":

$$\text{C\_energy\_bought\_centralized} \times (1 + (\sigma / \varphi(H)) > [\text{C\_energy\_bought\_decentralized} \times (1 + (\sigma / \varphi(H)))] + \text{C\_neighbour\_sell}$$

"C_energy_bought_decentralized" and "C_energy_bought_decentralized" are the variables which can be estimated according to components less dependent on the energy buyer, such as labor price, network fees and taxes. However, "C_neighbour_sell" relies on the trade between energy community members. "C_neighbour_sell" means no cost for the buyer as the costs of producing energy has already been covered by the energy producer (Austrian Coordination Office for Energy Communities). For this problem, it will be assumed that the neighbour would not charge any money for the excess electricity they want to share with their neighbours. Hence, isolating the variable, "C_neighbour_sell" would provide the necessary amount of electricity should be shared by the neighbours to decrease the energy costs in energy communities for socially disadvantaged households in a scenario where the annual energy consumption of the socially disadvantaged households, "C_energy_bought_centralized" and "C_energy_bought_decentralized" are being constant. In other words:

$$\text{C\_neighbour\_sell} < \text{C\_energy\_bought\_centralized} \times (1+ (\sigma / \varphi(H)) - [\text{C\_energy\_bought\_decentralized} \times (1 + (\sigma / \varphi(H)))]$$

However, one should also consider that because it is a cost estimation formula, C_neighbour_sell < 0. Thus, the equation should be reversed:

$$\text{C\_neighbour\_sell} > \text{C\_energy\_bought\_centralized} \times (1+ (\sigma / \varphi(H)) - [\text{C\_energy\_bought\_decentralized} \times (1 + (\sigma / \varphi(H)))]$$

For this problem, "C_energy_bought_centralized" will not be calculated manually due to the high number of offers for renewable energy by energy suppliers from central energy systems. Instead, I used *Tarifkalkulator* by the website, E-Control. *Tarifkalkulator* provides the offers for annual energy options from various suppliers in different price ranges when one enters their post code, annual energy consumption by kwh/year. I filtered the options for green electricity, entered the postcode for "1100" (11th district in Vienna as an example), "2384 kwh/year" as the annual electricity consumption and chose the "default" (popular options recommended by the website) for the preexisting brand and product. The annual consumption number, 2384 kwh/year is chosen according to the "Total consumption of all fuels 2023/2024 – in gigajoules" by Statistics Austria (2025), where the electricity consumption from grid per person is converted from gigajoule/year to kwh/year. Regardless, it should be noted that 1113.9 kwh/year is self produced (Statistics Austria 2025), which is relevant for the cost calculation in decentralized energy models. The household electricity consumption is chosen as per person due to the absence of detailed data about consumption patterns of households in Austria. The 10 cheapest offers per year in May 2025 prices (in EUR) were listed from *Tarifkalkulator* as: 690.07, 708.09, 714.41, 717.96, 719.66, 724.26, 724.72, 729.97, 730.63, 733.12. The average of the offers is 719.29 EUR. Thus, "C_energy_bought_centralized" is 719.29 in the formula, by taking the average amount.

The shock factor for the problem is how the price for private electricity consumption fluctuated over the years, and how the price shocks, such as COVID-19 and Russian Invasion of Ukraine have affected the private electricity consumption prices in Austria. To measure the impact of the price shocks, baseline gap is determined as 2009-2019 where the prices were relatively stable with 2009 as the base year. Then, the prices between 2009 and 2019 are being compared to the prices between 2020-2024, where the price shocks happened. The prices for private electricity consumption over the years in Austria were found in Statistics Austria (2025). The regression formula for electricity prices between 2009-2019 was calculated, then the prices of 2020-2024 were calculated with the regression formula. The average electricity prices were calculated for both real prices (real average) and expected prices (expected average). Finally, The shock factor was calculated by Real Average- Expected Average/Expected Average. The shock factor (σ) is 0.158 (%15.8).

Income Sensitivity Index (ϕ(H)) is more subjective as it changes by the annual household earning, meaning that Income Sensitivity Index varies by each households. However, for simplification, I used the data from Statistics Austria (2024) where the household annual income were listed by the demographics and quartiles. For the case, I prefer to use the income of a household "Citizenship Austrian, naturalised (Non-EU/EFTA)" and in bottom %25 of earnings in the statistics, whereas the median income is the income level of %50th percent of all people in statistics. Income Sensitivity Index for the problem is 22290/ 33210=0.671, which means a migrant (become Austrian citizen afterwards) household from a non EU country who is also earning less than at least %75 of the migrant households earn %67 of a median income.

With the variables, now the annual perceived household cost from a centralized energy system can be calculated:

C_house_centralized= 719.29 * (1+ 0.158/0.671)= 887 EUR

887 EUR is how a migrant (become Austrian citizen afterwards) household from a non EU country who is also earning less than at least %75 of the migrant households may perceive the electricity cost annually. The next step is to measure the "C_energy_bought_decentralized".

It was stated that measuring the costs of purchased electricity of decentralized energy models can be a challenge due to high variance in tariffs energy communities (Austrian Coordination Office for Energy Communities). One solution to the concern can be adapting the formula of cost measurement of centralized energy systems. The simplified formula (without promo codes, price bundles or discounts) for the C_energy_bought_centralized that was adapted from *Tarifkalkulator* from E-Control is:

C_energy_bought_centralized = [(Labor_cost + Flat_fee + Energy_tax) + VAT] + [(Grid_costs + Grid_tax) + VAT]

Where:

Labor_cost: Service labor fees

Flat_fee: Annual basic subscription or metering fee

Energy_tax: Tax on electricity usage (if applicable)

Grid_costs: Network tariffs

Grid_tax: Regulatory charges or taxes applied to network usage

VAT: Value-added tax (standard 20%) applied to both energy and grid costs

Recalling the formula for C_energy_bought_decentralized is:

C_energy_bought_decentralized= ((E_avg-E_pv)/ E_avg) × f_micro “f_micro” demonstrates the cost stemming from the microgrids, hence, the formula for C_energy_bought_centralized can be adapted into f_micro. The formula of *Tarifkalkulator* is adapted according to the guides of Austrian Coordination Office for Energy Communities: Tariff Design, Renewable Energy Communities Information Sheet and Renewable Energy Communities – Taxes and Levies (February 2024):

f_micro= labor cost+basic fee + 1/3 VAT_electricity + (gridtariff×(1−X) +1/3VAT_grids

“labor cost” is the same with central energy systems, whereas “basic fee” is replacing the flat prices. Assuming that the energy community of the problem generates income between 35000-100000 USD annually, the VAT is 1/3 than a bigger energy community; while the electricity tax is 0. The energy community in the problem is a medium sized energy community, yet small enough to be a local energy community, hence the X (tariff reduction rate) is %57.

To simplify the problem, the formula will assume that the labor costs, basic fees and grid tariffs will be similar to the central energy systems. The numbers of labor costs, basic fees and grid tariffs are taken from the n-1 median offer of the cheapest options of *Tariffkalkulator*. N-1 offer instead of the median is selected due to the median offer applying a high amount of promotion code that the costs being significantly higher than the other offers. Applying the formula for f_micro:

Fmicro=203.12+30.00+0+3.89+267.26*0.43+4.46=356.3918 EUR

“E_avg” for the problem is 2384 kwh/h, whereas “E_pv” is 1113.9 kwh/h. With all the variables, now the equation can be solved:

C_neighbour_sell>887- [(1113.9/2384) ×356.3918 ×(1+ 0.158/0.671)]

C_neighbour_sell> 887- [(0.533) ×356.3918 ×(1.235)]

C_neighbour_sell>887- 234.6

C_neighbour_sell>652.4 EUR

652.4 EUR is the annual amount of perceived electricity cost that should be shared from a neighbour in order for decentralized energy models to be a less costly option compared to central energy systems. If the neighbour shares more than 652.4 EUR of perceived electricity cost annually, then decentralized energy models would be an increasingly more attractive option for the energy vulnerability, whereas if the shared perceived cost of electricity exceeds 887 EUR, the household which faces energy vulnerability may not feel a burden hypothetically.

It should be underlined that these costs are not the real costs, and the "perceived cost" changes between every household. Instead, the equation was formed in order to reflect to what extent the role of social relations is being significant, and to conceptualize the inequality of burden in energy vulnerability. The scenarios demonstrated that for a migrant family who earns in the 4th quartile among the non-EU born migrant communities, they need to receive 3 times of electricity from their neighbours than what they spend. On the other hand, an affluent household would have much less perceived cost, and would have a greater incentive to join an energy community even if there would not be any energy sharing between the neighbours. However, it should be also stated that the electricity prices are the same for both energy systems, which decreases the incentive for socially disadvantaged households to form energy communities. If the shock factor had been significantly less for the energy communities, the necessary amount of perceived cost of energy shared could have been much less.

The results of the scenarios seem to be aligned with the survey results. Nevertheless, it should be considered that the sample size for the survey is only 13, implying that the margin of error is high. Regardless, the survey is still valuable due to the gap in the literature about the experiences and opinions of Turkish communities in Austria about energy vulnerability. The participants of the survey provided two different kinds of answers to the question of what percentage of their monthly income to the energy bills on average. Some participants entered manually that they were students hence the student housing price covers utility. They also answered that they did not struggle to pay their energy bills either last year or this year. Thus, it could be argued that affordable housing for students is an effective step to prevent energy poverty for migrants who are receiving education. On the other hand, some other participants stated that they spend 5-10% of their monthly income on energy bills. It is significantly higher than the national average, where the average national annual spending on energy bills is 2.38% of their annual incomes (Statistics Austria 2022). Figure 5 demonstrates that %54 of the participants face energy vulnerability, by stating that they either struggled to pay their energy bills in the previous year or this year.

Figure 5 Survey Result on Energy Vulnerability

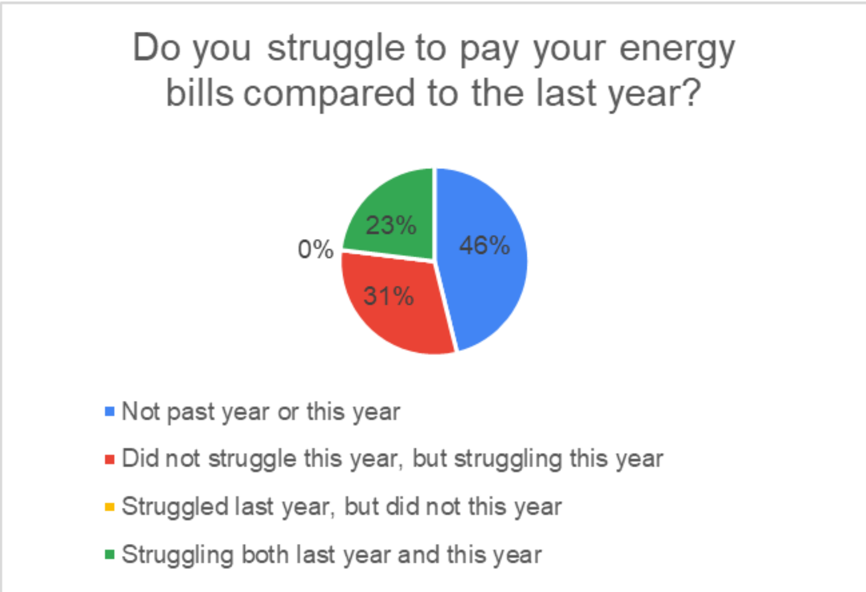
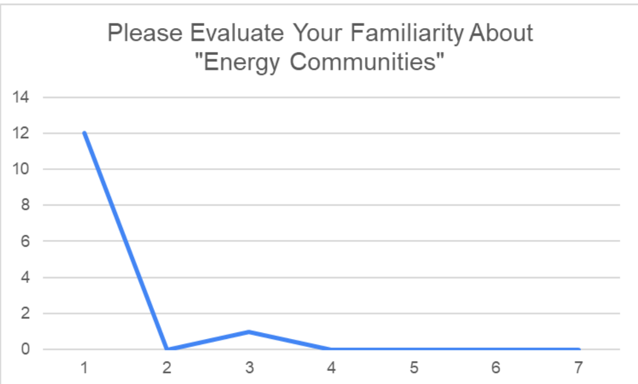


Figure 6 Survey Result in Familiarity About Energy Communities



When the participants were asked to self evaluate their familiarity towards energy communities, with 1 not previously hearing about energy communities and 7 being an expert about energy communities, almost all participants answered "1", indicating a very low familiarity about energy communities. The survey results may further support the expert consultations and scenarios that the energy community is more well known in households who have higher annual incomes.

Approximately %70 of the participants of the survey reported that they were not having a close relationship with "neither with their neighbours in an apartment or with their neighbourhood". On the other hand, Expert 2 from expert consultations argued that many people in Turkish communities in Vienna have strong relationships with each other. However, the difference in the survey may have been caused by the question asking the proximity in the closest few streets (in Turkish: "mahalle") or within the next flats. Turkish communities in Vienna can still be in close contact in social media, or in the same districts but not in the closest few streets. In other words, proximity in the migrant communities may be caused by cultural proximity rather than geographical proximity, which indicates that the "proximity" in the context of energy communities should be focused on the regional level rather than local level. Using micro grids on the regional level have increased the grid usage fee reduction: While it would decrease the perceived electricity cost by purchasing energy, it would increase the perceived cost of necessary shared electricity from the neighbour in the scenario. In other words, being connected to a regional energy community system would lead to a connection to a larger community, but also higher social interactions for energy sharing.

5.3. Popularity Analysis of the Energy Community Concepts

In order to forecast the possible popularity and future demand of the decentralized energy systems in the different Austrian districts, keyword popularity scores of Google Trends were analyzed and regression formulas for nine districts in Austria were formed. One may argue that nine regression formulas for each keyword can be impractical and time-costly. Hence, four keywords were chosen due to the relevance to the decentralized energy models: “"Energiegemeinschaft" (Energy Community)”, “"energiegemeinschaften" (Energy communities)” , “"Smart Meters"” and “"Fotovoltaik" (Photovoltaics)”. The former two were selected due to the keywords referring to the same decentralized energy models, “Smart Meters” were selected due to its role in self-governance in energy, and “Fotovoltaik” were selected due to solar panels being a key energy source in energy communities. To understand the relations of each keyword, correlation analysis between "Energiegemeinschaft" and three other keywords were conducted for the average popularity score of nine districts in Austria per year between 2020-2025. Correlation analysis indicated that popularity of "Energiegemeinschaft" has a very strong positive relationship with keywords “energiegemeinschaften” and “Smart Meter”, but a moderately positive relationship with “Fotovoltaik”:

Table 3 Correlations Between Popularity Scores of Keywords Related to Decentralized Energy Systems

Keywords	Correlation Score
"Energiegemeinschaft" and "energiegemeinschaften"	0.846
"Energiegemeinschaft" and "Smart Meters"	0.841
"Energiegemeinschaft" and "Fotovoltaik"	0.465

Due to the high positive relationship between all “Energiegemeinschaft”, “energiegemeinschaften” and “Smart Meters”, it can be reasonable to assume that regression analysis for these three keywords in each district may lead to similar results, hence the regression formulas were formed for one keyword, “Energiegemeinschaft” for simplification. The moderate positive relationship between “Energiegemeinschaft” and “Fotovoltaik” is understandable: even though the words are related, photovoltaics are commonly used in central energy systems with renewable resources as well. Furthermore, the graphs for each keyword demonstrate that the popularity of each keyword increased drastically after early 2022, possibly due to Renewable Energy Expansion Act in Austria in 2022. Hence, the regression formulas for each district were formed with the popularity scores of the 2022-2025 time period.

Figure 7 Google Trends "Energiegemeinschaft" Popularity Graph (Accessed in June 5, 2025)

Figure 8 Google Trends "Energiegemeinschaften" Popularity Graph (Accessed in June 5, 2025)

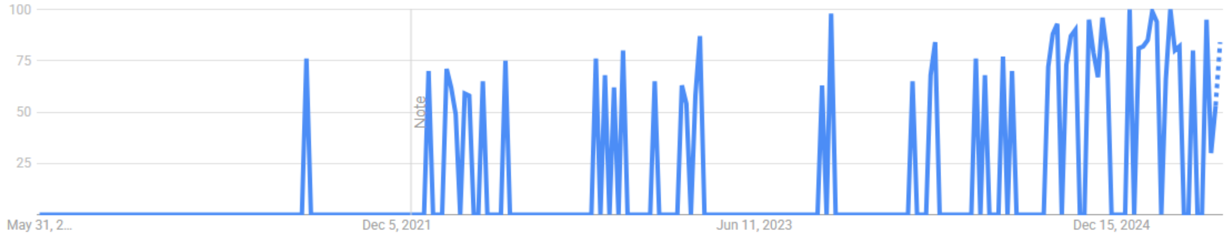
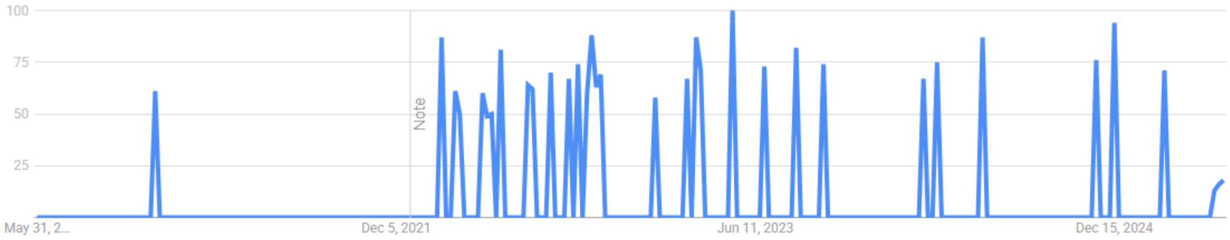


Figure 9 Google Trends "Smart Meters" Popularity Graph (Accessed in June 5, 2025)

Figure 10 Google Trends "Fotovoltaik" Popularity Graph (Accessed in June 5, 2025)



[2]

The regression formulas for the popularity score of "Energiegemeinschaft" between 2022-2025 in the districts in Austria could be stated to have an overall high reliability due to high multiple R scores for regression formulas, except for "Salzburg". For the regression formulas, the popularity scores of "Energiegemeinschaften" between 2022-2025 were used for "Salzburg" and "Lower Austria" as the regression formula for "Salzburg" had a higher reliability score in "Energiegemeinschaften" and Lower Austria had a linear regression graph in "energiegemeinschaft", which is not realistic. Using "energiegemeinschaft" and "Energiegemeinschaften" interchangeably for those two districts is justified due to very high positive correlation scores between those two terms (0.846) and by the fact that the two keywords are actually referring to same thing, only "Energiegemeinschaften" being the plural form of "energiegemeinschaft". The regression formulas for the districts are:

Table 4 Regression Formulas for Popularity Scores for Energy Community in Austrian Districts

Districts in Austria	Formulas of Popularity
Burgenland	Y=-7.5X+100.666666666667
Lower Austria	Y=8.5X+60.6666666666667
Upper Austria	Y=11X+45.6666666666667
Salzburg	Y=-6.5X+70.3333333333333
Carinthia	Y=7.5X+39.3333333333333
Styria	Y=12X+21.6666666666667
Tyrol	Y=X+29
Vienna	Y=-3X+36.6666666666667

[2] "Data source: Google Trends (https://www.google.com/trends)."
In all graphs, the vertical line writing "Note" refers to a break-even point in December 5,2021.

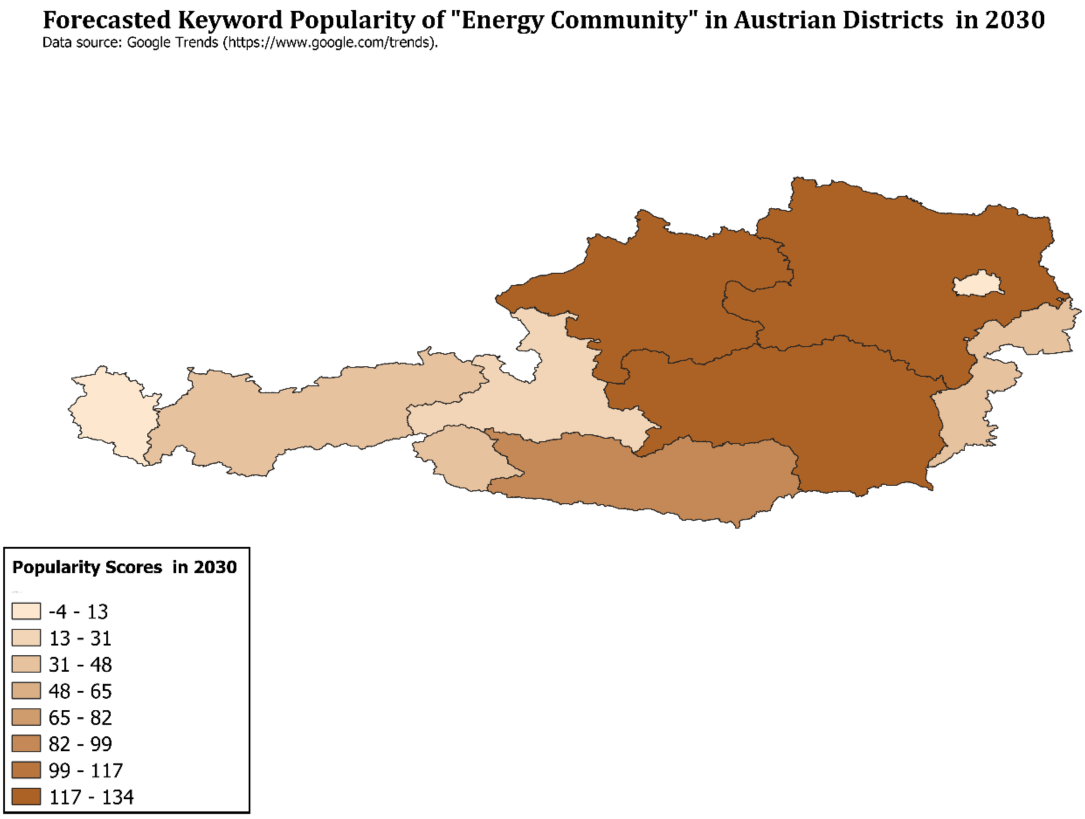
Vorarlberg	Y=-4X+28.3333333333333

"Y" in the regression scores refer to the estimated popularity score, while "X" is the year. However, while forming the table for the data sets, the base year, 2022 was considered as "0" in X. Thus, the "X" may actually refer to "Year Estimated-2022". The formulas, however, still have some considerations. To begin with, when the formulas were tested by the known popularity scores, 2022-2025, the accuracy rate increases over the years but still not equals to the exact same values. Furthermore, Google Trends tends to assign the popularity scores related to each other, on the other hand, my regression analysis assumes that the popularity scores of nine Austrian districts are changing independently from each other. Despite these concerns, the regression analysis still fits its main purpose: To understand in which districts energy communities can be in higher demand and to figure out possible reasons of the future popularity. Applying the regression formulas, the estimated Google Trends popularity scores of energy community in the Austrian districts in 2030 are calculated:

Table 5 Estimated Popularity Scores in 2030 for Energy Community in Austrian Districts

Districts in Austria	Popularity Scores in 2030
Burgenland	40.6
Lower Austria	128.6
Upper Austria	133.6
Salzburg	18.3
Carinthia	99.3
Styria	117.6
Tyrol	37
Vienna	12.6
Vorarlberg	-3.6

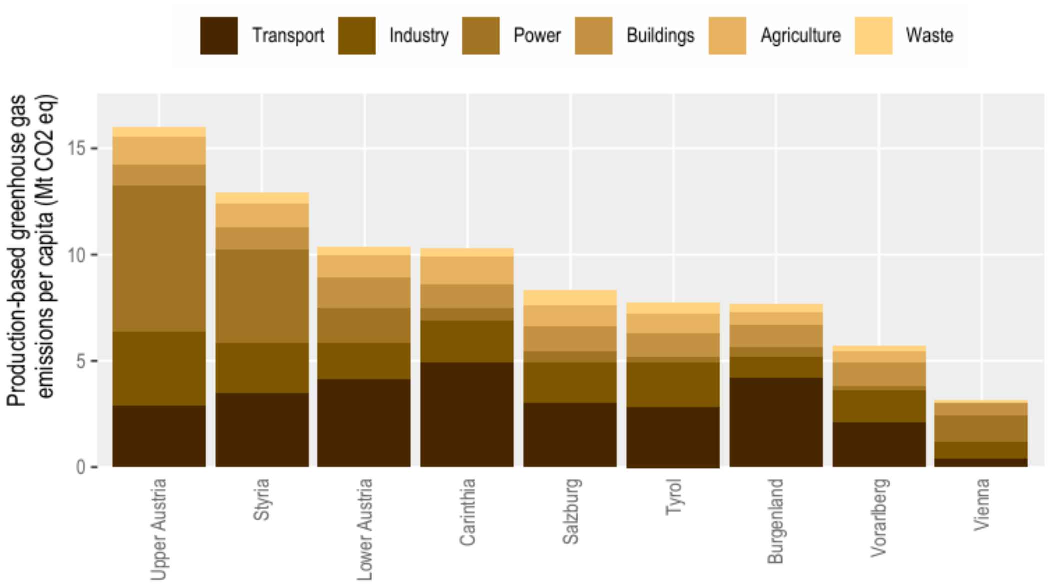
Table 6 Forecasted Keyword Popularity of Energy Community in 2030 Map



Map Source: The author

The popularity scores in 2030 themselves do not sufficiently reflect the geographical trends. Thus, I created a visual map in QGIS by using the regression formulas. The estimation about future popularity of the energy community in Austrian districts can be related to the income distribution and source of CO2 emissions per capita. According to OECD, Upper Austria, Lower Austria and Styria, the districts where energy community concept is projected to be popular in the future, are not the districts which have the highest GDP per capita but they have the lower relative poverty rates (2022). In other words, the income inequality can be lower in these districts. One possible reason relation between low income inequality and demand towards energy communities can be the high initial PV installment costs. Prices of standard module silicon are almost %50 more expensive by Austrian manufacturers compared to global prices (Fechner 2022, 8). Although the residential PV installments are less costly, the overall process may still create burden towards households who earn lower incomes.

Figure 11 CO2 Emissions Per Capita in Austrian Districts by Emission Source



Source: OECD (2022), *OECD Regions and Cities at a Glance 2022*, OECD Publishing, Paris, https://doi.org/10.1787/14108660-en

The top three districts that may be most interested in energy communities in 2030 tend to have the highest production based CO2 emissions per capita, with power being a significant source for CO2 emissions. While in the districts that may express lower interest towards energy community formation, such as in Tyrol or Vorarlberg, power is a very small percentage of CO2 emissions per capita. The results may indicate that the districts which have lower efficiency in heating or cooling may be more likely to demonstrate interest in energy communities. Thus, energy community formation can be rather thought as a holistic process which includes efficiency improvement in addition to the motivation aforementioned in literature review such as a sustainable lifestyle or a sense of community. The results support the Expert 7's arguments where he stated the energy policy of Austria emphasizes a high priority on the decarbonization of the industries by promoting a circular economy in heating and cooling. In other words, energy communities may be a niche subfield in renewable energy, on the other hand, however, the regression analysis for future popularity indicates that energy communities can support decarbonization if decentralized energy systems can provide sustainable alternatives towards high CO2 producing sources, where decentralized energy systems have the possible highest demand.

6. Discussion

The discussion section aims to explain the research question in three steps: First, it evaluates the concept of "decentralized energy systems" itself and explores the benefits and challenges of decentralized energy systems to a potential consumer. Then, the findings and literature review are being applied to the case study of the thesis. Finally, the discussion is being concluded with policy recommendations for the future.

6.1. Advantages and Disadvantages of Decentralized Energy Systems

Literature review and results of the thesis indicate that energy communities can help reduce energy vulnerability and may have environmental benefits, however, the benefits are rather implicit and theoretical. Meanwhile, the challenges for energy communities are largely caused by adaptation towards the preexisting infrastructure and entering towards the energy markets as a niche system. It could be stated the benefits being long term based and implicit whereas the disadvantages having immediate and financial effects could be a deterrent for households who have financial difficulties to join energy communities. Energy communities getting interest from more comfortable households has been a frequent assumption that also has been commented frequently by the experts and the literature (Hanke et al. 2021; Expert 9). In a broader term, it is also frequently questioned that energy transition benefits for whom, by the experts and the justice frameworks (Droubi et al. 2022; Heffron 2022 ; Expert 3, Expert 4, Expert 10). The scenario formation in the results section further supports the hidden cost of decentralized energy systems towards socially disadvantaged households. On the other hand, the popularity forecasting of energy communities in 2030 demonstrating that energy communities can be more popular in areas with lower GDP per capita in Austria may infer that this assumption may change in the future.

Even though it was argued that energy autonomy and fostering local economies were common motivations to join an energy community (see *Figure 3),* decentralized energy systems may not be as localised or self-sufficient as the literature claimed. The research suggests that the "self-sufficiency" varies greatly by each energy community, as the components in decentralized energy systems have a complex network and require cooperation in multiple levels (see *Figure 2,* Expert 7). On the other hand, the small incentive for competition in energy infrastructure creates additional monetary challenges for energy communities as the stagnation in energy infrastructure delays market readiness for innovation in decentralized energy models (see *"Lack of Market Competition").* However, it should be underlined that energy autonomy is covered mainly as a "motivation", which may also indicate how the concept was interpreted by the public as an isolated energy system. The lack of familiarity (see *Figure 6,* Expert 1) towards energy communities by the public may suggest that the concept mainly gathers attention from the people who already have some knowledge about energy systems or renewable energy sources, and energy communities should be marketed to the public with the different advantages. The nichery of the topic and the abstract positive aspects could also decrease public interest towards energy communities. On the other hand, the environmental benefits can be emphasized for energy communities, especially with the popularity forecasting indicating that energy communities can be more popular in the districts with high CO2 per capita. The possible environmental benefits can be an incentive to encourage energy communities memberships with public policy such as tax reduction in personal PV installments or corporate income tax. The financial incentives can be further measurements to mitigate some of the initial challenges in energy community formation.

The subjectivity of the advantages of energy communities were acknowledged in this thesis, hence, perceived household cost scenario was formed as an effort to quantify how household incomes may have been affected by the costs of energy in central renewable energy systems and decentralized energy systems as a comparative analysis. However, the scenario was heavily simplified to "income levels" as energy vulnerability is perceived differently by each household, pointed out by Expert 3. The gaps in perception, however, provide an opportunity for solidarity to overcome energy vulnerability. If a more affluent family produces excess energy in their houses, they can redistribute the excess electricity production to socially disadvantaged households without a fee. Due to different demographics and social relationships of each energy community, different pricing policies can be formed in each energy community.

One may question that if household perceived energy costs can not be precisely calculated in a simplified scenario, how can it be measured in greater energy communities? Coming up with a framework that is flexible to adapt from each energy community charter could be an appropriate method to increase accuracy of measuring the needs of each community, as the significance of development of multicriteria scale in social issues that need comprehensive policy was demonstrated by both the literature and the experts (Shyu 2021; Expert 10). Overall, *Table 7* concludes the main arguments of the thesis for the opportunities and challenges for an energy community:

Table 7 Benefits and Drawbacks of Energy Communities for the Consumers

Benefits	Drawbacks
• Opportunity for a socially just energy governance • Community building • A fair price policy can tackle energy poverty • Foster renewable energy transition and reduce co2 emissions per capita	• Reduced accuracy in energy demand forecast to protect privacy • Need high number of energy community members for financial gain • Small number of alternatives in infrastructure • High implementation costs • Time consuming for the users

6.2. Case of Turkish Communities in Vienna

The most challenging aspect of the thesis is to apply the advantages and disadvantages to a community and discuss whether decentralized energy models can help overcome energy poverty in the case study. To begin with, the survey itself asked questions that aimed to recognize the attitudes and opinions in a broader term, which does not reflect household specific experience. The fact that the survey was limited to Vienna in order to narrow down the focus is another consideration. The experts argued that the attitudes towards energy can vary between rural and urban areas (Expert 8, Expert 9), which may also apply for Turkish communities in Austria. However, the survey is still beneficial to the thesis: It is significant to understand to what extent energy communities can be a suitable model to address Turkish communities' needs in Vienna. Furthermore, energy communities are only a model of decentralized energy systems. The survey questions include questions that intend to obtain information about the determinants of decentralized business models (see *Table 1*), hence it could be identified if any decentralized business model can be appropriate to address energy vulnerability in the households of Turkish communities in Vienna.

Even though the benefits of an energy community take place in the long run, it can actually be an advantage for the case of Turkish communities. To begin with, the survey results suggesting Turkish communities' proximity being cultural and not always necessarily indicating a geographical proximity may indicate the organization for energy communities may take time in the Turkish communities, even in forms in civil society organizations. A civil society organization may thrive with the members who have close social ties, with a common goal. Social media and the other communication tools can be mediums to increase familiarity towards energy communities, and to communicate with people who may be willing to join an energy community. Moreover, the challenges of generalizability may also suggest that Turkish community members with different household incomes can enable creation of a more flexible energy community charter where the members can identify the households who face energy vulnerability and focus on the needs of each household. The loose ties in geographical proximity may also enable overcoming one of the drawbacks: a community with cultural ties may get more members compared to a small energy community based on a particular street. However, there are still some considerations: The survey did not evaluate the Turkish households' perception about time, hence the thesis can not discuss if energy communities can be perceived as time consuming by the Turkish communities in Vienna (even if asked, a survey alone may not be sufficient to reach such conclusions). Furthermore, the thesis did not consider the initial implementation costs of energy communities, and how it may be shared among prospective members in the cost calculation scenario. On the other hand, if the "Income Sensitivity Index" would be applied to initial energy community implementation costs shared between the members, where the more affluent members would pay a higher proportion of initial implementation costs, energy communities may be more attractive for households facing energy vulnerability.

When the determinants of decentralized business models from *Table 1* were evaluated, energy cooperatives could be a possible popular option among Turkish communities in Vienna. As the "network" between the energy community members among Turkish communities can be high, and excessive energy can be shared between the energy community members, a business model with high cooperation in energy trade can be more suitable. "Degree of Integration" should be also high, where the members can be highly involved to decide on energy pricing between the members, and rules. Only "Cooperative" meets these criterias among six different decentralized business models. The high value generation refers to a spillover effect on value creation among different steps in energy trade, which is an advantage for Turkish communities in Vienna. Even if two acquaintances were members of different energy communities, they may still indirectly benefit from each other. A mixed ownership between the community members and third parties could indicate a high stakeholder collaboration between various actors, however, the lower competition in energy communities can decrease the alternatives for energy suppliers in cooperatives model. To summarize, energy communities can be a proper alternative for Turkish communities in Vienna to central energy systems where there could be high cooperation between different actors, and in-between community members.

6.3. Policy Recommendations

Decentralized energy systems can be more inclusive and accessible to all socioeconomic backgrounds if the costs of electricity and the implementation costs are being shared according to the households' monthly incomes. The perceived cost for different households can be stated as the most crucial advantage of energy communities. Furthermore, the possible positive environmental effects of decentralized energy systems should be shared more equally. The policies should focus on increasing familiarity towards decentralized energy communities as an alternative, increasing social interactions for energy sharing, integrating decentralized energy systems to public policy of sustainability and stakeholder communication. To summarize, policy recommendations for decentralized energy systems could be:

- Creation of energy community charters which include the perspectives of socially disadvantaged households, and the differences of perceived energy cost for every households
- Supporting associations that create platforms to bring people from different socioeconomic backgrounds together to overcome energy vulnerability
- Coming up with new features in mobile apps or e-control platforms to include more affordable price bundles according to each household's income
- Tax reduction for energy communities which reduce tariffs for socially disadvantaged households, or shared a certain amount of electricity with disadvantaged households
- Increasing public engagement about renewable energy and decentralized energy systems: Organization of public events, festivals and information sessions about renewable energy transitions, and inclusion of energy communities as a topic or session in the events.

7. Conclusion

7.1. Summary of the Thesis

Energy vulnerability is a subjective term which makes creation of a single energy policy which may fit every resident unfeasible. This assumption was a consistent theme of the thesis, where the experts frequently commented about, and the literature covered. The thesis acknowledged the subjectivity, and focused on socially disadvantaged groups in order to test whether decentralized energy systems can reduce energy poverty, and to identify the unseen barriers to join a decentralized energy systems for socially disadvantaged groups in the society.

The study adapted preexisted economic frameworks from the energy studies and created own formula by adding the concept, "perceived costs" for cost calculation in different energy models. The scenario analysis built for both energy models (central/decentral) demonstrate that close social relations can compensate the spiking perceived energy costs for families facing relative poverty in the society. Importance of social relations have been emphasized in decentral energy systems, hence the thesis research focused the social aspects of different energy models. Similarly, in the situations with low energy trade between peers, decentral energy models would become less affordable compared to central energy systems for the socially disadvantaged groups.

Cultural determinants for each community are also subjective. Thus, the policy recommendations for inclusive energy communities focused on the case study, Turkish communities in Vienna. Overall, the policy recommendations could be summarized as integrating digital tools and social platforms to increase familiarity towards decentral energy systems and social interactions in the region with the involvement of various stakeholders. Furthermore, the findings suggest that cooperatives could be a possible business model for Turkish communities in Vienna.

The previous studies approached the prospects of the energy communities with mostly qualitative methods/case studies. The thesis inverted the question: Created a predictive regression analysis first, and identified possible patterns between different districts to compare what can incentivize decentralized energy systems in the future. The study argued that districts in Austria with power being a significant emission source can demonstrate higher interest towards the energy communities. The outcome fits to the claims of introduction of the thesis, where reducing emissions from power sources can be a significant topic of sustainability in the future.

7.2. Future Research

Future studies may apply the perceived cost formula for different case studies in different societies. Due to time constraints, the thesis only focused on a single case study, however, various case studies can lead into different policy recommendations, enriching the energy policy debate. Furthermore, demand forecasting for energy communities may focus on more comprehensive hypothetical environmental impact analysis within geographies. With more robust Environmental Impact Analysis in multiple districts in the future, energy communities can gather more financial and social support from local, national and international governments, to overcome the challenges joining energy communities which were discussed in the study.

BIBLIOGRAPHY

"Erneuerbare-Energie-Gemeinschaften – Steuern und Abgaben", *Energiegemeinschaften*, Energiegemeinschaften.gv.at. Published February 2024. Accessed June 15, 2025. https://energiegemeinschaften.gv.at/downloads/erneuerbare-energie-gemeinschaften-steuern-abgaben/

"Erneuerbare-Energie-Gemeinschaften (EEG)", *Energiegemeinschaften*, Energiegemeinschaften.gv.at. Accessed June 15, 2025. https://energiegemeinschaften.gv.at/erneuerbare-energie-gemeinschaften-eeg/ de.wikipedia.org+3energiegemeinschaften.gv.at+3energiegemeinschaften.gv.at+3

"Tarifgestaltung", *Energiegemeinschaften*, Energiegemeinschaften.gv.at. Accessed June 15, 2025. https://energiegemeinschaften.gv.at/tarifgestaltung/ arxiv.org+15energiegemeinschaften.gv.at+15energiegemeinschaften.gv.at+15

"Tarifkalkulator", *E-Control – Marktteilnehmer/Services*, E-Control. Accessed June 15, 2025. https://www.e-control.at/marktteilnehmer/gas/systemnutzungsentgelte

Adams, Sophie, Donal Brown, Juan Pablo Cárdenas Álvarez, Ruzanna Chitchyan, Michael J. Fell, Ulf J. J. Hahnel, Kristina Hojckova, Charlotte Johnson, Lurian Klein, Mehdi Montakhabi, Kelvin Say, Abhigyan Singh, and Nicole Watson. 2021. "Social and Economic Value in Emerging Decentralized Energy Business Models: A Critical Review." *Energies* 14: 7864. https://doi.org/10.3390/en14237864.

Alanne, Kari, and Arto Saari. 2006. "Sustainable Small-Scale Energy Solutions: A Review of Renewable Energy Sources and Technologies." *Renewable and Sustainable Energy Reviews* 10: 539–558.

Al-Shetwi, Ali Q., Izham Zainal Abidin, Khaled A. Mahafzah, and M.A. Hannan. "Feasibility of Future Transition to 100% Renewable Energy: Recent Progress, Policies, Challenges, and Perspectives." *Journal of Cleaner Production* 478 (2024): 143942. https://doi.org/10.1016/j.jclepro.2024.143942.

Barabino, Edoardo, Davide Fioriti, Emanuele Guerrazzi, Ivan Mariuzzo, Davide Poli, Marco Raugi, Ehsan Razaei, Eva Schito, and Dimitri Thomopulos. 2023. "Energy Communities: A Review on Trends, Energy System Modelling, Business Models, and Optimisation Objectives." *Sustainable Energy, Grids and Networks* 36: 101187.

Berger, Thomas. 2012. "Energy Poverty in Austria and Perspectives from Social Science." *Yearbook 2012 of the Institute for Advanced Studies on Science, Technology and Society.*

Biresselioglu, Mehmet Efe, Siyami Alp Limoncuoglu, Muhittin Hakan Demir, Johannes Reichl, Katrin Burgstaller, Alessandro Sciullo, and Edoardo Ferrero. 2021. "Legal Provisions and Market Conditions for Energy Communities in Austria, Germany, Greece, Italy, Spain, and Turkey: A Comparative Assessment." *Sustainability* 13 (11212). https://doi.org/10.3390/su132011212.

Brisbois, Marie Claire. 2020. "Shifting Political Power in an Era of Electricity Decentralization: Rescaling, Reorganization and Battles for Influence." *Environmental Innovation and Societal Transitions* 36: 49–59. https://doi.org/10.1016/j.eist.2020.04.007.

Bukovszki, Viktor, Ábel Magyari, Marina Kristina Braun, Kitti Párdi, and András Reith. 2020. "Energy Modelling as a Trigger for Energy Communities: A Joint Socio-Technical Perspective" *Energies* 13, no. 9: 2274. https://doi.org/10.3390/en13092274

Burgstaller, Katrin, Rudolf Kapeller, Johannes Reichl, and Mehmet Efe Biresselioglu. 2020. *Work Package 5 Policy Brief Series: Austria – Establishing Community Renewable Energy Webs*. Rolling out a business model and operational tool creating webs of households that jointly manage energy to improve efficiency and renewables uptake.

Burke, Matthew J., and Jennie C. Stephens. 2017. "Energy Democracy: Goals and Policy Instruments for Sociotechnical Transitions." *Energy Research & Social Science* 33: 35–48. http://dx.doi.org/10.1016/j.erss.2017.09.024.

Cali, Umit, and Austin Fifield. 2019. "Towards the Decentralized Revolution in Energy Systems Using Blockchain Technology." *International Journal of Smart Grid and Clean Energy* 8 (3).

Caramizaru, Aura, and Andreas Uihlein. 2020. *Energy Communities: An Overview of Energy and Social Innovation*. EUR 30083 EN. Luxembourg: Publications Office of the European Union. https://doi.org/10.2760/180576.

Ceglia, F., P. Esposito, E. Marrasso, and M. Sasso. 2020. "From Smart Energy Community to Smart Energy Municipalities: Literature Review, Agendas and Pathways." *Journal of Cleaner Production* 254: 120118.

Creamer, Emily, Will Eadson, Bregje van Veelen, Annabel Pinker, Margaret Tingey, Tim Braunholtz-Speight, Marianna Markantoni, Mike Foden, and Max Lacey-Barnacle. 2018. "Community Energy: Entanglements of Community, State, and Private Sector." *Geography Compass* 12 (e12378). https://doi.org/10.1111/gec3.12378.

D.F. Botelho, B.H. Dias, L.W. de Oliveira, T.A. Soares, I. Rezende, and T. Sousa. "Innovative Business Models as Drivers for Prosumers Integration – Enablers and Barriers." *Renewable and Sustainable Energy Reviews* 144 (2021): 111057.

Di Silvestre, Maria Luisa, Salvatore Favuzza, Eleonora Riva Sanseverino, and Gaetano Zizzo. 2018. "How Decarbonization, Digitalization and Decentralization Are Changing Key Power Infrastructures." *Renewable and Sustainable Energy Reviews* 93: 483–498.

Dioba, Albina, Amalia Giannakopoulou, David Struthers, Angelos Stamos, Siegfried Dewitte, and Isabel Fróes. "Identifying Key Barriers to Joining an Energy Community Using AHP." *Energy* 299 (2024): 131478. https://doi.org/10.1016/j.energy.2024.131478.

Dong, Jingya, Chunhe Song, Shuo Liu, Huanhuan Yin, Hao Zheng, and Yuanjian Li. 2022. "Decentralized Peer-to-Peer Energy Trading Strategy in Energy Blockchain Environment: A Game-Theoretic Approach." *Applied Energy* 325: 119852.

Doyle, Louise, Anne-Marie Brady, and Gobnait Byrne. "An Overview of Mixed Methods Research." *Journal of Research in Nursing* 14, no. 2 (2009): 175-185. https://doi.org/10.1177/1744987108093962.

Droubi, Sufyan, Raphael J. Heffron, and Darren McCauley. "A Critical Review of Energy Democracy: A Failure to Deliver Justice?" *Energy Research & Social Science* 86 (2022): 102444. https://doi.org/10.1016/j.erss.2021.102444.

Dudek, Grzegorz, Paweł Piotrowski, and Dariusz Baczyński. 2023. "Intelligent Forecasting and Optimization in Electrical Power Systems: Advances in Models and Applications." *Energies* 16: 3024.

Fina, Bernadette, Hans Auer, and Werner Friedl. 2020. "Cost-Optimal Economic Potential of Shared Rooftop PV in Energy Communities: Evidence from Austria." *Renewable Energy* 152: 217–228. https://doi.org/10.1016/j.renene.2020.01.102.

Gianaroli, Federico, Michele Preziosi, Mattia Ricci, Paolo Sdringola, Maria Alessandra Ancona, and Francesco Melino. "Exploring the Academic Landscape of Energy Communities in Europe: A Systematic Literature Review." *Journal of Cleaner Production* 451 (2024): 141932. https://doi.org/10.1016/j.jclepro.2024.141932.

Gianpaolo Iazzolino, Nicola Sorrentino, Luca Mendicino, Daniele Menniti, Anna Pinnarelli, and Monica De Carolis. "Energy Communities and Key Features Emerged from Business Models Review." *Energy Policy* 165 (2022): 112929.

Goedkoop, Fleur, and Patrick Devine-Wright. 2016. "Partnership or Placation? The Role of Trust and Justice in the Shared Ownership of Renewable Energy Projects." *Energy Research & Social Science* 17: 135–146. http://dx.doi.org/10.1016/j.erss.2016.04.021.

Google Trends, *Google*. Accessed June 5, 2025. https://www.google.com/trends

Gui, Emi Minghui, and Iain MacGill. 2018. "Typology of Future Clean Energy Communities: An Exploratory Structure, Opportunities, and Challenges." *Energy Research & Social Science* 35: 94–107.

Hanke, Florian, Rachel Guyet, and Marielle Feenstra. "Do Renewable Energy Communities Deliver Energy Justice? Exploring Insights from 71 European Cases." *Energy Research & Social Science* 80 (2021): 102244. https://doi.org/10.1016/j.erss.2021.102244.

Hassan, Qusay, Patrik Viktor, Haitham M. Alzoubi, Tariq J. Al-Musawi, Ali Khudhair Al-Jiboory, Bashar Mahmood Ali, Aws Zuhair Sameen, Sameer Algburi, Hayder M. Salman, and Marek Jaszczur. "The Renewable Energy Role in the Global Energy Transformations." *Renewable Energy Focus* 48 (2024): 100545. https://doi.org/10.1016/j.ref.2024.100545.

Heffron, Raphael J. "Applying Energy Justice into the Energy Transition." *Renewable and Sustainable Energy Reviews* 156 (2022): 111936. https://doi.org/10.1016/j.rser.2021.111936.

Heffron, Raphael J., Anita Rønne, Joseph P. Tomain, Adrian Bradbrook, and Kim Talus. 2018. "A Treatise for Energy Law." *Journal of World Energy Law and Business* 11: 34–48. https://doi.org/10.1093/jwelb/jwx039.

Hicks, Jarra, and Nicola Ison. 2018. "An Exploration of the Boundaries of 'Community' in Community Renewable Energy Projects: Navigating between Motivations and Context." *Energy Policy* 113: 523–534. https://doi.org/10.1016/j.enpol.2017.10.031.

Inês F.G. Reis, Ivo Gonçalves, Marta A.R. Lopes, and Carlos Henggeler Antunes. "Business Models for Energy Communities: A Review of Key Issues and Trends." *Renewable and Sustainable Energy Reviews* 144 (2021): 111013.

International Renewable Energy Agency (IRENA). 2020. *Innovation Landscape Brief: Peer-to-Peer Electricity Trading*. Abu Dhabi: IRENA.

International Renewable Energy Agency (IRENA). *World Energy Transitions Outlook 2024: 1.5°C Pathway*. Abu Dhabi: IRENA, 2024.

Jesse D. Jenkins, Samuel C. Huntington, and Ignacio J. Pérez-Arriaga. "Why Distributed? A Critical Review of the Tradeoffs Between Centralized and Decentralized Resources." *IEEE Power & Energy Magazine* 17, no. 2 (March/April 2019): 16–29. https://doi.org/10.1109/MPE.2018.2881783.

João Mello, Cristina de Lorenzo, Fco. Alberto Campos, and José Villar. "Pricing and Simulating Energy Transactions in Energy Communities." *Energies* 16, no. 4 (2023): 1949. https://doi.org/10.3390/en16041949.

Johnson, R. B., and Anthony J. Onwuegbuzie. "Mixed Methods Research: A Research Paradigm Whose Time Has Come." *Educational Researcher* 33, no. 7 (2004): 14-26. https://doi.org/10.3102/0013189X033007014. (Original work published 2004).

Jorgenson, Dale W., and Peter J. Wilcoxen. 1993. "Energy, the Environment, and Economic Growth." In *Handbook of Natural Resource and Energy Economics*, Vol. 3, 1267–1349. Elsevier.

Judson, E., O. Fitch-Roy, P. M. Connor, J. Britton, T. Pownall, B. Woodman, R. Bray, H. Poulter, C. Mitchell, I. Soutar, and R. Lowes. 2020. "The Centre Cannot (Always) Hold: Examining Pathways Towards Energy System De-centralisation." *Renewable and Sustainable Energy Reviews* 118: 109499.

Kettner, Claudia, and Eva Wretschitsch. 2025. "Support Measures for Austrian Households in the Energy Crisis: An Analysis of Social Effectiveness and Implications for Energy Efficiency." *Energy Efficiency* 18: 10. https://doi.org/10.1007/s12053-025-10296-3.

Koirala, Binod Prasad, Elta Koliou, Jonas Friege, Rudi A. Hakvoort, and Paulien M. Herder. 2016. "Energetic Communities for Community Energy: A Review of Key Issues and Trends Shaping Integrated Community Energy Systems." *Renewable and Sustainable Energy Reviews* 56: 722–744.

Kyriakopoulos, Grigorios L. 2022. "Energy Communities Overview: Managerial Policies, Economic Aspects, Technologies, and Models." *Journal of Risk and Financial Management* 15: 521. https://doi.org/10.3390/jrfm15110521.

Mahmoud Elkazaz, Mark Sumner, and David Thomas. "A Hierarchical and Decentralized Energy Management System for Peer-to-Peer Energy Trading." *Applied Energy* 291 (2021): 116766.

Małgorzata Wiatros-Motyka, Nicolas Fulghum, and Dave Jones. *Global Electricity Review 2024*. EMBER, 2024.

Mascherbauer, Philipp, Lukas Kranzl, Songmin Yu, and Thomas Haupt. 2022. "Investigating the Impact of Smart Energy Management System on the Residential Electricity Consumption in Austria." *Energy* 249: 123665. https://doi.org/10.1016/j.energy.2022.123665.

McKenna, Russell. 2018. "The Double-Edged Sword of Decentralized Energy Autonomy." *Energy Policy* 113: 747–750.

Mehdinejad, Mehdi, Heidarali Shayanfar, and Behnam Mohammadi-Ivatloo. 2022. "Decentralized Blockchain-Based Peer-to-Peer Energy-Backed Token Trading for Active Prosumers." *Energy* 244: 122713.

Melnyk, Anna, Hanne Cox, Amineh Ghorbani, and Thomas Hoppe. 2023. "Value Dynamics in Energy Democracy: An Exploration of Community Energy Initiatives." *Energy Research & Social Science* 102: 103163. https://doi.org/10.1016/j.erss.2023.103163.

Monash Business School. "Market Nicher." Marketing Dictionary. Accessed May 19, 2025. https://www.monash.edu/business/marketing/marketing-dictionary/m/market-nicher.

Monsberger, Carolin, Bernadette Fina, and Hans Auer. 2021. "Profitability of Energy Supply Contracting and Energy Sharing Concepts in a Neighborhood Energy Community: Business Cases for Austria." *Energies* 14 (921). https://doi.org/10.3390/en14040921.

Moroni, Stefano, Valentina Alberti, Valentina Antoniucci, and Adriano Bisello. 2019. "Energy Communities in the Transition to a Low-Carbon Future: A Taxonomical Approach and Some Policy Dilemmas." *Journal of Environmental Management* 236: 45–53.

OECD (2022), *OECD Regions and Cities at a Glance 2022*, OECD Publishing, Paris, https://doi.org/10.1787/14108660-en

Olawuyi, Damilola S. 2021. "From Energy Consumers to Energy Citizens: Legal Dimensions of Energy Citizenship." In *Sustainable Energy Democracy and the Law*. Leiden: Koninklijke Brill NV. https://doi.org/10.1163/9789004465442_006.

REScoop.eu. *Ensuring Access to Affordable, Secure Renewable Energy: Local Ownership through Energy Communities*. 2025.

São José, Débora de, Pedro Faria, and Zita Vale. 2021. "Smart Energy Community: A Systematic Review with Metanalysis." *Energy Strategy Reviews* 36: 100678.

Savelli, Iacopo, and Thomas Morstyn. 2021. "Better Together: Harnessing Social Relationships in Smart Energy Communities." *Energy Research & Social Science* 78: 102125.

Shapin, Steven. 2011. "The Sciences of Subjectivity." *Social Studies of Science* 42 (2): 170–84. https://doi.org/10.1177/0306312711435375.

Shyu, Chian-Woei. "A Framework for 'Right to Energy' to Meet UN SDG7: Policy Implications to Meet Basic Human Energy Needs, Eradicate Energy Poverty, Enhance Energy Justice, and Uphold Energy Democracy." *Energy Research & Social Science* 79 (2021): 102199. https://doi.org/10.1016/j.erss.2021.102199.

Soeiro, Susana, and Marta Ferreira Dias. 2020. "Renewable Energy Community and the European Energy Market: Main Motivations." *Heliyon* 6 (e04511). https://doi.org/10.1016/j.heliyon.2020.e04511.

STATISTICS AUSTRIA. *EU-SILC 2024 (EU Statistics on Income and Living Conditions)*. Compiled April 29, 2025.

STATISTICS AUSTRIA. *Household Budget Survey 2019/20*. Compiled May 5, 2022.

STATISTICS AUSTRIA; Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology; E-Control. *Energy Prices, Taxes: Material Input Statistics 2023 & Wholesale Price Index 2024*. Compiled March 11, 2025.

Stern, David I. 2011. "The Role of Energy in Economic Growth." *Annals of the New York Academy of Sciences* 1219: 26–51. https://doi.org/10.1111/j.1749-6632.2010.05921.x.

Taghizadeh-Hesary, Farhad, and Naoyuki Yoshino. "Sustainable Solutions for Green Financing and Investment in Renewable Energy Projects." *Energies* 13, no. 4 (2020): 788. https://doi.org/10.3390/en13040788.

Tian, Jinfang, Longguang Yu, Rui Xue, Shan Zhuang, and Yuli Shan. "Global Low-Carbon Energy Transition in the Post-COVID-19 Era." *Applied Energy* 307 (2022): 118205. https://doi.org/10.1016/j.apenergy.2021.118205.

Tim Schittekatte and Leonardo Meeus. *Introduction to Network Tariffs and Network Codes for Consumers, Prosumers, and Energy Communities*. Florence School of Regulation, European University Institute, 2018. https://cadmus.eui.eu/handle/1814/60799.

Tkachuk, Roman-Valentyn, Dragos Ilie, Remi Robert, Victor Kebande, and Kurt Tutschku. 2023. "Towards Efficient Privacy and Trust in Decentralized Blockchain-Based Peer-to-Peer Renewable Energy Marketplace." *Sustainable Energy, Grids and Networks* 35: 101146.

Van de Graaf, Thijs, and Fariborz Zelli. 2016. "Actors, Institutions and Frames in Global Energy Politics." In *The Palgrave Handbook of the International Political Economy of Energy*, edited by Thijs Van de Graaf, Benjamin K. Sovacool, Arunabha Ghosh, Florian Kern, and Michael T. Klare. Basingstoke: Palgrave Macmillan. https://doi.org/10.1057/978-1-137-55631-8.

Van der Wel, Kees, Sanne Akerboom, and Albert Meijer. 2024. "A Public Values Perspective on Energy Justice: Building a Theoretical Lens for Understanding Decision-Making in the Energy Transition." *Energy Research & Social Science* 116: 103677. https://doi.org/10.1016/j.erss.2024.103677.

Wieczorek, Anna J., Simon Bolwig, Harald Rohracher, Pieter Valkering, Dierk Bauknecht, Regine Belhomme, Klaus Kubeczko, and Simone Maggiore. 2024. "Citizen-Led Decentralised Energy Futures: Emerging Rationales of Energy System Organisation." *Energy Research & Social Science* 113: 103557.

APPENDICES

APPENDIX A: Survey Questions for Turkish Communities in Vienna

1) Avusturya vatandaşlığı veya oturum izninden hangisine sahipsiniz? *(Which of these residence status do you have in Austria: Austrian ctizenship or residence permit in Austria?)*

-Avusturya vatandaşı *(Austiran Citizen)*

-Avusturya'da oturum izni sahibiyim. *(I have residence permit in Austria)*

2) Avusturya'da kaç yıldır yaşıyorsunuz? *(How long have you been living in Austria?)*

(Gönüllü) Viyana'da kaçıncı bölgede ikamet etmektesiniz? *(Optional: Which district do you live in Austria?)*

3) Geçtiğimiz seneye kıyasla elektrik veya doğalgaz faturalarınızı ödemede bir zorluk yaşadınız mı? *(Did you face any difficulties to pay your electricity bills compared to the last year?)*

-Geçtiğimiz sene de bu sene de bir zorluk yaşamadım. *(I did not have any difficulties this year or previous year)*

-Geçtiğimiz senede zorlanmamıştım, ancak bu sene zorluk yaşıyorum. *(I did not have any difficulties last year, but I am facing difficulties this year)*

-Geçtiğimiz sene zorlanmıştım, ancak bu sene zorluk yaşamıyorum. *(I faced difficulties last year, but not this year)*

-Geçtiğimiz sene de bu sene de zorluk yaşıyorum. *(I faced difficulties in both this year and last year)*

4) Tahmininizce elektrik ve doğalgaz faturalarınız aylık bütçenizin ne kadarını oluşturuyordur? *(According to your estimation, what percentage your electricity bills consist of your monthly household budget?)*

5) Evinizin çatısında bir güneş paneli bulunmakta mıdır? (Bilmiyorsanız, bilmediğinizi belirtebilirsiniz) *(Do you have a solar panel in the roof of your house? If you don't know, you may state you don't know)*

6) Eğer bulunuyorsa, tahmininizce kaç hane elektrik ihtiyacını bu panel üzerinden karşılıyordur? *(If there is, according to your estimation, how many households receive electricity from these solar panels?)*

7) Oturduğunuz evde ve mahalledeki komşularınızla yakın mısınız? Sıklıkla görüştüğünüz arkadaşlarınız bulunmakta mıdır? *(Do you have a close relationship with the neighbours of your housing block or in the street? Do you have friends that you meet frequently?)*

-Evet, hem oturduğum evde hem de mahallemdeki komşularımla sıklıkla görüşürüm. *(Yes, I meet with my neighbours in both in my housing block and in the street)*

-Oturduğum evdeki komşularımla aram iyidir, ancak mahallemdeki insanlarla sıklıkla konuşmam. *(I get along well with my neighbours in my housing block, but I don't meet with my neighbours in the district frequently)*

-Oturduğum evdeki komşularımla fazla muhatap olmam, ama mahallemdeki insanlarla yakınım. (*I don't have a frequent contact with my neighbours in my housing block, but I am close with my neighbours in the street)*

-Hayır, hem evdeki komşularımla hem de mahallemdeki insanlarla fazla görüşmem. *(No, I am not close with my neighbours neither in my housing block nor in my street)*

8) "Enerji toplulukları" konseptinden haberdar mısınız? Bu konsept hakkında ne kadar bilgi sahibisiniz? *(Are you familiar with the concept, "Energy communities"? To what extent are you familiar with the concept?)*

1- Enerji topluluklarını daha önce hiç duymadım. *(1- I have never heard about energy communities)*

7- Enerji toplulukları alanında uzmanım. *(7-I am an expert in energy communities)*

9) Paylaşmak istediğiniz başka bir kısım var mıdır? *(Do you have anything else you want to share?)*