Personifying the Energy Transition: Unveiling Eindhoven's Voices

The development of energy transition personas for inclusive energy transition development

Thesis report

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Summary

The transition away from natural gas to renewable energy in the Netherlands involves complex challenges that require collaborations between (local government), residents, social housing corporations, and other stakeholders involved in energy transition developments. The effectiveness of new energy systems like district heating depends heavily on end-user acceptance and participation. This highlights the importance of community involvement and a user-oriented system design. Technical issues, like the optimization needed for lower-temperature heating systems, and personal motivations such as cost, comfort, and temperature control, add to the complexity of aligning individual actions with broader energy goals.

Eindhoven's Regional Energy Strategy (RES) sets ambitious targets, including a 55% reduction in CO2 emissions by 2030. Unfortunately, current developments such as the 'proeftuinen' projects face obstacles, mainly in resident participation and the financial constraints of connecting to new energy systems. These challenges are compounded by communications and informational gaps combined with trust issues between residents and the municipality.

Current academic and grey literature contain a significant research gap by focusing extensively on the economic and technological aspects of the energy transition and understating the critical impact of user lifestyles, preferences, and behaviors. This lack of knowledge suggests the need for a more comprehensive approach that integrates energy transition developments with social science insights, emphasizing a user-oriented strategy. The use of personas, or archetypal user models, is proposed as an effective tool to better understand and incorporate user needs into energy system design, potentially improving participation and acceptance. Despite the adoption of these approaches, there is a lack of comprehensive research on person-centered planning in the Dutch context, indicating an area ripe for further research to improve energy transition strategies. The context and the literature gap led to the following research question:

"How can the creation of evidence-based energy personas inform and enhance the development of energy transition projects in Eindhoven, the Netherlands?"

To answer this question, a case study is conducted in Eindhoven. Using the grounded theory methodology to create an understanding of the context, as well as develop framings about phenomena emerging from the data collection. 26 participants are interviewed, in either a formal or informal setting. These participants are either residents of Eindhoven, or expert stakeholders involved in energy transition projects in Eindhoven. From these interviews, three framings emerged. First, it is theorized that the willingness and ability to take action in forming one's energy future is dependent on the future timeline that is perceived by the individual. The length and coherence of this timeline vary between age and housing status. Second, the data suggests that people are that most inhabitants are not concerned with sustainable energy, in that they have minimal knowledge and interest in the sources of their energy, energy distribution systems, storage, etc. Most people are more interested in end-of-pipe solutions within their homes that lead to energy efficiency, lower energy bills, and a change in consumption behavior. Third, a framing is developed that the energy transition is a social transition, rather than a technological than. The enablers and barriers that impact the energy transition are mainly financial, informational, and communicational.

These framings are used to create the Energy Transition Persona (ETP) framework. This framework describes how the participants are differentiated on age, home ownership, and general attitude towards the energy transition. The contents of the personas are divided into five trait categories: human characterization, needs, mindsets, behavior, and resources. Lastly, the framework provided guidelines on

how to make the personas representative of the participants. The three framings and the ETP framework are applied to create six evidence-based personas, representative of the residents of Eindhoven who participated in the research.

In conclusion, the creation of evidence-based energy transition personas offers a detailed understanding of the diverse range of needs, mindsets, and behaviors concerning energy in the area of Eindhoven, which facilitates a more targeted and effective approach to energy transition projects. The personas can benefit the creation of communication strategies, financial incentives, technical designs, and information campaigns. A concrete example of a situation where personas can offer insight is the three types of energy advice that are available to the public. By providing detailed insights into what information is required by the public, a more engaged and tailored energy consult program can be established, which potentially yields more engagements. In conclusion, this user-centered tool can lead to increased acceptance, engagement, and satisfaction among the inhabitants, ultimately enhancing the efficacy and success of energy transition initiatives in Eindhoven.

This research contributes on three levels. First, the Energy Transition Persona framework provided theoretical contribution, by improving on existing academic frameworks for persona development. Second, this thesis fills a gap in the existing literature by detailing a method for making personas representative and actionable, starting from the data collection to the development of the persona contents. Third, this research provides empirical contribution by developing six energy personas for the context of Eindhoven.

Based on the results and the contributions of this thesis, a broad range of future research is opened up. First, it is recommended to further develop the framings using pattern modeling in the context of Eindhoven. For framing 1 specifically, it would be interesting to further research the potential of Future Time Perspectives theory in energy transition issues. Second, it is recommended to test the ETP framework in another context (whether it be another urban, suburban, or rural setting) to see whether the division of personas and trait categories still holds up. Lastly, it is recommended to scale up the persona development in Eindhoven, by conducting more data collection, filling in the gaps of age categories, and including more demographics in the division of personas. This is combined with using the personas for the development of tailored communication strategies, financial incentives, and targeted energy consults.

Contents

1 Introduction

In the past few years, the essence of addressing climate change has emerged as the primary catalyst for shifting towards renewable energy sources. The Paris Agreement goals have been set to limit global warming to 1.5◦C by the end of the century by peaking Green House Gas (GHG) emissions before 2025 at the latest, reduce emissions 43% by 2030, and reach carbon neutrality by 2050 (United Nations, 2015). Even though this agreement provides guidelines on how to set short and long-term greenhouse gas (GHG) reduction goals, the approach to realizing such reductions is lacking. Adequate policies and market organization are necessities for the transition towards renewable energy (IRENA et al., 2020). The Dutch government has translated the Paris Agreement goals towards national emissions reduction goals, called the Klimaatakkoord (Nederlandse Staat, 2019). This policy states that by 2030, 1.5 million buildings must be natural gas-free. By 2050, the goal is that 7 million dwellings and 1 million other buildings are natural gas-free. Per 2024, that would result in approximately 800 houses per day. With such numbers, it is imminent that this transition must be driven at the collective scale. One approach to large-scale decarbonization of dwellings is the development of district heating grids.

There is much potential for GHG reductions using distributed heating and cooling systems. One example is stated by the International Energy Agency (2019): ”Space heating and hot water production account for around 70% of energy consumption in residential buildings in International Energy Agency countries”. Next to that, approximately 50% of the current global energy consumption is for heat production, and this is responsible for 40% of energy-related greenhouse gas emissions, as well as intense levels of air pollution that threatens the environment and public health (IRENA et al., 2020).

This chapter defines the context of this thesis, by stating how the Netherlands will adapt to reach the climate goals stated above. The heat transition in the Netherlands is explained, followed by the end user’s role in this transition. Furthermore, a focused introduction to the energy transition in Eindhoven is given, including its ongoing projects and involved stakeholders. Lastly, an explanation of the conceptual framework used in this research is given.

1.1. Heat Transition in the Netherlands

In the Netherlands, district heating is a well-established type of energy system. In 2022, more than 95.000 reported buildings are connected to district heating grids (Netherlands Enterprise Agency, 2023). The Netherlands Enterprise Agency expects 40.000 unreported buildings on top of that. These district heating grids have a renewable energy share of 37.9%, consisting of mostly waste incineration plants and biomass plants. In the last years, there has been a debate on the sustainability of both of those energy sources. For example, waste incineration plants use imported waste to handle the heat demand (Loggers & Weijnen, 2022), which increases the footprint of this heat source. Next to that, if the heat demand is higher than its supply, fossil-fueled backup heat sources are used. Calculations also suggest that after deducting the CO2 savings from heat from a waste incineration plant, the CO2 emission from the electricity by burning fossil combustible materials such as plastics is twice as high as the emission from gray electricity (Welink, 2021). The discussion surrounding biomass plants arises from the fact that burning biomass still emits CO2 and it causes damage to the climate due to deforestation, which leads to a decrease in CO2 reduction (Milieu Centraal, n.d.).

These developments lead to a growing demand for renewable energy sources such as geothermal, solar thermal, and aquifer thermal energy. A problem arises with most renewable energy sources, which is that energy is not generated 24 hours a day (such as is the case with solar and wind energy). This is tackled in multiple ways. First, a mix of renewable energy sources is used, to increase the

reliability of supply. Second, energy systems must be designed with the concurrency of generation and consumption in mind. In this case, the role of the end user in the optimization of the energy system increases rapidly. Next to that, renewable energy sources most often generate lower-temperature heat than fossil-fueled sources. Not only the energy distribution system but also the internal energy system of buildings must be adapted to these lower temperatures. Based on the increased technological complexity of renewable energy and the need for balancing demand and supply, the rise of renewable energy sources leads to more complex energy systems in which the role of the consumer increases.

1.2. Role of the end user in energy transition developments

As emphasized by Klosters et al. (2020) and Kort et al. (2020), the residents/end users are the most vital stakeholders for the success of energy transition projects. This success is contingent on the acceptance and participation of stakeholders within the project. Acceptance refers to the level of approval or agreement from various stakeholders regarding the implementation of district heating grids or other energy systems. These stakeholders include residents, community organizations, social housing organizations, etc. Various frameworks and tools to increase the acceptance and participation of residents in energy transition developments have been created. Van Aalderen et al. (2021a) introduce a crucial dimension by defining three types of acceptance during the development of new energy systems:

1. *Socio-political acceptance*: The target here are the citizens as a whole. This type of acceptance is about creating awareness of global warming and the sustainability goals of the government and municipalities. Building trust between the residents and (local) government strengthens this acceptance.
2. *Process acceptance*: The target is the individual local resident. This type of acceptance is about accepting and joining the customer journey presented by Koning et al. (2020).
3. *Product acceptance*: The target is the customer and consists of accepting the product, which is the adjustment of the individual central heating system, as well as the energy system infrastructure.

Participation refers to the active involvement of stakeholders in the development process of energy transition projects, including planning, decision-making, and implementation & realization. In the energy sector, participation most often refers specifically to residents/potential end users.

Due to the application of lower temperatures within the district heating system, there is a lower margin for error. Therefore, demand and supply must be optimized. The end users determine the demand. As one does not want to leave people without heating, the demand is leading the supply in the case of district heating. This emphasizes the importance of user-centered energy system designs. Menkveld et al. (2021) emphasize the important role of the end user in the development of energy systems in general, and district heating systems specifically, which is also stressed by Klosters et al. (2020) and Kort et al. (2020). They discuss three strategies to involve the end users in the development of distributed heating systems. First, helping users to develop new energy consumption habits. Second, the co-creation of new routines considering the use of the energy system. Third, actively involving the end users in the development of district heating systems. This means that the inhabitants have responsibilities and mandate to decide on the development of the energy system.

Another participation strategy is proposed by Koning et al. (2020). They developed a customer journey for residents to transition away from natural gas consumption. This journey is illustrated in Figure 1.1. This framework describes the labor-intensive and time-consuming process of creating awareness of the general energy transition goals and letting individuals project these goals on their situation. Per step, certain drivers and barriers are defined that are overcome or reinforced by applying the right informational, financial, and communicational tools at the right moment.

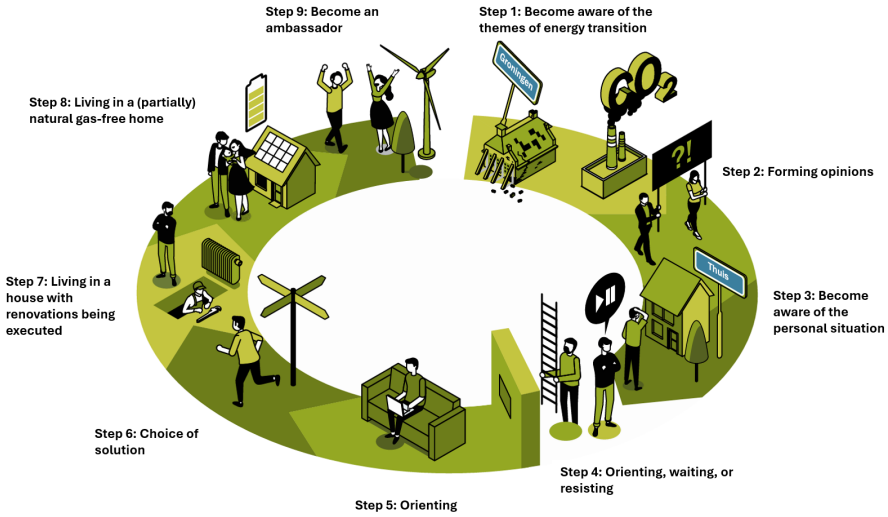


Figure 1.1: Customer journey: transition away from natural gas consumption (Koning et al., 2020)

Based on research conducted by Schreuders et al. (2021), the primary consideration for people to participate in taking collaborative action in energy efficiency is the cost of energy, mentioned by 60% of the residents. This consideration was followed by control over the temperature in the house (48%), living comfort (42%), climate change (34%), contributing to innovative solutions (27%), and privacy (26%). The least important considerations are the livability of the living environment (13%) and collaborating with neighbors (6%). These numbers give insight into the subjects that move people to take action in the energy transition in the Netherlands.

1.3. Energy transition in Eindhoven

Regional Energy Strategy Eindhoven

Eindhoven's short and long-term goals for the energy transition are described in their Regional Energy Strategy (RES). Regional Energy Strategy is a national program in which the Netherlands is divided into 30 regions, and each region develops its own strategy, whilst regions also collaborate (Nationaal Programma RES, n.d.). The goal is co-creation for large-scale renewable energy generation and renewable heat sources as alternatives to natural gas. The RES contains plans about the energy system, the living environment, participation, and communication. Key performance indicators for Eindhoven's RES are 55% less CO2 emissions by 2030 (compared to 1990) and 2 TWH renewable energy generation (Metropoolregio Eindhoven, 2023).

Considering the heat transition, the themes discussed in Eindhoven's RES are energy conservation, renewable heat generation, and co-creation (Metropoolregio Eindhoven, 2021). For energy conservation for the residents, the base goals are knowledge and information sharing about energy-saving routes and research, monitoring the energy conservation progress, and constant process evaluation. Additionally, the RES describes the aim for regional information campaigns, more resources towards energy coaching programs, and research towards system-wide energy conservation. The RES articulates goals towards renewable heat generation such as optimal use of regional heat sources, preventing disinvestment, and aiming for the lowest social costs possible. Concerning co-creation, the Region of Eindhoven aims to improve the involvement of residents in the energy transition, gain insight into the needs, values, and aspirations of the inhabitants, and create support by providing process, social, and financial participation incentives.

'Proeftuin' neighborhoods in Eindhoven

The research conducted by Koning et al. (2020) and Klosters et al. (2020) are conducted within 'proeftuin' neighborhoods, which are areas part of the national 'Programma Aardgasvrije Wijken' (Program Natural Gas-free Neighborhoods). Founded in 2018, the goal of these 'proeftuinen' (testing grounds) is to learn about the transition away from natural gas consumption in neighborhoods and define how to

do so in an efficient and scalable manner. Components of these plans are technical designs including individual and collective energy systems, financial incentives, and participation and information strategies (Programma Aardgasvrije Wijken, n.d.-c) (Rijksoverheid & Warmtetransitie, 2022).

As part of the Regional Energy Strategy, Eindhoven has appointed two 'proeftuin' neighborhoods, which are *'t Ven - Lievendaal* and the *Generalenbuurt*. In both neighborhoods, a district heating grid is being developed. The development of a medium-temperature district heating grid is expected to be finalized by 2025 in 'T Ven - Lievendaal. This project is realized by the municipality, the social housing organizations, and Enexis (Programma Aardgasvrije Wijken, n.d.-a). The Generalenbuurt is expected to be fully finalized by 2040, where a low-temperature heating grid is being developed (Programma Aardgasvrije Wijken, n.d.-b). Next to the municipality, the social housing organizations, and Enexis, two residents' organizations are partners in this project, which means that participation plays a greater role in the success of the project compared to 'T Ven - Lievendaal. An extensive participation strategy is vital for the Generalenbuurt, which is emphasized by Looijse et al. (2024). This news article published in the Eindhovens Dagblad, a local news outlet, emphasizes the residents' concerns about the potential costs of the new energy system: "At the moment, I am still making ends meet every month, as long as I don't do anything crazy. But the mere thought that I would have to spend thousands or even tens of thousands of euros on renovating my house is completely unrealistic to me. And it's already causing me stress." The article describes homeowners with limited financial resources to be the most vulnerable group in this transition. This "invisible group" is often hard to reach, due to feelings of shame about their financial situation. Uncertainty about the costs, both raised by the residents and the municipality reduces the trust between the two parties and forms a barrier to the development of the Generalenbuurt. Lastly, the municipality states in this article that they are increasing their awareness of the residents' needs, values, and concerns. However, more resources must be applied to increase this awareness.

The 'Proeftuin' neighborhoods are existing neighborhoods for which a new energy system is being developed. The neighborhood Fellenoord is a different type of development. This neighborhood, mainly consisting of business and office buildings, will be demolished almost completely and built anew from the ground up. The 'new' Fellenoord will consist of dwellings, recreation spaces, and business centers/buildings (Gemeente Eindhoven and KCAP Architects & Planners, 2023). Whereas it is possible to co-create with the inhabitants of the Generalenbuurt and 'T Ven - Lievendaal, this is more difficult for Fellenoord, as the future residents are not known yet. This makes this neighborhood an interesting case to align the new energy system to the needs and wishes of end users, and the end users are not known yet.

End user oriented stakeholders

The municipality of Eindhoven plays a vital role in informing, motivating, and engaging residents in taking action in the energy transition developments in Eindhoven. More specifically, employees of the municipality take on various roles. For example, the municipality has energy coaches, which are people who advise inhabitants on energy consumption, insulation, and renewable energy generation. The target group for these advisors is all residents of Eindhoven, whether it be a homeowner asking for support on subsidy applications for his heat pump, or a social housing renter asking for frugal draft-reducing products. Residents of Eindhoven have also access to other types of government-organized advice, which are Energiebox and Klusbus. Energiebox is a building energy scan in combination with a box of simple energy-saving products, such as radiator foil and LED lights. These products have a total value of around 25 euros, however, the real value is the building scan (project leader energy conserving program, personal communication, January 25th, 2024), meaning that the scan is the most beneficial for the resident rather than the box of products. The third energy advice option is Klusbus organized by the 'Duurzaamheidspact', a collaboration between the municipality, social housing corporations, installation companies, and co-creation bureau Cocosmos (Gemeente Eindhoven, n.d.). Klusbus will do small sustainability measures in and around the houses of Eindhoven for free, for a value of up to 300 euros.

Next to advising the public, the municipality is creating strategies for long-term co-creation of energy transition developments between the municipality and the inhabitant (project leader energy conserving program, personal communication, January 25th, 2024).

Lastly, starting January 1st, 2024, municipalities will play a key role in the heat transition through the Municipal Instruments for Heat Transition Act (Wgiw) (Provincie Noord-Brabant, 2023). Together with the provinces, they will also play a role in the Collective Heat Act (Wcw), which will take effect in 2025. The Wcw will replace the current Heat Act and aims to mandate a public majority interest in heat companies. With this shift, the national government envisions a role for local governments. Therefore the municipality of Eindhoven is founding its own public energy company: Energy Company Eindhoven (project director Energy Company Eindhoven, personal communication, February 20th, 2024).

Social housing corporations are also important stakeholders, as such organizations play a pivotal role in large-scale energy transitions like district heating grid developments. This is due to the large amount of assets (dwellings), often close to one another in one or more neighborhoods.

Large organizations such as the Eindhoven University of Technology and AMSL have an increasingly larger stake in the housing supply in Eindhoven, as these organizations are actively involved in the real estate industry in the city, securing housing options for their students and employees.

1.4. The ENCLUDE EU Project and conceptual persona framework

Next to the Dutch context described above, this thesis is related to a larger research project named ENCLUDE EU [1].

The main objective of this research collaboration is to ”address the need to better define, contextualize, and integrate energy citizenship into decision-making processes” (ENCLUDE EU, n.d.). ENCLUDE EU executes this via co-creating and sharing new knowledge and practices that maximize the number and diversity of citizens who are able and willing to contribute to the energy transition. Yusuf Dirie, the advisor of this thesis, has created a conceptual framework that forms the basis of one form of co-creation and knowledge sharing; the development of energy personas. This framework considers an energy supply chain (generation, transmission, distribution, consumption, and storage). The methodology of crafting energy personas within this framework is to connect emerging technologies, trends, and innovations with the potential to redefine the interaction of inhabitants with energy systems for each stage of the energy supply chain. By doing this, the researcher can highlight the anticipated transformations in values, skills, behaviors, and expectations the inhabitants face in the energy transition. It is assumed that if one looks across the energy system, one would be able to distill people’s preferences, needs, and values considering energy generation, distribution, and consumption.

In this framework, archetypal personas are defined, representing virtual end users within a potential future energy system, mirroring real-world contexts. The goal is that for each persona their unique energy aspirations, challenges, and routines are highlighted. These insights are then connected with current or developing energy solutions that would and could be applied by the personas. The framework is set up so that it can represent a worldwide span of geographical and socio-technical communities. The case study is selected based on the following three scales:

1. Geographical division, a division in population density.
    - *Urban*: These communities are based in densely populated areas, typically comprising of major cities or metropolitan areas.
    - *Suburban*: These communities are based on surrounding urban areas and are less population-dense. Examples are smaller cities, agglomerates, and large residential zones, characterized by shopping centers, schools, and other low-rise buildings.
    - *Peri-urban/rural*: These communities are based in low populated areas. Examples are villages and small towns, frequently bordered by vast open spaces.
2. Socioeconomic sub-division, the amount of investment potential.
    - *High external & high internal investment*: Communities that are significantly benefiting from both external investments (from government initiatives or international organizations) and

[1]The ENCLUDE project has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under grant agreement No 101022791

strong internal community-driven developments. Both result in a robust infrastructure and active participation of the local community.
- *High external but low internal investment*: Communities that have seen substantial investment from outside, but where local, self-driven developments are minimal.
- *Low external but high internal investment*: Communities characterized by substantial internal development and entrepreneurship lacking support from outside entities.
- *Low external and low internal investment*: Communities that potentially rely more on occasional external aid and have fewer local initiatives.

3. Renewable energy landscape: the regional potential of the application of renewable energy sources (RES) and the adoption rate of the technologies.

    - *High renewable potential & high adoption*: Areas with significant availability and adoption of RES due to infrastructure and/or supportive policies.
    - *High renewable potential but low adoption*: Areas with abundant availability of RES but lacking infrastructure or policy support to fully harness them.
    - *Low renewable potential but high adoption*: Areas RES are not abundantly available, but investments and policies can highly benefit the adoption of RES.
    - *Low renewable potential and low adoption*: Places lacking in both natural RES and infrastructure or policy support.

This framework is a work in progress, and this thesis contributes by validating the framework within the Dutch context. For this study, a case study on the application of future district heating technologies in medium to highly densely populated areas is applied. This means that the researched persona contains the following characteristics:

1. Geographical division: Urban or suburban
2. Socio-economic subdivision: High external and any internal investment
3. Renewable energy landscape: High renewable potential and any rate of adoption.

This conceptual framework is tested in Eindhoven, the Netherlands.

1.5. Outline of the thesis

The structure of this thesis is as follows. In chapter 2, a literature study is conducted on the current knowledge landscape of the topic. Based on the literature on energy scenario planning, persona creation, and policy theory literature, an academic research gap is defined. In chapter 3, a problem statement is phrased based on the context set in this chapter and the literature review. This statement is followed up with a research objective and the research questions. Next, in chapter 4, it is explained how the research questions are answered. Moreover, an outline of the case study is given, as well as data collection methods and a specification on how the quality of the research is embedded. chapter 5 explains how framings have formed using grounded theory, which is used to construct a framework for energy transition personas discussed in chapter 6. This framework is used to create energy transition personas based on empirical data collection and analysis in Eindhoven, described in chapter 7. These results are discussed in chapter 8. Lastly, the answers to the research questions are given in chapter 9.

2
Literature Study

Now that the empirical context has been portrayed, it is important to connect this context to the academic knowledge landscape. A literature study is conducted to review the current status of the knowledge on scenario-based energy futures, as well as more specific persona-oriented approaches to such social change processes. This exploratory literature review helps to create an academic foundation for the conceptual framework used in this thesis, as well as collect established methodologies useful to validate this framework.

2.1. Energy scenario planning

Scenario thinking involves a collaborative method for strategic planning. It revolves around creating various potential future scenarios, aiding in making informed decisions in the present (Chermack, 2011). The literature endorses the importance of incorporating social science in energy future planning. Kaviani et al. (2023) state that the main focus of research on energy planning is often economic and technological feasibility. Aspects such as the influence of lifestyles, emerging technologies, and household preferences are often overlooked in the current literature. This can result in an overreliance on assumptions about the individual end users of the new energy system. Kaviani et al. tackle this by developing a method that prioritizes the occupants of the new energy system and their future lifestyles. This method involves the collection and analysis of occupants' assumptions, beliefs, storylines, and interactions within each study area, also called the narratives of the end users.

Next to that, Grunwald (2011) states that futures in general and particularly energy futures are social constructs. Therefore, human interaction and cultural consensus should lay the foundation for constructing these futures. He also emphasizes that such interaction leads to another purpose of energy future planning. This purpose is that energy future planning is not simply a means to derive the 'best' future scenario, but enables the decision-maker to approach the new energy system with a more inclusive view.

Sahakian et al. (2023) describe future imaginaries as a part of teleoaffecticities, which are the "ends and aims tied to hopes and expectations of individuals" (Welch et al., 2020). Therefore, if one is to develop future energy systems, the aspirations and preferences of end users must be considered within the design. Sahakian et al. propose to use personas that envelop the aspirations and preferences of future users of energy systems.

Following the conceptual framework discussed in chapter 1, this thesis is focused on the preferences and aspirations of end users, and is therefore focused on bottom-up, qualitative research. The concept of personas and how to develop these are further explored in the next section.

2.2. Persona-oriented research

Personas are described as hypothetical user models, symbolizing typical users during the design process (Cooper, 1999). These personas serve as an effective communication mechanism within design teams, compelling designers to acknowledge the social and political dimensions of design that are frequently overlooked.

Personas are pivotal in design and development, acting as archetypes that encapsulate user needs, behaviors, and goals, thereby fostering empathy and informed decision-making within teams. Fergnani (2019) emphasizes how personas enhance communication and guide user-centered outcomes,

making abstract user segments more relatable. Haines and Mitchell (2014) and Cherry et al. (2022) further elaborate on the role of personas in understanding diverse user profiles, especially in contexts like home improvement, where they help tailor strategies to varied user motivations and preferences. This leads to solutions that are not only effective but also deeply resonate with users. Vallet et al. (2020) introduces the importance of detailed analysis through personas in scenario planning, enabling a nuanced understanding of how developments affect different social groups. By providing rich descriptions and fostering a structured approach to design, personas ensure that products and services are meticulously aligned with user expectations, thereby enhancing the adoption of targeted policies and interventions. In essence, personas serve as a crucial bridge between designers and users, facilitating a more empathetic and user-focused design process.

Similar to energy future planning, Haines and Mitchell (2014) have conducted interesting research in which they defined personas to align DIY technologies and the inhabitants' preferences and aspirations towards doing odd jobs around the house. This user-centered approach is useful for this thesis, as it uses a method in which users' preferences, consumer habits, and routines of a certain product or system are linked to the future design of this product/system. The researchers based the personas on the following criteria:

- The attitudes and motivations of homeowners related to making improvements to their homes, which is the level of acceptance and adoption.
- The difficulties relating to making home improvements, which can be described as the technological landscape and investment landscape
- How homeowners go about making these improvements, otherwise the contents of what is adopted. Not only whether the new technologies are used, but rather how they are used. Emotional energy and interest to care enough about new technologies and innovations are also important.

These personas are then used to identify how the attitudes, motivations, and behaviors of future users lead to certain opportunities and barriers for the development of the product or system.

This relates to the *Know Your Customers'"Jobs to Be Done"* framework by Christensen et al. (2016). This framework is used for identifying poorly represented preferences or aspirations (i.e. "jobs") of users of technology. Christensen et al. (2016) state that to increase the innovation success rate, one must emphasize these "jobs" and design their product/system around these jobs. Therefore, a combination of persona creation and identifying their "jobs" could benefit the success rate and acceptance rate of the development of large-scale energy systems.

Cherry et al. (2022) have also used a persona-oriented approach in their research. In this study, the researchers have created personas for the design of a future local energy system in Port Talbot, Wales. The difference in methodology between this research and one conducted by Haines and Mitchell (2014) is that the system characteristics are identified beforehand and put within a scenario, and the personas are used to determine the type of person best connected to each scenario. Therefore, the participants share their aspirations and preferences that fit inside these scenarios. Even though the four scenarios are designed to be technologically inclusive as characteristics such as the degrees of centralization and local control are considered, defining such scenarios beforehand might limit the participant to fit their insights within these scenarios.

This research is relevant for this thesis also in a methodological sense, as it shows the benefits of a multi-model research structure in which real-life inhabitants are interviewed to create the socio-demographic context of the area. This data is used as input for multiple focus group discussions in which people with varying expertise are gathered to design potential energy systems based on the scenarios and personas.

Cherry et al. (2022) also proposes that by creating personas, the complex socio-technical energy issues can be grounded in local context and connections in resident's everyday lives. Specifically, the incorporation of personal identities within these personas leads to a more involved community, resulting in a better fit between the energy system and the end user's preferences and aspirations.

Vallet et al. (2020) propose another method of grounding the personas within the local context. They propose to create narratives around the personas using the *Scenario Personarrative method*. This method uses scenarios to base their persona on, just as is the case with the research of (Cherry et al., 2022). However, in this case, no technical scenarios are defined, but narrative scenarios. A similar approach is designed by Fergnani (2019). He has created a step-by-step method for developing scenario-specific fictional personas. In this approach, future persona fact sheets and scenario fact sheets are created. These sheets contain information on the characteristics of scenarios (such as characteristics of technology development or policy) and personal traits of the personas (such as demographics, mindset, and values). By linking the key elements of both sheets, the future personas can iteratively be refined to optimally fit the scenario in which they live.

Miller et al. (2015) have conducted a focus group discussion for energy future planning in which narratives are used to determine these energy futures. Both technical and non-technical experts within the research area are participating in this discussion. The input of these focus group discussions is the expertise of the participants. Even though they might have extensive expertise on the aspirations or preferences of future inhabitants, these insights will always remain limited, as the occupants of the future energy system are not directly used as data sources. This could be tackled by combining this data collection method with the frameworks developed by Cherry et al. (2022) and Fergnani (2019). As the personas created in these studies are narrative-driven, they could be used as useful input for such focus group discussions.

Lastly, a recent study has been conducted on the development of renewable energy innovation adoption personas (Torma & AschemannWitzel, 2024). For this research, energy technology adoption personas are developed that consist of motivations, goals, needs, and frustrations considering the adoption of agrivoltaics. Goals are included because by understanding better what stakeholders aim to achieve, the innovation is better tailored towards future aspirations, making the solutions more future-proof. Needs are included to let the personas give insight into what stakeholders find essential, which helps to increase adoption. Frustrations are included to better identify potential barriers to adoption. It should be noted that the social dynamics within the communities and between the personas are not included in these personas, which are an important part of energy technology innovations (Cherry et al., 2022). Moreover, Torma and AschemannWitzel (2024) describe that common critiques on persona development such as a lack of representativeness, generalizability, and biases by the researchers are mitigated within their research by grounding the persona-development process in rigorous qualitative research methods.

In the Netherlands, various research has been conducted on the application of social science within energy future planning. In Enschede, a study is conducted on the application of the COLLAGE framework, a tool for increasing the involvement of stakeholders (Flacke & De Boer, 2017). The study has shown that the tool increases the inhabitants' awareness of the benefits and requirements of renewable energy systems. This tool contains technological information, as well as quantitative data on energy consumption on a neighborhood level. Unfortunately, this study does not map the aspirations and preferences of the participants. In Utrecht, a quantitative study is conducted on potential energy savings with the application of future renewable energy sources (Liu et al., 2021). Next to that, research has been conducted on user-centered design (Tolkamp et al., 2018). This research analyzes how providers of energy efficiency services co-create with their users and emphasizes the potential for co-creation with their user base. Unfortunately, the contents of this end user co-creation were not within the scope of this research. All in all, it can be concluded that various research has been conducted surrounding the topic of user-centered energy planning. However, prominent research on the creation of future energy systems via a persona-based approach conducted in the Netherlands has yet to be published.

2.3. Methodological analysis: uncovering context and theories

Considering the research gap in the grey literature containing specific end user insights in the Netherlands in general, and in Eindhoven more specifically, the research is exploratory. This nature asks for highly exploratory and flexible research methods, such as is the case with grounded theory and pattern modeling. Grounded theory and pattern modeling are two distinct approaches in research that function for different objectives and research questions. The choice between the two methods depends on the

research goals, the nature of the data, and the level of theory that is aimed to be developed.

Grounded theory vs pattern modeling

The literature describes multiple reasons why grounded theory is a useful methodology for conducting this thesis:

1. *Exploratory research*: Grounded theory is a well-established tool for exploratory research where little pre-existing theory or understanding of the context being studied is published. It allows the researcher to inductively develop theory from data, ensuring that the theory is closely tied to the empirical evidence (Heath & Cowley, 2004).
2. *Rich qualitative data*: When the research involves rich qualitative data, grounded theory provides an iterative and systematic methodology for organizing and analyzing this data to develop a well-grounded theory (Charmaz, 2006).
3. *Process, action, and interaction*: When research focuses on the social context and its processes, actions, and interactions between its stakeholders, grounded theory can be effective in uncovering the underlying and often implicit social processes and structures (Strauss & Corbin, 1992).

Next to that, the literature describes the potential for pattern modeling as a useful tool for this research:

1. *Data-Driven Insights*: Pattern modeling is useful when the goal is to identify patterns, trends, and relationships within large datasets. It is particularly useful in fields like data science and computational social science where large volumes of data are available (Han et al., 2021).
2. *Predictive Modeling*: When the research aim includes making predictions or identifying the likelihood of future occurrences based on identified patterns, pattern modeling is a suitable approach.
3. *Quantitative Analysis*: Pattern modeling is aligned with quantitative research, making it suitable for studies where numerical data and statistical analysis are central.

In conclusion, due to the novelty of the research goals, grounded theory is a better fit for data collection and analysis in the context of Eindhoven. Pattern modeling serves as a sufficient tool for the next step in research, once the initial framings have been established using grounded theory. Once the baseline has been established in this thesis, pattern modeling can be used for quantifying the personas or framings in this research, as well as defining futures (predictive modeling).

Methodological issues in grounded theory

Cutcliffe (2000) describes several methodological issues related to grounded theory are discussed.

Researchers often face dilemmas regarding sampling. Grounded theory uses theoretical sampling, which evolves as data collection progresses. However, some researchers confuse it with purposeful sampling. To mitigate this, researchers should consider their research question, clarify the level of the theory they aim to induce, and decide when to access and introduce the second body of literature. Acknowledge that purposeful sampling occurs initially, but theoretical sampling guides further selection.

Balancing creativity and reflexivity is essential. Some researchers suppress their tacit knowledge and creativity to appear objective. This is mitigated by embracing creativity as part of the grounded theory process. Researchers should acknowledge their prior knowledge, values, and beliefs, as it will impact the starting point, participation selection, and direction of the research. Beforehand, potential positionality biases should be considered. Creativity enhances understanding and theory development.

A discussion in the literature exists among researchers about the timing of literature studies when applying grounded theory. Some argue that a literature study should only be done after data collection and analysis, to prevent biases from emerging. Others argue that literature studies are vital for defining the broad context, as well as creating a starting point of the research (Dunne, 2011).

It is important to note that grounded theory evolves, and researchers may combine different approaches. The key is to maintain rigor, creativity, flexibility, and clarity throughout the process.

2.4. The role of end users in the development of energy systems in the Netherlands - Grey literature

This section describes the current literature landscape on the role of end users in the energy transition in areas in the Netherlands. The aim is to identify research gaps, the knowledge that is extended by

this thesis, and research that addresses the future research prospects for this thesis.

To establish a starting point for the data collection, current research on the role of end users in the development of energy systems in the Netherlands has been underrepresented in academic literature. To find such insights, one must look for grey literature, such as reports written by independent research institutes and policy theory articles. As stated by Bongers (2023), even though policy theory contains scientific foundations, they are useful for constructing and reflecting on the efficacy of policy. Insights about the role of end users in energy system developments are vital for policy implications, and therefore such literature must be included in this research. The literature reviewed for this thesis describes the importance of acceptance and participation of the inhabitants of the Netherlands, with quotes such as "The inhabitants of the Netherlands are the most influential stakeholders for the transition away from natural gas consumption, and therefore should be put at the center stage" (Klosters et al., 2020), and "The development of district heating systems are collective processes, in which residents of existing buildings must support them" (Van Aalderen et al., 2021a).

Energy transition: the customer journey

Koning et al. (2020) discusses the customer journey that the researcher at TNO created. This customer journey is applied often in the other grey literature discussed in this literature study. The customer journey consists of nine steps, described as follows:

- Step 1: Become aware of the theme of transitioning away from natural gas consumption by being informed iteratively.
- Step 2: Forming opinions on received information and community discussion.
- Step 3: Becoming aware of one's situation.
- Step 4: Choosing between exploring, waiting, or actively resisting.
- Step 5: Exploring the alternatives to natural gas within one's situation?
- Step 6: Choosing a solution.
- Step 7: Living in a house where renovations are being executed.
- Step 8: Living in a (partially) natural gas-free home.
- Step 9: Being an ambassador.

Even though the literature discussed above has described in-depth knowledge of this customer journey, it should be noted that this framework only considers individual homeowners. Renters and homeowner associations are excluded from this framework. Considering that energy systems such as district heating are more profitable in densely populated, urban areas, this customer journey might not be representative of a large part of the target group.

Van Aalderen et al. (2021a) and Schreuders et al. (2021) reiterate the critical role of early awareness and information dissemination in the customer journey towards a gas-free transition. The initial stages of becoming aware and forming opinions based on information are foundational to subsequent decisions and actions. Thus, strategies that enhance awareness and provide clear, accessible, and trustworthy information can significantly impact the success of transition initiatives.

Three types of acceptance

Van Aalderen et al. (2021a) introduces a crucial dimension by defining three types of acceptance during the development of new energy systems:

1. *Socio-political acceptance*: The target here are the citizens. This type of acceptance is about creating awareness of global warming, and the sustainability goals of the government and municipalities. Building trust between the residents and (local) government strengthens this acceptance.
2. *Process acceptance*: The target is the local resident. This type of acceptance is about accepting and joining the customer journey presented by Koning et al. (2020).
3. *Product acceptance*: The target is the customer, and consists of accepting the product, which is the adjustment to the individual central heating system, as well as the energy system infrastructure.

It should be noted that the targets here can be the same individual, filling three different roles, dependent on the type of acceptance. These types can also be linked to the various steps of the customer journey described by Koning et al. (2020).

Resident participation and engagement strategies

Klosters et al. (2020), Koning et al. (2020), and Kooger et al. (2023) underscore the importance of early and personalized resident engagement in the transition process. These studies reveal that mistrust between residents and authorities, financial constraints, and the lack of transparent information are significant barriers to effective participation ((Klosters et al., 2020) (Koning et al., 2020)). Moreover, the findings suggest that personalized approaches based on the customer journey can facilitate better engagement and trust-building (Koning et al., 2020).

The research highlights several drivers for resident participation, including the establishment of trust, personal communication, and clear articulation of the benefits and costs associated with the transition (Koning et al., 2020) (Kooger et al., 2023). Kooger et al. (2023), through a survey across 135 municipalities, further emphasizes the role of demographic, home-related, and financial factors in influencing residents' willingness to co-invest in district heating grids.

The role of municipalities and community initiatives

Martínez et al. (2022) and Kooijman and Lier (2022) detail the pivotal role municipalities play in the heat transition, outlining the strategies for data collection, technology selection, and the challenges of capacity and expertise (Martínez et al., 2022). The need for a long-term neighborhood strategy that includes efficient use of heat sources and technological advancements is also highlighted (Kooijman & Lier, 2022).

The literature illustrates the varying degrees of resident involvement, from advisory roles to active participation in energy-saving measures and discussions on heating transitions (Kooijman & Lier, 2022). The experiences in Apeldoorn, such as in the neighborhoods of Kerschoten and De Maten, serve as exemplars of community-led initiatives, albeit with noted limitations in broad citizen engagement and the need for more municipal support.

The importance of personal and collective experiences

The literature has emphasized the importance of individual and collective experiences in shaping community attitudes and reactions to systematic energy transition. Kooger et al. (2023) and Kort et al. (2020) emphasize the importance of the sense of community and personal communication between residents and other stakeholders in fostering a sense of belonging and shared purpose. These factors can significantly influence residents' willingness to participate in and support energy transition initiatives. Incorporating strategies that engage these community aspects can increase engagement and facilitate more effective change.

Methodological Reflections

The research methodologies employed across these papers include qualitative interviews, customer journey mapping, large-scale surveys, and literature reviews. These methods provided insights into the subjective experiences of residents, the systemic barriers to participation, and the effectiveness of various participation strategies. However, a recurring limitation is the lack of in-depth analysis of specific end user needs and a more comprehensive understanding of the socio-political context of energy transition. It is also important to note that Eindhoven is not mentioned as a use case during this research.

Financial considerations and incentives

It is pointed out by Koning et al. (2020), Kort et al. (2020), and Schreuders et al. (2021) that financial considerations are both a barrier and a driver for resident participation in the energy transition. The concerns about the cost of transitioning, the clarity on financial benefits, and the availability of subsidies and support are recurrent themes. Understanding the financial implications and developing clear, accessible incentives can play a critical role in encouraging resident participation and investment in the transition.

The need for a holistic and inclusive approach

The research indicates the importance of adopting a holistic and inclusive approach that considers the diverse needs, preferences, and situations of different resident groups. Van Aalderen et al. (2021b), for instance, highlights the differences between renters and homeowners in their needs for clarity and content during the transition. Addressing these diverse needs requires tailored strategies that consider the varying circumstances and concerns of different community members.

Personas as a powerful tool in policy theory

The literature also discusses the need for personas implicitly. As described by Koning et al. (2020), it is important to consider the individual wishes and constraints in the process more. Klosters et al. (2020) emphasizes the importance of mapping the inhabitants of energy development areas to employ the right resources. Lastly, Kort et al. (2020) states: ”A personal and individual approach based on where someone is in the customer journey is essential. Make time and resources available for this.” Developing personas can help map target groups, describe these groups’ wishes and constraints, and function as an evaluation tool for customer journeys.

2.5. Conclusion

In conclusion, this literature review underlines the significant role of integrating social science perspectives into energy future planning, emphasizing the potential of a user-centered approach. The literature discussed in this chapter contains a gap in the current research focusing mainly on economic and technological aspects, often neglecting the critical influence of user’s lifestyles, needs, and behaviors. This oversight highlights the need for a more holistic approach that considers the end users’ perspectives in energy system development.

The concept of persona development, as explored in this study, emerges as a powerful tool in addressing this need. Personas, representing hypothetical user models, enable developers and policymakers to better understand and incorporate the values, aspirations, and preferences of end users into the design of energy systems. This approach not only enhances the planning process but also ensures that the resulting systems are more aligned with the real-world needs and expectations of users. Furthermore, the literature discusses the effectiveness of implementing the ”Jobs to be done” framework into the development of the personas. The inclusion of human traits and local contexts into the contents of the personas strengthens the connection between residents and the energy systems they use. This ultimately leads to more tailored and effective energy products and services. Also, there remains a notable academic gap in research specifically focusing on persona-oriented energy planning within the Netherlands. While various studies have explored the application of social science in energy future planning, a detailed investigation into persona-based energy system development in this context is still to be conducted.

Extensive research is conducted about the role of the end user in the Dutch context, this is however mostly published in grey literature including policy theory articles and reports written by independent research institutes. This literature underlines the complexities of resident participation in the transition away from natural gas consumption in the Netherlands. This study highlights the need for further research that delves deeper into the specific needs of end users and the socio-political dynamics at play in the energy transition, considering not only homeowners but also renters and homeowner associations. Lastly, relevant research on the topics above has not been published specifically considering Eindhoven as a use case.

Lastly, this study highlights the need for further research that delves deeper into the specific needs of end users and the socio-political dynamics at play in the energy transition, considering not only homeowners but also renters and homeowner associations, specifically in Eindhoven.

3
Research Framework

3.1. Problem statement

The transition away from natural gas consumption and towards renewable energy sources in the Netherlands presents multiple challenges that necessitate an intricate approach. Aligning the national sustainability goals with the current status, the pace of the energy transition is under scrutiny.

The success of new regional heating and energy systems in this transition depends on the acceptance and engagement of end users, including residents, community organizations, and social housing agencies. While efforts have been made to increase stakeholder acceptance and engagement with programs aimed at increasing stakeholder engagement, challenges remain in the implementation of these strategies. Technical constraints of lower-temperature district heating systems stress the need for user-centered design as such systems demand precise optimization of demand and supply. Moreover, residents are primarily motivated to engage in energy-efficiency practices by cost considerations, temperature control in homes, and living comfort. These individual motivations underline the complexity of aligning the priorities with broader energy transition plans.

The area of Eindhoven has set ambitious goals for the energy transition away from natural gas consumption, as outlined in its Regional Energy Strategy (RES). This strategy aims to tackle challenges that concern energy conservation, renewable heat generation, and co-creation between local government and the residents. Eindhoven aims for a 55% reduction of CO2 emissions by 2030, and they already have made significant strides in this pursuit. However, some of the use cases of the 'proeftuinen' in Eindhoven have shown barriers in their development. For example, the Generalenbuurt faces hurdles concerning resident participation, based on the financial impact of potential high costs of connection to the neighborhood's future district heating grid. These concerns are strengthened by the perceived lack of communication and trust between the residents and local government. Even though the municipality of Eindhoven has acknowledged the value of the specific needs, values, and lifestyles of their residents, extensive resources are yet to be employed to map these insights for the city of Eindhoven, or for the Generalenbuurt specifically.

The literature study identified a significant gap in current research. Namely, the literature is mainly focused on economic and technological aspects, with a lack of attention to the influence of end users' values, lifestyles, and needs. This gap can be filled by providing a more holistic approach to energy system development, integrating the social science perspectives to stimulate user-oriented system design. The concept of persona development, representing archetypal end users of future energy systems, is named to be a useful tool to address this need. By understanding and incorporating the values, lifestyles, and needs of residents, developers, and policymakers can create energy products and services that are better aligned with the needs and expectations of their users.

Lastly, methodologies like the "Jobs to Be Done" framework, combined with persona creation, enhance the relevance and acceptance of energy systems. Incorporating personal narratives and local contexts into persona development creates a stronger link between energy systems and their users, leading to more tailored and effective solutions. Despite various studies exploring social science applications in energy planning, there is a notable academic gap in research specifically focusing on persona-oriented energy planning within the Dutch context. This gap is filled by grey literature, including policy theory reports. Even though such literature describes the complexities of resident participation and its crucial role in the success of energy system transitions, significant research on specific processes and system-related needs, values, and aspirations is lacking.

3.2. Research objective

The goal of this research is to conduct a case study in which the potential role of the end user in energy transition developments is explored. This case study emphasizes the integration of the needs, values, and aspirations of the inhabitants of urban Eindhoven in the transition away from natural gas consumption. Within the case study, grounded theory is applied to research what the contents of the personas should entail from the side of the inhabitants (what kind of data can the inhabitants provide) and from the side of the policymakers (what must the personas contain to be a useful tool for policymakers). The personas are based on actual inhabitants' aspirations, preferences, and habits concerning the energy systems they use. This research aims to create theoretical and methodological knowledge on how to create energy transition personas in a Dutch context (both existing and new/redeveloped urban areas), as well as create empirical knowledge on what makes Eindhoven's inhabitants tick concerning the energy transition. Due to the limited resources and time span of this thesis research, the researcher will work with a limited number of participants. Despite this limited *n*, this research strives to point out a broad range of insights and links between the insights that will point to future approaches to research on this topic.

3.3. Research questions

According to the academic knowledge gap found in chapter 2, the problem statement and the research objective, the main research question for this thesis is as follows:

"How can the creation of evidence-based energy personas inform and enhance the development of energy transition projects in Eindhoven, the Netherlands?"

The following sub-questions to answer the main question arise:

1. What are the values, behaviors, and needs concerning energy of residents of Eindhoven, the Netherlands?
2. How can these values, behaviors, and needs be represented by an energy transition persona?
3. What are the implications of the evidence-based personas on the policy-makers and realization stakeholders of energy transition developments in Eindhoven?

4
Methodology and Research Design

As stated by Grunwald (2011), assessments of energy futures should be conducted with a high level of scrutiny, specifically looking into the ingredients that have been used in the construction of these futures. Therefore, a detailed and academically grounded methodology is of high priority for this research. This chapter describes the case study that is being executed in a phased manner, the positionality of the researcher and its impact, how grounded theory is applied in this research, and how the quality of the research is embedded in the methodology.

4.1. Case Study Overview

The chosen research method is a case study. This research can be defined as both an intrinsic and instrumental case study (Cousin, 2005). The reason for this is that next to understanding the case in hand (such as with intrinsic case studies), the researcher also explores conceptual end users of the future energy system (such as with instrumental case studies), and uses these personas to explore their role in future energy transition developments.

The selected case is the development of future energy systems in Eindhoven, and more specifically, the role of the end users within this development. This research uses qualitative research methods, using grounded theory and interviews as the principal methods used in this case. the unit of measurement for these interviews is user-oriented stakeholders. User-oriented stakeholders can be divided into two groups: inhabitants of Eindhoven, and expert stakeholders involved in energy transition developments. The geographical demarcation is urban Eindhoven specifically, with the inclusion of a housing inspection at a social housing complex in Rotterdam, that functions as a proxy for the social housing complexes in Eindhoven.

This means that most participants either live (in the case of inhabitants) or are working (expert stakeholders in the energy transition) on energy transition projects in this area. This area consists of a wide variety of neighborhoods containing various types of dwellings, such as apartments, terraced houses, and detached houses.

During the interviews, the goal is to distill insights into the needs, mindset, and values of the inhabitants of Eindhoven concerning energy. Next, the expert stakeholders are interviewed about their views on the needs and aspirations of the inhabitants of Eindhoven, as well as their perceived role within the energy transition of Eindhoven. Due to the intrinsic nature of the research, grounded theory is used to assess the emerging themes and framings, and pivot and steer the research towards valuable data collection.

It is important to note that the case study has several layers. Phenomena are being studied that apply on a national, municipal, neighborhood, and individual level. For example, the application of grounded theory and development of the energy transition persona framework contribute to a national level, namely urban areas in the Netherlands. Second, the framings that emerge out of grounded theory are applicable in the municipality of Eindhoven. The evidence-based personas contribute to a neighborhood or individual home level. The actual contributions and their level of generalizability are evaluated in section 8.2.

4.2. Phased Research Design

This section outlines the four phases of the research design, based on the research (sub)questions defined in chapter 3.

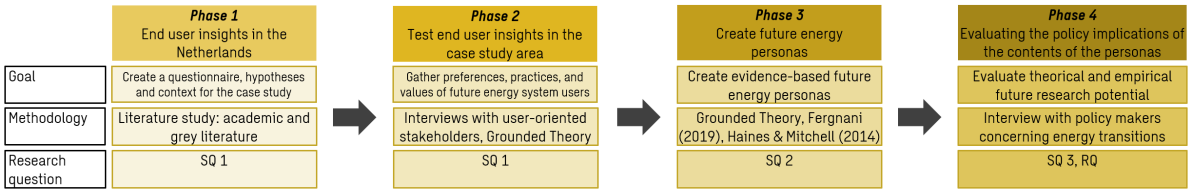


Figure 4.1: Graphic representation of the research design

Phase 1: Desk research

In this phase, existing literature, both grey and academic, is reviewed to create the foundation of the interview questionnaires, as well as build context for the case study. Knowledge of the values, preferences, and aspirations of end users is gathered out of existing literature. This phase creates a starting point for data collection.

A selective literature review is carried out. For the academic literature, Google Scholar and Scopus were the main search engines used. The keywords used to find relevant papers were: futures, energy futures, social futures energy scenario planning, personas, energy personas, energy needs, attitudes, grounded theory, and pattern modeling. For the grey literature, google has been the main search engine for this. Next to that, the TNO, Overheid.nl, and WarmingUp databases have been accessed. The keywords used in finding relevant documents were: acceptance, participation, energy values, residents, co-creation, energy transition, energy needs, and end user needs.

Phase 2: Interviews with user-oriented stakeholders

Next, the insights gathered from the literature are tested and expanded upon within the case study. The data collection method for this is semi-structured interviews. Due to the novelty of this research in this specific context, grounded theory is used in this phase of the research, to gather the themes and framings emerging from the data collection. This is further elaborated upon in section 4.4. The unit of measurement for these interviews is user-oriented stakeholders. User-oriented stakeholders can be divided into two groups: inhabitants of Eindhoven, and expert stakeholders involved in energy transition developments.
To be able to create evidence-based energy personas, the researcher must formulate questions to gather the following insights:

- To test the current knowledge on the values, habits, and preferences of end users of energy systems within a Dutch context specifically for this area.
- Characteristics such as the end user's view towards sustainability, economics, the organization of their new neighborhood, and consumption habits (Fergnani, 2019).
- Behavioral and demographic variables such as their motivation for joining the energy transition, price sensitivity, concern about climate change, and their willingness to change consumption behavior (Haines & Mitchell, 2014).

Using grounded theory, the researcher specifies these insights once more themes and framings emerge during the data collection part. The starting point of this research is defined in phase one with research questions and hypotheses, and the research might pivot and change direction depending on the data collected.

Phase 3: Creating evidence-based energy personas

Using the literary foundation created during the desk research and the case study-specific insights gathered during the interviews, evidence-based personas of future energy system users within Fellenoord can be created. Fergnani (2019) and Haines and Mitchell (2014) propose methods to create such personas. These methods are used as the base, and built upon using the emerging themes and framings during data collection.

Phase 4: Policy evaluation of the energy personas

This last phase of the research consists of a policy evaluation of the personas, to determine future research potential (theoretical and empirical) based on the contents of the personas.

4.3. Positionality of the researcher

To establish the transparency and reflexivity of the research, it is important to define the positionality of the researcher (Lu & Hodge, 2019). Positionality refers to the stance or positioning of a researcher in relation to the case study and the participants of the study. It acknowledges how the background, beliefs, social identities, and relationships might influence the research process, including data collection, analysis, and interpretation.

Personal background and identity

The researcher is a twenty-five-year-old man from the Netherlands, originally from Tilburg, a neighbouring city of Eindhoven. He knows people who live in Eindhoven and is known with their customs. Next to that, the researcher had experience working as a district heating engineer at energy company Eneco, working closely together with social housing organizations and municipalities. He is therefore well known with the organizations' positioning in the market, and their relationships with other stakeholders in energy transition projects. This was however mainly in and around Rotterdam and The Hague, not Eindhoven. During this work, he was also in close contact with the inhabitants of Rotterdam and their movements and beliefs within the energy transition. He, therefore, has experience in how to connect with the inhabitants of large cities and is aware of the nuances of this process.

Beliefs and assumptions of the researcher

By being daily involved in the developments of the energy transition, the researcher thinks that this plays a large role in most people's daily lives. This influences the research in that he thinks that most people have an abundance of technological needs, behaviors, and mindsets that are possible to link to energy system characteristics. The conceptual framework applied in this study implies the presence of technological know-how with end users and therefore strengthens the researcher's beliefs. As explained further on (in chapter 5), it became clear to the researcher that for most people, extensive or sometimes even basic knowledge of energy systems is lacking, and not a priority for most people. This was in contrast to what the researcher thought beforehand. The researcher acknowledged this shift in mindset and used these insights to pivot the research.

Position in relation to the participants

First, considering the expert stakeholders, the researcher could be perceived as an insider. He is well aware of the dynamics and roles in organizations such as the municipality and is, therefore, able to do a focused search on connecting with the right stakeholders. Next to that, Sweco works closely together with the municipality of Eindhoven. As an employee of Sweco, the researcher can have short communication lines with the municipality's employees.

Second, the researcher is both an outsider and insider when it comes to connecting with the inhabitants of Eindhoven. He is able to connect with people from his own network with similar demographics. However, some difficulties arose in connecting with inhabitants outside of the researcher's own network. This is explained in depth in section 8.3.

Impact on research process and outcomes

The positionality of the researcher has an impact on the process of the research, the outcomes, and also the dialogue with the participants. First, the researcher's background helped the researcher to map stakeholders for participants based on his experience working in similar environments, as explained in section 4.5. Second, it helped to develop the questionnaire, especially for the expert stakeholders, as he was able to have a basic understanding of the experts' role beforehand and base the questionnaire around it. Third, the positionality impacted the dialogue with expert stakeholders on two levels. On the one hand, due to the researcher's basic knowledge of the role of the experts, he was better able to pivot the interview if a concept outside the questionnaire was discussed. On the other hand, the preliminary knowledge might lead to biases considering the roles and mindsets of the expert stakeholders. This is mitigated by starting the interview by asking the participant to give an extensive description of his/her organization, role, and experiences. Most importantly, the positionality of the research, in combination with the desk research beforehand, gave the researcher the tools to create a starting point for the grounded theory approach.

4.4. How to pivot the research based on emerging themes and theories: Grounded theory

Because of the novelty of creating energy personas in the context of energy transition developments in Eindhoven (both existing and redeveloped areas), the methodology 'grounded theory' is applied in this research. As discussed in section 2.3, this is a methodology involving the construction of theories through the methodical gathering and analysis of data. Therefore, this research method operates almost in a reverse fashion in contrast to traditional research design.

Creating the starting point

This thesis applies a combination of both deductive and inductive research, in that the following hypotheses are constructed before data collection, which is the 'starting point' of the research: The hypotheses that are constructed beforehand are as follows:

- Residents of Eindhoven express needs and behaviors that are useful to create technological system requirements.
- Organisations such as the municipality of Eindhoven have difficulty connecting with certain groups of inhabitants of Eindhoven.
- Sustainability rarely plays a role in the inhabitants' everyday lives.

These hypotheses are proven or disproven, changed, supplemented, and even new hypotheses are constructed during the data collection according to the emerging themes and framings. To start data collection, the researcher defined a starting point in phase 1, based on the desk research and his positionality in the case study.
These hypotheses are created based on the desk research in phase one and the positionality of the researcher (his work experience and experience with residents of Eindhoven before this research).

Emerging themes and framings, and their impact on the direction of the research

During phase 2 of the research (see section 4.2 for more elaboration), grounded theory is applied to see what types of data are distilled from the interviews with both end users and expert stakeholders. The hypotheses stated above are tested during the interviews. Parallel to the interview, data analysis takes place to consider the emerging themes discussed during the interviews. The themes and framings that emerge from this data analysis steer the direction of the research. For example, it helps to refine the questionnaire to ask more detailed questions about existing themes or add themes to the questionnaire. Next to that, the analysis helps to steer to invite other types of participants if those better fit the emerging themes. It is important to note however that if a hypothesis appears to be disproven, the data collection on this hypothesis continues. The questionnaire still considers the initial hypotheses, to not rule out any theories before data collection is completed. Instead, the questionnaire is refined in other areas in which a certain frequency of data points arises.

Application of grounded theory

This methodology is executed iteratively in a step-by-step manner:

- *Starting point definition*: The initial questionnaire is formed based on the literature study and conceptual frameworks.
- *Data collection*: Through interviews with inhabitants of Eindhoven and expert stakeholders within Eindhoven.
- *Open coding*: The initial phase of coding in which the data is extensively examined to identify and name the key themes, points, and ideas that emerge. This is an exploratory approach to coding. where the researcher labels and categorizes the data without trying to fit it into preconceived theories or ideas.
- *Axial coding*: This phase of coding involves identifying the relationships between the categories that are identified during the open coding phase.
- *Selective coding*: This is the final coding phase, where the themes are constructed based on the categories and their relationships that emerge. Themes eventually lead to theories, that prove or disprove the hypothesis.

- *Theoretical sampling*: After analysis, the researcher decides to pivot the data collection towards the emerging themes and framings. The researcher decides what data to collect next based on what best develops the emerging framing.
- *Constant comparison*: Throughout the process, each piece of data is compared with all other data points to identify similarities and differences. This constant comparative method helps in refining and integrating categories.
- *Establishment of emerging framings*: During the data collection and analysis, framings start to emerge. These framings are used for creating the persona templates and doing the empirical analysis.

The process of persona creation is driven by grounded theory. Depending on the themes, framings, and concepts that emerge from iterative data collection, a methodology for dividing up the personas and defining the contents of the personas is created. As this is driven by grounded theory, the division of personas and their contents may greatly differ based on the context, the positionality of the researcher, and the data collection procedures. Based on the procedures and methods discussed in the sections before this one, a framework for energy transition personas is constructed. How this framework is constructed is elaborated upon in great detail in chapter 6.

This methodology results in a better representation of the participants in the personas. The reason for this is that the contents of the personas are not set in stone beforehand, but rather emerge as the interviews are conducted. Therefore, the most crucial data is represented in the personas, as insignificant themes make place for significant ones.

4.5. Data Collection Procedures

Ethics and privacy processes

During this thesis project, the Human Research Ethics of the Delft University of Technology is taken into account. The interviews are recorded. These recordings are stored on the researcher's TU Delft Onedrive. These recordings are transcribed and anonymized, after which the recordings are deleted. In both the transcriptions and summaries, the participants are only mentioned by what type of stakeholder they are and their characteristics.

Interviews

As discussed in the earlier sections of this chapter, the data collection method is interviews. As stated by Rodhouse et al. (2021): "Imagined publics become problematic when they build upon and reinforce simplified and stereotypical biases towards certain groups or individuals". Therefore, two types of stakeholder groups are interviewed: residents of Eindhoven and expert stakeholders involved in energy transition developments within Eindhoven, so both sides of the story get heard. Next to finding the themes surrounding the role of the inhabitants of Eindhoven in the energy transition, participants must be compared in some ways to be able to envelop their insights into representative personas, asking for both structure and leeway in the questionnaire. Therefore, semi-structured interviews are conducted, as they combine characteristics of both unstructured and structured interviews. Next to that, this method allows for greater replicability and less researcher control over the interview responses (Sekaran & Bougie, 1993). The full interview protocol is given in Appendix A. Ideally, all interviews are held according to the interview protocol. However, as discussed down below, some more informal methods of data collection have been applied. These methods still follow the HREC guidelines, but they are not recorded and are more in the form of short conversations rather than longer interviews. As shown in Table 4.1, next to the semi-structured interviews, six informal interviews were conducted during a housing inspection. These inspections were organized by a social housing organization in Rotterdam and executed by the researcher's team at Sweco. During these inspections, there was not much room for the researcher to conduct interviews. Instead, small questions were asked, in combination with the observations of the interaction between the residents and the employees of the social housing organization and Sweco. Also, to reach more residents outside of the network of the researcher, fieldwork has been conducted, as further elaborated on below. During this fieldwork, small interactions took place between residents of Eindhoven and the researcher. Those data points make up situations A to D, as described in Table 4.1.

Sampling strategy

Due to the nature of grounded theory, the sampling strategy follows a flexible structure. Both the reach within the network of the researcher as well as the connection methods stated down below yielded 26 participants in total, 15 residents of Eindhoven and 11 expert stakeholders. For the inhabitants of Eindhoven, the researcher first connects with people within his network. The researcher finds that not all social demographics can be reached via his network, and therefore the researcher tries to reach outside this network. The researcher has tried to expand the social demographic reach of the participant pool by doing fieldwork. The following approaches can yield these connections:

- Door-to-door
- Approach people on the streets in the city center
- Approach people in shopping centers
- Approach people in the library
- Social media
- local small businesses, such as coffee shops, barbershops

The residential participants are either young adults or elderly people, consisting of both homeowners and (social housing) renters. A full list of all participants is illustrated in Table 4.1.

The specific approaches to reach inhabitants of certain areas may vary depending on the area, as well as the positionality of the researcher. It is advised that a variety of approaches is applied to reach as many as possible.

The participation selection process for the energy development expert stakeholders is influenced by both the case study protocol and the positionality of the researcher. The case study protocol defines the boundaries of the selection, and the positionality of the researcher refines the search criteria. First, the researcher produces a list of potential participants based on his own experiences working in this industry and the case study protocol of Eindhoven. The stakeholders are then evaluated based on their technological and user-oriented expertise. For the sake of triangulation, this list is then validated and assessed by two colleagues within Sweco, both working as project leaders within the energy transition industry in Eindhoven and with an extensive network in this area and industry. Both also rank the expected value of the participant's expertise. After his process is conducted iteratively three times (first by the researcher, then by his colleagues), the list is expected to be as complete as possible in this stage of the research. The reason for creating the list via this method is to use the implicit knowledge and networks of established project leaders and make it explicit.

The sampling strategy used for this research is a combination of various approaches:

- *Purposive sampling*: The selection of two types of participants, both residents and experts, based on their specific characteristics or roles related to the research topic indicates a purposive sampling approach.
- *Theoretical sampling*: The iterative process of refining the list of expert participants, influenced by the case study protocol and the researcher's positionality, are elements of theoretical sampling. This method is characterized by selecting participants based on emerging patterns or framings during the research process. This also relates to the grounded theory approach described in section 2.3, in which participants emerge as the context evolves.
- *Convenience sampling*: Initially, the researcher uses their own network to connect with the inhabitants of Eindhoven. This approach is indicative of convenience sampling, where participants are chosen based on their easy accessibility and proximity to the researcher.
- *Snowball sampling*: The attempt to expand beyond the researcher's network, especially in the context of reaching out to experts within the energy transition field in Eindhoven, hints at a snowball sampling method. This is particularly evident when the researcher's colleagues within Sweco assess and add to the list of potential expert participants based on their networks and expertise.

Formal interview		
Participant	*Type of Stakeholder*	*Description*
Participant #1	End user	Young adult, renter
Participant #2	End user	Young adult, renter
Participant #3	Expert stakeholder	Project leader energy transition at Woonstichting 'Thuis
Participant #4	Expert stakeholder	Project leader energy conservation program at the Municipality of Eindhoven
Participant #5	Expert stakeholder	Energy coach at the Municipality of Eindhoven
Participant #6	Expert stakeholder	Energy coach at the Municipality of Eindhoven
Participant #7	Expert stakeholder	Energy coach at the Municipality of Eindhoven
Participant #8	End user	Elderly, homeowner
Participant #9	End user	Elderly, homeowner
Participant #10	Expert stakeholder	Project leader energy and student housing at the TUe
Participant #11	End user	Young adult, homeowner
Participant #12	End user	Young adult, homeowner
Participant #13	Expert stakeholder	Promoter of the Klusbus
Participant #14	End user	Young adult, renter
Participant #15	End user	Young adult, renter
Participant #16	End user	Young adult, homeowner
Participant #17	Expert stakeholder	Project director at Energy Company Eindhoven
Participant #18	Expert stakeholder	Business developer at Energy Company Eindhoven
Participant #19	Expert stakeholder	Independent Journalist
Participant #20	Expert stakeholder	Senior communications specialist at the Municipality of Eindhoven
Informal interviews (housing inspection)		
Participant	*Type of Stakeholder*	*Description*
Participant #21	End user	Elderly, renter
Participant #22	End user	Elderly, renter
Participant #23	End user	Elderly, renter
Participant #24	End user	Elderly, renter
Participant #25	End user	Elderly, renter
Participant #26	End user	Elderly, renter
Informal interviews - Fieldwork		
Situation	*Type of situation*	
Situation A	Door-to-door	
Situation B	Approach people on the streets	
Situation C	Approach people in shopping centres	
Situation D	Approach people in the library	

Table 4.1: Full participant overview including participant type, organization, and a short description of the participant.

Data analysis

The interview transcripts and summaries are analyzed via qualitative data analysis, using *Atlas.ti*. This analysis is conducted in two parallel approaches. On the one hand, the end user interviews are analyzed, to find comparable traits that can be combined into personas. This is done iteratively, after a certain amount of interviews. The themes and framings emerging from the interviews with inhabitants are also investigated, and refine the questionnaire and participation selection. On the other hand, the

expert stakeholder interviews are analyzed. This analysis helps to provide context to the personas set by the expert stakeholders and investigate the themes that arise during conversations with expert stakeholders of large energy transition developments. This is also done iteratively, and the direction of the research is evaluated after a certain number of interviews. Using Atlas.ti software, important insights are categorized using a coding scheme, which is based on the themes that emerged from the grounded theory methodology.

Extensive qualitative data analysis is conducted on these 26 participants. Even with this limited number of participants, many insights and links between these insights are described, resulting in a broad range of future approaches to empirical and academic research on this topic.

4.6. Quality of the Research

This section discusses how the quality of the research is embedded within the research design.

Validity & Reliability

Validity refers to the accuracy of an instrument in measuring the specific concept it is designed for (Sekaran & Bougie, 1993). Essentially, validity focuses on ensuring that the right concept is being measured, while reliability is about the stability and consistency of the measurement process. The validity and reliability of measurement are crucial indicators of the scientific thoroughness embedded in the research study. Both are evaluated via four tests commonly used in social science research: construct validity, internal validity, external validity, and reliability (Yin, 2017).

Construct validity

Construct validity refers to the degree to which the researcher is truly observing and measuring the concept that is supposed to be observed. This is ensured via the following measures:

- **Clear conceptualization**: This research builds upon a conceptual framework that is grounded within academic and grey literature.
- **Triangulation**: Multiple data sources and data collection methods are used. Sources include grey and academic literature interviews with end users and expert consultations. Methods include desk research and interviews with various formats dependent on the type of participant.
- **Traceability**: By creating a chain of evidence throughout the study, the traceability of the derived conclusions strengthens.

Internal validity

This type of validity refers to the extent to which a cause-and-effect relationship between variables can be established. This validity must be considered during the full research process and emphasized during two consecutive parts of the research. First, when creating personas based on the data generated by the desk research and the interviews.

The second part is when the potential policy and communications implications are connected to these energy personas. Internal validity is embedded in this research by considering and mitigating potential biases. The biases for this thesis are illustrated in Table 4.2. It is also embedded by applying proper experimental design, which is embedded by the academic foundation of the interview questions, based on earlier research considering similar contexts.

Limitation	Effect	Mitigation measure
Selection bias	Non-representative sample of neighborhood inhabitants.	Evaluate the inclusion of the sample with experts within the area.
Response bias	Participants may respond based on perceived expectations rather than their actual opinions.	Phrase neutral questions and ensure anonymity.
Confirmation bias	The researcher might favor information that confirms their preconceptions, ignoring contradictory evidence.	Actively consider insights that challenge the researcher's preconceptions.
Interviewer bias	Skewed results due to the influence of the interviewer's behavior or interpretation.	Standardize interview protocols and questions that minimize subjective interpretation.
Social desirability bias	Participants may respond in a way that they believe is more socially acceptable or favorable.	Ensure confidentiality and emphasize the importance of honest feedback.

Table 4.2: Potential biases within this research, their effect, and mitigation measure

External validity

External validity refers to the generalizability of the findings from the case study. This is embedded within the research by applying purposive sampling, as it enables the research to be more representative and applicable in other urban area development research. Next to that, the research is characterized by variables originating from the conceptual framework 'Persona-based energy futures' designed by Yusuf Dirie, which is designed as a framework to apply to 48 unique contexts [1].

Reliability

Reliability refers to the consistency and dependability of the research methodology over time. This concept is embedded within the research by keeping the execution of the research consistent. Triangulation also strengthens the reliability of the study. As mentioned above, multiple data sources are used, as well as various data collection methods.

[1] more information at: https://encludeproject.eu/news-events/energy-citizenship-making. Grant number of the project: GA101022791.

5 Grounded theory: A journey to new theories

This chapter describes the process of developing framings based on emerging themes distilled from the interview data. These framings are used to develop the energy transition personas elaborated upon in chapter 6 and chapter 7. Grounded theory is applied as follows. First, a starting point is defined from which the data collection will take off. This starting point consists of hypotheses and a corresponding questionnaire. These hypotheses are responded to according to the framework shown in Figure 5.1. This framework works as follows. The process of data collection is divided into four rounds: Orientation, Pivot, Development, and Validation, with evaluation moments in between. During the Orientation round, data collection and analysis focuses on detecting the themes that arise during the interviews with evaluation moments in between. These themes are evaluated, and the questionnaire is changed based on these emerging themes. If needed, during the Pivot round, a change of direction in the data collection is applied. During this phase, the first framings start to emerge, which are evaluated at the end of this Pivot round. The next round, Development, is used to strengthen and develop the framings. In the last round, Validation, the framings and their implications are validated by a senior communications specialist at the municipality of Eindhoven and a journalist who has conducted similar research. The key insights and their sources used for developing the three framings discussed below are illustrated chronologically in Figure 5.1.

5.1. Starting point

This section describes the initial hypotheses based on the positionality of the researcher (work and life balance) and the desk research in phase 1.

The hypotheses that are constructed beforehand are as follows:

- Hypothesis 1:Residents of Eindhoven express needs and behaviors that are useful to create technological system requirements.
- Hypothesis 2: Organisations such as the municipality of Eindhoven have difficulty connecting with certain groups of inhabitants of Eindhoven.
- Hypothesis 3: Sustainability rarely plays a role in the inhabitants' everyday lives.

The initial questionnaire for inhabitants of Eindhoven is specifically organized towards the first hypotheses. Therefore, the questionnaire included topics such as:

1. General energy consumption; how do people consume energy in their homes?
2. Generation; how is their energy generated, and more importantly, how much do they know about the generation of their energy?
3. Transmission and distribution; how aware are people of the energy distribution system they use?
4. Storage; do people make use of or think about energy storage?
5. Their views on energy economics, policies, and the energy transition in the Netherlands in general.

The topics are discussed in present and future tense, to understand the current stance of the inhabitant, as well as distill future energy aspirations.

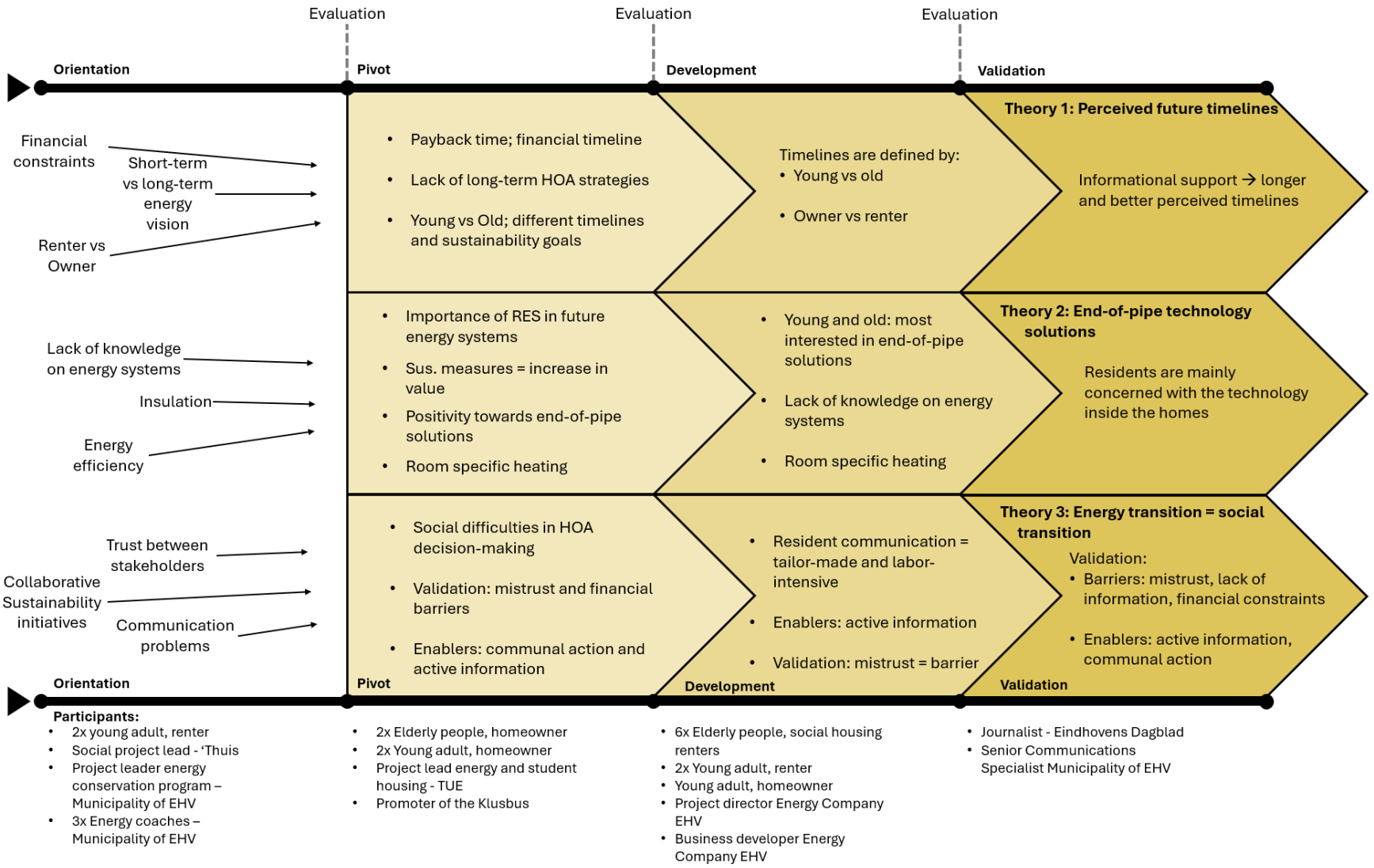


Figure 5.1: Overview of the key insights for each framing and their location on the chronological timeline

5.2. Framing 1: Perceived future timelines

This framing states that the willingness and ability to take action in forming one's energy future is dependent on the time span that is perceived by the individual. This means that only solutions that fit in the time span of an individual's perceived future are considered for feasible action.
The implications for this framing are that policymakers must align their far-reaching timelines for their policies (often up to 2050 and further) to the often shorter timelines that the participants perceived. All in all, most participants only thought ahead as much as 5 years in the future and did not consider taking action in sustainability measures if their benefits or payback time would persist beyond this time span.
If we look at the chronological development of this framing during the data collection phase, this framing was something that was not considered at the starting point of the grounded theory process. Arguments for this framing emerged as follows.

Orientation

Participant #1, a young adult renting an apartment mentions that he is willing to invest in more sustainable technologies, however, he is resistant due to having a short-term rental contract. The other renting young adult in this round, *participant #2*, shares this willingness and states that she is resistant due to being a student with financial constraints, and therefore does not think of long-term investments. Next to that, she states that she does not know how long she will live where she does now, and therefore only takes action on the behavioral side of energy efficiency/sustainability, even though she expresses keen interest in more sustainable practices. Both show little capability in perceiving their long-term futures.

On the other hand, *participant #4* and *participant #3*, a project leader energy conserving program at the municipality of Eindhoven and a project leader energy transition developments at social housing corporation 'Thuis respectively, state the importance of long-term planning for their projects. *Participant #4* necessitates long-term planning to provide "constant and consistent support programs", as well as make "more efficient use of our limited resources". At 'Thuis, *participant #3* helps with the realization of their sustainable renovations roadmap, planning to renovate all their home to be energy neutral by 2050.

These arguments represent the inability of young renters to look far into the future, specifically on the subject of sustainability. These participants do take action, but more short-term action such as behavioral action (consumption) and simple end-of-pipe solutions (insulation). On the other hand, the organizations such as the municipality of Eindhoven and the social housing organization 'Thuis, the organizations that realize developments in the energy transition, often work with long-term plans.

In the next round of interviews, the idea of timelines of perceived futures is embedded more into the questionnaire.

Pivot

When asked more specifically about the perceived timelines of the participants, *participant #11* and *participant #12* both state that they do not plan further than five years in general, as well as considering sustainability practices specifically. Both mention that they review the sustainability upgrades for their homes by the payback time, which is a practical manifestation of their perceived future timelines. *Participant #11* specifically states "When the pamphlet for cavity wall insulation stated the cost, benefits, and payback time, I was immediately moved to execute it". Showing a clear timeline helps her to align this action with her own perceived timeline, simplifying the decision-making.

Participant #9 lays out the problems concerning perceived timelines in HOAs quite clearly. Namely, all HOAs are obliged by law to have a long-term maintenance strategy for their building. However, a long-term sustainability strategy is not obliged, and therefore often not present. When the participant pitched ideas for executing sustainability upgrades, the decision-making processes often got jammed because of differing views and opinions within the HOAs. He mentions that the HOAs in which he is active consist of conservative and progressive people, both with differing perceived timelines. He states that older people often do not want to invest in sustainability measures, and younger adults are more willing to invest. Limited financial capabilities are also mentioned as a hindrance to creating a

long-term sustainability strategy.

Participant #8 strengthens the concept introduced by *participant #9*, in that she, as an older person, is ”content with what she has, and will make do with it”. Even though she is eco-conscious, she has no long-term sustainability goals. She mentions that in general, at her age, ”she only looks one year ahead”. Rather, she compensates on the behavioral and consumption side (with short-term solutions), by conscious energy consumption, transportation, and plastic use.

The existence of perceived timelines and their importance in planning sustainability upgrades start to take form, and will therefore be further developed in the following rounds.

Development

Similar to *participants #1 and #2* in the orientation round, *participants #14 and #15* share their future sustainability aspirations in combination with short-term perceived general futures. Their financial constraints and inability to act as renters are mentioned as barriers to taking considerable action in the short term. Both take short-term action in the form of behavioral action (consumption) and simple end-of-pipe solutions (insulation), similar to the other renting young adults.*Participant #16* shares the other young adults’ lack of long-term vision, but envisions more sustainability upgrades to his owned home, if financially interesting.

Participant #21, an elderly woman who lives in a social housing apartment, shares the following attitude: ”Sustainability? I won’t survive the energy transition anyway. I have been through a lot in life, and I think my situation is fine as is.” This demeanor is shared by her neighbors, *participants #24, #25, and #26*. This strengthens the idea introduced by *participant #9*, and grounded by *participant #8*, in that elderly people, for various reasons, do not consider long-term sustainability goals.

Validation

Participant #19, a journalist of Eindhovens Dagblad has been in close contact with the inhabitants of Eindhoven as well for her own research. She acknowledges the existence of timelines and states the following implication of this framing: ”If you inform the inhabitants more properly, and help them develop a better-perceived timeline, it is easier to create a collaborative energy future with (local) government and the inhabitants of Eindhoven.”

The existence of the timelines for perceived futures is also acknowledged by the senior communications specialist, (*participant #20*). She states that to increase the participation of the inhabitants, the perceived time spans of both the inhabitants and the policymakers should be aligned. Right now, as stated above, there is quite a large discrepancy, as end user participants often think short(er) term, and the policymakers long(er) term.

In conclusion, the perceived timelines of people’s future influence the willingness and ability to take action in forming one’s energy future. Younger people have idealistic long-term goals but lack actual long-term planning. Older people appear to not look far into the future at all, whether it be in general, or in sustainability practices specifically. Homeowners generally think more long-term than renters, and the timelines are also influenced by financial capabilities. It is proposed that informational support develops the extensions and coherence of the timelines.

5.3. Framing 2: End-of-pipe technology solutions

This framing states that most inhabitants are not concerned with sustainable energy, in that they have minimal knowledge and interest in the sources of their energy, energy distribution systems, storage, etc. Most people are more interested in end-of-pipe solutions within their homes that lead to energy efficiency, lowering the energy bill, and changes in consumption behavior.

Orientation

Both *participants #1 and #2* have limited knowledge about their energy distribution system, energy contract, or any other technical aspects of their energy system. They do not mention any needs that could pertain to these aspects as well. They do have some technical needs, but they are mainly concerned

with end-of-pipe solutions, such as insulation of their home, as well as behavioral measures such as smart thermostats. Both also mention room-specific heating as a requirement for their apartments' central heating system.

The energy coaches *participants #5, #6, and #7* mainly get asked for advice on reducing the energy bill via energy consumption behavior and small energy efficiency measures, mainly actions to be taken inside the homes. Next to that, the energy coaches state that their services are underutilized. The only time the coaches were at full capacity was when the inhabitants could apply for energy allowance and did not know how. In conclusion, people mainly ask the energy coaches for financial directions, rather than sustainability/technological directions.

This orientation round broad light to the lack of knowledge about and interest in the technology aspects of the energy system. The participants did however show interest in technical aspects within their homes. The next rounds of interviews will focus on gathering home-specific technical insights.

Pivot

The promoter of the Klusbus, *participant #13*, explained that people responded generally positively to the activities of Klusbus, who offer small, end-of-pipe solutions such as draft excluders, radiator foil, LED-lights, and other energy efficiency or insulation measures. He stated that people found such solutions more tangible, which made taking action in the energy transition more feasible.

Participant #11 is working a lot on energy efficiency in his home. He likes to work on optimizing his energy consumption with smart devices, super variable energy contracts, and his scripts. He is mainly concerned with optimizing on the consumption side (end-of-pipe) and is not considering more efficient or sustainable energy generation solutions as of the moment of the interview.

Participant #12 states that even though she has long-term idealistic sustainability goals of having a self-sufficient and energy-neutral home, she explains that end-of-pipe solutions are more tangible, and therefore move her to take action in the short-term. Similar to the other young adults interviewed before her, she mentions room-specific heating as a requirement for her home's central heating system.

Not all inhabitants are considering their central heating system. *Participant #9* states that if homeowners saw sustainability renovations more as upgrades and increases in the value of their assets, people would be more willing and interested in end-of-pipe solutions within their homes.

On the other hand, the project lead energy and student housing of the Eindhoven University of Technology *participant #12* states the importance of sustainable energy generation solutions for the development of future energy systems: "Considering the obliged technical requirements of future energy systems, we must not only consider end-of-pipe solutions but also emphasize renewable energy generation".

This round of interviews further defined the inhabitant's interest in their own homes. Considering the importance of end-of-pipe solutions for end user experience, it is also made clear that energy system innovations are vital for future energy systems.

Development

None of the elderly participants of the housing inspection *participants #21 to #26* were interested in the energy distribution system, energy contract, or any other technical aspects of their energy system. They were only concerned about end-of-pipe solutions for their homes such as simple-to-use heating technologies and insulation.

Participants #14, #15 and #16, three young adults, either renter or homeowner, show interest in room-specific heating, as well as insulation measures. All three participants lack knowledge about the energy distribution system, energy contract, or any other technical aspects of their energy system.

Both *participants #17 to #18*, the project director and business developer of the Energy Company

Eindhoven emphasize finding a balance between increasing energy efficiency and comfort in the homes (as stated by the inhabitants) and investing in large scale renewable energy generation solutions for future energy systems.

Validation

Participant #19 acknowledges that during her research if asked about the needs of future energy systems, rarely technical requirements came up. The requirements that did come up were only technical needs within the homes of the inhabitants.

In conclusion, most inhabitants are only concerned with what happens inside the walls of their homes. Within their homes, people are mainly concerned with insulation, energy-saving solutions, and one specific requirement that came up repeatedly; room-specific heating. On the other hand, the importance of renewable energy generation for future energy systems is articulated. Considering the participating inhabitants of this study, the policy-makers do not have to be concerned about the insights of end users, in the technical requirements of the energy system. Policymakers should focus their resources on supporting inhabitants in realizing end-of-pipe solutions for their homes.

5.4. Framing 3: Energy transition is a social transition

This framing states that the energy transition is not technologically driven, but rather a socially driven transition. The barriers and enablers for the progression of energy developments are communicational, informational, and community-oriented.

Orientation

Participant #1 expresses interest in joining energy collectives, communities, or neighborhood initiatives. However, he has not found any. They either are non-existent where he lives or not advertised enough.

Participant #2 acknowledges a tendency for procrastination when it comes to proactive information seeking about sustainable heating and energy conservation. She states that a lack of knowledge prevents her from taking action in the short term.

Participant #3: describes the main barrier for their energy transition projects to be the ”70% endorsement” rule. If they want to renovate their houses, the social housing organization must gain endorsement from 70% of the participating residents to be legally allowed to execute the renovations. They approach this in a labor-intensive manner. ’Thuis starts with a letter a year before the start of the renovations. Next, the organization goes door-to-door to speak to the residents, explain the renovations, etc. Then, a survey is sent out for all residents to indicate any concerns, needs, or wishes concerning the renovations. Lastly, the organization organizes a gathering for all participating residents to further explore any concerns. During each phase of this approach, the residents may sign the consent form. He emphasizes the positive impact of personal communication between him and the residents, as well as between the residents themselves.

Both the project leader energy conserving program at the municipality of Eindhoven (*participant #4*) and the energy coaches *participants #5, #6, and #7* state difficulties in communicating with certain groups of residents of Eindhoven. The project leader acknowledges the difficulties in coming into contact with certain groups of people. She thinks that this is due to the inhabitants’ mistrust towards the (local) government. Persistent communication with sending letters repeatedly is necessary, and even then, letters with the logo of the municipality appear to be unread mostly. ”Sometimes I feel like a stalker towards the inhabitants”. Lastly, she highlights the customized approach various groups require to be engaged on the subject of energy by the municipality. The energy coaches experience an existing mistrust towards (local) government, specifically from the group that is most desperately in need of support, they call them ’The silent middle class’. The energy coaches describe it as follows:

1. At the top end, consumers are well-informed about obtaining subsidies for their investments.
2. At the bottom end, things function smoothly, often managed centrally through social housing foundations.

3. The middle class faces challenges, including issues with exploitative landlords and homeowners with little financial capabilities.

The energy coaches give an example of this mistrust. A current subsidy in the city offers €4,000 for upgrading to high-efficiency (HR++) glass, but uptake is low due to disbelief in the offer's legitimacy. They mention reactions from residents when explaining the subsidy: "Free money? If it seems too good to be true, it probably is too good to be true." Next to that, they express that the format of communication might be a barrier for some people to take sustainability action. For example, the word "participation" is associated with debt restructuring programs for residents, and might therefore not be a positive phrasing. Lastly, the energy coaches state that mental barriers exist to taking sustainability action, articulating the example of someone refusing roof insulation because they then had to clean out the attic.

The starting point of the data collection was mainly focused on the technical aspects of end user insights. As described above, themes such as communal action, the importance of information, difficulties in communication, and mistrust played a more prominent role. Due to the amount of data surrounding these themes, the subsequent interviews are used for further defining these themes.

Pivot

Participant #9 describes the impact of the social dynamics during decision-making processes for maintenance, renovations, and (sustainability) upgrades by the HOAs. He states that support and policies are necessary to help the HOAs make considered decisions. He claims that too often decisions are made based on emotion rather than on rationale. "There is a clear split between conservative members and those with a more progressive vision, who see the necessity of adapting to changing circumstances. This regularly leads to clashes during decision-making processes." The social dynamics are stated as a barrier to progression.

Mistrust as a barrier for energy transition progression is elaborated upon during this interview round. The existence of mistrust between the residents of Eindhoven and (local) government and social housing organizations is validated by the promoter of Klusbus (*participant #13*). He emphasizes the importance of Klusbus being its own entity. This improves the engagement with the residents. Financial motives also play a large part in the inhabitants' engagement with Klusbus: "It might sound unfortunate, but it was mainly financial for about 85% of it. I would even go so far as to say that if the energy prices hadn't been so high, people would have been much less interested." This is backed up by *participant #10*. He states that the subsidies are vital for him to take action in sustainability practices, as it helps with the payback time. Parallel to this interview round, the fieldwork was conducted to include residents outside of the network of the researcher. During this fieldwork, mistrust was encountered to a great extent. During *Situation A*, the researcher went door-to-door in a street with mostly social housing residents. The encounters were seldom positive and friendly. Some people were afraid that the researcher wanted to sell the residents energy contracts. Once the words 'municipality' and 'social housing organization' came into the discussion, people reacted agitated and the conversations often ended shortly after. In *Situations B and C*, the researcher asked the residents on the streets and in the shopping centers about trust in national and local government. Most people expressed more trust in the local government rather than the national government, even though both were not trusted that much.

Communal action is further defined as an enabler for energy transition progression. *Participant #12* explains that she is driven by communal pressure; if the neighbors have solar panels, she feels like she needs them too. Both she and *participant #11* talked about actively contacting neighbors about installing green roofs. *Participant #8* also expresses her willingness to take communal action: "Collaborative efforts yield more results and progress the energy transition." She also feels that larger companies and organizations should take more responsibility in the energy transition, and stimulate such communal action.

Both *participants #11 and #12* express the impact of actively being informed about sustainability practices at home. *Participant #11* specifically states "When the pamphlet for cavity wall insulation stated the cost, benefits, and payback time, I was immediately moved to execute it". Active information appears to be an enabler in this case.

In this round, mistrust, financial motives, and communal action are further explored and elaborated upon.

Development

The process of the housing inspection laid out the nuances of the communication between the social housing organization and its residents. Before the inspection, a letter was sent out to the residents, explaining the reason for the visit, as well as the date, time, attendees, etc. This letter was followed up by a phone call. The reactions to this communication approach were quite divergent. Some people, *participants #21 and #22* were happy with the forms of communication, and gladly let the inspection attendees inside their homes. Others, *participants #24 and #26* thought the letter was a scam, but were convinced of its validity after the phone call. Lastly, *participants #23 and #25* did not trust both the letter and the phone call and alerted the neighbors before our arrival. In the end, all participants let the attendees in their homes. It can be concluded from these interactions that such communications are labor-intensive, and have to be tailor-made, as it necessitates easy-to-understand, clear, and simple instructions via clear communications channels, often with a personal touch. Next to that, there are strong communal bonds between neighbors and the participants of this house inspection. Lastly, mistrust is a strong barrier to carrying out such inspections fluently on a large scale.

Participants #14, #15, and #16 indicate that more information about available sustainability options and benefits would enhance their engagement with and commitment to energy-saving practices. As a homeowner, *participant #16* would greatly appreciate more information on subsidies and how to apply to them. *Participants #14 and #15* would like awareness and education about simple, cost-effective measures they can implement as renters.

As a business developer from Energy Company Eindhoven, *participant #18* explains the company's stance on societal values and needs being just as influential on the business case of new energy systems as technical feasibility. He acknowledges the barrier of mistrust within the community towards policymakers and acknowledges its impact on complicated energy developments.

Validation

In her journalistic research, *participant #19* encountered similar themes as mistrust, financial constraints, and the notion that the energy transition is rather a social transition instead of a technological transition. She mentions that to create well-working communication channels between them and the residents, one must start with ”building trust within the community and understanding the social context is crucial”.

Participant #20, the senior communications specialist at the municipality of Eindhoven sees her job as ”creating a relationship between the residents of Eindhoven and the municipality”. She is aware of the presence of mistrust and the nuances of communication between the public and the municipality and adds that comprehensive strategies are needed to tackle these problems with the limited resources they have.

In conclusion, rather than being a technological transition, the energy transition appears to be a social transition that necessitates collaborative efforts. The social enablers of this transition are informational support, financial impulses, communal actions, and tailor-made communications. Barriers are complex social dynamics, ambiguous communication, financial constraints, and mistrust between the residents of Eindhoven and their municipality. These barriers and enablers are also connected with one another, as is the case with financial constraints/impulses and trust. The financial aspects can vary between energy consumption costs, investment costs for renewable energy systems, maintenance costs, transition costs (such as insulation for the houses), financing costs (costs related to leans), and social costs. The level of trust will influence the residents' attitude towards the type of cost. For example, with higher levels of trust in government bodies, residents are more willing to invest in renewable energy, trusting that policies and subsidies will provide a sufficient payback time. It also works the other way around. The costs will determine the level of trust. For example, as stated by the energy coaches (participants #5, #6, and #6), the increase in energy consumption costs led to dissatisfaction and mistrust towards

the government.

5.5. Conclusion

From this chapter, it can be concluded that three framings have emerged that increase the understanding of the dynamics at play for the energy transition in Eindhoven. Framing 1 discusses that the willingness and ability to take action in forming one's energy future is dependent on the future time scale that is perceived by the individual. This perceived time scale differs greatly between age groups and between homeowners and renters. Second, framing 2 states that the residents of Eindhoven are mainly concerned with end-of-pipe solutions related to their homes, resulting in increased comfort and energy efficiency. Lastly, framing 3 describes that the energy transition is not a technological, but rather a social transition, impacted by socially driven barriers and enablers. The main issues at play were financial constraints, mistrust, and lack of (clear) information. Next to providing a better understanding of the energy transition of Eindhoven, these framings are the foundation of the Energy Transition Framework developed in chapter 6.

Considering the hypotheses stated in section 5.1, it appears that Hypothesis 1 has been disproven. Rather than expressing technical needs and consumption behaviors useful for the system design, the participants mainly stated financial, informational, and communicational requirements. Second, Hypothesis 2 has been strengthened during this research, as barriers such as mistrust between residents and (local) government complicate the communication between the two stakeholder groups. Lastly, Hypothesis 3 appears to be disproven as well, as multiple participants state extensive interest in sustainability, rather than being only financially motivated to take action.

Framing 1 helps to create a division of the personas, as the personas are divided based on age and home ownership. Next to that, framings 1 and 2 help to shape the traits of personas, in that they make the researcher consider both dwelling-specific technical traits and socially driven (financial, communications, and informational) traits.

6 Development of the Energy Transition Persona framework

This chapter outlines the development of the Energy Transition Persona framework. It describes how the insights of the participants are divided into personas, what the contents of the personas are, and how the personas are made representative of the participants. This framework is built upon the framework given by Fergnani (2019) and the framings of the grounded theory methodology. Even though this chapter describes a generalizable methodology, this framework is a result of the data collection procedures and therefore is discussed separately from the methodology.

6.1. Division of the personas

The fifteen inhabitants of Eindhoven who participated in this research are represented by six personas. As described in section 5.2, age and housing status impact individuals' ability to perceive a certain future time scale. As this time scale impacts the willingness and ability to take action in the energy transition, it is included as a criterion for the division of the personas. This leads to a set of personas of varying levels of willingness to participate in the energy transition. Therefore, the division is first and foremost based on differences in age and housing status. The spread of these demographics is shown in Figure 6.1.

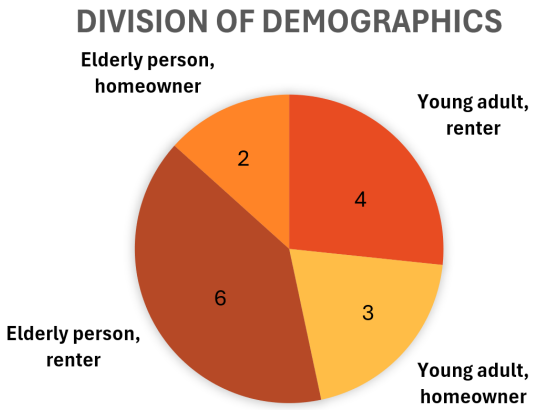


Figure 6.1: Division of demographics represented by the energy transition personas

Secondly, the participants showed various attitudes towards the energy transition within the four demographic personas stated above. These attitudes also impact the willingness and ability to take action and therefore should be included as a differentiating factor. This led to the final division of energy transition personas illustrated in Figure 6.2.

It is important to emphasize that these six personas are not representative of all inhabitants of urban Eindhoven for two reasons. One, due to the difficulties of gathering end user participants, the researcher had to make use of mainly his network and the efforts at the library in Eindhoven. This led to mainly Dutch young adults and elderly people making up the participant pool, excluding certain social

demographic groups from the research. Next to that, this group of personas represents a group of people who are willing to talk about energy and sustainability in general. These personas do not represent data collected from inhabitants of Eindhoven who are reluctant to converse about these topics.

Participant	Age	Housing Status	Attitude	
Participant #1	Young adult	Renter	Finacially limited and eco-friendly	→ Energy Persona A
Participant #2				
Participant #14				
Participant #15				
Participant #12	Young adult	Homeowner	Budget-savy energy conservator	→ Energy Persona B
Participant #16				
Participant #11			Pragmatic eco-visionary	→ Energy Persona C
Participant #8	Elderly person	Homeowner	Holistic compensator	→ Energy Persona D
Participant #9			HOA sustainability champion	→ Energy Persona E
Participant #21	Elderly person	Renter	Simple comfort seeker	→ Energy Persona F
Participant #22				
Participant #23				
Participant #24				
Participant #25				
Participant #26				

Figure 6.2: Energy Persona Division

6.2. Trait categories of the personas

The contents of the personas are made up of traits, which are divided into the following trait categories: needs, mindsets, behaviors, and resources. The reason for creating the trait categories is to make a structured and generalizable format to construct personas based on numbered facts about the represented participants.

The contents of each trait category are explained in the following subsections. The trait categories are an extension of the Fergnani (2019) framework, as shown in Figure 6.3. This framework proposes to divide the personas into three parts. The first part is 'human characterization', which is used to ground the complex socio-technical issues in the local context. The second part is called 'mindset and values', which contains future aspirations and the persona's views towards economic, societal, or political topics. The third part is called 'basic facts', which contains general facts about the persona's occupancy and social background, as well as pain points and (consumption)behavior.

For energy transition personas, 'human characterization' is expanded with living conditions and background next to the demographics. The living conditions connect the traits to the type of homes the personas live in, and build context to how and why these personas make certain decisions. The background is mainly used to ground the personas in the local context.

The 'mindset and values' is divided into the trait categories 'needs' and 'mindset'. In the Fergnani (2019) framework, 'mindset' mainly pertains to dreams and aims in life as well as general views. In the framework constructed for developing energy transition personas, the mindset trait category describes the adaptiveness of the personas towards innovations, societal views, and energy-specific views. The purpose of the personas is to be a positive and solution-oriented tool, and therefore the personas describe the participants' needs rather than' pain points', as is the case in the Fergnani (2019) framework. Next to that, the personas' needs not only describe long-term aims and dreams but also tackle problems that are present now.

Lastly, the 'basic facts' category is divided up into 'behavior' and 'resources' trait categories. Both trait categories describe how the personas act and make decisions, and with what available resources they can do so.

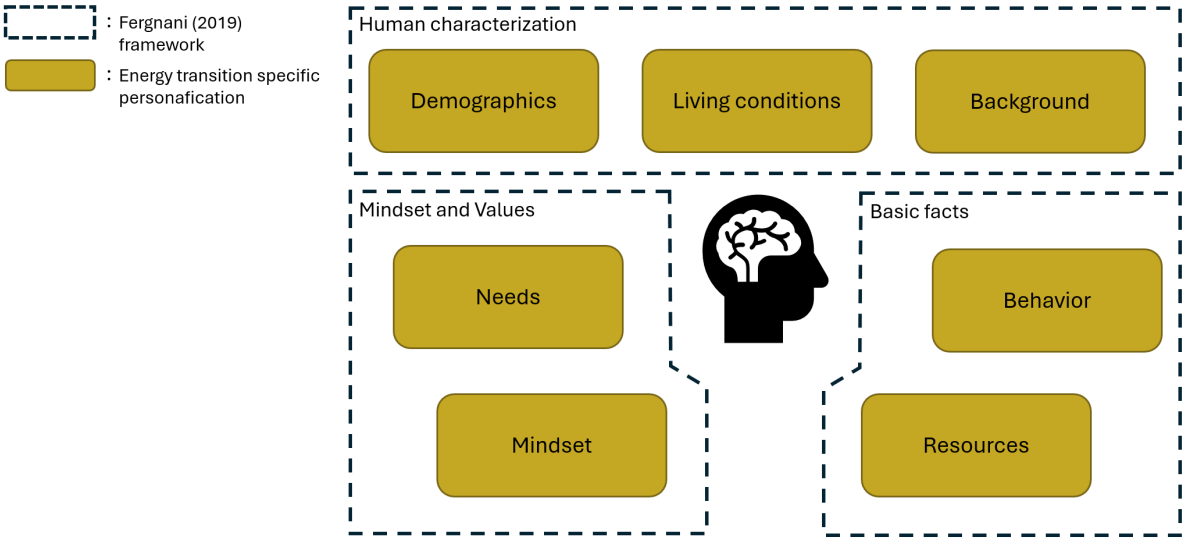


Figure 6.3: Theoretical framework: Energy transition personas

The contents of the trait categories are based on the notions that the participants are mainly concerned with end-of-pipe solutions (such as insulation and energy efficiency technologies) within their dwellings and that the social dynamics of the energy transition play a larger role than the technological innovations. This is shown in the traits of the personas. For example, the trait category 'needs' mainly consists of dwelling-specific technical, financial, communicational, and informational needs. The mindsets and behaviors often have the spatial scale of the dwelling or neighborhood, and relate to energy consumption and communal behavior.

Human characterization

Cherry et al. (2022) and Fergnani (2019) state the importance of personas reflecting human traits, as they help to ground the complex socio-technical energy-related issues in the local context and residents' everyday lives. Therefore, the personas represent the human traits of the represented participants. This is done by giving the personas a name, age, background, and current living conditions.

Needs

The needs represent inhabitants' requirements of the energy system and its stakeholders on a technical, financial, social, and informational level.

Understanding the needs of different personas helps in identifying the fundamental requirements and challenges faced by various segments of the population. For example, one persona might represent low-income families with a high need for affordable heating solutions, while another might represent tech-savvy individuals looking for smart energy solutions. By recognizing these diverse needs, policies can be tailored to address specific issues, ensuring that they are inclusive and effective in meeting the broad spectrum of community requirements.

Mindsets

The mindset represents how the personas see the bigger picture of the energy transition, as well as their role within it.

The mindset of a persona reflects their attitudes, beliefs, and values related to energy consumption and sustainability. This aspect can significantly influence the acceptance and success of policies. For instance, a persona with a strong environmental mindset might be more receptive to policies promoting renewable energy sources. Understanding these mindsets allows policymakers to craft messages and initiatives that resonate with the target audience, enhancing the likelihood of policy adoption and behavioral change.

Behaviors

The behavioral traits represent the participants' energy consumption habits, as well as communication with others and emotional behavior towards the themes arising from the interviews.

The inclusion of typical behaviors in personas provides insight into the actual energy consumption patterns and practices of different groups. This can highlight opportunities for intervention, such as promoting energy-efficient appliances to a persona characterized by high energy use but little awareness of consumption impacts. By aligning policies with the real-world behaviors of the community, initiatives can be more effectively designed to encourage sustainable practices.

Resources

The resources trait category can be divided into the following subcategories:

1. *Internal resources*: Personal financial and informational resources, such as savings and the know-how on how to apply for certain subsidies.
2. *External resources*: Financial and informational resources provided by organizations such as (local) government.
3. *Ease of access to resources*: The extent to which the persona has access to these internal and external resources.

The resources component of a persona covers the available financial, social, and technological assets that can influence energy decisions. A persona with limited financial resources but strong community ties might benefit from group purchasing schemes for solar panels, for example. Understanding the resources that different personas can draw upon allows for the design of policies that are not only feasible but also supportive of the community's capacity to implement and benefit from them.

6.3. How to build representative personas

For the development of the personas, a systematic approach is employed that starts with a thorough analysis of the qualitative data gathered from the interviews with the participants. Each interview transcript is examined to identify recurring themes. Specifically for this research, these themes are described in chapter 5. For each residential that participates in the data collection procedure, the needs, preferences, behaviors, mindsets, and resources are indexed per theme. The focus here is on extracting key insights that reflect the participants' lived experiences, motivations, and constraints within their unique living situations.

Subsequently, the insights are aggregated to identify commonalities and divergences among the participants. This involves synthesizing shared needs, mindsets, and behaviors to form the core traits of representative personas. Next, the variability within the data is to be acknowledged, by capturing the range of attitudes towards energy use, the diversity in participants' engagement with sustainability initiatives, and the spectrum of internal and external resources available to them.

Lastly, the personas are developed to embody the composite characteristics of the participating residents, with each persona representing a distinct combination of the identified commonalities, while also reflecting the broader variability observed across the dataset. This method ensures that the personas are not only grounded in the empirical data but also encapsulate the multifaceted nature of the participants' interactions with energy consumption and sustainability practices within their contexts. The outcome of this method, evidence-based personas, serve as archetypal users that encapsulate the key needs, mindsets, behaviors, and resources identified within the set of participants, providing a foundational tool for understanding user interactions in the context of social developments established within a certain context.

7
Application of the Energy Transition Persona Framework

This chapter describes the application of the framework within the context of the case study; the voice of end users in the development of energy transition projects in Eindhoven. A description of each of the personas is given, based on the design constructed in chapter 7. Next, the overarching themes that are represented by the personas are described via a cross-analysis of all six personas. Lastly, based on the contents of the personas and the overarching themes, the policy implications of these personas are discussed and validated during an interview with a senior communications specialist at the municipality of Eindhoven.

7.1. Overview of the personas

Based on the fifteen resident participants of this research, six personas have been created. The personas are divided based on age, housing status, and general attitude towards the energy transition, as illustrated in Figure 6.2. The personas are divided based on their willingness and ability to take action in the energy transition, which is impacted by their attitude, and the timescale of their perceived future (as was the conclusion of Framing 1: Perceived future timelines). These personas represent the participant's needs, mindsets, behaviors, and resources concerning energy transition developments in Eindhoven. Based on Framings 2 and 3 (see chapter 5 for more explanation), the personas will represent financial, communicational, informational, and dwelling-specific technical needs and resources. The mindsets and behaviors represent the spatial scale of the dwelling or neighborhood and relate mainly to energy consumption and communal behavior.

These personas represent six archetypal residents of Eindhoven with a specific profile for which a tailored participation strategy can be created. All six have their own specific priorities that lead to differences in customer journey, and therefore a difference in resource employment for the municipality and other stakeholders in the energy transition developments of Eindhoven.

As demonstrated in Figure 6.2, the personas vary in their representativeness of the participants. For example, Energy Persona F represents six participants, whereas Energy Persona C only one participant represents. This affects the quality of the personas. The more participants are used for the development of a persona, the greater the level of detail of the traits is. Next to that, it is easier to bridge gaps in the data collection. This is shown in the data. Energy Persona F, represented by six participants, has an increased number of needs that are more detailed than the needs of Energy Persona E, which represents one participant. The varying levels of detail based on the representativeness of the personas are perceived as a limitation of the study. The participants used to be represented by the personas are participants #1, #2, #8, #9, #11, #12, #14 - #16, #21 - #26.

7.2. Description of the personas

This section describes the six personas mentioned in the previous sections. The full personas with numbered traits per section are found in Appendix B.

Energy Persona A: Mr. Alex van Hoorn

Mister Alex van Hoorn represents four participants, young adults who are still students or just started working and renting an apartment in Eindhoven.

Mr. Alex van Hoorn is a 24-year-old student and a part-time engineer. He lives in a rental apartment in the city center. He prioritizes sustainability despite limited financial capabilities. Next to that, he seeks practical advice for energy-saving practices tailored towards renters, focused on affordability and communal support. He demonstrates engagement in green practices by adapting his behavior to minimize energy consumption and he shows interest in future sustainable investments. He leverages his internal resources whilst exploring external resources, such as community initiatives and renter-friendly programs to achieve his sustainability goals whilst being on a budget.

0. Demographics

Name	Mr. Alex van Hoorn
Age	24
Living conditions	Rents an apartment with roommates
Background	Both student and part-time engineer
General attitude	Financially limited and eco-friendly

1. Needs

1.1 Advice on energy-saving practices
1.2 Rental sustainability measures
1.3 Communal support
1.4 Financial affordability
1.5 Insulation

2. Mindset

2.1 Proactive in sustainability practices
2.2 Taking personal and behavioral action
2.3 Eagerness to learning and adaptation
2.4 Interest in sustainable futures

3. Behavior

3.1 Adaptive energy consumption
3.2 "First, let me put on a sweater"
3.3 Engagement in green practices

Resources

4. Internal

4.1 Limited but manageable budget
4.2 Basic understanding of energy practices, but lacks practical, renter-specific knowledge

5. External

5.1 Subsidies or governmental programs aimed at energy efficiency practices
5.2 Investment by the home owners
5.3 Educational and community programs

6. Ease of access to resources:

6.1 Effective use of internal resources, but lacks financial capacity
6.2 Keen interest in external resources, actual engagement may vary based on the required effort to access these resources

Figure 7.1: Energy persona A: Alex van Hoorn (headshot is generated using OpenAI's DALL-E 3)

Energy Persona B: Mr. Lucas van Dijk

Mister Lucas van Dijk represents two young adults, homeowners, who have been working for a few years, owning an early twentieth-century constructed multistory dwelling in Eindhoven.

Mr. Lucas van Dijk is a proactive 27-year-old homeowner. He lives in a multi-story upper house in the city center. He mainly seeks smart energy management solutions, balancing his financial motives with sustainability initiatives. He favors data-driven energy efficiency technologies. Next to that, Lucas is financially stable, focused on short-term living, and weighing his options to potentially rent out a part of his spacious home in the near future.

0. Demographics

Name	Mr. Lucas van Dijk
Age	27
Living conditions	Owns a multi-story dwelling in Eindhoven
Background	Active in his HOA, uses smart technologies for energy efficiency
General attitude	Budget-savvy energy conservator

1. Needs

1.1 Comprehensive energy management
1.2 Profitale renewable energy integration
1.3 Effective insulation solutions
1.4 Information and guidance on HOAs
1.5 Information on financial support

2. Mindset

2.1 Proactive and solution-oriented
2.2 Innovative and data-driven
2.3 Community engagement
2.4 Short-term living
2.5 Having a living space that feels too large

3. Behavior

3.1 Strategic and efficient energy use
3.2 Engagement in sustainability projects

Resources

4. Internal

4.1 Financially stable, individually and HOA funds
4.2 Knowledgeable on energy effiency and management technologies and has DIY skills

5. External

5.1 Access to subsidies and other incentives aimed at increasing sustainability
5.2 Community programs and local initiatives
5.3 Klusbus specifically

6. Ease of access to resources:

6.1 Efficiently utilizes his knowledge to pursue energy efficiency practices
6.2 He is knowledgeable on how to access subsidies

Figure 7.2: Energy persona B: Lucas van Dijk (headshot is generated using OpenAI's DALL-E 3)

Energy Persona C: Ms. Lydia Pieters

This persona represents one participant who has been working as a PhD student at Eindhoven University for two years, owning an early twentieth-century terraced house in Eindhoven.

Ms. Lydia Pieters is a 26-year-old PhD student at the Eindhoven University of Technology. She balances comfort with environmental consciousness in her comfortably equipped dwelling. She prefers simple energy management solutions and prioritizes clarity and practical benefits. Next to that, she values community engagement. Lydia's actions concerning the energy transition are driven by short-term financial motives and influenced by communal pressures. She favors hands-on projects with visible outcomes and she evaluates her investments pragmatically based on the pay-back periods. She employs her internal and external resources based on simplicity and tangible benefits in her journey towards eco-friendliness.

0. Demographics

Name	Ms. Lydia Pieters
Age	26
Living conditions	Owning a terraced house just on the edge of the inner city
Background	PhD student at the Tue, is creative and likes DIY
General attitude	Pragmatic eco-visionary

1. Needs

1.1 Simple energy consumption practices
1.2 Straightforward communication
1.3 Sustainable materials
1.4 Security of supply

2. Mindset

2.1 Pragmatic environmentalism
2.2 Long term sustainability vs short term financials
2.3 Socially-driven environmental conformity
2.4 Motivated and engaged by DIY
2.5 Evaluates projects by the payback period

3. Behavior

3.1 Adaptive and practical
3.2 Moved by community engagement

Resources

4. Internal

4.1 Financially stable, capacity for renewable energy projects
4.2 Favors actionable insights over complex data

5. External

5.1 Access to subsidies and other incentives aimed at increasing sustainability
5.2 Community programs and local initiatives

6. Ease of access to resources:

6.1 Reactive engagement with resources
6.2 Proactive stance toward community engagement and external resources

Figure 7.3: Energy persona C: Lydia Pieters (headshot is generated using OpenAI's DALL-E 3)

Energy Persona D: Ms. Clara Jansen

This persona represents one participant who is interviewed in depth about her traits, as well as the traits of her peers in her direct environment, people of the same age, and similar living situations within Eindhoven.

Ms Clara Jansen is a 67-year-old retired teacher who lives in an apartment complex in the city center. She embraces her urban lifestyle and is actively involved with her homeowner's association as a member of the board. She seeks cost-friendly electric cooking options and efficient heat solutions. Next to that, she advocates clear guidelines for sustainability practices within her HOA. Clara pleats for collective action toward systemic change, while also considering her own individual sustainability practices such as reducing the consumption of energy and plastics. Despite financial constraints, she employs both internal and external resources to improve the energy efficiency, comfort, and overall sustainability of her apartment and the complex as a whole.

0. Demographics

Name	Ms. Clara Jansen
Age	67
Living Conditions	Owns an apartment in the city centre
Background	Retired arts and crafts highschool teacher
General attitude	Holistic compensator

1. Needs

1.1 Cost friendly electric cooking options
1.2 Heating and thermal comfort
1.3 Clear communication on sustainability practices for her HOA

2. Mindset

2.1 Large corporates must take a more active role in the energy transition
2.2 Values collective action within her HOA
2.3 Individual contribution to the energy transition
2.4 Pragmatic yet Aspirational

3. Behavior

3.1 Energy conscious consumption habits
3.2 Environmentally conscious resource consumption
3.3 Communication and Interaction

4. Resources

4. Internal

4.1 Penion, savings, HAO funds
4.2 Direct access to discussions and plans regarding her buildings sustainability via the HOA

5. External

5.1 Subsidies/incentives from (local) government
5.2 Access to expert advice via the HOA

6. Ease of access to resources:

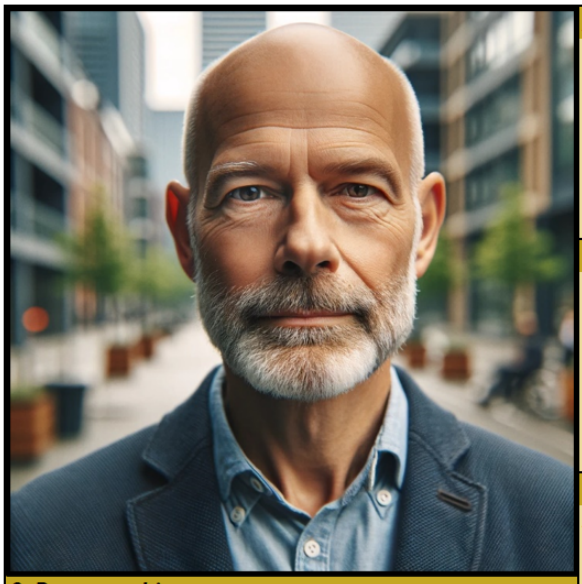
6.1 Potentially limited internal financial and informational resources
6.2 Access to eternal resources is more challenging, considering the decision-making processes of HOA and the complexities of subsidy applications

Figure 7.4: Energy persona D: Clara Jansen (headshot is generated using OpenAI's DALL-E 3)

Energy Persona E: Mr. Erik van der Meer

This persona represents one participant who is interviewed in depth about the dynamics of decision-making processes in homeowner associations within Eindhoven. This participant was able to provide insights as a proxy as to his peers in the various homeowner associations in which he is part of the board.

Mr Erik van der Meer is a 64-year-old homeowner who lives in an apartment complex in the city center. He is involved in managing two HOAs where he heavily promotes sustainability practices despite the wide variety of opinions within the HOAs. While he balances his progressive environmental vision with the practical realities of managing a HOA, Eric pleads for support in creating energy transition roadmaps for the homeowner associations. Employing the HOA funding, his knowledge of sustainability practices, and external support and policies he aims to advance the sustainability of his living environment despite the challenging decision-making processes.



0. Demographics

Name	Mr. Erik van der Meer
Age	64
Living Conditions	Owns an appartment in urban Eindhoven
Background	Serves on the board of various homeowner associations (HOAs)
General attitude	HOA Sustainability Champion

1. Needs

1.1 Effective strategies for consensus building for decisionmaking processes of HOAs
1.2 Access to educational information on long-term benefits of sustainability for HOA
1.3 Professional Support for HOA management

2. Mindset

2.1 Progressive with a vision for sustainability
2.2 Pragmatic realist, balancing idealism with the practical realities of concenus within the HOA

3. Behavior

3.1 Advocacy for Green Initiatives
3.2 Conflict Navigation for HOA decision-making

Resources

4. Internal

4.1 Financially stable, individually and HOA funds
4.2 Knowledgeable on energy practices and experienced in managing HOAs

5. External

5.1 Access to expert advice via the HOA
5.2 Subsidies/incentives from (local) government

6. Ease of access to resources:

6.1 Difficulty in accessing HOA funds due to the complexity of HOA decision-making processes
6.2 Moderate accessibility to external support, dependent on the interest and internal resistence of the HOA

Figure 7.5: Energy persona E: Erik van der Meer (headshot is generated using OpenAI's DALL-E 3)

Energy Persona F: Ms. Johanna Verbeek

This persona represents six elderly people living in two similar social housing building complexes. This means that these six people share similar living spaces, and encounter similar problems within their homes.

Ms Johanna Verbeek, a 72-year-old retiree leads a simple life in a social housing complex just outside of the city center. She prioritizes the comfort and safety of her one-bedroom apartment. She prefers clear communication and personalized interactions with the social housing organization. As Johanna is not interested in new innovations, she values simplicity and reliability in household appliances and energy systems. She is heavily engaged with her community and she prefers gradual and nondisruptive changes to her home. Despite her modest pension, she has external to a wealth of external financial and informational resources via the social housing corporation.

0. Demographics

Name	Ms. Johanna Verbeek
Age	72
Living Conditions	Resides in a two-room apartment within a social housing complex
Background	Retired, with strong communal ties in the neighborhood
General attitude	Simple comfort seeker

1. Needs

1.1 Comfort and warmth
1.2 Clear Communication with the social housing corporation
1.3 Personal interactions with the corporation
1.4 Simple appliance operation
1.5 Reliable heating to increase comfort
1.6 Easy access to technical support
1.7 Solutions that save energy without altering her lifestyle
1.8 Draft reducing and insulation solutions

2. Mindset

2.1 Value-driven and practical
2.2 Resilient and adaptable, embraces non-disruptive changes
2.3 Pragmatic sustainability with immediate effect
2.4 Health and Safety Conscious

3. Behavior

3.1 Proactive Comfort Management
3.2 Passive Energy Conservation
3.3 Selective technology adoption based on simplicity
3.4 High engagement with her community
3.5 Provides direct feedback on comfort, safety and communication directly to the social housing organisation

Resources

4. Internal

4.1 Modest pension
4.2 Savings

5. External

5.1 Investment by the social housing organization
5.2 Social housing residential benefits
5.3 Governmental subsidies for energy efficiency
5.4 Community-based assistance programs

6. Ease of access to resources:

6.1 Information and Awareness
6.2 Assistance and Support
6.3 Simplifying Processes

Figure 7.6: Energy persona F: Johanna Verbeek (headshot is generated using OpenAI's DALL-E 3)

7.3. Overarching themes represented by the personas

Even though the personas are constructed so that each has its own characterization, needs, mindset, and behaviors, some overarching themes have emerged that apply to some or all personas. The framings developed as the interviews were being held, founded by more insight as the data collection went on. The development of the personas, and subsequently the insights stated below, were developed after data collection was finished.

Considering the needs of the personas, a desire for a **comfortable living environment in combination with energy efficiency** is expressed. Some personas require heating systems that are reliable *(Personas C, D, F)*, and others require solutions to reduce drafts and improve insulation *(Personas A, B, F)*. Second, the necessity **clear and simple communication** is specifically articulated by all personas except *Persona D*. Third, the personas request **financial support**. Affordability is a key concern, with personas looking for cost-effective solutions *(Personas A, D)*, financial accessibility *(Personas A, B)*, and support in the form of subsidies or loans *(Personas B, E)*. Lastly, the personas value **community engagement and collective action**. The personas express the need for community initiatives and the importance of consensus in communal decision-making processes *(Personas A, C, D, E)*.

Considering the mindsets, the personas also share similarities. The personas take an **pragmatic approach to sustainability**. The personas display a *practical approach to sustainability*, focusing on actions and investments that yield immediate quality-of-life improvements and are cost-effective *(Personas A, C, D, F)*. Next to that, there is a *common mindset on communal efforts*. Several personas are involved in homeowners' associations or feel the influence of their community on their decisions related to sustainability *(Personas B, C, D, E)*. Moreover, the personas feel that *decisions related to sustainability are heavily influenced by financial factors*. This includes a focus on short-term financial gains and cost-benefits analyses for investments *(Personas A, B, C, D)*. Lastly, there is *an expressed feeling of responsibility and desire to take individual action*, within one's own capabilities, such as reducing one's energy consumption *(Personas A, C, D, F)*.

Considering the behavioral traits of the personas, they demonstrate a **willingness to adjust their lifestyle to increase energy efficiency**. This is achieved through the strategic use of heating systems *(Personas A, B, D)*, putting on extra clothing to increase comfort *(Personas A, C)*, or proactive comfort management *(Persona F)*. Next to that, the personas show an **openness to innovation within constraints**, in the form of interest in adopting new practices and technologies that increase personas comfort and energy efficiency without adding technical complexity and financial strain *(Personas A, B, E, F)*. Moreover, the personas exhibit *frugality in their resource use*, whether it is being mindful of appliance use, conserving water and energy, reducing plastic packaging, or preferring more sustainable transportation options *(Personas A, B, C, D, F)*. Lastly, while some personas are more proactive and involved in decision-making processes in energy transition developments *(Personas B, D, E)*, others take a more passive approach by taking more personal actions within their own space *(Personas A, C, F)*.

Lastly, a couple of insights on the personas' resources and their accessibility can prove useful for policymakers. First, each persona has some level of financial resource available, be it a limited budget, personal savings, a pension, or access to funds through a homeowners' association. However, they also face constraints such as the need for careful budget management and the prioritization of spending, which can limit their ability to make sustainable improvements. Second, all personas have access to various degrees of informational resources. While some have a basic understanding of sustainability and the energy transition, others are well-known with energy-efficiency practices and technologies. There is a shared need for practical, renter-specific, and homeowner-specific knowledge or advice on sustainability measures suitable for their living situations. Third, even though there is potential access to financial incentives, such as subsidies, grants, and programs, the ease of accessing these incentives varies, often requiring proactive engagement and navigation through application processes. Fourth, community initiatives, educational programs, and involvement in community organizations play a significant role in supporting the personas' sustainability efforts. These resources provide not only financial aid but also valuable information and practical support. Moreover, the personas' accessibility to internal and external resources varies. Policymakers must employ resources towards simplified processes, clear guidelines, and personalized assistance to improve access to resources. Lastly, several

personas rely on the investments made by others (*Personas A and B)* for sustainability improvements in their dwellings. This dependency highlights the significance of external stakeholders in their transition to more sustainable living.

These overarching traits give insight into what themes should be focused on by policymakers and other stakeholders of the energy transition in Eindhoven.

7.4. Policy evaluation of the personas

The role of the end user in the energy transition in Eindhoven

The senior communications specialist mentioned that the municipality steers towards homeowners in their energy transition policies, as this is where the largest strides are made. The energy coaches and other advisory programs are mainly for renters. Next to that, younger people will play a larger part in the energy transition, as younger people have a longer timeline to establish goals than in contrast to elderly people. Next to that, the specialist states that she is not sure if elderly people (often with less than ten years to live) should even be bothered with making their homes more sustainable.

Barriers and enablers of participating end users in the energy transition

The specialist mentions the municipality's amount of available funds as a barrier. Limited resources (financial and personnel) must be overcome by the smart application of resources. The municipality also tries to include key inhabitants of neighborhoods in their developments. These are people with a large network within a neighborhood and are knowledgeable about the topics at play in the areas. They use these people for sounding board groups, and these inhabitants could prove useful as sustainability champions within the area.

Bolstering citizenship in Eindhoven

The specialist mentions that it is important to let people choose their own timeline. This aligns with the timeline framing. She mentions that she thinks that it is much easier to get people involved in the energy transition if you let them pick their own timeline. Therefore, the focus on policy should be two-fold. First, help people to sketch a future timeline in which they can transition to more sustainable energy consumption, by providing financial, technical, and informational support and planning assistance. Second, provide building-specific technical advice for sustainability upgrades of homes of people who have that timeline ready. Another practical insight is that the specialist would like for all dwellings in Eindhoven to do a heat loss scan with an infrared camera. This is a visual indication of the potential for energy savings for the inhabitants. Next to that, she mentioned some persona-specific incentives and supports, such as the HOA support program persona E, Erik van der Meer, could benefit from.

Integration of end user perspectives into energy planning

As stated by the senior communications specialist (participant #20), these personas are useful for creating and testing customer journeys for energy system developments. The municipality is working on creating customer journeys when energy systems such as district heating grids within neighborhoods of Eindhoven are being developed. The personas help in two ways; to help better construct the customer journey from the viewpoint of the inhabitants, and to function as a reality check after the customer journeys are constructed. By doing this check, the policymakers review if their viewpoint is too narrow and biased.

7.5. Conclusion

The development of evidence-based energy transition personas in the context of the energy transition developments within Eindhoven serves as a tool in policy making and execution, as well as developing user-centered designs. By describing the specific characteristics, attitudes, and values of the residents via six energy transition personas, the framework facilitates an understanding of the residents' engagement in the energy transition. These personas, both young and old, renter and homeowner, not only represent the selection of the demographics of a part of Eindhoven, but more importantly highlight the commonalities between the residents within certain demographics and in general. The policy implications articulated by the senior communications specialist underline the importance of the inclusivity and adaptability of participation strategies. The contents of the personas advocate for a policy approach that acknowledges individual timelines, technical needs, and communication preferences, which foster

a more community-oriented and participatory energy transition. This tailored approach not only enhances the efficacy of energy transition strategies but also underlines the potential of the role of end users as active contributors to the transition away from natural gas consumption.

8
Discussion

In this chapter, the meaning behind the results of this thesis is discussed, by finding their links with existing literature. Next to that, the case study is reflected upon, including its context, generalizability, and triangulation. Afterward, the methodology is reflected, including the desk research, participant selection, and the application of grounded theory. This chapter concludes with a summary of the limitations of this study.

8.1. Interpretation of the findings

In this section, the meaning behind the framings created by executing grounded theory, the Energy Transition Persona Framework, and the application of the framework are evaluated. This evaluation is executed by finding the results' place within the existing literature.

Framing 1: Timelines

As explained in section 5.2, this framing states that the willingness and ability to take action in forming one's energy future is dependent on the future time span that is perceived by the individual. This means that solutions that fit in the time span of an individual's perceived future are considered for feasible action. In the context of this case study, young adults have idealistic long-term goals but lack actual long-term planning. Elderly people appear to not look far into the future at all, whether it be in general, or in sustainability practices specifically. Homeowners generally think more long-term than renters, and the perceived time spans are also influenced by financial capabilities.

The literature describes this phenomenon in depth, as it is an existing theory called the future time perspective (FTP) theory. FTP refers to an individual's or society's conceptualization of the future and how it influences present behavior and decision-making. More generally, in a business context, FPT can influence organizational decision-making and priorities (Henry et al., 2017).

Phan et al. (2020) highlights the complexity of the FTP. Developing an individual's or society's FTP can be executed in various dimensions. For one, development can mean the extension of the time span considered. Second, the level of coherence, meaning the organization of the envisaged events. The third dimension is the density of the FTP, which considers the number of anticipated events. This complexity suggests that simply extending the perceived time spans may be insufficient. A coherent strategy and roadmap for the energy transition over different time frames are crucial. This fits within the customer journey created by Koning et al. (2020), which not only provides the extension of the timeline but also organizes and gives insight into the expected events. Extensive academic research on the impact of FTP on energy transition developments has not been published yet. Nevertheless, some researchers touch upon its potential for climate change mitigation. For example, Andre et al. (2018) highlights that extending FTPs and having a longer-term perceived future can motivate actions to address long-term challenges, such as the energy transition. They also emphasize the importance of coherent visions and roadmaps.

Specifically for energy transition perspectives on a larger scale, extending and fulfilling society's FTP can motivate action to mitigate climate change. This is claimed by International Energy Agency (2017): "Defining the scenarios...determines energy supply and demand outlooks, emissions abatement and investment needs in the energy supply, power generation, and end-use sectors in the two main scenarios". This statement suggests that scenarios with longer FTPs can better inform the scale and urgency of transitioning the energy sector to limit the impact of climate change.

All in all, FTP is an established theory with extensive potential for increasing engagement by helping individuals and societies create an extended and coherent perceived future. However, the impact of FTP in increasing the engagement of the end user in energy transition developments is yet to be studied in detail.

Framing 2: End-of-pipe technologies

As described in section 5.3, this framing states that most inhabitants are not concerned with sustainable energy, in that they have minimal knowledge and interest in the sources of their energy, energy distribution systems, storage, etc. Most people are more interested in end-of-pipe solutions within their homes that lead to energy efficiency, lower energy bills, and a change in consumption behavior.

Extensive literature is yet to be published on the technical boundaries of people's interest in the energy system. However, some literature has been published on the potential of these end-of-pipe technologies. A report from the American Council for an Energy-Efficient Economy suggests that a 'deep energy retrofit' that consists of extensive insulation and renovations on the central heating system can result in an energy consumption reduction of 50% (Cluett & Amann, 2014).

Next to that, some articles and reports have been published on how to increase interest in one's energy system. For example, Klosters et al. (2020) states that it is important to inform homeowners that insulation upgrades are not only necessary evils that decrease the energy bill marginally but also increase the value of the houses. Investing in energy efficiency technologies also leads to more freedom of choice for energy generation, as stated by Koning et al. (2020). For such houses, it then becomes feasible to choose between all-electric, (hybrid) heat pumps, or district heating.

Moreover, it is interesting to note that this framing relates to the Jobs-to-be-done framework proposed by Christensen et al. (2016), as this framing relates to solutions that most resonate with what people want and need, a needs-oriented solution. This is also the case with the framework, which is built upon the idea that customers 'hire' products or services to get a specific job done. Otherwise, products or services that fill a wand or need.

Lastly, framing 2 can be influenced by the concept of future time perspectives. For example, end-of-pipe solutions often fill immediate, short-term needs. If an individual's perceived future time span is longer, their willingness to invest in technologies rather than end-of-pipe solutions might increase. This is a hypothesis. Both framings should be studied more in-depth in order to make definite statements.

All in all, the literature describes the potential in both engagement in the energy transition process and a decrease in energy consumption by engaging with end-of-pipe technologies.

Framing 3: The energy transition is a social transition

As described in section 5.4, this framing states that the energy transition is not technologically driven, but rather a socially driven transition. The barriers and enablers for the progression of energy developments are communicational, informational, and community-oriented. The social enablers of this transition are informational support, financial impulses, communal actions, and tailor-made communications. Barriers are complex social dynamics, ambiguous communication, financial constraints, and mistrust between the residents of Eindhoven and their municipality. These barriers and enablers are also connected with one another, as is the case with financial constraints/impulses and trust. The level of trust will influence the residents' attitude towards the type of cost. For example, with higher levels of trust in government bodies, residents are more willing to invest in renewable energy, trusting that policies and subsidies will provide a sufficient payback time. It also works the other way around. The costs will determine the level of trust. For example, as stated by the energy coaches (participants #5, #6, and #6), the increase in energy consumption costs led to dissatisfaction and mistrust towards the government.

First, the barriers mistrust, financial constraints, and ambiguous communication are described in the framing above and are also mentioned in the research conducted by Klosters et al. (2020) and Koning et al. (2020). These researches have been conducted in urban and semi-urban 'proeftuin' neighbor-

hoods of Assen, Noordoostpolder, Purmerend, Wageningen, Utrecht, Groningen, and Sliedrecht. It is interesting to note that these barriers are present in all areas, and with these barriers present in Eindhoven, they are increasingly more generalizable for the urban areas of the Netherlands. Koning et al. (2020) also emphasize that the barrier of mistrust can be overcome and generate better engagement of the residents by applying a personalized approach. This is something that is mentioned on multiple occasions during the interviews. Moreover, Kooger et al. (2023) describes that early and personalized resident engagement stimulates the trust between (local) government and the residents.

Second, the literature also highlights various drivers for resident participation, similar to the results of this study. Kooger and Langefeld (2024) and Koning et al. (2020) describe enablers to be personal communication and clear information about the costs and benefits of engagement with energy transition projects. Kort et al. (2020) also articulate the importance of financial incentives for residents to invest in energy transition developments, either as a threshold to take action (as was also shown in the interviews), or to bridge the gap between costs and benefits. The literature does not describe the importance of communal action between the residents, as discussed in the results of this thesis. Whether it be collective action, communal events, or communal pressure; the participants feel moved by the actions and attitudes of their neighbors.

Lastly, framing 1 influences this framing and vice versa. For example, this framing identifies barriers such as financial constraints, mistrust, and lack of information. These barriers may influence the future perceived time span of residents. The social enablers may increase the future perceived time span of individuals. On the other hand, the residents' perceived future time span might also influence the level of trust and financial constraints/capabilities. These are hypotheses, both framings should be studied in depth in order to make definite statements about their connections.

All in all, the literature discusses mainly financial, informational, and communicational enablers and barriers. Further research must be conducted on the enablers and barriers arising from communal action.

Energy Transition Persona Framework

The Energy Transition Persona Framework proposed in chapter 7 is conceptualized based on the framings that emerged from the data collection and analysis and the framework provided by Fergnani (2019). For energy transition personas, characters are divided into five categories. The first category is 'Human characterization', consisting of the persona's demographic data, living conditions, and personal background. Second, the 'Needs', described what the personas require for their new energy system on a technical, financial, and social level. Third, the 'mindsets', represent how the participants see the bigger picture of the energy transition, as well as their role within it. The fourth category is the 'Behaviors', which represent the persona's energy consumption habits, communication with other stakeholders, and emotional behavior. The last category is called 'Resources', which describes the persona's internal and external resources and their accessibility.

The Fergnani (2019) framework is comparable in that it uses similar categorizations, but on a broader level, which is shown in Figure 6.3. Nevertheless, there are important differences to be distinguished. For one, the framework in this thesis includes financial and informational resources. This is an important factor, as presented by the amount of financial and informational needs presented by the personas described in chapter 7 and framing 3 in chapter 5. Financial and informational capabilities play a significant role in the decision-making of the personas, and should therefore be included in the framework. Second, the proposed framework describes 'needs' instead of 'values' (as is the case in the Fergnani framework). The reason for this is that needs are more solution-oriented, and more tangible to use to implement in technical designs, financial business cases, and participation strategies. Lastly, the Energy Transition Persona Framework articulates specific behaviors of the personas, which are more actionable. The Fergnani (2019) framework does go more in-depth about the personal background of the persona, including lifestyle routines, hobbies, and such. For this thesis, this is an underexposed part of the persona. The reason for this is that the goal of the proposed framework is to include mainly energy-related insights.

During the final stages of this research, a new article was published by Torma and AschemannWitzel (2024), concerning the development of energy technology adoption personas for agrivoltaics. The personas in this article consist of 'motivations', 'goals', 'needs', and 'frustrations'. The main difference between the structure of these energy adoption personas and this thesis' energy transition personas is the use of both 'needs' and 'frustrations'. 'Frustrations' would be an interesting trait to consider in the future development of energy transition personas. As explained before, the personas are developed to be solution-oriented, filling the needs with the right resources. However, this considers that the end users define how frustration can be solved by the need they require. By including both, the policymakers can evaluate whether there is a more feasible approach to take away the frustration. This could be considered a limitation. On the other hand, 'frustration' has a negative connotation. Enough negativity has surrounded the energy transition. By enveloping the frustrations within the needs, a more positive attitude might be spread.

Application of the Energy Transition Persona Framework

As a result of this research, six energy transition personas have been developed. These personas represent a group of participants of both young adults and elderly people, either homeowners or renters, with varying attitudes towards the energy transition. These six personas represent fifteen participants who are inhabitants of Eindhoven.

As demonstrated in Figure 6.2, the personas vary in their representativeness of the participants. For example, Energy Persona F represents six participants, whereas Energy Persona C only one participant represents. This affects the generalizability of the personas. The more participants are used for the development of a persona, the greater the level of detail of the traits is. Next to that, it is easier to bridge gaps in the data collection. This is shown in the data. Energy Persona F, represented by six participants, has an increased number of needs that are more detailed than the needs of Energy Persona E, which represents one participant. The variety of levels of detail based on the representativeness of the personas is perceived as a limitation of the study.

Next to that, it is important to emphasize that these six personas are not representative of all inhabitants of urban Eindhoven for two reasons. One, due to the difficulties of gathering end user participants, the researcher had to make use of mainly his own network and the efforts at the library in Eindhoven. This led to mainly Dutch young adults and elderly people making up the participant pool, excluding certain social demographic groups from the research, such as varying nationalities and people below the age of 18 and between 30 and 65. Next to that, this group of personas represents a group of people who are willing to talk about energy and sustainability in general. These personas do not represent data collected from inhabitants of Eindhoven who are reluctant to converse about these topics. These two limitations of data representation are tackled somewhat by the more informal data points in Situations A to D (see Table 4.1 for more information) during the fieldwork and the information interviews during the housing inspection. However, as it is expected that these data collection formats would not have given the same depth of insights as with formal interviews, this is not a full mitigation of the limitations in data representation. On the other hand, by focusing on two age groups, young adults and elderly people, the personas provide a more focused result. The better the community of Eindhoven is represented in the same amount of personas, the more personas will lose quality and level of detail. Therefore, leaving out certain demographics and focusing on specific ones results in a more grounded persona.

Third, the desk research conducted before starting the data collection showed the necessity of enveloping the needs, values, and aspirations of end users via energy transition personas in the context of Eindhoven. This was also strengthened by the conversations with stakeholders within the context of Eindhoven during the proposal phase of the research. This choice of area brought unique challenges, specifically due to the positionality of the researcher. The researcher was not an inhabitant of Eindhoven, but lived in Rotterdam, which increased the threshold of executing meaningful fieldwork in the city. This made it more difficult to find inhabitant participants outside his network, resulting in a decreased representation of the whole of urban Eindhoven. As discussed within framing 3 in section 5.4, section 8.1, mistrust is an important barrier to overcome. Trust also has an impact on this research, as it is impacted by the positionality of the researcher. The level of interaction with residents will depend highly on the type of stakeholder that would carry out similar research. For example, the mistrust was

the highest towards the municipality, as described in section 5.4. On the other hand, there was a positive attitude towards Klusbus, a collaborative of organizations for energy advice in Eindhoven. The municipality is still connected, but not on the forefront of this initiative. If this research is replicated in similar or other contexts, it is recommended to think about who the face of the research will be. Due to the lack of participants for formal interviews with social housing residents, the researcher had the opportunity to conduct a housing inspection at the social housing residential complex in Rotterdam. During this inspection, the researcher was not able to conduct a formal and full interview and therefore relied on participation observation in combination with asking small parts of the questionnaire. These data points do not fit within the case study area of Eindhoven. However, as explained in section 1.4, the conceptual frameworks consider urban areas in the Netherlands to fall under one umbrella. For this reason, the participants are included in the research. For them to be applicable in the context of Eindhoven, there must be considerable overlap between the insights gathered during the fieldwork in Eindhoven and the housing inspection in Rotterdam. Similar themes arose, such as mistrust between the social housing organizations, financial constraints, and the communal attitudes of the residents. By only including context-independent, social housing-related insights, the participants of the housing inspection in Rotterdam are also applicable to the context of Eindhoven. This is however based on the assumption that these context-independent traits are interchangeable between Rotterdam en Eindhoven, and therefore a limitation to the value of the empirical findings for Eindhoven specifically. This limitation is set straight somewhat by data triangulation; the comparison of the traits between Eindhoven and Rotterdam. When compared to the other renters and elderly participants in this study, similar needs, behaviors, and mindsets are stated. Including the data collected during the housing inspection adds value to the research, as it gives insights into people's opinions when articulated in a safe space; their homes. More interestingly, when the safety of their home gets interrupted by a visitation of unknown people.

ENCLUDE EU: conceptual framework

In section 1.4, Yusuf Dirie's conceptual framework was introduced. In this framework, archetypal personas are defined, representing virtual end users within a potential future energy system, mirroring real-world contexts. The goal is that for each persona their unique energy aspirations, challenges, and routines are highlighted. These insights will then be connected with current or developing energy solutions that would and could be applied by the personas. The framework is set up so that it can represent a worldwide span of geographical and socio-technical communities. These archetypal personas were divided into the following categories:

- Geographical division, based on population density. These are either urban, suburban, or peri-urban/rural communities.
- Socioeconomic sub-division, the amount of investment potential. This consists of varying levels of internal and external investments.
- Renewable energy landscape. This consists of varying levels of regional potential and adoption rates of energy technologies.

Based on the results of this thesis, the following annotations can be made to this conceptual framework. First, the second category "Socioeconomic sub-division", is an important category. The accessibility and employability of both internal and external resources are vital for the decision-making of the inhabitants. However, it is proposed that this category does not only envelop financial resources, but also informational and communicative resources. The participants have shown the vital impact of the ability and willingness to communicate and collaborate within their communities and their appreciation of personal communication and active information channels from external organizations. Second, it might be interesting to include homeownership as either an extra category or include it within the internal resources. The housing status has a significant impact on the type of persona, as shown in chapter 6. Next to that, the end users' perceived role by policymakers differs based on the housing status. As discussed in chapter 7, the municipality of Eindhoven will mainly focus its efforts on home ownership. This means that the housing status affects the availability of external resources. Moreover, initially, it is assumed that if one looks across the energy system, one would be able to distill people's preferences, needs, and values considering energy generation, distribution, and consumption. As shown section 5.4, this was not the case. People are more concerned with the social aspects of the energy system. Also, this framework considers an energy supply chain (generation, transmission, distribution, consumption,

and storage). With the increasing complexity of new energy systems, this supply is not chronological anymore, and end user might even fulfill multiple roles in this chain. For example, end users increasingly generate their own power using solar panels. Next to that, the results show an interest in energy communities, which also could lead to end users distributing their excess energy locally.

Existing versus redeveloped areas

The participants that are represented by the personas are residents of urban neighborhoods in Eindhoven. These insights correspond to their current homes, experiences, and frustrations. By increasing the number of participants and choosing their demographics in a way that the participant pool is representative of a certain area, one can create an overview of the residents of this area. This set of personas can then be used to develop and reflect on customer journeys concerning a transition away from natural gas, such as the one described in section 1.1. But what if there is a newly developed or redeveloped area, such as is the case with Fellenoord (as discussed in section 1.3)? In this case, the new residents of this area are not known yet, so how does one go about creating personas for an unknown resident group? Based on the results of this thesis, the following approach could be used to create a representative set of personas for a new or redeveloped area.

It is all about making the current set of personas representative for the whole of Eindhoven, and connecting this to the urban migration and housing data.

1. Demographic and market research: To find out what demographic data and housing trends are relevant for the developed area. This includes defining the types of individuals and families that move into this area, such as young professionals, families, retirees, international migrants, etc. Useful sources are local government housing research reports, real estate market analyses, and area development plans.
2. Stakeholders interviews: Next to the market research, qualitative interviews must be held to understand the vision of this area according to urban planners, government officials, area developers, and social housing organizations.
3. Develop the current set of personas: Broaden the current set of personas to be representative of the whole of Eindhoven (quantitatively). Pick out the expected relevant personas based on the market research.
4. Scenario mapping: Develop scenarios that describe how these personas might interact with the new area. These scenarios include reasons for moving, expectations of the new area, level of community engagement, and area features based on the needs of the personas, such as public spaces and transportation. Framings 2 and 3 are useful knowledge to base the scenarios on. For example, for energy companies and housing developers, framing 2 is insightful. This framing states that residents are more concerned with comfort (insulation) and how to use the energy system. These stakeholders can focus more on the systems in the dwellings, and have more design freedom in other parts of the energy system, such as generation and distribution. Framing 3 is useful for the developers as well, as trust will impact the willingness to move to the new area. The more trust residents have in the developers, the more willing they are to invest and move there.
5. Create a new set of personas (draft): Based on the market research, the current set of personas, and the scenarios, create a new set of personas fit for the new residential neighborhood. These personas represent a range of potential residents and how they correspond to living in this area.
6. Community feedback: Reflect on these personas with potential future residents. The focus here should be on being able to identify with one or more personas. If not, the personas are less inclusive, and as a result, are less trustworthy.
7. Finalize the personas: After the feedback rounds, finalize the set of personas.
8. Integrate into the development process: Use the new set of personas in various processes of the area development, such as urban planning. The set of personas should inform developers on the types of housing, facilities, and services, (environmental) policies, and marketing and information campaigns.

The information this new set of personas provides can help stakeholders such as developers, engineering consultancies (such as Sweco), and real estate companies to be more efficient and profitable

in various ways. First, targeted development and marketing; by better understanding the preferences and needs of future expected residents, the stakeholders can better link their products and services to their users. This leads to an increase in customer satisfaction. Second, efficient resource allocation; by gaining insights into the future residents and how to are expected to behave in the new area, developers can more efficiently allocate their resources to provide more impactful products and services in the area. Third, strategic pricing; with an extensive understanding of the financial positions of the future residents, the developers can create more fitting pricing strategies for their products and services. Fourth, is risk mitigation; by creating more security in the early phases of the development with extensive research on future residents, developers can tackle potential challenges (such as low uptake) and resistance early on. Lastly, the set of personas can help to create long-term value and a strong sense of community, by guiding the development of public and communal spaces that foster this sense of community.

Lastly, it should be noted that these personas are based on what potential future residents think and are before moving into this area. Once landed in their new homes, the residents themselves adapt to their new living environment. Therefore, the area should not only adapt to the set of personas during the development process, but the personas will also adapt to their new living environment.
All in all, even though the thesis research project has a limited number of participants (*n*), a broad range of insights have been gathered due to extensive qualitative data analysis. The framings point towards new views on participation approaches, and give insights into the psyche of residents of Eindhoven in the context of Energy. The energy transition persona framework provides an insightful overview of how residents of Eindhoven think, and what they need. Due to the point-by-point design of the personas, they are useful to do cross-analyses on, which yielded a deeper layer of analysis on the data collected via the interviews. All in all, it is important to be aware of the limited empirical base of the thesis, but it still provides a new direction forward to research. This thesis is not the full picture, but rather a framework and recommendation for new lines of investigation and new ways of looking at the contexts discussed in this thesis.

8.2. Reflection on the case study

Layered structure of the case study

The social dynamics of the energy transition in Eindhoven are being studied. These dynamics consist of various layers, namely on a national level, municipal level, neighborhood level, and individual level. On a national level, the findings relate to the energy transition framework developed in chapter 6 and the conceptual framework designed by Yusuf Dirie in chapter 1. On a municipal level, the framings described in chapter 5 help to build the context of the barriers and enablers that drive or hinder the energy transition developments in the Netherlands. On a neighborhood and individual level, the six evidence-based personas provide a tool that describes the needs that must be fulfilled, as well as the mindsets and behaviors that determine action, and the resources that people possess to take this action and fill their needs. These insights help expert stakeholders in energy transition developments to apply the right resources to the right people to motivate, engage, and inform the residents of Eindhoven.

Generalizability

These layers and their contributions provide the level of generalizability of the results, shown in Table 8.1. The Energy Transition Persona framework relates to urban areas in the Netherlands, on a national spatial scale. The framings of the timescales, end-of-pipe technologies, and the social barriers and enablers of energy transitions relate to the spatial scale of the municipality of Eindhoven, at the municipal level. The application of the framework and its outcome; persona traits about the energy developments and dwelling-specific issues in Eindhoven relate to a neighborhood project or dwelling scale.

Case study layer	Contribution	level of generalizability
National level	*Energy Transition Persona Framework*	*Urban areas in the Netherlands*
Municipal level	Framings emerged from grounded theory	The Municipality of Eindhoven
Neighborhood level	Evidence-based personas containing energy transition project-oriented traits	Neighborhoods-scale energy transition projects
Individual level	Evidence-based personas containing dwelling-specific traits	Individual sustainability upgrades within the dwellings

Table 8.1: Levels of generalizability per contribution

Interestingly, one must ask themselves what the best level of generalizability is for the personas. Policymakers can choose to create a set of participation strategies applicable to the whole of Eindhoven. This set consists of various strategies tailor-made for the set personas representing Eindhoven. It is also possible to create a (smaller) set of personas per neighborhood, or even apartment complex or street. In this case, the set of strategies is smaller, and area-specific. This is a matter of the level of data aggregation according to the chosen participation strategy.

Triangulation of the research

Triangulation has been embedded in these resources with the application of varying types of interviews (data collection methods), varying types of stakeholders (varying units of measurement), using multiple academic and grey literature sources to create the theoretical foundation and validation of the findings with previously used and new sources as a feedback loop of grounded theory.

The data collection methods used as described in Table 4.1 are formal, informal interviews during the housing inspection, and informal interviews during the fieldwork. The formal interviews are recorded, transcribed, and summarized. The data points are mainly what the participant has articulated verbally. For the informal interviews during the housing inspection, it was not possible to conduct full, formal interviews. Therefore, the researcher relied on asking a few questions combined with participation observation during the inspection itself. How these participants reacted to the visit of the social housing employee and engineers of Sweco were data points during this data collection as well. Lastly, the fieldwork yielded data points without yielding formal interview participants. Namely, the unwillingness to participate during the Situations A to D is data as well. This data made it possible to include the housing inspection conducted in Rotterdam in this case study, as explained in section 8.2. By collecting data from both residents of Eindhoven and the expert stakeholders of Eindhoven, both sides of the story are documented. As stated by Rodhouse et al. (2021), stereotyping concerning the residents is present in organizations such as housing corporations and municipalities. Therefore, the data is validated by interviewing both stakeholder groups.

Multiple academic and grey literature sources are used for creating the starting point of the grounded theory methodology. For empirical insights into persona development, a broad range of reports were reviewed and published by established organizations such as TNO, WarmingUp, Enpuls, etc. Even though conducted in varying areas, these reports provide comparable insights to one another and are therefore interesting to apply in this specific context. For the design of the energy transition personas, both the Fergnani (2019) and Torma and AschemannWitzel (2024) frameworks are used as a foundation to base the personas on.

8.3. Reflection on the methodology

This research has been divided into four phases. The first phase consists of desk research, intending to create a starting point for the data collection executed in phase 2. Phase 2 consists of the execution of grounded theory combined with interviews. From the starting point defined in the first phase, a questionnaire, and certain hypotheses were used to start participation selection and data collection. Resulting of the emerging themes during the data collection, energy transition personas were designed in phase 3. This phase included building a generalizable framework to construct personas with, as well as analyzing the empirical data to create personas that represent the participants' energy characteristics. The last phase consists of an evaluation of the energy transition personas with policymakers, to evaluate the contents of the personas, and their implications, and determine future research recommendations.

Desk research

Extensive research is conducted about the role of the end user in the Dutch context, this is however mostly published in grey literature including policy theory articles and reports written by independent research institutes. This literature underlines the complexities of resident participation in the transition away from natural gas consumption in the Netherlands. This study highlights the need for further research that delves deeper into the specific needs of end users and the socio-political dynamics at play in the energy transition, considering not only homeowners but also renters and homeowner associations. Lastly, relevant research on the topics above has not been published specifically considering Eindhoven as a use case.

Participant selection

Due to the nature of grounded theory, the sampling strategy followed a somewhat loose structure. For the inhabitants of Eindhoven, the researcher first connects with people within his network. The researcher found that not all social demographics could be reached via his network, and therefore the researcher tried to reach outside this network. The researcher tried to expand the social demographic reach of the participant pool by doing fieldwork. The following approaches were taken to achieve these connections:

- **Door-to-door**: Two locations were selected based on the type of dwelling; social housings dwellings with either families/individuals. This method yielded zero responses from participants. In general, people were not keen on talking to the researcher. If the words ”municipality” or ”energy” were used, people often got suspicious and the researcher got cut off. People indicated a few times that they thought that the researcher was selling them a new energy contract, which raised the suspicion.
- **Approach people on the streets in the city center**: The researcher tried to connect with people within the city center. This yielded initial responses, however, no actual participants were gathered. The researcher was able to ask a few simple questions, but as the conversation got more in-depth, people indicated that they did not have that much time to do an in-depth interview, and were not keen on planning another moment with me in the future.
- **Approach people in shopping centers**: The researcher noticed larger groups of people hanging around shopping centers in Eindhoven, and tried to connect with those groups. Initially, the people were quite talkative, but not keen on being recorded and diving deeper into the conversation. This method yielded some initial insights, but the short conversations were insufficient to be used as full interviews.
- **Approach people in the library**: The library is a place in which people from varying socio-demographic backgrounds come together, often with time to spare to have a conversation. This method yielded two participants useful as inhabitants of Eindhoven. It is important to note that the library did not approve the researcher to conduct research within the library, stating that the library is a commonly used place to find units of measurement. The library found the number of research conducted on the library grounds to be too abundant. This can be considered as a reason for the library being a useful place to conduct qualitative research with human interaction.
- **Facebook groups**: The researcher tried to find participants via various Facebook groups in and around Eindhoven. This approach did not yield any responses.

From conducting the approaches stated above, it can be concluded that it can be a time-consuming process to connect with people from certain social demographics. Even though the number of connections made was not as hoped for, this process gave the researcher insight into the difficulties organizations face in connecting with certain groups of people. This helped the researcher to further develop the questionnaire towards themes such as participation and communication for the interviews with experts within the municipality of Eindhoven, the energy coaches, and the project leader from the social housing organization. It also emphasizes the theme of mistrust between the people of Eindhoven and the municipality. It is believed that the methods stated above are more useful with a shorter, more structured questionnaire when the research becomes more explanatory.

Grounded theory

The preparation of the starting point consisted mainly of conducting desk research to create the initial questionnaire. After the first two interviews with residential participants, it became abundantly clear that

the participants could not provide insightful answers to almost half of the initial questionnaire. Other themes emerged often from either answers to the participant's interpretation of technology-oriented questions or follow-up questions based on these answers, diverging from the questionnaire. The approach of semi-structured interviews was vital for including these emerging themes. After conducting more interviews with the project leads at the municipality of Eindhoven and 'Thuis, the questionnaire and therefore the direction of the research was evaluated. The pivots executed to define the framings found in this case study are explained in Figure 5.1. The application of the grounded theory benefited the research in that it provides the flexibility to steer the direction of the research. As discussed in chapter 2, literature discusses the timing of the literature study when grounded theory, either before data collection, or once data analysis has been completed and framings are formed. This thesis concluded that a combination of both is crucial. Initial desk research is necessary to create context and define a starting point, sometimes including hypotheses. However, it is important to ground the emerging framings with the existing literature, to put these framings in a broader context. The contents of this convergence and divergence of the research are elaborated upon in section 8.1. Next to that, whilst executing the desk research, it was not clear what the exact contents of the energy transition personas would be. Literature proposed frameworks, such as Fergnani (2019) and Torma and AschemannWitzel (2024). However, those personas were developed in different contexts, and therefore, the content might differ. That appeared to be the case, as was discussed in section 8.1. Grounded theory provided flexibility for changing the context of the energy transition personas in this context. If not, this research would have been impacted by confirmation bias, as the researcher would have been trying to apply a framework in a context for which it is not fully fit. All in all, when executing exploratory research in a context without an extensive research landscape, grounded theory functions as a distinguished methodology for developing initial framings.

8.4. Limitations of the research

This section summarizes the limitations stated in the sections earlier in this chapter.

First, the Energy Transition Persona Framework takes a solution-oriented approach, in that it does not state the personas' frustration, but articulates the needs based on these frustrations. By including both, the policymakers can evaluate whether there is a more feasible approach to take away the frustration. On the other hand, 'frustration' has a negative connotation. Enough negativity has surrounded the energy transition. By enveloping the frustrations within the needs, a more positive attitude might be spread.

The second limitation concerns the representativeness of the personas. Not all six personas represent an equal amount of participants. Energy Persona F represents six participants, whereas Energy Personas C, D, and E only represent one participant. The more participants are used for the development of a persona, the greater the level of detail of the traits is. Next to that, it is easier to bridge gaps in the data collection. This is shown in the data. For example, Energy Persona F has an increased number of needs that are more detailed than the needs of Energy Persona E.

Next to that, this group of personas represents a group of people who are willing to talk about energy and sustainability in general. These personas do not represent data collected from inhabitants of Eindhoven reluctant to converse about these topics. These two limitations of representativeness are tackled somewhat by the more informal data collection methods in Situations A to D (see Table 4.1 for more information) during the fieldwork and the information interviews during the housing inspection.

Lastly, the researcher was not an inhabitant of Eindhoven but lived in Rotterdam, which increased the threshold of executing meaningful fieldwork in the city. This made it more difficult to find inhabitant participants outside his imminent network, resulting in a decreased representation of the whole of urban Eindhoven. Due to the lack of participants for formal interviews with social housing residents, the researcher had the opportunity to conduct a housing inspection at the social housing residential complex in Rotterdam. During this inspection, the researcher was not able to conduct a formal and full interview and therefore relied on participation observation in combination with asking small parts of the questionnaire. This is therefore a limitation to the value of the empirical findings for Eindhoven specifically.

9 Conclusion

In this chapter, an answer is given to the research questions stated in section 3.3. Furthermore, the contributions of this thesis are explained in detail, followed by future research recommendations.

9.1. Answers to the research questions

Sub question 1: What are the values, behaviors, and needs concerning energy of residents of Eindhoven, the Netherlands?
Based on the participants used in this research, the inhabitants of Eindhoven prioritize cost considerations, adaptive temperature control in their homes, and living comfort when engaged in energy-efficient practices. Most participants express a desire for sustainable energy systems, but all participants desire energy efficiency, whether it be motivated by sustainability or financials. The challenges in the 'proeftuinen' developments, such as the Generalenbuurt, highlight concerns over participation and the financial impact of transitioning to new energy systems. Such challenges are articulated in needs such as clear communication with a personal approach, financial support, and trust-building between residents and the municipality.

Sub question 2: "How can these values, behaviors, and needs be represented by an energy transition persona?"
The values, aspirations, and preferences of the inhabitants of Eindhoven are represented within the Energy Transition Persona framework. This framework proposes to divide the contents of the personas into human characterization, needs, mindsets, behaviors, and resources. The human characterization describes the demographics, living conditions, and personal background that the personas represent. The needs represent the participants' requirements of the energy system and its stakeholders on a technical, financial, social, and informational level. The mindsets represent how they perceive the bigger picture of the energy transition including their role within it. The behavioral traits represent the personas' energy consumption habits, communication with others, and emotional behavior towards energy themes. The resources represent the financial and informational assets of the personas (internal resources), the resources provided by external organizations (external resources), and their ease of access to these assets.

Sub question 3: "What are the implications of the evidence-based personas on the policy-makers and realization stakeholders of energy transition developments in Eindhoven?"
The evidence-based energy transition personas can be used to significantly inform policy-makers and stakeholders by providing a user-oriented perspective in the development of energy transition projects in Eindhoven. The personas exemplify the importance of involving end users actively in the development process and ensuring that energy systems align with their needs and expectations. They also emphasize the need for tailored communication strategies and community engagement to overcome barriers in energy transition developments related to mistrust and participation.

Main question: "How can the creation of evidence-based energy personas inform and enhance the development of energy transition projects in Eindhoven, the Netherlands?"
The creation of the evidence-based energy transition persona framework and its empirical application offer a detailed understanding of the diverse range of needs, mindsets, and behaviors concerning energy in the area of Eindhoven, facilitating a more targeted and effective approach to energy transition projects. This framework can benefit the creation of communication strategies, financial incentives, technical designs, and information campaigns. For Eindhoven specifically, a concrete example of where these personas can offer insights is the three types of energy advice that are available to the inhabitants

of Eindhoven. By providing detailed insights into what information is required by the residents, a more engaged and tailored energy incentive and information program can be established, which potentially yields more engagement. In conclusion, this user-centered tool can lead to increased acceptance, engagement, and satisfaction among the inhabitants, ultimately enhancing the success rate of energy transition initiatives in Eindhoven.

9.2. Theoretical, methodological, and empirical contribution

The newness of the insights gathered in the research is a worthwhile means for future research recommendations. Despite a limited empirical base due to resource and time constraints, this research describes concepts that need further exploring both academically and empirically.

This thesis contributes to building knowledge on various levels. First, this research has a theoretical contribution, which is the energy transition persona framework developed for constructing the personas within the context of Eindhoven. This framework entails a more detailed approach to defining representative character traits in comparison to the Fergnani (2019) framework. This research contributes by further delineating the categorization of persona traits, by creating subcategories in the division proposed by Fergnani. This framework has been made generalizable by categorizing and structuring the persona traits and trait categories. This framework is built upon the framings developed using grounded theory. The framings state that people are mainly concerned with end-of-pipe, dwelling-specific energy solutions, time perspectives impact their ability to perceive energy futures, and the main barriers and enablers of the energy transition are social. These three framings help to understand the energy transition better, in that it points out issues that impact progress in the energy transition. The application of the framework appears to be a useful approach to map out these problems in a given context. This can help policymakers and other stakeholders in the energy transition employ the right resources for the necessary causes.

Next to that, this thesis also provides a methodological contribution. Current academic literature describes in detail how the contents of personas are defined. What is missing, however, is how these personas are made representative; how to divide up the personas, and how to go from the collected data gathered during qualitative data collection to the contents of the personas. Using grounded theory, data collection yielded the necessity for the personas to be divided up into age categories and housing status, two factors that determine the time span of the residents' perceived futures. Due to the varying attitudes among the participants with similar demographics, the personas were also divided based on the attitudes of the represented participants. This thesis provides a structured methodology containing the following steps:

1. Transcribe the interviews and divide the participants between the range of personas.
2. Data analysis: identify recurring themes using grounded theory
3. Index needs, preferences, behaviors, mindsets, and resources per theme.
4. Aggregate these data points to identify commonalities and divergences among the participants.
5. Form character traits based on the shared needs, mindsets, behaviors, and ranges of attitudes and resources available to the participants.

Lastly, this thesis provides empirical contribution. First, even though extensive research has been carried out in the Netherlands about the importance of the inhabitants' role in the energy transition, and the vital implications of their needs, values, and aspirations, in-depth analysis of these personal traits of end users of energy systems is limited. Next to that, current published academic and grey literature lacks specific research in the context of (urban) Eindhoven, this research contributes insights similar to the grey literature discussed in section 2.4, now applied in the context of metropolitan Eindhoven. Third, this research also contributes to identifying barriers and enablers not only for existing neighborhoods but also for redeveloping neighborhoods. By quantifying and extrapolating the energy transition persona framework so that the personas are representative of future residents, barriers and enablers for area development can be identified. This research also proposes an approach to further develop the personas to be used in the development of both existing and new or redeveloped neighborhoods. These representative sets of personas give policymakers, developers, and companies such as Sweco the insights to align future energy systems and newly developed areas to expected future residents.

This will lead to more tailored products and services by alignment of end user needs with future systems, more effective resource allocation, pricing strategies, better risk mitigation, and the creation of long-term value, all leading to more profitability.

9.3. Future research recommendations

The three framings emerged from grounded theory

For Framing 1: Perceived future timelines, it would be interesting to further research the potential of Future Time Perspectives theory in energy transition developments. As discussed in section 8.1, this is a theory that is extensively researched in areas outside of the energy transition. Literature does however state its potential in climate mitigation issues. It would be interesting to research in the context of energy transitions what the best approach to developing the FTP, whether it be extending the time span, increasing the coherence of the perceived future, or its density (as discussed in section 8.1. As it has not been researched in depth earlier on, it would be novel to research in both urban or rural locations, either in the Dutch or international context.

The literature describes the contents of Framing 3: Energy transition is a social transition to is applicable in other areas in the Netherlands. As this is a preliminary theory, it should be further developed in the area of Eindhoven to establish the social barriers and enablers that impact the energy transition. The same goes for Framing 2: End-of-pipe technology solutions. Its potential impact is discussed in section 8.1, and should therefore be further developed to ground this framing within Eindhoven. For all three framings, pattern modeling provides a useful framework to study the emerging themes on a more significant level.

Energy Transition Persona Framework

The framework is developed based on the context of the Eindhoven area. It would be interesting to test the framework in a different context and see if the same trait categories hold up. For example, in a different area, the level of frustration is much higher, in that people are mainly outing frustrations rather than solutions-oriented needs or goals. Then, it might be better suited to apply 'frustrations' as a trait category as well. This could be combined with the ENCLUDE EU research project; do the trait categories in this framework still make sense in a country outside of the Netherlands or Europe?

Second, it would be interesting to further develop the framework and design a methodology to rank or order the traits. By valuing what traits have higher priorities, policymakers can devise a potentially more coherent participation strategy. If applied in various contexts, it would be interesting to see how the order of the traits differs, and why.

Third, as discussed in section 8.1, it would be interesting to more research how people adapt to new living environments. The ETP framework uses the data of participants before their new situation. However, a transition is an interplay between the individual and its environment. In the development, the environment should adapt to its future residents. However, once landed in their new environment, residents also adapt to their new situation. It would be interesting to research what the experiences are of people moving into newly developed areas, and see how they would retrofit into the Energy Transition Framework.

Application of the framework in Eindhoven

For the application of the framework in Eindhoven, policymakers must first consider what the level of data aggregation is for the personas, as discussed in section 8.2. A decision must be made whether it is more beneficial to create a set of personas for the whole of Eindhoven, per neighborhood, or even per street or apartment complex.

Dependent on the recommendation described above, the next step for persona development in Eindhoven would be to expand the research to make the personas representative for the whole area. This means executing more data collection. The missing age demographics must be filled in, and it would also be interesting to include other demographics, such as nationality or a more extensive view of financial capabilities. Finally, a quantitative study could be carried out to determine what percentage of the population is represented by each persona.

Next to that, dependent on what stakeholder the personas are being developed, the contents of the personas may differ. For example, energy companies are more interested in the technological contents of the personas, whereas (local) government bodies may be more interested in the financial contents to create financial systems that facilitate subsidies. Therefore, it would be interesting to dive deeper into how the contents of the personas change based on the type of stakeholder that carries out the research.

A third recommendation is for policymakers to use the personas for the development of communication strategies, financial incentives, and targeted energy consults. In short, use the personas to efficiently employ the municipality's resources.

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A
Appendix A - Interview protocol

This appendix describes the interview protocol, consisting of the interview technique guidelines, consent form and the questionnaires used during the interviews. The same interview protocol will be followed for both the interviews with inhabitants of Eindhoven and expert stakeholders in the energy industry of Eindhoven.

A.1. Interview protocol

The steps of the interview protocol are as follows:

1. prior to the interview, the researcher sends over the participant the consent form. If this is not possible, the contents of the consent form will be discussed before starting the interview.
2. At the start of the meeting, the researcher explains the motivation and goals of the research.
3. If there are no questions about the consent form and research objectives, the researcher will start the interview and inform the participant that the recording has begun.
4. Interview starts of with the participant giving an extensive description of their role, organisation and experiences.
5. The researcher has prepared a set of questions divided into topics.
6. The interview will last anywhere between 30 to 60 minutes, depending on the participant.
7. After the interview, the researcher will write down his first impressions of the conversation.
8. To avoid information loss, the recording is transcribed within three days after the interview has taken place.
9. After the transcription is completed, the recording will be deleted immediately.

A.2. Consent form

Beste deelnemer,

U bent uitgenodigd om deel te nemen aan een masterthesis-onderzoek met de titel “User-centered design for energy scenario planning: A case study in the Netherlands” Het onderzoek wordt uitgevoerd door mij, Bart Hoefnagels, als onderdeel van mijn masterthesis aan de opleiding Management of Technology aan de Technische Universiteit Delft, faculteit Techniek, Bestuur en Management (TPM). Dit onderzoek voer ik uit in samenwerking met de TU Delft en ingenieursbureau Sweco Nederland B.V. Dit onderzoek wordt uitgevoerd voor het afstuderen van de masterstudent.

Het doel van dit onderzoek is het energiesysteem van de toekomst beter te laten aansluiten op de wensen en toekomstplannen van de eindgebruiker. Dit doen we door met eindgebruikers van Eindhoven en stakeholders van energietransitieprojecten in gesprek te gaan. Deze input wordt gebruikt voor het opstellen van representatieve energiepersona’s. Dit zijn virtuele eindgebruikers gebaseerd op de gewoontes en aspiraties van inwoners in stedelijke gebieden. Met deze energiepersona’s in ogenschouw gaan de engineers van het team *Energie-opwek & warmtenetten* binnen Sweco een nieuw energiesysteem ontwikkelen dat beter aansluit op de wensen van de eindgebruiker.

Dit interview zal worden opgenomen en worden getranscribeerd. De opname en uw antwoorden zullen strikt vertrouwelijk behandeld worden. De transcriptie zal worden geanonimiseerd, en wordt gebruikt om een anonieme samenvatting van dit interview te produceren. Als de participant geïnterviewd wordt vanuit diens rol als eindgebruiker, zal enkel de wijk en het type woning waarin deze persoon woonachtig is worden meegenomen in het onderzoek. Als de participant geïnterviewd wordt als stakeholder, wordt enkel een algemene functie benaming en type organisatie meegenomen in het onderzoek. Deze samenvatting zal u worden toegestuurd. De uitkomsten zullen in het eindrapport van dit onderzoeksproject gebruikt worden. Naast deze informatie is voor administratieve doeleinden de volgende persoonlijke informatie nodig: contactgegevens en dit getekende formulier. Deze informatie – samen met de opname, het transcript en anonieme samenvatting - wordt opslagen op een beveiligde Webdrive van de TU Delft en alleen de onderzoeker en zijn supervisors vanuit de TU Delft (Dr. Jenny Lieu, Dr. Aad Correljé en Bart Hoefnagels) hebben toegang tot deze informatie. De persoonlijke informatie zal na afloop van het onderzoek in mei 2024 worden vernietigd.

De anonieme samenvatting van dit interview zal u worden toegestuurd en u zult gevraagd worden naar de correctheid van deze informatie, waarna u schriftelijk akkoord geeft om deze informatie te verwerken in het eindrapport van dit thesis onderzoek. De anonieme samenvatting en het thesisrapport waarin de anonieme resultaten zijn verwerkt zullen uiteindelijk gepubliceerd worden op de openbare TU Delft Respository. Ook zullen alle respondenten van dit onderzoek en het bedrijf Sweco Nederland B.V. toegang krijgen tot het thesis rapport.

Uw deelname aan dit onderzoek is volledig vrijwillig en u kunt zich op ieder moment terugtrekken. Binnen dit interview bent u bij iedere vraag vrij deze niet te beantwoorden.

Hartelijk dank voor uw tijd en medewerking. Uw input is van grote waarde voor het uitvoeren van dit onderzoek. Ik waardeer de hulp van uzelf en uw organisatie enorm bij het bevorderen van dit onderzoek.

Met vriendelijke groet,
Bart Hoefnagels

Mocht u vragen hebben over de verzamelde informatie, de verwerking en/of publicatie daarvan, schroom niet om contact op te nemen via:

b.f.a.hoefnagels@student.tudelft.nl en bart.hoefnagels@sweco.nl

Handtekening

Ik heb de bovenstaande informatie gelezen en begrepen, ik ben minimaal 18 jaar oud, ik begrijp de impact van mijn participatie aan dit onderzoek en ik stem in om aan dit onderzoek mee te werken.

Naam deelnemer: Handtekening: Datum:

A.3. Initial end-user questionnaire

Questionnaire: End-users/inhabitants

The questionnaire is divided into five parts:

Part 1: Personal profile

- Who are you? Age, work, hobbies
- With how many people do you live here?
- In general, do you worry about being able to cover your costs?

Part 2: Understanding Present Energy Usage

1. General Energy Usage
   - How long have you been living where you live?
   - Can you describe me you typical day from beginning to end?
2. Generation
   - Do you know where your energy comes from?
   - How familiar are you with the workings of your main energy source (e.g., central heating boiler)?
   - What are your views on the environmental impact of your current energy sources?
3. Transmission and Distribution
   - Have you experienced any issues with the energy infrastructure in your area?
4. Consumption
   - What are peak times you/your household when energy is consumed?
   - What would you say are non-negotiable moments in which you must be able to consume energy?
   - Are there any energy-related tasks or needs in your household that are currently (unsatisfactorily) unmet?
   - How often do you think about your household's energy usage?
   - Could you describe the quality of life / contentment provided by your current heating or cooling systems?
   - Have you developed any workarounds for limitations in your current energy system (e.g., manual control of heating)?
   - Are there aspects of the current energy system that you deliberately avoid engaging with? Why?
   - Have you found any unconventional or innovative uses for your current energy system?
5. Storage
   - Do you currently use any form of energy storage (e.g., battery, buffer tank)?
   - If not, why not?

Part 3: Gathering Future Preferences and Aspirations

1. Future Generation Preferences
   - What factors are most important to you when considering future energy sources (e.g., sustainability, cost, reliability)?
   - What type of energy sources would you prefer in the future (e.g., district heating, solar, heat pumps)?
2. Transmission and Distribution Improvements
   - What improvements would you like to see in the neighborhood's energy infrastructure?
3. Future Consumption Aspirations

- Are there new technologies or energy-saving practices you are looking forward to adopting?
- What changes in energy consumption habits are you aspiring to implement?

4. Future Storage Solutions
   - What type of energy storage solutions are you interested in for the future?
   - How do you see these solutions fitting into your daily energy consumption patterns?
5. Future knowledge gain
   - What aspects of the energy system would you like to be more knowledgeable about in the future?

Part 4: Perspectives on Energy System Organization, Policy, and Innovation

1. Views on Energy System and Policy
   - What are your views on the organization of the energy system, including energy companies and policies?
   - How do you perceive the environmental impact of the current energy system?
   - What are your views on the energy transition in the Netherlands in general?
2. Opinions on Energy Economics
   - What are your views on the economics of the energy system, such as the cost of energy and financial aspects?
3. Perspectives on Innovation and Energy Transition
   - How do you view innovation in the energy sector?
   - In what ways do you feel under-informed or disconnected from your energy system?

Part 5: Open-Ended Feedback

1. Additional Thoughts

- Is there anything else you would like to share about your experiences or expectations regarding the energy system in Fellenoord?
- Are there any other interesting people you know that could would be of interest to interview?

B
Appendix B - Detailed descriptions of the personas

B.1. Energy persona A: Young adult – Renter – Financially limited and eco-friendly

Figure B.1: Energy Persona A: Alex van Hoorn

0. Demographics
Name & age:
Mr. Alex van Hoorn, 24 years

Living conditions:
Alex lives in a rented apartment in an urban setting, characterized by its strategic location that offers indirect heating benefits from neighboring units. He lives with roommates, and due to the higher energy prices, they have rules concerning energy consumption.

Background:
With a keen interest in sustainability, Alex juggles the roles of a student and a part-time engineering at a consultancy firm specializing in green energy solutions.

1. ***Needs:***

    1.1 **Advice on energy-saving practices**: Alex needs clear, actionable advice on energy-saving practices and sustainable living, especially solutions tailored to renters in urban settings.
    1.2 **Rental sustainability measures**: Guidance on implementing energy-efficient measures within the constraints of rental agreements and without extensive modifications.
    1.3 **Communal support**: Access to networks or community initiatives that facilitate collective action on sustainability, offering both support and the opportunity for active participation.
    1.4 **Financial affordability**: As a young professional and student, affordable solutions for sustainable living are crucial, including cost-effective energy-saving appliances and practices.

1.5 **Insulation**: Alex is currently mainly concerned with decreasing the drafts originating from substandard insulation measures. His comfort would greatly increase with simple insulation upgrades.

2. ***Mindset:***

2.1 **Proactive in sustainability practices**: Alex is environmentally conscious, seeking to balance comfort with energy efficiency. There's a strong inclination towards green energy, tempered by the practicalities of rental living and the current financial situation as a student. He would be willing to invest in sustainable energy solutions, but as a renter and student, this is not possible.
2.2 **Taking personal and behavioral action**: As Alex is not able to invest in insulation or sustainable energy upgrades, he makes efforts into changing his consumption practices of energy and other resources such as plastics.
2.3 **Eagerness to learning and adaptation**: Open to learning about and adopting new technologies and practices that promote sustainability, with a particular interest in end-of-pipe solutions that offer direct, tangible benefits without extensive changes in the energy system.
2.4 **Interest in sustainable futures**: Alex is open to and interested in sustainable investments in the future, when he is able to afford his own house.

3. ***Behavior:***

3.1 **Adaptive energy consumption**: Alex employs strategic behaviours to minimize energy consumption, such as optimizing thermostat settings and being mindful of appliance use, demonstrating a willingness to adapt daily routines for greater efficiency.
3.2 **"First, let me put on a sweater"**: Alex will always first put on a sweater before turning up the thermostat. The thermostat will only be turned up is he has visitors.
3.3 **Engagement in green practices**: Shows interest in participating in sustainability projects and is open to investments in renewable energy solutions, depending on future financial stability and technological availability.

4. ***Internal resources:***

4.1 **Limited but manageable budget**: As a part-time professional and student, Alex has a limited but manageable budget, with some capacity for sustainability investments that promise clear returns or benefits. Next to that, he only has influence on his energy bill on the consumption site, as it is not his role to invest in making his home more sustainable/energy efficient.
4.2 **Basic understanding of energy practices**: With a background in sustainable energy projects, Alex has a basic understanding of green energy but seeks more practical, renter-specific knowledge.

5. ***External resources:***

5.1 **Financial incentives**: Potential access to subsidies or programs aimed at encouraging energy-efficient practices among renters, including grants for purchasing energy-efficient appliances or joining green energy collectives.
5.2 **Investment by home owners**: The owner is responsible for making the property comfortable and energy efficient according to the current regulations.
5.3 **Educational and community programs**: Information and support from local sustainability initiatives, energy advisory services, and community groups focused on green living.

6. ***Ease of access to resources:***

6.1 **Internal resources**: Alex effectively leverages existing knowledge and financial resources for personal sustainability efforts but is cautious about overextending financially as a student.
6.2 **External resources**: There's a keen interest in exploring external resources, though actual engagement may vary based on the effort required to access these and their relevance to Alex's specific living situation. Community initiatives and renter-friendly sustainability programs are of particular interest, provided they offer straightforward benefits and easy participation.

B.2. Energy persona B: Young adult – Home owner – Budget-savvy energy conservator

Figure B.2: Energy Persona B: Lucas van Dijk

0. Demographics
Name & age:
Mr. Lucas van Dijk, 27 years

Living conditions:
Lucas owns a multi-story upper house in an urban area, characteristic of early 20th-century architecture, with its inherent challenges and charms. He is an active member of his Homeowners Association (HOA), contributing to communal decisions regarding building maintenance and sustainability initiatives.

Background:
Active in his Homeowners Association, he combines a passion for smart home technologies with a commitment to community-led sustainability efforts.

1. **Needs:**
    - 1.1 **Comprehensive energy management**: Lucas is keen on optimizing energy use within his home, particularly in reducing gas consumption and adopting induction cooking. He values smart technology for monitoring and controlling energy use, emphasizing the need for room-specific heating controls, underfloor heating and possibly integrating renewable energy solutions.
    - 1.2 **Profitable renewable energy integration**: He seeks feasible options for integrating renewable energy sources, such as community solar projects or individual solar installations, into his and the HOA's energy portfolio, balancing his financial motives with sustainability. His willingness to invest is contingent on financial feasibility.
    - 1.3 **Effective insulation solutions**: Given the challenges of heating and cooling in a communal living environment, Lucas is in need of innovative insulation solutions that can be applied within the constraints of an HOA, enhancing comfort while minimizing energy loss.
    - 1.4 **Information and guidance on HOAs**: Lucas seeks tailored advice on energy-saving measures suitable for his home's unique structure, considering both the architectural limitations and HOA regulations. He desires clear cost-benefit analyses for sustainability investments like insulation, heat pumps, and solar panels.
    - 1.5 **Information on financial support**: Information on and access to subsidies, loans, or other financial incentives to offset initial investments in sustainability measures are crucial for Lucas, making these projects more feasible and attractive.
2. **Mindset:**

2.1 **Proactive and solution-oriented**: Lucas adopts a forward-thinking approach to energy management, viewing it as an opportunity for financial saving. He is open to innovative solutions and constantly seeks ways to enhance the energy efficiency of his home.
2.2 **Innovative and data-driven**: He enjoys the intellectual challenge of optimizing home energy use, employing a data-driven approach to make informed decisions about energy consumption.
2.3 **Community engagement**: As part of the HOA, Lucas values collective action and community-based solutions for building-wide sustainability improvements.
2.4 **Short-term living**: Lucas is hesitant on heavily investing in upgrading his dwelling, as he is of the opinion that it is his first house, and he imagines himself living there five years at maximum. He mentions that when looking for his next home, he will focus more on the quality of insulation and the existing energy system of his new house.
2.5 **Having a living space that feels too large**: Lucas is considering renting out part of his house in the future, as he finds that is too much space for him, and the space should be used by more people, more efficiently.

3. **Behavior:**

3.1 **Strategic and efficient energy use**: Lucas actively manages his heating, turning it off at night and selectively heating spaces, such as for drying laundry. He is interested in DIY projects that increase his home's energy efficiency and uses smart devices for real-time energy monitoring and adjustments.
3.2 **Engagement in sustainability projects**: He participates in community initiatives like the "Klusbus" and is open to sharing unused space in his home for energy efficiency, reflecting a willingness to contribute to broader sustainability goals (if financially compelling).

4. **Internal Resources:**

4.1 **Financial**: Lucas appears financially stable, capable of investing in significant sustainability measures, and interested in enhancing his property's energy efficiency. He has his own savings available, as well as the HOA's funds.
4.2 **Informational**: With a good grasp of energy-saving technologies and practices, Lucas is well-equipped to make informed decisions about improving his home's sustainability. His technical skills further enable him to undertake DIY projects. Next to that, he is well aware of available subsidies, and where and how to apply to them.

5. **External resources:**

5.1 **Financial**: Lucas can access financial incentives from energy suppliers, government programs, and possibly community grants aimed at promoting sustainability in residential buildings.
5.2 **Informational**: External advice from energy consultants, online sustainability forums, and HOA meetings provides Lucas with a broad perspective on available energy efficiency technologies and practices.
5.3 **Klusbus**: He has used Klusbus for small energy saving activities and projects within his house.

6. **Ease of access to resources:**

6.1 **Internal resources**: Lucas efficiently utilizes his financial capabilities and technical knowledge to implement sustainable solutions, indicating high ease of access to internal resources.
6.2 **External resources**: His proactive nature and community involvement likely make it easier for Lucas to access external resources, including financial incentives and expert advice, to support his sustainability efforts.

B.3. Energy persona C: Young adult – Home owner – Pragmatically eco-visionary

Figure B.3: Energy Persona C: Lydia Pieters

0. Demographics
Name & age:
Ms. Lydia Pieters, 26 years

Living conditions:
Lydia lives in a comfortably equipped home, likely shared with a partner, where automated systems play a significant role in managing energy consumption. She values a balance between a comfortable lifestyle and environmental consciousness.

Background:
Lydia is a PhD student at the Eindhoven University of Eindhoven. She is creative, and in her free time she likes to paint, draw, and sew her own cloths.

1. **Needs:**
    - 1.1 **Simple energy consumption practices**: Lydia seeks simple and intuitive solutions to manage her home's energy use, prioritizing comfort and sustainability. She desires tools or systems that provide clear insights into energy consumption without requiring deep technical knowledge.
    - 1.2 **Straightforward communication**: Effective, straightforward information about energy-saving methods and the tangible benefits of sustainable living5 adjustments is essential for Lydia. She prefers clarity, especially regarding the financial implications and payback of energy investments.
    - 1.3 **Sustainable materials**: She is really interested in sustainable materials, such as sheep's wool as an isolation material.
    - 1.4 **Security of supply**: Her ideal future home is an energy neutral one, in which she generates her own electricity and heat, and security of supply in her ideal home is really important.
2. **Mindset:**
    - 2.1 **Pragmatic environmentalism**: Lydia is environmentally aware and inclined towards sustainable living, provided it aligns with practical benefits like cost efficiency and personal comfort. She values initiatives that offer clear, immediate advantages while also contributing to broader environmental goals.
    - 2.2 **Long term sustainability vs short term financials**: Her long term sustainability goals are driven by short term financial impulse. Her financial motives move her to take action.
    - 2.3 **Socially-driven environmental conformity**: She felt strongly that when she saw the neighbors having their solar panels installed, that she wanted to have them as well. She felled inferior to her neighbors, she therefore feels strong communal pressures and ties.

2.4 **Motivated and engaged by DIY**: When Lydia takes on a home project independently, she is highly engaged with its functionality, eco-friendliness, and expense. However, her emotional and informational involvement wanes if the project is outsourced to an expert. This shift occurs as relinquishing control over the project leads to a diminished understanding and influence over its sustainability features and financial aspects.
2.5 **Evaluates projects by the payback period**: When evaluating a potential home improvement, such as insulation or the installation of a new energy source, Lydia assesses its viability based on the return on investment period.

3. **Behavior:**

3.1 **Adaptive and practical**: While not deeply engaged in the technicalities of energy management, Lydia is willing to adapt her lifestyle for efficiency, such as layering up in colder temperatures. She's inclined towards hands-on sustainability projects with visible outcomes.
3.2 **Moved by community engagement**: Lydia shows openness to community-driven sustainability efforts, indicating a preference for collective action and shared learning in environmental initiatives.

4. **Internal Resources:**

4.1 **Financial**: Lydia has access to a degree of financial resources, evident from participation in significant home improvements aimed at enhancing sustainability, like solar panels and insulation projects.
4.2 **Informational**: Her approach to information is pragmatic, favoring actionable insights over complex data. Lydia values clear, concise information that supports informed decision-making in her daily life and sustainability efforts.

5. **External resources:**

5.1 **Financial**: Potential access to subsidies, grants, or incentives aimed at promoting residential energy efficiency and sustainability, offered by local authorities, energy suppliers, or environmental organizations.
5.2 **Informational**: Community programs, online platforms, and local initiatives likely serve as valuable sources of information for Lydia, providing practical advice on energy-saving practices and eco-friendly improvements.

6. **Ease of access to resources:**

6.1 Lydia's engagement with internal resources may be more reactive, influenced by household decisions and available automated systems. However, her proactive stance towards community and external resources, particularly those that are straightforward and directly beneficial, suggests she can navigate and utilize these effectively, especially when they align with her preferences for simplicity and tangible benefits.

B.4. Energy persona D: Elderly – Home owner - Holistic compensator

Figure B.4: Energy Persona D: Clara Jansen

0. Demographics
Name & age:
Ms. Clara Jansen, 67 years

Living conditions:
Mrs. Jansen lives alone in her own apartment in the city center, enjoying the convenience and vibrancy of urban life. As an active member of the homeowners' association board, she is engaged in her community and takes part in decisions affecting her building.

Background:
Clara is a retired Dutch and Crafts teacher with 35 years of experience at a vocational high school in Eindhoven. Her retirement years are spent enjoying the cultural and social offerings of city life, made easier by her central location and the absence of a need for a car.

1. **Needs:**
    - 1.1 **Cost friendly electric cooking options**: She's interested in transitioning to electric cooking but is deterred by the associated renovation costs. This transition may also necessitate an upgrade in electrical infrastructure to accommodate increased demand from electric cooking appliances.
    - 1.2 **Heating and thermal comfort**: Given her attentiveness to thermostat settings and the use of a high-efficiency boiler, maintaining a comfortable yet energy-efficient thermal environment in her home is crucial. Her practice of lowering the temperature at night and when she's away indicates a need for a heating system that's flexible and responsive to her lifestyle.
    - 1.3 **Clear communication on sustainability practices for her HOA**: She needs clear, straightforward communication regarding sustainable practices and initiatives, particularly those proposed by the homeowners' association for the building's sustainability.
2. **Mindset:**
    - 2.1 **Large corporates must take responsibility**: Clara believes the energy transition is progressing too slowly and that large companies should take a more active role in accelerating the process. She advocates therefore for systematic change.
    - 2.2 **Values collective action within her HOA**: As a member of the homeowners' association board, she values collective action and community involvement in decision-making processes, especially regarding making the building more sustainable.

2.3 **Individual contribution to the energy transition**: Despite systemic concerns, Clara is committed to doing everything within her power to live sustainably, focusing on what she can control, like her energy consumption, plastic use, and transportation choices.
2.4 **Pragmatic yet aspirational**: While she is practical about her current limitations, such as the financial barriers to switching to electric cooking, she also aspires to improve her living environment's sustainability within her means.

3. **Behavior:**

3.1 **Energy conscious consumption habits**: Clara meticulously manages her heating, using a high-efficiency boiler and adjusting her thermostat based on whether she is home.
3.2 **Environmentally conscious resource consumption**: She practices frugality in resource use, such as plastics, water and energy, influenced by her environmentally conscious upbringing, and prefers sustainable transportation options.
3.3 **Communication and interaction**: As a member of the homeowners' association board, Clara is involved in discussions about making the building more sustainable, although concrete plans are yet to be developed.

4. **Internal Resources:**

4.1 **Financial**: Clara's financial resources likely include her pension and any savings she has accumulated, which she can allocate towards sustainable home improvements within her personal space. Next to that, her homeowners association has funds available for physical changes to the building.
4.2 **Informational**: Being part of the homeowners' association board provides her with direct access to discussions and plans regarding building sustainability, though individual action is limited to her apartment.

5. **External resources:**

5.1 **Financial**: Potential subsidies or incentives from local government or environmental organizations for individuals or homeowners' associations making energy-efficient upgrades.
5.2 **Informational**: Access to expert advice from the homeowners' association, environmental organizations, and local government initiatives aimed at promoting sustainability in residential buildings.

6. **Ease of access to resources:**

6.1 **Internal resources**: Clara has direct control over her internal resources, though her pension and savings may limit the scope of sustainable improvements she can afford on her own.
6.2 **External resources**: Accessing external financial resources may be more challenging, depending on the availability of subsidies, the homeowners' association's willingness to invest in building-wide sustainability projects, and the complexity of application processes for available incentives. Informational resources are more readily available but require proactive engagement and possibly navigating through technical information to make informed decisions.

B.5. Energy persona E: Elderly – Owner, HOA sustainability champion

Figure B.5: Energy Persona E: Erik van der Meer

0. Demographics
Name & age:
Mr. Erik van der Meer, 64 years

Living conditions:
Erik lives in an urban setting where he is deeply involved in the management and decision-making processes of two distinct HOAs, one of which houses a notable percentage of rental apartments owned by landlords, contributing to a diverse and often conflicting set of interests among the members.

Background:
Erik van der Meer, 64, serves on the boards of two homeowners' associations and is an active member of a sustainability committee, dedicated to navigating the complexities of communal decision-making and advancing green initiatives.

1. **Needs:**
   - 1.1 **Effective strategies for consensus building**: Erik needs effective strategies to bridge the gap between conservative and progressive members within the HOAs, especially when discussing sustainability initiatives.
   - 1.2 **Access to information and education**: He seeks accessible and persuasive information to educate and sway members on the long-term benefits of sustainability measures, overcoming the financial concerns of landlords and conservative members.
   - 1.3 **Professional HOA support**: Given the complexities of managing HOAs, Erik values professional advice and organizational structures that can streamline decision-making and project implementation.
2. **Mindset:**
   - 2.1 **Progressive with a vision for sustainability**: Erik understands the necessity of adapting to changing environmental standards and the importance of a long-term sustainability vision within HOA policies.
   - 2.2 **Pragmatic realist**: He is acutely aware of the challenges posed by the diverse interests within the HOAs, balancing idealism with the practical realities of achieving consensus and implementing changes.
3. **Behavior:**
   - 3.1 **Advocacy for green initiatives**: Despite facing resistance, Erik champions sustainability proposals such as installing electric car charging stations, emphasizing their future relevance and value.

3.2 **Conflict navigation**: He navigates the varied dynamics and conflicts within HOA meetings, advocating for a structured, professional approach to manage these interactions and push for sustainable changes.

4. **Internal Resources:**

4.1 **Financial**: Erik has access to the HOAs' collective funds for communal projects, though these are often constrained by the members' approval and the need for careful budget management.
4.2 **Knowledge and Experience**: With experience on sustainability committees and in HOA management, Erik brings a wealth of knowledge on sustainable practices and organizational dynamics, though he continually seeks to expand his understanding to better argue for green initiatives.

5. **External resources:**

5.1 **Expert Consultation**: Access to external experts in sustainability and HOA management who can provide valuable insights and proposals to persuade the HOA members of the viability and benefits of sustainability projects.
5.2 **Governmental and Community Programs**: Potential subsidies or support programs designed to encourage sustainability in residential communities, which can offer financial and logistical support for approved initiatives.

6. **Ease of access to resources:**

6.1 **Challenging Internal Dynamics**: Accessing and utilizing internal resources can be complex due to the need for consensus among HOA members, which often reflects broader societal tensions between progress and conservation.
6.2 **Moderate Accessibility to External Support**: While Erik can reach out to external resources, the effectiveness of these engagements is contingent upon aligning them with the HOA's interests and overcoming internal resistance to change.

B.6. Energy persona F: Elderly – Simple comfort seeker

Figure B.6: Energy Persona F: Johanna Verbeek

0. Demographics
Name & age:
Ms. Johanna Verbeek

Living conditions:
Mrs. Verbeek resides alone in a two-room apartment within a social housing complex. She cherishes her small balcony for tending to her plants. On a modest pension, Johanna leads a life marked by simplicity and comfort.

Background:
Retired, Johanna has spent the majority of her life in the same neighborhood, establishing strong communal ties.

1. **Needs:**
    - 1.1 **Comfort and warmth**: Prefers a cozy home environment, often using an electric blanket and extra blankets for chilly evenings.
    - 1.2 **Clear communication with the social housing corporation**: Values straightforward communication from the housing corporation, avoiding complex letters or technical jargon.
    - 1.3 **Personal interactions**: Appreciates personalized interactions, finding reassurance in familiar faces or personal phone calls.
    - 1.4 **Simple appliance operation**: Needs easy-to-operate household appliances and systems with straightforward controls.
    - 1.5 **Reliable heating to increase comfort**: Essential for her comfort, desires a heating system that's easy to control and provides consistent temperature.
    - 1.6 **Easy access to technical support**: Requires easy access to support for technical issues, preferring patient helplines or local technicians for home visits.
    - 1.7 **Effortless energy efficiency**: Open to automatic energy-efficient solutions that save energy costs without altering her lifestyle.
    - 1.8 **Draft reducing and insulation solutions**: Seeks technical solutions for reducing drafts and improving insulation without major dwelling alterations.
2. **Mindset:**
    - 2.1 **Value-driven and practical**: Makes decisions based on personal value and well-being, focusing on practical solutions for her lifestyle.
    - 2.2 **Resilient and adaptable**: Embraces gradual, non-disruptive changes, demonstrating resilience through adaptability.

2.3 **Pragmatic sustainability with immediate effect**: Engages in sustainability through practical actions that offer immediate benefits to her quality of life.
2.4 **Health and safety conscious**: Prioritizes a safe living environment and is cautious about risk-invoking changes or activities.

3. **Behavior:**

3.1 **Proactive comfort management**: Actively manages her comfort through environmental adjustments and prefers manual over automated controls.
3.2 **Passive energy conservation**: Naturally conserves energy by minimizing unnecessary electrical appliance use and maintaining efficient home practices.
3.3 **Selective technology adoption based on simplicity**: Chooses technologies that are intuitive and enhance quality of life without adding complexity.
3.4 **Community interaction**: Engages with neighbors, sharing advice and communal solutions, reinforcing her community-oriented mindset.
3.5 **Provides direct feedback and values communication**: Provides direct feedback to the housing corporation about comfort or safety concerns, preferring personal communication channels.

4. **Internal Resources:**

4.1 **Pension**: Which is modest. This income covers her basic living expenses, including rent, utilities, groceries, and occasional personal indulgences.
4.2 **Savings**: She is cautious about using these savings, preferring to reserve them for emergencies or significant unexpected expenses.

5. **External resources:**

5.1 **Investment by social housing organization**: As owner of the dwelling, the SH-organization will have to invest in the sustainability of the dwelling.
5.2 **Social housing organization benefits**: As a resident in a social housing complex, Johanna may be eligible for various support programs designed to assist tenants with home improvements, especially those that enhance energy efficiency or accessibility. These could include grants or low-interest loans for specific upgrades.
5.3 **Governmental subsidies for energy efficiency**: There are often governmental programs aimed at promoting energy efficiency among homeowners and tenants. These programs might offer subsidies or rebates for installing energy-efficient appliances, insulation, or heating systems. Johanna could benefit from such programs, reducing her energy bills without significant personal investment.
5.4 **Community-based assistance programs**: Local community organizations or charities sometimes offer assistance to seniors or low-income residents for home improvements, emergency repairs, or energy-saving upgrades. These programs can provide both financial aid and practical support, such as volunteer labor.
5.5 **Utility company programs**: Some utility companies offer programs designed to help customers reduce their energy consumption, including free energy audits, discounted energy-efficient appliances, or rebates for participating in energy-saving programs.

6. **Ease of access to resources:**

6.1 **Information and awareness**: Ensuring Johanna is aware of available resources is crucial. This could be facilitated by regular, easy-to-understand communications from the housing organization, local community centers, or senior citizen networks.
6.2 **Assistance and support**: Providing personalized assistance, such as help with filling out applications or explaining program benefits, can significantly improve Johanna's access to these resources. This support could come from social workers, family members, or volunteers from community organizations.
6.3 **Simplifying processes**: Streamlining application processes and reducing bureaucratic hurdles can make it easier for Johanna and others in similar situations to access these resources. Clear guidelines, simplified forms, and the option for personal assistance in completing applications can be very beneficial.