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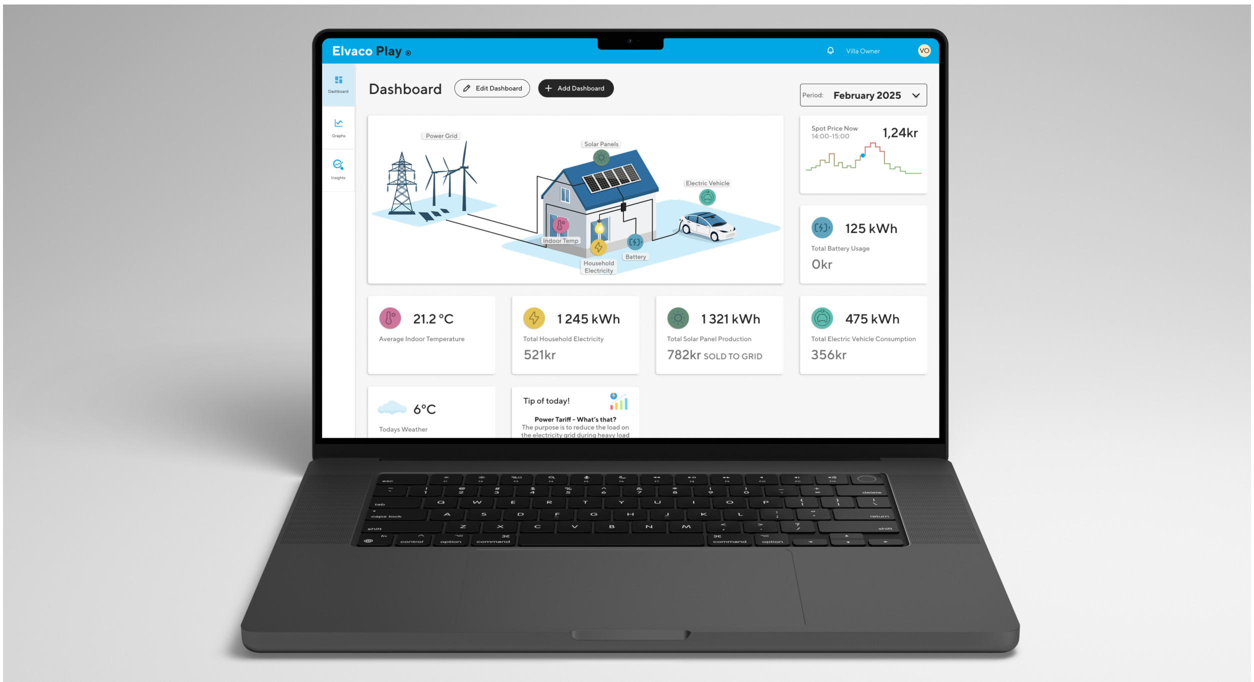

Enhancing the user experience for an energy metering platform

The full process from problem identification to concept development

Master's thesis in Industrial Design Engineering

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DEPARTMENT OF INDUSTRIAL
AND MATERIALS SCIENCE

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2025
www.chalmers.se

MASTER'S THESIS 2025

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Cover: Illustration of the final concept's Figma prototype for a villa owner with solar panels and an electric vehicle.

Chalmers Digitaltryck
Gothenburg, Sweden 2025

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Abstract

As energy consumption continues to rise, the need for effective tools that promote energy awareness and encourage sustainable behaviour has become increasingly important. This study explores how the user experience (UX) of energy metering data presentation in a digital platform can be enhanced and thereby support behavioural change toward energy efficiency. The project was conducted in collaboration with Elvaco, a company specializing in smart energy metering solutions, and focused on improving the user experience of their new digital platform, Play.

The initial phase of this study involved problem identification through user research, market analysis and literature review to understand the key challenges of Elvaco's digitalization. One aspect of the findings indicated that end users often are unexperienced regarding energy systems and lack knowledge of supporting insights and actionable recommendations, leading to limited behavioural change. By applying user-centred design principles, the study examined how end users interact with energy data and what design elements facilitate better understanding and decision-making. A combination of usability testing, interviews and prototyping in Figma was used to develop and evaluate approaches in presenting energy data in a clear and actionable way. Particular attention was given to behaviour-oriented design, including knowledge enhancement and decision-support tools, to motivate users toward more sustainable energy consumption.

The results indicate that a well-structured, intuitive data presentation, combined with additional support and recommendations, significantly improves user engagement and the ability to take informed actions. This study contributes to the field of sustainable UX design by demonstrating how digital solutions can bridge the gap between energy awareness and behavioural change.

Keywords: Energy metering, Digitalisation, Sustainable behaviour, User experience, Energy awareness, User study, Concept development.

Acknowledgments

This master thesis is a result of the project carried out in collaboration with Elvaco AB as part of the Industrial Design Engineering program at Chalmers University of Technology. I would like to express my sincere gratitude to everyone who has supported me and contributed to this project.

First and foremost, I would like to thank my academic supervisor and examiner, Helena Strömberg, for supporting me from start to finish. Her inputs and reassurance were valuable throughout the whole process, but especially during the initial phase when narrowing down the overwhelming possible directions of this project.

I would also like to thank my supervisor at Elvaco, Christopher Vonasek, for his continuous support and willingness to assist. His dedication in answering my questions or directing me to the right experts were extremely valuable. An extended thank you to the PM & RnD teams at Elvaco, whose knowledge, support and welcoming made me feel like one in the team. Their efforts gave me the opportunity to learn more about energy metering and efficiency, insights that I will carry forward.

Thank you to all participants involved in the research and user studies, including those from the Energy Day at Elvaco, the survey respondents and those who took part in usability testing and interviews. Your contributions were essential in shaping this project and achieving a successful outcome.

Finally, a great thank you to my opponents, Fokke Verburgh and Siyuan Hu, for their valuable feedback and comments, which helped improving the quality of this report.

Kungsbacka, March 2025
Linnea Bjöörn

List of Acronyms

Below is the list of acronyms that have been used throughout this report, listed in alphabetical order:

B2B	Business to Business
BACnet	Building Automation Control Network
ChatGPT	Chat Generative Pre-Trained Transformers
CSV file	Comma Separated Values File
DfSB	Design for Sustainable Behaviour
DLMS	Device Language Message Specification
KJ analysis	Kawakita Jiro Analysis
KPI	Key Performance Indicator
LTE	Long Term Evolution
LoRaWAN	Long Range Wide Area Network
M-bus	Meter-Bus
NB-IoT	Narrowband Internet of Things
OMS	Operating Metering Systems
ROI	Return On Investment
SDGs	Sustainable Development Goals
SWOT	Strengths, Weaknesses, Opportunities, Threats
UX	User Experience

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1 Introduction

Environmental sustainability has become a critical global priority, with the United Nations' 17 Sustainable Development Goals (SDGs) in front (United Nations, 2025). The goals are driven by the need to minimise climate change and preserve resources for future generations. It is widely known that actions must be taken to ensure a sustainable future. One key aspect of this is the digitalisation of energy metering and monitoring to ensure energy efficiency and reduce consumption. This master thesis is conducted in collaboration with Elvaco AB, a company operative in the energy metering field.

1.1 Background

Fossil fuels currently stand for approximately 80% (Environmental and Energy Study Institute, 2021) of the global energy consumption, over 75% of greenhouse gas emissions and 90% of carbon dioxide emissions (United Nations, 2024). Consequently, the main contributor to global climate change is fossil fuel consumption. Although renewable energy sources now stand for 15% of the total energy use worldwide, which is the highest number in history, it remains insufficient (Igini, 2024). The most effective strategy for reducing the overall fossil fuel consumption and demand is to increase energy efficiency through technical solutions, digitalisation and behavioural change (International Energy Agency, 2024). However, the historical rate of improvement in this area is not enough for reaching the Net Zero Emissions target by 2050 (University of Oxford, 2024), the rate needs to be doubled. Therefore, Elvaco's work in energy efficiency and metering is critical for a sustainable future, and this project contributes to that development.

The growing demand for sustainability, resource conservation and carbon footprint reduction has made the energy-efficient solutions increasingly desirable. Elvaco serves a diverse user base, all who can benefit from innovative smart energy solutions. The building sector alone accounts for 40% of global energy consumption and 33% of greenhouse gas emissions (Elvaco AB, 2023). Additionally, 75% of all buildings in Europe are considered energy inefficient, which implicates a significant opportunity for sustainable improvements. Moreover, at the household level, individual behavioural change can also have a substantial impact on energy efficiency. In 2016, the America's domestic sector accounted for nearly 19% of national greenhouse gas emissions (EnergySage, 2023). Of this, 69% resulted from residential electricity consumption, while 32% stemmed from fossil fuel-based home heating. Research suggests that behavioural changes at household level can lead to a 40-70% reduction in greenhouse gas emissions in certain sectors (Lamhauge, 2023), implying an opportunity for energy efficiency. To facilitate this transition, a supportive infrastructure is required, where Elvaco can play an important part.

Elvaco are focusing on renewing and developing their product line with the Play concept, which consist of a web-based platform, a mobile application and a gateway for energy meters. The goal of this new initiative is to enhance the customer experience of their products. Elvaco operates within a business to business (B2B) model serving three primary user groups: installers, customers and operators. These users are mainly experienced professionals with prior knowledge of energy systems and metering technologies. As a result, Elvaco's existing products require technical experience, practice and knowledge. While Elvaco's products, services and support are highly appreciated in the market, users have historically accepted the high technical demands of the system. Since market expectations have not previously emphasised usability and user experience, these aspects have not been prioritised in the development of previous product systems. However, to stay one step ahead of the market and make energy efficiency available for all they now want to enhance usability, self-service and automation in their new Play concept.

The solutions on the energy surveillance market today requires prior knowledge and a solid understanding of energy systems. Many available products are technically complex, featuring advanced functionalities that may be difficult for novice users to navigate. For individuals who lack foundational knowledge in energy concepts, such as the definition of Watt or Ampere (Vattenfall, 2023), interpreting the data can be challenging, making it difficult to make informed energy decisions. Addressing this issue requires more than simply a better usability but also a better user experience which could strengthen the relationship between user and product, enable a better understanding of energy consumption and enhance the commitment from the user to make the right sustainable choices. Consequently, by ensuring a pleasurable user experience of energy monitoring, optimisation and cost reduction, user adoption can be improved, ultimately leading to greater resource savings (Jordan, 2005).

This project must align with Elvaco's sustainability goals and their commitment to minimising their environmental footprint. According to Elvaco's sustainability report (Elvaco AB, 2023), the company is committed to establish a Science Based Target to support carbon reduction in line with the Paris Climate Accord's goal of limiting global warming to below 2 °C. Additionally, the United Nations' 17 SDGs play a central role in Elvaco's sustainability strategy. While the company acknowledges all 17 goals, three are particularly relevant given its industry and context, goal 7 "*Ensure access to affordable, reliable, sustainable and modern energy",* goal 9 "D*rastically increase access to information and communication to extend digitalization"* and goal 12 "*Ensure sustainable consumption and production patterns*". This project directly contributes to all three of their focused goals by enhancing usability and user experience, ensuring that Elvaco's products are more accessible, intuitive, and efficient. By improving data visualisation and decision-support mechanisms, the project facilitates better energy monitoring and helps users make more informed, sustainable choices regarding energy resource use.

1.2 Aim

The aim of this project is to explore whether enhancing usability and user experience in Elvaco's new user portal, Play, can contribute to greater energy awareness and a reduction in energy consumption. By improving the visualisation and presentation of energy data, the project seeks to make energy monitoring more accessible and engaging for a broader range of users, beyond industry specialists.

To address this aim, the following research questions will be explored:

- How can the visualisation and presentation of energy metering positively influence energy consumption and awareness?
- Which methods can be used for enhancing user experience within the Play concept?
- How can an energy metering platform be adapted to both specialists and unexperienced users without compromising functionality?

This study will apply user-centred design principles and behavioural insights to develop solutions that support sustainable energy use through an improved digital experience.

1.3 Deliverables

Elvaco's primary objective for this project is to validate whether the new Play concept meets user needs and requirements while ensuring that the company is progressing in the right direction with their platform. From the perspective of an Industrial Design Engineering student, the project's value lies in development and design of an improved solution that enhances usability and user experience. Therefore, the new solution will serve as a tool for validating user requirements and ensuring that all stakeholders are satisfied.

The key deliverables of this project are:

- Mapping out Elvaco's user groups, along with their needs and requirements.
- Focusing on one specific user category and conducting a user study to refine and update their needs and requirements with a list of requirements.
- Suggesting improvements for the Play concept and developing a new user-centred solution.
- Testing and validating the defined requirements using the new solution.
- Providing a future roadmap and an updated list of requirements to further optimise user experience.

By addressing these deliverables, the goal is to increase user engagement with the Play platform, thereby contributing to energy efficiency and reduced energy consumption. Additionally, the improved user experience will facilitate informed, sustainable decision-making, enhancing the platform's overall effectiveness in promoting energy savings.

1.4 Demarcations and limitations

Elvaco's product portfolio is extensive, encompassing meters, gateways, back-end systems, databases, user portals and mobile applications for iOS and Android. Due to the time constraints of this project, the focus will be limited to front-end products, specifically the user portals and mobile applications. Back-end systems and communication technologies will not be included in the scope. Nevertheless, compatibility with existing back-end infrastructure and technologies will be considered during the development.

Another limitation of this project is its focus on Swedish customers within Elvaco's existing market. Expanding the study to include international customers would significantly increase the project's scope and complexity, making it unfeasible within the time frame.

2 The Company: Elvaco

Elvaco is specialising in energy metering solutions with a strong emphasis on sustainability and energy efficiency. Operating within the installation and automation industry, Elvaco serves both the Swedish and international markets. They offer smart comprehensive energy measurement solutions for indoor climate monitoring, remote reading and individual metering of district heating, water, gas, electricity and others. Elvaco's product portfolio includes meters, infrastructure components such as gateways, back-end systems and databases, meter modules for connectivity, sensors, accessories and the user portals Elvaco Evo and MyEnergy. Elvaco strives for the right solution for each customer, tailored for their needs and conditions. They offer solutions ranging from turn-key solutions including installation and support to products and software delivery.

Elvaco employs standardised open protocols for its communication technologies, ensuring interoperability with various metering systems. These include:

- OMS, Operating Metering Systems, based on M-bus standards (OMS-group, 2024)
- DLMS, Device Language Message Specification (DLMS, 2024)
- BACnet, a widely used protocol for building automation and control networks (Schneider Electric Sverige, 2024)
- Ethernet, a foundational standard for network communication (TechTarget, 2023).

By adhering these industry standards, Elvaco ensures a seamless integration with third-party systems, providing a competitive advantage despite not being among the largest actors on the market.

The communication technologies that Elvaco's products utilize includes LoRaWAN, NB-IoT, LTE, M-bus and wireless M-bus (Elvaco AB, 2022). Each technology is tailored to specific applications:

- LoRaWAN is particularly suited for temperature sensors, where demands of long-lifespan, wireless communication, long-range and battery operation are crucial.
- NB-IoT, a radio technology standard, operates in the licensed frequency band and leverages the LTE mobile infrastructure, offering a long battery life and high reliability while remaining compatible with standardised networks and products.
- M-bus and wireless M-bus are also standardised and used for remote reading and control of energy resources, such as electricity, water, heat and temperature.
- Elvaco's infrastructure solutions, including gateways, receivers and extenders, are based on the M-bus protocol, enabling scaling and fully connected metering systems.

A key aspect of Elvaco's products, particularly its gateways and meters, is battery longevity. Since data transmission consumes battery power, reducing the frequency of energy metering data transmissions is essential for prolonging battery life.

Elvaco's primary users include installers, operators and customers, as illustrated in figure 2.1. The roles and needs of these user groups differ where the installers and operators focus on system functionality and maintenance rather than reading the energy consumption. Their priority is ensuing that the infrastructure operates efficiently while the customers are primarily interested in energy data presentation, using it to monitor and optimise energy usage.

Elvaco's customer base is divided into three main groups: buildings, energy companies or utilities, and other line of businesses (Elvaco AB, 2022). Utilities require smart metering solutions that enable instant leakage detection and optimised energy usage. The building segment uses metering data for individual billing, energy monitoring, and temperature control. In this customer category Elvaco offer the user platform MyEnergy that allows for each tenant to track their total energy consumption and costs. Other line of businesses includes solar panel monitoring, electric vehicle charging stations and greenhouse climate monitoring.

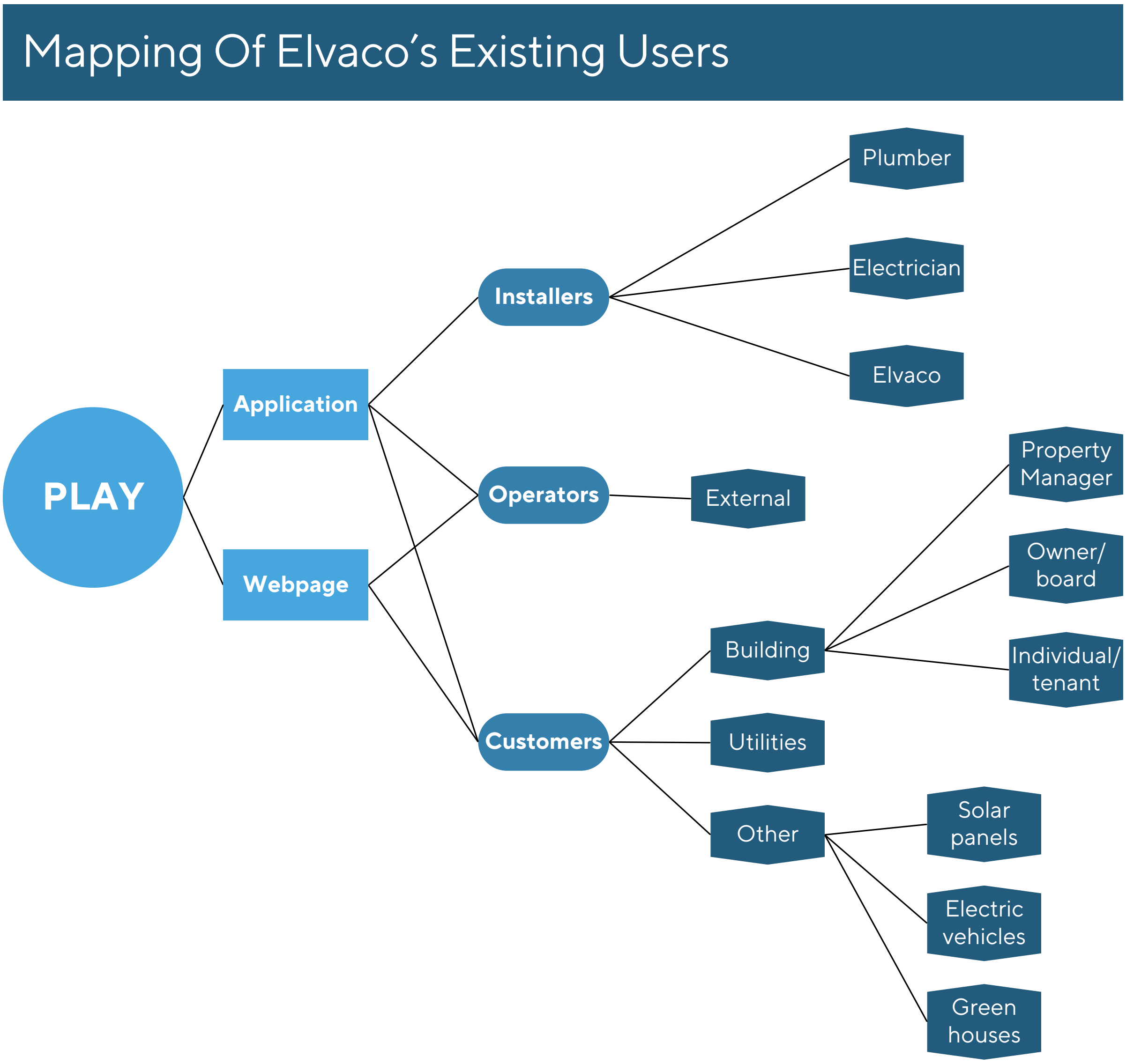

Figure 2.1 illustrates the mind map of Elvaco's existing users (Authors contribution)

According to Elvaco's sustainability report (Elvaco AB, 2023) their goal is to *"provide customers with effective, user-friendly solutions that enhance their ability to collect, process, and act on metering data, ultimately reducing resource usage. We are confident that this contributes significantly to a more economical, energy-efficient, and sustainable society"*. Sustainability is a core component of Elvaco's business model, with a focus on enhancing energy efficiency through digitalisation. By providing accurate metering data, the company empowers customers and partners to make informed decisions, reducing the overall energy consumption and environmental impact.

The following aspects from this section are particularly relevant to the project:

- High compatibility with existing networks and third-party products
- The relation between data transmission frequency and battery life optimisation
- User groups and their specific needs and requirements
- Sustainability aspects, ensuring alignment with Elvaco's environmental goals.

2.1 The Play Concept

The new Play concept that Elvaco is currently developing consists of a new user platform, Elvaco Play Portal, which includes both a web-based platform and a mobile application, as well as a new gateway, Elvaco Edge. The aim of this new system is to enhance usability, enable self-service and automate processes within their product line. Elvaco Edge is the world's first fully connected gateway for both wired and wireless M-bus meters (Elvaco AB, 2024), focusing on self-service and automation. It supports multiple power supply options, including a battery-powered version, and automatically connects to the Play platform, providing users with instant access to metering data.

Elvaco currently offers two user platforms: Elvaco Evo, see figure 2.2, and MyEnergy, see figure 2.3. The Evo platform provides users with an overview of their meters, including functionality and installation status, and energy data visualisation. Additionally, it enables users to create analyses and optimised energy use strategies (Elvaco AB, 2022).

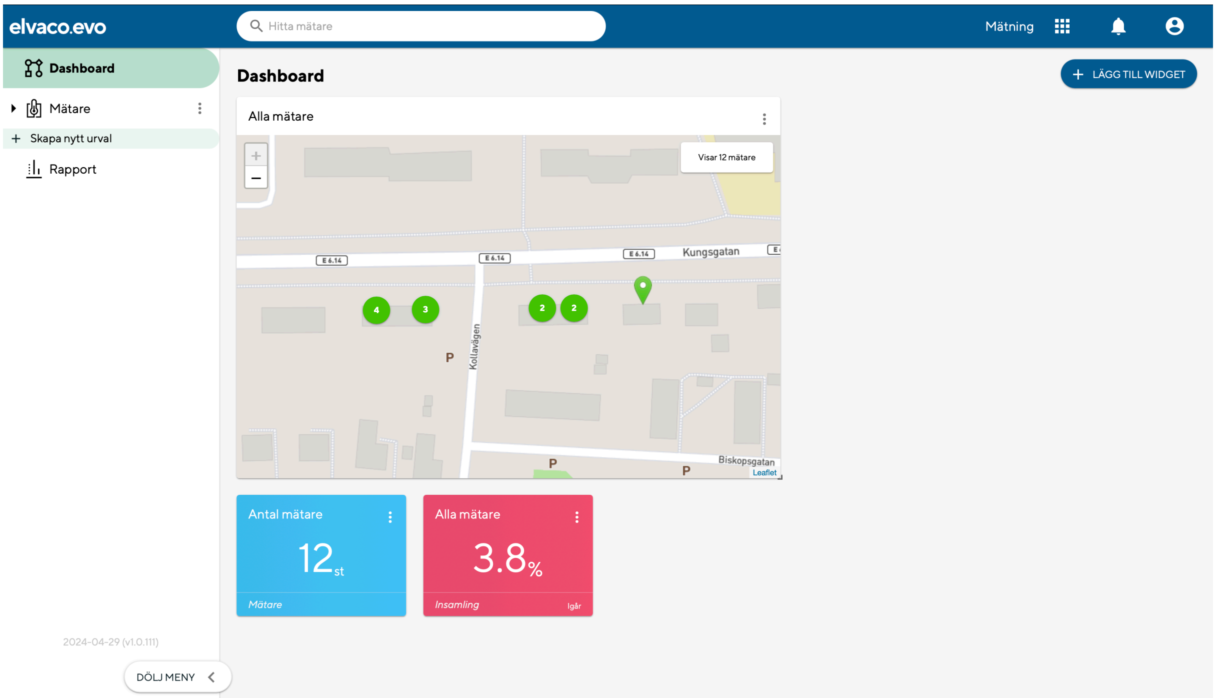

Figure 2.2 visualises the platform Elvaco Evo's dashboard (Elvaco AB, 2025)

In contrast, MyEnergy is designed for tenants and residents, focusing on presenting energy consumption data and associated costs (Elvaco AB, 2025).

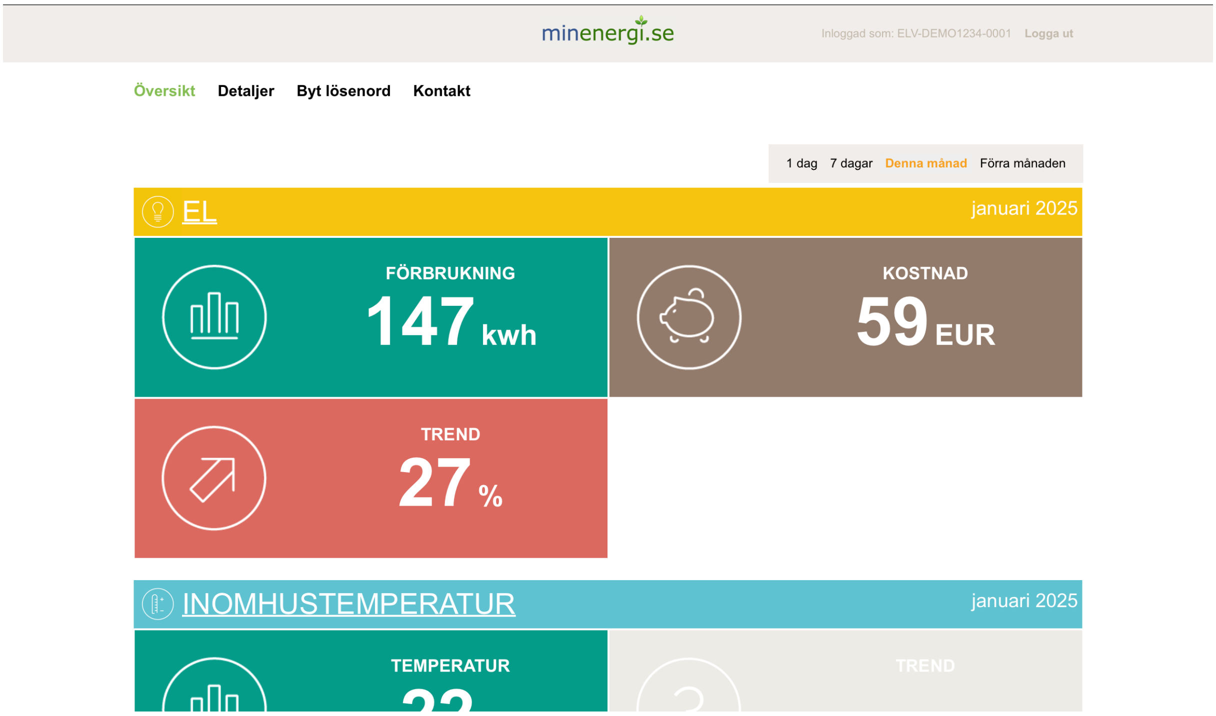

Figure 2.3 visualises the platform MyEnergy's dashboard (Elvaco AB, 2025)

The new Play portal is intended to replace Evo as the primary user platform and aims to optimise the usage for all types of users, both experienced and unexperienced. Although development of the portal is still ongoing, the initial focus has been on functionalities for installers and business customers. A key design consideration is the distinction between Elvaco's direct customers and end users. For example, property managers purchase Elvaco's meters and platforms and then provide housing cooperatives or apartment buildings with access to the energy monitoring tools. The residents or tenants within these buildings function as end users by using the platforms, such as MyEnergy, to view their energy consumption. By offering a user-friendly platform for tenants, Elvaco provides added value to the property manager, increasing their attractiveness as a supplier.

The Play portal is structured around a hierarchy model, as shown in figure 2.4, consisting of organisations, workspaces, and assets such as devices and facilities. The process of onboarding users to the platform follows these steps:

1. Account Creation: The business customer, such as an electrical installer, industry, utility company or property manager, purchases meters and access to the Play platform and then creates an organisation account.
2. Workspace Setup: Once the organisation is established, users can create workspaces to group assets, such as meters and devices as figure 2.4 illustrates. The grouping of assets in a workspace is fully flexible but is normally organised by city, street, apartment, room, meter type or gateways, depending on the customer's needs.
3. Invite Members: Within a workspace, additional members can be invited and assigned specific user roles including Owner, Can Edit and Can View.

These role-based permissions ensure that craftsmen, operators, installers and business users can access only the relevant data and functionalities within their respective workspace. By implementing this structured approach, the Play platform aims to simplify the user experience, provide greater flexibility in asset management and enhance accessibility for different user groups.

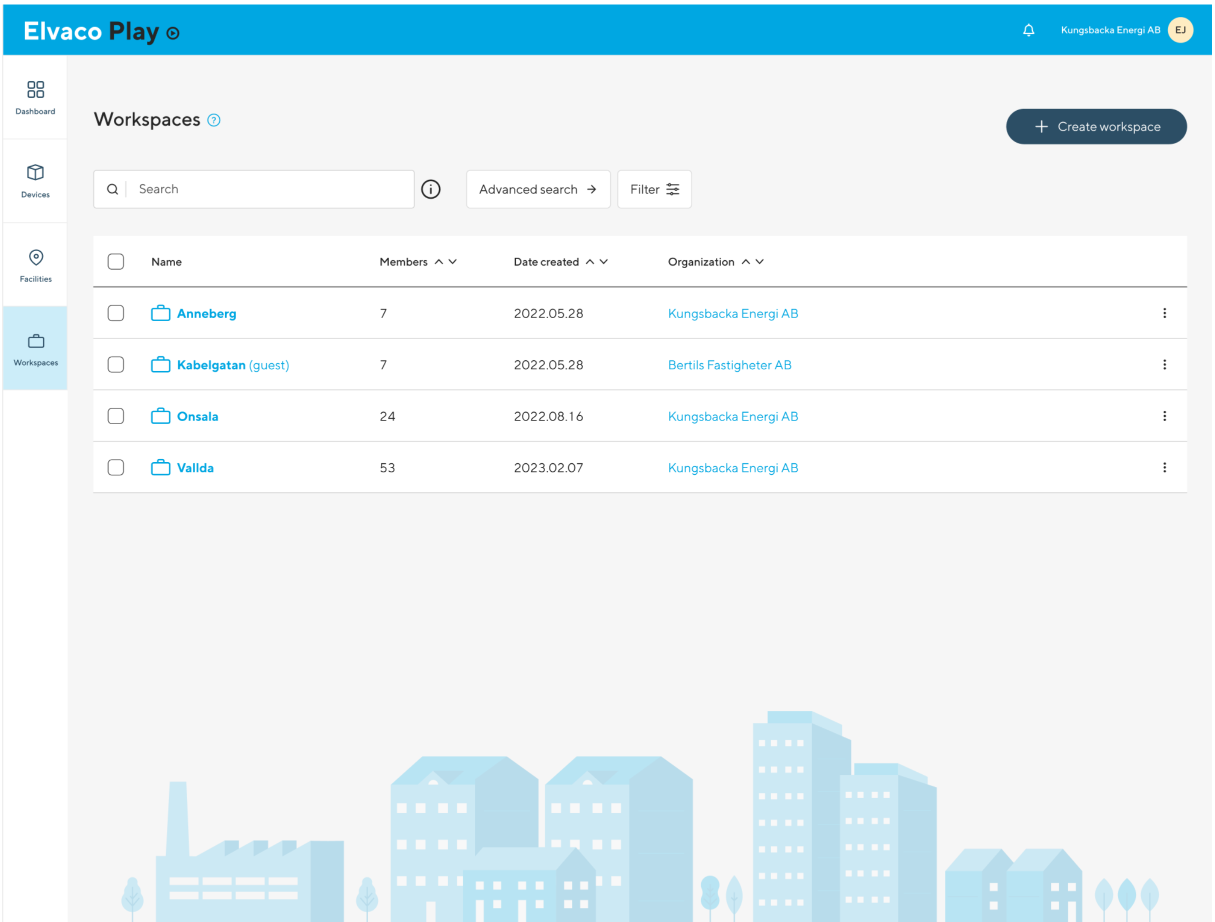

Figure 2.4 shows the new conceptual platform Play, specifically the workspaces menu tab (Elvaco AB, 2025)

3 Framework

To support the product development in this project relevant theory foundations are presented in this chapter including designing for sustainable behaviour and user experience. By integrating these theoretical perspectives, the project aims to create a solution that not only visualises data but also actively encourages behavioural change towards environmental sustainability.

3.1 Design For Sustainable Behaviour

A key focus in Elvaco's business model and this project was understanding how the presentation of metering data can influence energy consumption. As a result, designing for sustainable behaviour (DfSB) was a central aspect of the project, incorporating tools and methods to influence users to adopt more sustainable behaviours and habits. Several theoretical frameworks were applied, including the behaviour-oriented approach (Selvefors, 2023), nudging and power of decision making, as mechanisms for influencing behaviour. The core principle of the behaviour-oriented approach is to identify key determinants that can act as drivers or barriers to the behavioural change and design solutions that directly influence those determinants, which ultimately fosters behavioural change. By incorporating these theories and methods, the projects aimed to facilitate decision-making, and behaviour shifts in users' daily lives through encouragement, enlightenments and steering.

The motivation to change behaviour is determined by three key factors: individual attitude, subjective norms and perceived behaviour control (Selvefors, 2023). However, motivation alone is not sufficient for changing a behaviour, the ability to accomplish a behaviour, including knowing how, also plays a significant part. Lack of knowledge about how to perform a behaviour, combined with low consequence awareness, can act as barriers to change if not remedied. A clear understanding of future possibilities and benefits can instead serve as a driver for behavioural change since that affects the attitude.

A crucial aspect of increasing the motivation is the perceived control balance between the user and product. This project explored how different levels of user control influence whether users engage in reflective of automatic thinking when making decisions. According to Kahneman's dual-process theory (Selvefors, 2023), decision-making can be categorised in two cognitive modes: Automatic Thinking, System 1, and Reflective Thinking, System 2. The automatic thinking refers to the fast and unconscious decision-making and is often driven by emotions, while the reflective version is slow and conscious, often based on logics and effortful reasoning. This project prioritised reflective decision-making ensuring that users engage in deliberated and informed decisions rather than relying on habitual, unconscious behaviours. Consequently, increased user control, by facilitating thoughtful and conscious decision-making, can increase the motivation and intention to change behaviour.

A person's ability to change behaviour depends on three key factors: knowledge, ability and access to enabling technology (Selvefors, 2023). A lack of technological solutions and insufficient knowledge were identified as major obstacles that hinder users from making sustainable changes. This project sought to address these challenges by developing new functionalities that help users recognise potential benefits and direct impact of their actions on energy consumption plus enhancing knowledge to increase motivation and encourage users to invest time and resources in energy efficient solutions. Since behavioural change requires active engagement and effort from users, the solution needed to ensure that the proposed changes in behaviour were both relevant and easily understood, with clear financial and environmental benefits. Furthermore, any behavioural shifts had to align with the users' existing lifestyles and values to ensure long-term adaption.

The determinants of importance in this project are:

- Attitude towards the behaviour
- Ability to perform a behaviour
- Knowledge of how to perform a behaviour
- Awareness of consequences
- Awareness of future benefits
- Perceived user control of a behaviour
- Technological solutions

By influencing these determinants, the project aimed to increase engagement and motivation for sustainable behaviours and thereby ensure new habits in users' daily lives.

Nudging was explored as a powerful tool for influencing user decisions, particularly in shifting habitual, automatic behaviours toward conscious, intentional choices (Selvefors, 2023). Nudging strategies were implemented to interrupt undesired, automatic behaviours and replace them with conscious decision-making. Additionally, they were used to provide clear and informative messages explaining why and how users should reduce their energy consumption. By integrating effective nudging mechanisms, the project aimed to support users in sustainable choices without forcing or imposing restrictions, thus increasing both engagement and long-term behavioural change.

3.2 User Experience

The user experience of how energy metering data and information is presented, perceived and understood by users was a key focus of this project. The goal of enhancing UX on the platform was to facilitate user engagement, support energy efficiency and reducing energy consumption.

User experience design aims to create pleasurable interactions between users and products by recognising the broader relationship between the two. It includes more than merely a good usability but also how a product can align with users' personality, aspirations, attitudes, values and beliefs. According to Jordan there are four conceptual dimensions of pleasure related to product interaction: physio-, socio-, psycho- and ideo-pleasures (Jordan, 2005). This project primarily focused on the psycho-pleasure, emphasising the cognitive effort required to interact with the product and the emotional reactions the product evokes. A product can also enhance psycho-pleasure by providing external knowledge and simplifying cognitive capabilities, reducing the need for users to memorise complex information. In the context of an energy efficiency platform, this means productive utilization of metering data and providing support in understanding the energy systems and consumptions.

Usability plays a significant role in psycho-pleasures (Jordan, 2005) as a complex or difficult-to-use product can place excessive cognitive demands in the user, resulting in frustration, annoyance and disengagement. Therefore, ensuring usability was a critical aspect of this project. The usability pyramid consists of six stages: functional, reliable, usable, convenient, pleasurable and meaningful, see figure 3.1. This project focused on the "usable" and "convenient" stages by implementing simplified, intuitive and clear design elements to enhance user interaction. By ensuring a short learning curve and intuitive navigation, the platform encourages users to integrate it into their daily routines (Sakai, 2023).

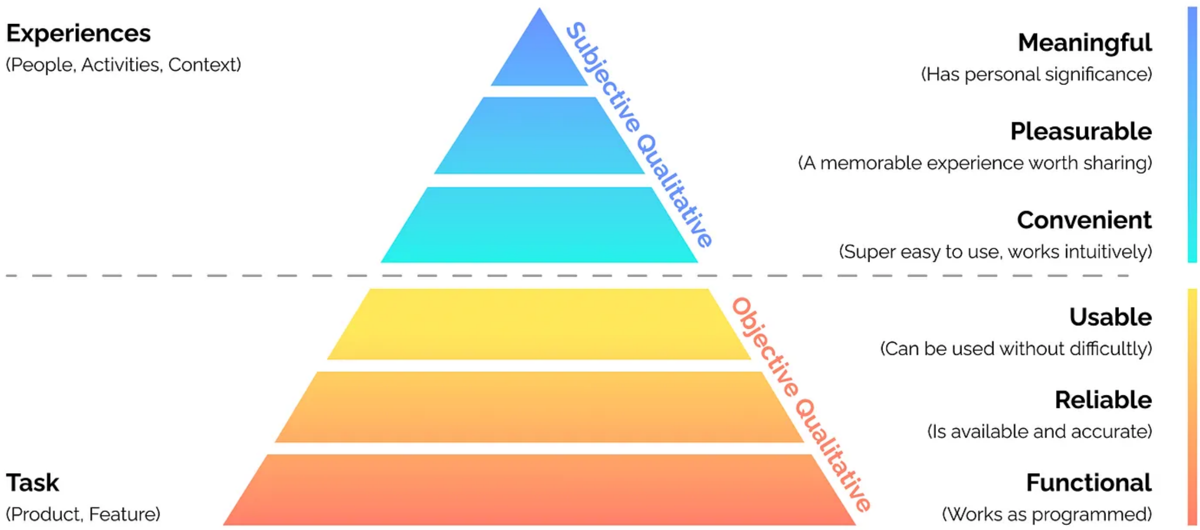

Figure 3.1 visualises the Usability pyramid and its subparts (Sakai, 2023)

To further support user comprehension of energy systems, this project applied cognitive mapping. A theory that describes how mental representations of complex systems help individuals learn, understand and retain information. Cognitive mapping enables users to visually organise knowledge, recognise patterns, and establish relationships within systems or processes (Gibbons, 2019). In an energy metering platform, this method can be used to illustrate energy flows or system dependencies, helping users develop a clearer mental model of their energy use.

Beyond usability and psycho-pleasure, this project also incorporated aspects of ideo-pleasure, which relates to the values a product represents (Jordan, 2005). In this case, the platform promotes environmental sustainability by encouraging energy efficiency and awareness. For users who prioritise sustainability and environmental responsibility, the platform's energy-saving features align with their values, reinforcing their motivation to engage with the system.

4 Method

In this chapter the project process and methodology are presented. The chosen approach was outlined to ensure a structured and efficient process, guiding the project from initial research to concept development and evaluation. The process phases of this project is described, along with descriptions of the methods used for data collection and analysis.

The process followed in this project aligns with the Industrial Design Engineering approach to ensure user-centred design (Interaction Design Foundation, 2016), as presented in figure 4.1. This methodology emphasises active user involvement trough the design process, including exploring the context of use, establish needs and requirements, developing and iterating on the concept and evaluating the design. By integrating users into each phase of the process, either through direct involvement or user-driven insights, the project ensured that the final concept effectively addressed user needs and enhance overall experience.

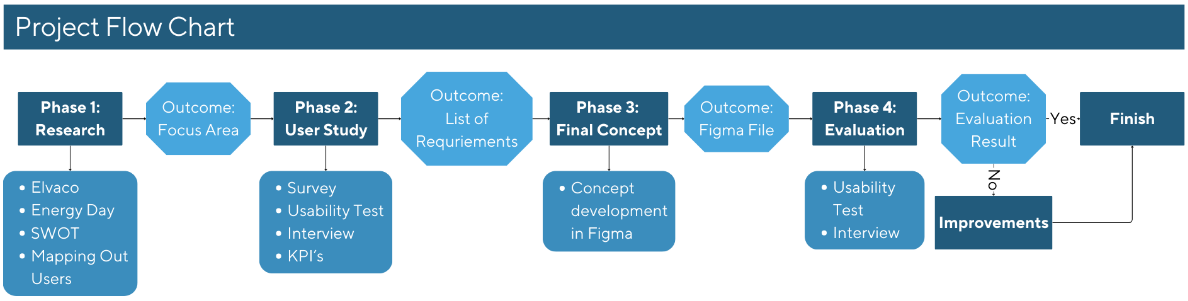

Figure 4.1 illustrates the project process with key activities and outcomes of each phase (Author contribution)

4.1 Phase 1: Research

The purpose of the initial research phase was to identify areas where a new solution could provide value. This phase involved research on Elvaco AB, customer and partner insights from Elvaco's Energy Day at their office, a SWOT-analysis from the perspective of Elvaco and their new Play-concept and mapping out Elvaco's users.

As a part of the research phase, valuable insights were gathered during the Energy Day, an event where Elvaco invited partners and customers to their office to learn more about the company and its new product development. This event provided a unique opportunity to engage directly with users and gaining first-hand industry and customer insights. To collect primary and qualitative data, 15 users and customers were interviewed using open-ended questions. Discussions focused on their experience with Elvaco's existing products, such as the Elvaco Evo user platform, frequency of use, desired features and initial impressions of the new Play concept. The responses, in form of notable quotes, were systematically analysed using a KJ-analysis (Scupin, 1997). This method provided a structured overview of key findings, helping to identify patterns and user needs and ensured that findings were based on real user experienced rather than assumptions. The insight gained played a crucial role in shaping the direction of the project by contributing with various focus areas where a new solution could add value.

A SWOT analysis was conducted from the perspective of Elvaco and their new Play platform, to evaluate internal strengths and weaknesses as well as external opportunities and threats (Raeburn, 2024).The data collection for this analysis included discussions with Elvaco's team to gain insight into internal aspects, findings from the Energy Day where customers and partners provided feedback, competitor research including analysing their websites and testing beta versions of competing energy monitoring platforms and exploring potential new users and markets to identify growth opportunities. By using a focused SWOT-analysis as a strategic tool, the project gained insights in Elvaco's market positioning and competitive landscape. Additionally, the analysis provided valuable understandings into how the Play platform could be optimised to meet both current market trends and future opportunities.

Elvaco aims to not only enhance and simplify the user experience for unexperienced users, such as building owners, tenants and villa owners, but also ensuring that the product system remains internally integrated, flexible and automated for experiences users, including installers and operators. To support this objective, the next step in the research phase involved mapping out all user groups and identifying their initial needs and requirements. The mapping of installers, operators, and customers was conducted through input from Elvaco, where they provided insights into who their customers and users are, as well as in their specific usage of Elvaco's products. Furthermore, findings from the Energy Day contributed to defining the initial needs for these user groups. For new users, the initial needs were established from findings in the SWOT analysis.

The findings from this research phase, including the KJ-analysis, SWOT-analysis and mapping of users, led to the identification of five key focus areas where a new solution could provide the greatest benefits. Ultimately, the project prioritised unexperienced users, defined as people who do not have expert knowledge about energy systems, as the focus area to pursue since this group was considered to benefit the most from an improved solution.

4.2 Phase 2: User Study

The user study focused on gathering both qualitative and quantitative data on the target group, unexperienced users, through a survey and usability tests of Elvaco's current platforms. These tests included direct observations followed by interviews to explore their experience. The main objective was to gain insights into users' needs and behaviours, focusing on identifying underlying challenges rather than suggestions for improvements. The results from the user study were compiled through a thematic analysis and presented in an overviewing summary. Based on this analysis, a list of requirements was formulated to translate the identified issues into clear, actionable design needs and system requirements. Additionally, the results were further validated by their alignment with existing literature on Key Performance Indicators (KPI's) for energy metering platforms, demonstrating consistency with established industry standards and research (InetSoft, 2025).

4.2.1 Survey Development

The purpose of the survey in the user study was to gather both quantitative and qualitative data to further validate the user needs and requirements through statistical analysis. The focus was on conducting initial research to understand the users' perceptions, challenges and motivations related to energy measurement and management. Key areas explored users' expectations and desired functionalities in an energy metering platform, perceived difficulties related to energy systems and consumption monitoring, and factors that would motivate users to reduce their energy consumption. The survey targeted two categories of unexperienced users: potential users and users today. The definition of potential users was individuals interested in monitoring their energy consumption but did not have an energy surveillance system installed. While users today were already using an energy surveillance system but did not consider themselves experts in energy systems. To ensure responses from the intended target group, the introduction of the survey stated the target audience and provided background information about the project.

The survey consisted of a combination of close-ended and open-ended questions, see appendix A for full version. The close-ended questions were designed with predefined multiple-choices options and the purpose was to distinguish responses from the two target groups. The open-ended questions provided a mix of qualitative data and quantitative insights, offering a greater depth to the responses. Since participants could answer freely without preset choices, recurring themes in responses from multiple independent sources added weight and validation to the findings (Bhat, 2025). Additionally, open ended questions also encouraged greater commitment and reflection from participants, as they allowed for more creative and personalised responses. Although, the open-ended questions remained consistent across both user categories, they were phrased differently to ensure relevance to the context. The questions included:

- What do you measure today/are you interested in measuring?
- How often do you see/want to see your energy consumption in a user portal?
- What purpose does/could an energy surveillance user portal have to you? What do you do in the user portal? Which functions do you use?
- Is there any functionality that is missing?
- How motivated are you to decrease your energy consumption?
- What could increase your motivation for reducing your energy consumption?
- Is there anything concerning energy consumption or energy monitoring that you find difficult?

The survey was distributed across various Facebook forums related to solar panels, electric vehicles, smart homes, energy efficiency and heat pumps. Furthermore, it was shared on private social media pages, ensuring responses from a broad audience. However, as a project demarcation considering time constraints, the survey was limited to Swedish users. Given that Elvaco operates internationally, the next step following this master thesis will be to conduct a user study focusing on the international users to further expand the research and validate findings across different markets.

4.2.2 Usability Test Development

As part of the user study, usability tests were conducted on the two different platforms: Elvaco Evo, designed for meter overview and data presentation, and MyEnergy, which focuses on data presentation for tenants, see figure 4.2. Both platforms are available as web-based interfaces and mobile applications. However, the web version was selected for usability testing due to its larger screen size, which is preferred for metering data analysis.

The usability test for Elvaco Evo involved three participants who were board members of a housing cooperative with 20 apartments. Since they were already using Elvaco's temperature and humidity meters in several apartments, the test conditions were realistic, minimising need for hypothetical scenarios or imagined data interpretation. For MyEnergy, six participants took part in the study, consisting of three tenants and three villa owners. Since they were not existing users, a demo account was used, requiring them to imagine that the represented data reflected their actual energy consumption.

An important consideration was that none of the participants had prior experience with the platform. Since this was their first time interacting with the interface, the results were analysed with this learning curve in mind. However, this also presented an opportunity to test and evaluate the platform's intuitiveness and assess how quickly users could navigate and understand the interface.

To ensure a natural interaction with the platform, the usability tests were conducted on the participants' personal computers, eliminating potential disturbances caused by unfamiliar hardware. The context of the usability test corresponded to the context of the potential authentic usage. For the platform MyEnergy the test was performed at the participants home and for Elvaco Evo the test took place in the meeting room for the board members of the housing cooperative. By ensuring authentic test conditions, the study provided reliable insights into user behaviour, platform usability and areas for improvement.

The usability test consisted of a series of tasks that participants were asked to perform while verbalising their thought process. This think-aloud method provided insights into how users interacted with the platform and identified any challenges they encountered. After completing each task, the participants rated its difficulty and, for certain tasks, estimated their confidence level when analysing the data. The rating scales used for these assessments are provided in the appendix B, along with the full version of the tests and interview questions. Observations and note-taking were done in parallel to capture user behaviour, navigation patterns and potential usability issues. The tasks were designed to be similar across both platforms but were adapted in their phrasing to suit the specific functionalities of each system. The following list highlights the tasks included in the test:

- Find an overview of all meters. Do all of them work?
- See your consumption in a graph.
- Change time interval.
- Compare your consumption during 2024 with 2023.
- Export the data to an Excel-file.
- Find your total consumption and cost.
- Find the average consumption.
- When was most energy consumed?
- Analyse the graph. Is there something that deviates? What could it be due to?
- Identify the biggest energy consumption source/Group the meters by house and compare. Does the temperature differ?

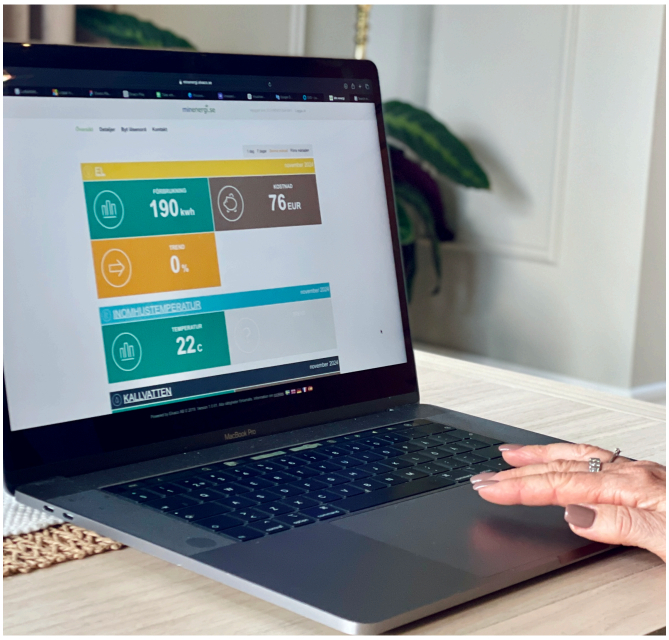

Figure 4.2 shows a photograph of the usability test on MyEnergy, performed on a laptop (Author contribution)

The purpose of the usability test was to observe and analyse the navigation and interaction with the two platform's interfaces and identify faults or obstructions that aggravated the usage. The focus was to identify difficulties, confusions or inexplicit information, while also recognising aspects that functioned well. Direct observation of user interactions revealed challenges and behaviours that participants did not explicitly express or were unaware of themselves, providing additional valuable insights into the platform usability. By addressing these findings, the development of a new solution could ensure a more intuitive and efficient interaction that aligns with the users' needs and increases overall satisfaction.

4.2.3 Interview Development

Following the usability test in the user study, a structured interview was conducted to allow participants to reflect on their experience with the platform. The purpose of the interview was to gain deeper insights into user behaviour and their understanding of the presented data. Conducting the interview immediately after the usability test ensured that participants could recall their interactions, allowing them to provide detailed feedback on both the interface usability and their interpretation of the measurement data.

To encourage deeper reflection, probing questions, such as "Why?", "Can you give an example?" and "How?", were used to clarify responses and explore user thought processes further (Birt, 2025). Additionally, since the interview was conducted directly after the usability test, the platform itself served as a mediating tool, enabling participants to navigate back to specific sections of the webpage to better illustrate their feedback and opinions.

The interview questions, including probing questions, were the same for both the Elvaco Evo and the MyEnergy tests. Appendix B shows the template used for the questions listed below:

- How would you describe the experience of navigating through the platform? Give examples.
- Was there something that was confusing or hard to comprehend? Give examples.
- On a scale from 1 to 10, how easy was it to understand the presented data? Explain your reasoning.
- On a scale from 1 to 10, how useful was the presented data? How could you utilize it?
- Does the presented data help you understand your energy consumption? How?
- Do you know what to do to decrease your energy consumption? Do you have a plan?
- Is there any functionality that is missing?
- Would you like more or less detailed data? How come?
- What would motivate you to decrease your energy consumption? Why?

4.2.4 Thematic Data Analysis

The results from both the survey and the usability tests with following interviews were compiled anonymously into two separate thematic data analyses. This method allows for qualitative data, which often are complex and extensive, to be compiled into illustrative themes, gaining a clear overview of key findings (Villegas, 2025).

Since the responses from the survey included both quantitative and qualitative data with open-ended questions this method was applied to identify patterns and categorise themes from the results. To ensure validation of qualitative findings, themes were supported by quantitative data by confirming responses from multiple independent sources. The answers from occasional participants lacked the quantitative validation and were therefore not considered in the thematic analysis.

For the usability tests and interviews, the themes were established by overlining sentences from the interviews and notes from the observations with different colours for each topic, see figure 4.3. This resulted in six themes: navigation, graph, understanding data, compare data, control and rating scale. Some aspects could be observed while other aspects required further questioning to apprehend.

The rating scale was established by compiling responses from two key interview questions: “How easy was it to understand the presented data on a scale from 1-10?” and “How useful was the presented data on a scale from 1-10?”. The answers were calculated to an average value and presented in a numerical scale from 1 to 10, providing a measurable value. Additionally, the question of “Do you know what to do to decrease your energy consumption? Do you have a plan?” was included in the analysis, with responses categorised on yes, no or maybe presented in a pie chart. This rating scale was used as a foundation during the evaluation of the final concept, allowing for direct comparison between the user study findings and the improved final concept.

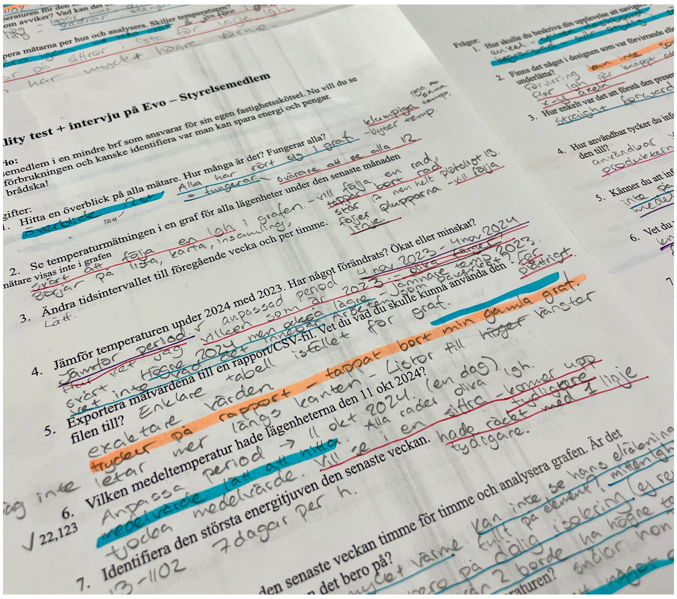

Figure 4.3 shows a photograph of highlighted text in different colours during the thematic data analysis from the usability test (Authors contribution)

Since the responses from the survey included both quantitative and qualitative data with open-ended questions this method was applied to identify patterns and categorise themes from the results. To ensure validation of qualitative findings, themes were supported by quantitative data by confirming responses from multiple independent sources. The answers from occasional participants lacked the quantitative validation and were therefore not considered in the thematic analysis.

4.3 Phase 3: Final Concept Development

In the next phase, the development of the final concept was guided by the list of requirements established in the previous stage. Each requirement was first examined separately and could be translated to solutions relatively straight forward. The solutions for each requirement were then written down in the last column of the list, see appendix C. Therefore, there was no need for using ideation methods during this phase, such as brainstorming or co-creation. Instead, the focus was on integrating these solutions into a cohesive final concept that met all identified user needs. To facilitate this process, the software Figma (Figma, 2025) was used through testing various ways of combining and refining the established solutions. This process ultimately led to a holistic concept that integrated as many solutions as possible. The outcome was a front-end Figma prototype of the final concept, sufficiently developed for evaluation testing. Additionally, Adobe Illustrator (Adobe, 2025) was utilized to create visual illustrations of the user’s household and energy system, further enhancing the clarity and usability of the design. These illustrations provided the users with an intuitive way to interact with their energy data and facilitating the cognitive understanding of the energy system.

4.4 Phase 4: Evaluation

During the evaluation phase, the Figma prototype was used for user testing with apartment owners, followed by interviews to assess whether the new solution met user requirements and was well received. This phase also involved iterative improvements and finalisation of the concept based on user feedback.

4.4.1 Evaluation Test Development

The usability tests for evaluation were conducted on the conceptual prototype in Figma for apartment owners as this use case incorporated most of the newly developed functionalities and was the most advanced prototype. Consequently, the test participants consisted of the three tenants from original the user study. Maintaining the same participants minimises external disturbances such as individual differences, level of technical skill, background or experience with energy systems (Nielsen, 1993). It ensures direct comparisons between the old and new platforms and more reliable statistics. Additionally, the users are already invested in the project which can provide more elaborate answers and constructive feedback.

The conceptual representation in Figma did not support metering data presentation in the graphs, necessitating modifications to some tasks. The tasks are presented below shortlisted:

- Locate your total hot water consumption for February 2025.
- Describe your system overview on the Dashboard. What does each widget display? Is there anything you do not understand or would like to change?
- Access your household profile. How did you navigate there?
- Input your information into the household profile.
- When registering the electricity price, would you rather do it manually or automatically via BankID?
- View your investments under “Graphs”. What investment did you make on December 6th? How would you use this functionality?
  Review your behaviours under “Graphs”. What activity did you record on December 6th? How would you use this functionality?
- What type of questions would you ask the AI-Assistant? Would you be willing to pay extra for this feature?
- Compare your consumption with other similar households.
- Examine the widgets under “Insights”. Is there anything you do not understand? How could this information assist you?
- What actions can you take to decrease your energy consumption?

The following interview consisted of predefined questions derived from the user study, including:

- How would you describe the experience of navigating through the platform? Provide examples.
- Was there anything confusing or difficult to understand? Provide examples.
- On a scale from 1 to 10, how easy was it to understand the presented data? Explain your reasoning.
- On a scale from 1 to 10, how useful was the presented data? How could you utilize it?
- Does the presented data help you understand your energy consumption? If so, in what way?
- Do you know what to do to decrease your energy consumption? Do you have a plan?
- If you were to use the platform daily to reduce your energy consumption, is there any functionality you feel is missing?

The evaluation process was intentionally similar to the usability tests and interviews conducted during the user study. By employing the same 1 to 10 rating scale and question “Do you have a plan?”, the assessment focused on measuring users’ understanding and the perceived usefulness of the information and metering data. This approach enabled statistic comparisons to verify improvements over the previous platforms, Evo and MyEnergy. The average values from the evaluation were presented alongside the corresponding results from the existing platform, providing a clear and visual result. Additionally, the same pie chart from the user study, illustrating whether users had a plan for reducing their energy consumption, was presented next to the existing platforms’ results. This method ensured that the final concept could be assessed and validated by quantifiable values.

5 Phase 1: Research

This chapter presents the results of the research phase, which aimed to gain a deeper understanding of user needs, market positioning and potential areas for improvement within Elvaco's Play platform. The research process included interviews during the Energy Day at Elvaco's office, conducting a SWOT analysis and mapping out users. The findings from these investigations resulted in five focus areas, where one would guide the continued progress of this project.

5.1 The Energy Day at Elvaco

Findings from the Energy Day at Elvaco's office were analysed using a KJ-analysis, where quotes were categorised into three main themes: general insights, feedback on an energy metering platform and first impressions Elvaco's new Play concept.

The general insights highlighted the importance of working together towards environmental sustainability. This was reflected in statements such as:

> *"Sustainability needs to be achieved together, and if there's anyone who can drive it, it's Elvaco. We want to be a part of the journey."*

> *"It's important to have an open dialogue and build trust. To do it together. Having the knowledge to meet and individualise."*

Participants also commented on Elvaco's strengths compared to competitors, for example:

> *"Good that it can be integrated with other products and systems. We don't want it to be like Kamstrup."*

The reference to Kamstrup's (Kamstrup, 2025) indicated a competitor, whose products are only compatible within their own system. Additionally, Elvaco was perceived as highly competent, as expressed by:

> *"Elvaco gives a good impression, they eat, sleep and breathe meters. Experienced!"*

A key general finding from multiple sources was technical complexity of energy metering and the need to support unexperienced users. Several statements reinforced this:

> *"Very technical."*

> *"We have customers who have never seen an energy system before."*

> *"Want to be able to attract smaller housing cooperatives with district heating, where they can see peaks and valleys and understand why."*

> *"Make it easier for customers who are not used to it."*

Under the energy metering platform category, participants provided insights into the needs of installers and operators. Key needs included:

"Want to see the work order in the app for the entire replacement."

"Alarm when the communication is lost or the value deviates, lights up red."

"Want to know why a meter isn't communicating? For example, if a cable has been cut."

Additionally, users highlighted the need for platform customisation to enhance usability since users often have preferred settings and functionalities which they utilize the most:

"Want the ability to set my own defaults, for example, per hour in the graph filter. Now that changes each time."

"Not too much clicking or opens new tabs all the time."

Security and access control were also mentioned as key considerations, strengthening the need for customisation:

"From a security perspective, it would have been good to have different levels. You can view, edit and admin can edit everything."

Some users expressed interest in leveraging platform metering data to optimise energy use:

"Want to be able to balance the environment in buildings regarding the energy aspect."

"The ability to see each individual apartment, but then privacy needs to be considered."

Regarding Elvaco's existing platform, Evo, participants indicated a need for a better overview of meters and their functionality:

"Okay to view individual meters, but harder to get an overview of all meters and what is working."

The first impressions of the Play concept were based on the customer's prior information gained from Elvaco and a presentation of the concept during the Energy Day. The feedback was overwhelmingly positive, describing the concept as:

"Fantastic!"

"A step in the right direction for device management."

"User friendly and innovative."

"Appreciate the simplicity and the compatibility with both wired and wireless."

However, some participants expressed scepticism towards automation:

"Not interested in the cloud, want to be able to physically interact with it"

"Pay and play is good, but it must not become too simple. Want to have control for troubleshooting and so on."

A question was also raised regarding visualisation capabilities:

"Can you view a floor plan?"

The question implies interest in competitors' advancements in 3D building models for visualising temperatures, a topic further explored in the SWOT analysis in section 5.2.

These findings provided valuable qualitative data and a better understanding of the users, their behaviour, pain points and needs. Key findings include the need for customisation, an improved overview of meters, 3D building visualisation and support for unexperienced users. The results were used for the SWOT-analysis, when mapping out the users and suggesting focus areas.

5.2 SWOT-analysis

This section concludes the SWOT-analysis, presented in figure 5.1, which describes strengths, weaknesses, opportunities and threats of Elvaco and their new Play concept (Raeburn, 2024). The analysis was established from the findings during the Energy Day, input from Elvaco and research on competitors, the market and potential new markets.

Figure 5.1 illustrates the SWOT analysis from the Play perspective (Authors contribution)

The strengths that Elvaco has compared to competitors are the open protocol that enables implementation in existing systems and that their products are compatible with other brands. This was found very appreciated among their users and customers and gives Elvaco an advantage when growing on the market. Another strength found during the Energy Day at Elvaco was the feeling of togetherness and community. That working towards sustainability needs to be done together, both internally and with partners and customers. This was considered done successfully by Elvaco. The third strength is that Elvaco's products and solutions are considered innovative and in front regarding energy metering.

One weakness found was the support for unexperienced users in Elvaco's products. The monitoring and controlling of energy systems are very technical, and hard for an unexperienced user to understand and navigate. Additionally, there was a need for experienced users, such as installers or operators, to have temporary control over the system. They did not want everything to be autonomous and they wanted to be able to troubleshoot by themselves. Subsequently, there is a need to customise the user experience, to facilitate the usage and understanding for unexperienced users and increase the sense of user control for the experienced users.

The opportunities found during the research lie foremost in new potential users and markets where the demand is increasing. In the industry and manufacturing market there is a great demand for energy surveillance and efficiency since there is a significant amount of energy to be saved, both in Sweden and globally. Approximately one third of all energy consumption and greenhouse gases in Sweden comes from the industry, implicating a great potential for saving energy (Energimyndigheten, 2024).

Another market, that some competitors are focusing on, is the agriculture (Sensor Online, 2024). Monitoring greenhouses, grains and crops connected to the weather and compared to their energy consumption can facilitate for farmers to plan their agriculture in an efficient way and saving energy, seeds and fertiliser.

A third opportunity is the energy communities that EU legislated in 2019 with the *"Clean energy for all Europeans package"* (European Comission, 2024). The concept is based on citizens, companies and organisations producing and sharing renewable energy in their own energy community where they build and operate their own power grid. It aims to promote local production of clean energy in a resource efficient way by attracting local and private investors. Subsequently, it could lead to reducing energy costs, increasing energy efficiency, decreasing energy poverty and new local green employment opportunities. In EU there is approximately 9000 energy communities today (Clean Air Task Force, 2024) which all demand energy monitoring and control. One example is a kindergarten in Switzerland where the municipality installed solar panels on the roof, but the rate of consumption was relatively low (University of Applied Sciences and Arts of Southern Switzerland, 2025). Thereby, they shared the produced energy with 18 nearby buildings to maximise the usage. Other countries that have started to implement energy communities, or have a high rate of energy communities, are Germany, Italy, the Netherlands, Denmark, Latvia, Greece and the United Kingdom (Clean Air Task Force, 2024). The adoption of energy communities in Sweden has been comparatively low since the state power grid is already well functioning and fossil free to 98% (Borglund, 2024). Nevertheless, there is still energy to be saved even in Sweden, primarily concerning heating. The project "Tamarinden" in Örebro is one example where different actors have worked together in a new construction to build and operate their own power grid including ten buildings and 800 apartments. According to Elvaco (Ingemarsson, 2024) there are no technical restrictions in their products for energy surveillance in a community. However, it needs to be a favourable business and a profitable investment, which needs further investigation to be confirmed.

The threats that Elvaco needs to be conscious about in their work towards a better user experience in their platform is their competitor's development of data visualisation. One competitor to the Play platform's device management is Mivo Connect (Mivo, 2024) that focuses only on managing and troubleshooting property meters and sensors, with no data presentation. On the other side, focusing on energy data presentation and increasing awareness is Tibber (Tibber, 2025). Even if their platform is directed to individual households and not competitors in the same market as Elvaco's B2B model, their solutions of how to make energy data understandable with insights and smart functions are highly appreciated from their users. Additionally, some of Elvaco's competitors are already working with 3D-models of buildings floor plans to facilitate the mental image of an energy system overview. Two examples are EcoGuard's digital platform Curves (EcoGuard, 2025) and Infometric's platform panorama

(Infometric, 2024) that visualises the variance in apartment temperature with a gradient colour scheme.

Another threat is the cyber security and the increasing cyber-attacks, not least involving Artificial Intelligence (Elvaco AB, 2023). When monitoring energy use in people's homes or utility systems the information security is of most importance. However, Elvaco is working daily to strengthen the data security and according to their sustainability report they started pursuing the ISO 27001 in 2024 which ensures safety against cyber threats in addition to confidentiality and integrity of sensitive information. Elvaco is already implementing data security in the Play-concept.

5.3 Mapping Out Users

The mapping of users is based on the initial research during the Energy Day at Elvaco, input from Elvaco and the SWOT-analysis. The findings resulted in a mind map, see figure 5.2, where Elvaco's users and their needs and requirements are presented. Apart from the previous mind map of Elvaco's existing users, presented in chapter 2, this also states users' overall needs from an energy metering platform, including potential new users from the SWOT-analysis. This mind map contributed with a clear overview of Elvaco's users and facilitated the process of suggesting different focus areas for the project to progress, presented in section 5.4.

Since this project revolves around the Play-concept's user platform, the distinguishing between the mobile application and webpage is of importance. The purpose of the application is primary system management where installers can follow the installation, and operators can ensure that everything is running. However, it contains some data presentation for the users to have easy access on a mobile phone. The purpose of the webpage is foremost presentation and data analysis since a larger screen facilitates the visualisation. However, it also includes system management for meters and devices. The connecting lines in figure 5.2, are based on the different users' need for the application versus the webpage and further elaborated in the yellow boxes.

The opportunity for new users is based on the SWOT-analysis and includes industries, agriculture and energy communities, as presented in section 5.2. The three types of users that Elvaco have today are the installers, operators and customers. The installers are mostly electricians but also plumbers or, in some cases, staff from Elvaco. Their requirements are an autonomous and easy installation and the possibility to implement in existing systems. This aligns with Elvaco's vision that the installation should be easy enough for anyone to install their products, for example an unexperienced villa owner. Furthermore, the installers are mainly concerned about the system management but also some data presentation to check instantly after installation and ensure a successful outcome.

The operators are external employees or individuals from the customers that are responsible for the device management, for example an employee from E.ON (E.ON, 2025) who are one of Elvaco's customers. Their requirements are system overview, detect errors, fleet management, system control, that the products work with other brands or systems plus a good support and service. They are concerned about both the system to make sure everything is working and the data to see deviances in the energy system.

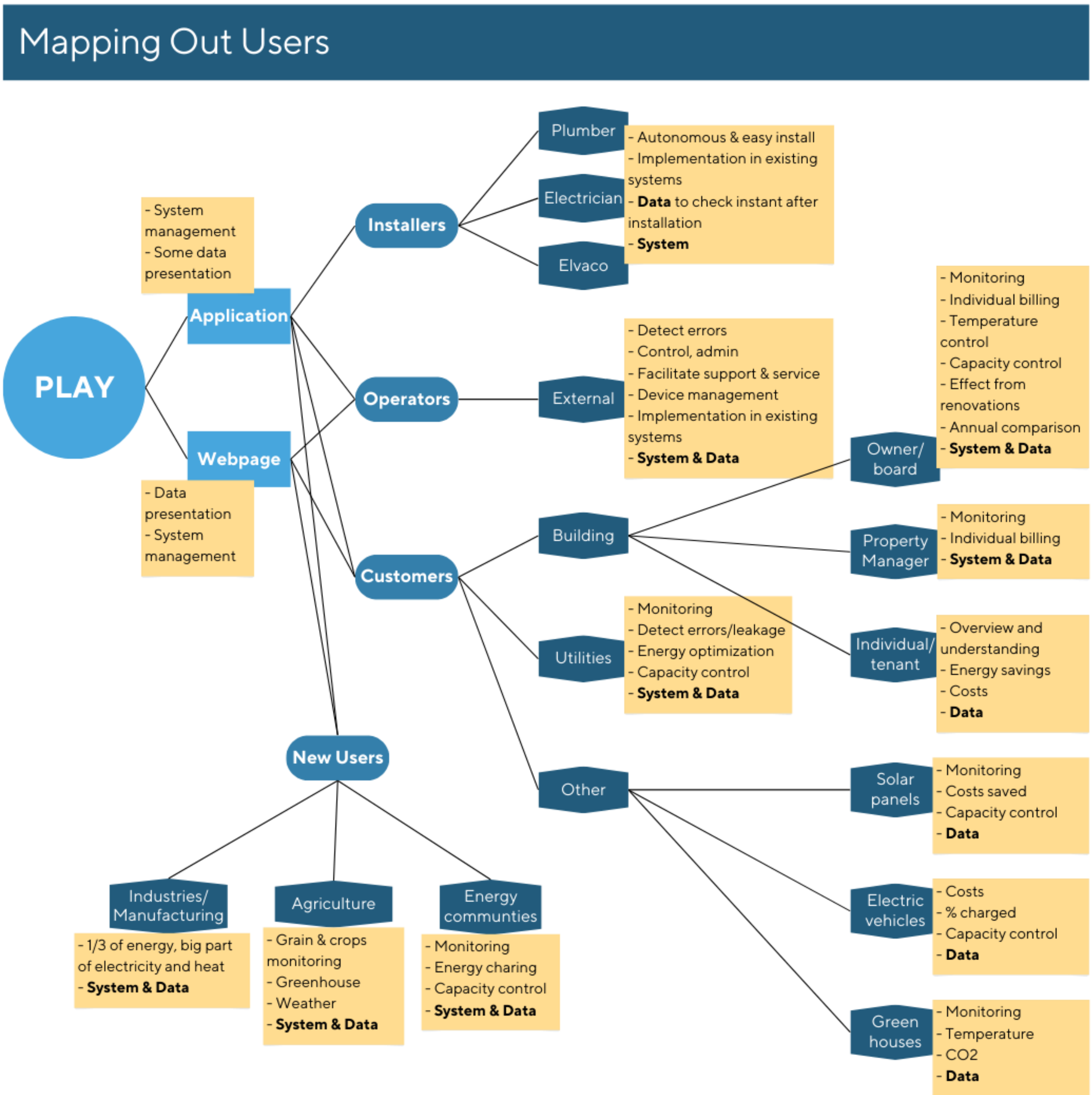

Figure 5.2 Mind map of Elvaco's users and their overall needs (Authors contribution)

The customers include utility companies, buildings and others. Utilities, such as E.ON, want to monitor their energy system, detect errors or leakage and enable energy optimisation including capacity control. Consequently, they are concerned about both the system management and the data presentation. Buildings have several categories of users; property managers, the owners of buildings, board members of a housing cooperative and the tenants or individuals that live in the buildings or companies that hires an office. However, it also includes villa owners who want to monitor their energy usage. The owners' requirements concern both the system and the data and involves monitoring, individual billing for apartment buildings, temperature control, capacity control and annual comparisons including effects from renovations. The individuals or tenants are only concerned about the data presentation that enables visualisation of energy savings and costs plus understanding and overview of their energy consumption. Other users include solar panel users that want to monitor, capacity control and to see costs saved, electric vehicle charger users that want to see costs, percentage charged and capacity control and greenhouses users that want to monitor and see temperature and carbon dioxide levels. These users are mainly concerned about the data presentation and if there is an error in the system, they generally contact an expert for help.

5.4 Choosing Focus Area

Based on the findings from the Energy Day, SWOT analysis and the mapping of users five suggestions for focus area were established, implicating where a new solution would be most beneficial, listed below:

- **Different interfaces for different users:** customisation, initial defaults and different levels of autonomy and control.
- **Overview and system management:** error signals and an enhanced overview of system and devices.
- **Capacity control:** a user interface for capacity control.
- **3D-model of buildings:** visualise temperature in a building pedagogically by a 3D model was found developed by competitors in the SWOT-analysis and a customer request from the Energy Day.
- **Unexperienced users:** facilitate and create understanding of energy consumption.

Findings from the Energy Day suggested a need for customisation since users have various aims with the user portal and diverse levels of experience. Consequently, the first suggestion of focus area was customised interfaces for different users. This would involve exploring how the sectioning of users could appear with an emphasis on individualisation encompassing various levels of automatism and control with an initial default setup.

The second focus area was an enhanced system overview since there was a need for monitoring and error detection in the mind map. Additionally, it was found during the Energy Day that the existing device overview on Evo was not satisfactory, and users stated a need for identifying the reason for lost meter communication. This area would include easy error detection, and that the overview of meters on the platform is clear and corresponds to users' mental image of the system.

The third suggestion was a user interface for capacity control since the need was confirmed when mapping out users. According to Elvaco, the functionality of capacity control is available in Elvaco's product portfolio but there is no user interface for manually controlling the capacity in the existing platform. Consequently, the functionally cannot be fully utilized. The development would involve exploring the capacity control context, identify needs and requirements and ensuring a good usability in the interface.

When researching on competitors in the SWOT analysis it became clear that 3D models of buildings visualising the indoor temperature distribution in different colours are a demand from the users and the market. Additionally, customers implied interest in this functionality during the Energy Day and Elvaco has ambitions to pursue this in the future. The project would explore how the functionality of importing floor plans could result in a 3D model, how the visualisation would look like to ensure a great user experience.

The last focus area, which was ultimately selected for further development, involved support for unexperienced users. From the initial research at the Energy Day, the need was found, through multiple sources, to facilitate for unexperienced users since energy systems are very technical and often difficult to comprehend. This group was defined as people who are interested in their energy consumption but lack expert knowledge of energy systems, including users such as villa owners, tenants, board members of housing cooperatives, electric vehicle charger user and solar panel users. From Elvaco's perspective these individuals are considered as end users and not direct business customers, as described in section 2.1. They primarily interact with the metering data and not the technical infrastructure of the energy metering system. Since the functionality of presenting of metering data is mostly developed for the webpage, while the mobile application is designed mainly for installers and operators, the web-based platform was selected as the primary focus over the mobile application.

The selection of focus area was based on an evaluation process that involved consulting Elvaco to determine where they saw greatest potential for improvement and aligning this with the project aim. The input from Elvaco revealed that unexperienced users had not been a primary focus in their previous development efforts. In the ongoing development of the new Play concept the focus had been on enhancing the functionality for installers and operators, leaving a gap in addressing the needs of unexperienced customer. However, they stated that focusing on this user group would be highly beneficial in the future, as Elvaco strives for simplicity for all with the new Play concept. While the primary goal of this project is to enhance the user experience and usability of an unexperienced user, an intuitive and user-friendly interface can also be beneficial for an experienced user, ensuring efficient and easy use across all levels.

Another key argument for choosing this focus area was the strong correlation with the project aim to enhance energy use awareness. Since experienced users are generally more conscious about their energy consumption, the potential impact of an increased awareness is superior for unexperienced users as they typically lack prior knowledge. Additionally, one of the central research questions in this project states *"How can an energy metering platform be adapted to both specialists and unexperienced users without compromising functionality?"*. By focusing on the interface and usability of an unexperienced user and how to implement this in the existing Play platform, the project also addresses this question.

6 Phase 2: User Study

After selecting unexperienced users as the focus area, a user study was conducted on this group to gain deeper insights into their needs and requirements. The study included a survey for gathering both quantitative and qualitative data, usability testing on the Elvaco Evo and MyEnergy platforms and following interviews for gathering qualitative insights. This approach ensured a comprehensive understanding of users challenges and how they interact with energy metering platforms. Resulting in identifying improvement potentials that could enhance usability and user experience.

6.1 Survey Result

The survey received a total of 92 responses, with an equal distribution of 50% potential users and 50% users today, see figure 6.1. The closed-ended questions, focusing on quantitative data, concerned areas of usage, preferred energy source to measure and frequency of platform usage.

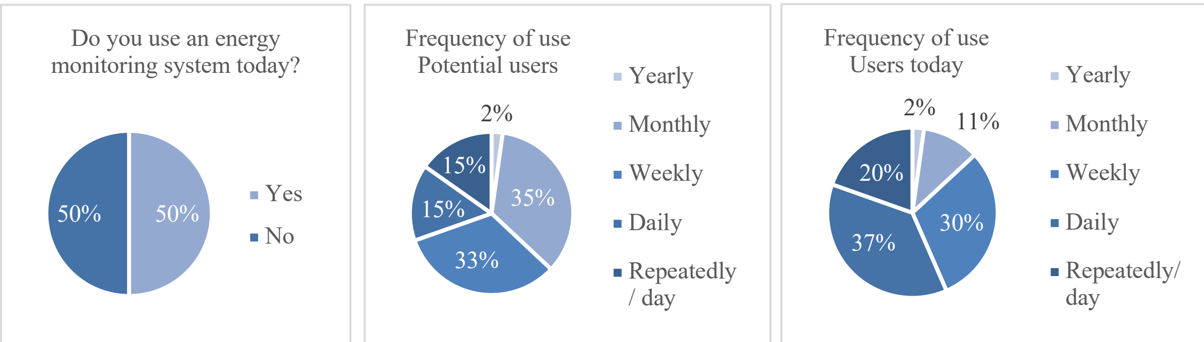

Figure 6.1 shows the survey participant distribution and the frequency of use for potential users versus users today (Authors contribution)

The frequency of use for an energy monitoring platform differed from the two participant categories, see figures. The majority of the potential users indicated that they would prefer to view their energy measurement data once a month or once a week, whereas most current users spend time on the user portal once a day or once a week. This variation could be due to the fact that current users already invested in an energy surveillance system, suggesting a greater interest in reading and analysing their energy consumption as they want to utilize their investment. From a product development perspective, this could indicate a high frequency of use which can support a short learning curve of the product as repeated use helps reinforce familiarity. However, since the new design prioritises intuitiveness, it is critical to ensure that the interface remains easy to comprehend with a short learning curve to encourage adoption and long-term use, regardless.

Regarding areas of usage, villa owners were overrepresented in both categories of current users and potential users, see figure 6.2. However, since the question offered multiple choices one participant could have selected several areas of usage, for example a villa with solar panels and electric vehicles. Among users today, 87% monitored their energy consumption in a villa and 74% of potential users expressed interest on monitoring their villa's energy consumption. Concerning tenants there is a pronounced difference in representation between the two categories with 22% of potential users and only 4% of users today. This could be explained by the fact that tenants depend more on the building owner to implement energy surveillance systems, creating a greater barrier to adoption. Other areas of usage reported by both categories were electric vehicles, solar panels, heating pumps and greenhouses.

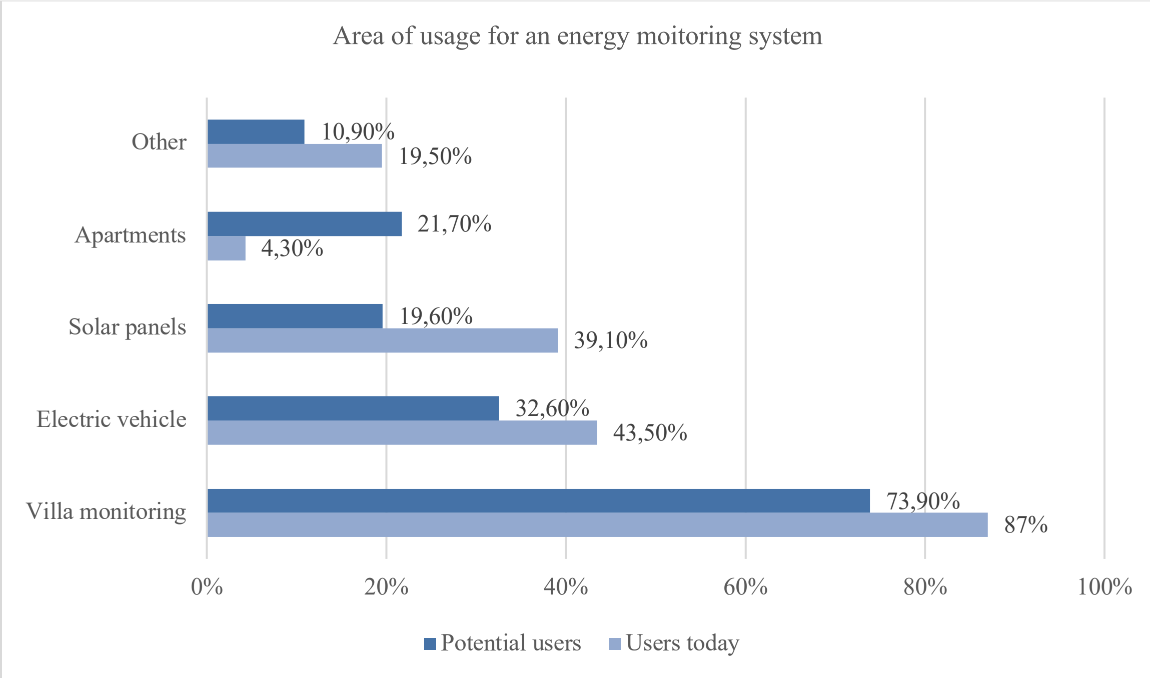

Figure 6.2 shows the distribution of usage areas for an energy monitoring platform (Authors contribution)

The energy source that was most preferred to monitor was electricity consumption, with 96% of the potential users and 98% of current users. Other frequently mentioned sources of interest to measure included temperature, heating, water consumption, electricity production, air quality, ventilation or humidity and gas or CO_2 levels.

6.1.1 Overall Themes

The result from the open-ended questions with qualitative data was established with a thematic data analysis. Firstly, there were two overall themes that concerns the bigger perspective of the participants thoughts and feelings: hard to comprehend and motivation where the top three categories of each theme were taken into consideration, see figure 6.3. The other three themes regard how users' want to utilize the energy metering data which involved monitor/read including presentation of data, understand/analysis including comparison of data and information about data and lastly control/regulate including acting based on the data, see figure.

Thematic data analysis - overall themes	
Hard to comprehend	Motivation
20% Everything: kWh, cubic water, costs, electricity bill, base knowledge of energy systems, very technical	**48%** Costs/economics: electricity price, taxes, house value, allowances for energy saving investments
9% Read and identify improvement potential	**17%** Comparison/see results/ concrete numbers on where to save energy and take action
9% Optimize/control energy consumption	**6%** Facilitate control/optimization: easy actions that lead to change

Figure 6.3 illustrates the result from the thematic data analysis rearding overall themes (Authors contribution)

The biggest motivator for decreasing the energy consumption was economics. A total of 44 independent sources, which equals nearly 48% of the participants, stated that high electricity prices, increased house value, allowances for investments or cost savings were the number one argument for energy savings. However, it was stated from 20% of the participants that energy systems and its subparts are very technical and hard to comprehend as an unexperienced user. Some stated that they lacked the basic knowledge and found everything to be difficult, even reading the electricity bill. The units such as kWh and m^3 does not tell the users anything and are hard to comprehend since they do not have a reference connection with something understandable. Another difficulty was reading the data and identifying improvement potentials based on the measurements. In connection to this, a big motivator was getting help with identifying improvement potentials by comparisons, seeing results or get concrete numbers on saving possibilities. Acting towards optimisation and controlling the energy consumption were also found hard to comprehend and the users were uncertain of how to act or where to start. Correspondingly, facilitating this and enabling easy actions that lead to change would increase the motivation.

6.1.2 Utilize Data

Figure 6.4 presents three overall themes, found in the survey, regarding how users want to utilize the data. The three themes include monitoring or reading data, understand and analyse data and control or regulate energy appliances based on the data.

The first theme concerned monitoring or reading of their energy consumption data. When presenting the measurement data, the interesting time intervals was yearly, monthly, weekly and hourly and they wanted to be able to see it both historically and in real time. It was also stated that seeing their consumption and costs in real time increased their understanding of their energy consumption and they "learned by doing". Regarding costs they wanted to see their total costs, historical costs, real time or spot price and upcoming electricity price. In addition to being able to read their total energy consumption, they wanted more detailed monitoring such as what is most consuming, consumption in real time, efficiency and proportions from green energy sources. The users that had solar panels also wanted to see the production of electricity and the amount that goes to the grid versus the household. Additionally, they wanted to monitor the energy system and measurements with an easy and informative overview in a unified interface to further facilitate the understanding.

Understanding the data and being able to analyse the data is the second theme. The answers from the survey stated that understanding and analysing data is complicated and that the users often must learn and analyse by themselves which takes time and effort. This theme is divided into two subcategories: compare data and information about data. Comparing different data could generate information that facilitates the understanding and their own analysis which in turn increases motivation. Additionally, comparing can also increase motivation by enabling to see improvements or identify improvement potentials. The participants wanted to be able to compare their energy consumption yearly, monthly, weekly and hourly in addition to the total consumption and what is most consuming. They also wanted to compare before and after an investment or change of behaviour to follow up, for example if they have isolated, renovated, changed their routine or invested in a new machine. As stated previously, being able to see the results or effect of change in concrete numbers increases the motivation to continue saving energy. The need for a common unit was also stated from multiple responses. This could facilitate to compare different sources of energy such as kWh electricity and litres of water. Being able to experiment or work with numbers by testing different actions would also increase motivation to save energy. Examples of this is to get specific numbers on how much the user can save if they invest in a new heat pump or if they cook dinner at 20:00 instead of 17:00 when the electricity costs often are at the highest (Fortum, 2025). To further increase the motivation, they wanted to set goals that they can work towards and compare with the actual outcome. The separation and sectioning of machines or energy sources was highly requested and would both increase the understanding of their energy consumption and increase motivation by helping to identify where the saving potentials are. Additionally, they wanted to compare with other similar households to get an indication on their performance and what is acceptable or standard regarding the energy consumption. Lastly, to compare the measurement data with the outdoor temperature and weather would increase understanding.

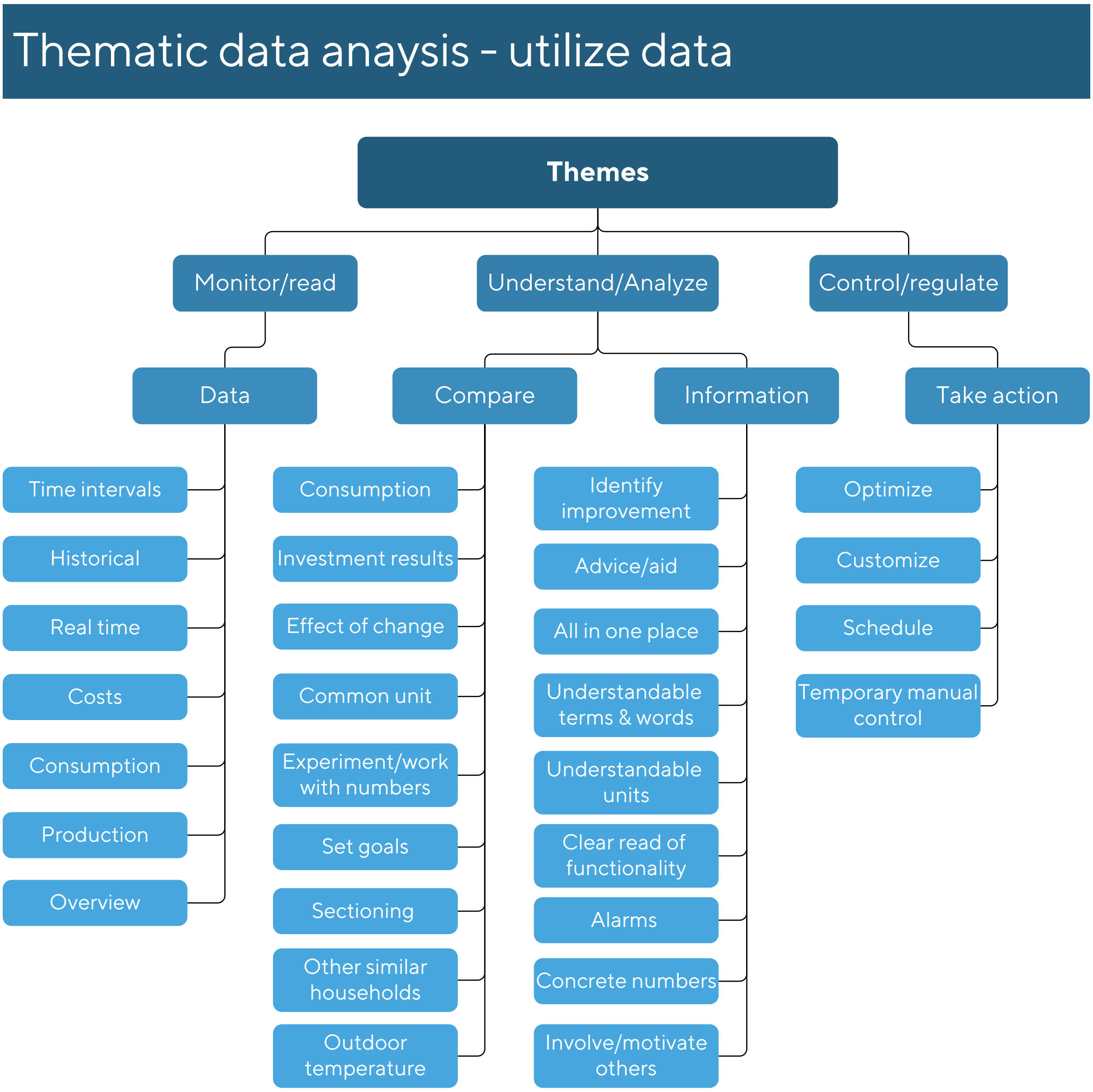

Figure 6.4 illustrates the results from the survey's thematic data analysis (Authors contribution)

The second subcategory in understanding the data concerns information about the measurement data that the users want to see. Firstly, they wanted help identifying improvement potentials to make use of the data without the need for a comprehensive analysis of their own. This can include advice such as "If you lower the temperature by 2 degrees Celsius, savings can be 183kr per month". Another request was an easy overview and all measurements in one place which is connected to the same need under monitoring data. It was stated that if all information and data is gathered at the same place where the user can get a full overview it would facilitate the understanding and analysis. Numerous participants found energy systems to be very technical and did not trust that they had the basic knowledge required. Therefore, a demand for understandable terms, words and units was found. This could include avoid using complex words or incorporate explanations to different functionalities in addition to using cost or number of trees saved as units since that was found much more commonly known and easier to comprehend. Information about and a clear read of the functionality including if the meters work or if everything in the house is operational was also a need from the users. Correspondingly, they wanted alarms or notifications if something did not work. This includes error in the meters or machines, deviations or peaks in consumption or costs and extra high or low prices. Furthermore, the need both for self-set and automatic critical values was stated. Lastly, the users wanted concrete numbers on savings, costs and saving potentials to increase motivation. Subsequently, this enables to increase motivation among others or family members which also was a stated need. The participants found it difficult to change behaviour if the family members were not equally committed and presenting concrete numbers in understandable terms could help increase the motivation.

The last theme found in the results from the survey was to control or regulate the energy consumption depending on the data presented. This includes to facilitate taking actions towards decreasing the consumption and increasing financial savings. As stated previously, it was found that easy actions that lead to change increases the motivation. The first example of this is facilitating the optimisation in different forms such as price or consumption both manually and automatic. The users stated a need for being able to go in and control the automatic optimisation and, for example, sometimes decide how much of the solar panel production goes to the grid. Another finding was the need for customisation with different levels of knowledge and detailed information in the presented data in addition to individual settings and defaults. Some users wanted to be able to go deeper in their own analysis while other only wanted the overview and a simple analysis. Additionally, optimisation does not look the same for every user and the need for individual customisations and settings was found. Correspondingly, they wanted to set schedules for optimisation or relative to costs both automatically and manually with the same argument. By ensuring temporary manual control of a set schedule or other automatic functionalities, it would increase the sense of control for the users and decrease frustration.

6.2 Usability Test & Interview Result

The findings from the usability tests and following interviews resulted in five themes: navigation, graph, understanding data, compare data, and control. The themes will be presented further below.

6.2.1 Navigation

The navigation results differed on the two platforms. On Elvaco Evo the navigation was considered inexplicit, difficult to comprehend and it took time to understand. Additionally, the overview of the meters was vague, and it was difficult to see if every meter was working, see figure 6.5. However, on MyEnergy the navigation was easier to comprehend, see figure 6.6, and simple with clear sectioning, but it was also considered too simple since the user could not customise the overview or decide what they wanted to see. Other findings on Elvaco Evo were that the user wanted to click on the meters on the map to see their data and sometimes this did not work which aggravated the user. This indicated that they used the map in their cognitive process to create a mental image of the system overview and placements of the meters with. When grouping the meters buy house, to be able to compare, the participants used the filter besides the graph instead of creating a selection of meters in the menu to the left. This could be because it was their first time using the platform and they did not know that function existed or that the task came after a task when analysing the graph. However, it could also be due to the platform's failure in intuitiveness regarding grouping meters. It was also found impossible to go back to the same graph after clicking around on the platform and the participants needed to start over with the graph preferences, such as time interval and choose meters. Lastly, on the Elvaco Evo platform the participants only used the meters category from the menu to the left when analysing the data and not the report category. It was found that the two categories had similar functionalities, and the participants did not know the difference.

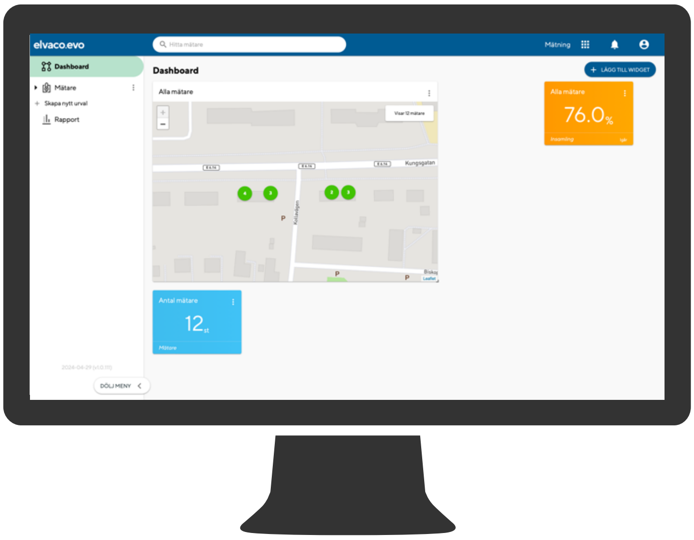

Figure 6.5 shows the dashboard on the platform Evo (Elvaco AB, 2025)

The findings on MyEnergy regarding navigation was that the platform needed limited clicking but a lot of scrolling. The overview of the different energy sources was presented in a long list which required scrolling. The participants missed the compare period-options under the graph which could be due to the need for scrolling. Additionally, it took unnecessary time for the users to understand that the headers and different boxes for the energy sources were clickable since there was no feedback when hovering over them with the mouse pointer. Nevertheless, the color coding of the overview was considered well-defined and clear. Lastly, the meaning of the headers and buttons on the platform were inexplicit. For example, the compare-button in the graph did not specify which period the users compared with, and "previous month" does not specify which month.

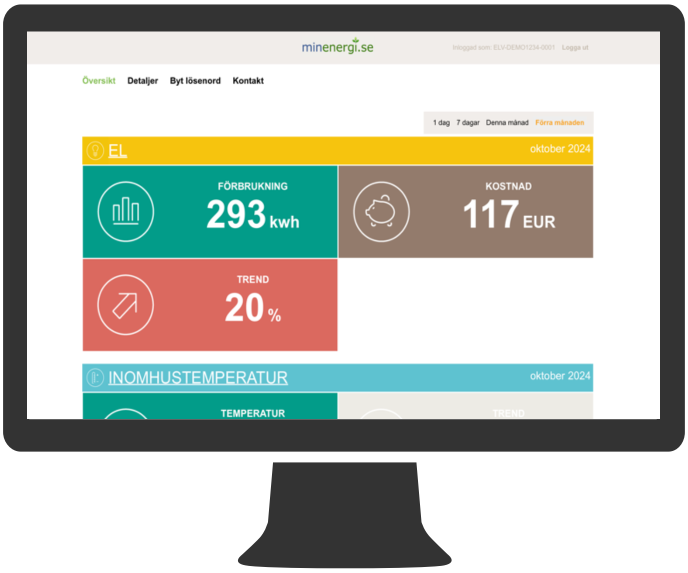

Figure 6.6 shows the dashboard on the platform MyEnergy (Elvaco AB, 2025)

6.2.2 Graphs

The presentation of measurement data differs between the two platforms. On Elvaco Evo there are line graphs while on MyEnergy there are mainly bar charts. The graph on Evo, shown in figure 6.7, presents the comparison of temperature between 2024 and 2023 for all meters plus the average value and the participants found it hard to read and analyse the graph for multiple reasons. One participant even expressed a sigh when seeing the graph. Every line has the same colour and the comparing period, 2023, consists of dashed lines and the average value is a bolded line which all forms a cluster and makes it difficult to separate the lines. To see the exact value of each line the user must hover the line for a box of information to appear. Additionally, it was found challenging to follow one line with the mouse pointer since it follows the dots on the lines and consequently jumps between the lines when hovering. Instead, the participants used the complementing list to see the exact temperature for each apartment. A desire that came from two of the participants was the ability to zoom within the graph or to start the y-axis at 16°C. In summary, the graph was challenging to understand, it did not tell the users much at first sight and it would require further analysis and time to make use of the presented data. Moreover, the compare period-button did not specify which period to compare with which was a reoccurring problem from MyEnergy. As stated previously it was difficult to navigate back to the same graph after clicking around on the webpage and connected to this was that the default time interval for the data measurement in the graph changed when altering the time period, without giving feedback. For example, if a user changed the time interval from daily to hourly first and afterwards altered the time period from last seven days to last month it would automatically change back to daily metering intervals. Consequently, the users believed the presented graph showed hourly data when it in fact showed daily data. Another setting that was found frustrating was that the graph only showed ten of the twelve meters as default and the message that informs this stated *"Two meters are not shown in the graph. Choose which meters you want to see with filter"*. One of the three participants noticed this and changed to showing twelve meters in the filter. Another participant though that the two meters had a malfunction and did not work while the third participant did not even notice the massage and believed that all meters were presented in the graph. The fact that the participants used the platform for the first time in the test could be a reason for why they did not understand this. However, even when being familiar with the platform it could be considered frustrating to be forced to change this setting at every usage.

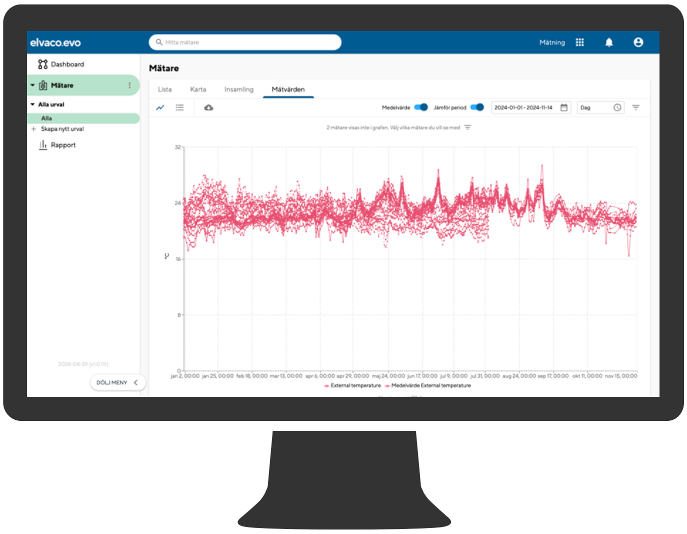

Figure 6.7 shows the graph on the platform Evo, comparing 2024 with 2023 (Elvaco AB, 2025)

The graphs on MyEnergy were presented mainly in bar charts, see figure 6.8, and considered easier to understand and more straight forward than the graphs on Elvaco Evo. However, they were also considered too simple and only presented the data, nothing more. The user could not manipulate the graphs the way they liked and there were preset options on which periods to look at. Additionally, there was no help with analysing or understanding why there was a deviation in the data, which the users requested. It was also found that the participants used the list underneath the graph to search for exact numbers, as they did on Elvaco Evo. This could indicate that a list is easier to understand and could be used as a complement to the graphs. Additionally, the total consumption of the year, month or day presented in the graph was only given in the list which forced the users to go there. When navigating in the graphs four of the participants clicked on the bars to get to that period. For example, if the users looked at the yearly bar chart, they clicked on October's bar directly in the graph to look at that period. This reminds of the same behaviour in Elvaco Evo when the participants wanted to click on the map to get to each meter. Both examples correspond to the users' cognitive image about how the navigation on the platforms is built or, considering the map and meters, how it would look in reality (Gibbons, 2019). The other two participants used the arrows on the top right to get to different periods of the graph which they thought were time consuming and irritating. Regarding the headers of the different energy sources, the text was only bolded when looking at that specific energy source. According to the users this was not enough feedback, and they were unsure on which page they were on. Additionally, after clicking around on the platform one of the users looked at the cold-water graph when the task was to find the total hot-water consumption and did not notice the difference because of the vague header. The compare-button was considered inexplicit, and the users wanted feedback on which period they were comparing with, both on the button text and when it was pressed there were no header that told them which periods they were comparing. The same goes for the one month-button where the users wanted the button to describe which month. This corresponds to the same findings on the Elvaco Evo. Moreover, the ability to choose any period they wanted was absent and there were only preset periods to look at which would obstruct the analysis of their energy consumption. Lastly, there were not enough feedback when looking at the kWh versus the EUR. These buttons were found in the top right corner but when pressing the graphs looks similar and the only feedback is that the y-axis changes from kWh values to EUR values. The participants found this confusing and the feedback to be incomplete.

Figure 6.8 shows the graph on the platform MyEnergy (Elvaco AB, 2025)

6.2.3 Understand Data

Understanding the data includes how the users interpret and comprehends the presented measurement data and makes use of it in an own analysis. On Elvaco Evo the participants could identify deviations with high or low temperature but only guess the reason behind since the board members do not know the tenants' individual routines or behaviour. The guesses varied from bad isolation, ventilation, apartment placement or cooking dinner. Some questions raised were *"Why is it 25°C in one apartment and 17°C in another?"* and *"I can see that there is a more even temperature in 2023 than in 2024 but what does that mean?"*. In summary, the participants needed more detailed information and time to conduct an own analysis that results in an action plan. They did not know what to do to improve the indoor temperature and they did not know what a good indoor temperature or climate should be. A reason for this could be that the housing association in the study only used temperature and humidity meters. If they used meters for heating or electricity in addition, it could facilitate the analysis to find something concrete to work on. However, the temperature could be used as an indication on where a problem lies, and the results show that the users need help understanding and identifying this.

On MyEnergy the participants could also identify peaks and deviations, and they guessed the reason by reflecting on their own routines. For example, there was a peak at eight o'clock in the morning on October 11th and the participants guessed that they used the kitchen for making breakfast with multiple machines running in parallel or that they charged their electric car for departure. Note that the presented data came from a demo account and not their own energy consumption which required imagination and could not result in a right or wrong analysis. Moreover, the participants stated that in a real-life scenario they would need to remember their routines or what they did the day of the deviation which obstructs the analysis. Figure shows the trend function on MyEnergy which compares the current period with the previous and states a positive or negative trend in their energy consumption. For example, comparing with the previous month and the difference is presented with a green downward pointing arrow or a red upward pointing arrow in combination with the percentage ratio. The participants used this to try to identify where there could be saving potential, but it did not help them understand why there was a negative trend or what to do to improve it. The trend did not state the reason which can have multiple causes, for example the outdoor temperature or a change in behaviour. Three participants stated than seeing their energy consumption in real time and in comparison to the electricity spot price would substantially help them understand and facilitate to identify the saving potentials. To see the change in costs or consumption when, for example, cooking dinner or taking a shower would enable the users to learn by doing. In summary, MyEnergy gives a good first sight of the measurements, but the users want to go deeper and have more detailed information to understand and make use of the data. The platform helps the users to be aware of their energy consumption, but it only states basic data and cannot be used as a tool for a deeper analysis. They did not know what to do and want help with the analysis with concrete actions or tips and tricks. Additionally, they want to know why they should save energy and what impacts it could have.

6.2.4 Compare Data

The results concerning comparing data includes what the user want to compare with and how comparisons could increase the understanding and facilitate the analysis. There was no vaster difference in the findings regarding Elvaco Evo and MyEnergy. Therefore, the results on the two platforms regarding comparing data are presented together.

One finding that multiple participants pointed out was the need for comparing with the outdoor temperature since it affects the indoor temperature, heating and electricity consumption. The participants also stated that an altered overview or dashboard could facilitate the comparison of the different energy sources without the need for clicking on each source and consequently speed up the identification of what is most consuming. Connected to this is the need for a common unit that enables comparison between different forms of energy, for example, electricity in kWh compared to Liter water. Moreover, there was a need for an understandable unit since kWh was found hard to comprehend, as also stated in the results of the survey. Examples of this was units in costs or number of trees saved since those were considered more relatable. Regarding costs there was a need to facilitate a comparison to an investment or change in behaviour and the following saving potential to ensure that the investment or change was worth implementing. To enable sectioning of machines would also facilitate the identification of saving potential by enabling comparisons between the machines and help detect which machine consumes most energy or costs. Additionally, they wanted the ability to assign personal knowledge into the system, for example if they know that their fridge has an A+ in energy labelling (Elon, 2021) or if they installed a new heat pump. This enables more detailed information and could facilitate comparison and analysis further. The participants stated that they wanted an indication on which amount of energy consumption is standard or average by comparing to other similar households or values connected to the sustainability goals, for example which indoor temperature is sustainable. They also stated that the trend function on MyEnergy was appreciated and used to understand their consumption pattern. However, it could be improved and utilized better by implementing tips or messages such as *"You have saved 100 kWh compared to last month!"*. Seeing clearly that the effort has paid off increases the motivation. A prognosis such as *"If you follow this trend, you can save 80kr per month!"* would also increase the motivation. A third option that could increase the motivation would be to work with numbers and see savings, for example investigate how much can be saved in costs if the temperature decreases by 2ºC. Lastly, to set goals, financially or environmental and to optimise and compare with the actual outcome would increase the motivation further. The participants stated that they wanted the ability to compare any period, which could be Mars 2020 versus Mars 2024 or the period before and after the installation of a new heating pump. This capability is not possible on the two platforms and if facilitated it would increase the understanding of the measurement data and subsequently increase the motivation by seeing results.

6.2.5 Control

The results from the usability test and interview regarding control includes facilitating taking action based on the measurement data or having control of what to see on the platform. The results from the two platforms were similar and therefore presented collectively. It was found that if the users could act on the presented data rapidly and easy it would increase the motivation to save energy. Initially, there was a requirement to control their energy products. Additionally, there was a need to have the measurement data and control of the machines in the same platform which would lower the threshold to act. However, control of machines is not possible with Elvaco's products but there could be other ways to inform the user so they could manually control their energy products based on the data. The biggest motivator to act was financial arguments, lowering costs or increasing house value. The second motivator was the environment and securing a sustainable future. Actions could include isolation, renovation, upgrade or install new machines or change routines but moreover to set an average temperature or goals to decrease the consumption. There was a need to enable setting a schedule automatically or manually plus temporary control of that schedule if routines would deviate for temporarily or if the user is away from home. Finally, the participants stated the need for customisation, to choose what they want to see or how detailed the information should be. This also includes assigning personal knowledge to the system, such as energy labelling on machines or what the user did during a peak in consumption. As stated previously this would increase the understanding of their energy consumption.

6.2.6 Rating Scale

The answers from the questions that included a rating scale from 1 to 10 along with the question about whether users had a plan to reduce their energy consumption, were summarised in figure 6.9, which presents the participants' average ratings. These findings were utilized in the evaluation process for comparison, allowing for statistical validation of an improved solution.

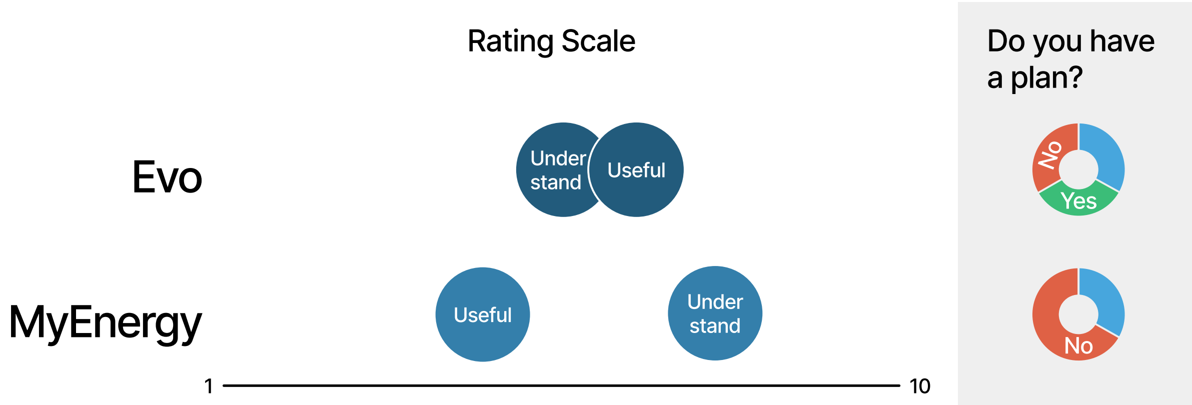

Figure 6.9 illustrates the results from the rating scale and question of a formulated plan during the interview (Authors contribution)

The findings established that Evo was considered moderately useful as a platform for energy efficiency, receiving an average rating of 5.6. Participant feedback included arguments such as: *"It is useful, but I do not know how to regulate the energy products"*, *"It is good that you can see the individual apartments and average values"* and *"If someone experiences their apartment as cold, you can evaluate based on the data and examine the cause"*. Since the usability test on Evo only displayed indoor temperature data, the participants requested the ability to compare this information with heating consumption data, which they believed would further facilitate the analysis. This limitation may have influenced perceptions of Evo's usefulness. However, the participants expressed a broader need for more advanced analysis tools and to make better use of the data it would require reviewing the apartments with extreme values manually.

Considering the understanding of the information presented on Evo the participants expressed divergent opinions, resulting in an average rating of 5. The primary reason for difficulties in understanding the information was related to the shortcomings in the graph, presented in section 6.2.2, "Graphs". One participant stated that they did not fully understand the graph, as the curves did not tell them anything. In contrast, other participants indicated that, despite the potential improvements to the graph, they were still able to interpret the curves and identify deviations and peaks.

When asked whether participants could formulate a plan to reduce their energy consumption based on the information provided from the platform, responses were mixed. One participant indicated that they had a plan which included improving the insulation and investigating the causes for extreme temperature values. Another participant stated that the platform provided a foundation for formulating a plan, marked in blue in figure 6.9, but emphasised that further analysis would be required. Lastly, one participant stated that they did not have a plan and felt that additional guidance and data were necessary to develop one.

The information presented on My Energy was considered relatively easy to understand with an average of 7. The participants highlighted that the bar charts and dashboard widgets were clear and straight forward. Additionally, they found the supplementary list accompanying the graphs to be clarifying, making it easy to retrieve exact numbers. The ability to view costs in relation to consumption further facilitated the understanding. However, despite its clarity, the information was not considered particularly useful, with an average of 4.5, as it only presented raw data without additional details or opportunities for deeper analysis. In terms of formulating an energy reduction plan, the majority of participants stated that they could not do so, as it would require a deeper knowledge of energy consumption which they were lacking. They expressed a need for greater insights into their energy consumption pattern as well as guidance on specific actions to take. Additionally, the platform did not offer decision-support tools or suggestions for improvement, instead simply displaying the data to raise awareness of energy usage. While two participants indicated that they might be able to formulate a plan, they acknowledge that doing so would require additional support and further analysis.

6.3 Key Performance Indicators

To summarise the user study, users have a need to see and compare their consumption with different values. This need can be translated to organisations need for key performance indicators, KPI, to evaluate and optimise their business or, in this case, energy use (InetSoft, 2025). Key performance indicators are tactical numbers or key values used for reaching the mail goal. As stated in the article (Persson, 2023), to reach the main goal of energy efficiency and optimisation on a platform for energy monitoring there are needs for indication values and analyses about the sub targets. Examples important KPI's for an end user to identify trends and patterns in the energy consumption are to see the consumption in real-time, provide alarms and notifications which enables monitoring and quick reactions to consumption peaks. Other KPI's of importance stated in the article, and translated to an end user of this project instead of an organisation, is cost analysis, carbon emissions tracking, energy intensity per square meter, peak demand costs such as spot price, equipment performance of different household suppliance, weather data to establish correlations, cost predictions for planning, set energy efficiency goals to establish objectives, renewable energy ratio and integration, quantify energy savings, compare with other to identify improvement potential, evaluate investments such as calculating return on investment (ROI), breakdown consumption by room or area, behaviour analysis and how activities impact the consumption, maintenance indications and sustainability reports with energy efficiency efforts to reduce carbon footprint. These KPI's corresponds to the findings from the user study and aim to help the user make decisions based on facts and data and thereby ensure energy savings.

KPI's regarding how the user platform interface can contribute to the main goal of energy efficiency and optimisation can also be found in the article (InetSoft, 2025). This includes, for example, content performers such as finding the page with most traffic or the page where users spend the longest amount of time which both indicates the most appreciated content. Moreover, scroll depth shows how far down the page a user scrolls and thereby indicates which content is being seen. Other KPI's related to enhancing the user journey on the platform are identification of user behaviour flow to identify popular paths or steps when navigating and user integrations such as clicks or hovers to identify improvements. Furthermore, user engagement metrics monitors the frequency of use of the dashboard plus how it is being used which can help customise the dashboard to user needs and make it more effective. These factors were observed during the user study, which the final concept aims to address and thereby further improve the user experience. Lastly, the KPI of constant access to the platform by a mobile alternative is of importance to enable monitoring energy use and make decision from anywhere at any time. Though this project only focuses on the webpage, the new Play Platform from Elvaco will offer an application for mobile devices, ensuring constant access to the metering data.

6.4 List Of Requirements

The findings from the user study, including the survey, usability tests and interviews, were analysed and translated into a list of requirements. A selection of these requirements is presented in table 6-1, while the full list can be found in appendix C.

Requirement 11 states the underlying need of users' desire to monitor their costs and consumption in real time, which is to see their cost and consumption of different energy products or behaviours and understand how much they consume and relate. A related insight, summarised in requirement 15, highlights the demand for sectioning energy consumption by specific appliances or energy products, enabling users to view exact consumption levels separately. While real-time monitoring could be one solution to meet these needs, other approaches could also be explored to achieve the same goal.

Another key requirement, requirement 21, reflects users' interest in comparing their energy consumption with similar households. The underlying need is to provide an indication of their consumption level, helping them to analyse whether their energy use is too high, too low or within acceptable range. This indication could be based on the standard level of other households or the sustainable level from an environmental perspective.

Table 6-1 shows selected parts of the list of requirements (Authors contribution)

List of requirements for unexperienced users on an energy metering platform					
Req ID	**Category**	**The new solution will…**	**Reason**	**D/N**	**Solution**
Req 3	General	…enable customisation for different types of users	Depending on level of knowledge about energy systems or what the user wants to see	Desire	Different account defaults for different users plus the user can change settings and choose what they want to see
Req 5.2	Understand	…align with the mental picture of an energy system	To increase understanding and facilitate analysis	Necessity	Illustrate a picture of a house with solar panels and electric car (or other users). Click on each part in picture to see data. Facilitates system overview (Req 5.1)
Req 8.1	Understand	…provide help identifying saving potentials	General and individual tips based on data. Improves motivation	Desire	Messages of most common improvements. AI assistant for individual tips based on data.
Req 11	Understand	…enable viewing the energy consumption and costs of different machines and behaviours	To increase understanding and motivation	Desire	Real time or calculate total consumption under graph
Req 12	Understand	…facilitate to involve and motivate others to save energy	For example, family members. To increase impact and motivation	Desire	Concrete numbers on consumption and savings. Visualise costs
Req 13	Understand	…enable assigning personal knowledge to the system	To increase understanding and facilitate analysis	Desire	Energy labelling, types of machines, number of residents
Req 15	Compare	…enable sectioning of machines	To facilitate the analysis and identify what's most consuming	Desire	Sectioning machines that run all the time and others that turns on temporarily
Req 21	Compare	…enable an indication of consumption level	To increase motivation and understanding	Desire	Comparing with other similar households/sustainable consumption/ standard consumption
Req 23	Graph	…present costs historically, total and upcoming	To increase understanding and motivation	Necessity	In graph and compared with consumption. Spot price

7 Phase 3: Final Concept

This chapter presents the final concept developed based on the user needs and requirements. The concept is described in detail by presenting and following different user cases with different needs and how they interact with the user portal. The unexperienced users, or end users, including housing cooperatives or rental apartment buildings, apartments and villas, are primarily interested in understanding and utilizing the energy metering data. Therefore, the new solution is designed to facilitate data analysis and comprehension by incorporating illustrations of the energy system, enabling multiple ways to utilize the measurement data, and increasing user motivation to reduce energy consumption. Additionally, the new solution aims to replace MyEnergy, integrating its purpose into the Play platform to create a more seamless customisation.

7.1 Hierarchy Of Final Concept

Since Elvaco's customers are businesses, such as utility companies, property managers, industries, installers or operators, they do not sell their solutions directly to the end user. Instead, it is the business customer who wants the ability to offer solutions to their end users. For example, a property manager buys Elvaco's Play solution, including meters and the user platform, and offers it to a housing cooperative which in turn wants their residents to have access to the metering data. Therefore, the user hierarchy of the new Play platform is highly relevant, as illustrated in figure 7.1.

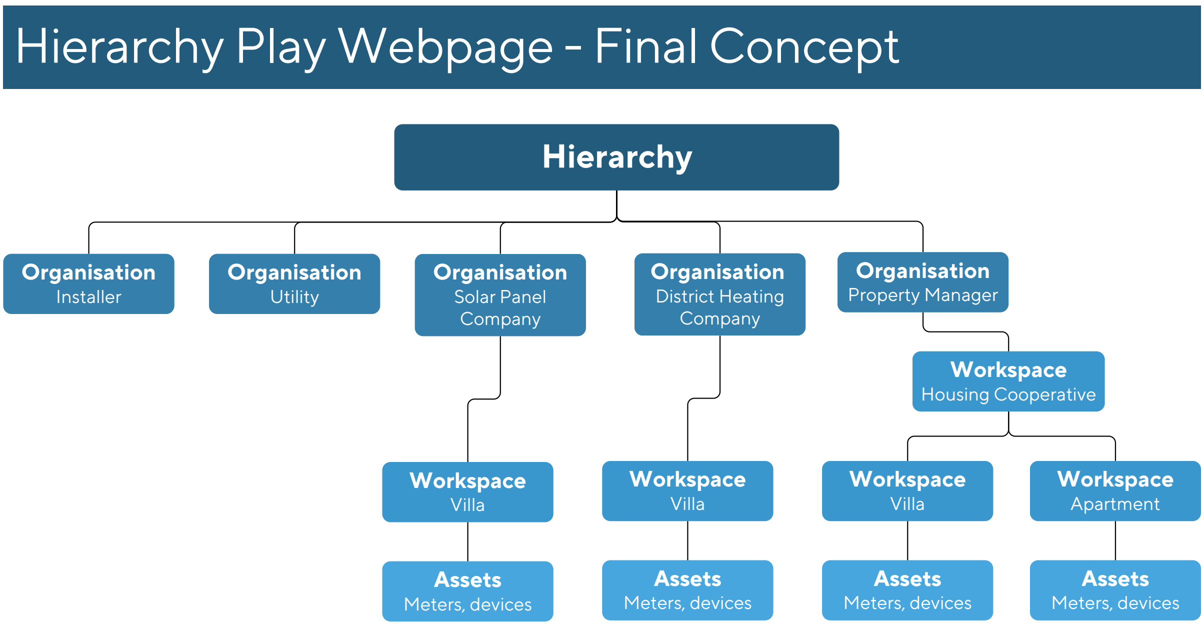

Figure 7.1 illustrates the user and workspace hierarchy structure of the new concept (Authors contribution)

In addition to the existing user hierarchy on the Play platform of organisations, workspaces and assets, as presented in chapter 2 section 2.1, the new solution introduces the ability to create workspaces within workspaces, such as apartments in an apartment building. Other user cases are district heating companies that use Elvaco's meters for individual billing where they can create a workspace for a villa or solar panel companies which creates workspaces for their villa customers. In each workspace the end user's assets, such as meters and devices, are grouped.

Figure 7.2 illustrates the final concept's dashboard of a housing cooperative that has logged in to their workspace.

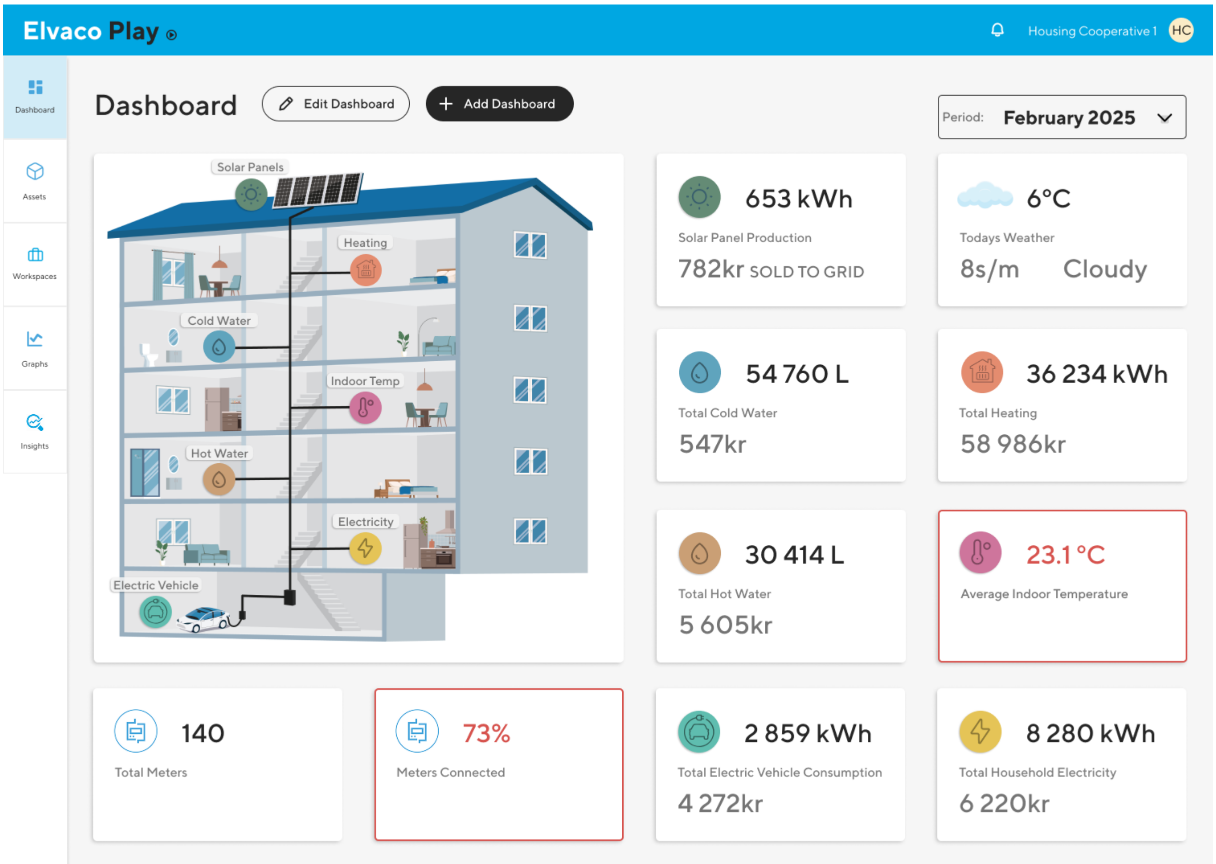

Figure 7.2 shows the dashboard of a housing cooperative logging in to their workspace (Authors contribution)

To describe the purpose of the workspace a specific workspace type can be set, such as city, street, apartment building, apartment, villa, water meters or electricity meters. The workspace type enables the display of an illustrated picture on the dashboard to further facilitate the overview and enhance the understanding of the workspace. As figure 7.3 shows, when the workspace type is set to apartment building a corresponding illustration is displayed. These illustrations were created in Adobe Illustrator and include a villa, an apartment and an apartment building. For further development, the workspace type could incorporate different functionalities depending on the needs and requirements for each use case which aligns with the need for customisation and individualisation from the research and user study.

The final concept introduces the ability to invite end users, such as apartment owners or villa owners, to a workspace with a role of "User". When logging into an account assigned this role the users are directed to the workspace to which they were invited. This role implicates two new tabs to the menu bar, "Graphs" and "Insights". Additionally, it also removes the "Assets" and "Workspace" tabs on the menu bar as the end user is only interested in the measuring data and not in the grouping, functionality or installation of the meters. Furthermore, when logging in as a user, the default widgets on the dashboard are preconfigured based on the workspace type defined by the organisation. Since the user is primarily concerned with metering data, the widgets display energy consumption and costs rather than connectivity or number of meters installed, see figure 7.2. However, this can be adjusted manually under "Edit Dashboard" enabling user control and customisation. Lastly, the user role enables a household profile where the user can add personal information such as number of residents, electricity machines used or their electricity price.

The new "User" role, together with the existing roles "Can Edit" and "Can view", and the corresponding menu tabs that are included in each role, are outlined below:

- **User:** Graphs and Insights.
- **User Can Edit:** Graphs, Insights, Workspaces and Assets.
- **Can Edit:** Workspaces and Assets.
- **Can View:** Workspaces and Assets but with no editing capabilities.

To provide further clarity, the overall functionalities included in each menu tab are listed below:

- **Assets:** Overview and list of meters, devices and facility identification numbers.
- **Workspace:** Grouping of assets.
- **Graphs:** Visualisation of metering data trough graphs with different filters and tools, including register investments and behaviours and an AI-assistant.
- **Insights:** Utilization of metering data in different ways, such as comparison or informational features such as Tips & Tricks to enhance understanding and facilitate analysis.

The hierarchy structure of the platform allows property managers and housing cooperatives to access personal energy consumption data, which can be linked to specific apartment numbers and, in turn, identifiable individuals. Consequently, residents' or tenants' consent is required to ensure compliance with General Data Protection Regulation (GDPR) (Wolford, 2018). Users must be fully informed about the data collection process, including which data is gathered, the purpose of collecting, which in this case is energy efficiency, the duration of storage, who have access, and their GDPR rights. Additionally, their consent needs to be in a written agreement. Several GDPR principles must be considered, including the minimisation principle which states that only necessary data should be gathered. Moreover, access restrictions must be enforced, ensuring that only authorised people can view the data, which is managed through the different roles on the platform. Additionally, data should not be stored longer that necessary, and security measures need to exist to prevent unauthorised access. From a technological standpoint, these security measures are already implemented in the Play concept by Elvaco, ensuring that data protection and access control aligns with GDPR.

7.2 Property Manager

To further outline the hierarchy of the platform the onboarding of a property manager's workspace for a housing cooperative is presented in this section and illustrated in figure 7.3.

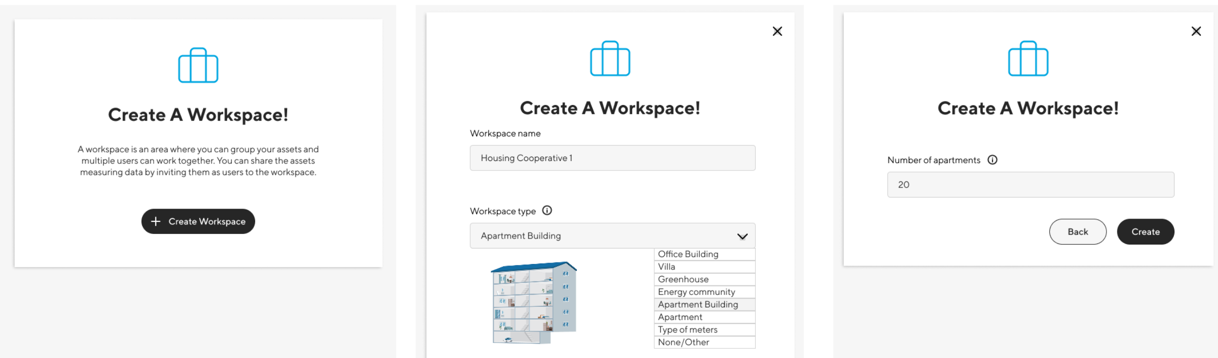

Figure 7.3 illustrates the onboarding of a property manager creating a workspace for a housing cooperative (Authors contribution)

First, the property manager navigates to the “Workspaces” menu tab where the “Create A Workspace” box is visible, see figure 7.3. Subsequently, the workspace name and type are set depending on the workspace’s purpose. In this example, the workspace type is set to “Apartment Building” which enables an additional step where the user can establish the number of apartments in the building. This creates 20 apartment workspaces within the housing cooperative’s workspace, see figure 7.4.

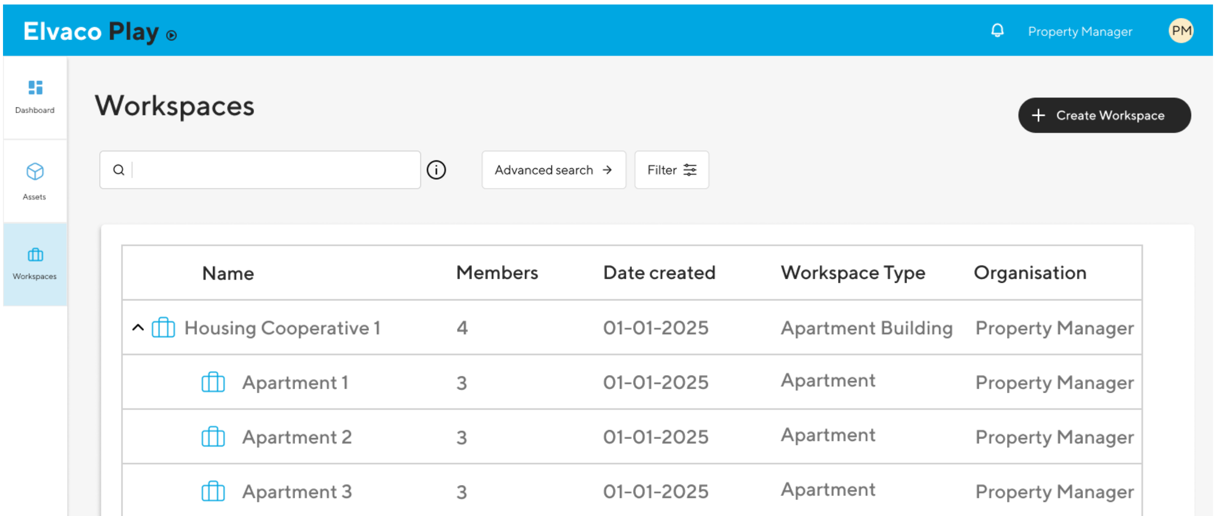

Figure 7.4 illustrates the workspace menu tab after creating workspaces for a housing cooperative (Authors contribution)

By clicking on “Apartment 1” the property manager is presented with an overview of the workspace with an illustrated picture of an apartment. Since property managers are more concerned about the system, the widgets display the functionality of the assets and the number of members in that workspace, see figure 7.5.

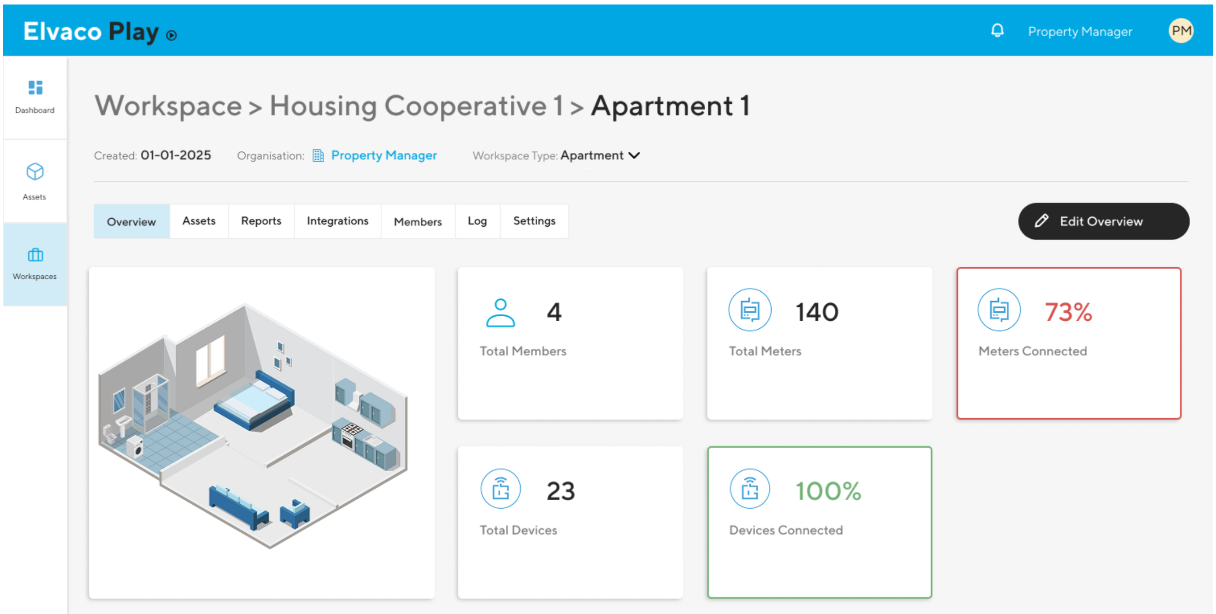

Figure 7.5 illustrates the workspace overview from an organisation’s perspective, in this case the propery manager (Authors contribution)

If the workspaces are created first, the installer can assign each device to its respective workspace directly during installation, facilitating more efficient grouping and time management. In the workspace under “Members” the property manager can invite board members of the housing cooperative, residents, or installers to respective apartment and set their roles, see figure 7.6.

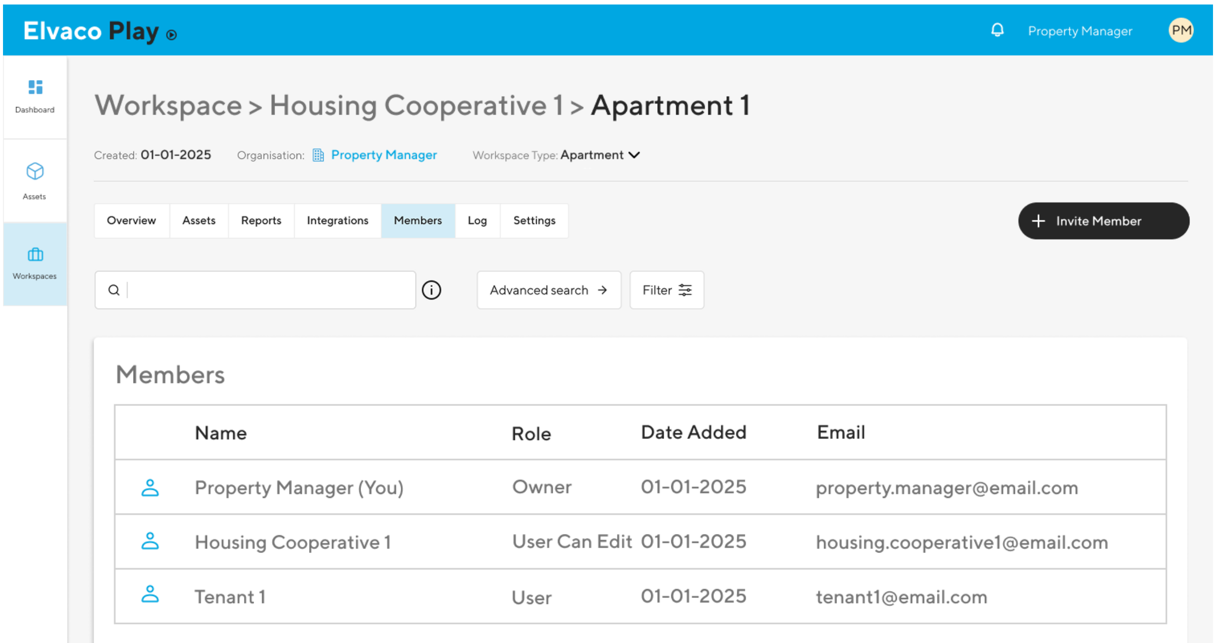

Figure 7.6 illustrates the organisations overview of workspace members (Authors contribution)

7.3 Housing Cooperative

The next use case is a board member of a housing cooperative who has been invited to the workspace "Housing Cooperative 1" with the role as "User Can Edit" by the property manager. The purpose of the Play platform for the housing cooperative is to enable individual metering and billing of the residents. Upon logging into the workspace, the board member is presented with an illustration of an apartment building on the dashboard, see figure 7.2. Since the role is set to "User" the widgets display the energy consumption data and costs, based on the primary concerns of this user type. The grouping of the different energy sources on the widgets, such as electricity, heating and water, are automatically configured by detecting the different types meters installed and grouped in the workspace. It can be expected that the property manager may charge extra for managing workspaces and members. Therefore, the role "User Can Edit" exists to allow the housing cooperative to manage their own workspaces and add members independently. Additionally, this aligns with the requirement for customisation from the user study, enhancing the user control.

7.4 Apartment Owner

By following the use case of an apartment owner, the new functionalities for understanding and analysing the data are presented. This section presents the use case of a resident who has been invited by the housing cooperative to the workspace "Apartment 1" with the role as "User".

7.4.1 Dashboard

Once again, the widgets on the dashboard display energy consumption and costs based on the "User" role, see figure 7.7. In the top right corner, the user can choose which default time period for which the total energy consumption is calculated and presented on the widgets. By clicking on the widget or icon corresponding to each energy consumption the user is navigated to the "Graphs" menu tab and the graph visualises the metering data for that specific energy source.

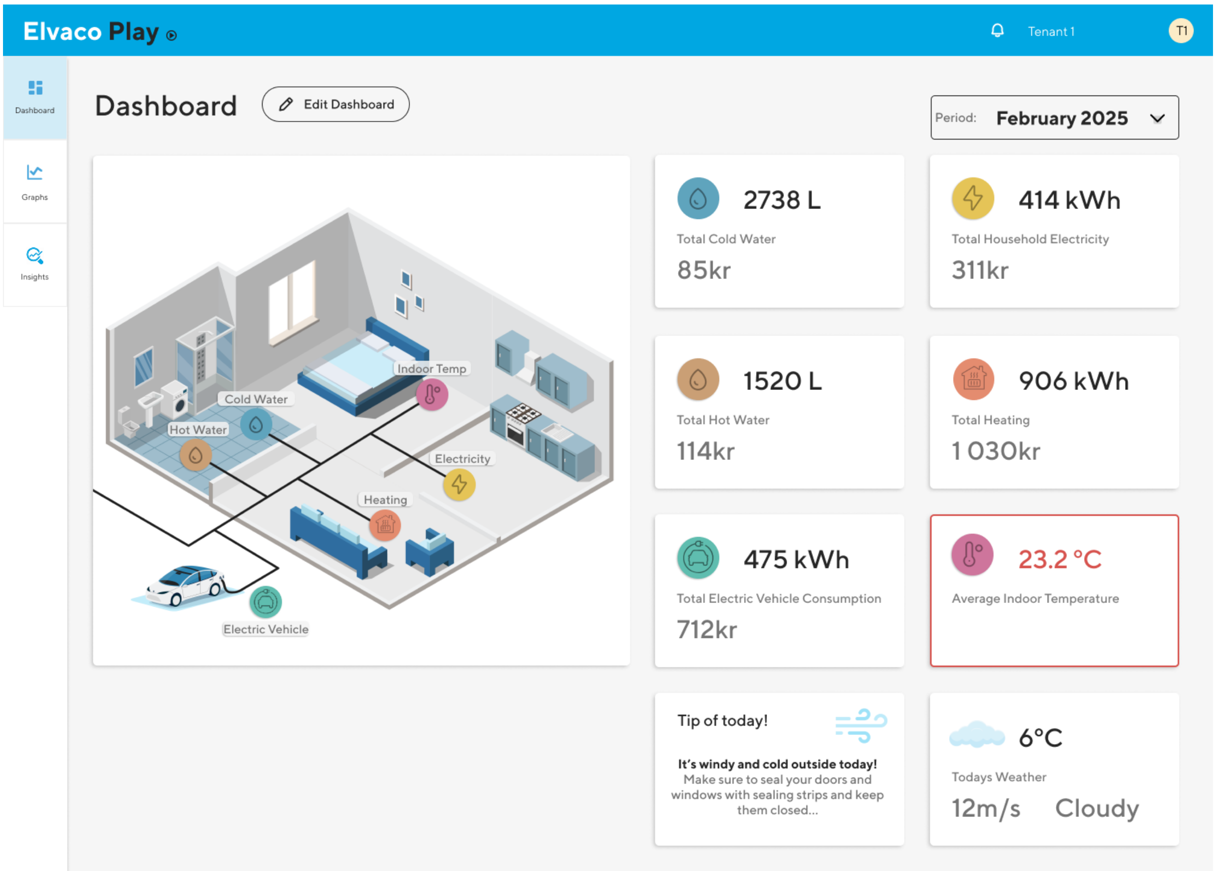

Figure 7.7 illustrates the dashboard of an apartment owner logging in to their workspace (Authors contribution)

One widget displays today's weather, including the outdoor temperature, wind speed and type of weather. This indicates that the platform records the weather, allowing consumption data to be compared with the outdoor temperature, as required from the user study. Outdoor temperature often has a direct impact on energy consumption. For example, heating consumption increases when it is cold outside. By incorporating outdoor temperature into the platform, the users gain a reference value for comparison, which enhances understanding and facilitates analysis. Additionally, by clicking in the weather widget the outdoor temperature is displayed in the graph.

By presenting energy measurements and costs, the dashboard facilitates the comparison and overview of the different energy sources, aligning with the need to accelerate the identification of the most energy-consuming aspects. Lastly, a widget called "Tip of Today" provides energy-saving suggestions or important insights about energy systems. These statements are up to date and continuously updated. For more details about this see "Insights" in section 7.4.4.

The illustration of the apartment is static and does not adapt to different apartment layouts. However, it helps the user form a mental image and cognitive understanding of their household and gain an overview of the monitored energy sources. The icons within the illustration change depending on which meters are installed, and by clicking on an icon the user is directed to the graph of that specific energy measurement, mirroring the functionality of the widgets. Additionally, the icons are color-coded on both the dashboard and the graphs to further enhance differentiation and comparison of the energy measurements. The visual representation of a household's energy system aligns with the finding from the usability tests where the users preferred to navigate using the visual map to locate the different meters and measurements. Since the user study indicated that basic knowledge of energy systems is often limited, this illustration aims to provide users with a clear reference point and facilitate the cognitive process of understanding the energy system through cognitive mapping (Gibbons, 2019) where the illustration represents the mental model of an energy system.

7.4.2 Household Profile

To meet the requirement of assigning personal knowledge to the system the final concept includes "My Household Profile" located under the profile menu, see figure 7.8. The Household Profile, along with additional system information, enables data utilization in different ways under the "Insights" menu tab. The user can set limits for indoor temperature and household electricity power consumption in the household profile, see figure 7.8. They can also input square meters and number of residents into the platform, see figure 7.9, to allow comparisons with similar households. Additionally, they can register their electricity, water and heating prices.

If the indoor temperature deviates from the set interval, a red outline appears on the dashboard widget, and the user can also choose to receive a mobile notification. Since the platform cannot directly control the heating system, this function allows the user to manually regulate the radiators. Similarly, the user can set a maximum power threshold for the electricity and turn off appliances manually when the limit is exceeded. This functionality aims to help avoid power tariffs, which are additional grid fees based on consumption peaks (Fortum, 2024). The notifications steer the user with just-in-time prompts, providing an opportunity to reflect on their energy consumption and thereby act to reduce energy usage and costs (Selvefors, 2023).

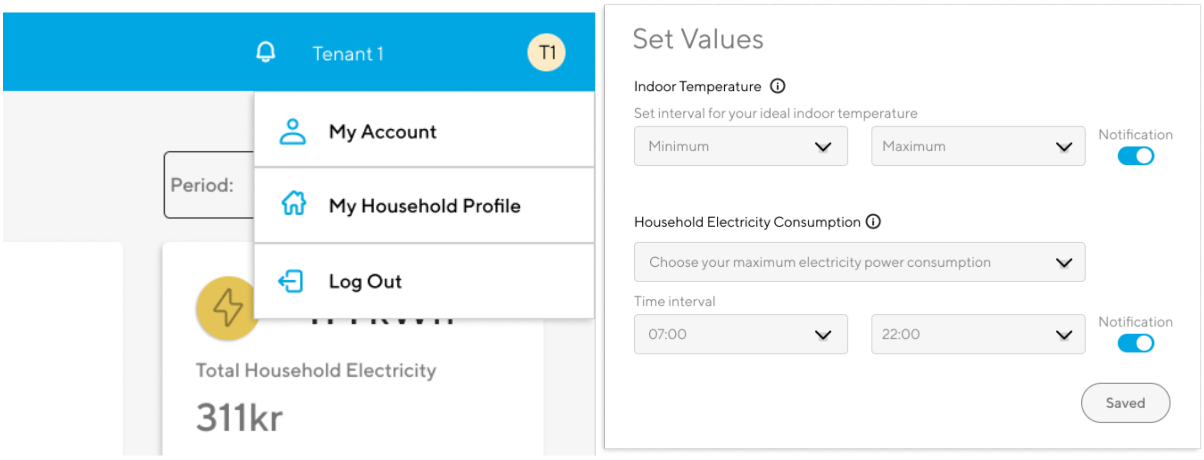

Figure 7.8 shows the location of the household profile on the platform and the settings for value limits (Authors contribution)

A key finding from the user study was the need to categorise different appliances and identify which consume the most energy. With Elvaco's existing technology this would require an electricity meter for each individual household appliance. However, the electricity consumption can be differentiated between appliances that run constantly and those that are used temporarily. In the graph, temporarily used appliances generate peaks while the constant-used appliances generate a straight line. The system then calculates the area under the curve to determine the total electricity consumption for both cases.

Another requirement from the users was to visualise the cost of their energy consumption. To generate the exact value, the user authenticates their identity via BankID to access price and fee information from their electricity retailer and grid fee provider. A summary of these costs is then displayed below, as figure 7.9 shows. This method is used by banks to gather the users balance from other bank's accounts and to have them all in one place (SEB, 2025). For example, a SEB customer with an additional account at Nordea can view all balances on the same platform. However, the user must manually refresh the authentication each time the balance updates to access the latest data. In this case, this method is suitable since the electricity price or grid fee subscription do not change frequently. The user only needs to renew the authentication when changes to the subscription occur.

The price for water is based on location and water meter size, the size is determined by the nominal flow (Göteborgs Stad, 2025), which the system already knows and therefore this is preconfigured. In the case of an apartment owner, the heating price of district heating is predefined by the housing cooperative, using the same functionality as for electricity pricing. The text "Your heating consumption is seen under 'Heating'", indicates where the data can be found. If a user has electric radiators or an electric boiler as heat source the consumption is included under household electricity, highlighting the need for further clarification.

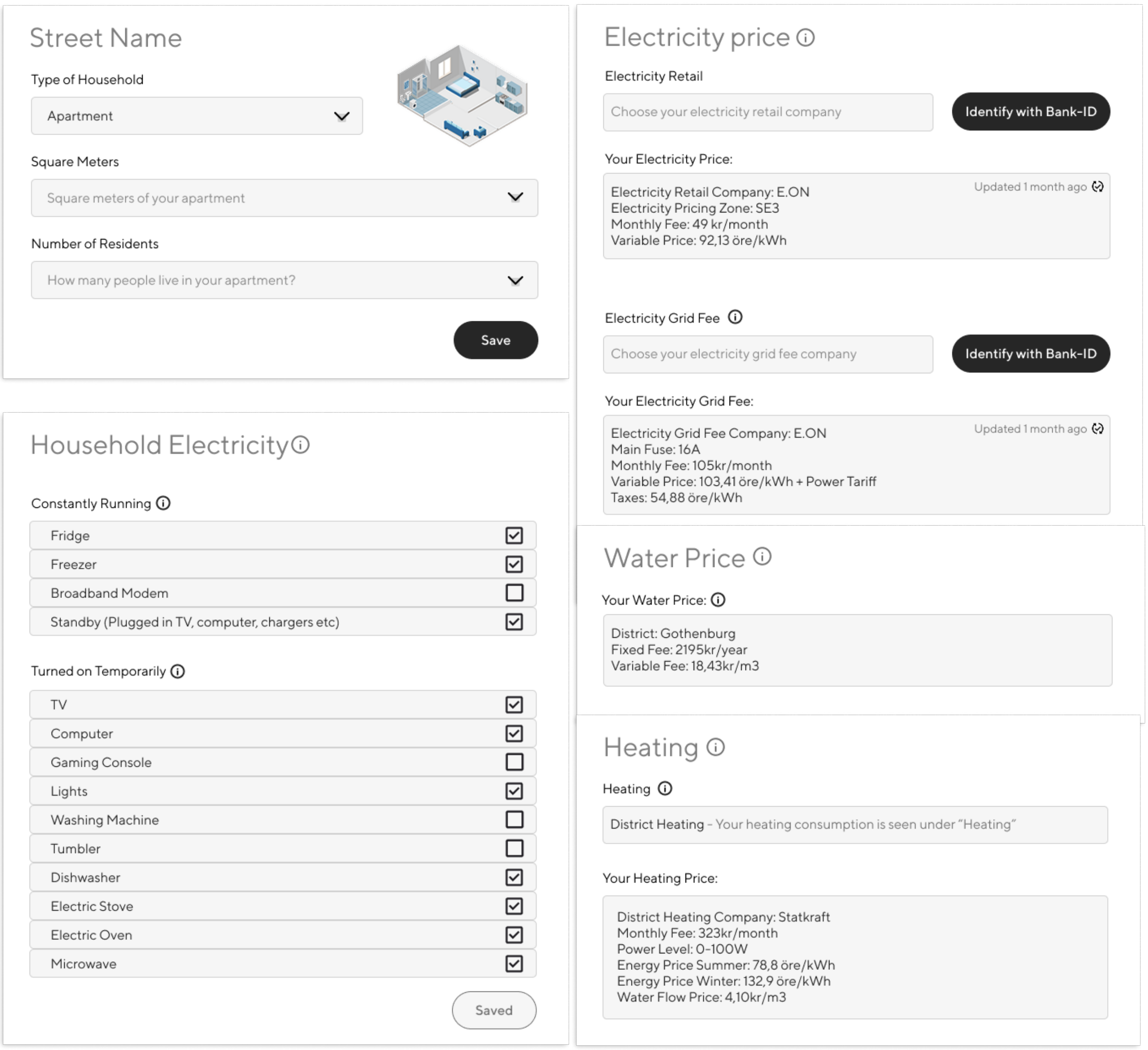

Figure 7.9 illustrates the different functionalities of the household profile (Authors contribution)

7.4.3 Graphs

The “Graphs” menu tab presents the metering data in a graph format with various filters. These functionalities and visual representations are already included in the early-stage development of the Play Platform from Elvaco and are thereby used as a foundation for this page. However, four additional functionalities have been introduced; “Compare Period”, “AI-Assistant”, “Behaviours” and “Investments”, see figure 7.10.

The ”Compare” function, located at the top of the page, enables users to compare energy consumption across different periods, addressing the need identified from the user study. The “AI-Assistant” provides support for specific analyses based on individual metering data and is further described under “Insights” in section 7.4.4.

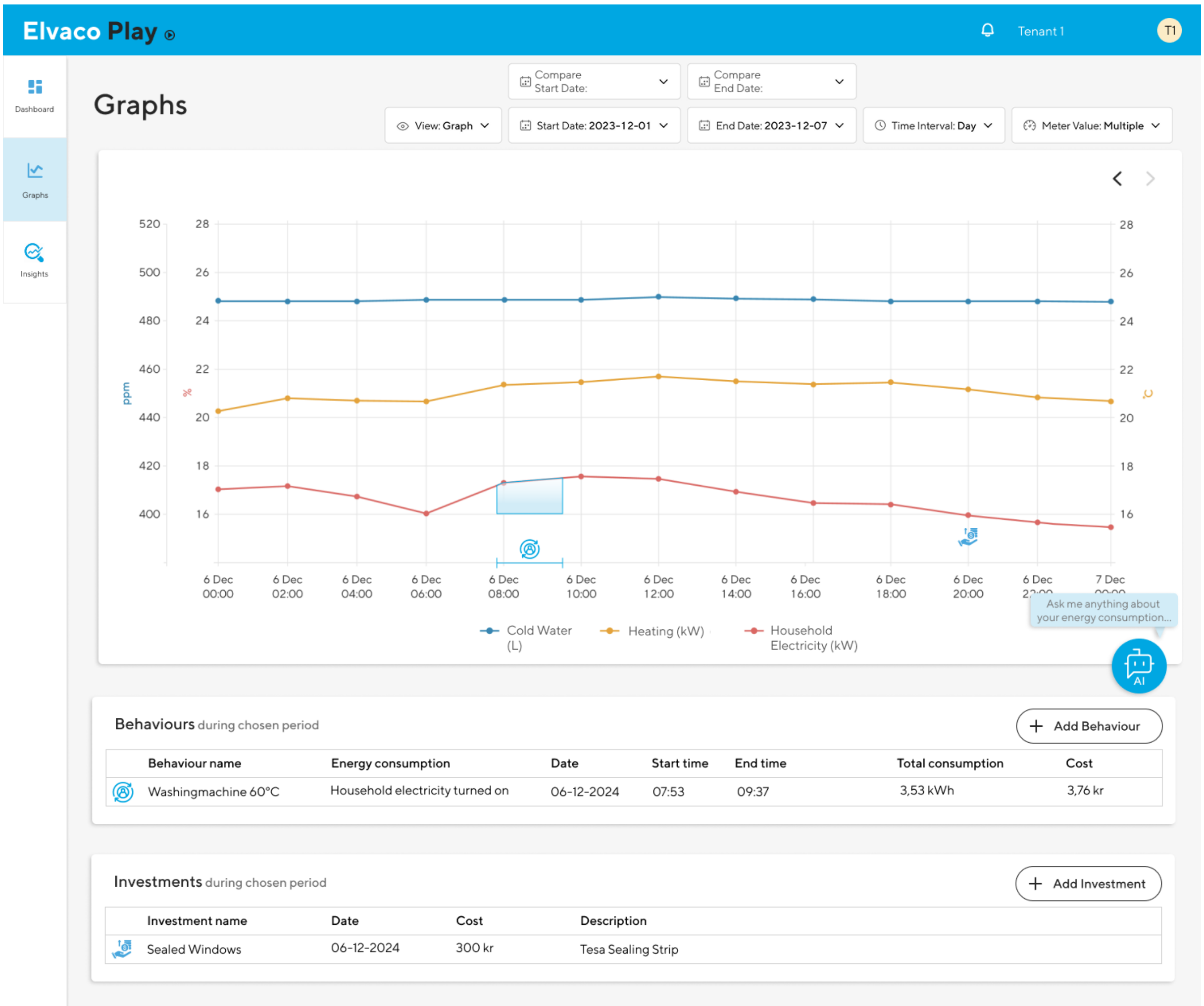

Figure 7.10 shows the Graphs menu tab with added functionalities (Authors contribution)

In the user study the participants expressed a desire to know how much energy a washing program consumes or how much it costs to run an air heat pump. A potential solution would be to present real time consumption data. However, Elvaco’s meters have a one-minute interval as the highest resolution for sending data. This delay disrupts the real-time experience, since users would need to wait a full minute after turning on a household appliance before observing changes in the graph. Nevertheless, the underlying user need for real-time monitoring is to understand how much each appliance consumes and how much it costs.

To address this, the "Behaviours" function has been added to the graph, allowing the users to select an energy measurement, a start time and an end time, see figure 7.10. This enables users to determine the cost and total energy consumption during a specific period. For example, if a user wants to know how much electricity their coffee machine consumes when brewing four cups of coffee, they first need to select "Household Electricity Turned on Temporarily" as the energy source. Next, they need to set a starting time, wait for the coffee to brew and then set the end time, which can also be done retroactively. The system then calculates the area under the curve, representing the total consumption, given that only one behaviour occurs simultaneously. Additionally, since the electricity price is registered in the Household Profile the system can also calculate the cost. In the example from figure 7.10 the user can see the total cost, water and energy consumption required for a 60 ºC washing program, which may be higher than expected. As a result, the motivation to save energy increases due to the exact figures provided by the platform.

Similar to the "Behaviours" function, the "Investments" feature allows users to follow up on their investments by registering the time and cost of an investment, see figure 7.10. This action adds a visual note to the graph and allows users to both visually analyse the graph before and after the investment to observe changes to the curve or to utilize the AI-Assistant to generate individual and precise data on energy and cost savings. According to the user study, motivation increased when the user can evaluate an investment based on exacts saving figures, allowing them to determine whether an investment has been financially beneficial or estimating when it is expected to break even. Additionally, the Investments function could assist housing cooperatives to follow up on their long-term maintenance plan.

7.4.4 Insights

The "Insights" menu tab is where the metering data can be utilized and compared in various ways, see figure 7.11. Its primary objective is to provide additional value to the user experience by enhancing the users' understanding and analysis of their metering data, thereby increasing motivation to save energy. A key requirement identified in the user study was the ability to compare consumption with other households, offering users indications on potential energy saving opportunities. In the example from figure, an apartment owner in a housing cooperative can compare their consumption with similar households within the building, as that data is gathered from the other apartment workspaces. However, from a GDPR perspective, ensuring data anonymity is crucial (Wolford, 2018). Therefore, this function is only available in large housing cooperatives or apartment buildings with sufficient number of apartments to prevent individual data to be identifiable. Similar households are defined as apartments with the same square meter area and number of residents, as registered in the Household Profile. Users can select the different energy consumptions, such as household electricity, heating, or water, and specify the period they wish to compare.

The "Costs" widget compares the cost of the different energy sources to facilitate analysis and accelerate the identification of potential savings, thereby increasing user motivation. Here, the household electricity is categorised into "Turned on Temporarily" and "Constant Running" to provide a clearer breakdown. When hovering with the mouse pointer over respective bar, a list appears displaying the appliances that were checked under the Household Profile. Additionally, in the "What consumes most energy?" widget, users can see how much energy each source consumes in kWh, further aiding in identifying areas where savings can be made.

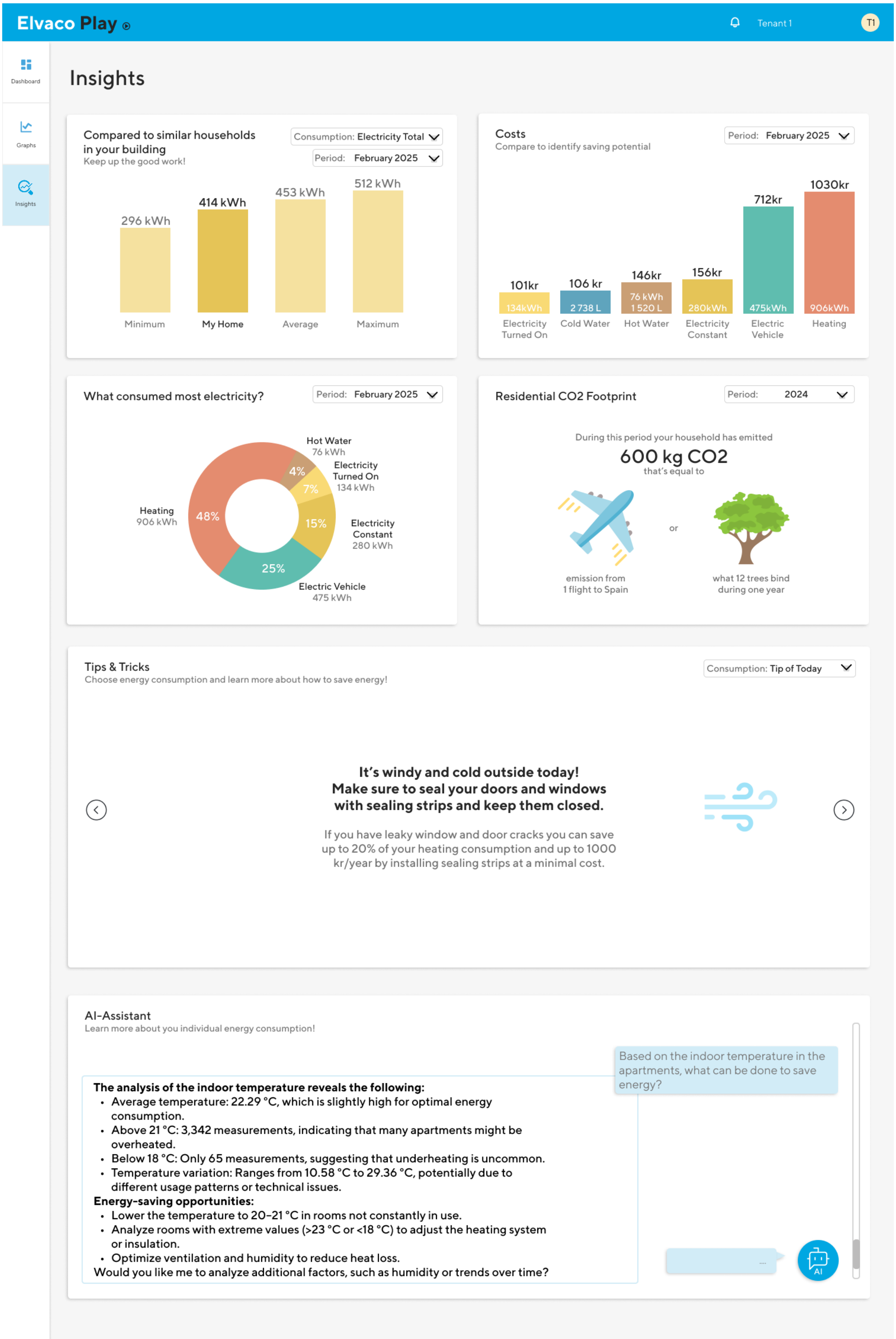

Figure 7.11 illustrates the Insights menu tab with functionalities (Authors contribution)

Furthermore, the "Residential CO_2 Footprint" widget provides an indication on the sustainability impact of a household's energy consumption, displaying the total CO_2 emissions for a selected period. Since the user study revealed a need for more understandable terms and units, the emissions data is contextualised by comparing it to the CO_2 impact of a flight (Fasadgruppen, 2025) and the amount of CO_2 a certain number of trees can bind (Plantmore, 2025). These comparisons make the information easier to grasp since the users already have a perception of the amounts. The function aims to facilitate the cognitive process of understanding emissions. The widgets on the "Insights" page are adaptable based on what is being measured and the workspace type, with additional examples presented in section 7.5 "Villa Owner with Solar Panels" and 7.6 "Villa Owner with District Heating".

The "Tips and tricks" function provides general information on energy consumption along with practical suggestions for reducing energy consumption. As stated in section 7.4.1 the "Tip of Today" widget on the dashboard links to this function, allowing users to toggle between the latest energy-saving recommendations. Two examples of these tips are presented in the figure 7.12 and include sealing the windows on windy days (Zeller, 2024) and explaining the relative new concept of power tariffs (Fortum, 2024). Other tips could also include estimating the electricity costs of Christmas lights in December (E.ON, 2025).

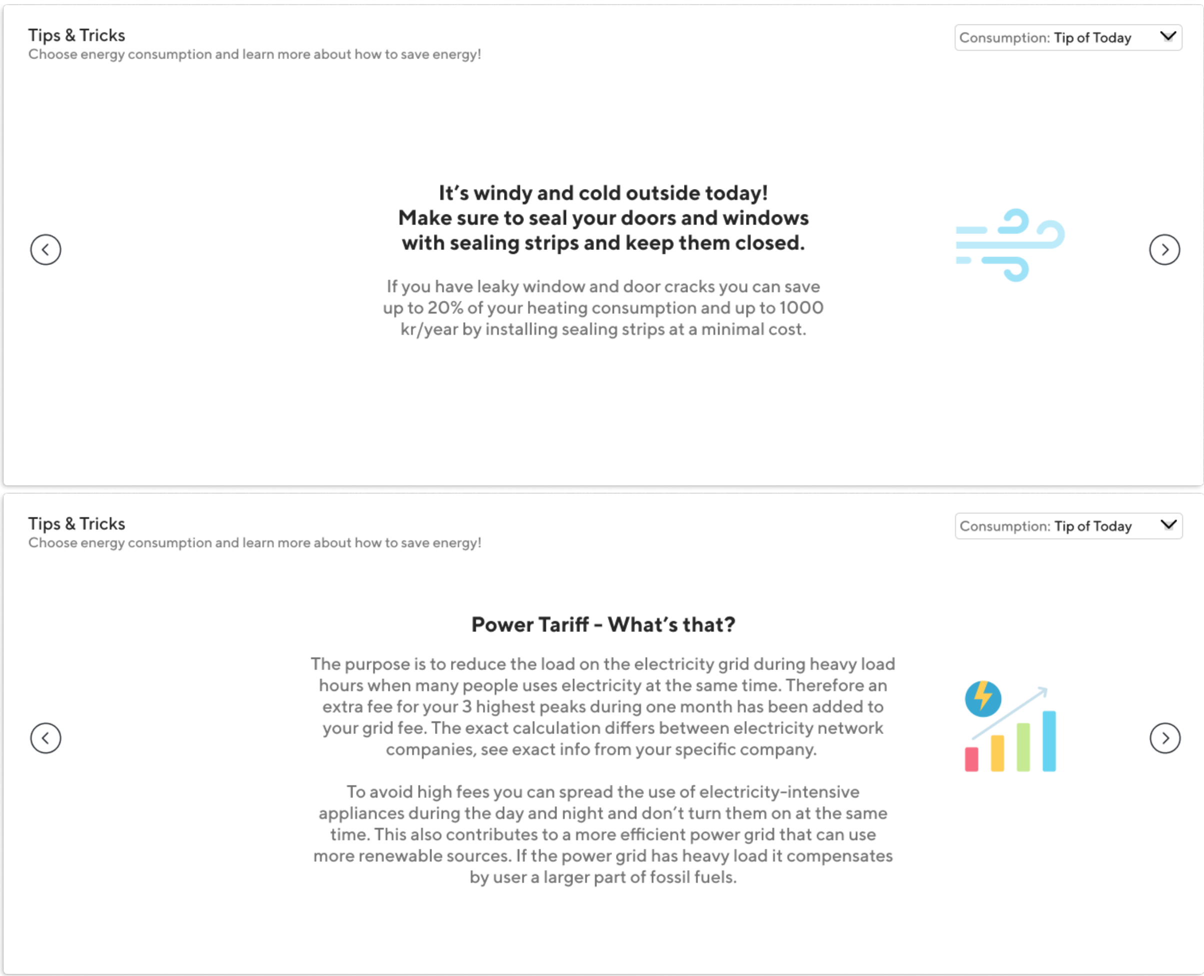

Figure 7.12 shows two examples of Tips and Tricks linked to Tip of Today on the dashboard (Authors contribution)

Moreover, users can select which energy source they want to learn more about using a dropdown menu in the top right corner of the widget, see figure 7.13. The available options depend on the energy sources registered in the workspace and the Household Profile, which in this case include electricity, water and district heating. Participants in the user study stated that “kWh” as a unit was difficult to interpret. Consequently, the “Tips and Tricks” section for electricity includes a table illustrating what 1 kWh equals to in familiar household activates, such as the duration various appliances can run on 1 kWh. This feature improves user comprehension by linking energy consumption to relatable real-life examples. Additionally, the “Tips and Tricks” function explains why users should save energy by presenting both environmental and financial arguments, along with actionable suggestions. For example, washing clothes at 40°C instead of 60°C reduces energy consumption (E.ON, 2024). Similarly, the water consumption section in figure 7.13, highlights that a 10-minute shower consumes approximately 120 litres and that heating 20 litres of water requires 1 kWh (E.ON, 2025). Suggested actions to reduce water consumption includes taking showers instead of baths, turning off the tap while brushing teeth, and fixing dripping faucets. Useful information regarding district heating could be recommended actions that include improving insulation and lowering the supply temperature by 3°C, which in practice reduces the indoor temperature by approximately 1°C and decreases the energy consumption by 5% (Özmen, 2023).

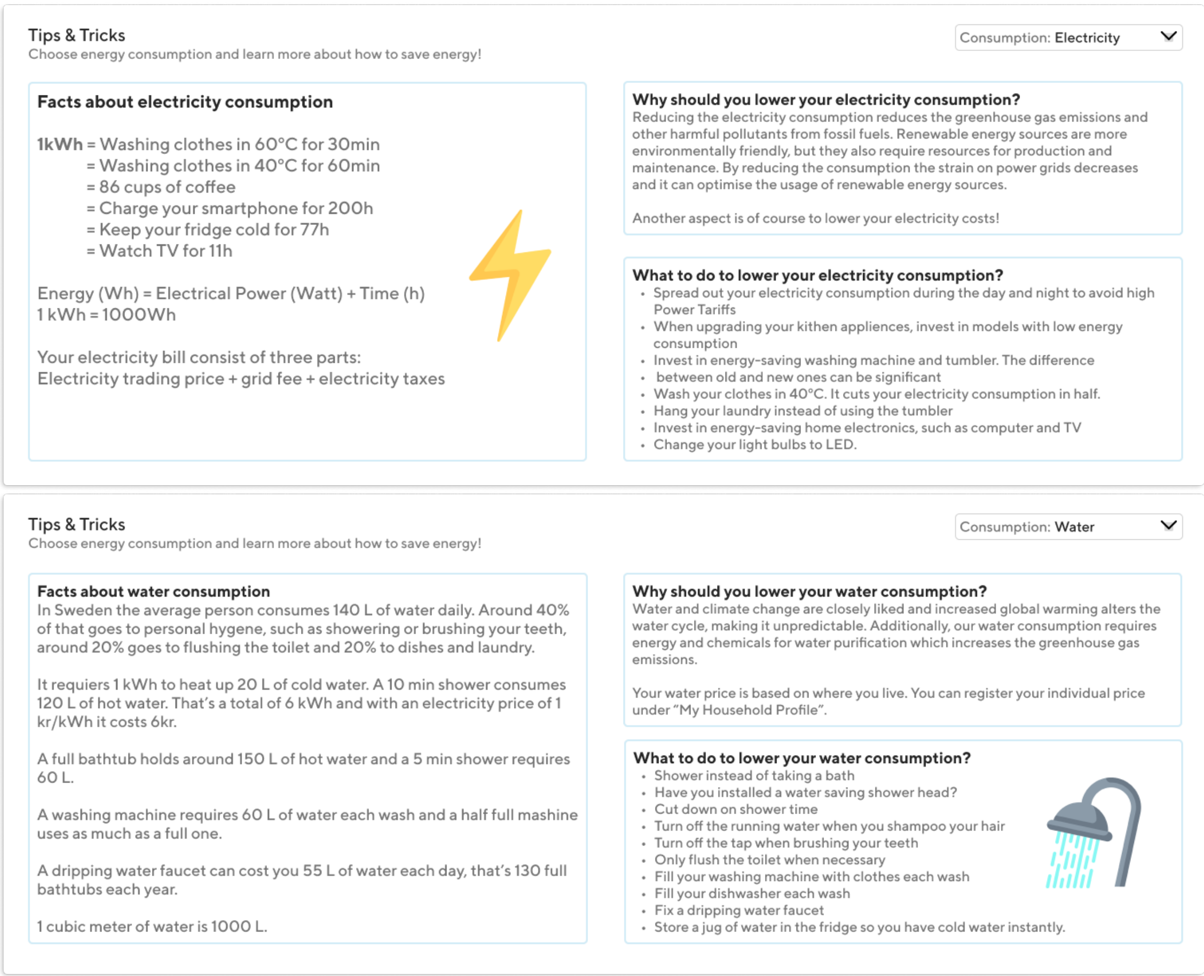

Figure 7.13 shows two examples of the Tips & Trick widget providing energy information (Authors contribution)

These relatable figures increase knowledge and facilitate understanding and thereby reinforces changes in energy-saving behaviours and actions. By utilizing nudging with the informative message in the “Tip of Today” widget, the user’s automatic behaviour of merely looking at the energy consumption data, breaks into reflective thinking of how to make changes to reduce energy (Selvefors, 2023).

To further leverage the "AI-Assistant" from the graph and enable a more in-depth analysis, an AI-powered chat function is integrated within "Insights". This feature allows users to further engage in interactive discussions and receive elaborated answers. As illustrated in figure 7.14, ChatGPT (OpenAI, 2022) was utilized to demonstrate the AI-Assistant's capabilities in generating tailored answers. In this example, ChatGPT was provided with specific instructions through prompts related to energy metering visualisation in an apartment building, along with an uploaded CSV file containing real indoor temperature metering data from the housing cooperation featured in the user study. The following inquiry was then made:

> *"Based on the metering data of indoor temperature in the apartments presented in this file, identify energy-saving actions."*

The AI's response highlighted a high average indoor temperature, suggestion to improve insulation and recommended further analysis of apartments exhibiting extreme values. Despite the absence of direct heating consumption data, the response was highly detailed and insightful, demonstrating the potential of the AI-Assistant in guiding unexperienced towards energy-efficient decisions. Additionally, this AI feature can be utilized by other stakeholders such as installers or operators. For instance, if Elvaco's device manuals were uploaded, the installer encountering an issue could directly consult the AI assistant for guidance, streamlining troubleshooting and installation processes.

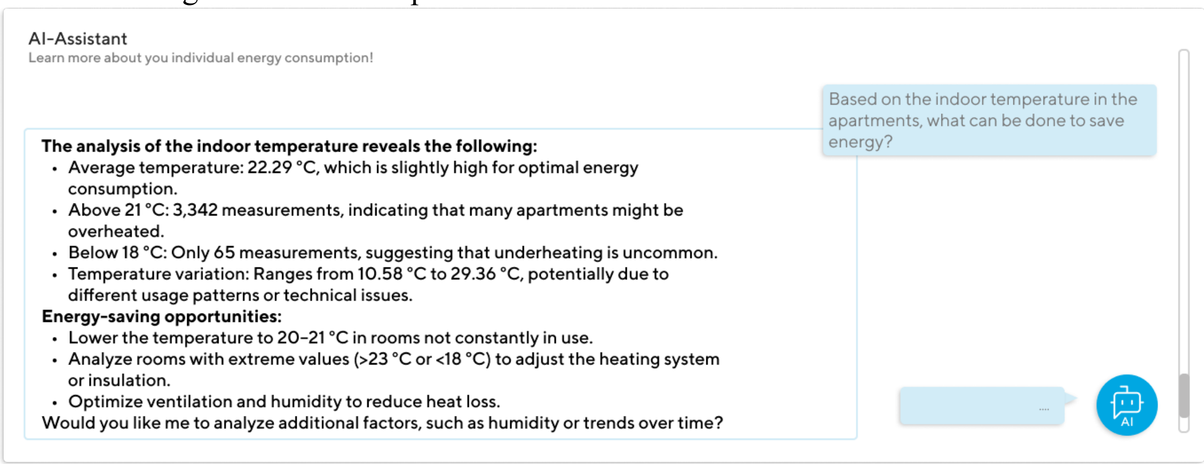

Figure 7.14 shows an example of utilizing the AI-chat under the Insights menu tab (Authors contribution)

7.5 Villa Owner With Solar Panels

A key use case of the user study was a villa owner with solar panels and an electric car. While this is not the typical customer profile for Elvaco, the findings from the user study indicate a market demand, presenting a potential future business opportunity. The modified widgets and functionalities on the "Dashboard", see figure 7.15 and under "Insights", see figure 7.16, are based on the installed meters in the workspace om addition to the workspace type.

A critical insight from this use case was the need for visualising the instantaneous status of the energy system, including solar panel production power, electric car charging status, battery load level and household electricity consumption. Considering the platforms limited real-time capabilities, the dashboard instead visualises the "Last reading" of the metering by setting the period in the top right corner to "Instantaneous", see the second example in figure 7.15. This feature displays the most recent meter reading, showing power in watts instead of total consumption in kWh, as well as the battery charge percentage. Additionally, since this user type typically utilizes spot pricing for electricity, a dedicated widget displays the current spot price, allowing users to plan their energy consumption accordingly.

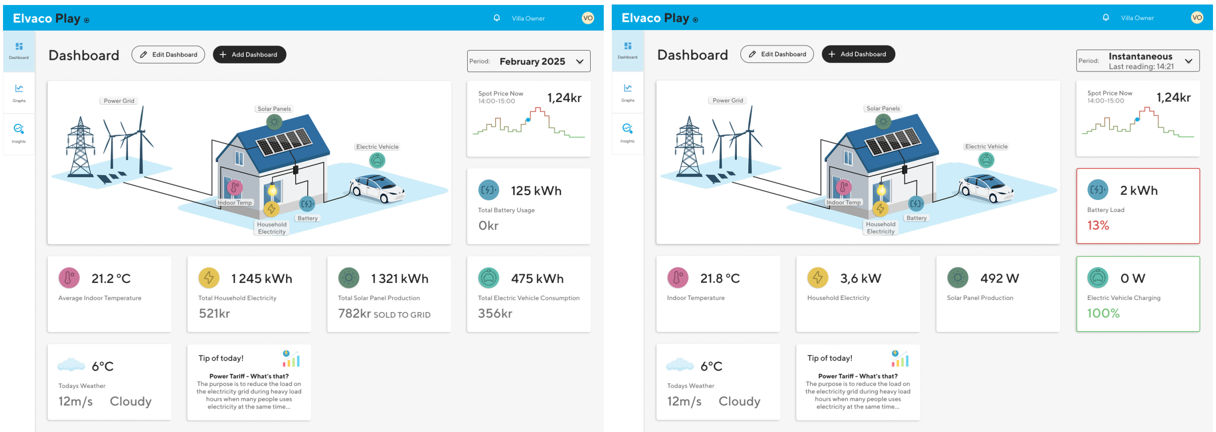

Figure 7.15 shows a villa owner's dashboard in two different states (Authors contribution)

Some widgets under "Insights" are added to meet the specific needs of users with solar panels and includes "Own Consumption" which shows the source of the consumed electricity and "Solar Panel Production" which visualises how the generated electricity is utilized. Additionally, the widget "Spot Price" displays today's price, the current electricity price and tomorrow's upcoming price, which is available daily after approximately 1 p.m. (Henrik, 2022). To further assist users in optimising their energy consumption, the current electricity costs of various household activities are also displayed within the "Spot Price" widget.

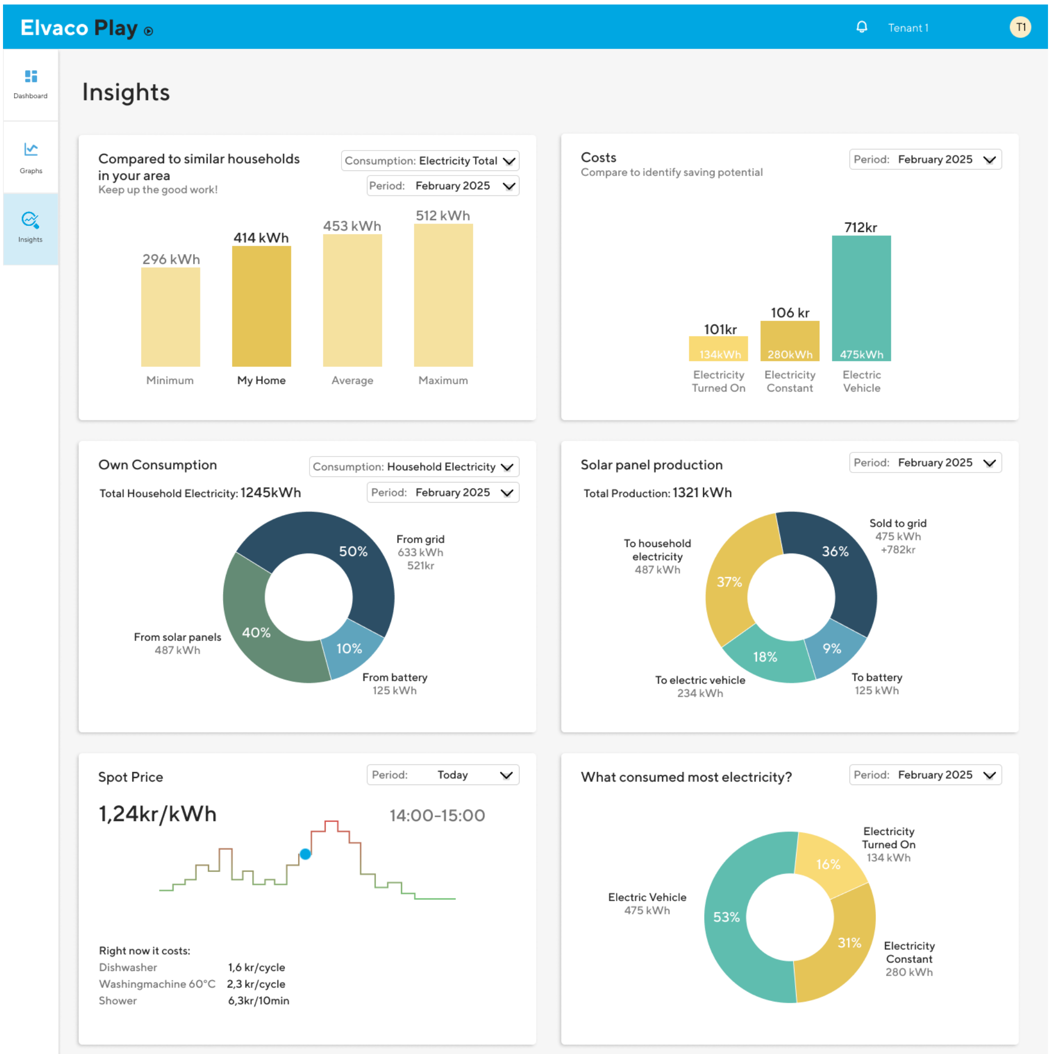

Figure 7.16 shows the Insight menu tab including solar panel widgets (Authors contribution)

7.6 Villa Owner With District Heating

The final use case illustrates a district heating company inviting a villa owner, or alternatively a housing cooperative representative, to its workspace as a “User”. Upon login, the Dashboard, shown in figure 7.17, display metering data related to district heating which includes cumulative thermal energy, water volume, instantaneous flow and power, supply temperature, return temperature and the differential temperature (Haraldsson, 2025). By utilizing the “Instantaneous” function, previously introduced in section 7.5, the last readings for flow and power can be displayed, see the second example in figure 7.17.

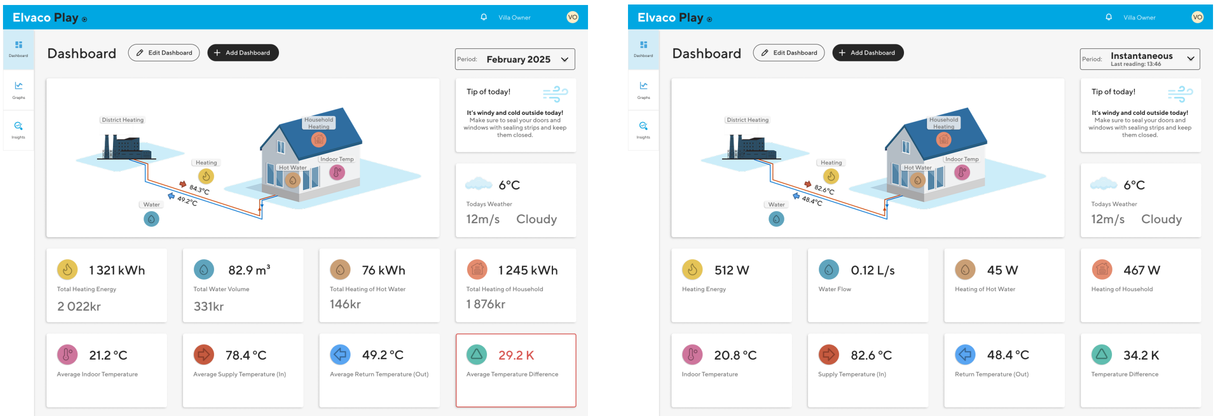

Figure 7.17 shows a villa owner's dashboard in two different states (Authors contribution)

Under the “Insights” menu tab, there are two additional widgets which provide information on the supply and return temperature and allocation of the heating consumption, see figure 7.18. Since the supply and return temperature are crucial for evaluating the efficiency of the energy system, the dedicated widget allows for further analysis. A low return temperature, which results in a high differential temperature, suggests that the building's heating and hot water system have efficiently absorbed heat from the district heating circuit. Ideally, a high differential temperature, within the range of 30-40K, indicates a well-optimised district heating system (Göteborg Energi, 2025).

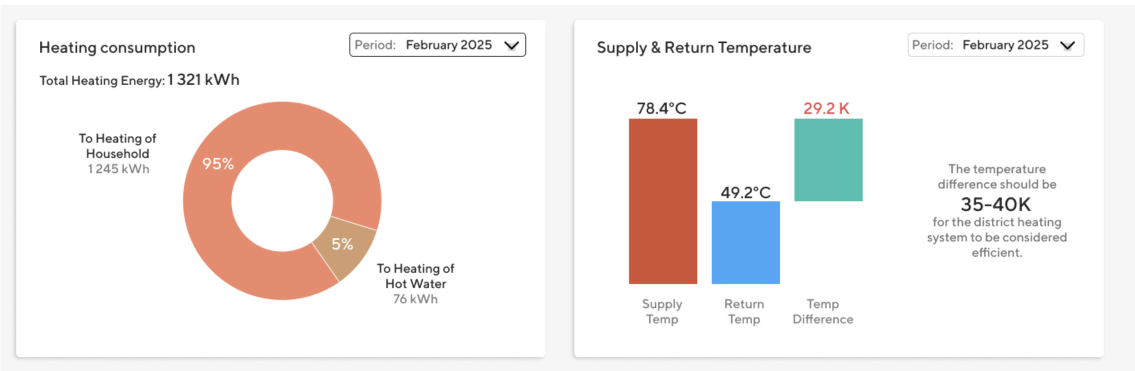

Figure 7.18 shows the added Insights widgets for district heating (Authors contribution)

In this case, however, the differential temperature is 29.2 K, slightly outside the recommended range. Consequently, the system marks the value in red and the widget displays a red boarder, urging the user to investigate the cause, see figure 7.17. Combined with the “Tips and Tricks” for district heating the platform offers guidance on system optimisation, enabling users to analyse the issue and implement actions for greater energy efficiency. The system overview and analysis tools are particularly beneficial for users who are renovating their home, assessing the performance of their heating system or seeking ways to reduce heating consumption.

8 Phase 4: Evaluation

The evaluation of the final concept was conducted through usability tests and interviews aiming to assess its functionalities, user experience and overall impressions. The results from the evaluation are summarised into three key aspects: positive feedback, constructive criticism and statistical analysis. By combining qualitative insights from user feedback with quantitative scales this evaluation offers a comprehensive understanding of the platform's user experience. The findings served as a foundation for improvements already implemented and presented in chapter 7, "Phase 3: Final Concept" and further described in section 8.2 "Constructive Criticism and Improvements".

8.1 Positive Feedback

The overall experience of navigating the platform was considered intuitive and the participants found it easy to locate the information they were searching for. The platform's structure was familiar, resembling other commonly used digital platforms. For instance, the household profile was considered easy to find since was located under the profile section, as shown in figure 7.8, a placement consistent with other websites. The dashboard offered a clear, structured, and informative overview. The period selection was highly visible on the dashboard due to its prominent font size, marking a notable improvement over the previous usability test on MyEnergy. The indoor temperature widget, which featured red highlights to indicate excessively high temperatures, functioned as intended. The participants found these red markings visually distinct and stated that they would first further analyse the cause of the high temperature before adjusting it accordingly.

The categorisation of electrical appliances into "constantly running" and "turned on temporarily" was well understood and considered useful for analysing electricity consumption. The participants grasped that temporarily turned on appliances resulted peaks on the consumption graph, whereas constantly running appliances contributed to the graph's flat baseline. For further development, participants requested the ability to enable register specific appliances by brand and energy classification to determine their independent energy costs.

The "Insights" page was considered highly valuable for comparing energy consumption in various ways to enhance understanding and analysis. The users identified potential energy saving, such as recognising that charging an electric vehicle was costly and concluding that they should charge it at night when electricity spot prices are lower.

"Tips & tricks" within insights was greatly appreciated, as it provides user with a better understanding of energy consumption and offered practical suggestions for reducing energy usage. Participants indicated that they would implement certain recommendations they found feasible in their daily life. Additionally, the section's short summaries of each consumption source were highly valued, as they helped deepen participant's knowledge and comprehension of energy usage. Another significant finding was that "Insights" and "Tips & Tricks" could help involve family members in energy efficiency efforts by presenting factual data and real saving figures. One participant stated, *"Tips & Tricks would really help me, and I would use it to involve my husband"*. Another participant expressed, *"I want more tips & tricks"* emphasising the functions value and anticipated frequent use. Suggestions of additional facts for further development included that it requires less energy to heat water in a kettle than on the stove or storing a jug of water in the refrigerator to reduce water waste when waiting for flushing tap water to cool.

The “Investments” feature was well received and deemed easy to use. Participants indicated that they would utilize it as intended by registering an investment, viewing its corresponding marker in the graph, and analyse the curve to identify changes before and after the investment. This function would assist in evaluating the effectiveness of energy-saving measures and determining whether additional actions are necessary. Moreover, it was noted that the feature could increase motivation since users could clearly observe results in black on white. For further development, participants requested the ability to filter graph data and period based on the investment date.

The “Behaviours” function was also highly appreciated, as it addressed the user need to track individual appliance consumption and related cost. The participants highlighted that this feature would aid in understanding how various appliances and energy systems operate and interact. On participant stated, *“I have always wondered how an eco-program on the washing machine, with a duration of three hours, can consume less energy than a short program of one hour. Now I can explore myself and get the numbers black on white”.* To further develop “Behaviours” a suggestion was to integrate recommendations for optimising behaviours such as *“try to wash your clothes at 9 p.m. instead, it would save you 1 kr”.*

The AI-assistant was recognised as a familiar concept, given its increasing occurrence on other platforms. Participants indicated that they would use it to obtain personalised energy-saving recommendations, thereby facilitating analysis and reducing the need for manual calculations. The users would ask questions such as *“What can I do to lower my electricity consumption?”*, *“How much money can I save by changing to a new fridge?”* or *“How much money have I saved since changing the windows?”*. However, despite recognising its potential benefits none of the three participants were willing to pay extra for this functionality. This finding underscores the importance of the “Tips & Tricks” feature, even if an AI-Assistant is available.

8.2 Constructive Criticism and Improvements

On the consumption widgets on the dashboard, an initial issue was identified regarding the presence of a minus sign in front of the costs, see figure 8.1. The meaning of the minus sign was considered unclear. The participants were uncertain whether it indicated a discount, an expense or a comparison to the previous period. To eliminate confusion, the minus sign was removed. However, when displaying solar panel production data, the text “Sold to grid” was added to clearly indicate that the value represents revenue, thus minimising potential misunderstandings.

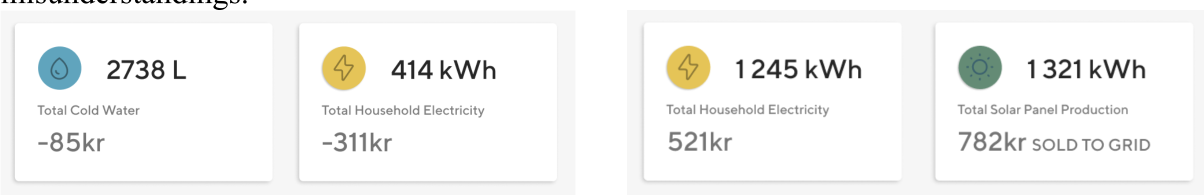

Figure 8.1 shows the widgets on the dashboard before and after evaluation, with the improvements on the right (Authors contribution)

Initially, the weather widget displayed the text “Real Time Weather”. However, the participants found this label ambiguous, as it was unclear if it referred to the current day’s weather or an average over the dashboard period. One participant stated that the lack of clarity disturbed the experience of using the dashboard since it did not align with the selected time period used in the other widgets. The purpose of the weather widget is to inform users that the weather is being recorded and that outdoor temperature trends can be observed in the graphs. Displaying the average weather on the widget was also considered problematic, as outdoor temperature fluctuate significantly between day and night and it would be difficult to present a meaningful average across conditions such as sunny, cloudy or rainy weather. To resolve this issue the text was changed from “Real Time Weather” to “Today’s Weather”.

When registering electricity costs and grid fees on the platform, the participants were presented with two options, as figure 8.2 shows: manually entering their electricity price or using BankID to retrieve the information directly from their energy provider. The manual entry option was considered challenging, and the participants felt an uncertainty towards the required data. They noted that retrieving the correct information would involve contacting their energy company or examining their electricity bill, which they found complicated and difficult to understand. Additionally, for two of the participants, registering the grid fee was particularly difficult since they were unfamiliar with the concept of a main fuse. In contrast the BankID option was perceived more user-friendly and would minimise errors. Consequently, the automatic option was implemented in the final concept and a summary of the electrical price and grid fee was provided, which the participants found helpful. The automatic water price calculation, which is preset based on where the user lives, was also well received and appreciated by the participants.

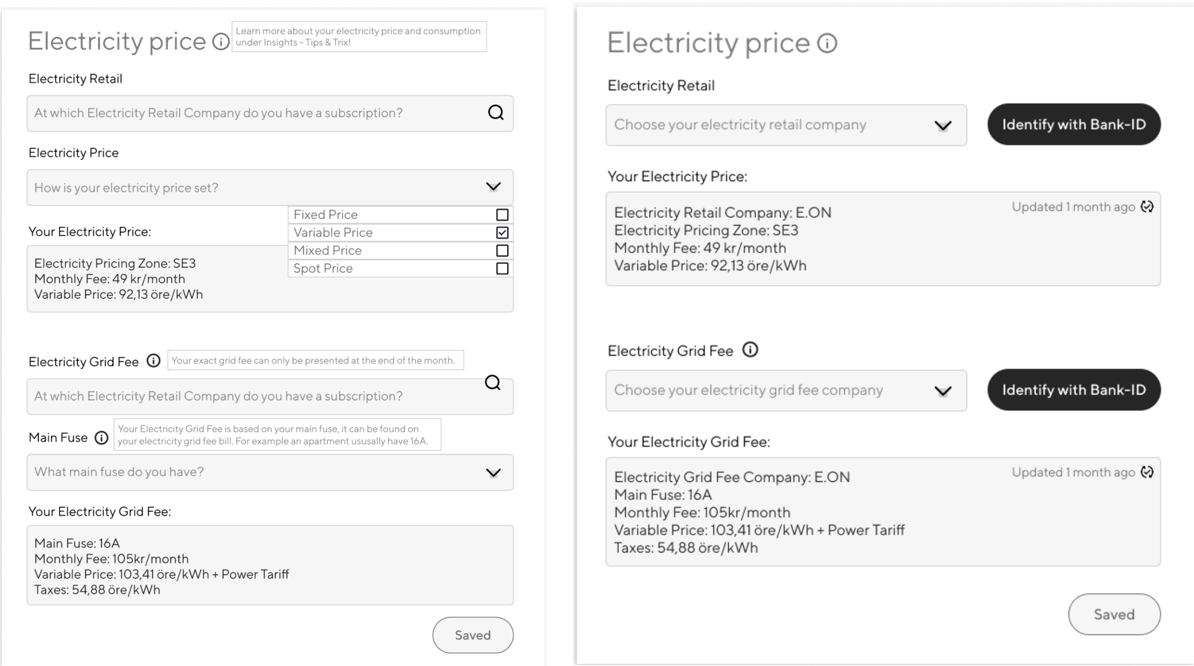

Figure 8.2 shows the user tests two options of registering electricity price, with the preferred option to the right (Authors contribution)

When comparing energy consumption with other similar households under the “Insights” menu tab, the users expressed interest in knowing which households they were comparing with. They wanted to know if the scope of the comparison was made within their building, street or city. To clarity this, the label “Compared to similar households” was modified to explicitly state either “Compared to similar households in your building” or “Compared to similar households in your city” depending on the area of comparison.

The “Residential CO2 footprint” widget under the “Insights” section required additional clarification, see figure 8.3. The users were unsure whether the CO_2 emission figure represented emissions per person or per household and whether it was equivalent to both the carbon footprint of one flight to Spain plus the amount of CO2 absorbed by twelve trees. To improve clarity, the text was updated to state: "During this period your household has emitted 600 kg CO2 that's equal to emission from 1 flight to Spain or what 12 trees binds during one year".

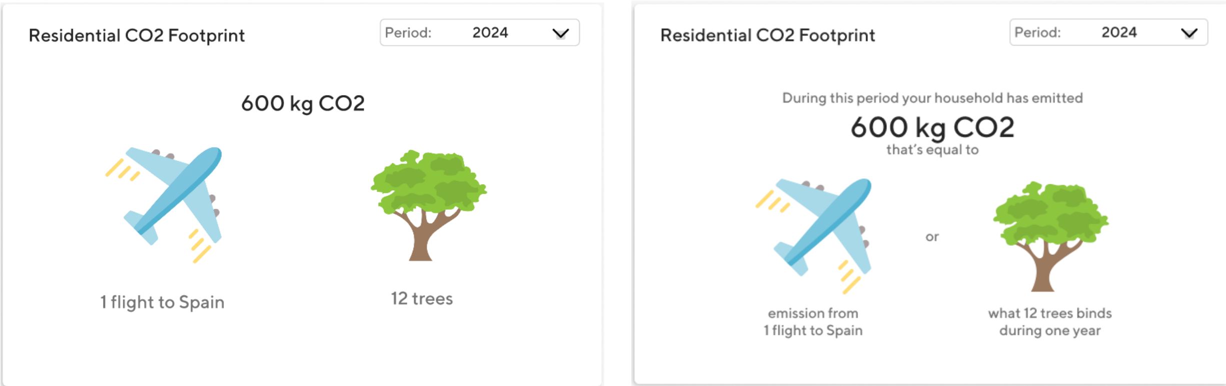

Figure 8.3 shows the CO2 footprint widget with incorporated improvements on the right (Authors contribution)

Additionally, the "Residential CO2 footprint" feature, revealed an important aspect of energy consumption behaviour. One participant stated, *"I have already booked a flight to the US, then it does not matter what I do at home, it is already ruined. This just gives me a bad conscience"*. This response highlights the potential issue of climate guilt when developing an energy metering platform, where users may feel discouraged rather than motivated by the metering data tools. For further development, the emotional impact of CO_2 footprint needs to be considered, and the content of this widget needs to be thoroughly analysed to find the right balance between raising awareness and enhancing motivation rather than triggering guilt.

Additionally, the participants requested more reference values including recommended figures based on sustainability, financials or consumption. Examples included sustainable indoor temperature, a recommended value for the maximum electricity power setting under "My Household Profile" and recommendations on planning energy consumption based on spot price variations. While these recommendations are not yet implemented in the final concept, they have been noted for potential inclusion for future development.

8.3 Rating Scale

Figure 8.4 displays the responses from the rating scale questions and the ability to formulate an energy efficiency for the final concept, compared to the results from the user study on Evo an MyEnergy.

The results indicate that the final concept has improved in several aspects. The understanding of the information was enhanced from Evo, with an average rating of 6.6. One participant stated, *"Now I know how much one kWh is"*. Additionally, the understanding improved due to the ability to compare costs related to the consumption and participants appreciated the structured data presentation, as highlighted by the comment *"I now know what belongs to what"*. However, comprehension was slightly lower compared to MyEnergy. This was due to the increased amount of information presented, which required more reading to access all relevant details. Nonetheless, the explanations and knowledge provided by the platform were appreciated, with one participant stating, *"If you do some reading you will learn a lot"*.

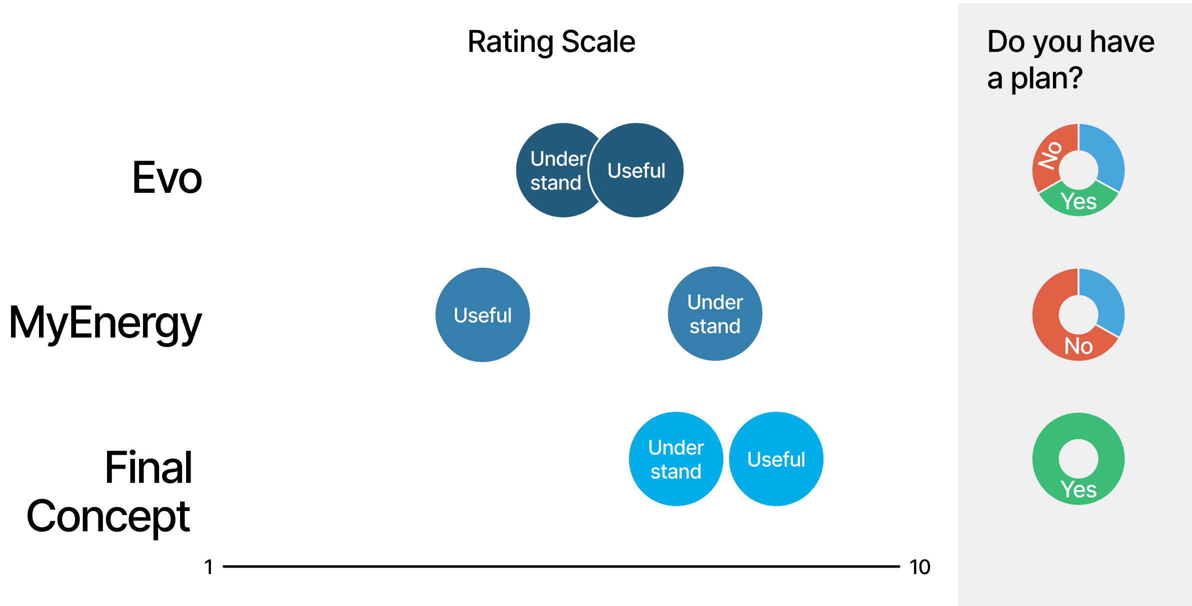

Figure 8.4 illustrates the evaluation results compared to the results from the user study (Authors contribution)

The information provided from the platform was considered highly useful with an average rating of 8.0. Participants noted that the ability to analyse high costs and search for reasons using detailed data and comparisons was beneficial. Furthermore, they could implement changes based on the recommendations from the "Tips & Tricks" section. One participant stated, *"It is very helpful, especially for me who doesn't know much about energy, and I can see the results from changes made black on white"*. The primary reason for not achieving a perfect score was the lack of appliance control features, as stated in section 6.2.5 "Control" from the user study.

Regarding the formulation of an energy efficiency plan, all the participants stated that they would be able to develop a plan based on the information on the platform. Their plans included actions such as spreading out the electricity consumption throughout the day, identifying and optimising constantly running appliances, and lowering the indoor temperature. Additionally, since heating costs were the highest in the test, one participant emphasised that they would begin by making adjustments in that area with support from "Tips & Tricks".

9 Discussion

Environmental sustainability is a core value in Elvaco's business model, with a focus on decreasing energy consumption and costs. As a result, sustainability aspects have played a significant role in shaping this project. The final concept is designed to support users in making informed decisions to reduce their energy consumption, thereby contributing to sustainable development and promoting a positive societal and environmental impact. Given its importance, sustainability was the most important criteria when evaluating the result of the final concept, further discussed in section 9.1. Additionally, ethical aspects related to both the process and the final result are presented in this chapter. The issue of personal integrity and data privacy in measuring energy use within private households is presented, with GDPR serving as a regulatory framework. Furthermore, ethical considerations regarding data collection and use of personal information were carefully addressed during the user studies, further discussed in section 9.2.

This project set out with the aim of assessing whether an enhanced usability and user experience could positively influence energy awareness and consumption. The results demonstrate that improving user experience, along with a better usability, in the Play platform contributes to increased user awareness and thereby decreased energy consumption. However, findings suggest that usability alone is not sufficient but an important aspect for the overall experience. It requires a better user experience that also focuses on designing for sustainable behaviour to influence barriers and drivers to behavioural change. The user study identified several key challenges for unexperienced users when interpreting metering data which served as barriers and resulted in disengagement. One of the most critical aspects was the lack of necessary knowledge where users found it difficult to translate energy data to actionable decisions. For the platform to contribute to decrease in energy consumption users need additional support which this project provides through increasing knowledge and structured utilization of data, resulting in bridging the gap between awareness and action. Another crucial factor was the importance of motivation for perusing behavioural change. The study found that providing users with feedback on their consumption and potential savings would engage users and ensure long-term adoption.

The SWOT analysis of competitor research found a distinction between two user groups for energy monitoring platforms: industry specialists and unexperienced individual households. Existing solutions from competitors on the market today tend to focus on only one of these groups, highlighting a gap for a platform that effectively serves both. For example, the platform Mivo Connect (Mivo, 2024) is used for device management but lacks data visualisation. Conversely, Tibber (Tibber, 2025) offers an appreciated platform for energy data presentation and management directed to primarily individual households rather than industry specialists. This market segmenting suggests an opportunity for a platform that integrates both user perspectives. This project addresses this gap by developing a customised solution that targets both types of users, where Elvaco have been focusing on specialists and this project on how the needs for unexperienced users can be integrated to their platform. The final concept achieve this by the hierarchy structure that allows for different user types and tailored functionalities with additional support for unexperienced users. This enables that users can interact with the platform in a way that aligns with their specific needs.

However, it is important to acknowledge that some competitors are also expanding their platforms in this direction. For example, Infometric provides the platform Panorama

(Infometric, 2024) that visualises temperature in different colours on a 3D building model, directed to experts such as property managers and energy specialists, while Panorama Home presents metering data for residents. Despite this, competitor platforms targeting residential users are generally less developed and less well-received compared to Tibber's solution. Given this competitive landscape, usability and user experience are of most importance for Elvaco to be in front in this market and create an advantage towards their competitors. Their strategic advantage lies in the ability to provide an intuitive user experience than meets the needs for both specialists and unexperienced users, thereby ensuring a successful adoption for the Play platform.

The methods used in the user study and evaluation ensures reliability trough the consistency in questions, participants and context. The usability and evaluation tests were conducted on the same apartment owners which minimises disturbances in the results (Nielsen, 1993). The methods were selected based on previous literature within user-centred design research and the structured approach, with predefined platform tasks and interview questions, contributes to reliability by ensuring the similar context and conditions for all participants.

The results from the user study were validated by gathering both qualitative and quantitative data, where qualitative insights were backed up with quantitative data. This ensures that findings from the thematic analysis, used for qualitative data, were based on reoccurring patterns rather than single observations. However, one limitation during the evaluation was the use of the new concept's prototype and not a fully functional platform, as in the user study. Therefore, the effectiveness of the new concept in a real context remains unvalidated. This highlights the need for further development and validation testing in real usage scenarios.

9.1 Sustainability Impact

One of the key issues considered in this project was how the presentation of energy metering data could positively influence the energy consumption. As mentioned in the literature review, a well-designed, user-friendly presentation of metering data had the potential to increase user awareness and motivate them to reduce their energy consumption. Additionally, a solution that not only presented energy data but also offered actionable recommendations for reducing energy consumption was considered to enhance this effect. This presented an opportunity for innovative design solutions to strengthen the platform's sustainability impact.

A central question that emerged during the project was whether presenting energy data alone was sufficient to encourage sustainable behavioural change or if additional nudging mechanisms were necessary. The findings from the usability tests and interviews on MyEnergy, participants indicated that the platform only stated metering data and thereby did not support users for behavioural change. Consequently, the user's awareness increased but they did not have a plan of how to reduce their energy consumption and were left incapable. This finding suggests a need of support for sustainable decisions from the platform to motivate behavioural change, concluding that energy consumption awareness alone is not sufficient. The findings from the evaluation of the final concept, where all users had actions in hand of how to decrease their energy consumption based on the additional support from the improved platform, further reinforces this theory.

The results of this study show that the final concept successfully has affected the barrier and driver determinants of importance when designing for sustainable behaviour stated in the literature review: ability, knowledge, attitude, intention, awareness, insufficient technology, perceived control and benefits of change in behaviour. The ability increases along with the knowledge of how to implement actionable changes with the “Tips & Tricks”, without forcing change. The new concept addresses the barrier of insufficient technology, providing multiple functionalities to understand and make use of the metering data. Moreover, since the actions are feasible, focusing on everyday chores in the context of user’s home, they are considered easy to implement and compatible with users existing everyday lives, increasing acceptance and thereby the ability. Users’ perception of potential benefits increases with the suggestions of how much energy or costs than can be saved. This aspect influences the attitude towards behavioural change and thereby, motivation increases. By addressing these determinants, the final concept successfully ensures persistent behavioural change.

The power of decision making between user and product was carefully considered during the development of the final concept. Prior studies have shown that persuasive technology can present ethical challenges when the product gains power at the expense of the user’s control (Fogg, 2007). The goal of the new solution was to reduce energy consumption, but an important question emerged: who determines the most sustainable approach? The benefits of taking away power from the user is that it could lead to greater energy savings. However, the risk of a rebound effect where the user does not accept the product due to restrictions or feelings of disempowerment, must be avoided. If users disengage from the platform, its effectiveness in promoting energy efficiency would be lost. Therefore, the final concept was designed to encourage sustainable behaviour by applying suggestions of change by increasing knowledge, along with some nudging mechanisms. By maintaining a sense of user control the solution fosters active user involvement. This approach enhances user motivation and thereby contributes to adoption.

An important consideration was the climate guilt, which influenced how messages about energy consumption should be framed. Additionally, it highlighted the potential negative effect of comparing personal consumption with large-scale emissions, as it could make users feel helpless rather than motivated. One way to address this could be to focus on the positive effects, progress over time and comparing in smaller scales, for example, stating how much energy and CO_2 emissions have been saved compared to last month. The personalised comparisons may enhance motivation and reinforce sustainable behavioural change. However, findings from the evaluation suggests that, even though the attitude towards the new concept is individual, the overall attitude is positive which reinforces the change in intention. Consequently, this aspect, along with the compatibility in users’ everyday lives, ensures long-term changes in behaviour towards sustainability.

Through focusing on digitalisation of energy metering this project has successfully contributed to multiple of the United Nations SDGs, particularly goal 7, 9 and 12. Goal 7, “*Ensure access to affordable, reliable, sustainable and modern energy”,* has been addressed by a more user-friendly experience and understanding of energy consumption. Through enhancing the user experience of energy metering data and providing concrete actions and insights, the platform increases energy awareness and a more efficient energy usage. Consequently, the energy consumption reduces and the opportunity to use a larger part of renewable energy sources increases.

The project aligns with goal 9, “D*rastically increase access to information and communication to extend digitalization”,* trough the digitalised platform with enhanced data analyses and sustainable decision-making support. This contributes to an improved energy metering infrastructure. Additionally, the access to metering data is considered inclusive by enabling use for not only energy professionals, with high technological experience, but also private individuals.

Goal 12, "*Ensure sustainable consumption and production patterns*", is addressed by the study's focus on sustainable behavioural change regarding energy use and results show a success in persistent behavioural change. This highlights the importance of a clear, user-friendly visualisation of energy metering data, comparisons and insights to support sustainable choices. Throught increased awareness and knowledge, user's ability to minimise unnecessary energy use enhances and thereby resource efficiency.

In addition to these SDGs that Elvaco already focuses on, further goals considered as an opportunity for Elvaco's future are the ones that concern assistance to developing countries. Elvaco is an international company with international customers and distributors in Europe, North America, South America, Africa and Middle East (Elvaco, 2023). Goal 17 *"Strengthen the means of implementation and revitalize the global partnership for sustainable development"* where target 17.6 *"Knowledge sharing and cooperative for access to science, technology and innovation"* could be addressed by assisting implementation of energy communities, stated as a new market opportunity in the SWOT analysis. Moreover, there is an opening for helping developing countries by implementing energy communities, making sure they have access to high-level sustainable technology. One of these goals is goal 11, *"Make cities and human settlements inclusive, safe resilient and sustainable"*, where this project can contribute to target 11.6 *"Reduce the environmental impact of cities"* by enabling access to metering data of energy consumption and air quality for energy communities and addressing the barrier of insufficient technology. As studies show, the building category stands for 40% of today's global energy consumption and 33% of greenhouse gases, indicating a great opportunity in the developing countries as a new market for truly changing the energy resource use and the world's sustainable future. By ensuring a well-defined user experience in energy metering products, the energy communities can be assisted in their goal of using 100% renewable energy sources and being independent in energy supply.

9.2 Ethical Considerations

When conducting user studies and gathering user data about behaviour patterns, the importance of personal integrity and responsible handling of personal information needs to be highlighted. In this study, user privacy was ensured by collecting user data anonymously and avoiding recordings of usability tests and interviews. Instead, insights were gathered solely thought observational notes. Additionally, participants were fully informed about the project's aim and how their data would be used, ensuring transparency and clear communication. Prior to participation all users provided their explicit consent, reinforcing ethical research practises.

Another ethical consideration of the user study that needs further consideration is the inclusiveness. The user study focused on Elvaco's existing user categories, meaning that potential new users were not included in the research. Furthermore, since only Swedish users participated, the study did not account for international perspectives. Given that Elvaco operates within several countries, further user studies with international participants must be conducted to ensure a comprehensive and inclusive user experience. Energy systems and housing structure vary significantly across different countries, influencing how energy consumption and billing are managed. For example, in Europe, owner-occupied apartments are more common (Hemnet, 2025) where the apartment owners have full ownership and are responsible for their own heating, water and electricity consumption, similar to villa owners. Unlike apartment owners in housing cooperatives, these owners do not pay fees to the shared board that oversees maintenance or centralised heating, which affects how the individual billing system operates. Additionally, the energy consumption for the individual apartment varies depending on the location within the building. For instance, centrally located apartments benefit from heat transfer from the surrounding apartments, whereas gable-end apartments need to consume more heating, leading to higher energy costs. Such differences highlight the importance of gathering user insights from international users to ensure a user-centred platform that is customised to various contexts.

Another example of variations is the use of BankID. While it is widely used in Sweden for secure authentication and transactions, its adoption across Europe is still growing (BankID, 2025). Since it is not yet commonly known internationally, the input of electricity price through BankID on the platform could be challenging. These insights further emphasise the need for customisation when expanding the platform to ensure a greater usability across different markets. Validating the needs for international users, including other cultures and market contexts, require additional research and user studies. However, based on the quantifiable results from the survey and similar responses during the interviews, the findings can be generalised for Swedish users with a high degree of reliability.

Data security is of most importance when monitoring energy use in private homes. Measuring energy consumption, temperature, electricity usage, humidity, and CO_2, can reveal sensitive personal information, such as when a resident is home or away for an extended period or even suspicious patterns that could indicate illegal activities. If unauthorised individuals have access to this information without proper safeguards, it could lead to serious privacy violations and compromise personal integrity. In a worst-case scenario, if this information falls into the wrong hands, it could be misused for criminal activities, such as planning a burglary based on the resident's absence. Additionally, in domestic abuse situations, access to energy data could be used to oppress and monitor individuals within their own home. These aspects raise concerns about the potential misuse of energy surveillance. While Elvaco is already working on strengthening their cyber security within the Play platform, the technological aspects of data security were not the primary focus of this project. However, the ethical implications of surveillance were carefully considered, with GDPR serving as a framework to ensure privacy, consent and data protection. By integrating GDPR principles in the Play platform, Elvaco can enhance user confidence and ensure responsible data management. This results in a platform that supports sustainable behaviours without compromising personal privacy.

10 Conclusion

The first question on this study sought to investigate how data visualisation and presentation can increase awareness and decrease energy consumption. The study demonstrates that utilizing the data in multiple ways, by comparisons, references and informative insights, helps users understand their energy usage and changing their behaviour, ultimately decreasing their energy consumption. Findings from the study show that even though the previous platforms, Elvaco Evo and MyEnergy, contributed to energy awareness the new concept further enhances the awareness on several aspects.

On the question of which methods can be used for enhancing user experience in the Play concept, this project explored the behaviour-oriented approach of DfSB and increasing psycho-pleasures of user experience. The results demonstrate that these methods successfully enhanced user experience, increased engagement and facilitated for unexperienced users to gain access to energy metering data. Additionally, the results align with the behavioural-oriented design principles that users are more likely to adopt a product or sustainable habit if the potential benefits are clearly presented.

The third question in this study was how the platform can be adopted by both an industry specialist user and unexperienced user without compromising. The hierarchy of the final concept, incorporating workspaces and specialised roles with tailored functionalities, allows for a customised experience adapted for different user types. This ensures accessibility and a greater user experience.

Apart from contributing to the SDGs, as discussed in chapter 9, the project contributes implicitly to reducing the CO_2 footprint and promotes energy efficiency on both individual and societal levels. This emphasises the importance of combining smart and innovative technology with behavioural change to reach a sustainable future. The study demonstrates that a well-designed user experience can promote energy efficiency and sustainability by addressing barriers, enhancing data understanding and increasing user motivation.

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Appendix

Appendix A

Användarundersökning av en användarportal för energimätning

Är du intresserad av din energiförbrukning men kanske inte har så mycket erfarenhet eller kunskap? Då är denna enkät riktad till dig!

Detta är en användarundersökning för ett examensarbete som civilingenjörsstudent på Industrial Design Engineering på Chalmers Tekniska Högskola i Göteborg. Examensarbetet är i samarbete med Elvaco som arbetar med energimätning och syftet är att utforska hur användarvänlighet kan se ut på en användarportal (hemsida eller app) för energimätning. Målgruppen är oerfarna användare som inte har expertkunskap på energisystem så om du känner att det stämmer in på dig hade det varit väldigt uppskattat om du vill svara på denna enkät!

Svaren är helt anonyma men om du kan tänka dig att ställa upp på en intervju eller vidare användartester får du gärna höra av dig till bjoornlinnea@gmail.com

Tack så mycket för att du tar dig tiden!

1. Använder ni energiövervakning eller energimätning idag?

Markera endast en oval.

- ◯ Ja *Fortsätt till fråga 9*
- ◯ Nej *Fortsätt till fråga 2*

Använder inte energiövervakning idag

2. Vad är ni intresserade av inom energimätning? Stämmer en eller flera av dessa alternativ in dig?

Markera alla som gäller.

- [ ] Villaägare som övervakar energiförbrukningen i huset
- [ ] Laddbox för elbil
- [ ] Solpaneler
- [ ] Hyresgäst eller bostadsrättsinnehavare som övervakar den individuella energiförbrukningen
- [ ] Styrelsemedlem i bostadsrättsförening som övervakar byggnadens energiförbrukning
- [ ] Växthus, övervakning av tex temperatur
- [ ] Övrigt: ______________________

3. Vad skulle ni vilja mäta?

Markera alla som gäller.

- [ ] Temperatur
- [ ] Värmeförbrukning
- [ ] CO2
- [ ] Elförbrukning
- [ ] Vattenförbrukning
- [ ] Gas
- [ ] Luftkvalitet/Ventilation
- [ ] Övrigt: ______________________

4. Hur ofta skulle ni vilja se er energiförbrukning i en användarportal (hemsida eller app)?

Markera endast en oval.

- ◯ Någon gång/år
- ◯ Någon gång/månad
- ◯ Någon gång/vecka
- ◯ Någon gång/dag
- ◯ Flera gånger/dag

5. Vad skulle ni vilja kunna göra om ni går in i en användarportal (hemsida eller app) för mätdata? Vilket syfte kan en användarportal ha för er?

6. Hur motiverad är du att minska din energiförbrukning?

Markera endast en oval.

	1	2	3	4	5	6	7	8	9	10	
Inte alls	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Otroligt motiverad!

7. Finns det något som skulle kunna öka din motivation?

8. Är det något inom energiförbrukning eller energiövervakning som ni tycker är svårt? Något som ni inte förstår eller inte vet hur ni ska gå tillväga med?

Använder energiövervakning idag

9. Vad använder ni energiövervakningen till? Stämmer en eller flera av dessa alternativ in på dig?

Markera alla som gäller.

- [ ] Villaägare som övervakar energianvändningen i huset
- [ ] Laddbox för elbil
- [ ] Solpaneler
- [ ] Hyresgäst eller bostadsrättsinnehavare
- [ ] Styrelsemedlem i bostadsrättsförening som övervakar energiförbrukningen
- [ ] Växthus
- [ ] Övrigt: ____________________

10. Vad mäter ni?

- [ ] Temperatur
- [ ] Värmeförbrukning
- [ ] CO2
- [ ] Elförbrukning
- [ ] Vattenförbrukning
- [ ] Gas
- [ ] Luftkvalitet/Ventilation
- [ ] Övrigt: ____________________

11. Hur ofta ser ni energiförbrukningen i en användarportal (hemsida eller app)?

Markera endast en oval.

- Någon gång/år
- Någon gång/månad
- Någon gång/vecka
- Någon gång/dag
- Flera gånger/dag

12. Hur ser användningen av användarportalen ut? Vad gör ni när ni är inne i appen eller hemsidan? Vilka funktioner använder ni?

13. Är det någon funktion i användarportalen som saknas och ni önskar skulle finnas?

14. Är det något inom energiförbrukning eller energiövervakning som ni tycker är svårt? Något som ni inte förstår eller inte vet hur ni ska gå tillväga med?

15. Hur motiverad är du att minska din energiförbrukning?

	1	2	3	4	5	6	7	8	9	10	
Inte	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Otroligt

16. Finns det något som skulle kunna öka din motivation?

Appendix B

Usability test + intervju på Evo Hemsida

Typ av användare: Styrelsemedlem i Brf

Scenario:
Styrelsemedlem i en mindre brf som ansvarar för sin egen fastighetsskötsel. Nu vill du se energiförbrukningen och kanske identifiera var man kan spara energi och pengar.
Ingen brådska!

Uppgifter:

1. Hitta en överblick på alla mätare. Hur många är det? Fungerar alla?
2. Se temperaturmätningen i en graf för alla lägenheter under den senaste månaden
3. Ändra tidsintervallet till föregående vecka och per timme.
4. Jämför temperaturen under 2024 med 2023. Har något förändrats? Ökat eller minskat?
5. Exportera mätvärdena till en rapport/CSV-fil. Vet du vad du skulle kunna använda den filen till?
6. Vilken medeltemperatur hade lägenheterna den 11 okt 2024?
7. Identifiera den största energitjuven den senaste veckan.
8. Se temperaturen för den senaste veckan timme för timme och analysera grafen. Är det något som avviker? Vad kan det bero på?
9. Gruppera mätarna per hus och analysera. Skiljer temperaturen?

Intervju:

1. Hur skulle du beskriva din upplevelse att navigera genom plattformen?
2. Finns det något i designen som var förvirrande eller svårt att förstå? Vad skulle kunna underlätta?
3. Hur enkelt var det att förstå den presenterade mätdatan på en skala från 1-10?
4. Hur användbar tycker du informationen är på en skala från 1-10? Vad kan du använda den till?
5. Känner du att informationen som visas hjälper dig att förstå energianvändningen?
6. Vet du vad du ska göra för att minska energianvändningen? Har du en plan?
7. Om du ska använda plattformen som ett verktyg för att minska energianvändningen, finns det någon funktion som du saknar?
8. Skulle du vilja ha mer eller mindre detaljerad information om energiförbrukningen?
9. Vad skulle motivera er till att minska energianvändningen?
10. Vad betyder dessa ikoner för dig?

Skattningsskala:

1. Hitta en överblick på alla mätare. Hur många är det? Fungerar alla?

1. Lätt	2.	3.	4.	5. Svårt att utföra
O	O	O	O	O

---

2. Se temperaturmätningen i en graf för alla lägenheter under den senaste månaden.

1. Lätt	2.	3.	4.	5. Svårt att utföra
O	O	O	O	O

---

3. Ändra tidsintervallet till föregående vecka och per timme.

1. Lätt 2. 3. 4. 5. Svårt att utföra

O O O O O

---

4. Jämför temperaturen under 2024 med 2023. Har något förändrats? Ökat eller minskat?

1. Lätt 2. 3. 4. 5. Svårt att utföra

O O O O O

Hur säker (0-100%) är du på din analys: ______

---

5. Exportera mätvärdena rapport/CSV-fil. Vet du vad du skulle kunna använda den filen till?

1. Lätt 2. 3. 4. 5. Svårt att utföra

O O O O O

---

6. Vilken medeltemperatur hade lägenheterna den 11 okt 2024?

1. Lätt 2. 3. 4. 5. Svårt att utföra

O O O O O

---

7. Identifiera den största energitjuven den senaste veckan.

1. Lätt 2. 3. 4. 5. Svårt att utföra

O O O O O

Hur säker (0-100%) är du på att du har rätt?: ______

---

8. Se temperaturen för den senaste veckan timme för timme och analysera grafen. Är det något som avviker? Vad kan det bero på?

1. Lätt 2. 3. 4. 5. Svårt att utföra

O O O O O

Hur säker (0-100%) är du på att du har rätt?: ______

---

9. Gruppera mätarna per hus och analysera. Skiljer temperaturen?

1. Lätt 2. 3. 4. 5. Svårt att utföra

O O O O O

Hur säker (0-100%) är du på din analys?: ______

Usability test + intervju på MinEnergi Hemsida

Typ av användare: Lägenhetsinnehavare, hyresgäst, villaägare

Scenario: Du vill se energiförbrukningen och kanske identifiera var man kan spara energi och pengar.
Ingen brådska!

Uppgifter:

1. Hitta din varmvattenförbrukning under den senaste månaden. Hur mycket har du förbrukat totalt?
2. Ändra tidsintervallet till den senaste veckan.
3. Jämför din elförbrukning under 2024 med 2023. Har något förändrats? Ökat eller minskat?
4. Exportera årsförbrukningen av el under 2024 till en Excel-fil/rapport. Vet du vad du skulle kunna använda den filen till?
5. Vilken totalkostnad och totalförbrukning av el hade du den 11 okt 2024?
6. Under vilken tidpunkt förbrukades mest el den 11 okt 2024? Vad kan det bero på?
7. Identifiera den största energitjuven föregående vecka.

Intervju:

1. Hur skulle du beskriva din upplevelse att navigera genom plattformen?
2. Finns det något i designen som var förvirrande eller svårt att förstå? Vad skulle kunna underlätta?
3. Hur enkelt var det att förstå den presenterade mätdatan på en skala från 1-10?
4. Hur användbar tycker du informationen är på en skala från 1-10? Vad kan du använda den till?
5. Känner du att informationen som visas hjälper dig att förstå din energianvändning?
6. Vet du vad du ska göra för att minska din energianvändning? Har du en plan?
7. Om du ska använda plattformen i din vardag för att minska din energianvändning, finns det någon funktion som du saknar?
8. Skulle du vilja ha mer eller mindre detaljerad information om din energiförbrukning?
9. Vad skulle motivera dig till att minska din energianvändning?
10. Vad betyder dessa ikoner för dig?

Skattningsskala:

1. Hitta din varmvattenförbrukning under den senaste månaden. Hur mycket har du förbrukat totalt?

1. Lätt att utföra	2.	3.	4.	5. Svårt att utföra
O	O	O	O	O

Hur säker (0-100%) är du på att du har rätt siffra?: ______

---

2. Ändra tidsintervallet till den senaste veckan.

1. Lätt att utföra	2.	3.	4.	5. Svårt att utföra
O	O	O	O	O

---

3. Jämför din elförbrukning under 2024 med 2023. Har något förändrats? Ökat eller minskat?

1. Lätt att utföra 2. 3. 4. 5. Svårt att utföra
O O O O O

Hur säker (0-100%) är du på din analys: ______

---

4. Exportera årsförbrukningen av el under 2024 till en Excel-fil. Vet du vad du skulle kunna använda den filen till?
1. Lätt att utföra 2. 3. 4. 5. Svårt att utföra
O O O O O

---

5. Vilken totalkostnad och totalförbrukning av el hade du den 11 okt 2024?
1. Lätt att utföra 2. 3. 4. 5. Svårt att utföra
O O O O O

---

6. Under vilken tidpunkt förbrukades mest el den 11 okt 2024? Vad kan det bero på?
1. Lätt att utföra 2. 3. 4. 5. Svårt att utföra
O O O O O

Hur säker (0-100%) är du på din analys?: ______

---

7. Identifiera den största energitjuven föregående vecka.

1. Lätt att utföra 2. 3. 4. 5. Svårt att utföra
O O O O O

Hur säker (0-100%) är du på att du har rätt?: ______

Appendix C

List of requirements for unexperienced users on an energy metering platform					
Req ID	**Category**	**The new solution will…**	**Reason**	**D/N**	**Solution**
Req 1	General	...enable usage for all types of users	The customer base of Elvaco includes both experienced and unexperienced users of energy systems	Necessity	Different account defaults for different users
Req 2	General	...enable understanding of metering data for all users	Energy systems are complex, especially for unexperienced users	Necessity	Different account defaults for different users
Req 3	General	…enable customization for different types of users	Depending on level of knowledge about energy systems or what the user want's to see	Desire	Different account defaults for different users plus the user can change settings and choose what they want to see
Req 4.1	Navigation	...have an intuitive interface and navigation	The learning curve of the platform needs to be short to increase acceptance for unexperienced users	Necessity	
Req 4.2	Navigation	...align with the mental picture of a webpage	To facilitate the short learning curve of the platforms interface	Necessity	
Req 4.3	Navigation	...provide clear headings and navigation feedback	To facilitate the short learning curve of the platforms interface	Necessity	Feedback when hoovering, clear symbols, big headings
Req 5.1	Navigation	...provide a clear and informative system overview	Including read of functionality. To increase understanding and facilitate analysis	Necessity	See meters and machines plus if they work
Req 5.2	Understand	…align with the mental picture of an energy system	To increase understanding and facilitate analysis	Necessity	Illustrate a picture of a house with solar panels and electric car (or other users). Click on each part in picture to see data. Facilitates system overview (Req 5.1)
Req 6	Understand	...provide explanations of functionality and errors.	To increase understanding and acceptance	Desire	Messages of functionalities and the most common errors
Req 7	Understand	…utilize understandable terms, words and units	For unexperienced users to understand. Common knowledge.	Desire	Different account defaults for different users

Req 8.1	Understand	…provide help identifying saving potentials	General and individual tips based on data. Improves motivation	Desire	Messages of most common improvements. AI assistant for individual tips based on data.
Req 8.2	Understand	...provide help with concrete actions to decrease consumption	General and individual actions to take based on data. Improves motivation.	Desire	Messages of most common improvements. AI assistant for individual tips based on data
Req 9	Understand	…provide answers to the users questions about energy systems and decreasing consumption	How come? How does this work? What should I do? What happens if?	Desire	AI assistant. Tips & Tricks.
Req 10	Understand	…inform about reasons to save energy	To increase motivation	Desire	AI assistant. General/concrete numbers on why, financially and environmental
Req 11	Understand	…enable seeing the energy consumption and costs of different machines and behaviours	To increase understanding and motivation	Desire	Real time or calculate total consumption under graph
Req 12	Understand	…facilitate to involve and motivate others to save energy	For example family members. To increase impact and motivation	Desire	Concrete numbers on consumption and savings. Visualize costs
Req 13	Understand	…enable assigning personal knowledge to the system	To increase understanding and facilitate analysis	Desire	Energy labelling, types of machines, number of residents
Req 14	Compare	…enable comparing with common unit	To enable comparing different energy sources.	Necessity	Costs or savings on environment
Req 15	Compare	…enable sectioning of machines	To facilitate the analysis and identify what's most consuming	Desire	Sectioning machines that runs all the time and others that turns on temporarily
Req 16	Compare	…enable following up on investments	See savings and improvements from investment with concrete numbers	Desire	Add note in calendar when investment was made. Compare period before and after. See when the investment has paid off.
Req 17	Compare	…enable following up on change of behaviour	See savings and improvements from change of behaviour with concrete numbers	Desire	Use trend to present savings. Compare before and after change. Calculate consumption.

Req 18	Compare	…enable experimenting or working with numbers	To increase motivation and understanding.	Desire	Enable changing factors in graph. AI assistant message "If you charge the car at 02:00 instead of 17:00 you can save 100SEK per charge"
Req 19.1	Compare	…enable setting goals and comparing with actual consumption	To increase motivation	Desire	Goals: financial, consumption, environmental, optimization
Req 19.2	Compare	…enable prognosis of consumption	To increase motivation	Desire	Message "If you follow this trend…" In connection to the set goal (Req 19.1)

Req 20	Compare	…enable comparing with outdoor temperature	To increase understanding and facilitate analysis.	Necessity	Line in graph with outdoor temperature. Weather and temperature on dashboard (req 5.2)
Req 21	Compare	…enable an indication of consumption level	To increase motivation and understanding	Desire	Comparing with other similar households/sustainable consumption/ standard consumption
Req 22	Graph	…present energy consumption historically	Total consumption, what is most consuming. To increase understanding.	Necessity	In graph
Req 23	Graph	…present costs historically, total and upcoming	To increase understanding and motivation	Necessity	In graph and compared with consumption. Spot price
Req 24	Graph	…present energy consumption and costs instantaneous	To increase understanding and can identify what's most consuming. Instantaneous overview of system and system functionality	Desire	Real time or last reading of consumption and cost in graph/dashboard
Req 25	Graph	…present energy production	Solar panel production. How much goes to household/grid. To increase motivation and understanding	Necessity	In graph/Insights
Req 26	Graph	...enable choosing any period to present in graph	Increase user control. To facilitate analysis.	Necessity	Calendar in graph. Compare any period. Period before and after investment.

Req 27.1	Graph	…facilitate following one line in graph	To facilitate reading and understanding graph	Necessity	Highlight one line by clicking while the other lines fade.
Req 27.2	Graph	…facilitate separating lines in graph	To facilitate reading and understanding graph	Necessity	Colour coding. Enable changing y-axis interval for zooming in graph (for example start at 16°C instead of 0°C)
Req 28	Graph	…enable setting defaults in graph and remember them	Customization. Facilitating navigation by remembering defaults. The user does not need to start over for every graph	Necessity	Settings. Save graph settings for next time. Multiple different settings.
Req 29	Take action	…enable control of energy consumption machines on the platform	To facilitate taking action and increasing motivation by enabling easy actions.	Desire	Press a button on platform.
Req 30	Take action	…provide notifications or alarms at deviations or malfunction	To facilitate taking action.	Desire	App notifications on mobile phone when price peaks, high load or meter/machine malfunction. Red marking at system overview (Req 5.1)
Req 31	Take action	…enable setting a schedule for machines	Relative to price or consumption optimisation	Desire	Manually or automatically. If automatic, provide explanation of priorities and functionality.
Req 32	Take action	…enable manual temporary control of schedule or machines	If routines deviates, for example not home	Desire	Manual control over schedule.

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