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## Article

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## Article

# Different Types of Heat Pump Owners in Austria—Purchase Arguments, User Satisfaction, Operating Habits, and Expectations Regarding Control and Regulation Strategies

Gabriel Reichert <sup>1,\*</sup> , Sophie Ehrenbrandtner <sup>1</sup>, Robert Fina <sup>1</sup>, Franz Theuretzbacher <sup>1</sup>, Clemens Birklbauer <sup>2</sup> and Christoph Schmidl <sup>1</sup>

<sup>1</sup> Campus Wieselburg, University of Applied Sciences Wiener Neustadt GmbH, 2700 Wiener Neustadt, Austria

<sup>2</sup> Ochsner Wärmepumpen GmbH, Ochsner-Straße 1, 3350 Stadt Haag, Austria

\* Correspondence: gabriel.reichert@fhwn.ac.at; Tel.: +43-5-0421-2-485

**Abstract:** Heat pumps (HPs) are considered as a key technology in the future energy system. Besides technical and ecological aspects, user acceptance and user friendliness are also essential. The aim of the study was therefore to research which aspects are decisive for the purchase decision, which different types of HP owners can be distinguished, how their specific user behavior can be characterized in terms of control and operation, and what their respective requirements and wishes are for the functions and operation of their HPs. A mixed-methods approach in an exploratory sequential design was used. Based on nine qualitative interviews and a survey with 510 respondents, both conducted in Austria, it is observed that the most relevant arguments for the purchase decision of HPs are high environmental friendliness and efficiency, as well as resource independence. Respecting certain usage and requirement patterns, four user types could be identified and defined—the minimalist, the functionalist, the tech-savvy tinkerer, and the anxious user. In the future, intelligent control and regulation approaches and the integration of HPs into a holistic energy and building management system (smart home) will become more important. Based on the results, tailor-made system solutions can be developed, user friendliness optimized, and new services developed.

**Keywords:** heat pumps in Austria; smart home; control and regulation strategy; user acceptance; user friendliness; user behavior



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## 1. Introduction

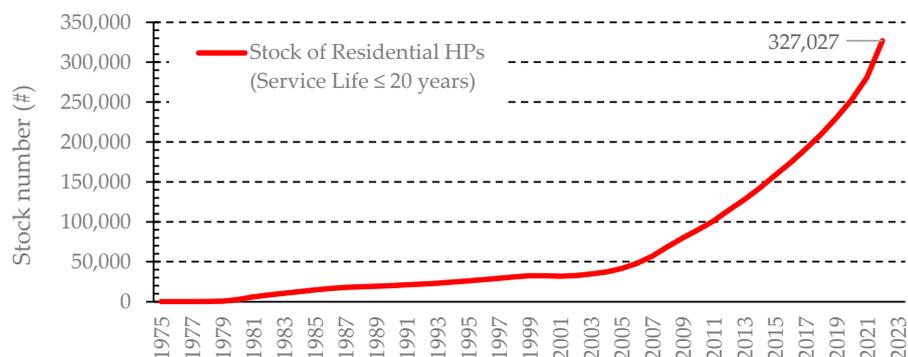
### 1.1. Market of HPs and Scenarios for Market Development

In Austria, the use of heat pumps (HPs) to cover the heating energy demands of buildings has increased significantly over the last 10 years (Figure 1).

In the last ten years, the number of HPs has grown by an average of 10% per year. In 2021, the stock amounted to approx. 327,000 units. The sales figures for HPs amounted to a total of 31,184 units in 2021 and 49,192 units in 2022. This corresponds to an overall increase of around 35%. Air-to-water HPs have the largest share of the market volume with 82.5% (2021) and 86.2% (2022), followed by brine-to-water HPs with around 14% (2021) and 10% (2022). The share of water-to-water HPs is a low 1.8% (2021) to 1.0% (2022), just like the share of air-to-air HPs (0.6% for 2021 and 2.4% for 2022) (Biermayr et al., 2023).

For Europe, the number of installed HPs for residential heating (as of 2021) is estimated at around 16.8 million units. Worldwide, the number of HPs is currently estimated at 180 million units, with China accounting for the largest share of the total at just under

60 million units (Lyons et al., 2022). According to data from the European Heat Pump Association (EHPA), 1.62 million HPs were sold across Europe in 2020 and just under 2.18 million in 2021 (Lyons et al., 2022). This represents an increase in market volume of around 34%.



**Figure 1.** Development of the stock of HPs for residential heating (service life = 20 years) by 2022 in Austria (source: own illustration, data from Biermayr et al., 2023).

According to the scenarios of the International Energy Agency (IEA), in order to meet the “Net-zero emissions by 2050” target, the number of HPs would have to increase to 600 million by 2030 (IEA, 2021). This means a threefold increase in the global stock of HPs within nine years. In the final stage in 2050, 55% of all heating systems would have to be based on HP technology, which would mean a tenfold increase in installed HPs compared to 2021 (1.800 million) (IEA, 2021).

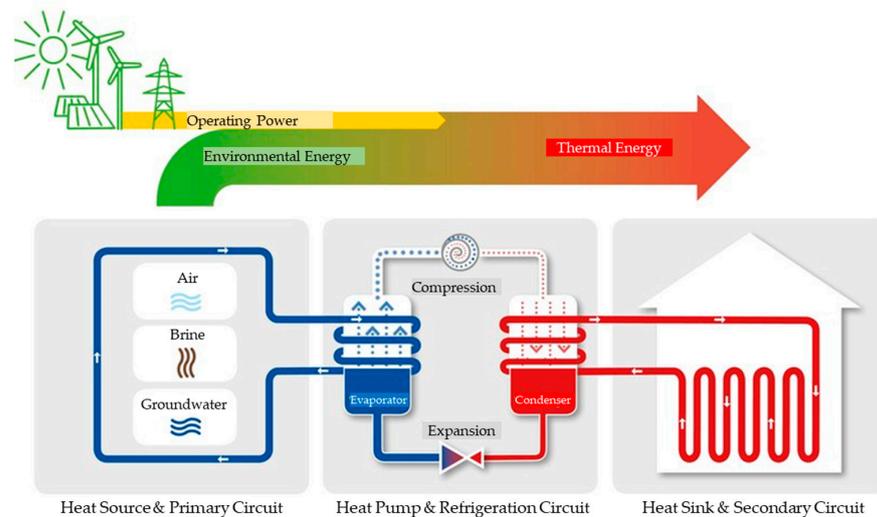
The study “Wärmezukunft 2050” by Kranzl et al. (2018) also developed and analyzed scenarios for future heat supply in Austria that are as fossil-free as possible. According to this study, HP technology will cover around 42% of the installed capacity for heating purposes (space heating and hot water) in buildings in 2050, although direct electricity heating systems will be significantly reduced or replaced. This increase in installed capacity means an increase of 30% in absolute terms between 2018 and 2050 (Kranzl et al., 2018).

These scenarios and analyses, as well as the development of existing stock and sales figures, underline the importance of HPs as a key technology in the energy transition. Furthermore, they indicate that the importance of HPs for the provision of heating energy in the domestic sector will continue to increase (Rosenow et al., 2022; EHPA, 2024).

### 1.2. Technical Functionality, Heat Sources, and Efficiency of HPs

HP systems consist of three subsystems, i.e., the heat source (primary circuit), the HP with the refrigeration circuit, and the heat sink for space heating distribution and, frequently, the hot water supply (secondary circuit) (Figure 2).

HPs for buildings work according to the compression HP process. This is based on a left-hand thermodynamic cycle (refrigeration circuit). A working fluid, i.e., a special refrigerant, passes through various states or phases, absorbing thermal energy at a low pressure level (evaporator) and releasing thermal energy at a higher pressure level (condenser). The pressure of the gaseous refrigerant is increased by an electrically driven compressor. After the condenser, the refrigerant is expanded in a throttle element, typically an expansion valve, from the high pressure to low pressure level, and the process starts again (Figure 2) (Handagama et al., 2023; Von Cube & Steimle, 1981; Olympios et al., 2024; Vellei, 2014; Dott et al., 2018).



**Figure 2.** Operating principle of a compression HP (translated into English). (© Bundesverband Wärmepumpe e.V.). Reproduced with permission from the German “Bundesverband Wärmepumpe e.V. (n.d.)”.

Hydronic HP systems, which are used as central heating systems for room heating and, in most cases, also for hot water production (domestic hot water), can be divided into three categories according to the heat source used for refrigerant evaporation (Figure 2) (Olympios et al., 2024; Vellei, 2014; Dott et al., 2018):

- Air-to-water HPs: The energy of the ambient air and the water vapor it contains is used as a heat source. A finned heat exchanger is typically used as an evaporator heat exchanger, where the thermal energy of the ambient air is transferred directly to the refrigerant. The water vapor in the ambient air also cools down, condenses on the refrigerant pipes if necessary, and thus also transfers heat energy to the refrigerant.
- Brine-to-water HPs: The energy stored in the ground is used as a heat source. Either flat-plate collectors (near-surface use up to approx. 2 m) or deep probes (boreholes, typically 50 to 100 m deep) are used to tap the heat source. The brine circuit (mixture of water and antifreeze) circulates in the shallow collectors and deep probes, transporting the energy from the ground to the HP’s evaporator, where it is then transferred to the refrigerant. Depending on the ground conditions, the water in the ground also transfers heat energy to the brine circuit (primary circuit). The design of the brine circuit must ensure that the heat energy extracted and the heat input, e.g., through solar radiation in summer or active regeneration through cooling operations of the HP, are in balance in the long term. The brine heat source can also be tapped by direct evaporation. Instead of an antifreeze mixture, the refrigerant circulates in the pipes in the ground and is evaporated directly. HPs that work according to this principle play a subordinate role in the Austrian stock and only have a marginal market share (2021: only 0.8%) (Biermayr et al., 2023).
- Water-to-water HPs: The energy of the groundwater is used as a heat source. Therefore, groundwater is pumped to the HP’s evaporator heat exchanger, e.g., plate or tube bundle heat exchanger, via a delivery well (primary circuit). The groundwater releases energy to the refrigerant and is thus cooled and returned to the groundwater via a seepage well. Depending on the quality of the groundwater, an intermediate brine circuit with an antifreeze mixture is installed between the HP or refrigeration circuit and the well circuit to protect against heat transfer damage, e.g., due to frost and corrosion.

In addition to availability, economic aspects, e.g., costs for drilling wells and deep boreholes, and legal framework conditions, especially for brine (deep drilling) and groundwater, are relevant for the choice of heat source. As a result, air-to-water HPs are the most frequently used type of HPs, as the availability of ambient air as a heat source is generally significantly higher than that of the ground (brine) and groundwater, and the costs for heat source development and the legal requirements and barriers are also the lowest (Biermayr et al., 2023; Dott et al., 2018). In Austria, the installed capacity of air-to-air HPs is about 2.7 GW, followed by 1.4 GW for brine-to-water HPs and 0.25 GW for water–water HPs in 2023 (Eurostat, 2025). In Europe, the ranking is equal; in 2023, the installed capacity was 415.9 GW for air-to-air HPs, 25.7 GW for brine-to-water HPs, and 2.0 GW for water–water HPs (Eurostat, 2025).

The efficiency of HPs is expressed by the coefficient of performance (COP), which is defined by the ratio between the heat output ( $\dot{Q}_{HP}$ ) and the electrical power input ( $P$ ) at a specific operating point (Equation (1)) (O’Hegarty et al., 2022; Carroll et al., 2020). The thermodynamically maximum possible COP ( $COP_{max}$  or  $COP_{Carnot}$ ) is largely determined by the temperature range, i.e., the temperature difference between evaporation ( $T_0$  [K]) and condensation ( $T_c$  [K]) (Equation (2)).

$$COP = \frac{\dot{Q}_{HP}}{P} \quad (1)$$

$$COP_{max} = COP_{Carnot} = \frac{T_c}{T_c - T_0} \quad (2)$$

The relationship between the maximum possible coefficient of performance ( $COP_{max}$ ) and the real coefficient of performance (COP) is described by the Carnot efficiency ( $\eta_{Carnot}$ ), which is typically in the range between 0.4 and 0.6 (Equation (3)) (Vellei, 2014; Arpagaus et al., 2018).

$$\eta_{Carnot} = \frac{COP}{COP_{max}} \quad (3)$$

Seasonal efficiency is represented by the seasonal coefficient of performance (SCOP) or seasonal performance factor (SPF) and describes the ratio between the heating energy delivered and the electrical energy consumed under changing operating conditions during the operating period, which is typically one year.

The coefficient of performance (COP) for defined operating conditions or the seasonal coefficient of performance (SCOP) is determined in a standardized manner using special test procedures and calculation methods (COP: ÖNORM EN, 2023, 2023/SCOP: ÖNORM EN, 2023, 2023). The seasonal performance factor (SPF) is typically a measured variable for a specific system. Consequently, the choice or comparability of the system boundary for the measurements or calculations is also important for a comparison of the seasonal performance factors of different systems. Between the operation in the field (SPF) and the product rated performance in the lab (SCOP), there is a difference of about 40% (O’Hegarty et al., 2022).

The SPFs of HPs whose heat source is ambient air are lower than those of brine or groundwater heat sources due to the seasonal temperature fluctuations (Miara et al., 2011; Schibuola & Scarpa, 2016). Particularly in the winter months, i.e., when ambient temperatures are low and heating energy demand is high at the same time, COPs or seasonal performance factors below three are not uncommon (Miara et al., 2011; Schibuola & Scarpa, 2016). As a result, intelligent control and regulation approaches that take future weather and temperatures into account and are integrated into a holistic energy and building management system (smart home) are the subject of current research and development activities (Christensen et al., 2020; Afram & Janabi-Sharifi, 2014). Combinations of different

heat generators with air-to-water HPs in bivalent operation are also of interest. For example, air-to-water HPs in combination with gas (Beccali et al., 2022), pellet, or firewood boilers (BHT, 2024), as well as stoves (VestaTherm, 2024), are available on the market.

The use of potential synergy effects and increased energy efficiency are very promising with such hybrid HP systems. For example, in the summer months, the HP can reduce the running times in a partial load or low load operation of the boiler (e.g., for the provision of domestic hot water), and the building can also be cooled if required. On the other hand, the HP benefits from the bivalent mode of operation in that the biomass-based heat generator provides the required heating energy sustainably, efficiently, and comfortably in phases with increased power peaks in the grid or in cold winter periods (Beccali et al., 2022; Vellei, 2014).

### 1.3. User Experience of HPs

In addition to technical aspects, the user acceptance, user satisfaction, and user friendliness of HP systems (e.g., app-based control and regulation concepts, connection of the system to the Internet, or integration of the system into a smart home) also play a key role in achieving broad market penetration on the one hand and exploiting all efficiency and optimization potential on the other.

There are several studies and surveys that have analyzed the user experience, especially user satisfaction, such as thermal comfort, cost, and other factors that influence overall satisfaction.

For example, in Germany, a nationwide study was conducted in 2018 to evaluate the experience of HP users in terms of the usability, thermal comfort, operating costs, and maintenance of HPs (Vorbeck & Weinreuter, 2019). In 2029, Michelsen and Madlener surveyed 2135 users to investigate the satisfaction of homeowners with regard to residential heating systems (RHSs) based on renewable energy. They found that knowledge about the heating system and the compatibility of the heating system with daily habits and routines have a strong effect on user satisfaction. (Michelsen & Madlener, 2013).

In Norway, a study was conducted to evaluate the success of a subsidy program promoting renewable heating technologies (Bjørnstad, 2012). About half of the households (440 out of 896 households) that received a subsidy adopted HPs. The study showed that indoor quality, thermal comfort, electricity prices, technical quality of the equipment, and availability of services from the supplier influenced the overall satisfaction of the users.

In the United Kingdom (UK), three studies (Caird et al., 2012; Lowe et al., 2017; Taylor et al., 2023) evaluated user behavior, satisfaction, and performance. The results of Caird et al. (2012) indicated that users were predominantly satisfied with the reliability, heating, and thermal comfort provided by the HP system. Furthermore, the results indicated that there may be a correlation between the users' understanding of the HP system and the overall system efficiency and continuous operation of the HP system (Caird et al., 2012). According to the evaluations of Lowe et al. (2017), user satisfaction depends on a combination of several factors, such as thermal comfort and cost or environmental aspects and maintenance requirements (Lowe et al., 2017). A comprehensive user survey of 2549 HP owners and 1025 domestic gas boilers was conducted by Taylor et al. (2023). Data were collected in England, Scotland, and Wales on user satisfaction with the performance of HPs, the installation process, ease of use, and access to relevant information about the operation of HPs compared to gas boilers (Taylor et al., 2023). It was found that people using HPs were generally very satisfied with their heating systems. In the range of 85% and 92% of respondents, HPs are considered to be "safe, reliable, quiet heat sources that are effective for space heating and hot water production" (Taylor et al., 2023). However, in terms of cost, both HP and gas boiler users were predominantly satisfied with maintenance

costs but less satisfied with running costs compared to other features. It was also found that there is potential for improvement in terms of ease of use and control, particularly for people who have inherited an HP, e.g., by moving into a house where one is already installed (Taylor et al., 2023). In the UK, another survey was conducted in northern Scotland to identify and understand the potential problems of HP users (Lackova & Dinnie, 2016). Accordingly, a lack of information about the correct operation of HPs and noise were identified as the main problems for HP users.

A study in New Zealand analyzed a random sample of 160 households using HPs for heat supply (Burrough et al., 2015). In addition to interviews with householders, on-site inspections and a year of data collection were used to assess the energy use of HPs and the indoor quality conditions achieved, i.e., indoor temperature and humidity conditions. The results showed high overall satisfaction with HPs, and about 94% of respondents would recommend an HP to their family or friends. The heating performance of HPs was described as “excellent” by 42% of respondents, while only 15% of respondents were satisfied with the running costs (Burrough et al., 2015).

At least two studies have been conducted in the United States to evaluate HPs by surveying users about their satisfaction with the heating system. The Massachusetts Clean Electric Center evaluated the feasibility of air-to-water HPs as a primary heating source to replace gas boilers in about 150 projects. Six months after completion of the projects, users were asked about their satisfaction with the HPs. It was found that 95% of the users were satisfied with the comfort for heating and 100% of the users were satisfied with the comfort for cooling (“completely satisfied” or “somewhat satisfied”) (Howard, 2021).

The second study in the USA investigated brine-to-water HPs installed in 24 buildings located in cold climate regions of the USA (North Dakota). Surveys were conducted to determine user satisfaction, technology selection issues, operational performance and difficulties, and cost issues. The results showed that 75% of respondents were satisfied with their systems in terms of indoor comfort, noise, and cost. In addition, about 85% of the respondents would recommend their system to others (Y. Yu et al., 2017).

A recent European study published in 2022 presents the results of surveys conducted in 22 EU countries, i.e., 20 EU member states plus Norway and the United Kingdom (Olesen et al., 2022). The aim of the study was to “provide a snapshot of HP users’ perceptions of comfort, running costs and overall experience” (Olesen et al., 2022). The study shows an average of 88% satisfied users. On average, 64% of users had reduced operating costs after installing an HP, and 81% of users reported improved thermal comfort after installing an HP (Olesen et al., 2022).

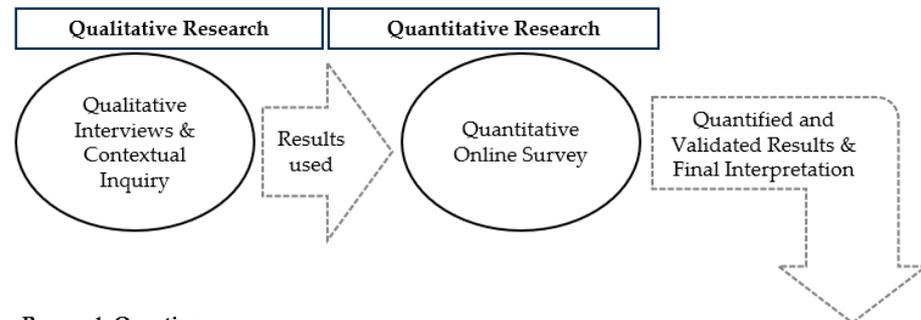
However, Austria was not included in this study. Furthermore, user behavior in terms of typical operating habits and expectations regarding control and regulation strategies were not part of this study. In conclusion, scientific studies that focus on the requirements and expectations of Austrian users, especially with a strong focus on operating habits and expectations regarding control and regulation strategies, are currently scarce or unknown to the authors. Similarly, the potential existence of different types of users with different expectations and requirements for HPs are not known for Austria.

#### *1.4. Objectives and Approach*

The aim of the study was therefore to find out which aspects are decisive for the choice of HPs over alternative hydronic systems for central heat supply, i.e., room heating and domestic hot water supply, which different types of HP owners can be distinguished, what is the overall satisfaction of users of HPs, how their specific user behavior can be characterized in terms of control and operation, and what their respective requirements and wishes are for the functions and operation of their HPs. The study focused on Austria.

A mixed-methods approach was used in an exploratory sequential design (Weber, 2024; Johnson & Onwuegbuzie, 2004). This means a combination of qualitative and quantitative approaches to data collection and analysis (Figure 3).

**Research Design:** Mixed Methods Approach – Exploratory Sequential Design



**Research Questions:**

- What are purchase arguments for HPs compared to other hydronic central heating systems?
- What is the overall-satisfaction of users of HPs?
- Which different types of HP users can be distinguished?
- How can their specific user behavior be characterized in terms of control and operation?
- What respective requirements and wishes have users regarding and functions and operation of their HPs?

**Figure 3.** Scheme of research design used for evaluating the research questions (source: own presentation).

Therefore, as a first step, qualitative interviews were conducted with selected HP users in order to investigate basic insights into the user experience with HPs. The qualitative interviews were accompanied by contextual inquiries to assess the practical user behavior of HP operation of the selected users. Based on the evaluation of the qualitative interviews and the contextual inquiries, the questionnaire for the quantitative online survey was developed in order to validate and quantify the results of the qualitative interviews, as well as to evaluate further aspects and questions derived from the results of the qualitative interviews in a second step.

Despite the limitation that the study was limited exclusively to Austria, it can be assumed that the results are easily transferable to European conditions, in particular to Germany and Switzerland. Based on the results, tailor-made services and marketing strategies can be developed for the respective user types and promising strategies for future product developments and optimizations can also be derived for HP manufacturers. In addition, many results regarding user behavior as well as the requirements and wishes regarding the control and operation of different user types can be interesting and applicable for manufacturers of other domestic central heating systems (e.g., biomass boilers).

### 1.5. Structure of the Paper

Section 2 describes in detail the methodological approach for the quantitative interviews accompanied by the contextual inquiry (Section 2.1) and the quantitative online survey (Section 2.2). Section 3 presents and discusses in detail the results of both approaches, qualitative (Section 3.1) and quantitative (Section 3.2). Furthermore, limitations of the study (Section 3.3), as well as possible further research directions (Section 3.4), are mentioned. Finally, in Section 4, conclusions are drawn by summarizing the study and its main findings, as well as providing an outlook on how the results can be used by manufacturers in the future.

## 2. Materials and Methods

This study was conducted by the Institute for Sustainability and the Department of Consumer Science at the University of Applied Sciences Wiener Neustadt—Campus Wiesel-

burg. The research was carried out using a mixed-methods approach in an exploratory sequential design. As a result, qualitative interviews were conducted as a first step. In a second step, a quantitative survey was developed and conducted based on the qualitative data collected. All interviews were conducted with participants from Austria.

1. Qualitative interviews (contextual inquiry) among nine HP users to explore fundamental findings in connection with the use and operation of HPs and to identify and classify potential user types. The following key questions were answered during the interviews:
  - How does the user operate the HP?
  - What operating errors/usability errors occur or have occurred so far?
  - To what extent are the users familiar with certain functions of the HP and to what extent have they already used them?
  - What requirements do the users have for the functions and operation of the HP? Are there different types of users?
  - How do they rate the concept of an app that can be used to control the HP?
2. A quantitative survey (online survey) with 510 participants to validate the results of the qualitative interviews and to evaluate and analyze the differences between the user types. The following key questions were answered according to the survey:
  - What is the distribution of the four types of HP owners defined based on the qualitative study?
  - What information about the HP heating system is relevant for the users?
  - What (additional) functions should an HP offer?
  - Is an app for operating the HP desired? What functions should an app for controlling the HP offer?
  - Which HP functions should be controlled via a smart home solution?

### 2.1. Qualitative Interviews

The qualitative interviews were conducted in July and August 2020 as in-home interviews with nine HP owners at their homes. Each interview lasted 45 min on average. A guideline with open questions was used to conduct the interviews. In addition, photos were taken of the HP and the use of the HP. A checklist of possible usable functions was used to record the functions already used and those already known or unknown when operating the HP. The selection of the interview partners was based on the customer list of Ochsner GmbH (=project partner), as well as from the circle of acquaintances of the scientific staff of the University of Applied Sciences Wiener Neustadt—Campus Wieselburg. All participants owned an HP, were involved in the decision-making process for the choice of HP, and usually also operated the HP.

The interviews were conducted by the research assistants using “contextual inquiry”. This means that the active user acts as a teacher for the researcher and demonstrates how he interacts with his current HP control system and reveals what optimization potential he still sees.

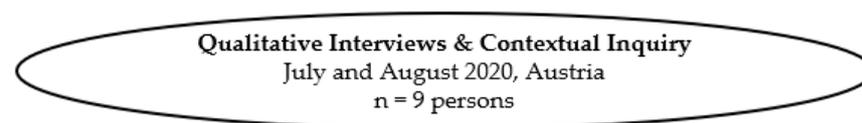
The guidelines used for the contextual inquiry were divided into the following three sections:

1. Pre-session interview
  - Associations that users associate with the HP;
  - General information about the HP (type of HP, number of heating circuits, additional heating, satisfaction, expectations, reason for purchase, advantages and disadvantages, smart home).
2. Contextual inquiry

- General information on operating the HP;
  - Demonstration of HP use by the test subjects. The contextual inquiry was introduced with the following instruction: “I would now like to find out more about how you use and operate your HP. Please explain your HP to me and exactly how you operate it. Please show me everything you use/operate in your home in connection with the HP. I would like to understand everything, so please explain the steps to me in detail.”;
  - Functions and settings;
  - Usage problems and error messages.
3. Post-session interview
- User manual;
  - App;
  - Satisfaction and recommendations and suggestions for improvement.

The interview guide and the checklist for querying the functions can be found in the Supplementary Materials and in Appendix A (Supplementary Materials: S1. Qualitative survey (contextual inquiry)—guidelines; Appendix A: Table A1).

The qualitative interviews were evaluated according to [Mayring \(2015\)](#) and further analyzed using descriptive statistics and MS Excel (Figure 4).



#### **Participant Recruitment**

- Selection of interview partners based on...
  - ... the customer list of Ochsner GmbH;
  - ... the circle of acquaintances of the scientific staff of the University of Applied Sciences Wiener Neustadt-Campus Wieselburg.
- Requirement for participants: owner of HPs (1); involved in the purchase decision (2) and in the operation (3) of the HPs.

#### **Data Collection**

- In-home interviews and contextual inquiry among nine HP owners;
- Duration of interviews: ~45 minutes;
- Informed consent was obtained.

#### **Data Evaluation**

- Qualitative content analysis according to [Mayring P. \(2015\)](#);
  - Identification and definition of user types;
- Descriptive statistics using MS Excel.

➤ Results were then used for elaborating the questionnaire for the quantitative online survey.

**Figure 4.** Summary of the methodological approach of the qualitative interviews and the contextual inquiry. Qualitative content analysis of qualitative interviews was carried out according to [Mayring \(2015\)](#) (source: own presentation).

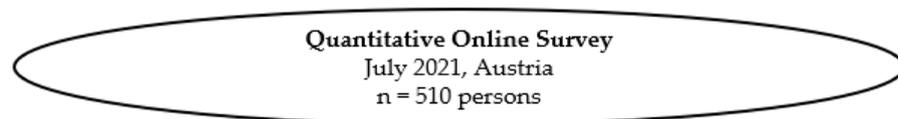
## 2.2. Quantitative Survey

Based on the results of the qualitative interviews, a questionnaire was developed in collaboration with Ochsner GmbH to validate and quantify the results of the qualitative interviews. The target group for the quantitative survey comprised both HP owners and interested persons in Austria who are planning to purchase an HP in the next two years as part of a new build or renovation project. Membership of the target group was determined at the beginning of the survey by means of a screening question.

The questionnaire, consisting mainly of closed questions, was structured into five sections as follows:

1. Key data on HP
  - General information about the HP (manufacturer, type of HP, additional heating, year of purchase, frequency of use, satisfaction, recommendation, expectations, reason for purchase, allocation of HP usage type).
2. Information about the HP heating system
  - What information is important? How is the HP operated? What information should be visible at first glance? Which settings would you like to make? Which additional functions are required? What historical data are required—time period, level of detail, form, willingness to pay? Is a report required?
3. App for operating the HP
  - Do you want an app? Where should it be available? What functions should the app offer?
4. Smart home
  - Is a smart home available? What type of smart home is available? Is the HP connected to the smart home? Which functions should be controllable via smart home?
5. Statistics
  - Age, gender, federal state.

The entire questionnaire of possible response options can be found in the Supplementary Materials (Supplementary Materials: S2 Quantitative survey—online questionnaire). The questionnaire was implemented by the company “MindTake” as a CAWI (=Computer Assisted Web Interviews) questionnaire, and the target group was surveyed online via the sister company “Talk Online Panel”. The period of the online survey was July 2021. The evaluation and analysis of the quantitative survey results were carried out using descriptive statistics in SPSS version 28 and MS EXCEL 2019 (Figure 5).



#### **Participant Recruitment**

- Access to the Austrian online panel for market research “Talk Online Panel” by the company “MindTake”;
- Computer Assisted Web Interviews (CAWI) among registered participants of the “Talk Online Panel” in Austria;
- Requirement for participants (screening question): owner of HPs (1) or interested person (2) for HPs within the next two years, e.g., due to new build or renovation of house.

#### **Data Collection**

- Completed online questionnaires of 510 participants;
  - 325 HP owners;
  - 185 interested persons;
- Informed consent was obtained.

#### **Data Evaluation**

- Results handed over in anonymized form by the company “MindTake”;
  - Descriptive statistics using SPSS and MS Excel.
- Results of qualitative interviews were quantified and validated, e.g., user types, as well as further aspects assessed;
- Final interpretation and discussion of results carried out and conclusions derived.

**Figure 5.** Summary of the methodological approach of the quantitative online survey (source: own presentation).

### 3. Results and Discussion

#### 3.1. Qualitative Interviews

##### 3.1.1. Pre-Session Interview—Key Data on the HPs and Purchase Reasons

Of the nine participants interviewed, six people owned an air-to-water HP and three people owned a brine-to-water HP from different manufacturers. The oldest HP was purchased in 2016, the youngest at the end of 2019. This means that the HPs were between four years and six months old at the time of the survey. All HPs represented hydronic heating systems used as a primary heat source for domestic heat and hot water supply (Table 1).

**Table 1.** Results of the qualitative interviews regarding the technical framework conditions of the HP and the reason for selecting the manufacturer (pre-session).

Requested Parameter	Interview 1	Interview 2	Interview 3	Interview 4	Interview 5	Interview 6	Interview 7	Interview 8	Interview 9
Heat source	Birne	Air	Air	Air	Air	Air	Birne	Air	Birne
Manufacturer	Vaillant	Austria Email	Viessmann	Viessmann	Dimplex	Ochsner	Drexel und Weiss	Elko	Rockenbauer
Model of HP	n.s.	Not really sure, but ECO	Vitocal 200-A	Vitocal-200-S	LAW 14ITR	GMLW 14 HK plus	X2S3	Airotop Split 9kW	SP10
Additional heating	Tiles stove	Chimney stove	Chimney stove	Electrical	Chimney stove	Not any	Chimney stove	Chimney stove	Chimney stove
Year of purchase	2017	2019	2017	2017	2016	2017	2019	2020	2017
Reason for manufacturer selection	Recommendation by installer	Recommendation by installer	Was included with the pre-fabricated house (exclusive)	Cheapest variant (works at the manufacturer)	Personal relationship with installer and wholesaler	Recommendation by installer	Good reputation manufacturer and recommendation by installer	Recommendation by installer	Recommendation by installer
Smart home	Yes (Loxone), HP is not integrated	Yes (KNX and Loxone), HP is integrated	Nein	Yes (KNX), HP is not integrated	Nein	Nein	Yes (Loxone), HP is not integrated	Nein	Yes (KNX), HP is not integrated
Combination with PV	No	Not yet, but the possibility exists	Yes	Not yet, but the possibility exists	Not yet, but the possibility exists	No	Not yet, but the possibility exists	Not yet, but the possibility exists	Yes

n.s. (not specified).

According to users, the advantages of purchasing a brine-to-water HP are that there is no need to provide space for a split evaporator in the garden, that it is not dependent on the ambient temperature compared to an air-to-water HP, and that you can expect higher efficiency (COP/SCOP). In contrast, the air-to-water HP is cheaper, easier to install, and easier to replace if something breaks. For both types of HPs, the recommendation from the installer was decisive for the choice of manufacturer. The importance of the installer is also highlighted by the findings of [Vorbeck and Weinreuter \(2019\)](#). They found out that information for purchase decisions is gathered from the installer (47%) but also largely from the internet (55%) ([Vorbeck & Weinreuter, 2019](#)). Another study found that peers, i.e., friends, colleagues, or neighbors, can influence the decision to choose a specific heating technology ([Caird et al., 2008](#)).

All but one respondent had an additional heating system installed, i.e., either a wood-burning stove (7) or additional electric heating (1). The additional heating system is a secondary heating source that is used only to heat the room in which it is installed or, in the case of manually operated stoves, can be used as an emergency heat source in the event of a power failure.

Two interviewed people have a PV system, but these are not connected to the HPs in terms of control and regulation (power-to-heat; P2H). Five interviewees stated that they would have the option of installing a PV system. Of these, two people and the two PV owners were interested in control and regulation coupling with the HP (P2H).

The advantage was seen as better electricity utilization and thus electricity savings. The disadvantage was that this is technically very complicated and would result in additional investment costs. However, the results of the surveys conducted by Olesen et al. (2022) showed that the combination of HPs with PV systems resulted in lower overall costs and correlated with high user satisfaction with this combination (Olesen et al., 2022).

Five of the nine interviewees have a smart home solution in their house in the form of Loxone or KNX. For one of the five people, the HP is also networked with the smart home, although only the operating status (on/off) is displayed. The other respondents do not see networking or integration of the HP into the smart home system as necessary.

At the beginning of the interview, the respondents named three features that “come to mind when you think of your HP”. This shows that most of the names and associations with the HP are positive (Table 2).

**Table 2.** Results of the qualitative survey regarding users’ associations with their HP, the reasons for purchasing it, and the advantages and disadvantages of choosing an HP compared to alternative or previous heating systems (pre-session).

Respondent/Interview	Which Associations Do You Have with Your HP? (Three Mentions)?	Which Reasons for Purchasing an HP Were Important to You?	Which Advantages and Disadvantages Do HPs Have for You Compared to Alternatives or Previous Heating Systems?
1	Uncomplicated, comfortable, cooling is cool	Convenient, environmentally friendly, little effort	Alternative would have been a firewood boiler, HPs more expensive to purchase, but no storage room necessary and less operating effort, i.e., ash disposal and fuel loading
2	Heating, heating and cooling, “Big ugly box”	The cheapest solution to purchase and maintain	Previous heating system was based on pellets; but with the HP, it is much more convenient and requires less operating effort
3	Environmentally friendly, energy efficient, no fuel storage	Environmentally friendly, easy to use, modern technology	Alternative would have been a (liquid) natural gas heating system; however, no fossil fuels and also no raw material storage with an HP
4	Efficient, affordable, environmentally friendly	Efficient appliance, easy to install, quiet operation	Oil and gas would have been an option; however, an HP is more environmentally friendly, space-saving, and energy-efficient in a modern house
5	Pleasant, uncomplicated, fulfills its purpose	Ecological variant, environmentally friendly	n.s.
6	Cheapest solution, unobtrusive, quiet	Low space requirement (no chimney, storage room), compact appliance	n.s.
7	Green footprint, low maintenance (hopefully), expensive	Environmental awareness, ease of use	Natural gas was previously used (different location) and gas pipeline would have been available; however, independence from fossil fuels was important
8	Heating, warming water, cooling	Independence from fossil fuels (oil, gas), cooling function (heating and cooling)	The HP requires no storage space and no fossil fuels; it also has a cooling function
9	Inexpensive, sustainable, low maintenance	Sustainability (especially with PV combination)	n.s.

n.s. (not specified).

From the positive associations and the mentions regarding the reasons for purchasing an HP, arguments that speak for or are relevant to the purchase of an HP can be identified or derived.

In comparison to previously used heating systems or alternative heating systems about which the test persons have informed themselves, they see the advantage of HPs, for example, that no storage space is required, that it takes up little space, is convenient, and does not produce any residues such as ash. The higher purchase costs are seen as a disadvantage.

Compared to hydronic pellet and firewood heating systems, the HP is very convenient, as there is little operating, maintenance, and servicing work with this heating system, i.e., no ash disposal, no firewood handling such as provision, storage, and manipulation work, and manual fuel loading of the boiler.

Compared to hydronic oil or gas heating, the advantage of the HP is that no fossil fuel is required and no raw material storage is necessary (oil or liquid–gas tank). In addition to being environmentally friendly, the HP is also considered to be energy-efficient and quiet.

The purchase arguments presented in Table 2 correspond well with the findings of Michelsen and Madlener (2013). In addition to costs, financing conditions, and environmental aspects, they identified low effort in fuel procurement, low maintenance requirements, and independence from fossil resources as essential purchase arguments for residential heating systems based on renewable energy (Michelsen & Madlener, 2013).

### 3.1.2. Contextual Inquiry—User Habits for Operation and Functions

As part of the contextual inquiry, the interviewed persons demonstrate the use of their HP to the interviewer and at the same time explain what they like and dislike about it and what suggestions for improvement or optimization potential they see.

Almost all interviewees (8) operate their HP via a room terminal with a touch display or control dial (Figure 6).



**Figure 6.** Room terminal with touch display (a) or setting wheel (b) of two test subjects from the qualitative interviews.

Only two respondents stated that they use their mobile device (smart phone) and also operate the HP via an app. In contrast, one respondent used the basic operating device directly on the HP exclusively and three respondents used it in addition to the room terminal or the app.

The spontaneous associations with the operation of the HP can be divided into four categories, “Visual appearance” and “Operation positive/negative/neutral” (Table 3).

**Table 3.** Classification of the spontaneous associations of the interviewees regarding the operation of their HP into four categories based on the qualitative survey (contextual inquiry).

Visual Appearance	Operation Positive	Operation Neutral	Operation Negative
old-fashioned not visually appealing	simple (6) rare (2)	my husband does it temperature	Not intuitive (2) Complicated
super user interface	you can't do anything wrong		inflexible (no individual customization of the start screen)
	self-explanatory		too extensive functions in layman mode
	automatic no technical know-how necessary		

() Numbers in brackets indicate multiple answers.

The operation of the HPs is predominantly associated with positive associations, such as “simple operation”, “no technical know-how required”, or “self-explanatory”. However, it was also criticized that the operation is partly “inflexible”, which means that an individual adjustment of the start screen is not possible, as well as that the functions are too extensive for the “layman mode”. Based on the feedback, there was a general desire for simple operations and the need for operations should be rare. Simple, problem-free, and self-explanatory operation with an uncomplicated menu structure and support for set up by the service technician during commissioning is desired.

The frequency of use of the HP, i.e., using the control panel, room terminal, or smart phone (app) to receive information about the HP and/or change any settings, varied considerably among the respondents. The answers range from “only once so far” to “three to five times a year” to “every day”. The HP control unit is primarily used in winter (e.g., regulating the room temperature, checking the brine temperature). In summer, on the other hand, only the cooling mode is controlled (flow temperature). In the transitional period (i.e., autumn and spring), more settings are made or adjusted, e.g., switching the HP on/off, adjusting the room temperature with suboptimal heating curve settings, or setting the heating times. Furthermore, the operating functions are used depending on the situation, e.g., “when you are cold for a moment”, when an error occurs or when, for example, a function is extended (e.g., pool heating is integrated into the HP). Those tested people who use a certain control of the HP very frequently (i.e., sometimes even daily) do so to read about the outside temperature or to ventilate the bathroom daily using the living room ventilation integrated into the HP.

To find out which functions are already being used, a function checklist was used to query the HP owners (Supplementary Materials: S1 Qualitative survey (contextual inquiry)—guidelines). This was used to find out to what extent the user is aware of certain HP functions and to what extent they are already using them. The most frequently used functions are in the categories “Heating/Cooling” and “Hot water”. The special functions, as well as the general functions, were hardly used or not used at all (Appendix A: Table A1).

The question of whether error messages had already been provided by the appliance was answered by three test persons with “Yes” and six with “No”. All error messages were rectified with the help of the manufacturer’s customer service.

### 3.1.3. Post-Session Interview—Operating Instructions, App Usage, User Satisfaction, and Potential for Improvement in Functionality and Operation

Another interesting result of the qualitative interview is that only three of the nine respondents stated that they had read the operating instructions. The reasons for not reading the operating instructions varied as follows:

- Everything necessary explained by the company/installer;
- Operation very intuitive (“learning by doing”);
- Too much information in the manual.

Paying less or even no attention to the manual was also found for a remarkable share of users of other heating technologies (Reichert et al., 2016; Wöhler et al., 2016). During the post-session interview, the interviewees were also asked how they would rate the concept of an app that could be used to operate the HP and control the functions remotely. Four respondents were interested; the remaining five rejected this concept due to a lack of interest, a lack of added value, and concerns about data security. The respondents who would be interested in the app, which can be used via mobile phone or tablet, would like it to be easy to use and have a modern user interface, as well as the following functions:

- Setting the temperature room by room;
- Overview of whether the HP is switched off or on;

- Display of faults and error messages;
- Control the room and water temperature;
- Preparing hot water;
- Change operating mode;
- Read data (outdoor temperature, time setting);
- Memory function for seasonal settings (change summer/winter);
- Manual accessible for reading;
- Ventilation status can be viewed.

The app should be available via the app store, as it is usual and familiar for the interviewees. A pure web app is not desired.

Finally, the respondents were asked about their overall satisfaction with their HP and whether they would recommend the HP to others. In this respect, the picture was very uniform, as all nine people stated that they were satisfied or even very satisfied and would be prepared to recommend their HP to others (Table 4).

**Table 4.** Summary of the results of the interviewees regarding their overall satisfaction with their HP and their willingness to recommend it to other people (qualitative interview, post-session).

Respondent/Interview	Are You Satisfied with Your HP? Why or Why Not?	Would You Recommend the HP Incl. Control Panels to Another House Builder?
1	Very satisfied, good training by manufacturer, no problems so far	Yes
2	Very satisfied, good training by manufacturer	Yes
3	Yes, no problems with the system so far	Yes
4	Yes, good service and very good support	Yes
5	Basically yes, but analysis of troubleshooting very difficult/troublesome; accessibility of support unsatisfactory	Yes
6	Basically yes, manufacturer is expensive (upper pain threshold), but quality and service very good	Yes
7	Yes, problem-free operation so far	Yes
8	Basically yes, but there is a problem with an error message that has not yet been resolved (but the manufacturer is making efforts)	Yes
9	Yes, the appliance is very reliable and has worked perfectly so far. Energy costs are also very low so far	Yes

Important for customer satisfaction is problem-free operation, good training in the operation and mode of operation of the HP, and good availability of support and rapid rectification of any faults. This is consistent with the findings of Bjørnstad (2012), who found that the technical quality of the installation, thermal comfort, and the availability of the heating system supplier were critical factors in user satisfaction (Bjørnstad, 2012).

When asked what suggestions for improvement the interviewed people had regarding the general operation and control of the functions of their HP, the following points were expressed:

- Faster feedback from the control panel, e.g., that a changed setting has been accepted;
- Simplify menu levels, some of which were perceived as very complex and unnecessarily convoluted;
- Improve the visual display of the operating devices and allow for individualization of the start screen and display in standby mode (basic operating device and/or room terminal);
- Make a double assignment of buttons recognizable;

- Create brief instructions with the most important main functions and attach them next to or on the HP;
- Provide sufficient options for temperature settings;
- Provide an app with a description of the main functions;
- Provide sufficient information on error messages so that the user really understands what the problem is.

Comparing the previously listed points with the findings of Taylor et al. (2023), it is confirmed that well-designed and intuitive controls have the potential to improve the user experience (Taylor et al., 2023).

#### 3.1.4. HP User Types—Definition and Description

Based on the qualitative content analysis of interviews according to Mayring (2015) and the contextual inquiry, four different user types of HP owners were identified, categorized, and described (Table 5). The user types differ in the type, frequency, and intensity of use of control possibilities of their HP, as well as in their technical understanding of the HP and its integration into the building's energy management system.

**Table 5.** Description of different user types of HP owners derived and defined based on the results and experiences of the qualitative interviews.

User Type (Characterizing Quote)	Description
The functionalist "I'm happy when I don't have to work with the HP."	The functionalist is characterized by the fact that he hardly deals with the functions of the HP and primarily uses it to adapt the room and water temperature. They rely on the default settings and recommendations of the service technician and try to make as few changes as possible themselves. The functionalist is not very tech-savvy and does not want to deal with the HP.
The minimalist "It doesn't need to be able to do much, just provide hot water and heat. These basic functions must appear in the first interface."	The minimalist does not need any frills and does not attach any importance to the visual appearance of the controls. They are tech-savvy, know their way around the HP and do not like it when the menu navigation is less intuitive and complicated. The minimalist only needs a few functions (ideally individually adjustable on the start screen) and only uses them when necessary.
The tech-savvy tinkerer "The operation is really foolproof."	The tech-savvy tinkerer is very well informed about the HP and is characterized by a high level of technical know-how. He wants or has a smart home system and has integrated it into the building independently. Operation is mainly via the app and is perceived as very simple, and the functions are easy to find.
The anxious one "If you get lost once, it's rather difficult to reset."	The anxious one is characterized by the fact that they do not like to use the HP but are happy to leave this to their partner. They relinquish responsibility for operation because they have had no or bad experiences with operation.

### 3.2. Quantitative Survey

#### 3.2.1. General Information About the Survey Participants

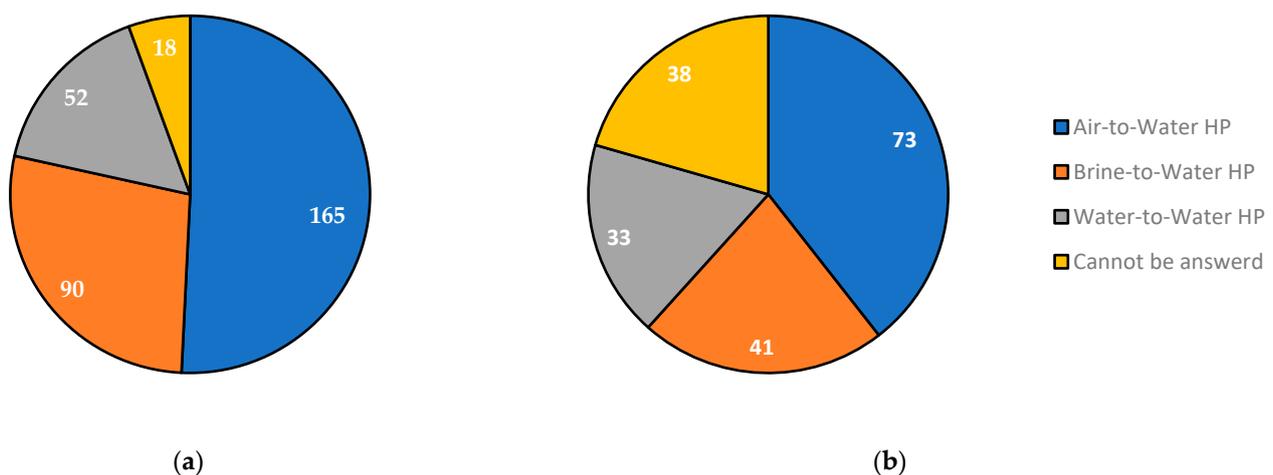
A total of 510 people from all nine Austrian provinces took part in the survey in accordance with the target group. According to the screening question, 325 people were HP owners and 185 were interested and planning to purchase an HP within the next two years as part of a new build or renovation project at the time of the survey. The average age of the participants was 46.8 years (Table 6).

**Table 6.** Results of the quantitative online survey regarding the composition of the survey’s target group and relevant statistical data.

Question	Answer Options	Frequency (Absolute)	Frequency (Relative)
Screening HP owners (target group)	Current HP owner	325	63.7%
	Potential HP owner (interested party—new build)	49	9.6%
	Potential HP owner (interested party—renovation)	136	26.7%
Gender	Male	296	58.0%
	Female	214	42.0%
	Lower Austria	172	33.7%
Place of residence (federal state)	Vienna	111	21.8%
	Styria	74	14.5%
	Upper Austria	46	9.0%
	Carinthia	37	7.3%
	Burgenland	30	5.9%
	Tyrol	21	4.1%
	Vorarlberg	10	2.0%
Age	Salzburg	9	1.8%
	18–29 years	80	15.7%
	30–39 years	122	23.9%
	40–49 years	78	15.3%
	50–59 years	92	18.0%
	60–69 years	89	17.5%
	70 years and older	49	9.6%

### 3.2.2. Key Data on Survey Participants and HPs

Of the 325 HP owners who took part, around half owned an air-to-water HP (50.8%), followed by brine-to-water HPs (27.7%) and water-to-water HPs (16%). The order of the 185 interested persons was also comparable. The dominant technology type was the air-to-water HP (39.5%), followed by brine-to-water HPs (22.2%) and water-to-water HPs (20.5%) (Figure 7). This distribution corresponds qualitatively to the HP market in Austria, where air-to-water HPs dominate with around 85%, followed by brine-to-water HPs (approx. 10–15%) and water-to-water HPs (approx. 1–2%) (Biermayr et al., 2023).

**Figure 7.** Technology distribution among HP owners (n = 325) (a) and among interested persons (n = 185) (b) (source: own illustration).

The appliances of the HP operators surveyed were predominantly less than five years old (132 devices). The oldest appliances (41 appliances) were purchased in 2001 or earlier, meaning that these HPs were 20 years old or older. In total, 79 of the respondents’ HPs were more than five years old and 73 appliances were between 10 and 20 years old.

Of the 73 manufacturers represented among the HP owners, the three most frequently named were Vaillant (25.8%), Ochsner, and Viessmann (8.3% each). In the low single-digit percentage range were Dimplex (4.9%), Austria Email (3.4%), Drexel and Weis and Steibel Eltron (3.1% each), IDM (2.8%), and Elko (2.5%).

About two-thirds (68%) of HP owners (n = 221) had an auxiliary heating system. More than half of these stated that they had another central heating system as an auxiliary heating system, i.e., oil, gas, or biomass boilers. Approximately 40% of them had a space heater as additional heating and just under 14% stated that they had an additional electric heating system (Table 7).

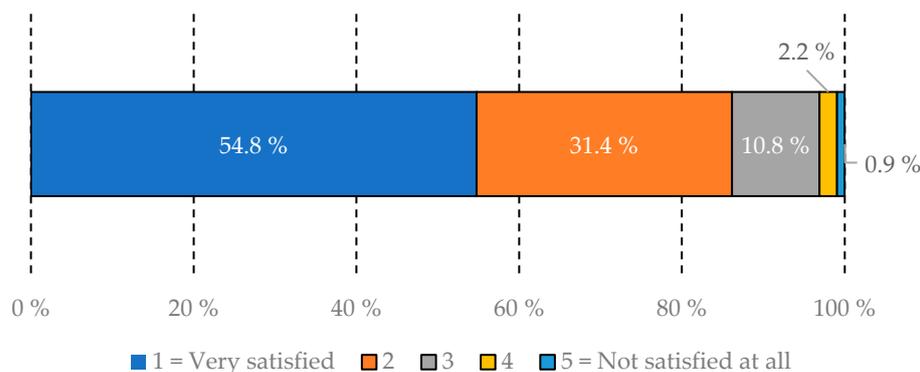
**Table 7.** Frequency of responses regarding the presence of an additional heating system in addition to the HP heating system based on HP owners who have an additional heating system (n = 221).

Type of Additional Heater	Frequency (Absolute)	Frequency (Relative)
Oil boilers	38	17.2%
Natural gas boilers	54	24.4%
Biomass boilers (e.g., logs, wood chips, pellets)	43	19.5%
Wood-burning stove (e.g., logs, pellets)	96	43.4%
Electric additional heating (e.g., infrared radiant heaters, night storage heaters)	30	13.6%
Other (e.g., open fireplace, solar thermal system)	8	3.6%

These findings are in good agreement with those of a recent user survey of 2549 domestic HP owners in the UK (Taylor et al., 2023). This study also found that two-thirds of HP users have a secondary heating source. Wood stoves are also the most common (49%), followed by gas boilers (34%). Like our study, the study by Taylor et al. (2023) did not ask about the reasons for having a secondary heating system and the mode of operation in which it is used. However, it is suggested that secondary heating sources are typically used either for esthetic and comfort reasons or as a supplemental heating system to provide heat in a specific area (Taylor et al., 2023). In Germany, gas, oil, or biomass boiler systems and HPs are also used in a bivalent operating mode for domestic central heating (Vorbeck & Weinreuter, 2019). Such systems are also available for renewable heating systems in Austria, especially pellet or firewood boilers in combination with air-to-water HPs (e.g., BHT, 2024).

### 3.2.3. User Satisfaction and Arguments for Purchase

The high level of overall satisfaction from the qualitative study was clearly confirmed in the quantitative survey (see Tables 2 and 3). As a result, more than 85% of HP owners are satisfied and awarded at least a score of two (Figure 8).



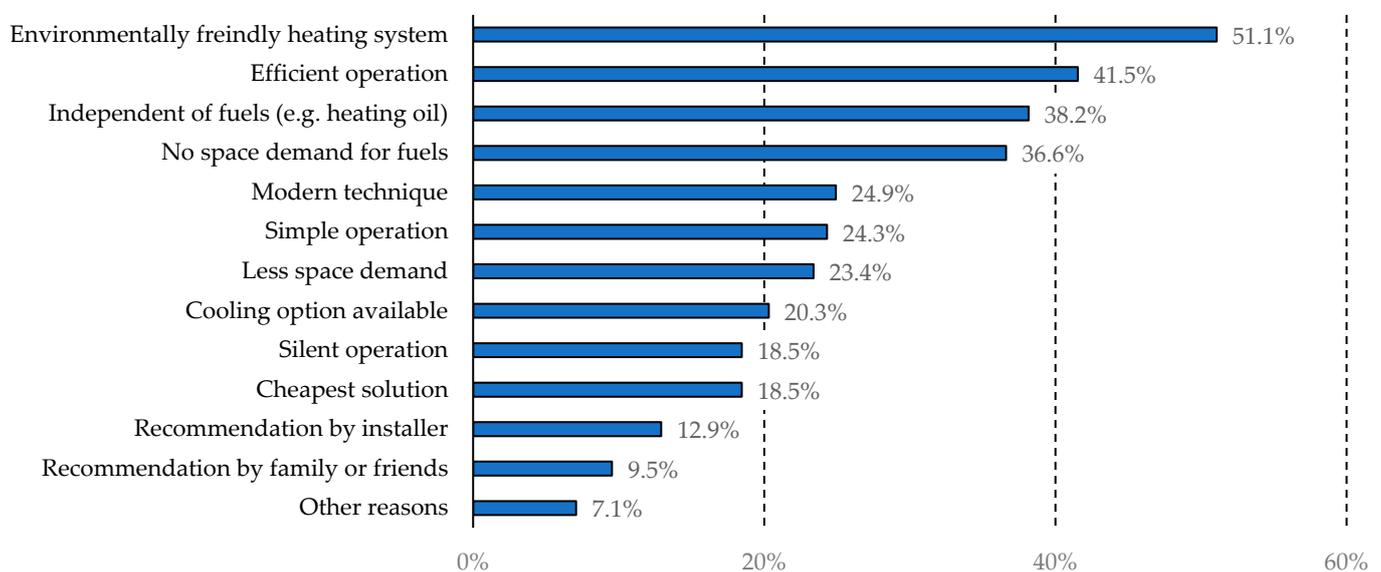
**Figure 8.** Overall satisfaction of HP owners with their HP (n = 325) (source: own illustration).

The high level of overall satisfaction among HP owners is also reflected in their high willingness to recommend the system to others. Over 80% of HP owners are “very likely” (57.8%) or “likely” (24.6%) to recommend their HP system to others. These results are in line with several studies that have found a generally high overall satisfaction of HP owners with their heating systems (Bjørnstad, 2012; Burrough et al., 2015; Howard, 2021; Caird et al., 2012; Lackova & Dinnie, 2016; Lowe et al., 2017; Michelsen & Madlener, 2013; Olesen et al., 2022; Taylor et al., 2023; Vorbeck & Weinreuter, 2019; Y. Yu et al., 2017).

According to the study by Olesen et al. (2022), the overall satisfaction of HP users in Europe is around 88%. (Olesen et al., 2022). About 10.8% of HP users rated their overall satisfaction with a median between “very satisfied” and “not satisfied at all”. Approximately 3% of HP users surveyed were “not satisfied” or even “not satisfied at all”. In this study, a lack of information about proper instructions for heating operation and unrealistic expectations about running costs and comfort were identified as potential reasons for dissatisfaction (Olesen et al., 2022). In addition, poor installation (Burrough et al., 2015; Taylor et al., 2023) or noise disturbance, an insufficient adaptability of controls, and a lack of technical support are aspects associated with potential dissatisfaction (Lackova & Dinnie, 2016; Olesen et al., 2022; Taylor et al., 2023).

The high percentage of recommendations of the HP system to others was also observed in the study by Y. Yu et al. (2017), with approximately 85% for brine-to-water HPs (Y. Yu et al., 2017). Taylor et al., 2023, also observed a high likelihood of recommending HPs to others (Taylor et al., 2023).

The main arguments for purchasing an HP compared to alternative heating systems are the high level of environmental friendliness, efficiency, and independence from fossil fuels in the eyes of the HP owners (Figure 9).



**Figure 9.** Percentages of responses of HP owners to the question “Why did you choose an HP and not another heating system?” (multiple answers possible; number of respondents: n = 325) (source: own illustration).

These results are also in line with the results of Neves and Oliveira (2021), as well as Matschegg et al. (2023), who found out that the environmental concern of users, as well as environmental performance, are clearly more valued than financial aspects when people chose an energy supply system. However, it is important to note that the electricity consumed by the HP also affects the environmental performance. This means that when comparing a fossil-based heating system with an HP in terms of carbon dioxide equivalents

(CO<sub>2e</sub>), the HP may only have advantages at a certain HP efficiency in combination with a certain CO<sub>2e</sub> factor, which represents the electricity production used to operate the HP (Walker et al., 2022). In Austria, the CO<sub>2e</sub> for electricity production is 227 g/kWh, while the CO<sub>2e</sub> for natural gas and heating oil is 247 g/kWh and 375 g/kWh, respectively (OIB, 2019). Therefore, compared to heating systems based on these fossil fuels, the application of HPs would be advantageous even at low COPs. However, it has to be considered that the CO<sub>2e</sub> for district heating based on renewable fuels or CO<sub>2e</sub> for solid biomass fuels are 59 g/kWh and 17 g/kWh, respectively.

It is also interesting to note that almost a quarter (24.9%) of HP owners cited simple operation as one of the reasons for purchasing the appliance, putting it ahead of the economic argument, i.e., the “cheapest solution” (18.5%). This confirms the findings of Michelsen and Madlener (2013), as well as Karytsas, 2018, who evaluated that the ease of use is an important factor which influences the choice of users for a specific residential heating system (Michelsen & Madlener, 2013; Karytsas, 2018). Approximately 18.5% of HP owners stated that the silent operation of HPs was a purchase argument. This is interesting because there are studies that indicate that noise could be a negative issue of HP operation. For example, according to the study by Lackova and Dinnie (2016), about 43% of respondents declared that their HPs are too noisy (Lackova & Dinnie, 2016). According to the findings of Taylor et al. (2023), about 10% of respondents were “not very satisfied” and about 5% were “not at all satisfied” with the noise of their HPs (Taylor et al., 2023).

However, the results are consistent with the German study, where only 6% of respondents complained about noise and vibration problems in their own homes and only 1% of respondents faced noise complaints from their neighbors (Vorbeck & Weinreuter, 2019). In addition, the New Zealand study found that 91% of HP users did not have problems with noise or vibration from their HP, even for the adjacent property (Burrough et al., 2015).

The quantitative results very accurately reflect the information provided by the respondents in the qualitative interviews. Here, too, environmental friendliness, high efficiency, low space requirements (no fuel storage), independence from fossil fuels, and simple operation were the most important arguments in favor of purchasing an HP (see Table 2). In addition, a HP is currently the only heating system for single-family homes that can heat in winter and cool in summer.

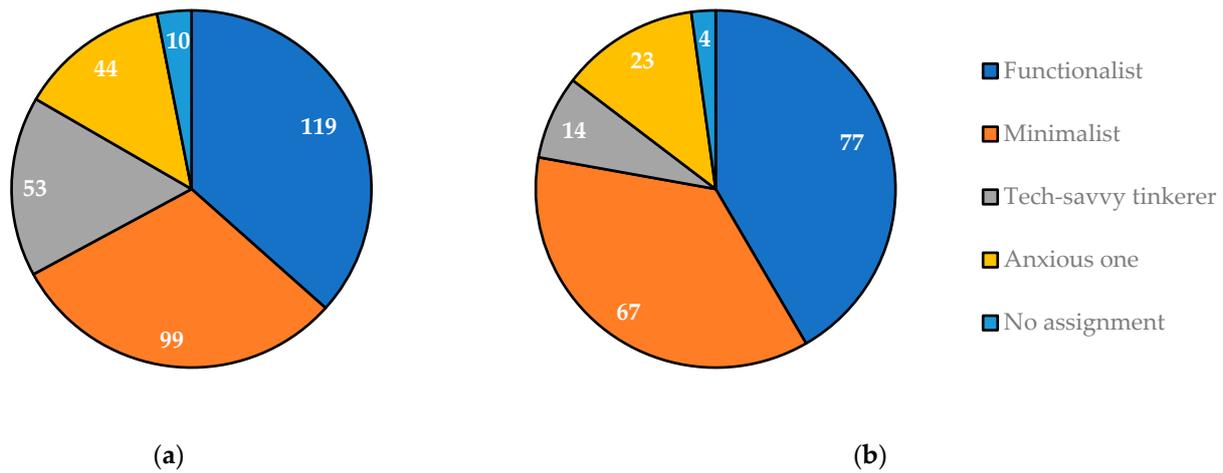
However, there are also studies that have shown that costs, especially investment costs, represent barriers against choosing a renewable heating system, especially when changing a fossil fuel-based heating system (Puente et al., 2020; Billimoria et al., 2018; Kevin et al., 2021).

In the German HP survey, environmental arguments (72%) and economic arguments (71%) were mentioned equally, indicating that both environmental aspects and economic considerations are relevant purchase arguments (Vorbeck & Weinreuter, 2019). In addition, Olesen et al. (2022) also concluded in their study that the use of HPs for heating is motivated by a mix of arguments, i.e., environmental/climate concerns, economic reasons, and expectations of improved comfort (Olesen et al., 2022). This mix of arguments is also validated and confirmed by the findings of Taylor et al. (2023).

The recommendation by installers (12.9%), as well as by family or friends (9.5%), as purchase arguments for HPs confirms the results of the qualitative study that installers (Table 1) and potentially other people have an influence on the purchase decision of HPs (Vorbeck & Weinreuter, 2019; Caird et al., 2008).

#### 3.2.4. HP User Types—Owners Versus Interested Persons

Participants in the user survey were asked to assign themselves to a specific user type (see Table 5) to validate the four user types according to the analysis of the qualitative interviews (Figure 10).



**Figure 10.** Self-assignment of the respondents to the predefined user types among the HP owners ( $n = 325$ ) (a) and among the interested persons ( $n = 185$ ) (b). Definition of the user types based on the selectable response options: “A HP has to perform for me, I trust the default settings and want to have as little work as possible with it” (=functionalist); “I’m interested in technology, but what matters to me with a HP are the essential functions. It should be intuitive to use and not need any frills” (=minimalist); “I know the functions of the HP inside out and often adapt the settings. Operating the HP is not a challenge for me” (=tech-savvy tinkerer); “I prefer to leave the operation of the HP to others, I’m afraid that I might misadjust something” (=anxious one). (source: own illustration).

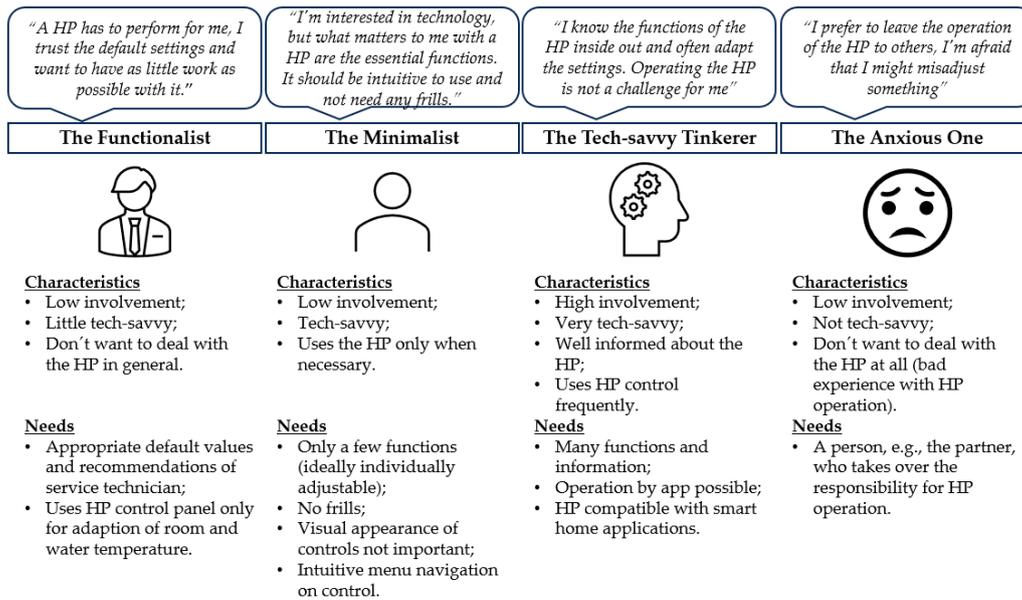
In terms of the types of HP users, the functionalist and minimalist clearly dominate. Together, both user types comprise just under 70% (HP owners) and just under 80% (interested persons or future HP owners). The tech-savvy tinkerer and the anxious user type are significantly less common (HP owners: 16% and 14%, respectively/interested persons: 8% and 12%, respectively).

A comparison of the two groups (owners and interested people) shows that the proportion of tech-savvy tinkerers in the group of WP owners is more pronounced than in the group of interested persons.

A statistical analysis of the qualitative interviews and the contextual survey was not possible due to the limited number of respondents. Therefore, an important question was whether the four user types were sufficient to adequately categorize HP owners in terms of their usage habits and their expectations regarding control and regulation strategies for their HP. Therefore, participants in the quantitative survey were able to assign themselves to one of the four user types on the basis of a characterizing description (see caption of Figure 10). What was important in this context was whether or not all participants could find themselves in one of the four categories.

The proportion of people who could not be assigned to any of the predefined user types was less than 5% (HP owners: 3%/interested people: 2%). In conclusion, the results of the quantitative survey can validate the four categories of user types derived from the contextual survey, as well as the qualitative interviews using qualitative content analysis, according to Mayring (2015). This confirms the impression from the qualitative study that the four predefined user types can cover the user spectrum sufficiently.

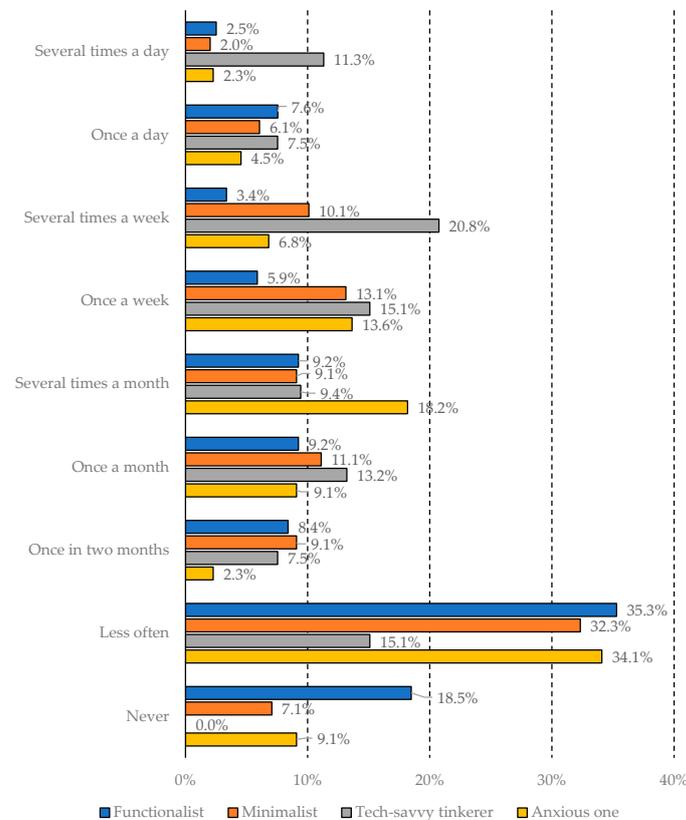
The four user types have different needs regarding the control possibilities of the HP and can be characterized according to their involvement in the operation of the HP, as well as according to their technical understanding of the HP and its integration into the energy management system of the building (Figure 11).



**Figure 11.** Characteristics and needs of the four identified user types (source: own illustration).

### 3.2.5. Operation and Functions—User Habits, Wishes, and Requirements

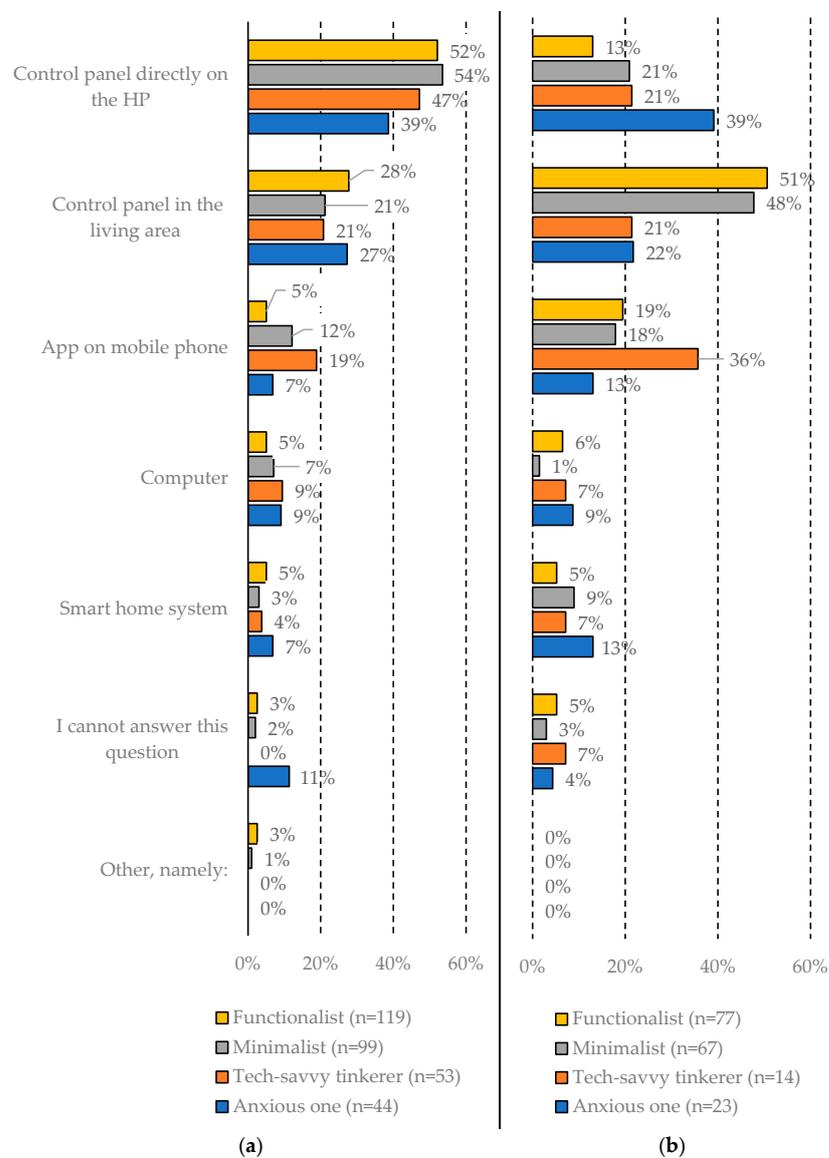
The frequency of use, e.g., the use of the room terminal or the control panel for the HP in the qualitative study, varied substantially (see Section 3.1.2.). Based on the results of the quantitative survey, the frequency of use, i.e., any adaptation of the control panel of the HP, is similar or different depending on the user type (Figure 12).



**Figure 12.** Percentages of responses (no multiple answers) to the question “How often do you operate the HP using the control panel (e.g., make changes to the settings, check values on the control panel, switch the HP on and off)?” depending on the user type (functionalist; n = 119; minimalist: n = 99; tech-savvy tinkerer: n = 53; anxious one: n = 44) (source: own illustration).

The frequency of use of minimalists, functionalists, and anxious users does not differ significantly. The most common frequency of use in terms of changing any settings is less than once every two months. However, there is a clear difference in the operating frequency of the tech-savvy tinkerers, who operate their HP several times a week; in 11.3% of cases, it is even several times a day. In conclusion, tech-savvy tinkerers are characterized by high involvement in HP operation, whereas functionalists, minimalists, and anxious users are characterized by low involvement in HP operation. The functionalists who want to have the least to do with their HP (see Table 5) are the group of users who consequently make up the largest proportion of users who do not operate their HP at all (18.5%). The results thus indicate and validate that the people have correctly assigned themselves to the user categories.

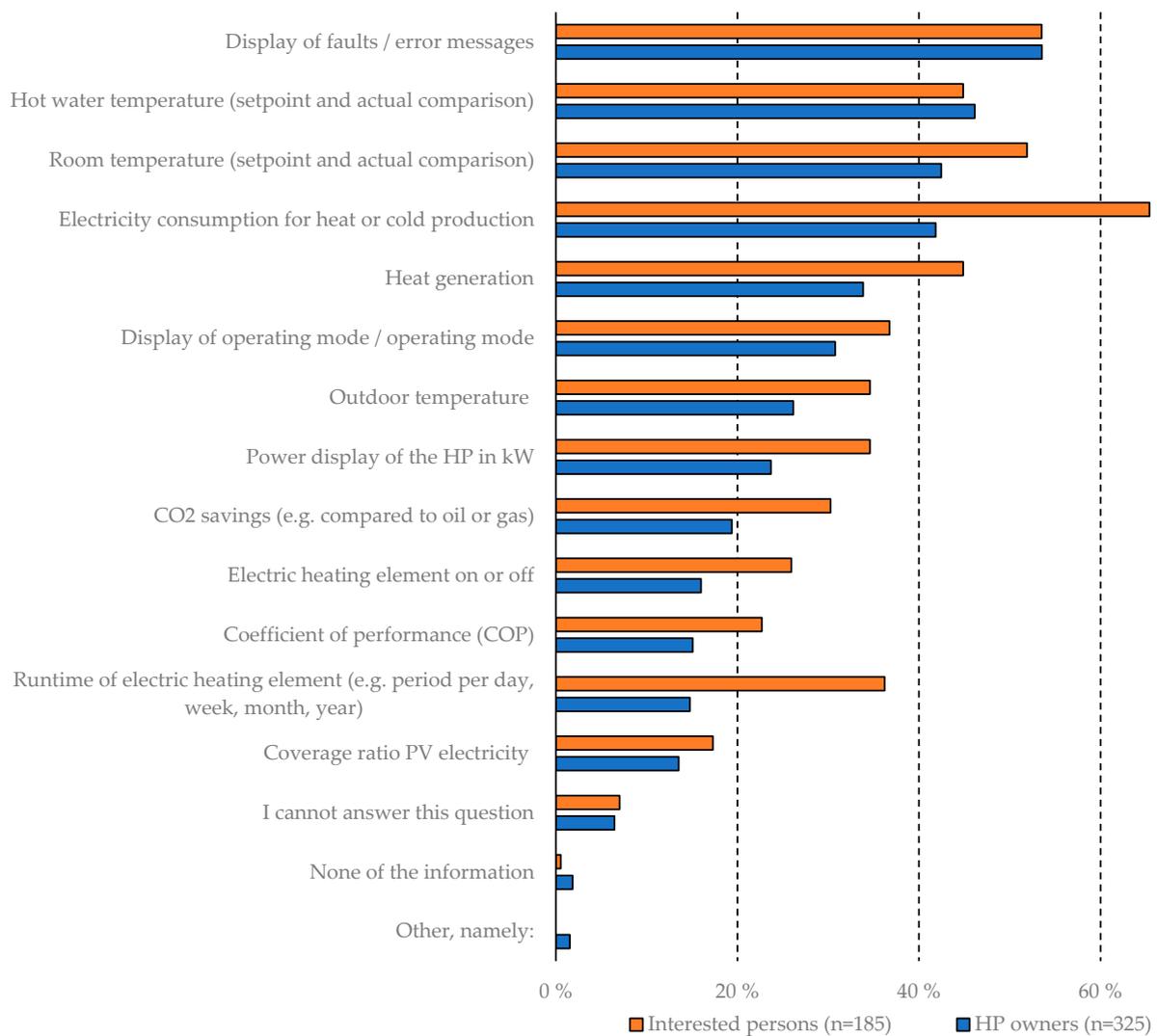
The question regarding the way in which users operate the HP (owners) or would operate the HP (interested persons) showed that the control panel on the HP or in the living room is generally preferred (Figure 13).



**Figure 13.** Percentages of responses to the question: “How do you mainly operate your HP, or would you like to operate your HP?” HP owners (a) and interested persons (b), basis: total, n = 496 (all persons who assigned themselves to a user type—see Figure 7); multiple answers possible (source: own illustration).

The control panel in the living area is even more preferred by the minimalists and functionalists among the potential interested parties compared to the current HP owners, who tend to favor the control panel directly on the HP. Operation via an app is particularly interesting for the “tech-savvy tinkerer” user type and appears to be even more relevant for potential new customers in this user category. However, for potential future HP owners of the other user types, the app is also mentioned more frequently as a control unit, as is the smart home, compared to current HP owners. As a result, it can be assumed that opportunities to use the HP via such solutions will increase in importance in the future (see also Section 3.2.6).

Two questions dealt with the topic of what information about the HP system is fundamentally important and what information the user would like to see on the control panel at a first glance. The answers were very similar for current and future HP owners (Figure 14).

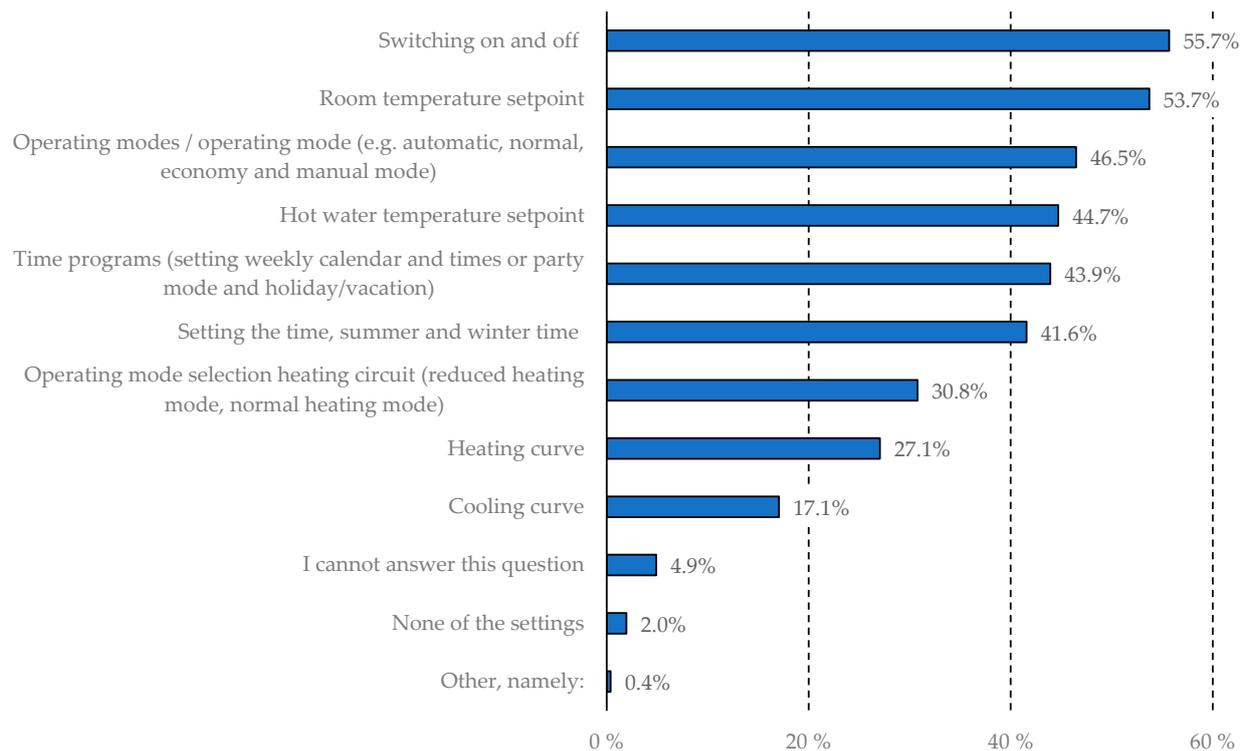


**Figure 14.** Percentages in response to the question “What information would you (as a user/operator) like to see at first glance on your preferred control panel?” Basis: total, n = 510; multiple answers possible (source: own illustration).

The display of faults or error messages and the target/actual comparison of the room temperature are the most important information that the people surveyed want to see “at first glance” on the control panel. Equally important to users is information on the room tempera-

ture (setpoint and actual comparison) and information on the current power consumption of the HP (in heating or cooling mode). It is interesting to note that future users seem to rate this information as significantly more relevant than fault or error messages. The increased awareness of the relevance of electricity consumption in HP systems is also confirmed by the fact that information on the running times of a potential electric heater is also rated as more important for future HP operators compared to current operators.

When asked which settings on the preferred control panel should be very easy to change, more than half of the respondents indicated the option of switching the system on and off (55.7%) and setting the target room temperature (53.7%) (Figure 15).



**Figure 15.** Percentages in response to the question “Which settings would you like to be able to change very easily on your preferred control panel?” Basis: total, n = 510; multiple answers possible (source: own illustration).

More than 40% of respondents would also like to be able to change the operating mode (e.g., automatic or manual mode), the target hot water temperature, and time programs or prime times on their preferred control panel. In addition, the use of time programs, for example, for holidays or changing settings in different seasons, must also be very easy to change, which is consistent with the findings of [Lackova and Dinnie \(2016\)](#).

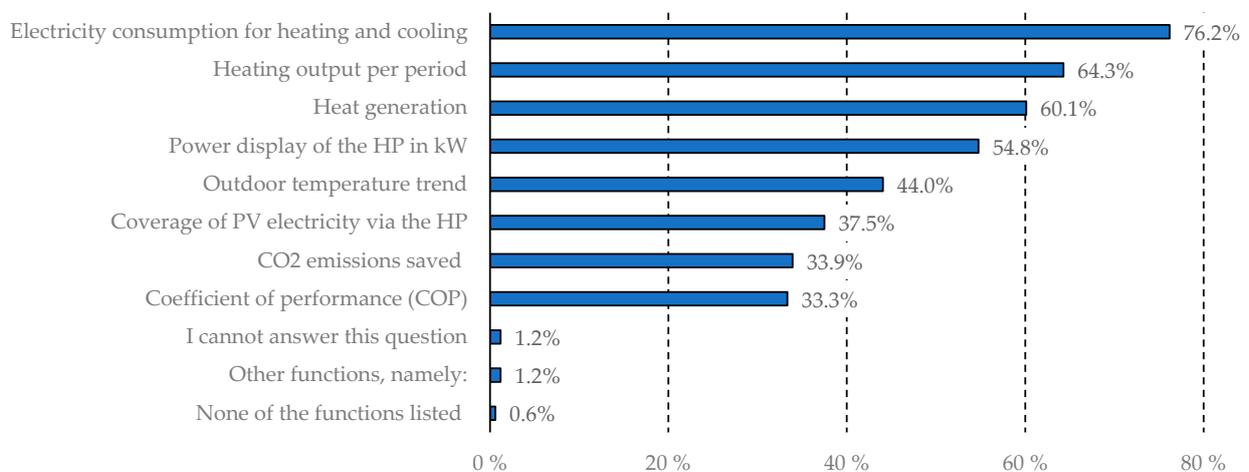
Of the options that an HP should offer as possible additional functions, the following response frequencies were given by more than a quarter of the respondents (basis: total, n = 510; multiple answers possible):

- Status display directly on the HP: 42.0%;
- Control panel directly on the HP: 38.2%;
- HP can be connected to the Internet (e.g., for control, maintenance, etc.): 38%;
- Access to historical HP data (e.g., output, outdoor temperature trend, etc.): 32.9%;
- Automatic system analysis and troubleshooting via remote access by the manufacturer (requires connection of the device to the Internet): 29%;
- Automatic updates (requires the appliance to be connected to the Internet): 28%;

- Automatic fault report to manufacturer/service center (requires connection of the device to the Internet): 27.1%;
- Automated information for the next maintenance or inspection dates (requires connection of the device to the Internet): 25.9%.

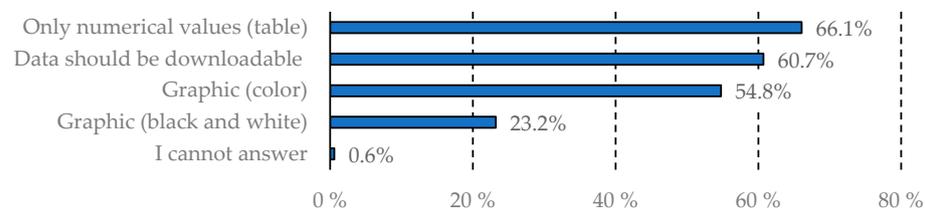
It is interesting to note that just under 40% of respondents see the connection to the Internet or the services for which an Internet connection is necessary as a desired additional function. It can therefore be concluded that there is also a proportion of users who are skeptical about Internet-based services, e.g., because they are concerned about data or investment security.

For 168 people (32.9%), access to historical data is an interesting additional function. In further questions, these 168 people were asked about this in more detail. This showed that relevant parameters for performance and efficiency (economic efficiency) but also ecological aspects, such as CO<sub>2</sub> emissions saved, play a role or would be of interest (Figure 16).



**Figure 16.** Percentages of responses to the question “Which historical data would you like to be able to access?” Basis: people who were interested in accessing historical data (see previous question), n = 168; multiple answers possible (source: own presentation).

The period within which the historical data can be accessed was stated by 66 people as “Up to one year” (39.3%). Furthermore, 78 people stated that they were interested in access beyond one year (46.4%). Regarding the format and resolution of the data, it was found that the data were preferably requested in daily (44%) or hourly (28.6%) resolution, either in table format as numerical values or as graphics, in black and white or preferably in color. The data should also be available for download (Figure 17).

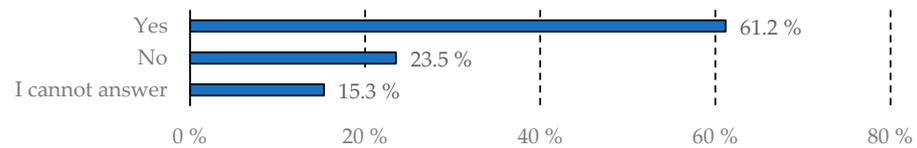


**Figure 17.** Percentages of responses to the question “In what form should the historical data be presented?” Basis: people who were interested in accessing historical data, n = 168; multiple answers possible (source: own presentation).

However, the willingness to pay extra for access to historical data is low. Out of 168 people, 130 people (77.4%) stated that they were not willing to pay for it. The remaining 38 people were willing to do so in principle. Twenty-four respondents (14.2%) were in

favor of a one-off payment, while 14 respondents (8.3%) would prefer an annual payment method. The costs stated by the 38 participants ranged from EUR 2 (annual payment) to EUR 1000 (one-off payment). The most common cost figures were EUR 20 (annual payment) and EUR 100 (one-off payment).

Irrespective of the 168 respondents who were asked about the historical data, all respondents were asked whether they would like “a report on your HP including information on potential savings” and, if so, whether they would be prepared to pay for this report. This question was answered in the affirmative by 312 people (61.2%) (Figure 18).

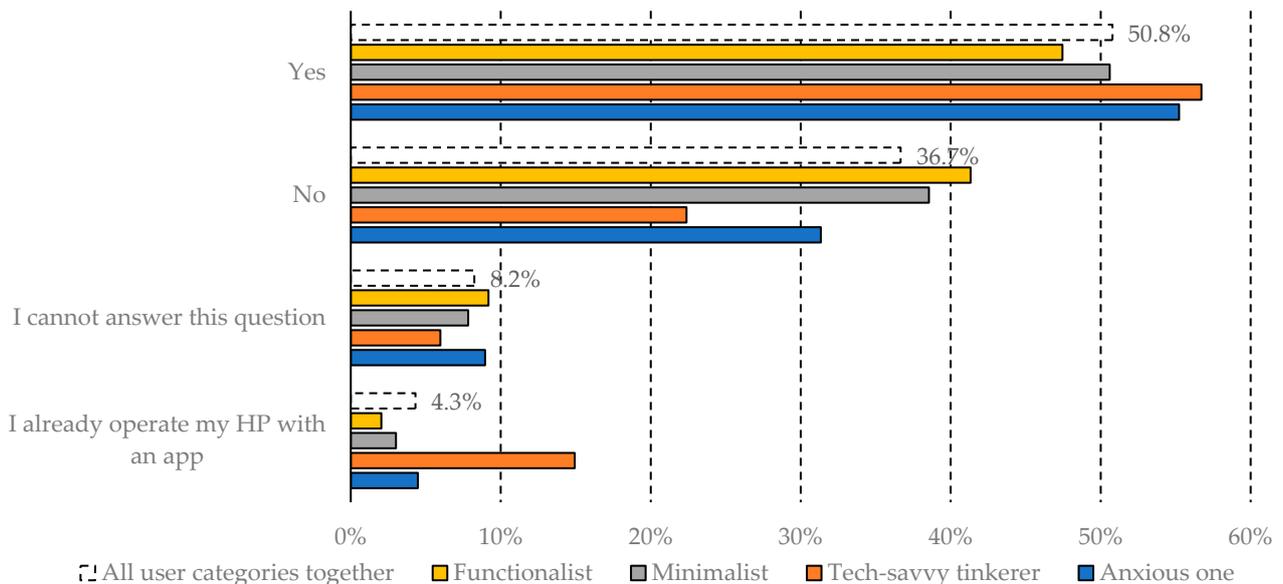


**Figure 18.** Percentages of responses to the question “Would you like a report on your HP including information on potential savings?” Basis: total, n = 510 (source: own presentation).

In terms of willingness to pay, however, the picture was similar to that of willingness to pay for access to historical data. More than three-quarters of the respondents (241 people, 77.2%) who would like to receive a report refused to pay extra for it. Of the 71 people (22.8%) who would be willing to pay in principle, the range of amounts they were willing to pay was between EUR 3 and EUR 1000. The two most frequently mentioned amounts were EUR 10 (15 people) and EUR 50 (13 people).

### 3.2.6. Operation via App—Wishes and Requirements

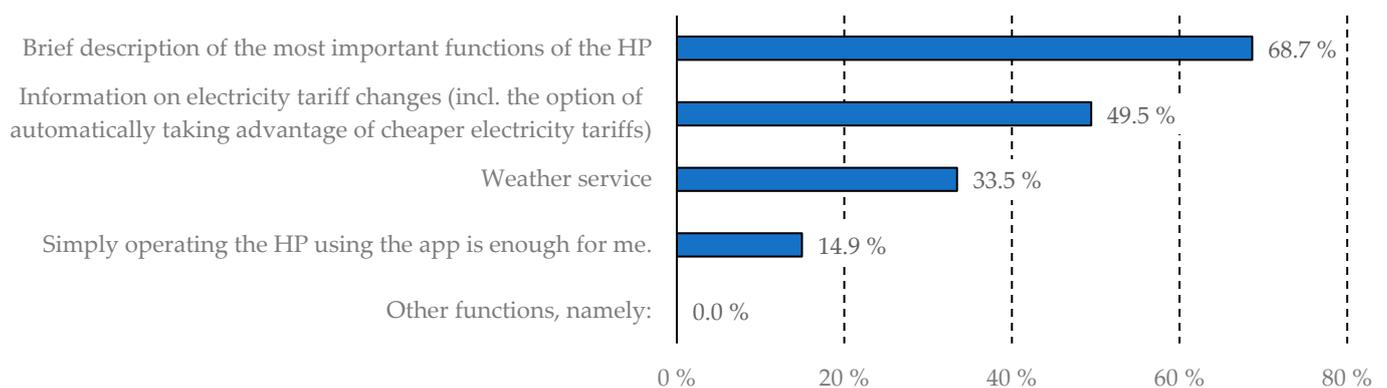
The question regarding the wishes and requirements for operating the HP via an app showed that around half of all respondents (n = 259; of which 151 current HP owners and 108 potential future HP owners) would like this option for operating the HP. In addition, 22 people (4.3%) already operate their HP via an app (Figure 19).



**Figure 19.** Percentages of responses to the question “Would you like to be able to control the HP via an app?” Basis: total, n = 510. Percentage response frequencies for the respective user types; basis: n = 496 (source: own presentation).

The proportion of around 50% of respondents who would like an app corresponds roughly to the proportion of respondents from the qualitative survey who were also in favor of an app (see Section 3.1.2).

When analyzing the different user types, it is noticeable that operation via an app is particularly interesting or relevant for the tech-savvy tinkerer (71.6% agreement in total). The distribution of statements for the other user types was very similar, and it is striking that the anxious user, who actually does not like using or controlling the HP, has the second-highest share of approval (59.7%). The follow-up question to the people who wanted an app for operation (n = 281, multiple answers possible) was “Where should the app for operating the HP be available?” Here, the option “app/play store” was by far the most common answer (77.9%), followed by “manufacturer’s website” with 36.7% and a purely “web-based app” with 23.1%. When asked what other functions (beyond just operating the HP) the app should offer, the most common answer was “Brief description of the most important functions of the HP” (68.8%), followed by “Information on electricity tariff changes (incl. the option to automatically take advantage of cheaper electricity tariffs)” (49.5%) and as a “weather service” (33.5%). Nevertheless, 85% of app users or potential app users stated that they would like the app to offer additional functions that go beyond simply operating the HP (Figure 20).



**Figure 20.** Percentages in response to the question “What other functions of the app (beyond just operating the HP) would you like?” Basis: current and potential app users, n = 281; multiple answers possible (source: own illustration).

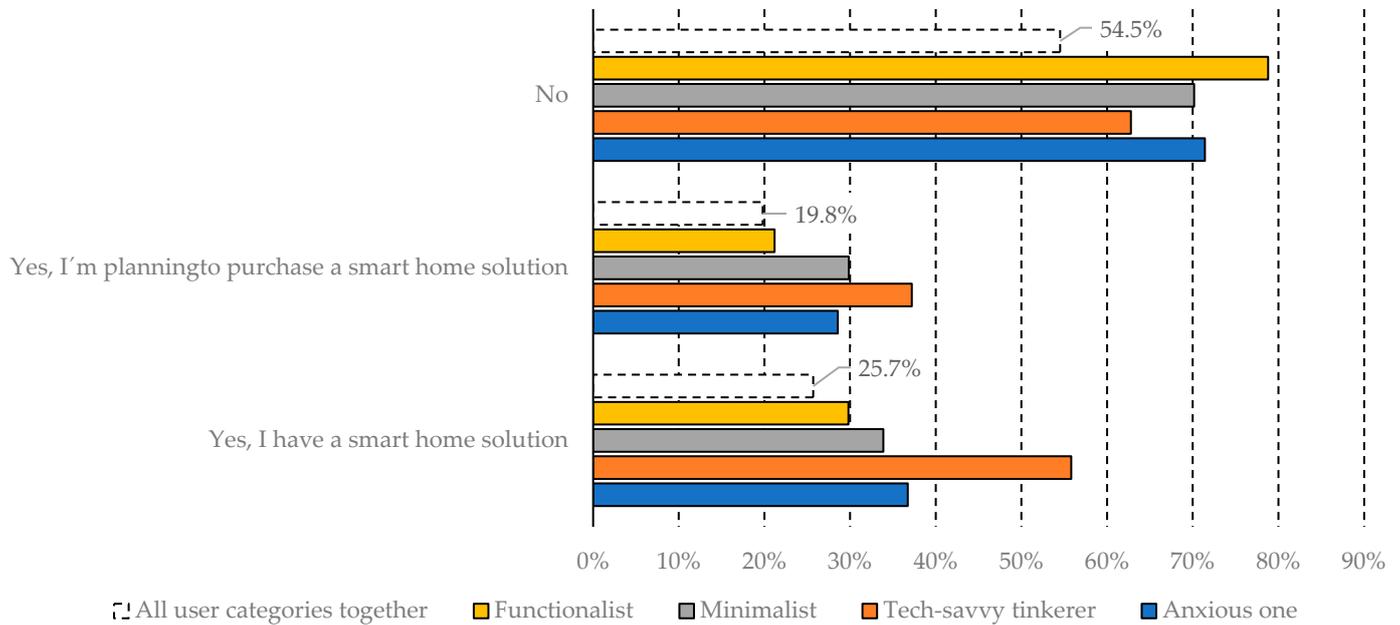
### 3.2.7. HP in the Smart Home—Wishes and Requirements

Around 50% of current or future HP users are current or potential future smart home users. In total, 131 people, i.e., 25.7% of those surveyed, stated that they already have a smart home solution. Additionally, 101 people, i.e., just under 20%, are planning for a smart home solution (Figure 21).

A smart home is a building in which individual components or devices are networked with each other. The devices and components can be controlled and monitored centrally via end devices, e.g., mobile phones. The added value of a smart home lies in the intelligent interaction of the components. Smart homes make it possible to implement holistic energy and building management concepts with intelligent control and regulation approaches (Dede et al., 2021; F. Yu et al., 2023).

In terms of the respective user types, the results are very similar to the results regarding app use. Over 50% of users classified as tech-savvy tinkerers have a smart home solution, and the approval or planning of smart home solutions is also the highest or most common among future HP owners, at 37%. Users who count themselves as functionalists reject a smart home solution in just under 80% of cases. However, minimalists and the

anxious group also rejected a smart home solution with just under 70% as a group-specific response frequency.



**Figure 21.** Percentages of responses to the question “Do you have a smart home solution (e.g., Alexa and co., home automation systems such as KNX or Loxone) in your house or are you planning to purchase a smart home solution?” Basis: total, n = 510. Percentage response frequencies for the respective user types; basis: n = 496 (source: own presentation).

The people who answered yes to the existence of a smart home solution or a smart home solution being planned (n = 232) were asked two further questions, namely “which smart home solution is used or should be used in the future” and whether the “HP is also connected or should be connected to the smart home” (Table 8).

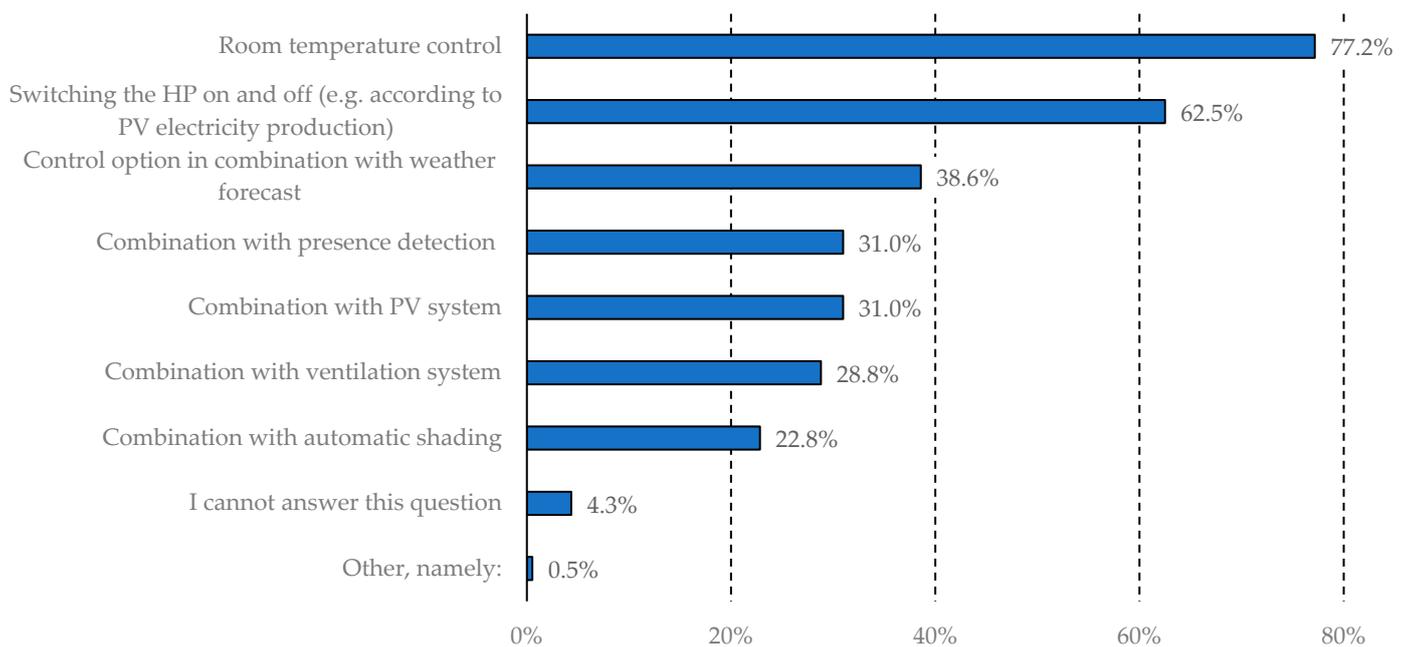
**Table 8.** Frequency of responses regarding smart home solutions and the integration of the HP into the smart home based on HP owners who own a smart home or are planning a smart home solution (n = 232).

Question	Options	Frequency (Absolute)	Frequency (Relative)
Which smart home solution do you have, or which one are you planning to purchase?	Alexa	137	59.1%
	KNX	20	8.6%
	Loxone	19	8.2%
	Other, namely: ____	15	6.5
	I don't know yet	41	17.7
	Total	232	100
Is or should the HP also be connected to the smart home?	Yes, the HP is already connected to the smart home.	45	19.4%
	Yes, the HP is to be connected to the smart home.	139	59.9%
	No	48	20.7%
	Total	232	100%

The dominant smart home communication system is Alexa (59.1%) from Amazon. Loxone and KNX are used far less frequently, with a response rate of less than 10%. In just under 80% of cases, users also stated that the HP is or should be connected to the smart

home. However, it is also interesting to note that around 20% of respondents decidedly refused to integrate the HP into the smart home system. This is in line with the results from the qualitative study, according to which as many as four out of five people who own a smart home did not see the need or benefit of integrating the HP into the smart home system (see Section 3.1.1). To conclude, some smart home users appear to need information regarding the benefits or purpose of HP integration into the smart home system.

The follow-up question to the people who integrate or want to integrate the HP into the smart home (n = 184) dealt precisely with this topic, i.e., with the purpose or benefit of the smart home in combination with the HP. This showed that room temperature control and optimum operation in combination with a PV system and on the basis of weather forecasts are the most important functions in connection with the implementation of the HP in the smart home system (Figure 22).



**Figure 22.** Percentages in response to the question “Which functions should be controllable via the smart home system?” Basis: people who have a smart home solution or are planning to purchase one and would like to control or manage the WP via the smart home, n = 184 (source: own presentation).

### 3.3. Limitations

As mentioned above, the interviews and survey were conducted in Austria. Therefore, the results cannot be generalized to other countries, as climatic conditions, subsidy programs for heating systems, or the thermal quality of buildings may be different.

In addition, the results of the quantitative survey are not representative. All respondents were members of the “Talk online panel”, which is a voluntary platform for people who want to participate in market research surveys. For participating in the surveys, people receive a certain amount of credit, which can either be paid out or exchanged for certain products.

No questions were asked about the installation conditions of the HP. Therefore, no statements can be made about the installation quality. This may be particularly relevant for people who are not satisfied or not satisfied at all with their HP systems. For about 135 respondents, it cannot be guaranteed that the HP is the primary heating system, because they use another boiler system as an additional and maybe even as the primary heating system (see Table 7). While stoves or additional electric heating systems are usually used only temporarily and are limited to the installation room, boiler systems, e.g., oil, gas, or

biomass boilers, could be used in combination with the HP in a bivalent operation mode, which could influence the user behavior regarding the control panel settings for the HP. This is confirmed by the findings of [Vorbeck and Weinreuter \(2019\)](#), who assumed that in Germany, old fossil boilers are either used as reserve boilers after being replaced by HPs as primary heating systems or as primary heating systems at low ambient temperatures in a bivalent operation mode ([Vorbeck & Weinreuter, 2019](#)).

The four user types were primarily defined based on the qualitative interviews and the contextual inquiry using a qualitative evaluation approach, i.e., qualitative content analysis according to [Mayring \(2015\)](#). Even though more than 95% of the interviewees could assign themselves to one of the four user types, one category might be missing, as about 14 users could not assign themselves to one of the predefined user types (see [Figure 10](#)).

### 3.4. Further Research Directions

Detailed research into the factors responsible for the number of respondents who were “not satisfied” or “not satisfied at all” with their HPs would be a relevant and interesting topic.

Another interesting line of research would be to correlate user types with more socio-economic factors, such as a correlation between education and salary ranges. Furthermore, the motivations for using smart homes, apps, and digital services as a control tool for the heating system could be further assessed. On the one hand, lack of information seems to be a barrier to digital control options, e.g., apps or smart homes, while on the other hand, security concerns about data may play a certain role.

Furthermore, it would be interesting to see if the user categories also apply to other hydronic central heating systems, e.g., biomass boilers.

An interesting aspect, slightly indicated by the results of the quantitative survey, is the more detailed assessment of the operation of hybrid heating systems, i.e., the combination of two hydronic heating systems in a bivalent operation mode (see [Table 7](#)).

In addition, further research should focus on a better understanding of user types, especially the anxious one, since he is involved in the choice of the heating system on the one hand but wants nothing to do with the heating operation on the other. There is a need to develop appropriate strategies that can reduce anxiety and at the same time provide ease of use.

## 4. Conclusions

### 4.1. Summary

A mixed-methods approach in exploratory design was used to research user behavior, identify potentially different user types and their specific wishes, and requirements for the HP system. This means that the research questions and research objectives were processed and analyzed with the help of qualitative and subsequent quantitative surveys (mixed-methods approach in an exploratory sequential design). During the qualitative survey, nine people were interviewed with regard to their HP technology and relevant aspects for the purchase decision, and the use and operation were recorded and analyzed using contextual inquiry. In the subsequent quantitative survey, a total of 510 people were interviewed. This allowed the results from the qualitative interviews with current and future HP owners/users in Austria to be validated and substantiated on a broader basis.

### 4.2. Purchase Arguments

The most relevant arguments for purchasing HP as opposed to alternative heating systems are their high level of environmental friendliness, efficiency, and independence from resources, particularly fossil fuels. Furthermore, the small space requirement, ease of operation, and the possibility of using the HP as a cooling device in summer are other

important arguments in the purchasing decision. When choosing the heat source (air, brine, water), space requirements, efficiency, and price, as well as advice from the installer, play a decisive role. The installer's opinion is also decisive when it comes to the specific HP model or HP manufacturer. It is therefore an important conclusion that installers should be extensively informed and trained to provide users with the best possible advice.

#### *4.3. User Satisfaction*

The overall satisfaction of the HP users surveyed is high to very high, and the willingness to recommend the HP as a heating system (recommendation rate) is over 80% of those surveyed. These are important factors for the technological image of the HP and enable a high level of user acceptance so that further market potential can be exploited in the future.

#### *4.4. User Types*

Regarding certain usage and requirement patterns, four user types were identified and classified based on the surveys—the minimalist, the functionalist, the tech-savvy tinkerer, and the anxious one.

The user behavior regarding operating the HP as well as the wishes and requirements in relation to the HP in the context of the entire building and energy system differ according to the defined user types. Minimalist and functionalist are the most common users of HP systems. Both user types want as little effort as possible in the operation of the HP. For them, it is important that the HP functions reliably and is as simple as possible to use. This also applies to the anxious user type. Except for the tech-savvy tinkerer, operation should mainly take place/be possible via the control panel on the HP or on the control panel in the living area. The tech-savvy tinkerer tends more towards operation via an app compared to the other user types.

#### *4.5. User Behavior—Operating Habits and Expectations*

As a basis for operation, the interviewees primarily want information on faults or error messages, relevant temperature displays (e.g., room and hot water temperature, outside temperature), and a display of power consumption and energy produced (heating and cooling). Switching on and off and setting temperatures and operating modes should be as simple as possible using the control element. Almost a third of respondents would like to have access to historical data on their HP (e.g., graphically or as a table), automatic analysis and troubleshooting via remote access by the manufacturer, and automatic system updates as additional functions. It is interesting to note in this context that just under 40% of respondents were in favor of connecting their HP to the Internet. Consequently, there appears to be clear uncertainties or concerns in this regard. Just under 60% of respondents would also like a report with information on possible savings potential. However, the willingness to pay for an extra report or for extra access to historical data is rather low.

Around half of those surveyed would like to be able to control the HP via an app and around 25% have or are planning a smart home. The tech-savvy tinkerers are particularly well represented. Any app should briefly describe the most essential functions of the HP and provide information on the weather conditions and electricity tariff changes. The benefits of implementing the HP in a smart home are seen in the fact that room temperature control, switching the HP on and off, and an optimum combination of the HP with the PV system and ventilation system and automatic shading can be set via the smart home system.

#### *4.6. Application and Outlook*

In conclusion, it can be stated that the study enabled a comprehensive analysis of current and future HP users in Austria. Through the characterization and specific analysis of the different user types, tailor-made system solutions can be developed, user friendliness

can be optimized, and new services and marketing strategies can be developed. HP manufacturers can use the results to derive their own strategies for product and service development. It can be assumed that digital services, i.e., apps, historical data access, remote monitoring, and optimization, as well as smart home concepts, i.e., holistic energy and building management concepts with intelligent control and regulation approaches, will become increasingly relevant and in demand in the future. However, the study also shows that there is a clear need for information regarding the benefits and advantages of these services and concepts and that concerns and reservations, i.e., internet connection and external data access options, may also need to be considered and overcome.

Although the study was limited to Austria, it can be assumed that the results are easily transferable to European conditions, in particular to Germany and Switzerland. It can be assumed that several results and conclusions relating to control and operation, as well as desired additional functions, are also interesting and applicable for manufacturers of other domestic central heating systems, e.g., hydronic biomass heating systems.

**Supplementary Materials:** The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/businesses5020018/s1>, S1: Qualitative survey (contextual inquiry)—guidelines; S2: Quantitative survey—online questionnaire.

**Author Contributions:** Conceptualization, G.R.; methodology, G.R., S.E., R.F. and C.B.; software, G.R., S.E. and R.F.; investigation, G.R., S.E. and R.F.; data curation, G.R., S.E. and R.F.; writing—original draft preparation, G.R.; writing—review and editing, G.R., F.T., C.B. and C.S.; supervision, C.S. and F.T.; project administration, G.R. and F.T.; funding acquisition, C.S. and F.T. All authors have read and agreed to the published version of the manuscript.

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**Institutional Review Board Statement:** Institutional Review Board Statement Ethical Review and approval were waived for this study due to all data processing has been carried out in accordance with Austrian national law, i.e. Federal Act on the Protection of Natural Persons with regard to the Processing of Personal Data (Data Protection Act—DSG) (Bundesgesetz zum Schutz natürlicher Personen bei der Verarbeitung personenbezogener Daten (Datenschutzgesetz—DSG) StF: BGBl. I Nr. 165/1999).

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**Data Availability Statement:** The data for the article are based on the references provided.

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## Appendix A

**Table A1.** Results regarding awareness and use of individual functions for operating the HP. The figures indicate the number of people.

Function	Function Known (Unused)	Function Known (Used)	Function Already Used (Operation Shown in Contextual Inquiry)
<b>General functions</b>			
Switch off the system	3	3	4
Operating modes/operating mode HP	7	0	3
Service report function	4	3	2
Error message function	6	0	1
Operating modes/operating mode auxiliary heating	3	0	1
Heat meter	2	0	1
Manual defrost start	0	2	0
<b>Heating/Cooling</b>			
Room temperature setpoint	9	0	6
Set heating limit	6	2	5
Set cooling limit	6	2	4
Set time program	7	1	3
Operating mode heating circuit	6	1	3
<b>Hot water</b>			
Set hot water temperature	9	0	5
Set time programs	7	1	2
Operating mode selection hot water circuit	5	1	2
<b>Special features</b>			
Smart grid function	2	0	0
Integrate photovoltaic system	1	0	0

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