THE COMFORT ZONE

EUROPEAN USERS' PERCEPTION OF RENEWABLE HEATING PERFORMANCE

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coolproducts for a cool planet

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Table of Contents

Executive summary

Heat pumps are among the best technologies available for heating decarbonisation today, but though their sales are growing fast, heat pump solutions are not yet a reality for most European households. Lack of incentives, information and even trust contribute to the slow transition to these alternatives. In some EU countries, there is also a negative narrative around the switch from fossil fuel boilers to heat pumps, making potential heat pump users worried about the comfort they will get when embracing this technology.

This report attempts to verify those claims by providing a "snapshot" of heat pump users' perceptions of comfort, running costs and overall experience in 22 countries: 20 EU Member States, as well as Norway and the UK. It is based on 670 responses to an online survey and 40 telephone interviews. With the exception of Belgium, where participation was higher, we surveyed 10 to 20 households per country.

The most outstanding result is that comfort improved for the vast majority of respondents. As an average of all 22 countries, it improved for 81%, while it only was reduced for less than 1%.

Another outstanding result is that there is a large satisfaction with heat pumps in all countries, with five countries where all respondents answered that they were either very happy or somewhat happy with their heat pumps. As an average of all 22 countries, 88% were satisfied and 8% neutral. In six countries, one respondent was not satisfied or had some concerns, while in five countries, this was the case for two or more respondents, the highest fraction being in Italy with 17% of respondents.

Regarding changes in heating costs, as an average of the 22 countries, 64% found that they spent less on heating with the heat pump. In nine countries, no-one reported higher costs changing to a heat pump, while in 12 countries one or two people reported higher costs, as did14% of respondents in Belgium. This was not unexpected, as Belgium is known to be one of the least favourable markets for heat pumps based on the big gap in the energy taxation between gas and electricity [1].

We identified gas and oil boilers as the most common sources of heating among participants before the change to heat pumps (HPs) in 11 countries, which were the countries where gas is popular heating, while for the other 11 countries (Bulgaria, Croatia, Denmark, Estonia, Norway, Latvia, Poland, Romania, Slovenia, Spain and Sweden), there was a mix of previous heating sources, including electric heating, coal, biomass, and a bit of district heating.

The solutions adopted by respondents to the survey were mainly hydronic systems: air-water and ground-water heat pumps. Only in six countries, the majority of respondents had chosen air-air heat pumps. This includes Malta, Spain, and France, but also Norway, Estonia, and Poland.

The change to heat pump heating was motivated by a mix of economic, environmental/climate concerns and expectations of improvements of comfort. The

environmental concerns were the main reasons for more than half of the respondents in Germany, Ireland, the Netherlands, and the UK. In addition, they then got lower heating costs and most of them also better comfort. Also, the reduction of hassle (i.e. getting rid of the oil or biomass supply) was the reason for some respondents, and for the majority of respondents in Malta.

While the survey showed large satisfaction with heat pumps, in the interviews several issues were reported by users, such as unexpected noise disturbance, adaptability to the controls of the system and lack of technical support (see national interviews).

Overall, the results of the online survey are compatible with the literature (see Chapter 2), as the level of user satisfaction, comfort and heating costs are within the ranges observed in the literature (see Table 1 below). Possible causes for (the few) discrepancies are noted in the national chapters.

Table 1 User Experience' results compared with case studies found in literature.

	Overall satisfaction with the heat pump	**Running costs**	**Comfort**
Case studies, from literature	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Surveys (average of results of the 22 countries)	88% (satisfied users)	64% (users that spend less after installing a heat pump)	81% (users that have better heating after installing a heat pump)

It is interesting to note that while some of the literature studies considered only one or a few countries in their scope, the results are still largely comparable with the ones of the present survey, thus reinforcing one another.

We draw the following main conclusions from the online survey and interviews:

1. HPs can deliver the same or better comfort than gas/oil boilers, except in a small minority of situations, that we expect to be primarily in poorly insulated houses or badly adapted heating systems.

2. Switching to a HP is likely to result in lower or about the same annual costs for heating in most regions, including cold climates. Lower costs are seen in comparison to electric heating, oil heating and in many cases in comparison to gas heating too. Costs in comparison to biomass will depend on local biomass prices that vary considerably. The surveys were done before the current gas price peak, which in most countries will improve the relative economic benefits of heat pumps. Households reporting higher bills were also largely satisfied due to improved comfort conditions.

3. Interviews showed that combining the HP with solar thermal and photovoltaics resulted in lower costs and many users had a high level of satisfaction with the combination. This is, in particular, the case in countries with net metering, such as Poland and Hungary.

We make the following recommendations for promoting the adoption of HPs:

- Provide information on subsidies, tax credits and soft loans to families interested in installing HP technologies and combined solar technology; several participants in interviews reported that they could not find information about possibilities available at the time of change1.
- Provide information on special electricity tariffs for using the HP (when available); several interview participants in countries with special heat pump tariffs did not know that this possibility was available in their country2.
- Ensure that users receive proper instructions on the operation of the system (e.g. constantly on vs. turning it on when heat is needed; most efficient operation) as these types of information are not always clear to users and result in the (few) unhappy users, even in countries where there are general cost savings.
- Improve the availability of both qualified installers and advisers to users.
- Combat misleading information: some users are disappointed because of unrealistic expectations of running costs and the level of comfort. These unfulfilled expectations directly impact overall satisfaction.

We make the following economic recommendations to people interested in adopting HPs, based on the experience of interviewees:

- Improving insulation is highly recommended in the case of old buildings before installing a heat pump.
- Careful evaluation of the building, identifying potential costs with additional piping and wiring.
- Careful evaluation of the building design, identifying the best location for installing the HP's indoor unit and outdoor unit to reduce noise disturbance.

1 The effect of the tax-driven high costs is documented in the study "*Green Heat for All*", October 2021

2 The taxation on energy carriers is documented by Eurostat *here* and *here*.

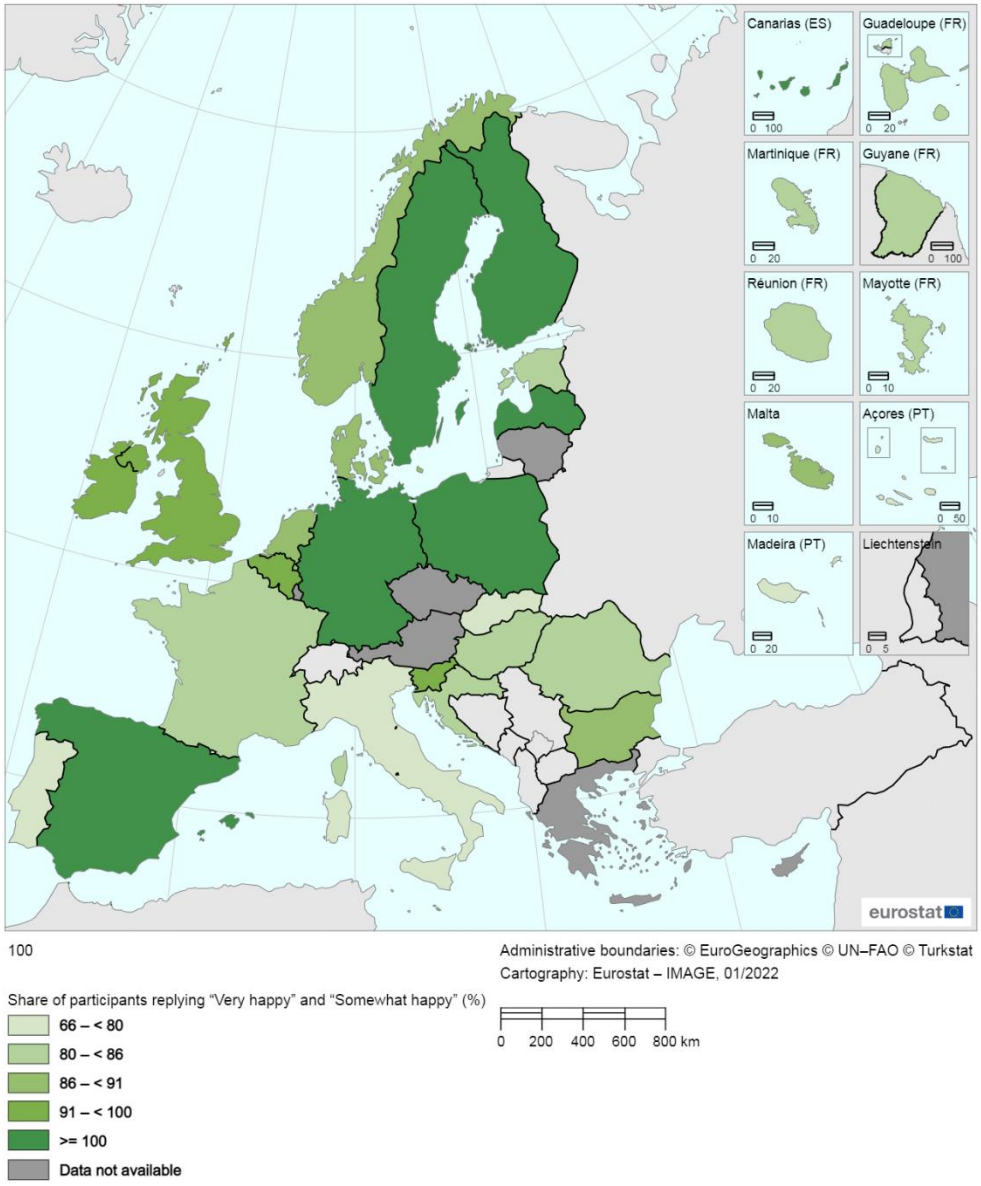

Figure 1. Survey question: Overall, how satisfied are you with your heat pump? Percentage of respondents replying "Very happy" and "Somewhat happy". Source: Online survey.

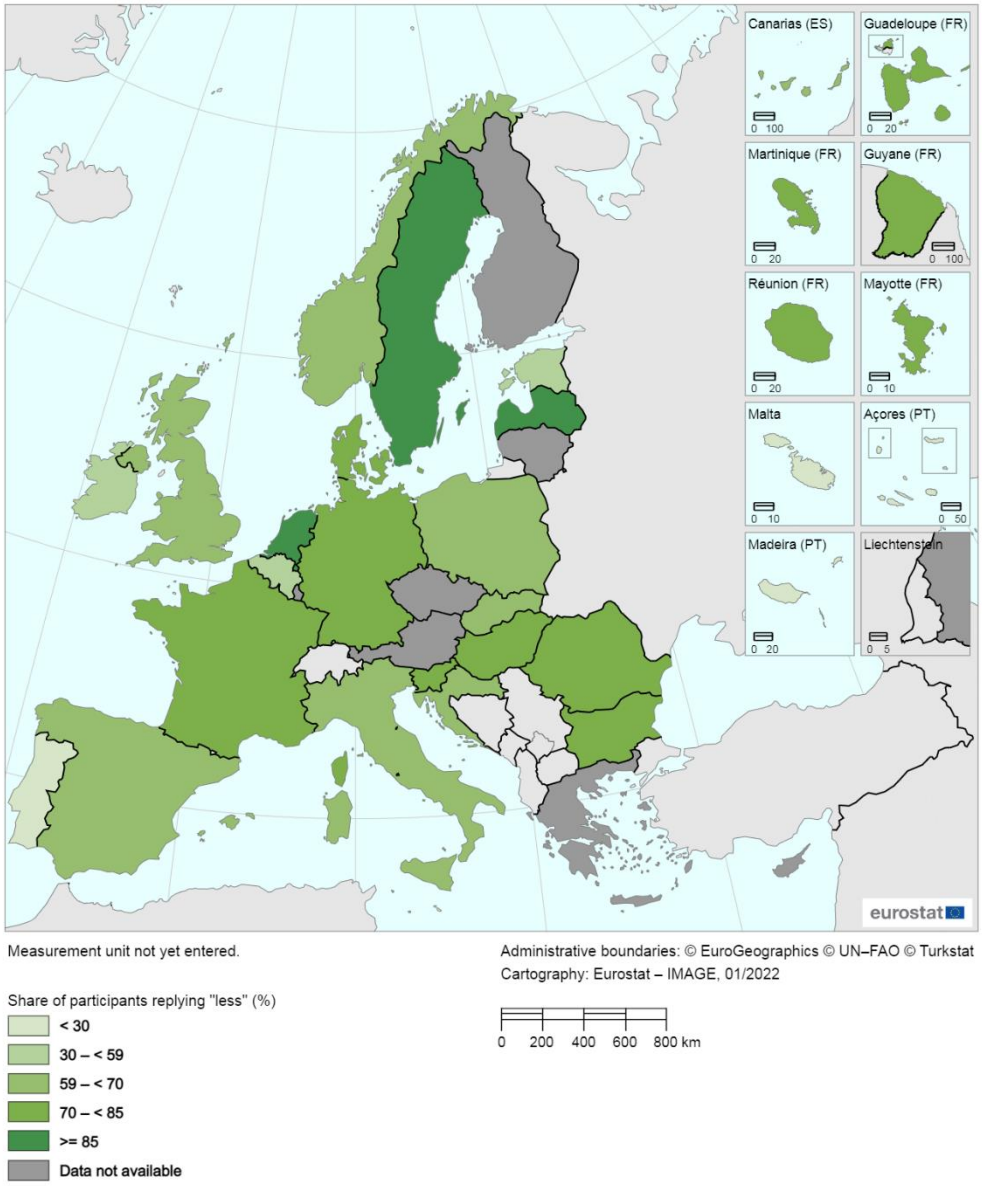

Figure 2. Survey question: Compared to your previous situation, on a yearly basis to heat your home, how much do you spend? Percentage of respondents replying “less”. Source: Online survey.

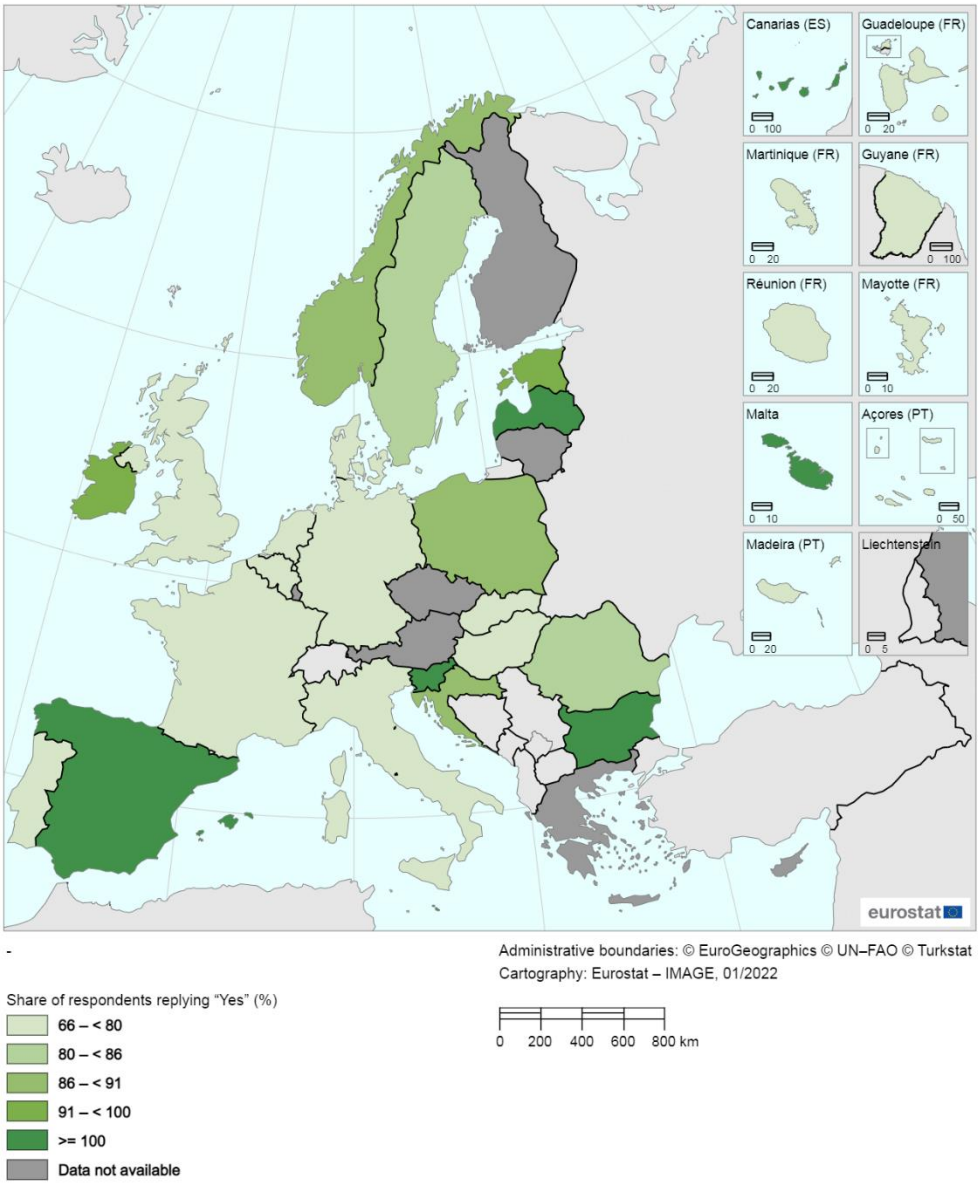

Figure 3. Survey question: Did your heating comfort improve after you installed a Heat Pump? Percentage of respondents replying "Yes". Note: respondents also had the choices "No, it remained the same" and "No, it got worse". Respondents in only four countries declared to have a worse level of comfort. Many respondents chose "No, it remained the same"; see national chapters for detailed responses. Source: Online survey.

Introduction

This report consists of two parts: the first is a literature analysis on the satisfaction of heat pump users and the second features a report on the results of a new online survey and interviews of heat pump users, covering their satisfaction as well as comfort, costs, and several other issues.

The online survey reached out to users of heat pumps (HPs) in 20 EU Member States, Norway and the UK. We collected 752 responses to the online survey, which were later filtered out by removing users that combine heat pumps with fossil fuel-based heating (gas or oil boilers). As one of the intentions of this work is to scrutiny the claim that often appears in press articles and Opeds that only gas can deliver comfortable heating all over Europe, we focused on users that do not rely on gas or oil boilers as a backup system.

Therefore, we report on the comfort perception of 670 users that do not use gas or oil heating.

The qualitative interviews were carried out in 19 EU Member States, Norway and the UK with heat pump users that did not supplement with gas or oil heating. Two interviews were completed per country, except for Latvia and Spain, where we only have one interview. The target group was selected households that had adopted HP technology, sometimes combined with solar thermal, as the main heating source.

It should be noted that the responses to the online survey and interviews are not statistically representative of the countries. They are rather a snapshot of the users' experiences. The invitations to reply to the survey and interviews were mainly distributed via the International Network For Sustainable Energy (INFORSE) members and contacts. The surveys were available online and were also advertised via Facebook etc. See more details of the data collection in Annex A1.

The countries covered in the report are Belgium, Bulgaria, Croatia, Denmark, Estonia, France, Germany, Hungary, Ireland, Italy, Latvia, Malta, The Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. The main findings are presented in chapter 2.

1. Analysis of the literature on heat pump satisfaction

The first part of the analysis is a brief description of heat pump technology. The second part is the analysis of the existing literature on the topic of heat pump users' comfort perception and general satisfaction. Journal articles, reports and other relevant documents describing the experience of users in Europe, the US and New Zealand were reviewed. The documents were located by searching the keywords "Heat pump" in combination with "user comfort", "user satisfaction" and "user experience" on the Scopus/ScienceDirect database and Google Scholar. As an example, the combination of words "Heat pump user satisfaction" returned 22 results on the Scopus database, of which two were found relevant to this work. The same combination returned hundreds of documents on Google Scholar; however, most documents concern technical aspects and only a few focus on the user perspective. The Danish study was found with a Google search in Danish.

1.1. Technology introduction

Fossil fuels are still the largest source of space heating and hot water production in most households worldwide [1]. In the European Union, fossil fuels provide 84% of heating and cooling [2]. However, the climate emergency and the reliance on fuel imports require more efficient energy use and the transition to renewable alternatives. Heat pumps and solar thermal heating are some of the best and most efficient alternatives currently available for the residential sector.

The use of a heat pump system is attractive owing to its higher Coefficient of Performance (COP) for heating compared to the efficiency of conventional technologies, such as boilers and electric heating. The COP characterises the performance and refers to the "ratio of heat exchanged with the indoor environment and the mechanical work supplied to the machine" [3]. If a heat pump operates with a COP of 3, for each unit of electricity used by the system, ~2 units of ambient heat are delivered to the building as useful heat in addition to the electricity, meaning an efficiency of ~300% [3]. In comparison, pellet furnaces and natural gas boilers can reach in the best cases 83 and 98% efficiency, respectively [4], [5].

An air-source heat pump (ASHP) extracts heat from the outdoor air to warm up air or water inside buildings. An ASHP can provide sufficient heat even at relatively low temperatures (e.g. –15°C), which covers standard conditions in European climate zones. However, as the temperature decreases, the COP also decreases. If heat is extracted from the ground or water, the system operates more efficiently due to a more constant average temperature at the source throughout the year. In this case, the systems are referred to as ground-source (GSHP) and water-source heat pumps (WSHP). Remarkably, the function of heat pumps can be reversed to provide cooling [6], another fast-growing part of the energy demand.

Solar thermal (ST) water heating technologies provide domestic hot water and, less frequently, they can provide space heating. Collectors, a heat transfer loop, and a hot water storage tank are the main components of an ST system. These systems are suitable for combination with another renewable-based system, such as biomass or heat pump technologies. The combination of heat pumps and ST is particularly advantageous in southern Europe, since air-to-air heat pumps generally cannot provide hot water.

1.2. Literature review

Analyses of comfort, satisfaction, and issues with heat pumps were reviewed from the literature identified as described above. The most important aspects that influence the change to renewable heating were also collected. However, the number of published studies investigating the users' satisfaction is limited; for instance, only one of 34 ASHP case studies reviewed by Carroll *et al*. (2020) had users' satisfaction as a central aspect [7].

User (or customer) satisfaction is a measure of how a product or service meets expectations. Farris *et al*. (2010) formulated it as "the number of customers, or percentage of total customers, whose experience with a firm, its products, or its services (ratings) exceeds specified satisfaction goals." [8].

Regarding renewable heating, the users' satisfaction is likely to be connected to two main factors: the fulfilment of the motivations for adoption (satisfaction goals) and the amount of knowledge about the system before the change [9]. Among the motivation factors, indoor environmental quality, thermal comfort, service availability (support from the supplier/service provider), the electricity price (special tariffs for heat pump use), and the availability of grants for the adoption are largely responsible for the users' overall satisfaction [9], [10]. Access to information is also critical, since well-informed users are less likely to be surprised and more likely to be satisfied [9].

2.2.1. Case studies

The scale of the reviewed studies varies from specific neighbourhood/towns with a few hundred answers to studies at the national level with thousands of answers. A summary table concludes the chapter.

2.2.1.1. Denmark

In a project to regulate heat pumps with signals from the power grid and with online information on the performance of the individual heat pumps concerning average performance, around 200 Danish families installed heat pumps in the period 2010-2015. At the end of this period, 189 families were asked to evaluate their satisfaction of the performance, among other factors, with a total of 122 replies. 97% of respondents were men that answered on behalf of their families. 70% of the families had income above the Danish average of 500,000 DKK (67,000 €). Most installations (68%) had costs in the range of 100,000- 150,000 DKK (13,000 – 20,000 €) [11].

Users were asked primarily about their opinion on the regulation of the heat pump. 66% declared they would allow external control if it could optimise the operation and lead to savings [11]. 71% were making changes to the settings less than once a month, but 49% were checking the operation of the heat pump at least weekly via the (user-friendly) web interface provided by the project [11].

On general satisfaction, 99% answered that they were satisfied or very satisfied with the heat pump system and 1% were dissatisfied [11]. To the question on combining heat pump

installations with energy renovations, 1/3 answered that they had made major energy renovations. The survey did not include questions on the specific satisfaction with heating costs, noise or other aspects.

2.2.1.2. Finland

Heat pumps have gained great importance in residential heating in Finland, particularly in the last two decades. Between 2000 and 2018, the number of installed units went from around 1,500 to 930,000 units [12]. The country is a leader in the number of heat pumps per number of households, with an estimated penetration rate of about 34% of the stock in 2018 [12]. This fast diffusion happened mostly in detached and semi-detached houses, which in many cases chose to adopt heat pumps as a replacement for oil-based heating and/or in combination with wood-based systems [12]. Sovacool (2020) attributes the adoption to the awareness of the environmental consequences of using oil, the construction of new and more energy-efficient houses (with 70% of them installing a heat pump), and the taxation of fossil fuels [12].

Despite a large number of heat pumps in use, no studies on the users' satisfaction were found.

2.2.1.3. Germany

In 2018, a nationwide study asked 751 users of heat pump systems about their experience with usability, thermal comfort, running costs, and maintenance. Half of the users had ASHP systems, nearly 40% had GSHP systems and 5% had WSHP systems. Moreover, 9% of the houses were equipped with a solar thermal water heating system. The results show a high level of satisfaction; 87% of users were satisfied with the usability of the HP systems, 94% of users were satisfied with the thermal comfort, 85% of users were satisfied with the running costs, and 90% of users were satisfied with maintenance costs [13]. The main motives for choosing heat pump systems were environmental protection (72%) and economy (71%). Repairs and system failures that occurred in nearly one-quarter of the houses did not seem to make the users regret their choice, since 91% of users would still recommend changing to heat pump systems [13].

Michelsen and Madlener (2017) surveyed 2,135 users in newly built and existing single-family houses that received a financial grant to install a system based on renewables (including heat pumps, solar thermal, and wood pellet boiler) [9]. The results indicate that a heating system compatible with family habits significantly impacts overall satisfaction. This means that a heating system that requires less amount of work compared to the previous system or that is easy to use results in higher levels of satisfaction. Another impacting factor is the availability of a grant to support the change [9].

In the analysis by Sovacool *et al*. (2021), 80.5% of users reported to be satisfied or even very satisfied with their current heating, these being fossil fuel-based or renewable-based technologies [14]. In an eventual change of the heating system, 36.1% of surveyed users stated that they would choose solar water heating [14].

2.2.1.4. New Zealand

A study by Burrough *et al*. (2015) examined 160 households nationwide using HPs. Sample targets were established for each of the 16 regions in the country, based on population and proportions of houses with HPs in the region. The project collected data on heat pump energy consumption over one year and carried out questionnaire surveys and site inspections. The results show overall satisfaction, with 94% of users stating they would recommend a heat pump to their family or friends [15]. Regarding comfort, 65% of users declared to always be satisfied with the warmth provided and 27% were satisfied most of the time. The report suggests that many users never received proper instructions on the operation of the system, which could impact the achieved comfort. 47% of users declared to be satisfied with the running costs. However, almost one-third of users did not have an opinion about this aspect [15]. 91% of users stated that vibration or noise of the outdoor unit did not disturb them or the adjacent property, 6% said the vibration or noise was a reason for disturbance and 3% could not answer. The reason for the 6% dissatisfaction is likely the fact that about 10% of all outdoor units checked in the study were poorly installed, meaning that they were unstable. Often units were connected to a bracket to keep them off the ground, but the bracket had not been placed on the levelled ground [15].

2.2.1.5. Norway

The so-called Household Subsidy Programme was an instrument of the Norwegian energy policies to reduce the use of electricity for heating in the residential sector by increasing efficiency. Launched in 2003, the programme provided a subsidy of up to 20% of the investment cost for households to adopt heat pumps or wood pellet stoves [16]. Due to the subsidy availability and an increase in the electricity price in the same period, the use of air-to-air heat pumps increased significantly [16].

Bjørnstad (2012) analysed data from a sub-population of households that applied and received a subsidy to adopt heat pumps (N=440). The author highlights that the data refers to households characterised by higher income and higher education than average in the country. Users that responded to the questionnaire demonstrated satisfaction towards indoor climate and heat comfort achieved with the newly adopted technology [10]. The majority of users declared to be “Quite satisfied” or “Very satisfied” when evaluating investment satisfaction [10]. The author connects this evaluation to electricity prices, since higher prices could influence the user to conclude that the decision to change to a heat pump was the right one [10]. The positive evaluation is also attributed to the technical quality of the equipment; the better the technical quality of the equipment was perceived to be by the user, the higher the investment satisfaction [10]. Finally, the importance of service available from the supplier was also found to influence the overall satisfaction [10].

2.2.1.6. United Kingdom

In the analysis by Caird *et al*. (2012), users completed questionnaires regarding experience, behaviour and satisfaction with their heat pump system. The sample size was 78 users (50 GSHP and 28 ASHP users) and a mix of different heat distribution systems (i.e. domestic hot water and radiator, domestic hot water and underfloor, warm air). The results show a relatively high level of satisfaction: 83% agreed with the statement “The heat pump system

has made my home warm and comfortable" [17]. Moreover, 73% of users confirmed that the heat pump system met the household's requirements for room heating and 77% stated that the system performed reliably. Three-quarters of users considered their heat pump system "much better/better" than their previous heating system, which was mainly natural gas, oil central heating or electric heating. Issues pointed out by the users included the lack of simplified instruction on how to operate the system, the slow warm-up and the running costs in comparison to their previous system [17].

In another case study, 18 out of 21 users declared to be satisfied or very satisfied and preferred the heat pump to their previous system [18]. Overall, users attributed satisfaction to a combination of factors, such as thermal comfort and costs or environmental aspects and maintenance requirements [18].

Lackova and Dinnie conducted surveys to understand the problems HP users were having in the Orkney Islands (northern Scotland). This unique study aimed to also contribute insights for the development of simple operational guides for homeowners. The study was divided into two phases; the first one in 2014 and the second one in 2016. 61 respondents participated in both phases. 54% of systems in the study were ASHPs and 3% were GSHP. The results show that the majority of users that responded to surveys in 2014 and 2016 were satisfied with how the HP provided hot water (73%) and space heating (60%) [19]. When the users were asked about the agreement with the statement "The HP is too noisy", approximately 43% agreed, 29% disagreed, and another 29% neither agreed nor disagreed [19]. 25% of users were satisfied with the running costs and 27% were neither satisfied nor dissatisfied [19].

Investigating the adoption of solar thermal water heating, Caird *et al*. (2008) reported that most users investigated (nearly two-thirds) were satisfied with their system and the possibility of lower fuel bills. Regarding the choice of this technology, three-quarters of the adopters confirmed that friends, colleagues or neighbours influenced their decision [20].

2.2.1.7. United States

The Massachusetts Clean Electric Center's Whole Home Heat Pump Pilot investigated the feasibility of heat pumps serving 100% of a building's heating needs in the state of Massachusetts. The programme offered a flat incentive to 168 ASHP projects: 31 new construction projects and 137 retrofit projects where users switched mainly from natural gas boilers and electric heaters. Users in the pilot were surveyed six months after project completion. The results show that 95% of users were fully or somewhat satisfied with the comfort of heating [21].

Yu *et al*. (2017) investigated GSHP systems in 24 buildings located in cold-climate regions in the US (North Dakota). The focus of the study was on user satisfaction, the reason for their choice, operational performance, potential energy and cost savings, system cost information and operating difficulties. The results indicate a high-level satisfaction; approximately 75% of users were very satisfied with their systems regarding indoor comfort, noise, and cost (25% declared to have some complaint about these aspects) [22]. Yet, 85% of users would recommend this type of system to other people. The interviewed residential users

declared that the main reason for installing GSHP systems was to lower heating and cooling costs (long-term cost savings) [22].

The study suggests energy savings of 7.2% and energy cost savings of about 6.1% in comparison to the median of similar buildings nationwide [22]. The reason for relatively low savings could be the comparison to the national average instead of comparing to buildings also located in cold-climate regions or the same building before the installation of the GSHP systems.

2.3. Summary

The opinion of earlier adopters and the availability of grants are factors that influence the decision to change to heat pump systems [9], [10]. Consequently, the influence of colleagues, family members, or neighbours is a strong motivational factor [9]. A common response among users in different studies is the pride to use renewable energy and contribute to a cleaner environment.

The literature describes that most users were satisfied with the comfort provided by the heat pump. The main reason for complaints was the noise level of the outdoor unit and the running costs in some regions. In some cases, the noise disturbance was caused by improper installation of the outdoor unit [15]. The overall evaluation was positive and most users would choose these systems again or would recommend them to family members or neighbours (Table 1).

Table 1. Summary: users' satisfaction based on case studies.

Country	**Case study**	**Type of heat pump system**			**Experience (% of satisfied users)**				
		ASHP	GSHP	WSHP	Thermal comfort	Running costs	Noise	Overall experience	Would recommend
Denmark	[11]	n/a	n/a	n/a	n/a	n/a	n/a	99%	n/a
Germany	[13]	51%	38%	5%[a]	94%	85%	n/a	91%	91%
New Zealand	[15]	100%	-	-	92%	47%[b]	91%	94%	94%
Norway	[10]	100%	-	-	n/a	n/a	n/a	91%	n/a
United Kingdom	[17]	36%	64%	-	83%	62%	81%	77%	n/a
USA (Massachusetts)	[21]	100%	-	-	95%	n/a	n/a	n/a	n/a
USA (North Dakota)	[22]	-	100%	-	75%	75%	75%	85%	85%

Notes: [a] 6% of HPs in the study were not identified; [b]27.5% did not have an opinion about this aspect.

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2. Snapshot of users' experience by country

Belgium

Survey

Gas boilers (methane/LPG) were the most common source of heating among the participants (n=363) before the change to HP. Economy and environmental/climate issues was the most cited reason for changing. Air-to-water HPs, followed by ground-source HPs, were the preferred choices. Most participants also performed energy renovations of the building when the HP was installed (i.e. insulation of walls, replacement of windows) and most participants believed their heating comfort improved after the change. Most declared to be happy/very happy with their heat pump and now paid less or about the same for heating yearly.

Figure 1 Question: Overall, how satisfied are you with your heat pump?

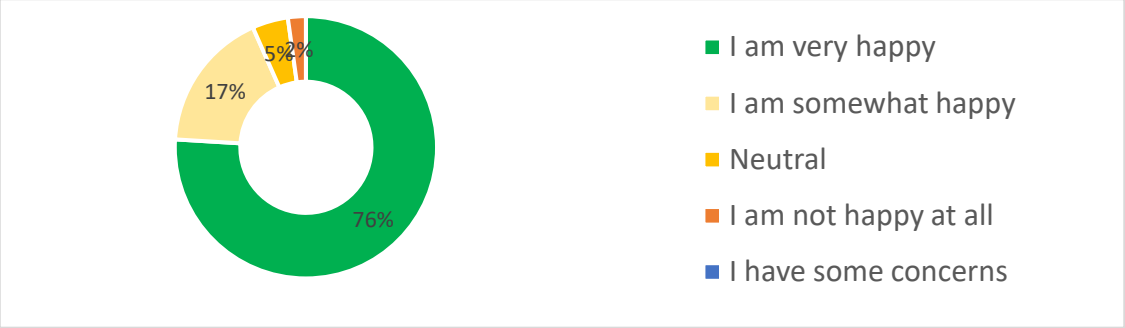


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

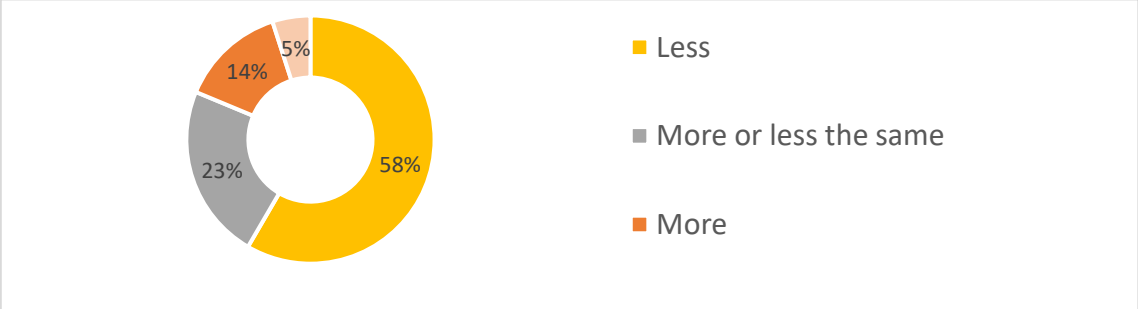
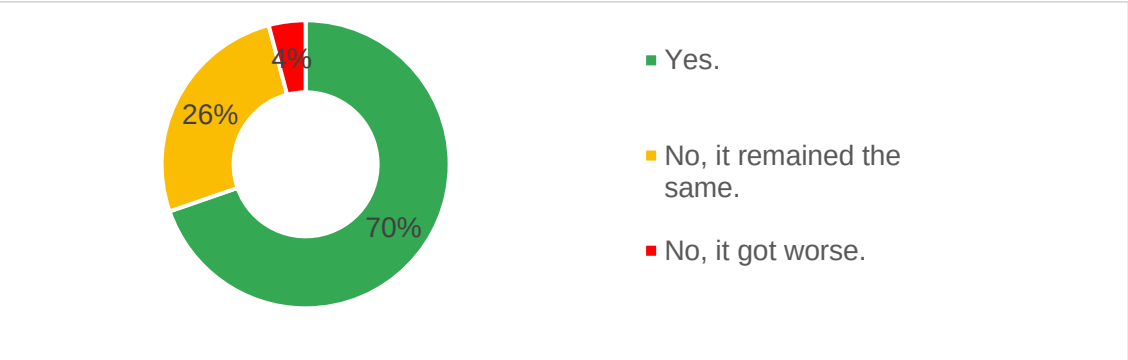


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with S. Tachelet from Antwerp

Figure 1 Photo by S. Tachelet.

This family of two adults and three small children lives in Antwerp (cool winters). The heated area of the terraced house is around 200 m^2 (three floors). The air-to-water HP was installed in 2019, replacing natural gas. The house now has underfloor heating in some rooms, and radiators. At the time of installation, the house was also renovated with new windows and insulation of the roof and walls. Solar PV panels were also installed. They received some subsidy for the change as part of a pilot scheme. They use renewable electricity from Ecopower. Environmental concern was the main reason for making the change. The family is very satisfied with the comfort in comparison to the previous system, which they believe is also due to the energy renovations of the building and underfloor heating. They are also happy with the cooling possibility on the top floor. Overall, they are satisfied with the choice, since the system has been working well.

Interview with Bart T. from Ghent

This family of two adults lives in the town of Ghent. The heated area of the terraced house is 120 m^2. The 6.7 kW air-to-water HP replaced an old natural gas boiler. At the time of installation, the house was completely renovated with improved insulation and underfloor heating. The house is now very energy-efficient. The family received a loan for the renovation and a subsidy of 1,500€ for the HP (the total cost of the HP was 10,000€). They have a solar PV system and produce about 4,000 kWh/year, while the HP consumes around 1,800 kWh/year. Therefore, the family is satisfied with the comfort achieved. They would recommend the change but highlight that greater support would be needed for many, since the initial costs are quite high.

Overall data assessment

Survey results on overall satisfaction are compatible with the literature on the topic. The small discrepancy regarding running costs is explained by the share of participants that pay about the same (23%). Regarding the lower level of comfort in comparison to the literature, we highlight that many participants (26%) declared to have the same level of comfort as they had with the previous heating system.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	93% (satisfied users)	58% (users that spend less after installing a heat pump)	70% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver the same or even a better level of comfort in comparison to gas boilers. However, most participants stated that their houses were well insulated, which can contribute to higher comfort.
- Switching to a HP is likely to result in lower or about the same running costs. However, this is not the case for all participants, as 14% spend more. Natural gas heating was the most common source among participants that paid more before switching to a HP.

Bulgaria

Survey

District heating and biomass stoves were the most common sources of heating among the participants (n=8) before the change to HPs. Economy, improvement of comfort and environmental/climate reasons were the most cited reasons for changing. Air-to-air and air-to-water HPs were the preferred choices. Most participants did not perform other energy renovations to the building when the HP was installed, and half considered their houses to be well or very well insulated. All participants believed their heating comfort improved after the change. Most declared they were happy with the system (Figure 1) and in many cases, the change resulted in yearly savings (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

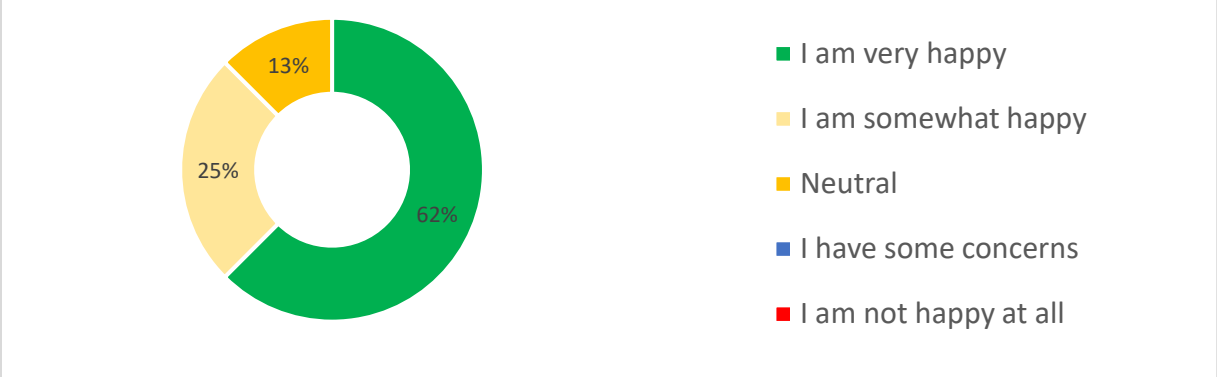


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

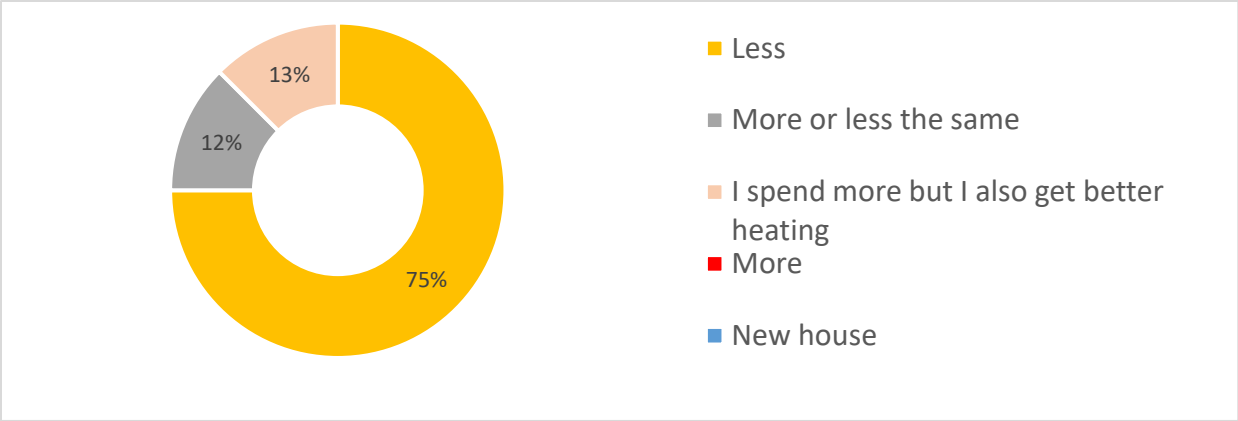
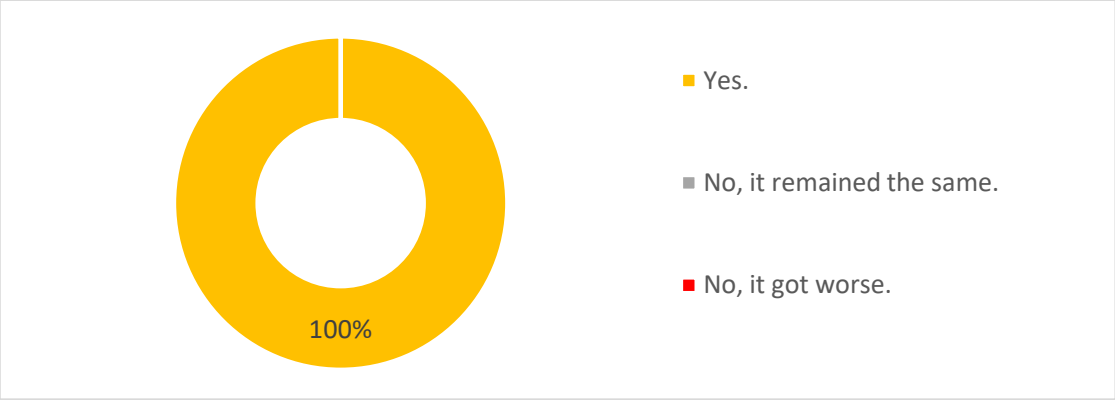


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with family in central Bulgaria

This family of four adults and one big dog lives in the northern part of the country at the foot of the Balkan Mountains (cold winters). The village is situated 800 m above sea level. The detached house was built by the grandfather of the family and did not have insulation. The heated area is 150 m^2 spread on two floors. Before changing to an air source HP they used to heat the house using a wood pellet system. The family decided to change because the owner works in the field of selling HVAC equipment and was aware of the advantages and disadvantages of HPs. He made a detailed analysis of the cost of such a system, the ROI, the pros and cons and the effect on the environment. He says that the environmental aspect also weighed on his decision and that he chose a HP because this is a more environmentally friendly solution. He also considered ground source HP but decided to install an air-to-water system. The 12kW HP has been in use since spring 2019 and provides heat to the entire house and domestic hot water with a water tank of 260 L. Around the same time, the HP was installed, they also changed windows and doors and rebuilt

"The first type [of comfort] for me comes from the psychological fact that I am no longer polluting the environment. The second type of comfort for me is the fact that you only need to push one button or use the Wi-Fi kit in order to start or stop the heat pump. This is unbelievably comfortable."

"We now see a decrease in the vicinity of 30 to 40% in running costs compared to the previous system we had. Moreover, after I put in the solar thermal panels, I expect them to be even higher."

the roof, adding proper insulation. They did not need to change the pipes and radiators inside the house. The owner has plans to install solar collectors to lower the electricity consumption for hot water. He also plans to install a solar PV system. In comparison to the previous system, the owner evaluates that the comfort in the house has improved and the burden of providing the fuel is no longer there: – "You don't need to take care of going somewhere to buy pellets or another type of solid fuel source. Moreover, you are spared of cleaning the dirt from the boiler, as before. If at any point maintenance is needed, there are specialised technicians that come to visit to do the checks on the heat pump. It is very easy. However, the most important factor for me is the environmental benefit. The 12kW capacity is enough to heat the area very well during winter. Even at -10°C ambient temperature, it keeps 90% of its capacity". In terms of running costs, the owner observed savings in comparison to the previous system The owner often recommends to neighbours to also switch to a HP – "I am recommending them because they will pay lower bills for heating. But what is most important for me is to preserve the air quality in the area, as the air there is one of the cleanest in the whole country. However, in the wintertime, it is unbelievable that you can't breathe from all the wood and coal, and other unknown substances that are burned. When you wash your clothes and you put them on the line to dry, later on, when you bring them inside they smell like a chimney. It is one big disaster. You can't find good, fresh, clean air during winter. You can see the smoke cloud hanging above the village all winter long, and it is really bad, really unpleasant."

Interview with family near Sofia

This family of two adults and two children lives in a village near Sofia (cold winters, elevation 600 m). The single-storey detached house has a heated area of 190 m^2. Before the change installing the air-to-water HP the family was living in an apartment with central heating (district heating) and radiators in Sofia. "When we were planning the house, there was an option to connect it to the gas network, but we chose not to, and to invest in a heat pump," said the owner. The 16kW air source HP was installed in the autumn of 2020 and provides heat and hot water. The house was new, with 15cm of external insulation, triple-glazed windows, and high-quality doors. The roof is insulated too. No subsidies were received for installing the HP. It is not possible to directly compare the comfort in the new house with the situation in the apartment. "I can't really make a comparison, as the house is new. There was no other heating system. I can compare it to the district heating we had in Sofia. In terms of comfort, both options are very good. However, in our communist-style apartment, there was no insulation (internal or external), and the quality of the windows was pretty low. There it was not really possible to control the right temperature inside, and here I can set it to 20°C for example and it will maintain it at 20°C. The operation is very easy." explains the owner. He is also pleased with the running costs – "I am very satisfied up to now. The monthly monetary expenses are pretty much the same as we had in the apartment. However, the apartment was 80 m^2 and the house is 190 m^2. So, I see that it is a much more efficient option. Of course, it has to do with the energy efficiency parameters of the two buildings, but I think that this particular brand is quite good too." Overall, the family is satisfied with the system and would recommend it – "My wife and I are very pleased with our decision to choose this type of heat pump. For now, we haven't got any problems. Last winter the system functioned properly. So, yes! I will recommend a heat pump as an option for heating and hot water".

"The operation is very easy. With the remote control, you can play with it. One can even set it to work in between certain hours or turn it on remotely. I used this option last winter pretty much every single day. It was perfectly warm when we were coming home with the kids at night."

Overall data assessment

Overall, the survey results are compatible with the literature on the topic. Interestingly, most participants did not consider their house well insulated, but still, the level of satisfaction with comfort was very high.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	87% (satisfied users)	75% (users that spend less after installing a heat pump)	100% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver a good level of comfort. An added benefit is the controllability in comparison to district heating.
- Switching to a HP is likely to result in cost savings, or at least about the same yearly costs, with heating.
-

Croatia

Survey

Biomass, gas heating and district heating were the most common sources of heating among the participants (n=10) before the change to HPs. An air-to-water HP was the preferred choice to provide heating/hot water. Half of the participants performed some type of energy renovation on the building (insulation of walls, improvement of windows, etc.) when the HP was installed, while the others did not. Most considered their houses to be well insulated. All participants believed their heating comfort improved or at least remained the same after the change. No participants have concerns that affect their overall satisfaction (Figure 1) and most pay less or about the same yearly to heat their homes (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

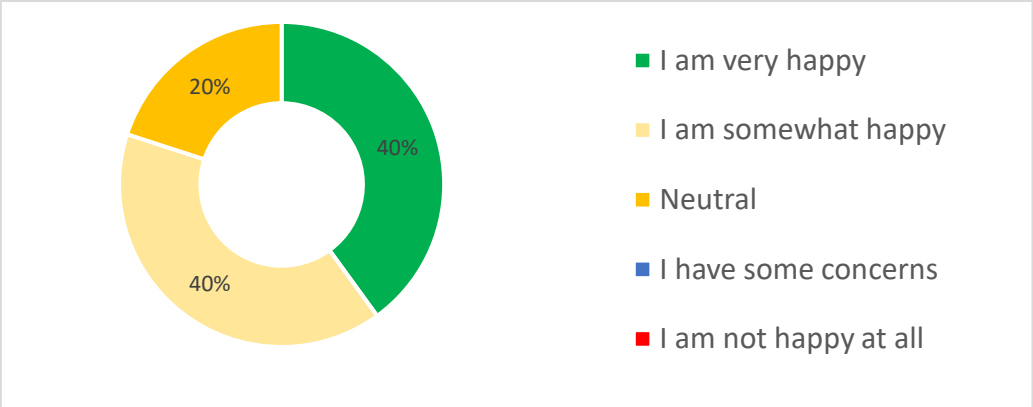


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

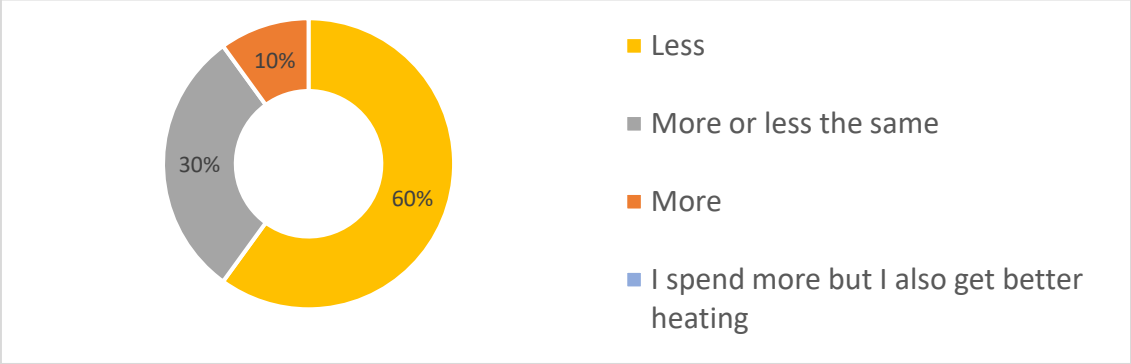
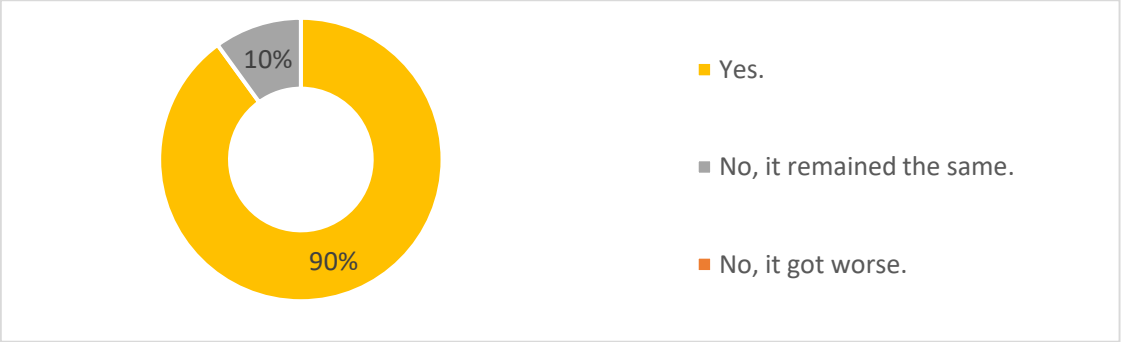


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with family in Istria

This family of four adults lives in a coastal town in Istria (a peninsula located at the head of the Adriatic – Mediterranean climate). The flat is 95 m^2 and is occupied all the time by at least two adults. In 2016 they chose an air-to-water HP (8kW) to have an individual heating source separate from the common building system (fuel oil central heating). They consulted an expert to obtain more

"The HP is flexible, comfortable, easy to operate, and highly adjustable, I am extremely satisfied, and my wife even more so."

details before the change. At the time the HP was installed, the family did not perform other improvements to the thermal insulation of the flat, which did not impact their comfort: "The noise/vibration transmitted through the piping is the only aspect we are not completely happy about." The family is still satisfied with the running costs and would recommend to their neighbours to install a HP.

Interview with family in central Croatia

Table 2 Photo by Katica Pocrnja

This family of two adults and two young adults lives in the central part of the country (continental climate). The building is a 125 m^2 detached house. In 2018, they were looking to replace their wood heating system with an alternative that required less hassle. They considered gas heating but decided to install an air-to-water HP (6kW). At the same time, they insulated the walls and roof and installed energy-efficient windows. They are satisfied with the comfort achieved and with how easy they can operate the HP. The noise created is not a disturbance and overall they are very satisfied with the HP. They are also satisfied with the running costs – "The initial investment was costly but when we started using it, it was much more cost-effective."

Overall data assessment

Overall, the survey results are compatible with the literature on the topic. The small discrepancy regarding running costs is explained by the percentage of participants who pay about the same (30%).

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	80% (satisfied users)	60% (users that spend less after installing a heat pump)	90% (users that have better heating after installing a heat pump)

Conclusion(s)

- Switching to a HP seems to improve the comfort, even when no extensive building renovations are performed.

- Based on replies, switching to heat pumps seems to result in lower heating bills in most cases. In some cases, heating bills are approximately the same after the change.

Denmark

Survey

Biomass (wood, wood pellets, or others) was the most common source of heating among the participants (n=15) before the change to HP. Environmental/climate issues and reducing the hassle with the heating system were the most cited reasons for changing. Air-to-water HPs were the preferred choices. Most participants did not perform energy renovations on the building when the HP was installed (i.e. insulation of walls, replacement of windows), however, many perceived that their comfort had improved after the change. Most declared they were happy/very happy with their HP and now pay less for heating yearly.

Figure 1 Question: Overall, how satisfied are you with your heat pump?

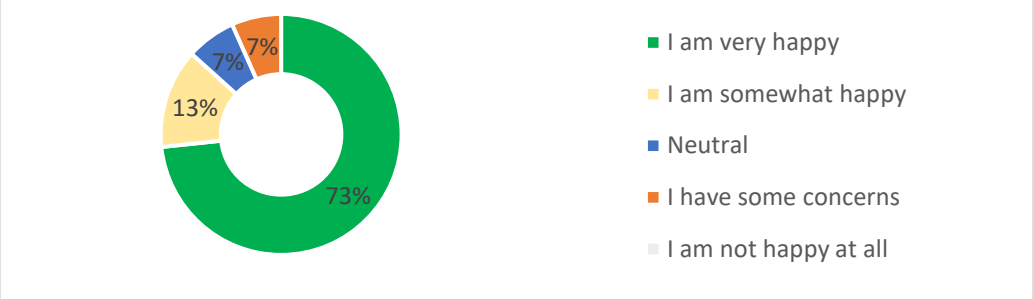
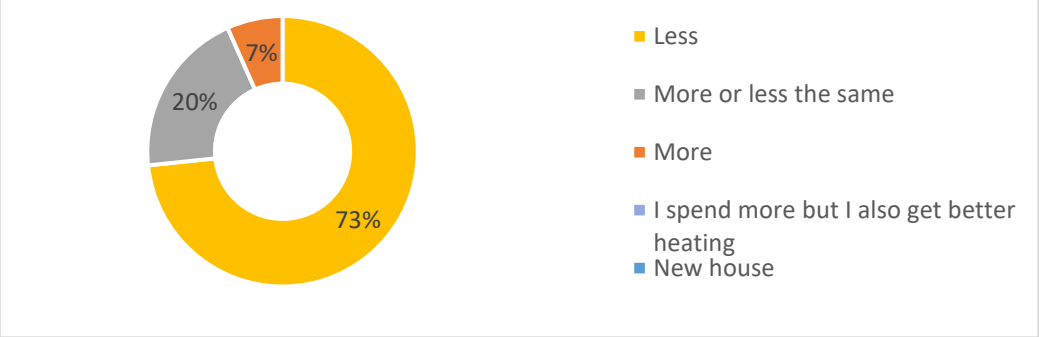


Figure 2 On a yearly basis, compared to your previous situation, you now spend...



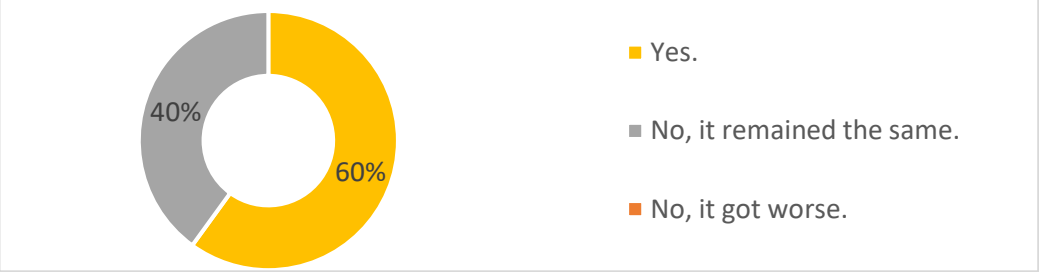


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?

Interviews

Interview with C. Draiby near Vedersø

This family of two adults lives in Vedersø, western Denmark (mild winters). The building is a detached house with a heated floor area of 150-160 m^2. The heat source was an oil boiler before changing to an air-to-water HP. The 10kW HP is the main heat source. The house has underfloor heating and a few electric radiators. The family did not receive any subsidies when the HP was installed, but now they get a rebate on energy tax for consumption over 4000kWh. The main motivations for choosing a HP to replace the old oil boiler were environmental and economic aspects of the system. At the time of installation, they improved the building insulation, installed better windows and a 6kW solar PV system. In comparison to the previous heating, the HP provides better comfort, as described by the owner: "The HP is better… much better comfort and cheaper heating." He is also happy with the running costs, as he describes that he can afford it with pension money. He has recommended the system to others - even made "open house" events with local energy groups, and events in connection with EU Sustainable Energy Week and he believes this is the best way to heat the house if it is not possible to connect to a district heating network.

Interview with P. Bendsen near Hundested

This family of two adults lives in Hundested, eastern Denmark (mild winters). The building is a detached house and the heated floor area is 145 m^2. The heating was supplied by electric panels, a small air-to-air HP, electric heating on the kitchen floor and by a wood stove before the HP was installed in 2013. The 6.5kW air-to-water HP supplies heating to the entire house and the underfloor electric heating is never used now. They decided to change to improve the old system, which was not performing

Table 4 Photo by P. Bendsen.

according to their needs (several electric panels were not functioning and the comfort was low) and also to use less firewood. Another refurbishment of the house was performed at the time the HP was installed, namely the installation of low-temperature radiators, wall insulation and underfloor heating in the bathroom. The owner reports an improvement in the perception of comfort: “The HP has worked continuously without trouble since 2013, with only a few random alarm messages that require a reset. That is all the work one needs to do" When asked about the noise level, they have no complaints: “It is a very silent heat pump. We installed it on a separate plinth with 1 cm solid rubber between pump and plinth for silent operation." Regarding running costs, the owner perceived annual savings of 732€ on the combined bills for heating and electricity. The owner has recommended to his neighbours to also switch to HPs and two of them have already done so.

Overall data assessment

Overall, the survey results are compatible with the literature on the topic. Regarding the lower level of comfort in comparison to the literature, we highlight that many participants (40%) declared to have the same level of comfort as they had with the previous heating system and none of the participants had less comfort after installing a HP.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	86% (satisfied users)	73% (users that spend less after installing a heat pump)	60% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver the same or even a better level of comfort in comparison to other heating sources. Nevertheless, it is important that the house is well insulated.
- Switching to a HP is likely to result in lower or about the same running costs.

France

Survey

Gas (methane/LPG) and oil boilers were the most common source of heating among the participants (n=6) before the change to a HP. Improvement of heating comfort was the most cited reason for changing. Air-to-air HPs were the preferred choices. Half of the participants performed energy renovations on the building when the HP was installed (i.e.

insulation of walls, replacement of windows). Most participants believed their heating comfort improved after the change. Most declared they were happy/very happy with their HP and now pay less for heating yearly.

Figure 1 Question: Overall, how satisfied are you with your heat pump?

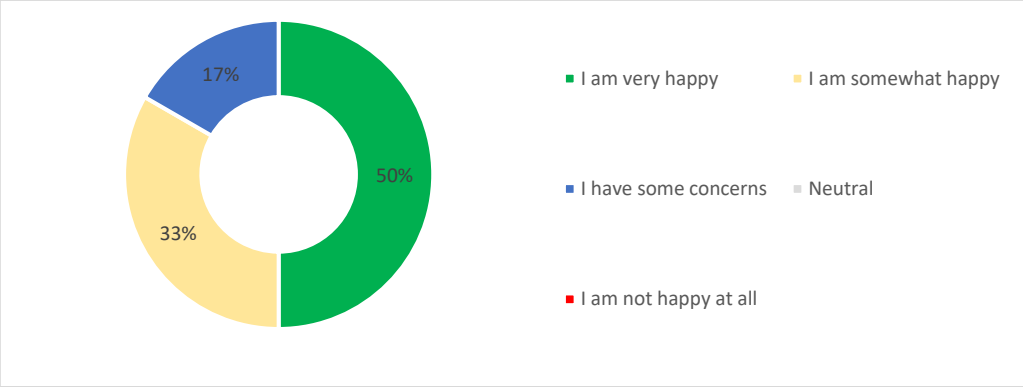


Figure 2 Question: On a yearly basis, compared to your previous situation, you now spend...

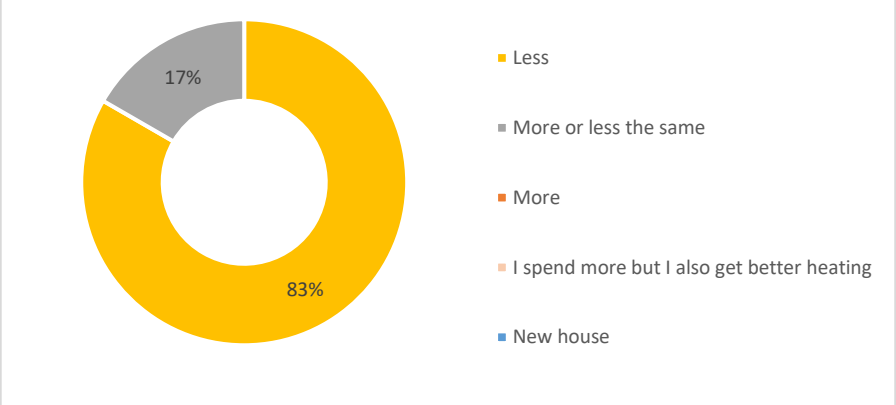
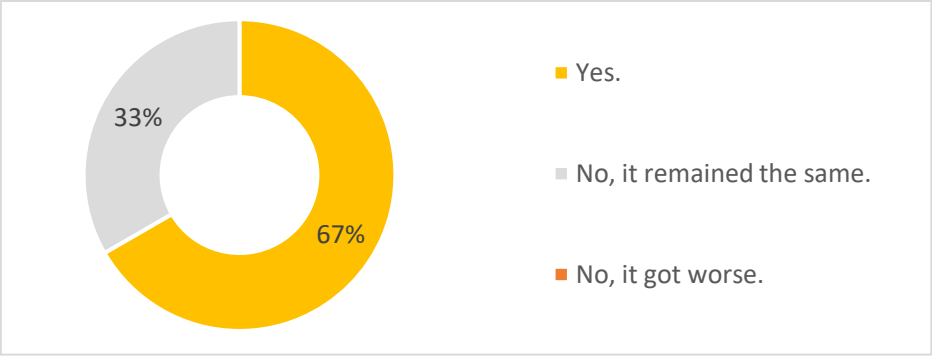


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Overall data assessment

Overall, the survey results are compatible with the literature on the topic. Regarding the lower level of comfort in comparison to the literature, we highlight that many participants (33%) declared to have the same level of comfort as they had with the previous heating system and none of the participants had less comfort after installing a HP.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	83% (satisfied users)	83% (users that spend less after installing a heat pump)	67% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver the same or even a better level of comfort in comparison to gas and oil boilers.
- Switching to a HP is likely to result in lower or about the same running costs.

Germany

Survey

Oil boilers were the most common source of heating among the participants (n=11) before the change to HPs. The concern with environmental/climate issues and economy was the most cited reason for changing. Ground-source HPs followed by air-to-water HPs were the preferred choices among respondents. Most respondents also performed energy renovations on the building when the HP was installed (i.e. insulation of walls, replacement of windows). Most participants believed their heating comfort improved after the change. Most declared they were happy with their heat pump and, in many cases, the change resulted in yearly savings.

Figure 1 Question: Overall, how satisfied are you with your heat pump?

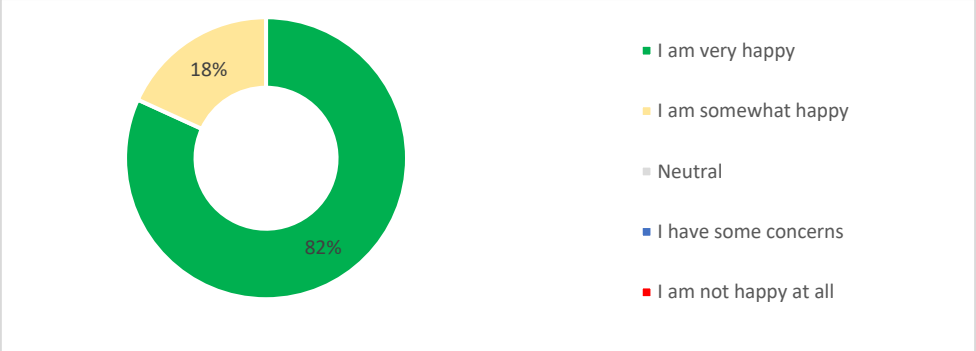


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

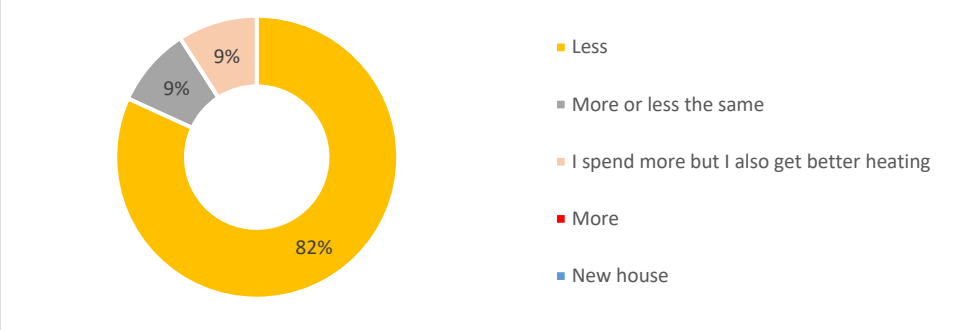
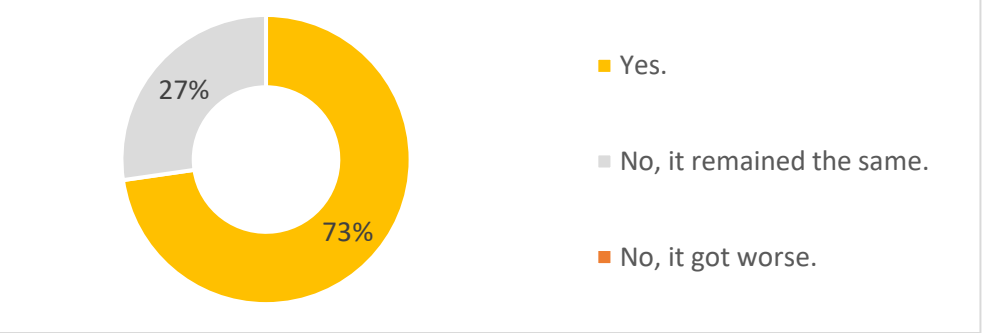


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with D. Schüwer from Münster

The Schüwer family lives in Münster, North Rhine-Westfalia, (mild winters, elevation 60 m). Two adults and two

children live in one of the four connected two-storey houses. The house was built in 2019 and has underfloor heating. The heated area is approximately 300 m^2. The building has common heating based on a ground-source HP, which is shared with the other three houses. In addition, each house has a system for hot water with solar thermal collectors and a small air-source HP, combined with a 300 litre hot water storage tank. 70% of energy for hot water comes from the solar thermal system. The other 30% is supplied by the small heat pump, which runs for approximately 900 hours/year. The family actively searched for an energy-efficient building with renewable heating. They also contributed to the design of the building, further improving its energy performance. The family is very satisfied with the running costs as it only costs 30 €/month to heat the house. The only problem has been the lack of air filter in the ventilation system, which was changed. Overall the Schüwers are very satisfied with the comfort and would recommend using a HP system.

Interview with O. Wehde from Eutin

This family of four lives in Eutin, northern Germany (cold winters, elevation 33 m). The well-insulated house was built in 2019. The heated area is 112 m^2. The average energy consumption is 80kWh/m^2 for heating and 4-5kWh/m^2 for hot water. The 6kW air-source HP was installed when the house was built. The main reason for the choice was environmental protection. At the time, they also considered solar thermal. The annual electricity consumption is around 2,200kWh. They have a special electricity tariff for HP operation and spend around 700 €/year on heating. The owner describes that this is significantly cheaper than what they would spend with a different system. The family is satisfied with the comfort level but it took some time to get the system to work as they wanted it.

"We are very satisfied now, but it took us 12-18 months to adjust the radiator system to make it deliver the right temperature."

Overall data assessment

Overall, the survey results are compatible with the literature on the topic. Regarding the slightly lower level of comfort in comparison to the literature, we highlight that many participants (27%) declared to have the same level of comfort as they had with the previous heating system and none of the participants had less comfort after installing a HP.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	100% (satisfied users)	82% (users that spend less after installing a heat pump)	73% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver the same level or even better comfort in comparison to gas/oil boilers. However, many participants also improved other aspects of the building when the HP was installed, which can contribute to higher comfort.
- Satisfaction with running costs could be connected to the availability of special electricity tariffs for the operation of HPs.

Hungary

Survey

Gas boilers were the most common source of heating before the change to HPs for Hungarian participants (n=18). Air-to-air and air-to-water HPs were the preferred choices. Interestingly, more than half of participants combine the heat pump with either wood heating or solar collectors and most of them have solar panels for electricity generation. Most users perceived that their heating comfort improved after the change, even though other elements of the building were not changed. Therefore, 85% declared they weree happy with their heat pump (Figure 1) and nearly 70% now pay less yearly to heat their homes (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

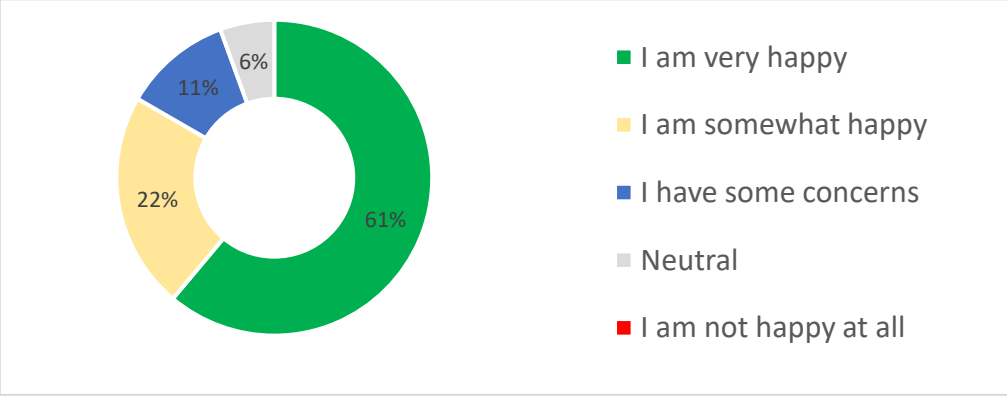


Figure 2 Question: On a yearly basis, compared to your previous situation, you now spend...

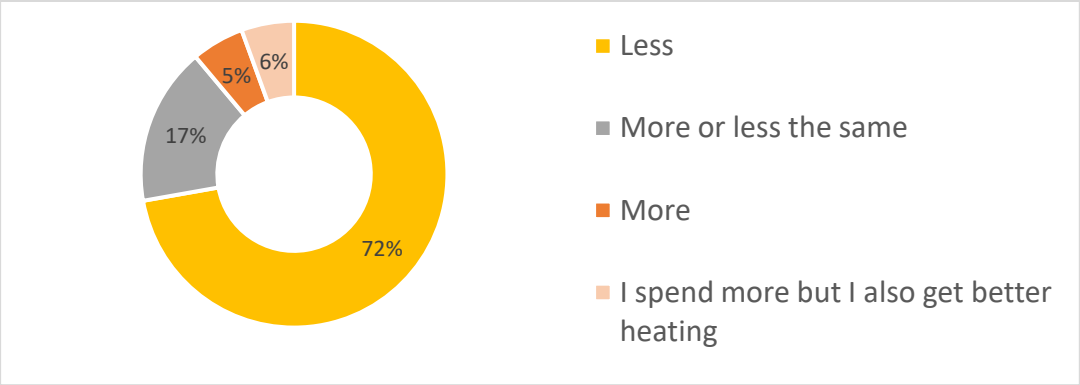
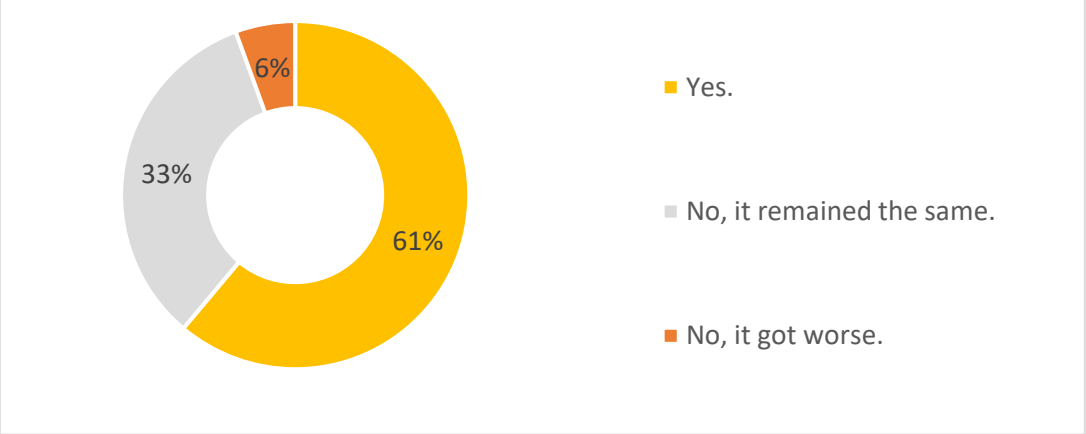


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with Baranyák family

Table 6 Photo by Zoltán Baranyák.

This family of five lives in an area characterised by a mild climate in Central Hungary in a 110 m^2 detached house. They changed from wood-burning central heating and have been using a ground-source heat pump for five years to heat and produce domestic hot water. They now use HP for an estimated 95% of heating demand, leaving wood for the remaining 5%. Before the change, the family considered a woodchip system, but they realised it would be more expensive. At the time the heat pump was installed, the family also improved the insulation of the attic. They perceived improvement in comfort with the change and they are very satisfied that they can essentially

heat the house for free since the system is powered by solar PV. This is possible because the PV system is connected to the grid in a net metering billing mechanism. Hungary has a comparatively high potential for solar energy exploitation, thus electricity produced in the summer can reduce the user's future electric bills.

Table 7 Photo: Google Street View.

Interview with Borsos family

This family of two adults lives in an area characterised by a mild climate in the Central Transdanubia region in a 95 m^2 semi-detached house. They changed from wood heating (tile stove) and have been using an air-to-water heat pump for six years for space and water heating. They now use HP for an estimated 95% of heating demand, leaving wood (fireplace) for the remaining 5%. At the time the heat pump was installed, the family also improved the insulation of the entire building and installed low-temperature underfloor heating. They have recently installed a solar PV system. Compared to the previous situation, Mr Borsos believes the noise generated is low and not disturbing and he evaluates the comfort as excellent. He is also satisfied with the running cost, but not satisfied with an 'operating licence fee' which is paid based on documented yearly maintenance.

Overall data assessment

Overall, the survey results are compatible with the literature on the topic. Regarding the lower level of comfort in comparison to the literature, we highlight that many participants (33%) declared to have the same level of comfort as they had with the previous heating system.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	83% (satisfied users)	72% (users that spend less after installing a heat pump)	61% (users that have better heating after installing a heat pump)

Conclusion(s)

- Switching to a heat pump seems to improve or at least guarantee the same level of comfort as the previous heating system.
- Based on replies, switching to heat pumps seems to decrease running costs for Hungary. The combination of a heat pump and solar PV is advantageous in terms of running costs because the electricity produced can be used on different occasions thanks to the net metering system.

Estonia

Survey

Biomass (wood, wood pellets, etc.) was the most common source of heating among participants (n=27) before the change to a HP. Economy, improvement of comfort and having less hassle with the heating system were the main reasons to adopt the technology. Air-to-air HPs followed by air-to-water HPs were the preferred choice. Half of the participants only changed the heating/water heating when the HP was installed, while the other half improved the insulation of walls or replaced windows at the same time. Almost all participants believed their heating comfort improved after the change. Most declared they were happy with their heat pump (Figure 1) and, in many cases, the change resulted in savings (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

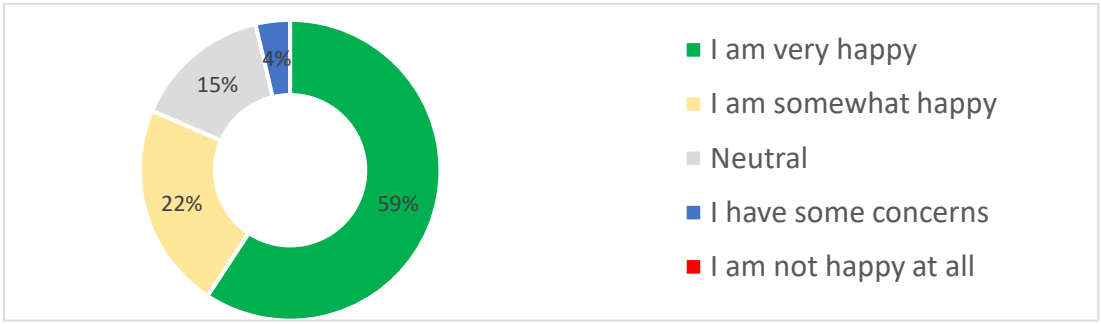


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

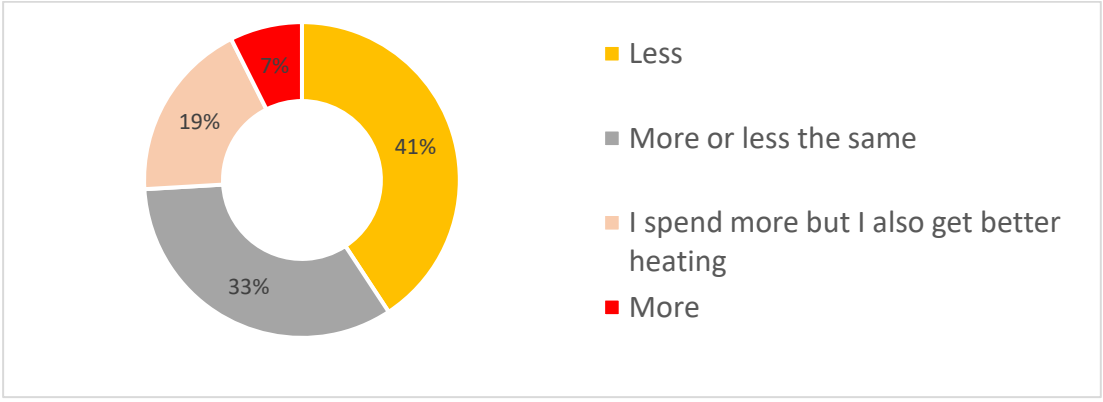
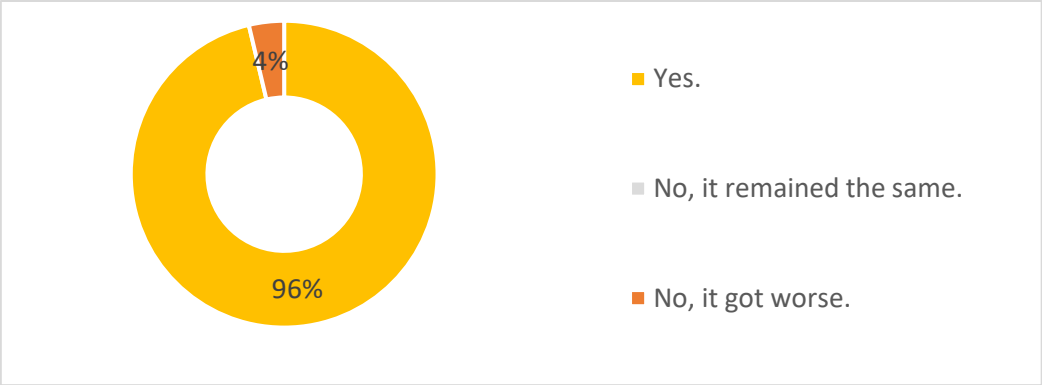


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with family in northern Estonia

This family of three adults lives in the countryside in the Lääne-Viru County, northern Estonia (continental climate, elevation 82 m). The house is a detached building. Before changing to an air-to-air HP they used to heat the house using biomass. The family decided to change to improve comfort. They asked the opinion of friends and researched the options themselves. They believe that choosing a HP was the cheapest and easiest choice. At the time they also improved wall insulation and installed new windows. The HP has been operating since 2016 and they did not receive any subsidy. In comparison to the previous system, the comfort in the house has improved – "It is very comfortable, and heats up quickly," said the owner. In terms of running costs, they are also satisfied with the HP – "It is a bit more expensive but the comfort pays up." Overall, they were satisfied with the system, particularly with the comfort provided. If they were to choose again they may have preferred an air-to-water HP to also have domestic hot water.

> *"It is a bit more expensive but the comfort pays up."*

Interview with family in eastern Estonia

Table 8 picture provided by the family

This family of two adults, two children and two dogs lives in an apartment building in a small town near Tartu, eastern Estonia (continental climate, elevation 57 m). The heated area of the house is approximately 46 m^2. Before the change to an air-to-water HP, the heating was based on biomass

(wood) and electric heating. The family decided to change to improve comfort. They did not consider other options because of the space required; the HP was the easiest option in terms of installation. Many people around them have HPs, they could ask for information and this seemed the most logical option. At the time it was not possible to improve the wall insulation, but they improved floor insulation and installed better windows. The HP has been operating since 2018 and they did not receive any subsidy. In comparison to the previous system, the comfort in the house has improved and the running costs are lower – "Very comfortable, low cost and silent," was the description from the owner. Overall, they are satisfied with the system, and they often recommend it to others.

Overall data assessment

Survey results on overall satisfaction and comfort are compatible with the literature on the topic. The discrepancy regarding running costs is explained by the share of participants that pay about the same (33%). Moreover, 19% of participants believe it is worth it to pay more as they get more comfort than before.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	81% (satisfied users)	41% (users that spend less after installing a heat pump)	96% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver the same or even a better level of comfort in comparison to biomass heating. However, many participants also improved other aspects of the building when the HP was installed, which can contribute to higher comfort.
- Switching to a HP is likely to result in lower or about the same running costs. In case of higher costs, most participants believed that despite paying more they had better heating.

Ireland

Survey

Oil boilers were the most common heating source among participants (n=26) before the change to HPs. Air-to-water and ground-source heat pumps were the preferred choices. The heat pump alone provides all the heating for more than half of the respondents, and many combine it with solar panels for electricity or hot water. At the time of change, most users also

improved other components of the building (e.g. insulation of walls, improvement of windows). All respondents perceived that their heating comfort improved or at least that they had the same level of comfort as before. Therefore, 92% declared thet were happy with their heat pump (Figure 1). Less satisfied respondents attribute their opinion to expensive repair and the need to improve the building insulation. No respondents stated that they paid significantly more yearly for heating (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

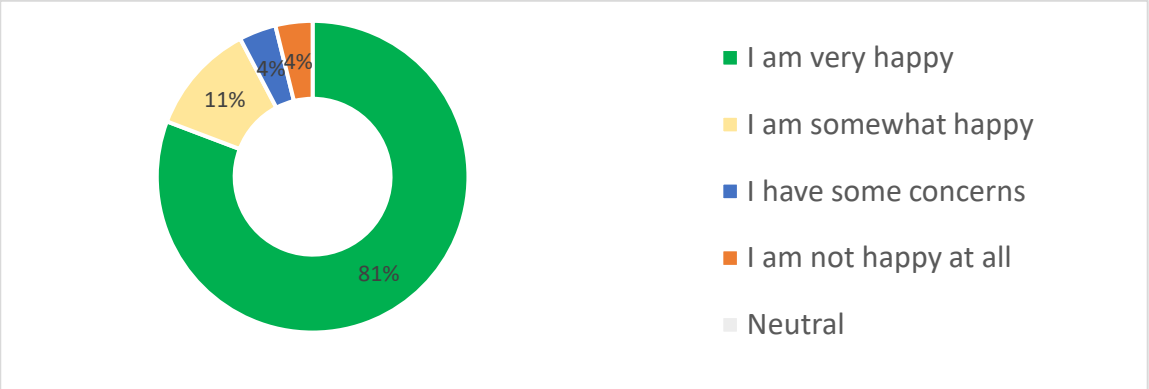


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

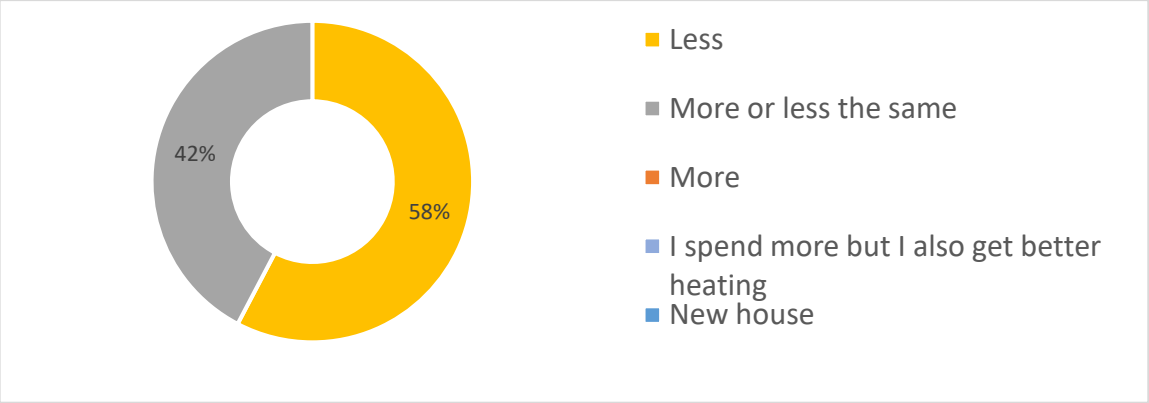
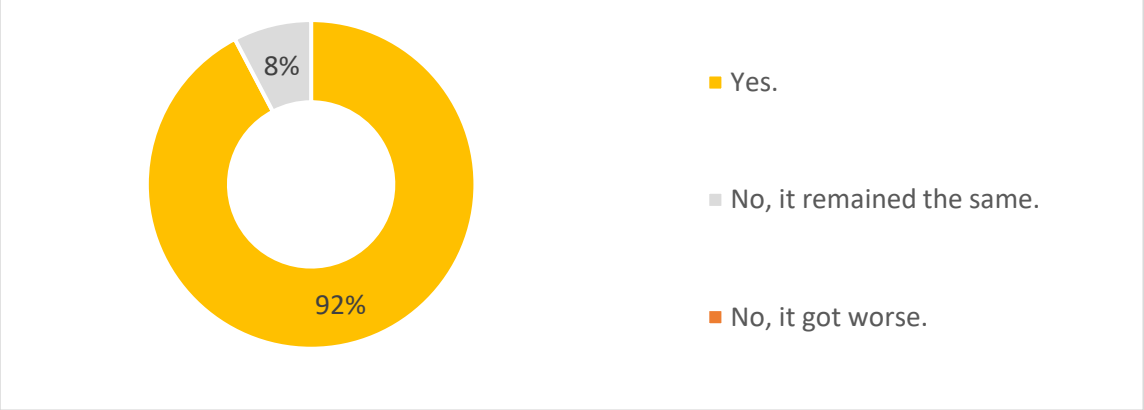


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with S. Hoyne, a family from Birr

Table 9Photo by S. Hoyne

This family of two adults and four children lives in Birr, central Ireland (mild winter, elevation 75 m). The house is a detached building (bungalow) in a rural setting. The house was built in 2005-2006 and the heated area is 165 m^2. The HP was installed in 2015 as part of a major renovation under the Superhomes programme. Before the change, they had oil-fired central heating, which was replaced with a 6.5kW Mitsubishi Ecodan MonoBloc air source HP. They also installed a 300-litre hot water storage tank and thermal solar panels. The heating system is radiators all over the house. The primary reason for the change was environmental protection. At the time they also performed other energy renovations of the building, improving airtightness, ventilation and replacing windows. The total cost of renovation was approximately 20,000 € with subsidies/tax credits of approximately 6,000 €. The family is very satisfied with running costs – "The only issue is with the size of the exchanger in the Domestic Hot Water cylinder, which is too small for the low temperature HP. We plan to replace this next year," said the owner. They use night-rate tariff to operate the HP; They would recommend others to switch to HPs and often find that friends want to know more about such a heating system.

"The tariff at night is approximately 11c/kWh versus 20c/kWh during the day; therefore, the HP is set to run primarily at night."

Interview with P. O´Reilly

This family of two adults and four children lives in a well-insulated home. The house was built in 2014 and the heated area is 185 m^2. The heating system is composed of a 10kW ground-source HP, solar thermal water heating, a 300-litre hot water storage tank and underfloor heating. The main reason for the choice was an environmental concern. The family is very satisfied with running and maintenance costs, since no repairs were needed for seven years. They currently do not use any special electricity tariff. The family is very satisfied with the comfort, particularly with the floor heating at 40 degrees that keeps the air temperature at 21 degrees. Therefore, they would recommend that others choose to heat with a HP as well.

Overall data assessment

Overall, the survey results are compatible with the literature on the topic. A few respondents stated that it was necessary to improve the building insulation to achieve the desired comfort level. The discrepancy regarding running costs is explained by the share of participants who pay about the same (42%). No participants reported paying more.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	92% (satisfied users)	58% (users that spend less after installing a heat pump)	92% (users that have better heating after installing a heat pump)

Conclusion(s)

- Switching to a heat pump seems to improve comfort in comparison to the previous heating system, most commonly oil boilers. However, many buildings could require further energy retrofits.
- Switching to a HP is likely to result in savings, or at least about the same yearly heating costs.

Italy

Survey

Gas boilers were the most common type of heating source among participants (n=12) before the change to HPs. Improvement of comfort and concern about the environment/climate were the most cited reasons for changing. Air-to-water and air-to-air HPs were the preferred choices. Most participants performed some kind of energy renovation on the building when the HP was installed (insulation of walls, improvement of windows, etc.). Similarly, most participants believed their heating comfort improved after the change. Two-thirds declared they were happy with the system (Figure 1). These participants also saw savings on yearly heating costs (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

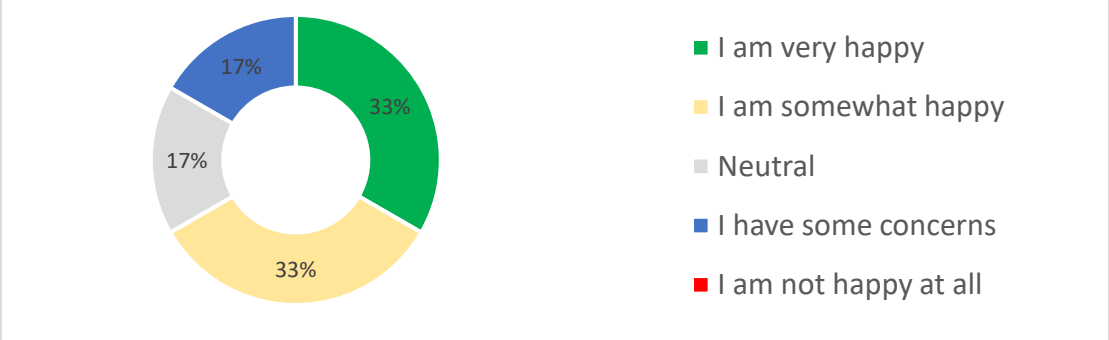


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

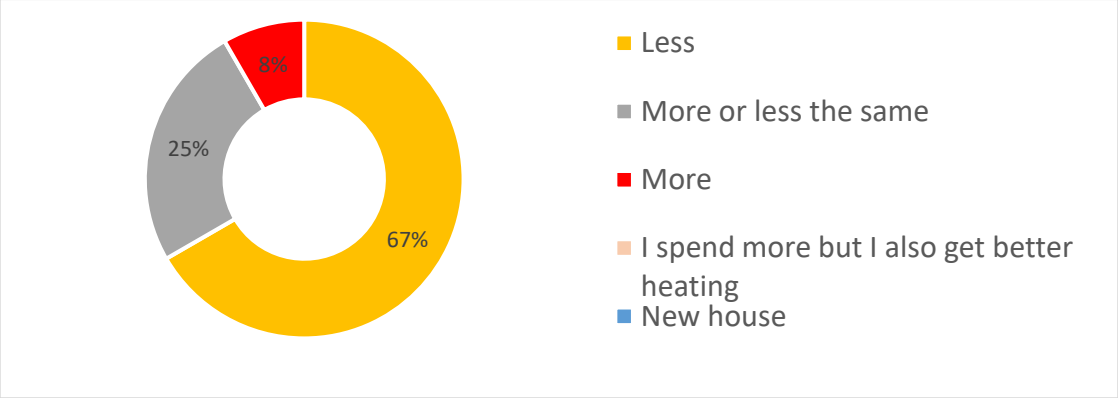
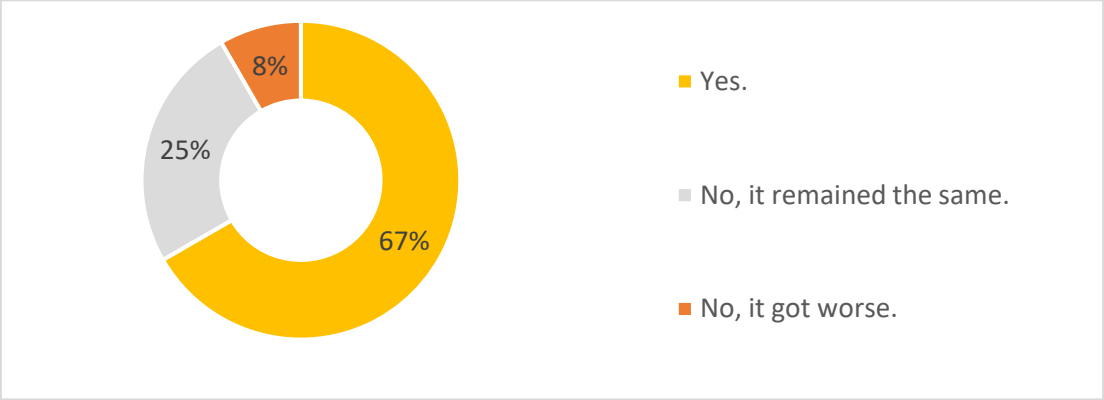


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with family in Rome

This family of two adults lives in a flat in Rome (mild winters). The heated area is 70 m^2. Before changing to an air-source HP the flat was heated using gas. The family decided to change because some of the pipes broke and they used the opportunity to replace the gas boiler with a HP. The owner obtained information from the online magazine QualEnergia.it and did not consider other alternatives at the time. The 6.8kW HP has been in use since spring 2017 and provides heat to the entire flat. Before installing the HP, the windows were replaced with more energy-efficient ones. In comparison to the previous system, the owner evaluates that the comfort is mostly the same, but that the house is cooler than before on very cold days. One advantage is that the HP heats the house more quickly. The family received a 50% tax credit when the HP was installed, and they are currently happy with the running costs. Overall, they are happy with the system and would recommend it.

Interview with family in Como, Northern Italy

This family of four adults lives in Como, northern Italy (subtropical climate, elevation 201 m). The building is a detached house, and the heated area is 200 m^2. Before changing to an air-source HP, the house was heated using gas. The family decided to change because they had to choose an energy-efficient solution to be able to renovate the house. They are also members of an energy cooperative

and were able to obtain information from friends. The air-to-water HP has been in use since 2018 and provides heat and hot water (518 L storage) to the entire house. When the HP was installed, the family renovated the house, insulating walls, the roof, and all windows. They also installed solar PV panels for electricity on the roof. In comparison to the previous system, the owner evaluates that the performance of the HP is better and delivers more comfort. The family received a tax credit when the HP was installed, and they are very satisfied with the running costs, as the owner described that the HP is much more efficient. Overall, the family is very happy with its choice because – "We had to go for an energy-efficient solution to be able to renovate the house. That being said, we appreciated this option also because of its impact on the environment."

"We had to go for an energy-efficient solution to be able to renovate the house. That being said, we appreciated this option also because of its impact on the environment."

Overall data assessment

Survey results on running costs are compatible with the literature on the topic. Interestingly, 17% of participants stated to be "neutral" regarding their overall satisfaction. Regarding the lower level of comfort in comparison to the literature, we highlight that many participants (25%) declared they had the same level of comfort as they had with the previous heating system.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	66% (satisfied users)	67% (users that spend less after installing a heat pump)	67% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver a better or at least the same level of comfort in comparison to gas heating.
- Switching to a HP is likely to result in savings, or at least about the same yearly heating costs.

Latvia

Survey

Biomass (wood, wood pellets, etc.) was the most common source of heating among the participants (n=12) before the change to HPs. Economy, improvement of comfort and reducing the hassle with the heating system were the main reasons to adopt the technology. Ground-source HPs were the preferred choice. Most participants also improved the insulation of walls or replaced windows when the HP was installed. All participants believed their heating comfort improved after the change and declared they were happy with the system

(Figure 1). However, switching to a HP resulted in higher annual costs with heating in some cases (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

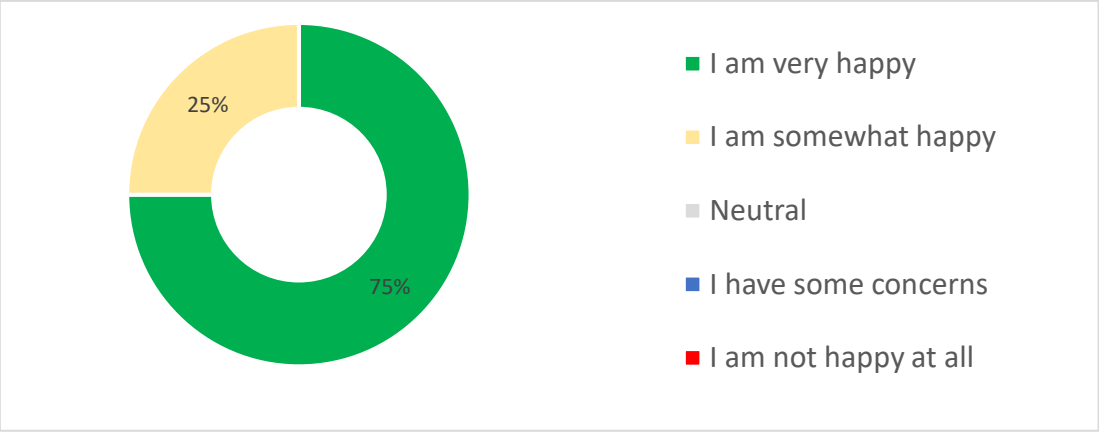


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

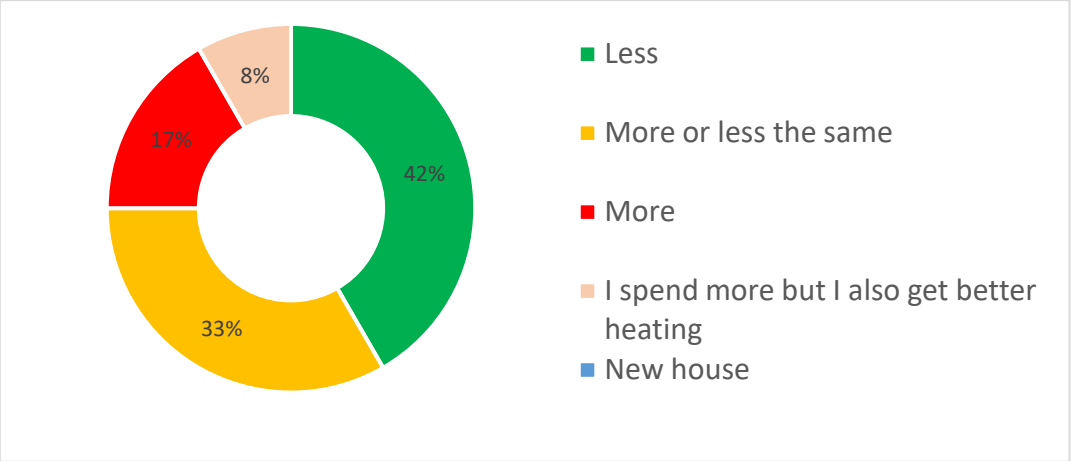
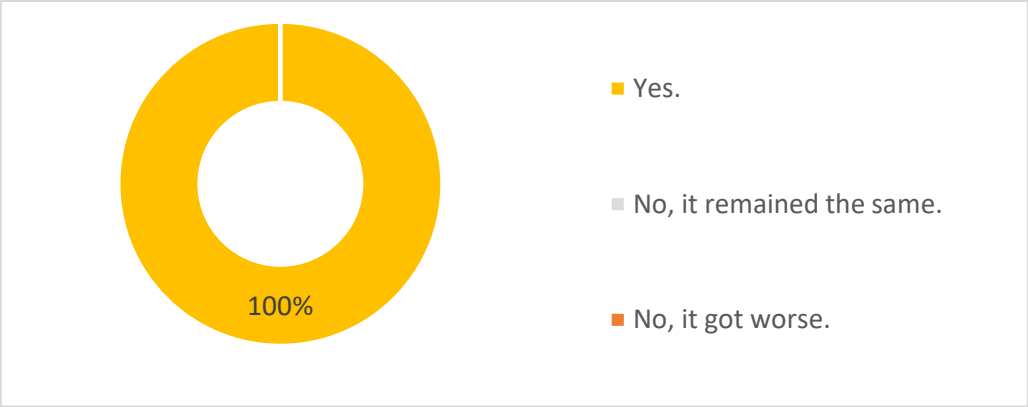


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with family in Valmiera

This family of two adults and two children lives in Valmiera, a mid-size town northeast of Riga (cold winters). The house was built in 2018 and the total heated area is 186 m^2. It is an energy-efficient building with an average yearly consumption of 45kWh/m^2. One of the adults works from home, and therefore there is always at least one person in the building. In the previous house, the family used firewood for heating. The 8.7kW ground-source HP has been in operation for three seasons, providing space heating, domestic hot water and cooling in the summer. The system is also equipped with a 178 L hot water storage tank. The owner evaluates that the indoor comfort is very good but that the efficiency of the system could be better if vertical boreholes were used instead of the horizontal loop. "Very happy with the cost and level of comfort. No special care is required (in comparison to firewood heating). Everything works. The manufacturer will provide free updates and services to the system for 5 years. There is a mobile application that allows viewing and adjusting the operation of the HP by adjusting the curves. When it was -30°C outside, the floor went to 28°C degrees inside, but the indoor temperature has always been kept around 22°C." The family did not receive support for the HP but they are looking into possible support schemes for the installation of solar PV panels. "The household's total annual electricity consumption is around 7,200kWh. The plan is to install 6 solar PV panels in the future, which could cover half of the electricity consumption," explains the owner. Initially, the family was paying a flat rate of 110EUR a month for electricity, but now they have switched to the market tariff because the pump is running at night when the electricity price is the cheapest. Overall, the family is happy and would recommend the system, as long as some conditions are met – "Our climatic conditions are suitable for HPs. The company installing the HP must be also providing the service and guarantee. The building itself must be energy-efficient to use the HP properly."

"It is very important that the company installing the HP is also providing the service and guarantee. The building itself must be energy-efficient to use the HP properly."

Overall data assessment

Survey results on overall satisfaction are compatible with the literature on the topic. The discrepancy between results and the literature regarding running costs could be explained by the share

of participants (33%) who pay about the same. Moreover, 8% of participants were happy to pay more as they got more comfort than before.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	100% (satisfied users)	42% (users that spend less after installing a heat pump)	100% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver the same or even a better level of comfort in comparison to biomass heating. However, many participants also improved other aspects of the building when the HP was installed, which can contribute to higher comfort.
- Switching to a HP does not result in lower costs in all cases. However, some participants that paid more believed it to be worth it as they had better heating.

Malta

Survey

Gas boilers were the most common source of heating among the participants (n=10) before the change to HPs. Convenience and improvement of heating comfort were the main reasons identified by the participants to switch to a HP. Air-to-air HPs were the preferred choice. Most users only changed the heating/water heating system and did not perform other energy renovations on the building (insulation of walls, improvement of windows, etc.) when the HP was installed. Nevertheless, all participants believed their heating comfort improved after the change, including those who switched from gas boilers to HPs. Overall, 90% declared they were happy with their heat pump (Figure 1). Most participants paid about the same in comparison to their previous heating system (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

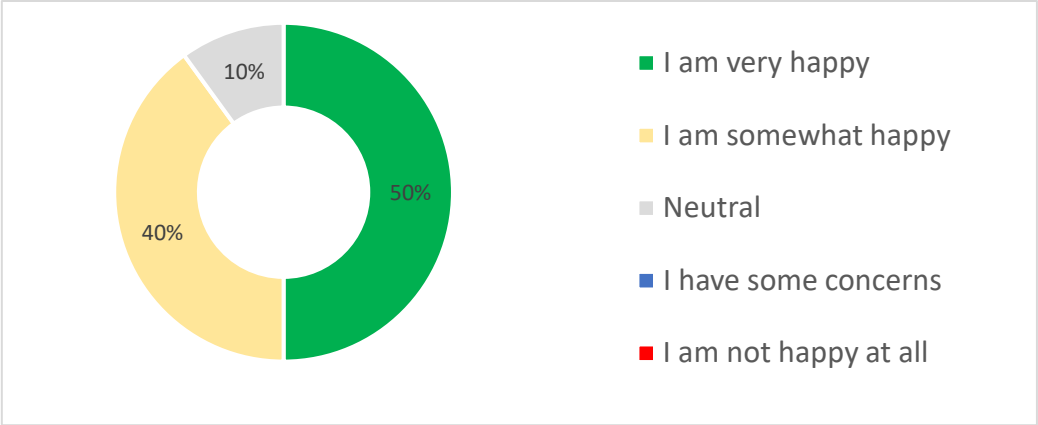


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

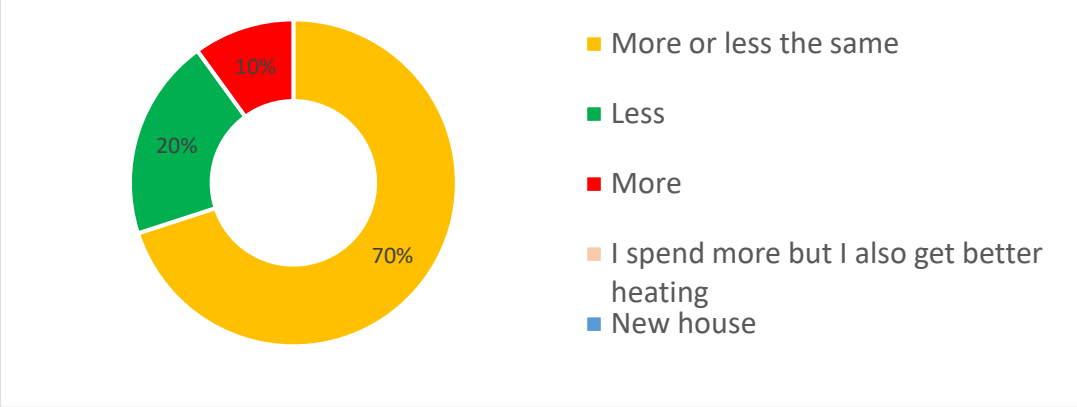
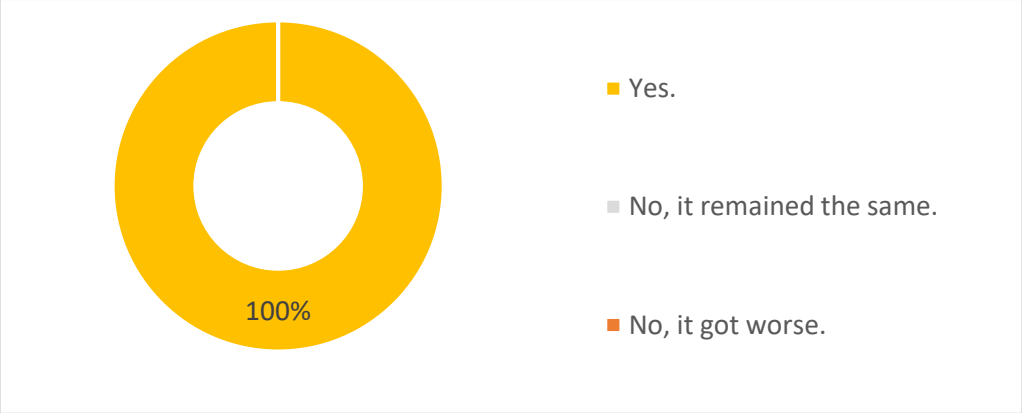


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with family in northern Malta

This family of two adults and two children lives in the northern part of the country (Mediterranean climate). The building is a 75 m^2 detached house. They moved from an apartment to a house, switching from a gas boiler to space heating to air-to-air HPs and from electric water heater to an air-to-water HP and solar heating. The owner believes a HP is the best choice for the local climate. At the time of installation, the windows were also changed to

It is very efficient and only needs to be switched on for a couple of hours to maintain the room warm all night

double glazing, since the house was old and only single glazing windows were in place. The HP for water heating has been in use for five years and the HPs for space for three years. The family received a rebate for installing the solar water heater and the HP providing hot water. They are also happy with the water heating system, which is in use all year. One negative aspect is the space required for the 250 L hot water tank. However, this is not a problem for them since they have a washroom to accommodate the system. They have no complaints regarding the running costs either.

Interview with family in Gozo

This family of two adults and two children lives in Kerċem, Gozo, in the south-west of the country (Mediterranean climate). The house is a terraced building and the heated area is approximately 280 m^2. The family used electric water heaters before the change to HPs. They did not have space heaters before. The family decided to replace the water heating system (80 L) with a system that had bigger storage and that would be more economical. They considered solar heating but decided to install an air-to-water HP and air-to-air HPs for space heating and cooling, which is a relevant need in Malta because of its hot summers. The air-to-air HPs have been in use since April 2017 and the air-to-water HP since April 2021. In comparison, the HP is noisier than the electric heater, which practically did not make any sound. The bigger water tank was important to guarantee enough hot water for the family. The home did not have space heating before and they believe they are more comfortable now. There is no noise disturbance from the air-to-air systems. In sum, they are satisfied with the services delivered by both systems. Comparing the running cost of the HPs to the previous equipment, they are also satisfied. They are satisfied with the costs of the space heating, but they cannot quantify how much they spend, since they had no previous heating costs. “Operational costs are electricity consumption and annual service filter-cleaning; however, I cannot quantify since I do this myself," declared the interviewee. They received a grant for installing the HP water heating system. Overall, they are happy with their choice and would recommend it to others in their community.

At the time of change, they installed solar PV panels as well, but did not make other changes relating to the insulation of the house.

Overall data assessment

Overall, the survey results are compatible with the literature on the topic. The large discrepancy regarding running costs could be explained by the share of participants who pay about the same (70%).

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	90% (satisfied users)	20% (users that spend less after installing a heat pump)	100% (users that have better heating after installing a heat pump)

Conclusion(s)

- Air-to-air and air-to-water HPs seem to deliver the same, or even a better, level of comfort in comparison to electric heaters and gas boilers.
- Based on the replies, switching to a HP will result in about the same running costs in comparison to gas boilers, but likely lower running costs in comparison to electric heaters.

The Netherlands

Survey

Gas boilers (methane/LPG) were the most common source of heating among the participants (n=8) before the change to a HP. Environmental/climate issues were the most cited reason for changing. Ground-source HPs and air-to-water HPs were the preferred choices. Most participants also performed energy renovations on the building when the HP was installed (i.e. insulation of walls, replacement of windows) and most participants believed their heating comfort improved after the change. Most declared they were happy/very happy with their HP and now pay less for heating yearly.

Figure 1 Question: Overall, how satisfied are you with your heat pump?

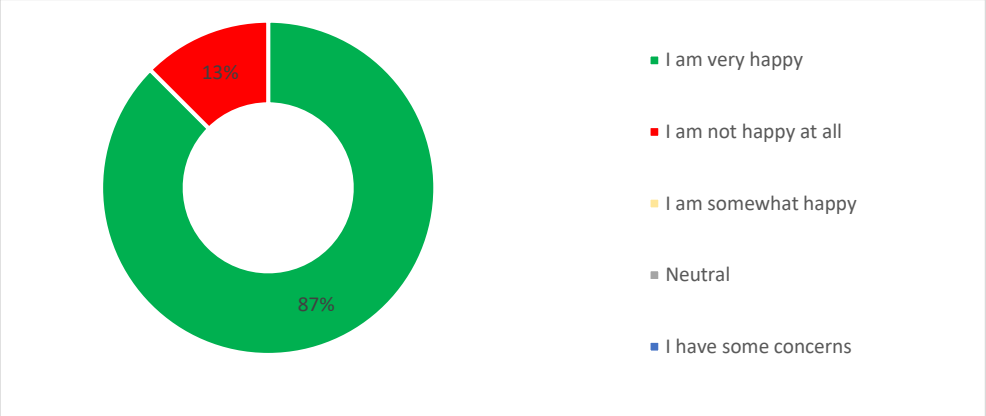


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

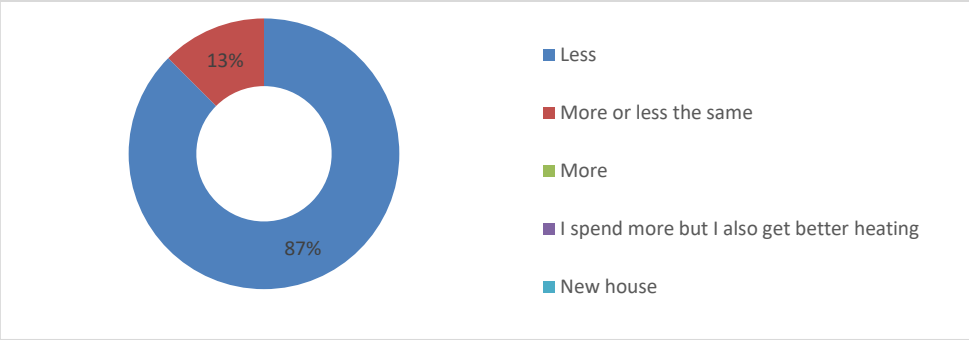
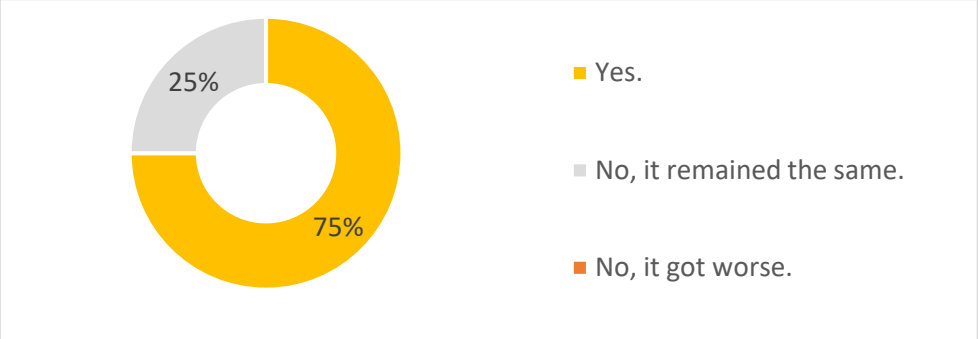


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with J. Kleijweg

Table 10 Photo by J. Kleijweg.

This family of two adults lives in a village in the Utrecht area. The semi-detached house has an area of 128 m^2. Before changing to an air-source HP, the family used a natural gas boiler for heating the house. The building comprises three houses and recently received energy renovations, with improved insulation and a rooftop solar PV system. The aim was to reduce heating costs to zero with the solar PV system, which produces around 6,000kWh/year. Before the change, they were spending approximately 400 € on natural gas. They received a subsidy for the total energy renovation. The motivation for the major energy renovation was the concern about environmental impacts. The family is very satisfied with the more comfortable house and the solar PV and HP system and would recommend this combination to neighbours.

Interview with M. de Vor family

This family of two adults lives in the Utrecht area. The house is a ground floor apartment and was built in 2018. A ground-source HP supplies all heating and cooling via underfloor heating. The building is well insulated. The rooftop solar PV system with 18 panels supplies electricity for appliances, the HP and electric car charging. The decision to use a HP was motivated by environmental reasons. The family does not have a special electricity tariff, but they receive self-produced electricity. They are very satisfied with the heating system, since it provides a good level of comfort at a low cost.

Overall data assessment

Overall, the survey results are compatible with the literature on the topic.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	87% (satisfied users)	87% (users that spend less after installing a heat pump)	75% (users that have better heating after installing a heat pump)

Conclusion(s)

- Switching to a heat pump seems to improve comfort in comparison to gas boilers. Nevertheless, it is recommended to properly insulate the house before changing to a HP, as most participants considered their houses to be very well insulated.
- Switching to a HP is likely to result in savings on yearly heating costs.

Norway

Survey

Biomass (wood/wood pallets) and electric heating were the most common sources of heating among participants (n=18) before the change to a HP. Improvement of comfort and environmental/climate concerns were the main reasons to adopt the technology. Air-to-air HPs were the preferred choice. Most participants only changed the heating/water heating when the HP was installed. Nevertheless, most participants believed their heating comfort improved after the change and the others believed it remained the same. No participants perceived having less comfort after changing to HPs. Most participants declared they were happy (very happy and somewhat happy) with their heat pump (Figure 1) and all of them paid less or about the same to heat their homes in comparison to the previous heating (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

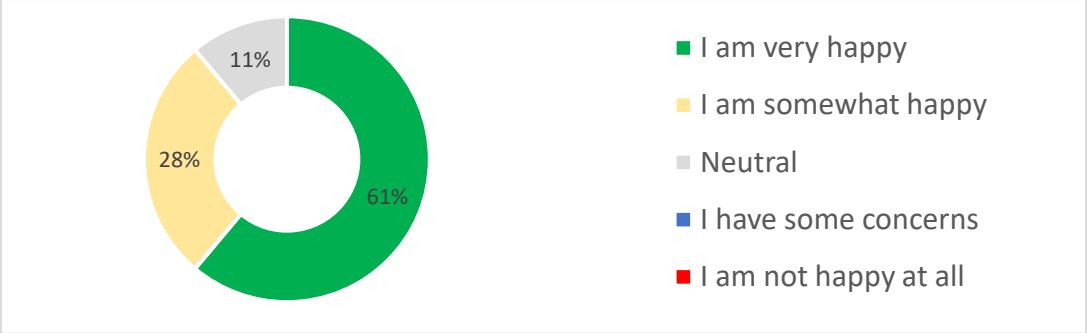


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

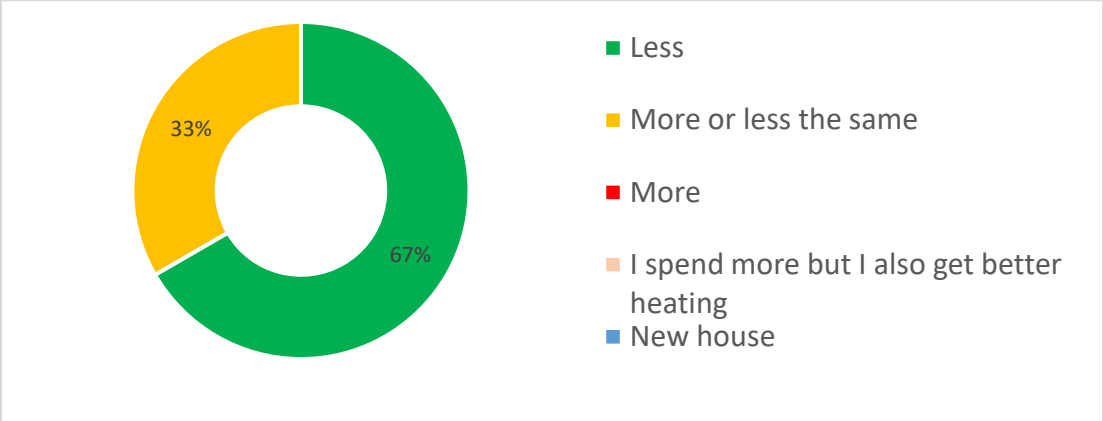
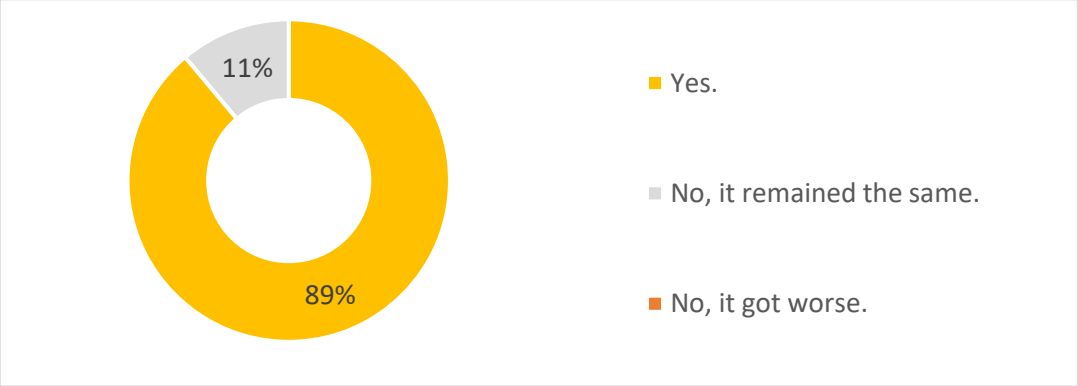


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with the Nysæther family

This family of two adults lives in Bergen, south-west Norway (mild winters). The house was built in 1967 and the total heated area is 250 m^2. Before changing to an air-to-air HP, they used kerosene, wood and electricity for heating. The change happened because they wanted a cleaner heating option. The owners explained that when the family house was built, oil was both an easy and modern choice: “If we had known what we know today, we would have never chosen that solution." Before installing the HP, the family replaced the original windows with 3-layer energy-efficient windows. These measures resulted in energy savings that they could notice. The air-to-air HP is now used in combination with a modern wood stove. The HP and the new stove were installed quickly and without

inconvenience. In comparison to the previous system, the comfort in the house has improved. The owner is particularly satisfied with the lower expenses for electricity. Before the change, they used about 34,000kWh/year. After the HP was installed, they consumed on average less than 20,000kWh/year. “We have become better at heating only the parts of the home that we actually occupy and we keep the temperature lower than before," explains Gunhild. She believes that the entire investment will be repaid within 10-11 years, but that the HP and the wood-burning stove will be repaid within 3-4 years. Becoming “oil-free” has brought great joy to the family and a feeling of contributing to a cleaner environment, describes the owner. They are now even more motivated to implement other energy-efficient measures and she hopes that they can be an inspiration to others.

Interview with the Løken family

The Løken family lives in Nordstrand, near Oslo (cold winters). The house is a villa with three floors and was built for two generations (two dwellings). The heated area is approximately 350 m^2. The heat was originally based on wood, but in 1954 radiators and an oil boiler were installed. Kjellaug and Johannes Løken are concerned about the environment and did not like to heat with oil. When Kjellaug heard about a colleague who had a ground-source HP installed, the couple decided to investigate the possibility of doing the same. The 12kW ground source HP was installed in 2014. “The HP collects heat from the bedrock via a liquid that circulates in a separate pipe down the borehole and back to the HP. The liquid is approximately six degrees when it enters the heat pump, and three degrees when it goes out again. It is this heat energy that is used to heat the water in the central heating system and the hot water tank. It takes about 4kW of power to operate the HP, while it provides 12kW in the form of heat energy,” describes Johannes Løken. The family chose to install underfloor heating in parts of the ground and the first floor at the same time the HP was installed. However, the house is not very well insulated (according to the owner) and radiators in the old central heating system were designed for a water temperature of up to 70 degrees, while the HP can heat water up to 56 degrees. The existing radiators provided enough heat in the first winter. However, last winter when it was colder outside, the family felt that it was a little too cold in the entrance hall and the stairs between the first and second floor. The family installed a fan convector radiator in the entrance hall. The fan convector connects to the HP system and blows hot air into the room. The family is happy that they put underfloor heating on the ground floor at the same time as they installed the HP, and they think the underfloor heating provides better comfort. The couple is also happy with the extra space they now have in the house, as the oil tank occupied a separate room in the basement, which is now a hobby room. The family received the support of approximately 20% of the total costs (including the HP, removal of oil tank and boiler, drilling and piping) from the Oslo Municipality's Climate and Energy Fund. The hope was to save approximately NOK 30,000 (3,000 €) a year: “We expect to recover the investment cost over a relatively short period, partly because the oil boiler was needing replacing. In addition, the oil price is high and the CO_2 tax is increasing. The oil boiler required an annual service from a professional; now we can almost manage the service ourselves," says Johannes. “Contributing to a better environment in our city is as important as economic considerations," adds the couple.

“We think we deserve to feel good and warm now that we have retired. Besides, it really contributes to the good feeling that the HP is so economical, reliable and environmentally friendly."

Overall data assessment

Overall, the survey results are compatible with the literature on the topic.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	89% (satisfied users)	67% (users that spend less after installing a heat pump)	89% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver a better level of comfort in comparison to oil boilers. Many participants who had biomass stoves and electric heaters perceived an improvement in comfort after the HP was installed. Some still use biomass and electric heaters on colder days.
- Based on the replies, switching to a HP is likely to result in lower running costs, particularly for those using oil boilers.

Poland

Survey

Biomass and coal were the most common source of heating among the participants (n=8) before the change to a HP. Environmental/climate issues and the economy were the most cited reasons for changing. Air-to-water HPs were the preferred choices. Most participants only installed the HP and did not perform energy renovations on the building at the time (i.e. insulation of walls, replacement of windows). Most participants believed their heating comfort improved after the change. Most declared they were very happy with their heat pump and now paid less or about the same for heating yearly.

Figure 1 Question: Overall, how satisfied are you with your heat pump?

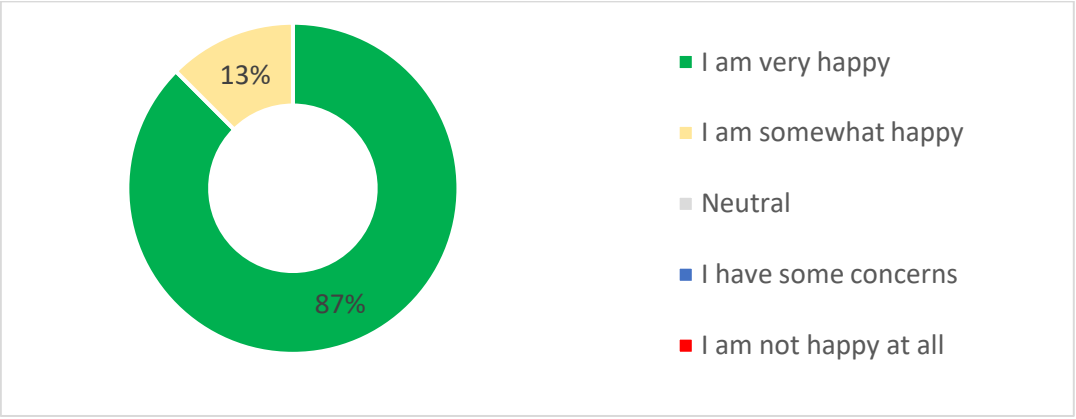


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

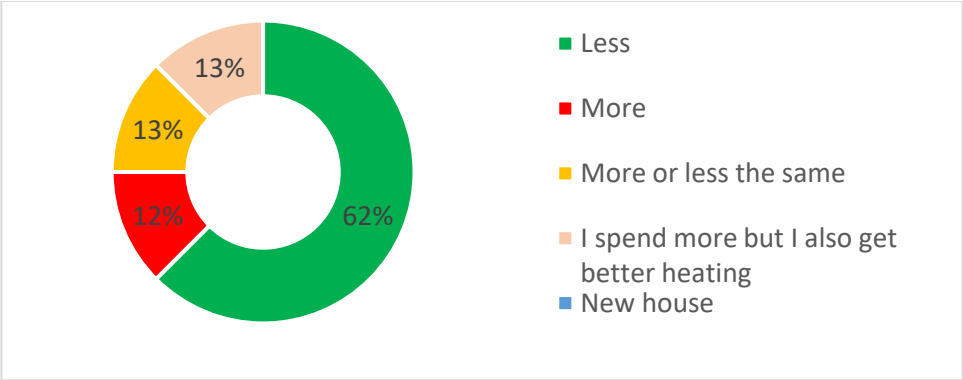
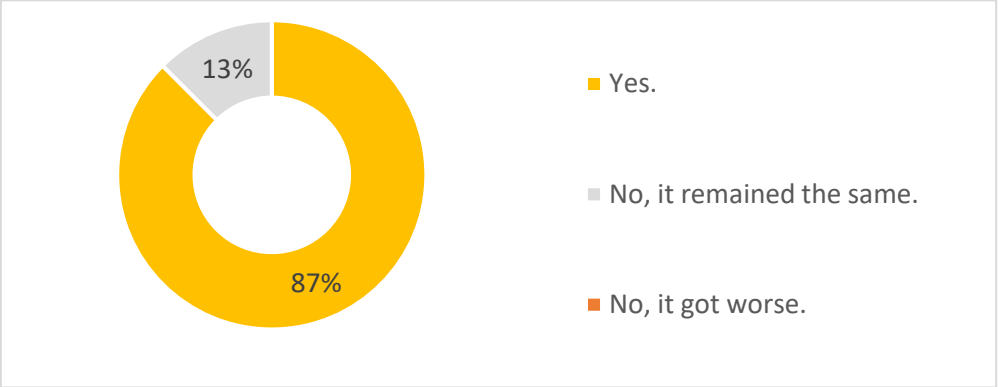


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with A. Krenz

This family of one adult and one child lives in Puszczykowo, Poznań county, in the centre of the country (cool winters). The detached house was built in 1934 and the heated area is about 200 m^2. The 16.7kW ground source HP was installed in 2016. Before the house was heated using a coal/wood stove. At the time of installation, they did not perform other energy renovations. The house has thick walls and double glazed windows. The reason for the owner to install the HP was to stop using coal and to give more comfort to her mother who lived in the house. The owner describes that the installation had not been finished by the installing company, which was very frustrating to her. Some rooms are not heated by the system. Some radiators were exchanged for new ones, some cleaned and some are still the originals from the 1930s. Nevertheless, the HP has been working and they feel comfortable. The owner described that the system was too expensive to install and is expensive to run, but that she is happy to not use coal any more. Her main frustration is that the installers never finished the job.

Interview with J. Czajkowski

This family of two adults lives in a two-storey detached house. The house was built in 2020 and the heated area is 150 m^2. The house was designed to be energy-efficient with good insulation, underfloor heating and equipped with mechanical ventilation with heat recovery and a ground heat exchanger. The 6kW air-to-water HP with cooling option is the only heat and hot water source. Initially, the building was going to be heated with a gas boiler, but delays in the gas grid development and decreasing HP prices made the owner change his mind. A couple of months after installing the HP, the family invested in a 10kWp PV system, which reduced electricity costs to zero. Generally, the family is very satisfied: “No issues with usage and noise. It's simple and comfortable. The only disadvantage is the high initial cost," said the owner. The family did not receive any subsidy, as nothing was available from the government or local authorities. They use a standard electricity tariff (fixed rate), without special schedules. “I would strongly recommend to anyone, especially if there is the possibility to invest some additional money, to install PV panels together with a heat pump," said the owner.

Overall data assessment

Overall, the survey results are compatible with the literature on the topic.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	100% (satisfied users)	62% (users that spend less after installing a heat pump)	87% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver a better level of comfort. However, many participants declared that their houses were well- or very well-insulated, which could contribute to the comfort level.
- Switching to a HP results in low running costs if combined with solar PV.

Portugal

Survey

Gas boilers were the most common source of heating among participants (n=32) before the change to a HP. Several participants chose to install a HP in new houses. Economy, improvement of comfort and environmental/climate reasons were the main reasons to switch/adopt the technology. Air-to-air and air-to-water HPs were the preferred choices. About half of the participants only changed the heating/water heating system and the other half also performed other energy renovations on the building (insulation of walls, improvement of windows, etc.) when the HP was installed. Nevertheless, all participants believed their heating comfort improved after the change, or at least remained the same. Overall, 75% declared they were happy with their heat pump (Figure 1). Most participants paid less or about the same to heat their homes with a HP in comparison to their previous heating. Users that were living in a different house did not compare the costs with the previous heating system (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

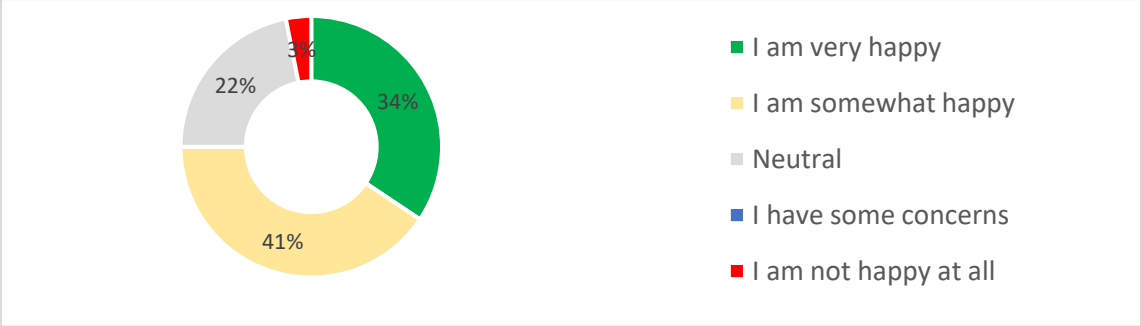


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

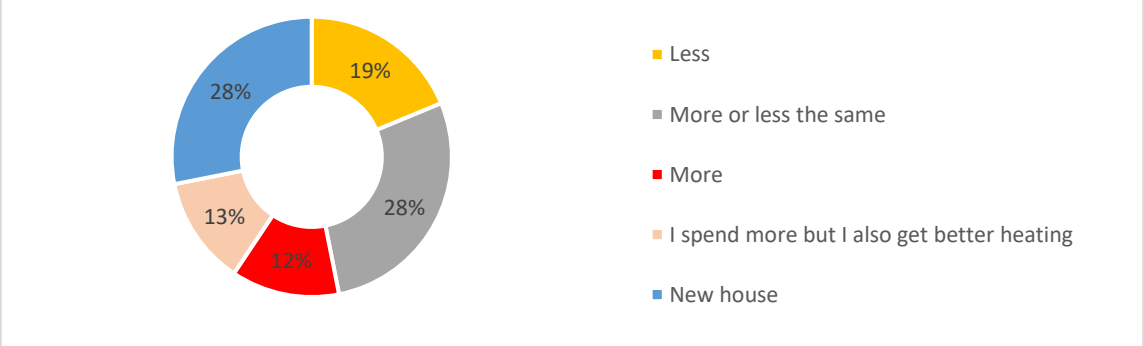
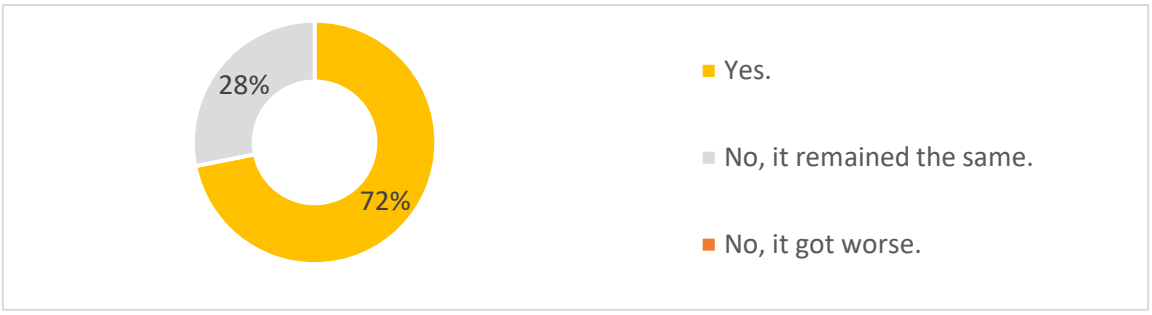


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with family in Alto Minho

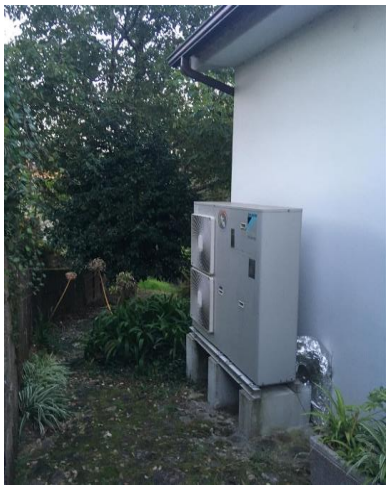


Table 11 Photo by Ja Pinheiro.

This family of two adults and two children lives in Alto Minho in the northern part of the country (elevation 47 m, temperate climate). The house is a detached building, and the heated area is approximately 255 m^2. Before changing to a HP, they used to heat the house using a diesel boiler. The change was motivated by Mr Pinheiro's professional knowledge in engineering and the classification of thermal energy needs of buildings. They did not consider other alternatives. Since they already had underfloor heating, choosing a HP would be the most suitable option, according to him. At the time of change, they did not need to make other improvements because the house had already been built considering energy efficiency requirements. The only necessary adjustment was to find a proper place for the outdoor unit. The air-to-water HP has been in use since 2016 and provides heat and hot water to the entire house. Comparing the running costs of the HP to the previous equipment, they are satisfied. However, the HP is noisier than the previous system. "The noise does bother us a little, even though there is a function to reduce noise, the noise still disturbs us a little, particularly at 10 pm," mentioned the owner. Regarding comfort, they do not feel any difference in comparison to the previous heating. They also consider the system very easy to use. Overall, they are satisfied and would recommend changing to HPs.

Interview with family in Beira Litoral

Table 12 Photo by João Miranda Santos.

The family lives in Beira Litoral province, Pinhal Interior, Central Portugal (elevation 300 m, mild climate). The house is a detached building occupied by eight people with a heated area of 364 m^2. Before changing to a HP, they were using electric heaters and mechanical ventilation heat recovery. They decided to change because they wanted a system that could deliver constant comfort, would be sustainable and convenient to operate. At the time of change, they also considered wood pellets and firewood furnaces. They did not make other improvements to the house (i.e. thermal insulation). The air-to-water

HP was chosen to provide heat for the entire house. Since the previous heating only covered part of the house and did not maintain a constant temperature, they are very satisfied with the comfort achieved by the HP. “The HP is very easy to use; after defining the desired temperature, the system functions autonomously and I don’t have to do anything,” said the owner. Regarding the amount of noise, he mentioned a positive surprise: “I was surprised that there is no significant noise." Evaluating running costs, he mentioned that these were not higher than the cost of an alternative that would deliver the same level of comfort, such as wood pellets. Moreover, the HP has more ecological advantages in his view. So far, they have not received any subsidies, but they are still waiting on the possibility. In sum, they are satisfied with the running costs and with the system in general.

“The HP is very easy to use; after defining the desired temperature, the system functions autonomously and I don’t have to do anything […]. I was surprised that there is no significant noise.”

Overall data assessment

Overall, the survey results show lower satisfaction than the literature on the topic. It should be noted that 22% of respondents are “neutral” towards their overall satisfaction. Regarding running costs, 28% of respondents could not compare, as the house was new, and another 28% spent about the same as they did before the change. Regarding the lower level of comfort in comparison to the literature, we highlight that many participants (28%) declared to have the same level of comfort as they had with the previous heating system. Based on the comment section of the survey, we believe that the implications of installing a HP in a house that does not have the required piping/wiring, leading to more work and extra costs, caused some users to be unhappy.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	75% (satisfied users)	19% (users that spend less after installing a heat pump)	72% (users that have better heating after installing a heat pump)

Conclusion(s)

- Air-to-air and air-to-water HPs seem to deliver the same level or even a better level of comfort in comparison to gas boilers, electric heaters and biomass heating.
- Based on the replies, switching to a HP is likely to result in more or less the same running costs in comparison to other heating. However, there is no strong evidence, since many participants had moved to a new house and could not compare the HP to their previous heating system.

Romania

Survey

Biomass was the most common source of heating among participants (n=10) before the change to HPs. Air-to-water heat pumps were the preferred choice to provide heating/hot water. Almost all participants combined the HP with either solar collectors for water heating or solar panels for electricity generation. All participants believed their heating comfort improved or at least remained the same after the change. Only a small number of participants still used biomass in combination with the HP. About half of the participants performed some type of energy renovation on the building (insulation of walls, improvement of windows, etc.) when the HP was installed, while the other half did not. Most participants were overall satisfied with their choice (Figure 1) and now pay less yearly to heat their homes (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

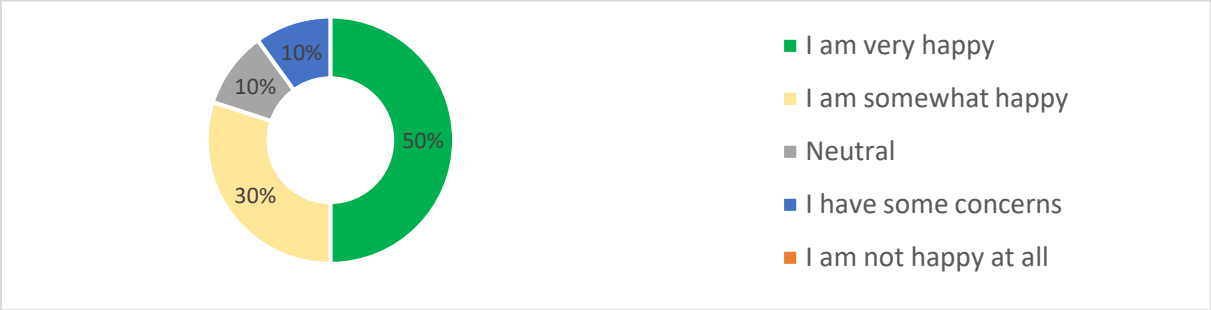


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

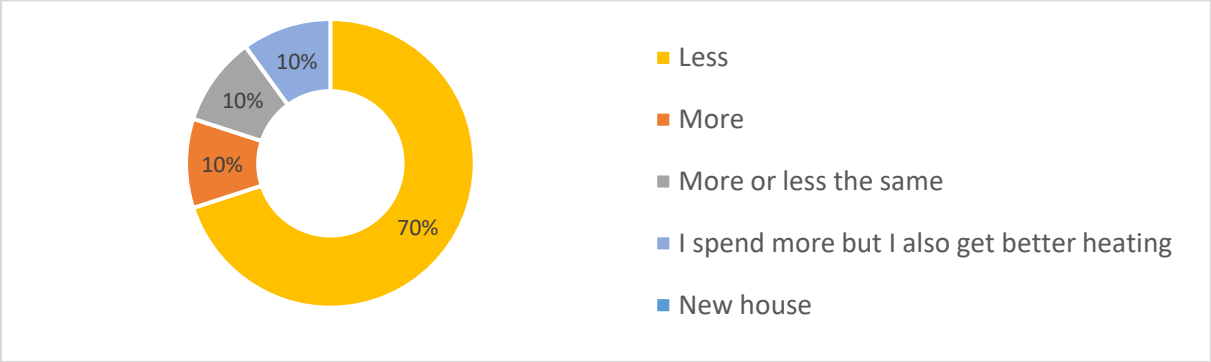
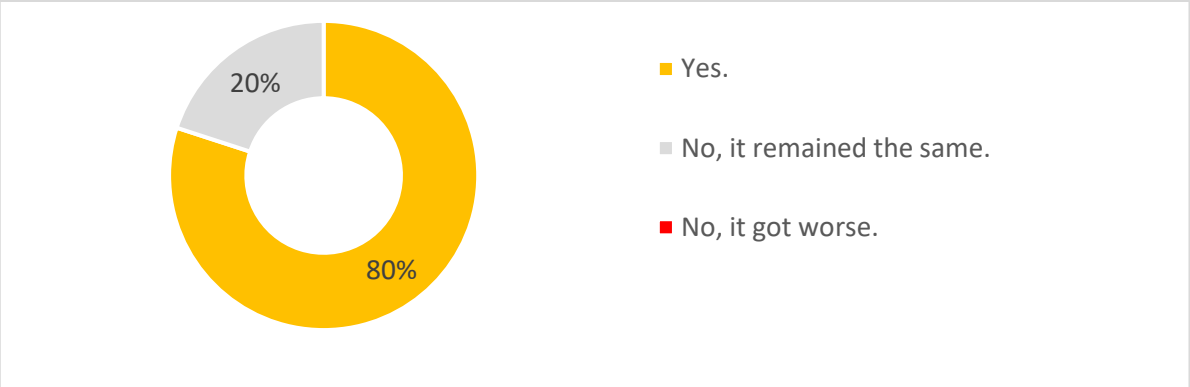


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with family in north-west Romania

This family of two adults and one child lives in the north-western part of the country (elevation 340 m, continental climate). The building is a 120 m^2 semi-detached house. In 2010, they replaced the biomass heating and electric heaters with an air-to-air HP. They decided to change because (a) the wood became expensive and difficult to obtain, (b) the electric heating option also was far too expensive. They obtained a grant of approximately 75% of the cost of the change. They received advice from a friend of the family. In comparison to the previous system, the HP is providing more comfort and is cheaper, according to the family. They are not completely satisfied with the running costs, due to electricity prices. They are overall satisfied with the HP system and would recommend it.

Interview with family in western Romania

This family of two adults and two children lives in the western part of the country (elevation 90 m, temperate-continental climate). The building is a 60 m^2 detached house. They had wood-based heating before and in 2015 they installed an air-to-air HP. Now they use the HP and a small amount of wood. They decided to install the HP because wood became more difficult to obtain and more expensive. District heating or the gas network were options in the area. They received a grant from the Environmental Fund Administration to make the change and obtained information from a friend of the family. At the time, they renovated the house completely because the house was "very old", according to the owner. They plan to install solar panels and/or solar PV when some type of grant is available. They are satisfied with the comfort achieved. However, they are not completely satisfied with the running costs, due to electricity prices and the service provided by the electricity supplier.

However, they are not completely satisfied with the running costs, due to electricity prices and the service provided by the electricity supplier

Overall data assessment

Overall, the survey results are compatible with the literature on the topic.

		User experience	
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature	77-99%	62-85%	75-95%

[11, 13, 15, 10, 17, 21, 22]	(satisfied users)	(satisfied users)	(satisfied users)
Survey	80% (satisfied users)	70% (users that spend less after installing a heat pump)	80% (users that have better heating after installing a heat pump)

Conclusion(s)

- Switching to a heat pump seems to improve or at least guarantee the same level of comfort as the previous heating system.
- Based on replies, switching to heat pumps could result in lower heating bills. However, electricity prices are a concern to participants.

Slovakia

Survey

Gas boilers were the most common source of heating among participants (n=18) before the change to a HP. Air-to-water HPs were the preferred choice to provide heating/hot water. Economy and improving heating comfort were the main reasons to switch to HPs. Most participants believed their heating comfort improved after the change. All users that previously had gas/oil boilers stated that their comfort improved or at least remained the same after the change. Half of all participants performed some type of energy renovation on the building (insulation of walls, improvement of windows, etc.) when the HP was installed. Overall, 73% declared to be happy with their heat pump (Figure 1). Installing a HP resulted in savings on heating bills for about 60% of participants (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

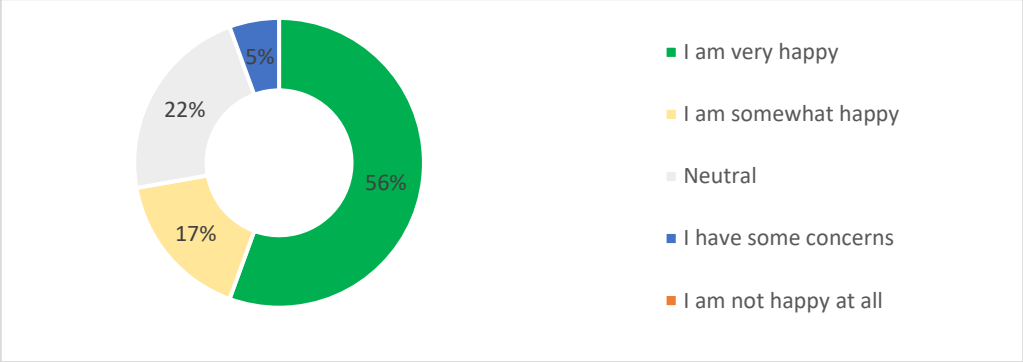


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

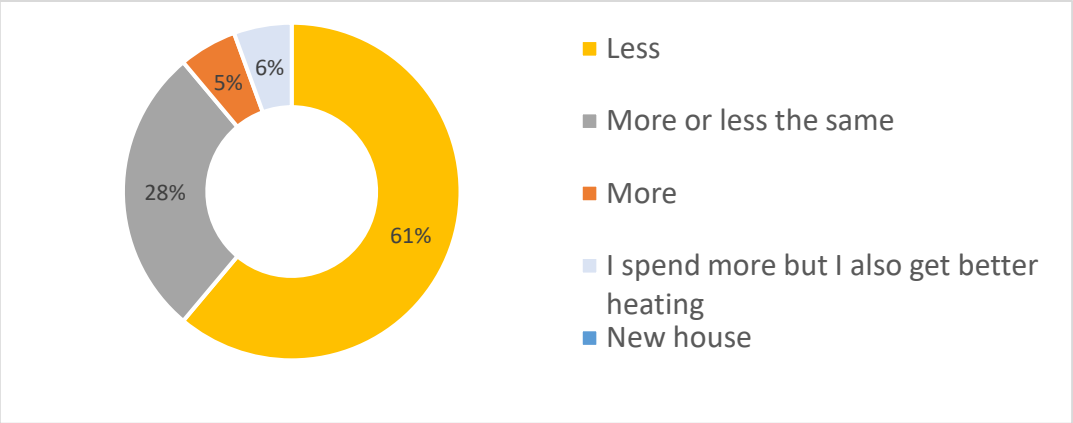
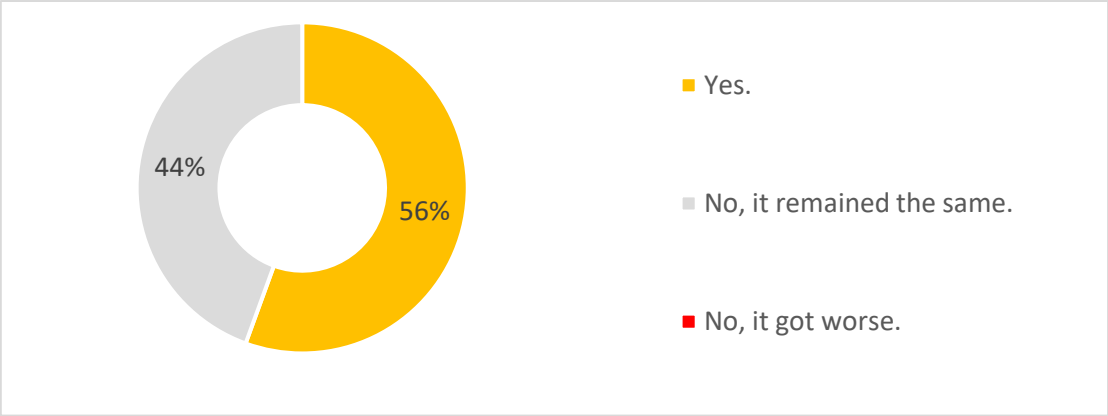


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with the Kovács family

Table 13 Photos by Tamás Kovács.

This family of two adults lives in the Dunajská Streda District, in the south-west of the country (elevation 115 m, continental climate). The building is a 100 m^2 detached house. They switched from wood pellet heating to an air-to-water HP, which has now been providing heating and hot water for two years. Before the change, the family was advised by a friend. Then they consulted a private company that handled the project and the paperwork to obtain a subsidy. At the time the HP was installed, the family did not perform other energy renovations on the house. The comfort of the family has improved in comparison to the previous system. They are satisfied that there is less hassle with the new system: “All that is needed is to adjust the thermostat. I am very satisfied, it’s more comfortable and even cheaper to heat with this system," said the owner. The family would recommend a HP to their neighbours.

Interview with family in south-west Slovakia

This family of two adults and one baby lives in the Dunajská Streda district, south-west of the country (elevation 115 m, continental climate). The building is a 130 m^2 detached house. In 2020, they switched from gas boiler heating to an air-to-water HP. The system provides heat to the entire house. They decided to change following the recommendation of a friend. Then they consulted a private company that handled the project and the paperwork to obtain a subsidy. At the time the HP was installed, the family did not perform other energy renovations on the house. They are very satisfied with the level of comfort, including the pleasant temperature kept in the summer. They are also satisfied with the running cost, but not satisfied with the yearly service cost. "The yearly revision of the gas boiler was around 50 € while the revision of the HP costs 200 €," said the owner. She mentions that this service is expensive to them and that it could be associated with the brand they have. Therefore, they are unsure about recommending it due to the cost aspect.

"The yearly revision of the gas boiler was around 50 € while the revision of the HP costs 200 €."

Overall data assessment

Overall, the survey results show lower satisfaction than the literature on the topic. It should be noted that 22% of respondents were "neutral" towards their overall satisfaction. Regarding running costs, 28% of respondents spent about the same as they did before the change. Moreover, 6% of participants believed it was worth it to pay more as they got more comfort than before. Regarding the lower level of comfort in comparison to the literature, we highlight that many participants (44%) declared to have the same level of comfort as they had with the previous heating system and none of the participants had less comfort after installing a HP.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	73% (satisfied users)	61% (users that spend less after installing a heat pump)	56% (users that have better heating after installing a heat pump)

Conclusion(s)

- Switching to a HP seems to improve or at least guarantee the same level of comfort obtained with other heating systems, most commonly gas boilers.
- Based on replies, switching to HPs may not result in lower heating bills in all cases. In some cases, the energy costs may be more or less the same. Nevertheless, some participants that paid more believed it was worth it as they also had better heating.

Slovenia

Survey

Biomass heating was the most common source of heating among participants (n=12) before the change to HPs. Air-to-water HP was the preferred choice to provide heating/hot water. All participants believed their heating comfort improved after the change, even though only a few of them performed some type of energy renovation on the building (insulation of walls, improvement of windows, etc.) when the HP was installed. Therefore, 91% declared they were happy with their heat pump (Figure 1) and nearly 83% now pay less yearly to heat their homes (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

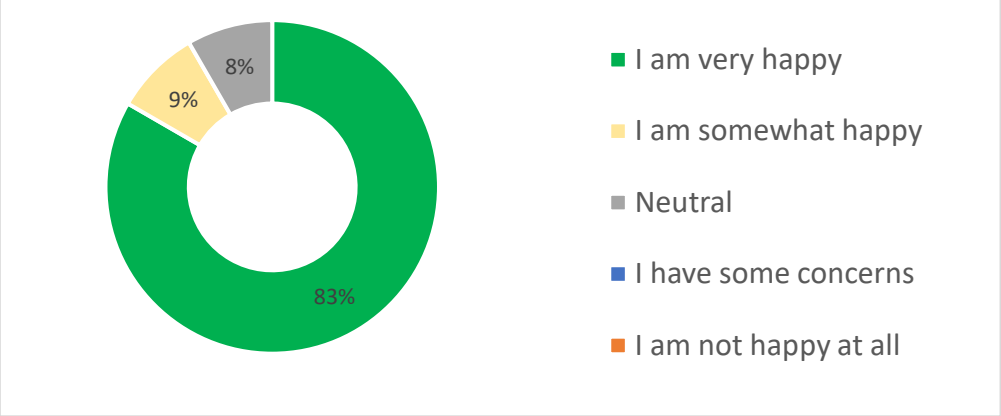


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

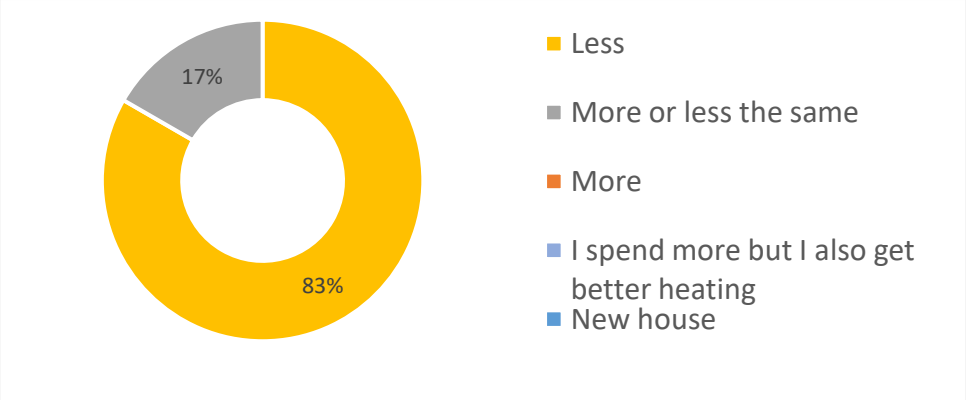
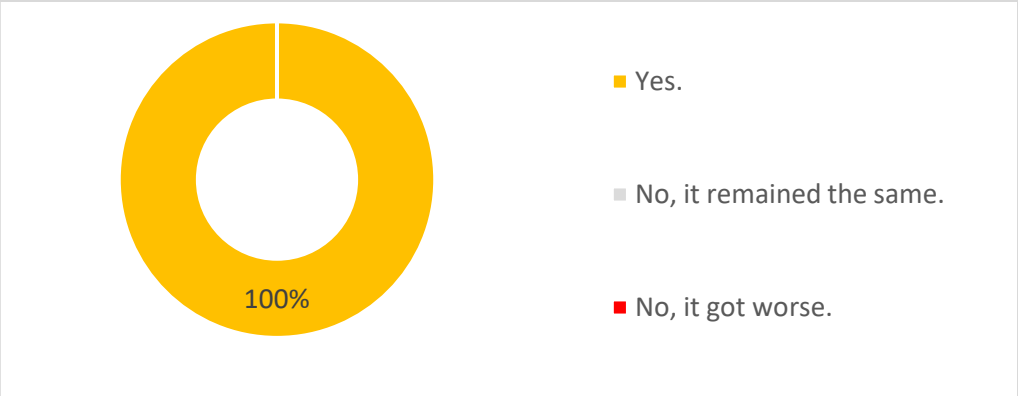


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with the Hvala family

Table 14 Photo by Lara Hvala.

This family of four adults and one child lives in Central Slovenia (mild climate). The building is a 150 m^2 detached house. They replaced their oil boiler heater with an air-to-water HP, which has now been providing heating and hot water for 14 years. Before the change, the family considered other alternatives, but they realised that the HP would be more cost-effective yearly. They obtained information, mainly from other users and manufacturers' websites. At the time the HP was installed, the family also improved the insulation of walls (thickness of 10 cm). They have more comfort with the change and are very satisfied with the system: “It is very economical, always providing heating when needed, there is no noise and no need for additional work to operate it," said one member of the family. Thanks to lower running and maintenance costs, the family would recommend heating with a HP to their neighbours.

Interview with the Kastelic family

Table 15 Photo by Alenka Kastelic.

This family of two adults and two young adults lives in Central Slovenia (mild climate). The building is a 400 m^2 detached house. They replaced their gas boiler with an air-to-water HP, which has now been providing heating, hot water and pool heating for five years. The construction of the pool was one of the reasons to look for alternatives to reduce energy costs.

They obtained information from the web and by visiting installers. At the time the HP was installed, the family did not improve other aspects of the building. They are satisfied with the comfort and with the energy bill: “We are satisfied with running costs compared with the gas heating. Costs are lower than previously," said the owner. Even though there is noise from the outdoor unit, this is not disturbing: “The outside box of the HP is usually loud

but doesn't bother us." The reason is the distance of the unit to the wall. However, they are not completely satisfied due to maintenance needs; the system has been breaking down about once a year. The owner believes that the brand was not the most suitable one for their house. Nevertheless, they would still recommend changing to HPs.

Overall data assessment

Overall, the survey results are compatible with the literature on the topic. Many participants consider their houses to be well insulated, which can contribute to the high level of satisfaction with comfort.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	92% (satisfied users)	83% (users that spend less after installing a heat pump)	100% (users that have better heating after installing a heat pump)

Conclusion(s)

- Switching to an air-to-water HP seems to improve comfort in comparison to the previous heating system, most commonly biomass and gas boilers.
- Based on replies, switching to heat pumps seems to result in lower heating bills in most cases, particularly if the change is from a biomass or gas boiler.

Spain

Survey

Electric heating was the most common source of heating among participants (n=12) before the change to a HP. Economy, improvement of comfort and environmental/climate issues were the most cited reasons for changing. Air-to-air HPs were the preferred choices. Half of the participants performed energy renovations on the building when the HP was installed (i.e. insulation of walls, replacement of windows). All participants believed their heating comfort improved after the change. All declared they were happy/very happy with their HP and many paid less for heating yearly.

Figure 1 Question: Overall, how satisfied are you with your heat pump?

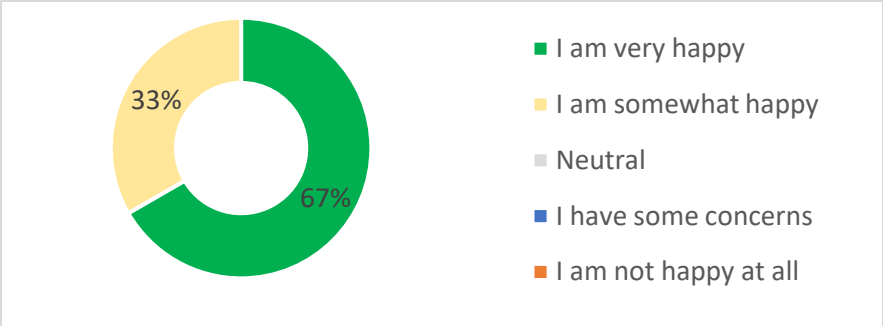


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

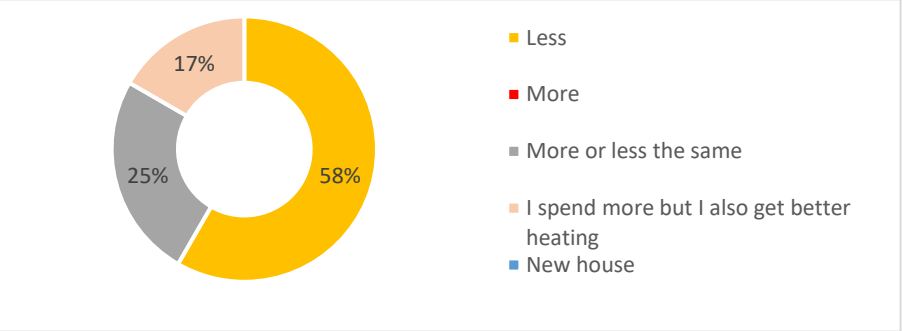
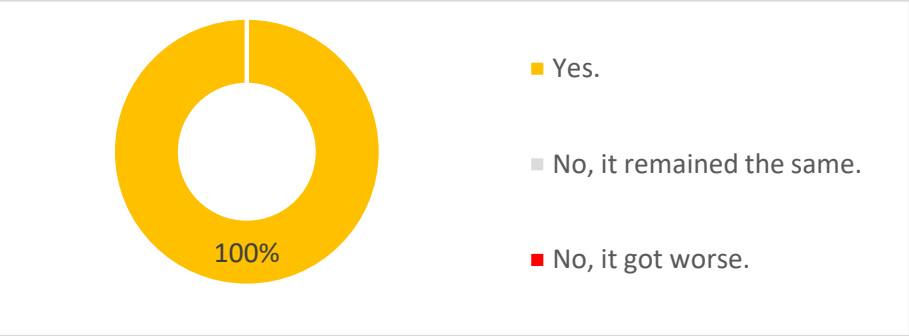


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with family in northern Spain

This family lives in a semi-detached house in the Gipuzkoa province, northern Spain (Basque Country). The region is characterised by mild weather. The semi-detached house has two occupied floors and a total heated area of 150 m^2. There was a gas water heater for domestic hot water (DHW) production and a wood stove for heating before the air-to-water HP was installed at the beginning of 2021. The change happened because the previous system did not cover the heat demand completely. The air-to-water HP covers 100% of the heat demand and DHW production. The interviewee is very satisfied with the level of comfort: “Now it is nice and warm in the house. The thermostat is constantly at 17 degrees,” she explains. Regarding the noise level, she explains that there is some: “The outdoor unit makes some noise, but it is an acceptable level. It does not disturb me when I watch TV, for example." No maintenance work has been needed so far. The electricity bill for December was 240 €, which the

interviewee considers high. But she also explains that this includes all the electricity consumption of the house and is the only utility bill. The house was renovated with wall insulation and insulating windows at the time the HP was installed. Overall, she is not completely satisfied with the running costs, but very satisfied with the comfort level.

Overall data assessment

Overall, the survey results are compatible with the literature on the topic. Regarding running costs, 20% spend about the same as they did before the change.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	100% (satisfied users)	58% (users that spend less after installing a heat pump)	100% (users that have better heating after installing a heat pump)

Conclusion(s)

- Switching to a HP seems to improve comfort in comparison to other heating systems, most commonly electric heating.
- Based on the replies, switching to a HP is likely to result in lower running costs in most cases. Some participants spent more but they believed it to be worth it as they had better heating.

Sweden

Survey

Electric heating was the most common source of heating among participants (n=13) before the change to a HP. Economy, improvement of comfort and environmental/climate reasons were the main reasons to adopt the technology. Ground-source HPs, followed by air-to-air HPs, were the preferred choice. Most participants only changed the heating/water heating when the HP was installed. Nevertheless, most participants believed their heating comfort improved after the change and the others believed it remained the same. All participants declared they were happy with their heat pump (Figure 1) and most of them paid less to heat their homes with a HP in comparison to their previous heating (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

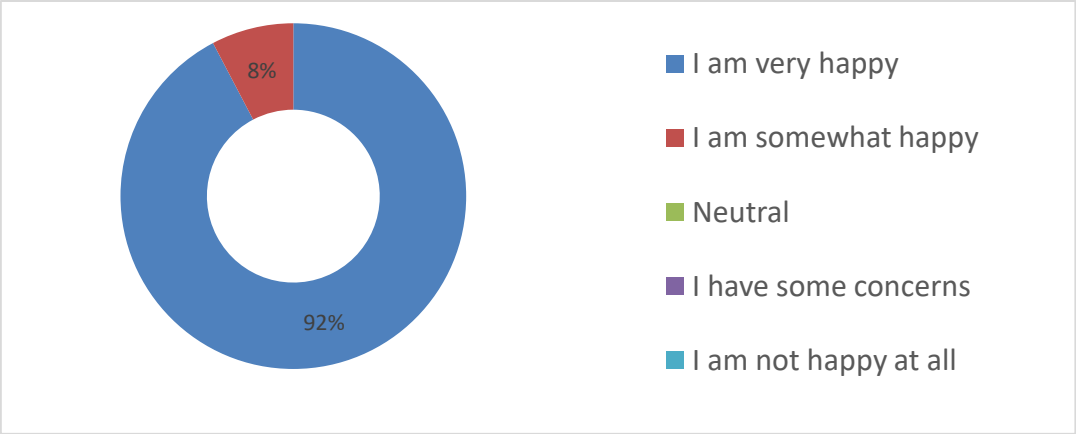


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

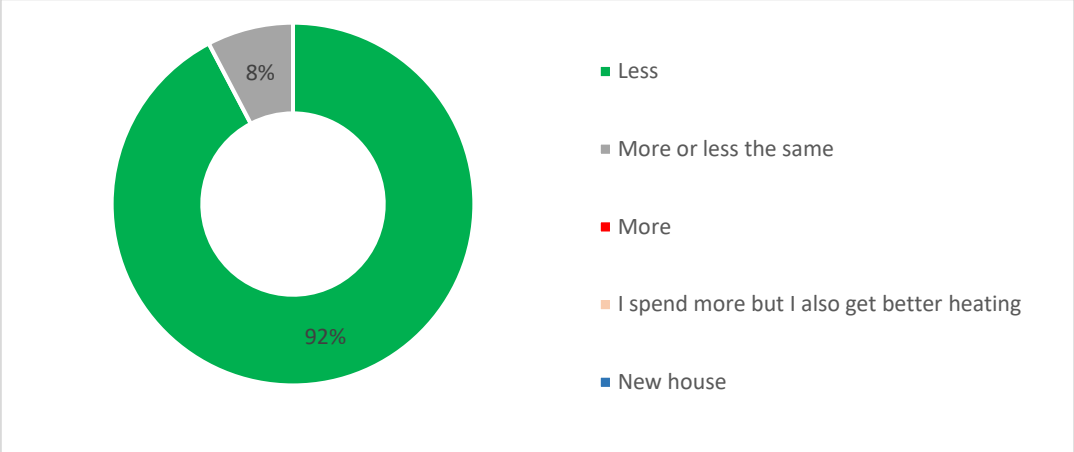
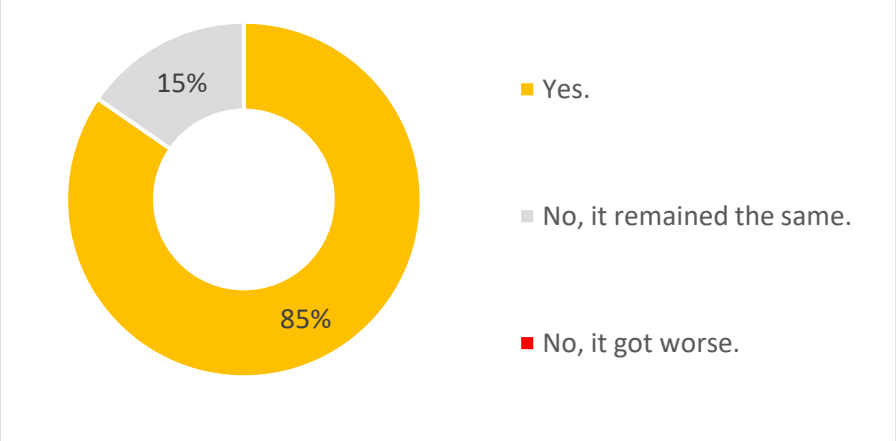


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with a family in Älvsjö

This family of two adults and two children lives in Älvsjö, near Stockholm (temperate climate, elevation 32 m). The house is a detached building with a heated area of 235 m^2 (158 m^2 of living space and a heated basement of approximately 77 m^2). Before changing to a ground-source HP, they used to heat the house using an oil boiler. The change happened because HP seemed a better choice to them in terms of economy and environmental impact. At the time, they did not consider solar thermal and neither a district heating network nor a gas network was available on their street. At the time of the install, they also installed radiant floor heating in the bathrooms and two additional radiators in the basement. No additional electrical work was needed and they did not receive subsidies to install the HP. The 11kW ground-source HP has been operating since 2004. In comparison to the previous system, the comfort in the house has improved. The owner is particularly satisfied that the HP is much quieter than the oil boiler. The owner mentions that the cost comparison is easy: "We used to purchase 4,500 litres of oil/year; once installed, the HP consumes on average about 15,000 kWh/year. The owner explains that the HP required very little maintenance in the first 10 years. Then they purchased an extended service package to avoid expensive repair or degradation of the equipment. The family is satisfied with the running costs and with the HP system in general. They have recommended the change to friends many times.

"We no longer need to schedule an oil truck to fill up the tank nor does it require yearly inspection, which is mandatory for homes heated with oil."

Interview with a family in Stockholm

This family lives in a building with 12 apartments/households in Stockholm (temperate climate), where the heating is based on a ground-source HP. The heated area is approximately 800 m^2 and the building is home to 35-40 people. Before the change to a ground-source HP, the heating was provided by an oil boiler. The condominium association saw a HP as the most modern choice. At the time it was not possible to connect to the district heating network and solar thermal was not considered. At the time of the install, they improved the ventilation system by adding extra vents. They did not receive any subsidies to make the change. The system is composed of five boreholes in the property and has been in operation since 2001. The owner describes that before the change the house was over-warmed; the radiators were set at 40 degrees and many residents had to have the windows open, which was not an efficient solution. "After the change, there was a transition period when some residents thought the house was too cold. The system setting needed to be adjusted, which happened, and people were used to the overly hot radiators....

It took a couple of years for residents to adjust to the new temperatures [...]. After the initial period, the indoor comfort levels have been fine

The family is satisfied with the indoor comfort and with the running costs, however, not so satisfied with the most recent maintenance needs. "The ground-source HP system worked well for the first 10-12 years. Then the first compressor broke down. In the past 5-7 years, there has been a lot more maintenance (every other year). The second compressor just broke down as well. So one issue is that the compressors have had a shorter life than promised (10 years as opposed to 15 years)." Overall, the

family is satisfied with the system. “One additional benefit of installing the heat pump has been to recover the space where the heating oil tank and unit used to be. This room was always dirty but now they have converted it to a bike room and carpentry area. So, this is useful space and a nice environment."

Overall data assessment

Overall, the survey results are compatible with the literature on the topic.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	100% (satisfied users)	92% (users that spend less after installing a heat pump)	85% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver the same, or even a better, level of comfort in comparison to electric heaters.
- Based on the replies, switching to a HP is likely to result in lower running costs.

United Kingdom

Survey

Gas boilers and oil boilers were the most common source of heating among participants (n=22) before the change to a HP. Concern with environmental/climate issues was the most cited reason for changing. Air-to-water HPs, followed by ground-source HPs, were the preferred choices. Most participants also performed energy renovations on the building when the HP was installed (i.e. insulation of walls, replacement of windows). Most participants believed their heating comfort improved after the change. The others stated that they had the same level of comfort as before the change. Most declared they were happy with their heat pump (Figure 1) and in many cases, the change resulted in savings yearly (Figure 2).

Figure 1 Question: Overall, how satisfied are you with your heat pump?

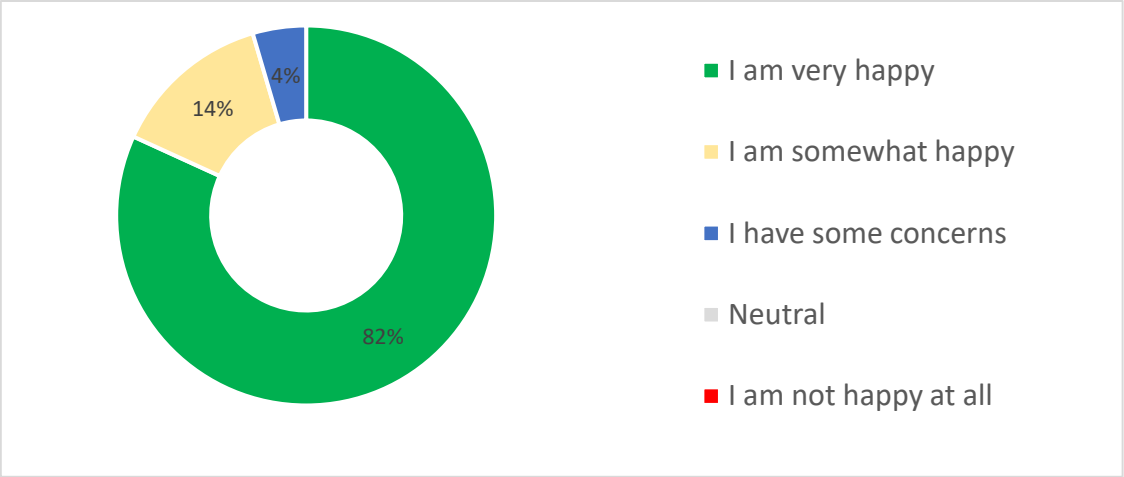


Figure 2 On a yearly basis, compared to your previous situation, you now spend...

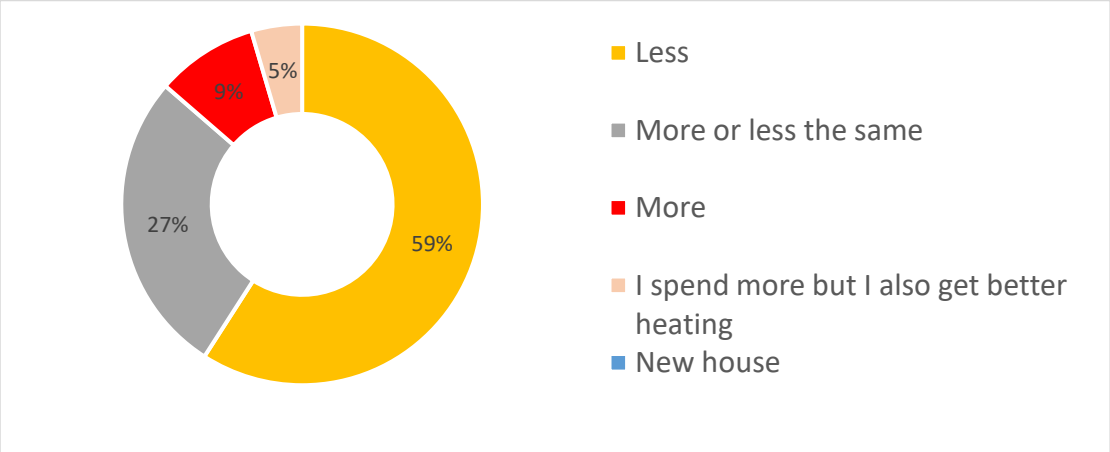
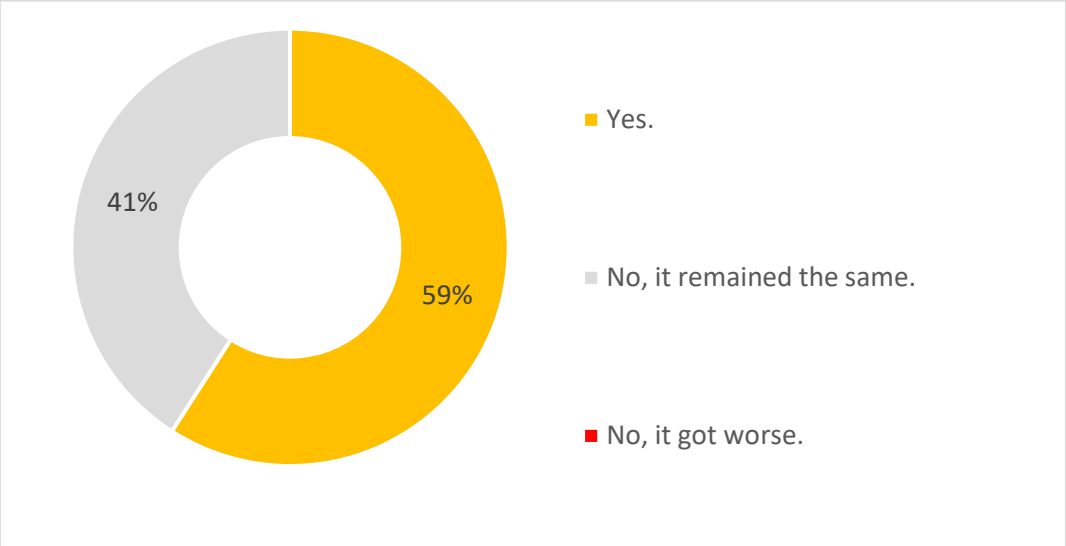


Figure 3 Question: Did your heating comfort improve after you installed a Heat Pump?



Interviews

Interview with the Gibson family – Wales

Table 16 Photo by Philippa Gibson.

The Gibson family lives in a village near Llandysul, (mild climate, elevation 140 m). Two adults live in the house, a semi-detached building. Before changing to an air-source HP, they used to heat the house using biomass and an electric storage heater. The family decided to change because they were not satisfied with the electric heater. After speaking with a friend who already had an air-source HP, they did some more research online and consulted a local installer who also explained the pros and cons of several alternatives. “District heating and gas were not available, we decided that electric was too expensive, biomass needed too much storage space and the heat pump seemed to be the most environmentally friendly,” said the owner. The HP has been in use since September 2011 and provides heat to the entire house (two reception rooms, hall up and down, kitchen, two bedrooms, study and bathroom). At the time of installation, they added insulation to a sidewall that was missing it. They also had 10 solar PV panels installed about three months before the HP. They already had three solar collectors for water heating. In comparison to the previous system, the owner evaluates that the comfort in the house has improved “More even comfortable temperature, programmed for when needed. Controls too complex apart from turning the temperature up and down, we don’t use any other controls except for the occasional radiator thermostat to turn it down in an unused room." Noise is not an issue to them: “Noise is fine; I hear the outside pump occasionally, but generally only in winter when in the garden. Inside noise, not an issue." In terms of running costs, the owner observed savings in comparison to the previous system: “Previously we were using an average of 20 units of electricity per day in winter with the electric storage heaters, and we are now using 15 units of electricity per day in winter with the heat pump." There was one problem, which caused it to break down twice in January to March 2019, but eventually fixed by fixing a wiring problem in the outside unit, which was causing the 3A fuse to blow." The family received the ‘Renewable Heat Premium’ for installing the HP and ongoing yearly compensation. Overall, the family is very satisfied with the system and would recommend it.

“Previously we were using an average of 20 units of electricity per day in winter with the electric storage heaters and we are now using 15 units of electricity per day in winter with the heat pump.”

Interview with the Chapman family - England

Table 17 Photo by Soo Chapman

The owner lives in a detached house in Bournemouth, south England (mild winter, elevation 42 m). The heated area of the house is 110 m^2. Before the change to an air-to-water HP, the heating was based on natural gas. The change was made because of environmental reasons to reduce CO_2 emissions compared to gas heating. She obtained information from an NGO, the Dorset Energy Advice Centre, and also from a heat pump advice leaflet from the local authority, Dorset County Council. The HP was installed in 2009 and supplies space heating only. Hot water is supplied by a separate solar water heating system. Solar PV panels were installed in 2018 and a Tesla battery was installed in 2019. At the time of change, large size radiators and additional insulation were fitted. No subsidies were received for installing the HP. In comparison to the previous system, the comfort in the house has not changed: "The comfort is the same as with the previous natural gas central heating, but the heat pump control system was more difficult to understand. There has been no problem with noise." It was not possible to compare the running costs with the gas heating system. Overall, the owner is satisfied with the system and would recommend it to others.

Overall data assessment

Survey results on overall satisfaction and running costs are compatible with the literature on the topic. Regarding the lower level of comfort in comparison to the literature, we highlight that many participants (41%) declared to have the same level of comfort as they had with the previous heating system and none of the participants had less comfort after installing a HP.

	User experience		
	Overall satisfaction with the heat pump	Running costs	Thermal comfort
Case studies, literature [11, 13, 15, 10, 17, 21, 22]	77-99% (satisfied users)	62-85% (satisfied users)	75-95% (satisfied users)
Survey	96% (satisfied users)	86% (users that spend less after installing a heat pump)	59% (users that have better heating after installing a heat pump)

Conclusion(s)

- HPs seem to deliver the same level of comfort in comparison to gas or oil boilers. However, many participants also improved other aspects of the building when the HP was installed, which can contribute to higher comfort. Therefore, we recommend improving the building insulation before switching to a HP.
- Based on the replies, switching to a HP is likely to result in lower or about the same running costs in most cases. Some participants spent more but they also believed they got better heating.

Annexes

Annex A1. Methodology

The surveys were done with an online questionnaire that was translated into 22 languages and that is available at the website: *https://www.inforse.org/europe/heatpump_survey.htm*. The heat pump users were filling out the online form themselves and the form is anonymous.

The replies were made in the period September–December 2021. Contacts for the heat pump users and interviews were made by INFORSE Secretariat and members, as well as national partners including Ecopower for Belgium, Norges Naturvernforbund for Norway, Dorset Energy Community for the UK, EPEN for Hungary, Zero for Portugal, Focus for Slovenia, Earth Association for Bulgaria, Arin Association for Romania, Tipperary Energy for Ireland, Kyoto Club for Italy, CETIAT for France, Ecodes for Spain, CNI Confederación Nacional de Instaladores for Spain, and MEEREA for Malta.

In addition to INFORSE contacts of mainly environmental NGOs and associations of renewable energy communities, we also reached out to the European Heat Pump Association, national heat pump associations, and university departments.

Among others, we asked contacts to promote the survey on national social media and for some countries, we tried advertisements on Facebook and Google.

The vast majority of responses were results of contacts to INFORSE members and contacts, including via INFORSE's contacts in renewable energy community networks (RESCOOP etc.).

The data was collected per country, and the averages were reported in the executive summary as averages of the results from all 22 countries, to avoid a country with more respondents having a higher weight in the averages.

The staff involved from INFORSE were Gunnar Boye Olesen, Henning Bo Madsen and Jose Campos. (EPEN Network, Hungary)

Annex A2: collection of information

The questions and the answer options for the online survey are shown in the table below (English language version):

1/17. Where do you live? (Choose a country)
[Choice of EU countries, Norway, UK]
2/17. I am answering this survey for
the building I am living in - a detached house
the building I am living in - a semi-detached house

the building I am living in - a flat
the building I am working in - an office building
3/17. What source of heating did you have before moving to a Heat Pump?
Gas boiler (methane and/or LPG)
Oil boiler
District Heating
Biomass (wood, wood pellets, or others)
Biomass and solar water heating
Biomass and coal
Other
4/17. Is your Heat Pump combined with another technology?
No, the heat pump is providing all of the heating/hot water
I also have solar heating (solar collectors for hot water/heating)
I also have solar panels for electricity (Photovoltaic)
I also have gas or oil boiler
I also use wood for heating
5/17. Is the building/flat supplied with cooling?

No
Yes, with separate air conditioning
Yes, the heat pump provides both heating and cooling
6/17. Is the building/flat supplied with forced ventilation?
No
Yes, with a separate ventilation system
Yes, the heat pump is integrated in the ventilation system
7/17. Is your home well insulated, compared to the other ones in your area, according to you?
Yes, very well insulated
Yes, well insulated
Average insulation
It's not very well insulated
8/17. What type of Heat Pump do you use?
Ground source heat pump (using pipes or borehole in the ground)
Air-to-water heat pump (air source heat pump)
Air-to-air heat pump (reversible heat pump / air conditioner)
Apartment with centralised heating based on heat pump

9/17. When did you install your heat pump?
In 2020-2021
Between 2017 and 2020
Between 2010 and 2017
Before 2010
10/17. When you installed the Heat Pump...
you did so during an energy renovation of your building (insulation of walls, improvement of windows, etc.)
you only changed your heating/water heating system
11/17. Overall, how satisfied are you with your Heat Pump?
I am very happy
I am somewhat happy
Neutral
I have some concerns
I am not happy at all
12/17. Did your heating comfort improve after you installed a Heat Pump?
Yes

No, it remained the same
No, it got worse
13/17. What room temperature do you keep during winter?
Above 25 °C
Between 22 and 25 °C
Between 18 and 22 °C
Below 18 °C
14/17. Is your electricity supply from renewable energy?
Yes, from my Photovoltaic panels + renewable electricity from the grid
I buy mixed electricity from the grid but I also use my Photovoltaic panels
Yes, I only use renewable electricity from the grid
No, I am purchasing the normal (mixed) electricity from the grid
I don't know
15/17. Compared to your previous situation, on a yearly basis to heat your home you now spend...
Less
More
more or less the same

I spend more, but I also got better heating
16/17. What was your main reason for choosing a heat pump?
Economy
To improve heating comfort
To have less hassle with heating system
For environment / climate reasons
17/17. Would you suggest to your neighbours to switch to Heat Pump?
Yes, surely
I am not sure
No, I would not
Leave a comment if you wish

The interviews were done by INFORSE members and contacts, and in some cases also by the INFORSE staff involved. The interviews were done in national languages and translated to English. The interviewees were only identified with family name and region/town to keep them anonymous. The above-mentioned organisations made the interviews for their respective countries.

The interviews were semi-structured with the following interview guide.

Proposed questions

1. **Facts about house and family:**

- Type of house (detached house, semi-detached house, flat):
- approximate size of heated area:
- size of family (number of adults and children):
- town and country:

2. **Picture** of the house or family, if possible. (permissions to use pictures were collected separately)

3. **Facts of change of heating**:

When was the change?

What type of heating did you have before?

What type of heat pump do you have now? What is the size? (for instance heating capacity in kW or share of the house that it can heat fully). If you have solar thermal, what is the size? (for instance number of solar collector panels/number of vacuum tubes)? Possibly also brand(s).

4. **How is the heat pump/solar compared with previous heating? (regarding comfort, providing heating when needed, work to operate it, noise, others).**

5. **How satisfied are you in general with the heat pump/solar heating?**

Are you satisfied with the running costs and maintenance of your heat pump (+ solar) compared with the previous heating?

6. **Indicate approximate costs of change**. Did you get a subsidy or tax credit or a soft loan?

7. **Do you get a special electricity tariff or tax rebate etc**. **with the heat pump?** Do you have a tariff/electric connection, where the power company can disconnect the heat pump for one or a few hours?

8. **The decision about change**: why did the family decide to change? From where did you get information about heat pumps/solar? Did you consider other alternatives? (electric heating, gas, biomass, district heating, etc.)

9. **Did you also make other energy renovation** of the house (insulation of walls, roof, improvement of windows etc.) and/or **invested in other renewable energy** (such as solar PV panels for electricity)? If yes, what was the other solution?

10. **Would you recommend a heat pump/solar to your neighbour**?