15TH IEA HEAT PUMP CONFERENCE
MAY 26–29, 2026 | HOFBURG VIENNA 2026
DECARBONISATION THROUGH INNOVATION

Analysis of the installation process of heat pumps and the craftsman´s needs in the renovation of existing single-family houses

Annette Uhl[a], Robert Meyer[a], Matthias Thiel[b], Kilian Schramm[c], Sebastian Herkel[a]

[a]Fraunhofer Institute for Solar Energy Systems ISE, 79110 Freiburg, Germany
[b]Zentralverband SHK in Berlin, 10787 Berlin, Germany
[c]Hans Schramm GmbH, 80337 München, Germany

Abstract

The paper focuses on the examination of the installation processes of heat pumps within the HVAC (Sanitary, Heating, Ventilation, Air Conditioning) trades in Germany. Conducted as part of the WESPE research project, this analysis aims to identify ways to optimize the installation of heat pumps in existing residential buildings. Utilizing both quantitative and qualitative methods, the researchers carried out a detailed assessment of 30 construction sites, capturing installation times through a time-tracking application onsite and structured interviews with experienced craftsmen.

Results indicate that installing a heat pump necessitates approximately three times the labor hours compared to gas boilers, emphasizing the need for efficiency improvements. Furthermore, the shares of work required for different tasks, such as writing quotes, equipment transport, deconstruction, piping, and electrical installation, were identified. It is shown that, on average, only 19 % of labor hours account for office work, while the rest pertains to onsite work and transport. Additionally, 25 % of the installation work is non-familiar to HVAC tradespeople, such as earthwork and electrical installation.

Moreover, the study highlights significant issues within the prevailing operational practices based on expert interviews and surveys, such as coordination challenges among different trades and inefficiencies stemming from manual data transfers between digital tools. The findings advocate for enhanced digital integration and better communication to alleviate these bottlenecks. Ultimately, this report provides vital insights through surveys conducted among workshop owners, which could lead to improved installation practices, reducing both costs and waiting times for consumers while bolstering the HVAC sector's capacity to meet rising demands associated with the transition to sustainable heating solutions. By focusing on elements such as standardized workflows, training, and innovative technologies, the competitiveness of traditional craft operations in a rapidly evolving market can be strengthened.

Selection and/or peer-review under the responsibility of the organizers of the 15th IEA Heat Pump Conference 2026.

Keywords: Heat pump installation; process analysis; time requirements; tools; HVAC trades; Germany

1. Introduction

Efficient and widespread adoption of heat pumps in existing buildings is a cornerstone of Europe’s pathway to climate‑neutral heating. Although heat pumps (HP) accounted for 74 % of new single-family home heating systems in Germany in 2024, their penetration in the overall building stock remains below 5 % [1]. One of the main barriers to faster uptake is the long and resource‑intensive installation process: replacing an oil or gas boiler with a heat pump in a residential retrofit in Germany takes, on average, three

times more installer hours than replacing it with a conventional gas boiler. This not only drives higher installation costs but also leads to a slower decarbonization of the building sector.

Several structural challenges compound this issue. HVAC companies in Germany are structured in such a way that most specialist companies install both heating and sanitary systems. A growing shortage of qualified installers and service technicians is putting pressure on the skilled trades sector. This shortage of skilled workers is exacerbated by the increasing demand for barrier-free sanitary facilities.

There are differences between various European countries in the structure of the skilled trades landscape and the challenges involved in heat pump installation. Specific differences exist both in terms of the duration of training and the qualifications required to perform certain activities. The technological, climatic, and regulatory conditions for HP installation also vary. For example, a study examined the current situation of heat pump installation in Germany and the UK and highlighted several key asprects (such as climatic conditions, the electric systems and VAT reductions) that increase both the installation costs and the complexity of the systems in Germany [2].

The German HVAC craft sector is highly fragmented, with an average of eight employees per company in 2022 and limited capacity to invest in process innovation or automation [3, 4]. Further challenges are specific to heat pump technology. Planners and installers must expand their expertise in electrical integration, control systems, and refrigeration technology - areas that differ significantly from previous combustion technologies - and take into account additional requirements such as foundations and other construction work. At the same time, market dynamics are changing with the emergence of full-service providers that use professional sales and marketing strategies and investor-backed financing models. This intensifies competition and changes project execution and value creation.

These developments underscore the need for optimization. In order to accelerate heat pump installation and explore potential for optimization, the first step is to conduct an in-depth analysis of the retrofit heat pump installation by tradespeople in Germany. By combining process mapping, time studies and stakeholder surveys, the WESPE research project aims to develop and validate targeted interventions - ranging from digital tools with seamless data‑exchange interfaces to pre‑assembled hydraulic modules and enhanced coordination protocols. Existing studies on these topics predominantly address the installation process of individual manufacturers or focus only on specific phases such as the consultation process [5, 6]. This research project fills a gap in the knowledge about an overview of the entire process.

2. Methods

To analyse the situation of the craft process, a mixed-methods approach was employed. This includes time-tracking of 30 retrofit installations, several online surveys of HVAC craft professionals, semi-structured expert interviews addressing media breaks and error sources, and development of a standardized process map. The results of this mixed-method approach were discussed several times in workshops and discussion rounds with craftsmen and industry representatives for validation and interpretation.

2.1. Field of application

The installation of heat pumps differs greatly in terms of costs and effort, depending on whether you consider air/water HP, groundwater heat pumps or geothermal heat pumps. To ensure the relevance of the investigations, the most frequently installed heat pump types in existing buildings were determined in advance. The data for this was determined by the German Central Association of HVAC craftsmen (ZVSHK) in an online survey with more than 2.000 answering persons. In order to represent the usual standard case, the following analysis focuses on the most common heat pump systems: air-to-water heat pumps as a mono-energetic system or a hybrid heating system with an additional gas boiler for both heating and domestic hot water. Heat pumps are considered both with a monobloc or split design.

2.2. Time-tracking study

A key component of the analysis of heat pump installation is the systematic recording of installation time. Between August 2024 and February 2025, eleven HVAC companies documented 30 complete installation projects of air-to-water heat pumps. The distribution of the systems is shown in Table 1.

Table 1. Heating systems in the time-tracking study

Air to water heat pump	**Number**
Monobloc	25
Heat pump split-unit	3
Hybrid system with gas condensing boiler	2

The companies are of varying size and from diverse regions across Germany, to represent the diversity of regional preferences on the study. To quantify the labor effort of heat-pump retrofits, time recordings were classified into on-site and office-based activities. All entries adhered to the REFA single-time-measurement principle, which defines each task by a precise start and end event [7]. The resulting dataset was cross-validated against existing literature, manufacturer-internal surveys and findings from prior research projects, confirming its plausibility for the current "as-is" effort of heat-pump retrofits in Germany [8].

Installers logged every work step on the construction site either in real time via a mobile app or retrospectively at the end of each day. A predefined taxonomy of thirty task categories covered installation tasks, travel time and auxiliary processes (e.g. customer and trade coordination, system dismantling, customer handover). No distinction was made between time records from qualified installers, assistants or trainees. For each task category, the average duration was calculated as the mean of all nonzero entries: The duration for externally contracted services such as electrical installations and earthworks was only taken into account if companies commissioned them. If homeowners contracted these services directly, there were no corresponding time entries. In these cases, the service was not included in the average value of a process step.

Office processes here refer to the upstream and downstream work steps. These include consulting services, inventory, planning, design, and quotation preparation for the heat pump, as well as billing. Office-based activities - including consultation, planning, quotation preparation, subsidy application processing and invoicing - were logged daily by planners or managers in a standardized spreadsheet. Time tracking for the 30 retrofit projects ceased upon completion of invoicing and archiving of all project documentation. Subsequent service tasks (maintenance and defect remediation) were omitted, as they are typically performed later under separate service contracts. Consequently, the resulting dataset captures person-hours for planning, on-site installation, commissioning and immediate project closure, but excludes all post-commissioning interventions.

2.3. Online surveys

In order to survey the habits and perspectives of the HVAC trade, several surveys with varying scope were conducted. Between August and October 2024, a web-based questionnaire received responses from 129 HVAC professionals. The survey investigated perceived time sinks, needs for digital and physical tools, and satisfaction with existing processes from the skilled trades´ point of view. Using multiple-choice and ranking items, it identified priorities for process acceleration and tool development. 73 % of the respondents are working in management roles, 27 % are planners, masters or fitters. Responses were anonymized and aggregated for frequency analysis.

In the quarterly economic survey conducted by the ZVSHK with over 2,000 participants in July 2024, questions were asked about the average total service life of heat pumps and boiler heating systems, typical system configurations, and satisfaction with the systems. Due to the large number of participants, these results can be considered representative.

2.4. Expert interviews

Eleven semi-structured interviews were conducted in Q1-Q2 2024 by project partner Hans Schramm GmbH, involving planners or managing directors of HVAC companies. These guided interviews addressed workflows, media breaks and tool usage in office processes. The evaluation was carried out by means of thematic clustering and structured transcription of the core content to extract both qualitative and quantitative results. The results are not representative of the HVAC sector, but they do provide a particularly good picture of the mood, as there is the possibility of direct inquiry here.

2.5. Limitations

The self-recorded times from the time-tracking inevitably introduce greater uncertainty than third-party measurements: short interruptions such as breaks, informal discussions or cigarette pauses are not separately flagged. For this reason, self-recorded times may under- or overestimate true durations. Manual entry of office tasks introduces potential recall bias. Although the sample of 30 projects and 11 interviews captures diverse practices, it does not fully represent the entire German HVAC sector. Triangulation across methods and external validation mitigate, but do not eliminate, these uncertainties.

We also see time deviations between the installation times queried in the surveys and the results of the time measurement. This is due, on the one hand, to the much larger database of the survey and, on the other hand, to the different methodology. The rough time estimate in the survey is likely to be significantly more uncertain than the process-accurate recording.

Since direct exchanges and responses to questionnaires and surveys were mostly conducted with the managing directors, their views are very well represented here. Greater involvement of the installers might change slightly some of the results.

3. Results

3.1. Time recording

A key component of the analysis of heat pump installation in existing single-family homes is the systematic recording of installation time. This allows the duration of the entire process to be mapped and the duration of various work steps to be compared with each other.

3.1.1. Comparison of heat pump and gas boiler

On average, installing a heat pump in an existing single‐family home requires about 110 installer‐hours versus 36 hours for a gas boiler - roughly three times longer. The data shown in Figure 1 is based on self-reported information from employees of HVAC companies and clearly shows the time difference between the installation of heat pumps and gas boilers. This difference is mainly driven by multiple factors:

- Precise planning and system sizing are essential to achieve correct dimensioning. Oversizing increases the cycle time of the system and accelerates component wear. In addition, it increases the investment cost of heat pumps to a greater extent than with gas boiler systems. Under dimensioned systems lead to higher use of electric rods and lower system efficiency.
- Additional trades work such as electrical installations, groundwork (e.g. foundations), and refrigerant-works need to be done in a heat pump installation. These works often involve external contractors and extra coordination.
- Work on the existing hydraulics is more complex when installing heat pumps than when installing gas boilers. To reduce cycle rates and separate the volume flows of the heat pump and heating circuit, a buffer tank is usually installed in heat pump systems. This component requires a more elaborate hydraulic design. In addition, heat emitters are retrofitted much more frequently to enable low-temperature operation installed.
- Subsidies are usually applied for when installing heat pumps. Preparation and submission of subsidy applications add administrative hours.
- When installing a heat pump, more optimizations are usually made to the existing system than when installing a gas boiler. This means that installing a heat pump not only involves more time-consuming installation and higher installation costs, but also a better-adjusted overall system, mainly on the hydraulics.

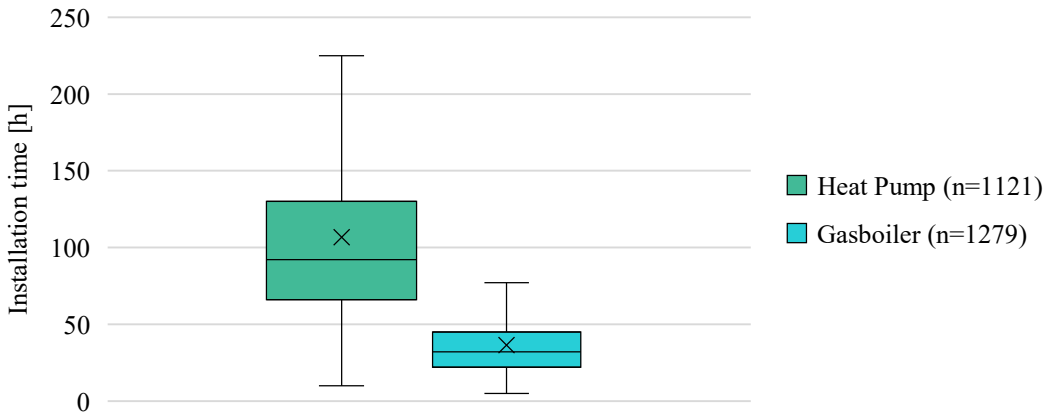

Figure 1. Installation hours for an average installation of HP in an existing single-family home. ZVSHK survey panel, July 2024. Data does not include lowest outliers.

3.1.2. Installation times

To get an initial overview of the distribution of hours involved in installing heat pumps in existing buildings, the typical phases from Figure 2 are shown below with the corresponding time requirements. At the 30 construction sites surveyed, installation, including travel time and consultations at the construction site, accounts for an average of 81 % of working time, while 19 % is spent on consulting, planning, preparing quotations, commissioning the system, and billing. In the figure, installation phase is divided into actual installation activities (I1) and construction site activities of an organizational nature, such as coordination, travel time, and tidying up (I2), in order to highlight the large proportion of supporting activities.

Optimizing site preparation can have a particularly positive effect on this area I2 and speed up installation through improved project organization, for example by avoiding unnecessary trips and making arrangements more efficiently. To speed up the overall process, it is essential to consider the installation phase.

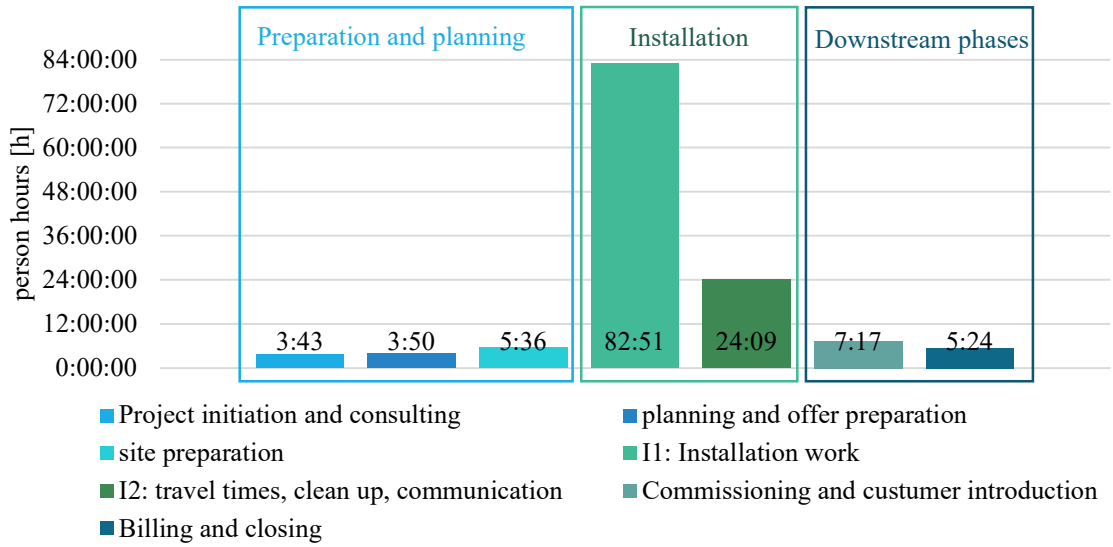

Figure 2. Installation time by phases (n=30). Average values from construction site and office surveys added together.

The installation times are particularly influenced by the existing buildings, heating systems, and accessibility of the construction site. Clustering the projects according to their system configuration did not reveal any significant differences in project duration. The box plot-graph in Figure 3 shows the relation between installation times and office hours, and the large time span between the fastest and slowest construction projects recorded. The mean value determined here of approximately 114 person-hours exceeds the result from the panel survey (Figure 1) by about 5 %. This is probably due to the fact that self-assessments tend to assume that a process takes less time than measurements do.

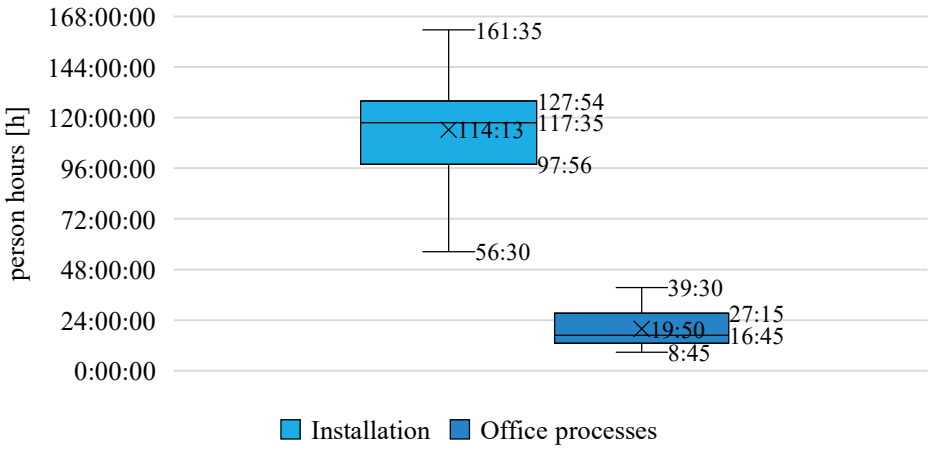

Figure 3. Installation and office hours. Average, median and outliers. Results of time-tracking study. (n=30)

3.1.3. On-site time tracking

Figure 4 shows the most time-consuming installation steps on the construction site. By far the longest task is the piping of the heating system, followed by the travel time to and from the construction site, the installation and assembly of the main components such as storage tanks or expansion vessels, and the piping of drinking water and hot water pipes. Taken together, an average of almost 25 man-hours per construction project are spent on piping work, which accounts for over 20 % of the total duration. Accelerating piping work is a promising lever for making the installation of heat pumps more time-efficient.

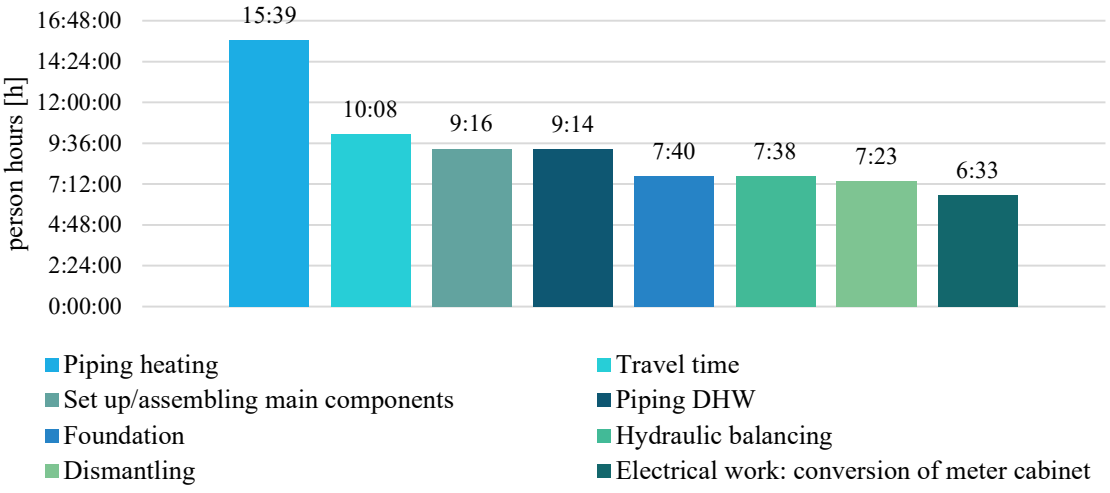

Figure 4. Installation: Average of longest process steps. Results of time-tracking study. (n=30)

3.1.4. Time recording office processes

Internal communication during the construction phase represent the most time-consuming part of the office processes, followed by on-site consultation of clients, construction scheduling and site coordination, and plant planning, see figure 5. Compared to the installation processes, these tasks take relatively little time. However, since not every initial contact with customers and every order creation leads to an offer, these early work phases account for a relatively larger share of a company's total hours than the present analysis of the entire installation process would suggest.

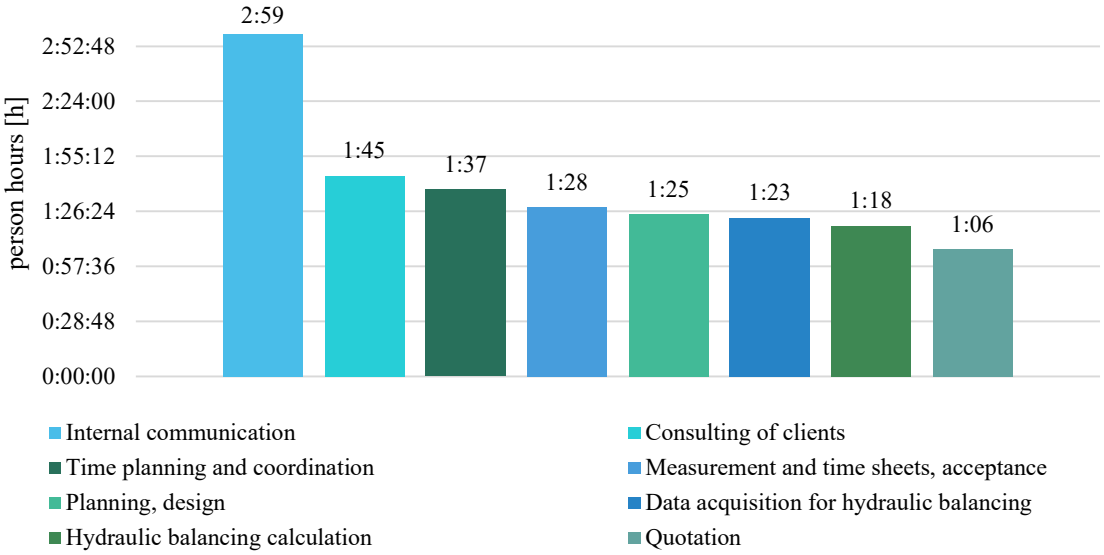

Figure 5. Office processes: Average of longest process steps. Results of time-tracking study. (n=30)

These times tracked mirror real-world conditions, but they do not represent the fastest theoretically achievable times, since installers prioritise technical quality and flawless system performance over sheer speed, in this context. The recorded times reflect a balancing act between efficiency and craftsmanship, where the avoidance of errors and the assurance of long-term reliability outweigh the incentive to minimise minutes on the clock.

3.2. Interfaces and media breaks

Interfaces with external trades emerge as critical bottlenecks in heat-pump retrofit projects. The process analysis revealed that 26 % of working time spent installing heat pumps is devoted to tasks outside the specialist area, such as electrical installations and groundworks. Electrical and foundation work in particular is often carried out by external companies. This interface between trades can lead to unclear handovers and responsibilities, as well as uncoordinated schedules or additional effort in coordination of those. The survey results in figure 6 further highlight that interfaces with external trades and customer communications are perceived as significant sources of time loss.

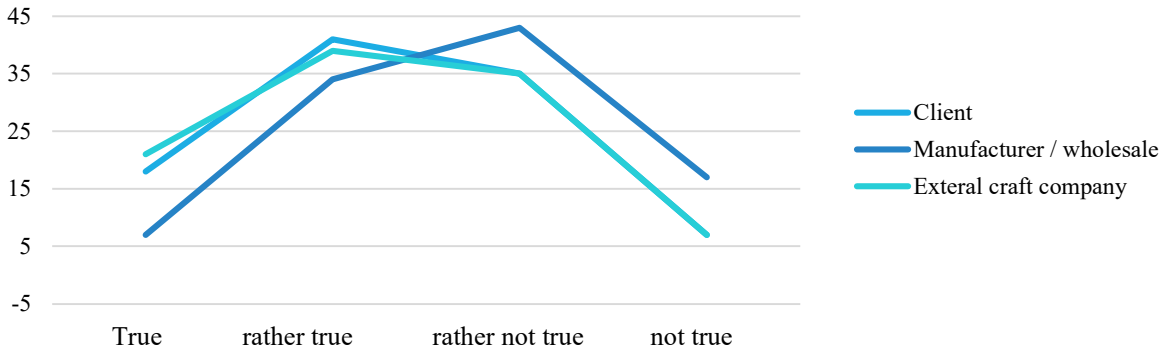

Figure 6. “Contact with […] provokes time losses” Multiple selections possible. Online survey with HVAC professionals. (n=102)

Within the office environment, process continuity is disrupted by “media breaks”, which occur wherever data or specifications must be reentered manually between planning, quoting or ERP tools, or when translating digital plans into on-site instructions. Together, these findings point to the urgent need for interoperable digital data standards and rigorously defined handover protocols to bridge both inter-organizational and intra-organizational divides.

3.3. Error sources in installation and office processes

Errors in the planning, preparation, or installation of heat pumps increase the cost of a installation project and the time required, as they can lead to corrective work and operational errors. When considering optimization options, it is therefore important to analyse the sources of error.

An expert survey with 12 HVAC planners and managing directors identified the most frequent error categories as shown in figure 7. Due to the small number of respondents, the survey is not representative, but it nevertheless provides a clear picture of the areas in which errors occur most frequently. Issues relating to electrical systems and control systems, as well as plant hydraulics, stand out in particular. Typical interface issues such as the interface between hydraulics and electrical engineering or coordination with energy suppliers are also frequently cited as sources of error.

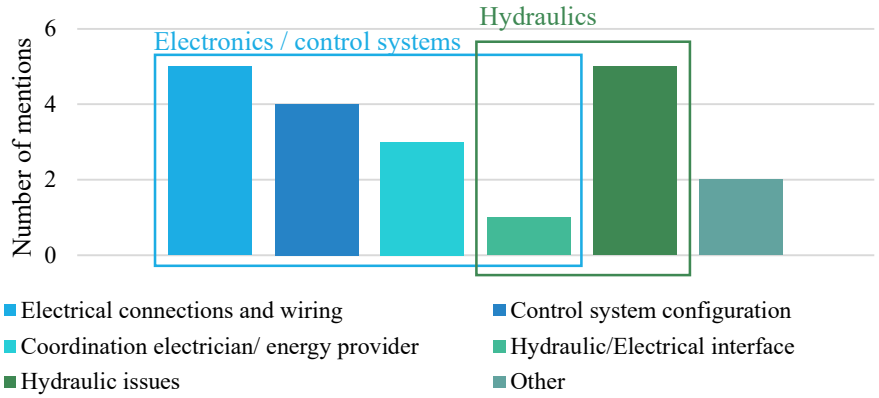

Figure 7. “Which installation tasks are most prone to errors?” Survey of skilled tradespeople, multiple answers possible. (n=12)

Office-phase errors are more heterogeneous and affect all pre- and post-installation tasks as shown in figure 8. The sources of error are spread across various work phases and do not show any particular accumulation. They appear equally in the phases of quotation preparation, planning, and construction preparation. Errors in the preparation of quotations were mentioned most frequently. Under the heading “Quotation” the estimation of the working hours required for a project was specifically mentioned.

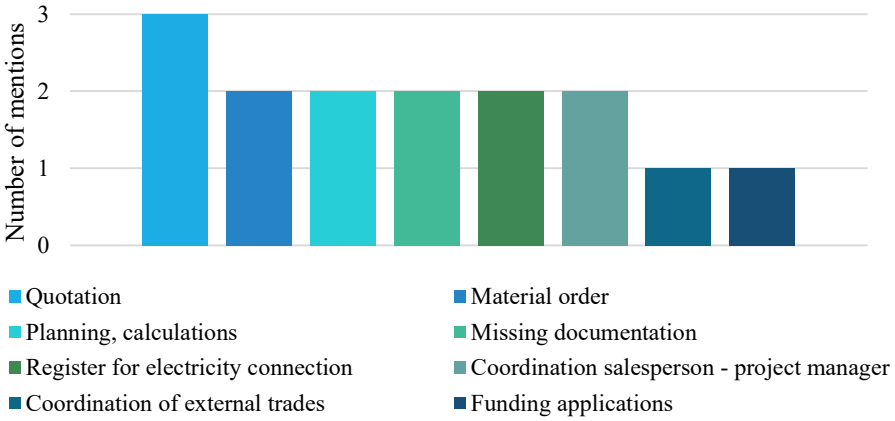

Figure 8. »Which tasks in the office are most prone to errors?« Survey of skilled tradespeople, multiple answers possible. (n=12)

3.4. The perspective of the craft companies

3.4.1. Perception of the situation by the trade

A survey of employees at HVAC companies asked about their needs in terms of optimizing heat pump installation. Figure 9 shows the phases in which there is a desire for a reduction in time. There is a noticeable discrepancy between the measured time expenditures (see chapter 3.1) and the survey results. The two most frequently mentioned phases, “planning and quotation” (3:50 hours) and “project initiation and consultation” (3:43 hours), are among the phases with relatively low workloads when viewed as a whole. Fewer respondents are looking to speed up the installation phase, which based on the measured duration of one installation project, takes many times longer than the phases mentioned above.

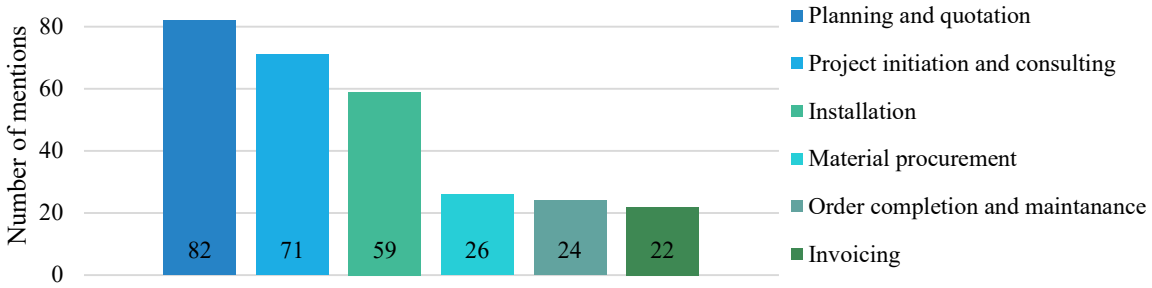

Figure 9. “I would like the following work phases in heat pump installation to take up less working time in the future: […]” Online survey with HVAC professionals. Multiple selections possible. (n=129)

Similar results emerge from the question: "The following process steps run largely optimal”, see figure 10. Some of the process steps that take the longest on the construction site, such as piping (approx. 25 hours) and installation of the main components (over 9 man-hours), are rated positively, in contrast to the upstream planning and consulting tasks. Craft businesses are particularly dissatisfied with the processing of subsidy applications.

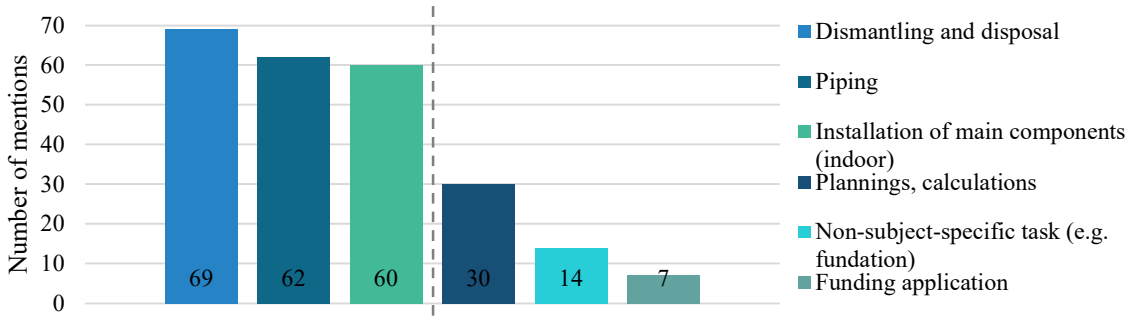

Figure 10. “The following process steps run largely optimal: […]” 3 most frequent and least frequent mentions. Online survey with HVAC professionals. Multiple selections possible (n=104)

It is important to highlight the methodological differences between this survey and the time recording on construction sites: The survey was mainly completed by managing directors, planners, and foremen whose main tasks lie precisely in these particularly critically evaluated processes in the office. These individuals probably intuitively focus more on office processes and are familiar with the sources of problems there in detail, which leads to a more critical assessment. The statement that this work takes too long should be seen as an indicator of general dissatisfaction with these process steps, in which duration is one of several factors that could be optimized. Errors in the planning phase also often have a greater impact on the installation, thus multiplying in the further course of the project. In addition, acquisition and planning tasks are also performed for construction projects that are not commissioned and do not lead to implementation. These so-called “dead leads” are performed more frequently than an installation, but often come to nothing, which increases the perceived need for improvement of these process steps. A short survey of six companies revealed that, on average, around two-thirds of quotes result in a heat pump order and one-third do not. Depending on the company, the range is between 10 and 50% of dead leads.

Furthermore, it is noticeable that work steps that correspond to the HVAC specialist's own area of expertise tend to receive more positive ratings than those that have changed significantly or been added as a result of the introduction of heat pump technology for HVAC companies For example, although the total cost of laying pipes for a heat pump is higher than for a gas boiler, the individual work steps involved in laying a pipe are identical.

3.4.2. Need for tools

There are numerous digital and physical tools on the market to support planning, administration and installation tasks. In most craft businesses, the use of various tools is a natural part of the work process. However, the products on offer do not always meet the needs of the craft sector. The need for tools and the required features of the tools were the subject of an online survey. The main criticism is that some software tools are too complicated to use and lack adequate technical support. Physical tools are also considered difficult to use, in addition to often being too expensive to purchase. The purchase price and running costs of tools are considered important, but not the most decisive purchase criteria for tools.

The desired characteristics of aids were surveyed, see figure 11. The most important criterion for software tools is ease of learning. The desire for greater legal certainty at work is also frequently mentioned. Other highly rated features include the reduction of workload for highly qualified employees and ease of use for all employees. According to the results of the same survey, physical tools on the construction site should primarily speed up installation, minimize the amount of physical effort required and help prevent errors. Fewer people consider ease of learning to use the tool to be as important as in office processes. Beyond the options available in the survey, there is also a demand for tools that are as manufacturer-neutral as possible and have functioning data interfaces to other programs.

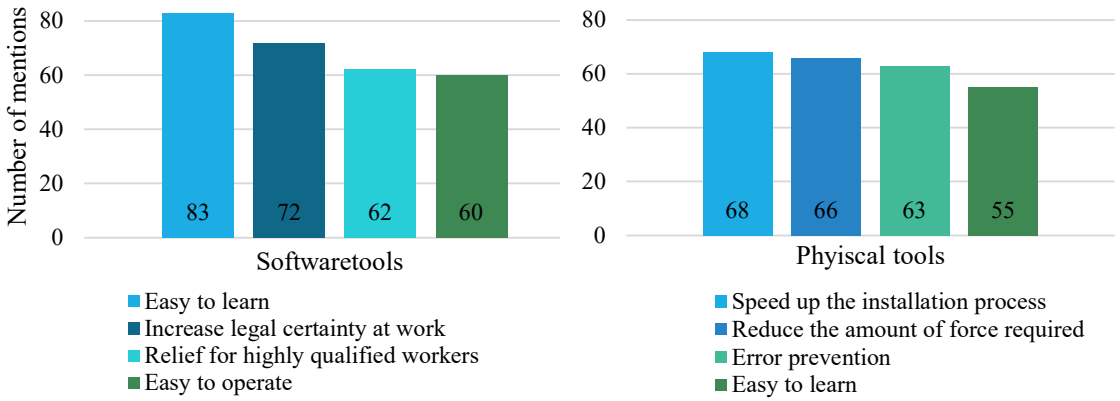

Figure 11. “I expect a softwaretool / physical tool to […]”. Most frequently given answers in online survey with HVAC professionals. Multiple selections possible. (n=96)

4. Conclusion

The installation of heat pumps in existing buildings is governed by a variety of interdependent factors. A thorough baseline analysis of the current state is therefore essential for targeted optimization.

Some critical challenges within the overall installation workflow have been identified:

- Significant time losses arise from particularly labor-intensive tasks, monopolizing skilled personnel and driving up on-site costs. On the construction site itself, pipework emerges as the most time-consuming single activity, absorbing over 20 % of the total installer hours.
- Although individual aids exist for specific questions, the workflow remains highly fragmented, relying on a disparate set of tools that seldom interoperate, thereby increasing the risk of data loss at media boundaries.
- Coordination processes - especially between trades such as electrical and heating - amplify both logistical complexity and the potential for misunderstandings.
- Incorrectly performed work steps frequently necessitate corrective rework which can leading to further delays, financial penalties, or suboptimal system performance. Typical sources of error lie in

both office processes and installation processes. This includes, in particular, planning and quotation preparation as well as electrical work and parameterisation of the control system.

Common optimisation strategies include process standardisation, prefabrication of components, outsourcing of non-core tasks to specialized service providers, and the deployment of physical or digital tools alongside stable, team-based collaboration protocols. Early-phase improvements can lead to a disproportionately positive effect on the entire project by preventing error cascades, and focused upskilling of personnel further enhances overall efficiency. Even though there is a wide range of solutions available on the market, only a few address the critical interfaces that fragment the planning and installation phase. Therefore, there is still a need for research into the development of a consistent, manufacturer-neutral workflow tool that, among other things, bridges the transition from the office to the place of use.

Moreover, commercially available solutions often overlook the specific constraints of small craft enterprises or prove economically unviable. Beyond technical functionality, true adoption requires intuitive user interfaces, rapid onboarding, responsive support, and a strong alignment with on-site practice.

The high frequency of technical innovations - especially in the area of operational control - as well as changing regulatory conditions require installers to be open to lifelong professional development and companies to adapt their processes to changing market dynamics. Sticking to familiar procedures slows down the introduction of new working methods in some areas. In terms of that, companies can benefit from a culture of continuous learning and organizational flexibility.

Acknowledgements

Acknowledgements are adressed to the funding institution BMWE, funding number 03EN1080C; to the project partners Zentralverband Sanitär Heizung Klima (ZVSHK), Fraunhofer IBP, Innung SHK Berlin, Hans Schramm GmbH; to the industrial advisory board and to the craftsmanship expert group of the project WESPE.

Literatur

[1] Statistisches Bundesamt, Mehr als zwei Drittel der im Jahr 2024 errichteten Wohngebäude heizen mit Wärmepumpen: Pressemitteilung Nr. N031 (Zugriff am: 8. Oktober 2025).
[2] A. Vering, "Analysis of Heat Pump Prices in Germany and UK", RWTH Aachen University, Institute for Energy Efficient Buildings and Indoor Climate; Octopus Energy, 2025.
[3] Statistisches Bundesamt, Handwerkszählung: Handwerksunternehmen, Tätige Personen, Umsatz: Deutschland, Jahre, Handwerksarten, Gewerbegruppen und Gewerbezweige. Code: 53111-0002.
[4] P. Thomas, "Branchenanalyse SHK-Handwerk: Aktuelle Herausforderungen und Chancen" Working Paper Forschungsförderung, No. 010, 2016.
[5] A. Kloep, Zwischen Tradition und Disruption - Chancen und Notwendigkeiten der Digitalisierung.
[6] E. Rechsteiner et al., "Das Handwerk als Gestalter der Wärmewende(c.HANGE)" Endbericht, 2019.
[7] R. F. REFA Fachverband e.V., REFA-Grundausbildung 4.0 - Begriffe und Formeln. München: Carl Hanser Verlag GmbH & Co. KG, 2021.
[8] R. Meyer, WP Quali FR: Einbindung von Wärmepumpen in den Gebäudebestand mit besonderem Fokus auf die Fachhandwerker und -innen. Forschungsvorhaben.