PUMP-UP

Open Educational Resources

Learning Unit 2

Site assessment

Upskilling HVAC technicians on heat pump technologies for green energy transition

2023-1-ES01-KA220-VET-000164956

Co-funded by the European Union

Project details

Project acronym:	PUMP-UP
Project name:	Upskilling HVAC technicians on heat pump technologies for green energy transition
Project code:	2023-1-ES01-KA220-VET-000164956

Document Information

Document ID name:	PUMP-UP_Lecture Notes_Module2_2025-07-11
Document title:	Module 2
Output Type:	OER
Date of Delivery:	11/07/2025
Activity type:	Project implementation
Activity leader:	CELF
Dissemination level:	Public

Document History

Versions	***Date***	***Changes***	***Type of change***	***Delivered by***
Version 1.0	01/02/2025	Initial document		UPV
Version 2.0	20/03/2025	Revised version		UPV
Version 3.0	01/07/2025	Revised version		UPV

Disclaimer

PUMP-UP

1 Contents

1 INTRODUCTION

1.1 Lesson 1. Client expectations management

Effective management of client expectations is crucial for successful heat pump installations. Installers should prioritize clear communication from the initial consultation through to post-installation follow-up. This involves educating clients about heat pump operation, addressing common misconceptions, and setting realistic expectations regarding system performance and energy savings. A comprehensive site survey and detailed proposal help tailor solutions to specific needs and prevent misunderstandings. Installers should explain the differences between heat pumps and conventional heating systems, emphasizing the long-term benefits while being transparent about potential challenges. Providing a "key facts" document can help inform customers without overwhelming them with technical details. Throughout the process, it's essential to actively listen to client concerns, offer expert guidance, and maintain open lines of communication. By positioning themselves as trusted advisors and managing expectations effectively, installers can enhance customer satisfaction, reduce complaints, and foster long-term relationships.

1.2 Lesson 2. Site examination & preparatory work

Site examination and preparatory work are crucial steps in the heat pump installation process, ensuring optimal system performance and efficiency. A thorough site assessment is conducted by an experienced energy advisor or HVAC professional to determine the best location for the heat pump, considering factors such as proximity to doors and windows, existing insulation levels, and available space for outdoor and indoor units. The outdoor area is cleared of debris and vegetation, with a gravel base prepared and a composite pad installed, elevated about 25 centimetres above ground level to protect from snow and ice. Indoor preparation involves determining the best location for indoor units and hot water cylinders, clearing access paths, and moving furniture away from installation areas. A comprehensive evaluation of the existing HVAC setup, including ductwork condition, is performed, along with a room-by-room heat loss survey to calculate energy needs. Additionally, necessary permits and approvals are obtained, and compliance with local noise regulations and planning permissions is ensured. This meticulous preparation phase sets the foundation for a smooth installation process and optimal heat pump system performance.

1.3 Lesson 3. Site-specific heat loss, radiator energy output and hot water requirements calculations

The accurate determination of site-specific heat loss, radiator energy output, and domestic hot water requirements is crucial for the optimal design and implementation of heat pump systems. These calculations involve thermodynamic principles and require a nuanced understanding of building physics and HVAC engineering.

Heat loss calculations necessitate an elemental approach, considering the thermal transmittance (U-value) of various building components, including walls, roofs, windows, and floors. Radiator energy output calculations require consideration of the logarithmic mean temperature difference (LMTD) between the radiator and the room. Domestic hot water requirements must be assessed based on occupancy patterns, usage profiles, and peak demand periods. These calculations inform the sizing of the heat pump and storage systems to ensure adequate hot water provision without compromising overall system efficiency.

These intricate calculations underscore the necessity for a comprehensive, multifaceted approach to heat pump system design, ensuring optimal performance and energy efficiency in diverse residential and commercial applications.

2 LECTURE NOTES

2.1 Lesson 1. Client expectations management

The effective management of customer expectations in heat pump system implementation necessitates a comprehensive approach that encompasses various aspects of the customer journey, from initial consultation to post-installation support. This multifaceted strategy is essential for ensuring customer satisfaction and promoting broader adoption of this emerging heating technology.

Clear, non-technical communication serves as the cornerstone of this approach. Installers must elucidate heat pump system operation using accessible language, eschewing industry jargon that may confuse or intimidate customers. This is particularly crucial when delineating the differences between heat pumps and traditional heating systems, especially for those transitioning from fossil fuel-based heating. Customers require a fundamental understanding of heat pump principles, including the concept of heat transfer rather than heat generation, and its impact on energy efficiency.

Comprehensive consultations are imperative to address concerns and demonstrate expertise. These initial meetings should be thorough, allowing sufficient time for customer inquiries and detailed explanations from installers. This presents an opportunity to establish trust and position the installer as a knowledgeable partner in the customer's heating solution. During these consultations, it is essential to discuss the specific requirements of the property, potential challenges, and the long-term benefits of heat pump systems.

Transparent proposals are crucial for establishing realistic expectations. These should encompass detailed estimates, clear timelines, and potential challenges that may arise during installation. It is imperative to be forthright about factors that could affect system performance or installation timelines, such as the necessity for additional insulation or electrical system upgrades. This transparency aids in preventing misunderstandings and fosters trust with the customer.

Education and guidance on proper system operation and maintenance are vital components of customer expectations management. Many homeowners are unfamiliar with heat pump technology; therefore, providing clear instructions on effective system use and maintenance is crucial. This may include guidance on optimal temperature settings, the utilization of programmable thermostats, and regular maintenance tasks. Offering this information empowers customers to maximize the benefits of their new system and can prevent issues arising from improper use.

A personalized approach, tailoring recommendations and services to meet individual customer needs and preferences, enhances overall satisfaction. This may involve considering factors such as the customer's lifestyle, budget constraints, and specific comfort requirements when designing the system. It is important to recognize the uniqueness of each installation and adapt the approach accordingly.

Post-installation support is a critical element in managing customer expectations. This includes providing ongoing assistance and conducting follow-up surveys to gather feedback and address any issues promptly. Regular check-ins, particularly during the first heating season, can help identify and resolve any problems expeditiously, enhancing customer confidence in both the system and the installer.

For installations where heat pumps coexist with existing heating systems, managing partial conversions requires clear explanation of operation strategies. This may involve implementing integrated controls and educating customers on how to optimize the use of both systems. It is important to set clear expectations about when and how each system should be used to maximize efficiency and comfort.

Setting accurate performance expectations involves informing customers about factors affecting system efficiency, such as climate conditions and proper usage. This includes explaining how extreme temperatures might impact system performance and providing guidance on how to adjust usage patterns accordingly. It is also important to discuss the potential for energy savings and how these might vary throughout the year.

By implementing these strategies, installers can significantly enhance customer satisfaction, minimize complaints, and foster positive experiences with heat pump systems. This approach not only benefits individual customers but also contributes to the wider adoption and acceptance of heat pump technology. As more customers have positive experiences, word-of-mouth recommendations can help overcome scepticism and promote the benefits of this efficient heating solution.

Moreover, effective customer expectations management can lead to long-term relationships between installers and customers. Satisfied customers are more likely to return for maintenance services, upgrades, or additional installations, and to recommend the installer to friends and family. This can result in a loyal customer base and a strong reputation in the industry.

Some of the best practices in customer management involve:

2.1.1 Customer Inquiry & Consultation

Building trust with potential customers is a crucial first step in the heat pump installation process, beginning with the initial inquiry. Skilled installers should promptly schedule a comprehensive consultation to discuss potential solutions and address any customer concerns. This meeting serves as a prime opportunity for installers to demonstrate their industry expertise, offering expert guidance that reassures customers about their decision to invest in a heat pump system. During this consultation, it's essential for installers to practice active listening, gaining a deep understanding of the customer's specific needs and property details. By providing tailored advice based on this information, installers can position themselves not just as service providers, but as trusted advisors in the realm of renewable energy. Effective communication during this initial phase sets a positive tone for the entire installation process, building customer confidence and laying the groundwork for a successful project. Moreover, this consultation allows installers to eloquently showcase the broader benefits of renewable energy, potentially inspiring customers to view their investment as part of a larger sustainability initiative. Ultimately, a well-executed initial consultation transforms the installer-customer relationship from a simple transaction into a valuable partnership, setting the stage for a smooth installation process and long-term customer satisfaction.

2.1.2 Conducting a Site Survey

The site survey is a pivotal phase in the heat pump installation process, serving as a comprehensive evaluation of the property's suitability for the system. During this critical assessment, installers meticulously inspect the location, available space, and existing infrastructure to ensure compatibility and identify potential challenges. This thorough examination encompasses various crucial factors, including property size, insulation quality, and the current heating system configuration. By carefully considering these elements, installers can accurately determine the most appropriate heat pump solution and anticipate its effectiveness within the specific context of the property. Moreover, a well-executed site survey enables the identification of any necessary modifications or preparatory work, thereby preventing unforeseen delays and complications during the installation phase. This proactive and detailed approach not only facilitates the selection of an optimal heat pump system but also lays the groundwork for a smooth, efficient installation process. Ultimately, the site survey's thoroughness directly contributes to the long-term success and performance of the heat pump system, ensuring customer satisfaction and maximizing energy efficiency.

2.1.3 Building a Comprehensive Proposal

Following the completion of a thorough site survey, the next critical step in the heat pump installation process is the development of a comprehensive and detailed proposal for the customer. This document serves as a crucial communication tool, outlining various heat pump options, associated costs, and projected installation timelines. A well-crafted proposal goes beyond mere technical specifications; it should effectively highlight the potential energy savings, environmental benefits, and long-term cost advantages of each option. By presenting a clear, structured plan, installers can proactively address potential customer concerns while showcasing the unique benefits of different systems. This level of detail and transparency not only aids customers in making informed decisions but also sets realistic expectations for the entire installation process. Moreover, a meticulously prepared proposal demonstrates the installer's professionalism and expertise, fostering customer confidence and trust. Ultimately, this comprehensive approach to proposal development lays the groundwork for a positive customer relationship, ensuring clarity and alignment of expectations throughout the installation journey and beyond.

2.1.4 Selecting the Right Heat Pump

Selecting the appropriate heat pump is a critical decision that significantly impacts the overall success of the installation and long-term customer satisfaction. Skilled installers should leverage the comprehensive data gathered during the site survey to recommend options that align perfectly with the customer's specific needs and circumstances. This recommendation process should carefully balance multiple factors, including potential energy savings, cost-benefit analysis, and individual customer preferences. When presenting options, it's crucial to emphasize the value proposition of each system, highlighting key aspects such as energy efficiency, long-term durability, and projected savings on energy bills. This approach not only educates the customer but also underscores the long-term benefits of investing in a heat pump system. By meticulously aligning the system choice with the customer's unique requirements, installers demonstrate their expertise and commitment to quality service. This thorough and personalized selection process not only ensures optimal system performance but also enhances customer satisfaction, potentially leading to positive referrals and repeat business.

2.1.5 Applying for Funding/Incentives

Reducing customer costs through available incentive programs is a crucial aspect of heat pump installation services that extends beyond technical expertise. Knowledgeable installers should proactively guide customers through the often-complex application processes for various rebates and incentives, such as the Boiler Upgrade Scheme (BUS). This assistance significantly enhances the overall value proposition of the service. By helping customers access these government-backed funds designed to support renewable energy adoption, installers can make heat pump installations more financially accessible and attractive to a broader range of clients. This proactive approach not only boosts customer satisfaction but also plays a vital role in promoting wider adoption of sustainable technologies. Furthermore, by positioning themselves as informed partners in the transition to renewable energy, installers demonstrate added value, potentially differentiating their services in a competitive market. Ultimately, this comprehensive approach to customer support, combining technical expertise with financial guidance, can lead to increased customer satisfaction, improved project feasibility, and contribute to broader sustainability goals.

2.1.6 Collaborating with DNO and MCS

Regulatory compliance is a critical and non-negotiable aspect of heat pump installation, requiring installers to navigate a complex landscape of standards and certifications. This process involves crucial coordination with the Distribution Network Operator (DNO) to verify grid compatibility and secure necessary permits, as well as submitting applications for the Microgeneration Certification Scheme (MCS) package to certify the installation's quality and efficiency. Early engagement with these entities is essential to prevent delays and ensure full compliance with legal and professional standards. By meticulously adhering to these regulations, installers not only protect their professional reputation but also guarantee customer satisfaction and safety. This rigorous approach to compliance ensures that the heat pump operates efficiently and safely within the existing infrastructure, ultimately contributing to the long-term success and reliability of the installation. The commitment to regulatory standards demonstrates an installer's dedication to quality, safety, and professional integrity, fostering trust with customers and regulatory bodies alike.

2.1.7 Preparing the Installation Site

Successful heat pump installation begins with comprehensive site preparation, a critical phase that extends beyond mere physical readiness. Installers must meticulously clear the installation area, ensuring all necessary tools and materials are readily available to minimize potential disruptions and streamline the entire process. This preparation encompasses more than logistical arrangements, involving critical administrative tasks such as confirming all required permits and communicating a detailed installation schedule to the customer. By prioritizing thorough preparation, professionals can proactively prevent unnecessary delays, maintain a structured and professional work environment, and set a positive tone for the entire installation project. This methodical approach not only demonstrates technical competence but also builds customer confidence by showcasing a systematic and organized workflow. Ultimately, careful preparation serves as the foundation for a smooth, efficient, and successful heat pump installation, reflecting the installer's commitment to quality and customer satisfaction.

2.1.8 The Installation Process

During the heat pump installation process, meticulous adherence to guidelines is paramount for ensuring optimal performance and longevity of the system. This critical stage demands a high level of technical expertise and unwavering attention to detail, as errors can lead to significant costs and complications, especially in ground-source heat pump installations where rectifying issues may require extensive re-excavation. Installers must approach the task systematically, methodically verifying that each component is correctly fitted and functioning as intended. By rigorously following best practices, installers not only maximize the system's efficiency but also demonstrate their commitment to quality workmanship. This level of diligence serves a dual purpose: it optimizes the heat pump's performance and cultivates customer trust in the installer's capabilities. Ultimately, a precise and carefully executed installation lays the foundation for long-term customer satisfaction and system reliability.

2.1.9 Testing the System

Upon completion of a heat pump installation, conducting comprehensive testing is a critical step that serves multiple important purposes. This process not only verifies the system's functionality and efficiency but also allows installers to fine-tune settings for optimal performance. Thorough testing provides an opportunity to document results, creating a valuable baseline for future reference and maintenance. This documentation serves as a tangible reassurance to customers, demonstrating the installer's commitment to quality and attention to detail. Moreover, it acts as a crucial resource for ongoing system management and troubleshooting. By adopting a meticulous approach to testing, installers can swiftly identify and address any potential issues, thereby ensuring immediate customer satisfaction and laying the groundwork for long-term system reliability. This proactive stance not only enhances the customer's experience but also reinforces the installer's reputation for professionalism and expertise.

2.1.10 Post-Installation Follow-Up

Maintaining customer satisfaction extends far beyond the initial heat pump installation. Successful installers recognize that post-installation support is crucial in building long-term customer relationships and generating future business opportunities. By proactively addressing customer queries, offering comprehensive maintenance tips, and providing expert ongoing advice, professionals can transform a simple transaction into a trusted partnership. Follow-up interactions serve as strategic moments to reinforce the heat pump's benefits, demonstrate technical expertise, and validate the customer's investment decision. These interactions not only enhance system performance and customer understanding but also create opportunities for referrals and repeat business. The key to sustainable success lies in treating each installation as the beginning of a relationship, not the end of a transaction. By consistently delivering exceptional support, installers can differentiate themselves in a competitive market, build a reputation for reliability, and create a network of satisfied customers who become enthusiastic advocates for their services.

2.2 Lesson 2. Site examination & preparatory work

Prior to commencing an air source heat pump installation, a comprehensive site assessment and preparation process is essential. Installers should conduct a thorough evaluation of the property's existing heating system, insulation levels, and overall energy efficiency. This assessment includes calculating the building's heat loss to ensure proper sizing of the heat pump unit. The electrical system must be inspected to determine if upgrades are necessary to support the new heat pump. Exterior spaces should be evaluated to identify an optimal location for the outdoor unit, considering factors such as noise, aesthetics, and proximity to windows or neighbouring properties. Indoor spaces must be assessed for the placement of the indoor unit and any necessary ductwork modifications. Installers should also review local building codes and obtain any required permits. Additionally, they should discuss with the homeowner any potential disruptions during installation and establish a clear timeline for the project. This meticulous preparation ensures a smooth installation process and optimal performance of the air source heat pump system.

2.2.1 Heat pump location

All heat pumps will make a noise and create a cold air discharge. It is important to discuss this potential nuisance factor with the end user when considering the final position of the heat pump. Taking the proximity of neighbouring properties into account as well as the heat pump position when opening doors and windows on the customer's own property. Where possible, choose a position which is protected from the wind and where the unit will not obstruct access to doors or paths. The orientation of the heat pump should also be considered – to ensure maximum efficiency, ideally a heat pump should be positioned on a warmer side of the property, preferably on a South facing side.

2.2.2 Suitable installation base

An air source heat pump must also be installed on a firm, flat, level surface. The surface on which a heat pump is fitted must be able to support the weight of the heat pump unit and minimise the transmission of noise and vibration. If a suitable surface is not already in place, installers will need to prepare a suitable base for the heat pump prior to installation by either laying a flat trowelled concrete base 150mm thick or by positioning paving slabs on compacted hard core of sufficient depth.

2.2.3 Clearances around the heat pump

Suitable clearances must also be in place around the heat pump – for Grant heat pumps, the recommended clearances are detailed in the Installation and Servicing Manual. These clearances are important because they allow for the adequate air flow in and out of the heat pump while also making the heat pump easy to access for commissioning, servicing and maintenance.

2.2.4 Assessing the electrical system

When planning a heat pump installation, an assessment of the existing electrical system at the property should be undertaken to confirm its suitability. Furthermore, with every heat pump installation on a premises, there is a requirement to inform the relevant Distribution Network Operator (DNO) – this can either be done via a DNO application (Apply to Connect) or a DNO notification (Connect and Notify). With Grant's Aerona^3 6kW, 10kW and 13kW heat pump models and the Grant Aerona 290 models, they are DNO 'Connect and Notify' approved. With heat pump units which are not DNO approved, an application must be made to the DNO before connecting the heat pump to the mains electrical supply.

2.2.5 Choosing the right size air source heat pump

Specifying the correct size of heat pump is essential to ensure that the heating and hot water system perform correctly and efficiently. Please visit one of our other blogs to read more about specifying and sizing a heat pump system.

2.2.6 Installation best practices

We have collated a few of the top tips for good heat pump installation practices here but for more in-depth training, please enrol onto one of Grant UK's in-person or online heat pump training courses.

2.2.7 Start with good design

We have mentioned it before but every heat pump installation should start with the planning, design and specification of the heating system. It is essential that the full layout of the system is understood before the installation of any components is undertaken. A heat pump installation involves a lot of technical considerations so taking the time to correctly design the system beforehand will make the installation easier and help ensure your customers are left with a correctly installed and efficient heating system.

2.2.8 Location and positioning

Make sure the heat pump is securely fixed on top of suitable anti-vibration mounts as well as ensuring that all of the recommended clearances are achieved around the unit. It is also important to position the heat pump controller in line with the guidance given in the installation and servicing instructions. Also ensure that all safety requirements have been complied with.

2.2.9 Water circuit pipework and appliances

This is a large part of an installation and should involve checking or completing all of the following. The water connections should be made tight and secure. A suitable in-line filter should be correctly installed. The pressure gauge should be correctly installed on the sealed system pipework or expansion vessel manifold. Connection pipes should be suitably supported. The expansion vessel should be suitably sized to accommodate the system volume. A volumiser tank should be installed unless there is a buffer, thermal store or combined buffer/cylinder is connected to the heat pump system.

The complete heating system should be thoroughly flushed out, this is especially important when a heat pump is being installed on an existing system. After flushing a suitable thermal fluid should be used to fill the system. Any Legionella protection installed on the system should be set up based on a risk assessment of the customer's vulnerability. All system pipework should be suitably insulated, and a flow regulator should be fitted on the return pipe to the heat pump to ensure that the required flow rate is achieved and maintained through the heat pump at all times.

2.2.10 Electrical connections

All electrical work must be undertaken by a competent person and installed as outlined in the installation and servicing manual. A dedicated power supply with a correctly sized breaker must be used, with the final power supply being made from a weatherproof lockable isolator located outside of the building.

2.2.11 Check the refrigerant

Grant Aerona[3] R32 and Aerona 290 air source heat pumps are all air-to-water and a monobloc design where the refrigerant is pre-charged into the unit during the manufacturing process. Any work that is required on the refrigerant circuit, must only be carried out by a competent person that holds the relevant F-gas qualification.

2.2.12 Ensure clear drainage

Heat pumps can produce several gallons of condensation every day depending on the level of humidity and usage. On the underside of the Aerona[3] R32 heat pump, there is one condensate outlet and at the base of the Aerona 290 heat pump units, there are multiple condensate holes - these allow any condensate to drain from the heat pump and it is the installing or service engineer's responsibility to ensure that provision is made to safely collect and dispose of this condensate. It is essential that this condensate is not allowed to run onto paths or driveways as this will turn to ice during the winter.

2.2.13 Follow manufacturer instructions

As previously mentioned, during any installation work, the manufacturer's Installation and Servicing instructions should be adhered to. The latest installation manuals for Grant's products can be downloaded from our online Customer Support Centre or via the TechBox app.

2.3 Lesson 3. Site-specific heat loss, radiator energy output and hot water requirements calculations.

2.3.1 Heat Loss Calculations

For the purposes of final design and system selection, heat loss calculations should be conducted utilizing an elemental approach. This methodology involves the discrete calculation of heat transfer through various building components, including walls, roof structures, fenestration, floor assemblies, and ventilation/infiltration pathways, followed by a comprehensive aggregation of these individual losses14.

The total heat loss (Q) for a building can be expressed as the sum of fabric heat loss and ventilation heat loss:

$$Q = \sum (A * U * \Delta T) + (V * n * c * \Delta T)$$

Where:

A = area of each building element (m^2)

U = U-value of each element (W/m^2K)

ΔT = temperature difference between interior and exterior (K)

V = volume of the space (m^3)

n = air change rate (h^{-1})

c = volumetric heat capacity of air (J/m^3K)

This approach allows for a more nuanced and accurate assessment of a building's thermal performance, enabling the precise sizing of heating systems, particularly for low-carbon technologies such as heat pumps.

To facilitate this process, the Microgeneration Certification Scheme (MCS) provides a publicly accessible heat loss calculator on their official website, offering a standardized tool for practitioners in the field.

2.3.2 Heat Emitter Types

2.3.2.1 Radiators (Natural Convectors)

Radiators, or natural convectors, represent the predominant heat emitter type in residential heating systems, owing to their cost-effectiveness, widespread industry acceptance, and user familiarity. These emitters exhibit diverse configurations, including single panel, single panel with convector, and double panel with single convector variants, each characterized by distinct thermal performance profiles.

In the context of low-temperature heating systems, such as those employing heat pumps, these emitters typically operate at water temperatures below the standard design conditions associated with combustion-based systems. Consequently, appropriate sizing adjustments are necessary to ensure optimal heat distribution.

The concept of 'oversize factor' has emerged as a methodological approach to address the requisite dimensional increase of heat emitters operating at sub-optimal temperatures. This factor enables contractors to utilize conventional published data for emitter selection, obviating the need for individual correction factor applications. The oversize factor is defined as the multiplicative coefficient applied to the room heat loss (measured in watts) to determine the required emitter output at a mean water-to-air temperature difference of 50°C.

2.3.2.2 Fan (Forced Draught) Convector/Coil

A fan convector comprises of a series of heat transfer fins with a fan placed over one end to increase the flow of air hence convective effect heat transfer.

These heat emitters are extremely useful in providing relatively high heat outputs for their size (volume), and they are very useful where wall space may be limited.

These devices will need a small electrical power connection in order to operate the fan etc.

2.3.2.3 Underfloor Heating (UFH)

Underfloor heating is a series of pipework loops that are embedded into the floor.

As floors generally represent a much larger surface area to emit heat than other systems, they can often deliver sufficient heat into the room while operating at relatively low temperatures which makes them a natural complement to heat pump systems if that heating flow temperature can be replicated throughout the whole building.

It is important to ensure that all rooms have their own independent temperature control capability.

Other benefits of UFH systems can be identified as:

- more even heat distribution as UFH relies less on heat transfer by convection

- improved comfort as floors are not cold and UFH heats people and objects from the floor up

UFH systems are also beneficial when heating spaces with high ceilings

It is widely accepted that UFH can reduce energy costs in high heat loss rooms as spaces with UFH tend to be heated to lower air temperatures for the same perception

of warmth compared to other heat emitters, and that this reduces heat loss and hence may reduce energy requirements. It also reduces the effect of stratification of air and hence the need for higher temperatures at heights above the occupied space.

UFH should be designed to operate at the lowest possible temperature to achieve the desired demand output. Mixing manifold circuits are often employed however the efficiency of the heat pump will be determined by the flow temperature of the heat pump prior to any mixing hence the rest of the heating system needs to be designed for low temperature operation.

2.3.3 Hot Water Requirements

The current heat pump community lacks a definitive consensus on the optimal sizing methodology for heat pumps in domestic hot water production. The efficacy of sizing is largely contingent upon the control strategy implemented. Contemporary heat pump systems often employ automated mode-switching mechanisms, alternating between space heating and domestic hot water production, typically on a half-hourly basis when concurrent demands are detected.

Alternative systems prioritize hot water demand until either the requirement is met or a predetermined time threshold is exceeded. In scenarios where the system fails to adequately heat either the space heating circuit or hot water storage, internal or external direct electric resistance immersion heaters may be activated. This supplementary heating, however, can significantly diminish overall system efficiency and should be minimized to the extent practicable.

A salient trend in modern construction is the increasing prevalence of highly insulated buildings, which necessitates a paradigm shift in heat pump sizing methodologies. It is no longer sufficient to size the heat pump solely based on space heating requirements. In well-insulated structures, particularly those adhering to Passivhaus standards, the domestic hot water load assumes greater significance, potentially becoming the primary or sole load consideration.

To ensure accurate load determination for domestic hot water production, contractors are advised to consult and familiarize themselves with the most recent iteration of BS EN 16147. Furthermore, it is imperative to engage in detailed discussions with clients regarding their typical consumption patterns and to provide clear guidance on the designed reheat time.

It is crucial to note that domestic hot water cylinders must be equipped with heat exchangers that are compatible with the temperatures and outputs generated by the selected heat pump system. This compatibility is essential for optimal system performance and efficiency.

3 QUESTIONS & ANSWERS

3.1 What is a heat pump site assessment?

A heat pump site assessment is a comprehensive evaluation of your property to determine its suitability for a heat pump system. It typically involves a surveyor capturing information about your home's heating system, construction, and heat retention capabilities.

3.2 How long does a site assessment take?

The assessment usually takes 1-3 hours, depending on the size of the home.

3.3 What factors are considered during a site assessment?

Key factors evaluated during a site assessment include:

- Home construction and heat retention.
- Insulation, ventilation, and windows.
- Space for the heat pump unit and any noise, planning permission, or technical considerations.
- Site access difficulties.
- Electrical supply issues.
- Radiator condition.

3.4 Who conducts the site assessment?

The assessment is typically carried out by a qualified surveyor or energy advisor.

3.5 What does the assessment process involve?

The process usually includes:

- A room-by-room heat loss survey.
- Identification of suitable locations for the outdoor unit and hot water cylinder.
- Evaluation of potential issues like electrical supply problems or site access difficulties.

3.6 Do I need an Energy Performance Certificate (EPC) for a heat pump installation?

While not always required, an EPC can be helpful in determining your home's energy efficiency. Some grant programs may require an EPC.

3.7 Do I need planning permission for a heat pump?

Most heat pumps can be installed under "*permitted development*," which doesn't require planning permission. However, certain scenarios may necessitate planning permission, such as proximity to property boundaries or location in conservation areas.

3.8 What information will I receive after the assessment?

The assessment report typically recommends the most suitable heat pump type and size for your home, estimates installation costs and necessary upgrades, and provides advice on next steps.

3.9 What factors are considered in a heat loss calculation?

Key factors include:

- Building dimensions and layout.
- U-values of walls, windows, doors, roof, and floor.
- Indoor and outdoor design temperatures.
- Air changes per hour.
- Thermal bridging.

3.10 What is the standard temperature difference for rating radiators?

The standard temperature difference (ΔT) used to rate radiators is 50°C.

3.11 Do I need to install underfloor heating to have a heat pump?

No, not necessarily. Heat pumps can work on underfloor heating systems but can also work with radiators and convectors of all sizes.

3.12 Are heat pumps noisy?

Indoor units of heat pumps produce sound levels between 18 and 30 decibels, comparable to a gentle whisper. Outdoor units typically generate around 60 decibels of noise, which is equivalent to the sound of moderate rainfall or a normal conversation. These low noise levels make heat pumps an unobtrusive heating and cooling solution for residential and commercial environments, addressing potential concerns about acoustic disruption.

3.13 Do heat pumps require regular maintenance?

Heat pump maintenance, similar to other household appliances, requires routine servicing with frequency dependent on the specific type and location of the system. To ensure optimal performance and longevity, it is recommended to consult the heat pump manufacturer or seller for tailored maintenance guidance and to seek assistance from qualified technicians or professional installers who can provide expert advice and conduct comprehensive system checks.

3.14 Will my energy bill increase if I install a heat pump?

According to the International Energy Agency (IEA), households that switch from a gas boiler to a heat pump save significantly on their energy bills, with average annual savings ranging from USD 300 in the United States to nearly USD 900 (€830) in Europe*.

This is because heat pumps are highly energy efficient.

To make heat pumps even more cost efficient for consumers, EHPA calls for governments to ensure the electricity price is no more than twice the price of gas.

Electric home heating paired with improved energy efficiency and smart system interaction for demand-responsive heating, could "*reduce the annual consumer fuel cost, saving consumers up to 15% of the total fuel cost in single-family homes, and up to 10% in multi-occupancy buildings by 2040",* according to the study published by the European Consumer Organisation (BEUC).

**Based on 2022 gas prices.*

3.15 Will a heat pump help to reduce my home's carbon footprint?

Heat pumps play a crucial role in reducing greenhouse gas emissions and enhancing energy efficiency. As of 2020, fossil fuels satisfied over 60% of global heat demand in buildings, contributing to 10% of global CO_2 emissions. In Europe, the impact of heat pump installations is significant, with units installed by the end of 2023 achieving greenhouse gas emission reductions equivalent to removing 7.5 million cars from the roads. This underscores the substantial environmental benefits of widespread heat pump adoption in combating climate change and improving overall energy sustainability.

Heat pumps, powered by clean and renewable energy sources, are poised to significantly reduce global CO_2 emissions by at least 500 million tonnes by 2030, according to the International Energy Agency. This transition away from fossil fuel heaters not only contributes to improved air quality and climate change mitigation but also addresses concerns over gas supply costs and security. As countries increasingly phase out traditional heating systems, heat pumps emerge as a crucial technology for sustainable heating, offering substantial environmental benefits while enhancing energy independence. This shift represents a key strategy in the global effort to combat climate change and ensure a more sustainable energy future.

4 PRACTICAL EXERCISES

4.1 Exercise 1. Room Heat Loss Calculation and Radiator Sizing

Determine the total heat loss for a specific room and select an appropriately sized radiator for a heat pump system.

a) Choose a room and collect the following data:
- Area (m^2) and U-value (W/m^2K) for each building element (walls, windows, roof, floor)
- Internal design temperature and external design temperature (°C)
- Room volume (m^3)
- Air change rate (h^{-1})
- Volumetric heat capacity of air (c = 0.33 Wh/m^3K or 1200 J/m^3K)

b) Then, calculate the fabric heat loss for each element:

$$Q_{fabric} = A\ x\ U\ x\ \Delta T$$

Where,

$\Delta T = (internal\ temperature - external\ temperature)$

c) Next, it is calculated the ventilation heat loss:

$$Q_{vent} = V\ x\ n\ x\ c\ x\ \Delta T$$

Where,

A = area of each building element (m^2)

U = U-value of each element (W/m^2K)

ΔT = temperature difference between interior and exterior (K)

V = volume of the space (m^3)

n = air change rate (h^{-1})

c = volumetric heat capacity of air (J/m^3K)

d) Finally, sum all losses to find the total room heat loss, Q

$$Q = \sum (A * U * \Delta T) + (V * n * c * \Delta T)$$

Additionally, the selection of the radiator is defined using the calculated heat loss and a radiator output table (for a typical heat pump flow temperature, e.g., 45°C), identifying a radiator with sufficient output. If necessary, apply an oversize factor (e.g., 1.5–2.5) to account for lower flow temperature.

4.2 Exercise 2. Sizing a Domestic Hot Water Cylinder for a Heat Pump

A household of 4 occupants. The target hot water temperature is 50°C, and the incoming cold water temperature is 10°C. Each person is estimated to require 50 liters of hot water per day during peak demand.

Calculate the minimum required cylinder volume and the energy needed to heat the water.

<u>1. Estimate Total Hot Water Demand</u>

As a Rule of thumb, allocate 40–50 liters per person for peak demand.

$$Required\ Volume = n.occupants\ x\ litres\ per\ person$$

$$Required\ Volume = 4\ x\ 50(\frac{l}{per})\ \text{=200 liters}$$

<u>2. Calculate the Energy Required</u>

- Specific heat capacity of water (cc): 4186 J/kg·K
- Temperature difference (ΔT): 50°C−10°C = 40°C
- Mass of water (m*m*): 200 liters ≈ 200 kg (since 1 L ≈ 1 kg)

$$E = m\ x\ c\ x\ \Delta\mathrm{T}$$

$$E = 200\ x\ 4186\ x\ 40 = 33488000\ \mathrm{J}$$

- Convert joules to kilowatt-hours (1 kWh=3600000 J):

$$E = \frac{33488000}{3600000} = 9.3\ kWh$$

<u>3: Consider Heat Pump and Cylinder Characteristics</u>

- Cylinder coil surface area: Should be at least 0.2 m^2 per kW of heat pump output, or a minimum of 1.5 m^2 for small tanks, to ensure efficient heat transfer.
- If the heat pump has a slow reheat rate, consider a slightly larger cylinder to avoid running out during peak demand.

<u>Step 4: Final Recommendation</u>

- Cylinder volume: 200 liters for a 4-person household with average to high demand.
- Energy required to heat from 10°C to 50°C: ~9.3 kWh

5 MULTIPLE CHOICE QUESTIONS

5.1 What is a crucial aspect of managing customer expectations in heat pump installations?

A) Ignoring customer feedback

B) Focusing only on post-installation

C) Comprehensive approach throughout the customer journey

D) Reducing installation costs

5.2 Why are regular check-ins important during the first heating season?

A) To sell additional services

B) To reduce customer interaction

C) To increase installation time

D) To identify and resolve problems quickly

5.3 What should installers provide to enhance customer satisfaction post-installation?

A) Comprehensive maintenance tips

B) Limited maintenance tips

C) No follow-up support

D) Only emergency contact information

5.4 What is essential when managing partial conversions with existing heating systems?

A) Ignoring the existing system

B) Clear explanation of operation strategies

C) Installing without customer input

D) Using only one system

5.5 What can transform a simple transaction into a trusted partnership?

A) Proactive addressing of customer queries

B) Minimal communication

C) High-pressure sales tactics

D) Ignoring customer needs

5.6 What should installers emphasize to clients regarding heat pumps?

A) Short-term benefits only

B) Complexity of installation

C) Energy efficiency and long-term savings

D) High maintenance costs

5.7 What is a key benefit of educating customers about heat pump systems?

A) Increased confusion

B) Enhanced customer satisfaction

C) Reduced installation time

D) Higher costs

5.8 What is the role of integrated controls in heat pump systems?

A) To complicate the system

B) To eliminate existing systems

C) To reduce energy efficiency

D) To manage operation strategies effectively

5.9 What should installers do to ensure optimal system performance?

A) Align system choice with customer needs

B) Ignore customer requirements

C) Use a one-size-fits-all approach

D) Focus solely on cost

5.10 What is the primary goal of post-installation follow-up?

A) To increase installation fees

B) To maintain customer satisfaction

C) To limit customer interaction

D) To sell additional products

5.11 What is a common expectation from customers regarding heat pump systems?

A) Immediate results without maintenance

B) No need for follow-up

C) Clear understanding of system operation

D) High energy consumption

5.12 What can lead to positive referrals and repeat business?

A) Poor customer service

B) Thorough and personalized selection process

C) Ignoring customer feedback

D) High-pressure sales tactics

5.13 What is a key factor in promoting broader adoption of heat pump technology?

A) Effective management of customer expectations

B) Lack of customer education

C) High installation costs

D) Limited product offerings

5.14 What should installers do during the initial consultation?

A) Rush through the process

B) Discuss customer needs and expectations

C) Focus only on technical details

D) Avoid discussing costs

5.15 What is the benefit of setting clear expectations with customers?

A) Increased confusion

B) Higher installation costs

C) Maximized efficiency and comfort

D) Reduced customer satisfaction

5.16 What is an important aspect of the customer journey in heat pump installations?

A) Only focusing on installation

B) Limiting communication

C) Ignoring customer feedback

D) Comprehensive support from consultation to follow-up

5.17 What should installers highlight to demonstrate their expertise?

A) Long-term benefits of investing in heat pumps

B) Complexity of the installation process

C) High maintenance requirements

D) Short-term savings only

5.18 What is a potential outcome of effective post-installation support?

A) Customer dissatisfaction

B) Long-term customer relationships

C) Increased installation costs

D) Limited customer interaction

5.19 What is a key strategy for installers to enhance customer confidence?

A) Avoiding communication

B) Focusing solely on installation

C) Regular check-ins and support

D) Ignoring customer concerns

5.20 What should installers do to ensure customers understand their systems?

A) Provide minimal information

B) Limit customer interaction

C) Focus only on technical jargon

D) Educate customers on system operation

6 REFERENCES

[1] Winskel, M., et al. (2024). Reducing heat pump installed costs: Reviewing historic trends and forecasting future reductions. Applied Energy, 389, 121397. https://doi.org/10.1016/j.apenergy.2024.121397

[2] Pertzborn, A., Nellis, G., & Klein, S. (2010). Research on Ground Source Heat Pump Design. International Refrigeration and Air Conditioning Conference, Paper 1048. Purdue University. https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2047&context=iracc

[3] Péan, T. Q., Salom, J., & Costa-Castelló, R. (2020). Review of control strategies for improving the energy flexibility provided by heat pump systems in buildings. Energy and Buildings, 203, 109399. http://www.iri.upc.edu/files/scidoc/2033-Review-of-control-strategies-for-improving-the-energy-flexibility-provided-by-heat-pump-systems-in-buildings.pdf

[4] UKERC. (2023). An Evidence Review of Domestic Heat Pump Installed Costs. UK Energy Research Centre. https://d2e1qxpsswcpgz.cloudfront.net/uploads/2023/03/UKERC_Decarbonising-Home-Heating_Evidence-Review-of-Domestic-Heat-Pump-Installed-Costs-.pdf

[5] Scottish Enterprise. (2022). Heat Pumps and Heating Systems Components Analysis. Scottish Enterprise. https://www.scottish-enterprise.com/media/jftj41sz/heat-pumps-and-heating-systems-components-analysis.pdf

[6] Zhang, X., Lin, Y., & Zhang, X. (2021). Control strategies for heat pumps in a residential area under smart grid-ready conditions. Energy and Buildings, 266, 112103. https://www.sciencedirect.com/science/article/pii/S0378778825001720

[7] Schmidt, T., et al. (2020). Heat pump and thermal energy storage: Design and control for optimal integration with photovoltaics. RWTH Aachen University Publications. https://publications.rwth-aachen.de/record/997163/files/997163.pdf

[8] KU Leuven. (2024). Heat pump control and behavioural characterisation under energy flexibility. KU Leuven Research Portal. https://research.kuleuven.be/portal/en/project/3E200137

[9] Tihana, T., et al. (2023). Comparative analysis of hydraulic configurations in hybrid heating systems. DiVA Portal. https://www.diva-portal.org/smash/get/diva2:1870874/FULLTEXT01.pdf

[10] Péan, T. Q. (2021). Heat pump controls to exploit the energy flexibility in buildings: Rule-based vs. model predictive control. Digital CSIC. https://digital.csic.es/bitstream/10261/235591/1/TTQP1de1.pdf

[11] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). (2005). ASHRAE Handbook—Fundamentals (Chapter 29: Heating and Cooling Load Calculations)

[12] European Committee for Standardization. (2003). *Heating systems in buildings – Method for calculation of the design heat load (EN 12831)*.

[13] United States Department of Housing and Urban Development. (1968). Heat Loss Calculations (Vol. 7).

[14] Moss, G. (2008). Heat and Mass Transfer in Buildings. Routledge

[15] Primo, J. (2016). HVAC – Practical Basic Calculations. PDH Online.

[16] American Society of Plumbing Engineers (ASPE). (2003). Domestic Water Heating Design Manual (2nd ed.).

[17] CED Engineering. (n.d.). Design Considerations for Hot Water Plumbing

[18] Intellihot. (2023). Engineers' Guide to Commercial Hot Water Design.