Encouraging heat pump installations in Ireland

Strategies to maximise heat pump installation and the savings produced

Behavioural Insights Paper Series

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November 2020

Sustainable Energy Authority of Ireland

SEAI is Ireland's national energy authority investing in, and delivering, appropriate, effective and sustainable solutions to help Ireland's transition to a clean energy future. We work with the public, businesses, communities and the Government to achieve this, through expertise, funding, educational programmes, policy advice, research and the development of new technologies.

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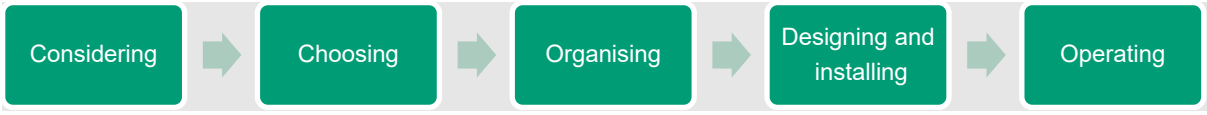


Encouraging heat pump installations in Ireland: Strategies to maximise heat pump installation and the savings produced

Executive summary

Context

There were 1,325 grant-aided heat pump installations in 2019 across all SEAI programs. To meet the targets for existing buildings set out in the Climate Action Plan, the annual number of heat pumps installed in existing homes will need to increase by over a factor of 30. The annual number of heat pumps installed in new homes annually will also need to double.

Given the urgent need to increase the number of heat pumps installed in existing homes each year from now until 2030, it is important to identify the barriers and drivers that may reduce or boost adoption respectively. This short policy insight paper will review the existing evidence and provide recommendations for key stakeholders, including policymakers, heat pump installers, those who sell heat pumps, and heat pump manufacturers, so that the number of heat pumps installed and the savings achieved following installation can be maximised.

Aims and objectives

The aims and objectives of this paper are to:

- Identify the barriers and drivers to heat pump adoption at each part of the adoption lifecycle;
- Identify factors that influence the realisation of the potential savings from heat pump adoption in Ireland; and
- Identify potential strategies for increasing heat pump adoption in Ireland and realising higher operational efficiency.

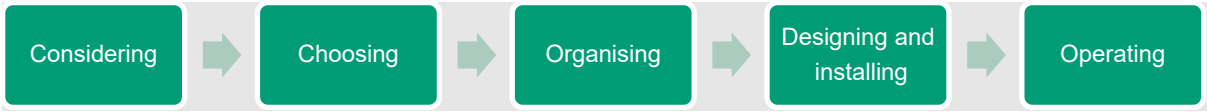
Insights

Following consideration of the consumer journey to purchasing a heat pump, more behavioural barriers were identified than behavioural drivers. This means that interventions will be required from policymakers, heat pump installers, and heat pump manufacturers to make heat pump adoption easier and more appealing to homeowners.

Considering – low awareness of heat pumps and the tendency to replace heating systems with the same technology

There is a strong tendency for homeowners to continue using their existing heating system until it breaks down. Similarly, when homeowners replace their existing heating system, they often replace it with the same technology. At the same time, awareness and understanding of heat pump technology in Ireland is low. Regulatory measures, and their potential to influence consumer behaviour, should also be considered to encourage further uptake of heat pumps in coming years.

Significant communication campaigns, demonstration events, and pilots will be required to raise Irish households' familiarity with heat pump technology. These campaigns should support actions



outlined in the Climate Action Plan to effectively ban the installation of oil boilers from 2022 and the installation of gas boilers from 2025 in all new dwellings, by highlighting heat pumps as a reliable alternative.

Organising – complexity of retrofitting and the lack of finance

Given that the Climate Action Plan calls for 400,000 heat pumps to be installed in existing dwellings over the period to 2030, a large number of homes will also need to retrofit their home (wall/roof insulation, windows, doors) to ensure the home is 'heat-pump ready'. Homeowners often find the process of organising and coordinating a complex retrofit difficult. Making heat pumps, and the accompanying fabric upgrades where required, affordable for homeowners is critical. Homeowners will require access to low cost finance and further consideration should be given to other cost reducing policies such as the use of tax incentives.

While government grants are already available for households willing to change to a heat pump, homeowners will require support with the installation process as well as access to financing options to make this affordable. The provision of strong support services from one-stop-shops will be important in facilitating greater levels of heat pump adoption.

Designing and installing – complexity of heat pump design and the need to focus on installation quality

The design and installation of a heat pump system also plays a large role in determining the amount of savings realised from its installation.

Ensuring that homes are well insulated and that the heat pump is adequately sized for the heat demand in the property is key to realising savings. Further development of standards and provision of training will be required to ensure heat pumps are designed and installed correctly.

Operating – lack of homeowner training and complicated heating control design

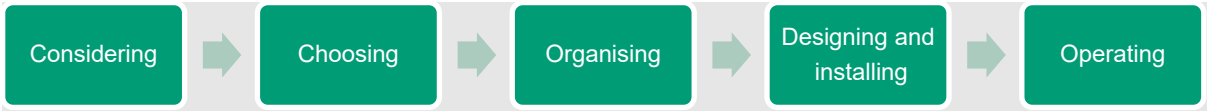
While often overlooked, correct operation of the heat pump system is essential to realise savings. Studies have shown that homeowners are often not provided with adequate training/advice to help them operate their heat pump efficiently. Users also find heat pump controls complicated and difficult to use, noting they do not provide adequate feedback on energy use and costs.

Heat pump manufacturers should work to simplify heating controls and installers, in coordination with one-stop-shops, should ensure homeowners know how to most efficiently operate their system. Providing user friendly feedback on the system's performance and energy savings would help to increase customer satisfaction based on existing studies.

Targeting promotion to maximise uptake

Finally, research has shown that certain groups of homeowners are more likely to install a heat pump than others.

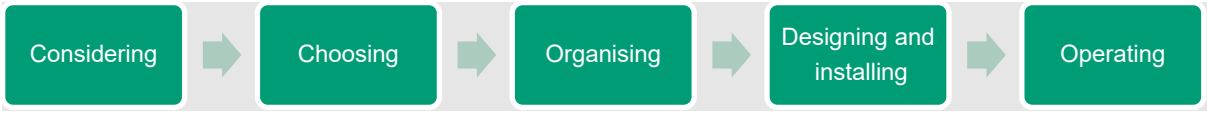
Policymakers and installers should firstly focus on encouraging those with the ability to pay, as well as those living in larger houses using oil or electricity off the gas grid, to install a heat pump. Policymakers and installers should design interventions that encourage people to install a heat pump during key moments of change such as when they are purchasing a home.



Potential policy solutions

A number of potential policy solutions have been identified for further consideration:

- Use community-based social marketing to encourage heat pump adoption;
- Develop online recommender tools/calculators to simplify choice for potential adopters;
- Conduct research outside of behavioural barriers on operational performance, incentive impact modelling, labour supply, and the design of heating controls to further inform policies that could spur further heat pump adoption;
- Work with the Environmental Protection Agency to consider the implications of changes to regulations on refrigerant gases to heat pump adoption;
- Introduce requirements for the provision of householder training on grant schemes to maximise operational efficiency;
- Establish a register of qualified recommended professionals to help homeowners choose high quality installers;
- Encourage the development of one-stop-shops to simplify the customer journey;
- Create a role for an assigned certifier to provide quality assurance on all heat pump installations;
- Create a registered quality mark for heat pump installers along with an independent redress board to provide assurance for homeowners;
- Encourage the development of energy tariffs specifically for heat pumps to incentivise homeowners to operate their heat pumps efficiently;
- Provide networking events for project managers from local authorities and approved housing bodies; and
- Provide training to BER assessors, home surveyors, boiler repairers, and heat pump installers on how to recommend a heat pump to householders.



Motivations for this policy report

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Background

Heat was the second largest source of energy-related emissions in Ireland in 2018 (Sustainable Energy Authority of Ireland [SEAI], 2020). The biggest contributor to heat emissions in 2018 was heating demand from residential homes, which accounted for 47% of heat emissions. This can be partly explained by examining how Ireland's residential building stock differs from that of other European countries. Irish homes are relatively less energy efficient and a greater proportion of them rely on more carbon intensive fuel sources such as oil/solid fuel for heating. They require higher temperatures to maintain comfort levels due to their construction and the Irish climate. Irish buildings also tend to be larger and more geographically dispersed. As a result, there is a recognised need to both improve the energy efficiency of residential buildings in Ireland and decarbonise their heating source.

The Climate Action Plan was published in 2019 (Government of Ireland, 2019) setting out a road map to improve the Irish residential building stock and decarbonise heating in the sector. Analysis indicated that the most cost-effective way to achieve these goals is to retrofit 500,000 existing homes to a BER rating of B2 and to install 600,000 heat pumps (400,000 to be in existing buildings).

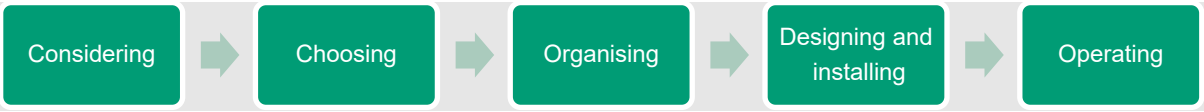
Achieving these goals will require a step change in the number of heat pumps adopted annually. According to SEAI databases, between 2018 and October 2020, there have been over 2,900 grant-aided heat pumps installed in existing buildings. Between 2018 and October 2020, 26,900 heat pumps had been installed in newly built homes, according to the BER database. To meet the targets set out in the Climate Action Plan, the annual number of heat pumps installed in existing homes will need to increase by over a factor of 30. Installing heat pumps in existing homes, in a lot of cases, will require the installation of insulation also to ensure the home is 'heat-pump ready', meaning additional intervention is likely to be necessary to encourage people to install a heat pump instead of an oil/gas boiler. For most households, this would represent a significant change from the status quo.

Given the urgent need to increase the number of heat pumps installed in existing homes each year from now until 2030, it is important to identify the barriers and drivers that may reduce or boost adoption respectively. This short policy insight paper will review the existing evidence and provide recommendations for key stakeholders, including policymakers, heat pump installers, and heat pump manufacturers, so that the number of heat pumps installed and the savings achieved following installation can be maximised.

Aims and objectives

This paper will examine evidence from previous studies and pilots to identify successful strategies for maximising the adoption of heat pumps and the savings realised from their adoption. The aims and objectives of this paper are to:

- Identify the barriers and drivers to heat pump adoption at each part of the adoption lifecycle;
- Identify factors that influence the realisation of the potential savings from heat pump adoption in Ireland; and
- Identify potential strategies for increasing heat pump adoption in Ireland and realising higher operational efficiency.



Layout of the report

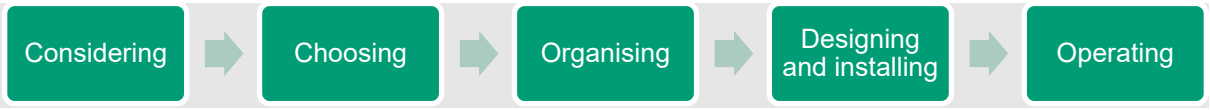
This report firstly explores each step in the customer journey in detail as shown in *Figure 1*. The main barriers and drivers of heat pump adoption are then summarised. To avoid repetition, each barrier has not been explicitly linked to the stage in the customer journey it applies to. Tables available on the SEAI website links each barrier or driver to the relevant stage in the customer journey.

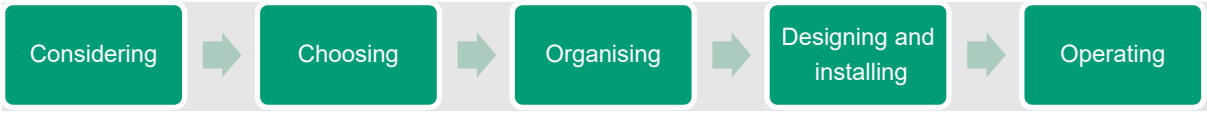
Following the exploration of the barriers and drivers of heat pump adoption, the main socio-demographic factors and building characteristics that influence heat pump adoption are outlined. This will help both policymakers and heat pump installers identify the households that are most likely to install a heat pump.

The main factors that influence the savings realised following installation are then presented.

The report then concludes with several recommendations for increasing heat pump adoption and realising the greatest proportion of the potential energy savings.

Figure 1: A typical heat pump adoption customer journey





Considering

The 'Considering' stage is the first stage in the heat pump adoption life cycle. It involves the householder thinking about their heating system. Most of the time, people do not think about their heating system. Most people's interactions with their heating system are limited to increasing the temperature when it is cold or turning off the system when the weather becomes warmer. Typically, people only think about their heating system when it becomes notably more expensive, when it becomes unreliable, or when it completely breaks down.

The considering stage may or may not include the householder becoming aware of heat pumps or considering them as an option. It is important to keep in mind that a recent energy literacy survey conducted by SEAI (2019) showed that only 33% could correctly define what a heat pump is and that surveys conducted by Mukherjee, Meles and Ryan (2020) showed very low awareness of heat pumps among the general population. There is a small number of qualified heat pump installers compared to the number of boiler repairers, and so the majority of installers may not be fully aware of heat pumps in order to advise their customers on heat pump technology.

Behaviours in the consideration stage

Searching for information

Previous SEAI surveys have shown that when people are looking for information on retrofitting their home in general, the main sources of information they use are the internet, their energy supplier, a BER assessor, their family/friends, and local contractors in that order.

However, research by Ipsos MORI and the Energy Saving Trust (2013) for the UK Department of Energy and Climate Change showed that 61% of those changing their heating system were doing so because theirs had broken down or was breaking down. It is likely then that most people considering changing their heating system will contact a boiler repair service or their utility when looking to change their heating system.

Contacting installers for information

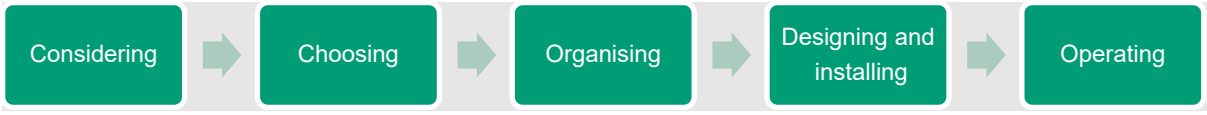
Previous SEAI research has shown that one of the most trusted sources for information on retrofit projects are local contractors/installers. In relation to heating systems in particular, previous research shows that installers play a large part in the householder's decision over what type of heating system to install. Householders are more likely to install a heating technology they are already familiar with (Ipsos Mori, 2013) or that is recommended to them by the installer.

Contacting boiler repair services

Given that the majority of heating system changes are driven by boiler breakdown, householders are likely to contact a boiler repair service company or their utility if they provide servicing. It's important to remember that these purchases are usually made as a 'distress purchase' where the householder sees the boiler breakdown as an emergency event as they cannot heat their home. Google searches for 'boiler repair' or 'boiler service' show that the ads emphasise quick turnaround's, 24/7 services, and 'same-day repairs', implying these decisions may not often be the most deliberative.

Choosing

The 'Choosing' stage is the second stage in the heat pump adoption life cycle. The choosing stage assumes that the householder makes an active decision between a number of alternatives for replacing/repairing their heating system. **This is a strong assumption to make** and may not



accurately reflect the decision-making process involved in repairing/replacing a heating system or installing a heating system in a newly built home.

In many cases householders do not actively choose between alternatives. Status quo bias is common and often people simply choose to repair or replace their heating system with a newer model of the technology they previously had installed. In relation to newly built properties, it is common for the developer to make the choice about which heating system will be installed with no input from the prospective owner of the house.

It should also be noted that householders most likely have limited attention when choosing between alternative heating systems. Studies have shown that householders are inattentive to long-term running costs and instead prioritise familiarity, comfort, and reliability as important attributes when choosing which heating system to install. Up-front costs are a more important determinant for large portions of the population in comparison to running costs.

Behaviours in the choosing stage

Searching for information

Once the householder has decided that they want to repair/replace their existing heating system, they will typically search for additional information. Householders usually consider up-front costs and may seek out recommendations from friends/family who have recently carried out similar works.

It should be noted that this process does not resemble the type of information searching considered in rational actor models. Instead, householders satisfice, pay limited attention, and can be considered boundedly rational. They do not pay attention to long run considerations like energy price inflation and are usually unaware of the exact unit price differences between different energy sources like oil and electricity.

Contacting installers for information

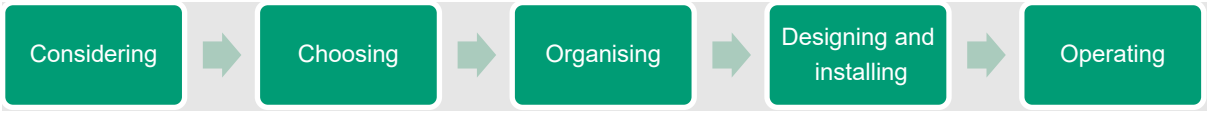
According to a UK survey by Caird and Roy (2010), on average, the 546 households who proceeded to purchase a microgeneration heat system organised two to three installer visits and typically choose installers who appear to be knowledgeable, trustworthy and reliable (49%), local (32%), and come with a personal recommendation (21%).

Comparing options on attributes that are important

Some householders will seek out information on multiple heating systems and compare the options available on attributes they deem important such as up-front cost, system reliability/familiarity, ease of install and comfort. A smaller portion (roughly 20% based on a choice experiment from Italy) may pay closer attention to running and maintenance costs.

Negotiations between contractors and the project commissioner

Contractors often negotiate with housing bodies and local authorities about energy efficiency targets and the technologies required. Depending on the strength of the contracting arrangement, and the relationship between the stakeholders, negotiations can result in energy efficiency improvements being avoided. Often this will be justified on the basis of the cost of the measures and their potential to delay upgrade projects. Some contractors may **feel** that heat pumps **may** be more likely to lead to project delays given that they are still **perceived** as a relatively new technology in Ireland.



Organising

The 'Organising' stage is the third stage in the heat pump adoption life cycle. At this point in the heat pump adoption life cycle, households have decided ***to try to*** install a heat pump and undertake a number of actions to coordinate and organise the installation of a heat pump. It should be noted, that there is still a probability that the household will ultimately not install a heat pump if barriers present during the organising stage cannot be overcome, for example if the household cannot arrange for a contractor to assess their home's heat pump eligibility quickly enough or if the technical assessment shows that significant other retrofit works are required before installing a heat pump.

While the simplified heat pump adoption life cycle shown in *Figure 1* suggests that the households' decision-making process has been completed in the choosing stage, in reality, the householder will continue to make decisions throughout the rest of the process. For example, in the organising stage the technical assessment may show that the householder needs to upgrade the insulation of their home to ensure that a heat pump can operate efficiently. The extra cost and hassle associated with these additional works may cause the homeowner to decide not to install a heat pump, or to install some insulation measures and simply repair their current heating system.

Behaviours in the organising stage

Contacting technical assessors to arrange technical assessments

If the household wishes to avail of grants from the SEAI to reduce the cost of their heat pump installation, they are required to conduct a technical assessment to assess if their home is heat-pump ready. Households need to contact a technical assessor from a list of registered assessors and organise for the technical assessment to take place in their home.

Contacting SEAI to apply for available grants

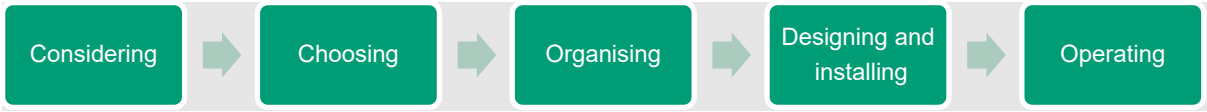
Before starting works, the household is also required to submit an application, with a valid certificate from a technical assessment, in order to claim the heat pump grant.

Organising and arranging finance to cover the cost of the upgrades

The median household savings for an Irish household are €4,500 (Central Statistics Office [CSO], 2017). The median household savings for an Irish household with two adults and two children is €3,900 (CSO, 2017). The cost of installing a heat pump can be from €4,000 to €27,000 for an air source heat pump, and between €7,000 and €32,000 for a ground source heat pump. The average cost of a grant-aided heat pump as of 4 April 2019 was €11,000. With a grant of available of €3,500 available, the average cost paid by homeowners was €7,500. As a result, it is likely that a large proportion of households will require financing to be able to afford the installation of a heat pump and organising this financing can be time consuming for the consumer.

Contacting insulation contractors and arranging site visits to price insulation works if they are required to facilitate heat pump installation

Depending on the results of the technical assessment, further insulation works may be required to reduce the home's heat loss. This may require installing underfloor insulation, wall insulation, and/or attic insulation depending on the current condition of the home. This may deter the householder from installing a heat pump or cause them to reprioritise their spending to focus on installing insulation measures.



Arranging for time off work, childcare needs, alternative temporary accommodation, and other necessities to facilitate works

Once the works have been scheduled, the homeowner may need to make arrangements to facilitate the works such as taking time off work or finding temporary accommodation if extensive works are required.

Designing and installing

During the designing and installing stage, households may be asked to make decisions about the placement of the heat pump, the sizing of radiators, and other elements of the system which will ultimately affect the system's performance.

Contractors will require access to the household to take measurements, replace existing insulation/heating systems, resize or add radiators, and install the heat pump. In some cases, this can lead to significant disruption for the people living in the house being retrofitted, sometimes requiring people to move out of their house for a number of days/weeks.

The designing and installing stage is typically described by households as being stressful (SEAI, 2018). Householders are required to make many decisions in a short period of time that they feel they do not have the required expertise to make. At the same time, their regular home life is disrupted.

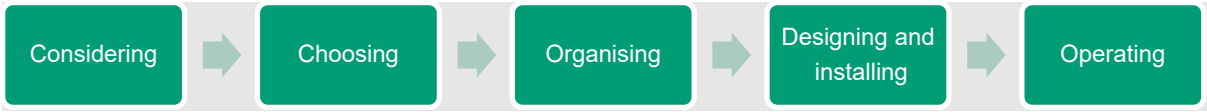
While households are unlikely to drop out of the process of installing a heat pump at this stage, their experience during the designing and installing stage has been shown to strongly influence householders' satisfaction, their willingness to recommend a heat pump to a friend or neighbour, as well as their energy use post installation. Similarly, choices made by the householder and the contractor during the design and installation stage will impact the heat pump's operational energy use.

Behaviours in the designing and installing stage

Make decisions about the design and placement of the heat pump system and any other works required to facilitate it

Some design decisions, such as whether an air source heat pump or ground source heat pump would be more appropriate, are likely to have been made during the organising stage. However, a number of decisions will be required during the design and installation stage. The householder will likely be asked where they would like their heat pump placed outside their home and are often asked to input into decisions surrounding radiator sizing and placement.

Contractors will also make a number of decisions, both with and without householder input about the design of the heat pump system. While engineering calculations, industry practices, and installation guidelines shape these decisions, there is evidence from other countries that contractors sometimes rely on rules of thumb and make mistakes when designing heat pump systems. These deviations from best practice can lower the operational efficiency of the heat pump and result in higher energy use post installation. Other decisions such as the type of heating controls installed on the heat pump system may also influence the householder's ability to correctly operate the system post installation.



Organise access to the home for contractors and clean out workspaces

Depending on the works required, contractors may require access to multiple/all rooms within the home as well as the front and back of the house. To facilitate this, householders have to provide a means of access which often involves having someone home for the duration of the works. Householders will also need to clean workspaces to remove items which may limit contractors' access. This can involve moving furniture, moving personal items into storage, or fitting protective measures such as plastic sheeting to protect items/parts of the home. Contractors often rely on sub-contractors to complete different elements of the works, and currently project managers are often not appointed, meaning the homeowner may need to coordinate with multiple different contractors during the designing and installing stage.

Relocate to temporary accommodation

In a small minority of cases, especially when additional insulation works such as underfloor insulation are required, the householders may be required to relocate to temporary accommodation. This is a large disruption to householders' comfort and daily routines, which can act as a stressor, worsening their experience of the installation process.

Operating

Once a heat pump system has been installed, its full energy-saving potential is only realised if it is operated efficiently. For example, if the boost function is used too frequently the system may not operate efficiently, reducing the savings realised. A number of international studies and case studies have shown that there is not enough emphasis placed on teaching homeowners how to operate their heat pump correctly.

Behaviours in the operating stage

Setting heating schedules and temperature set points

To provide satisfactory comfort levels for the householder and ensure the heat pump operates efficiently, the householder will need to set a heating schedule and choose temperature set points. Often, different schedules and setpoints are required for the summer and winter seasons, and this requires additional programming at setup or reprogramming when the seasons change.

Maintaining the heat pump system

Depending on the heat pump installed, its placement and the local weather, heat pumps can require varying levels of maintenance. Air filters should be checked monthly, the system should be cleaned of debris and ice, the outdoor coils should be kept clean, and shrubs should be pruned to stay clear of the system.

Selecting/changing an electricity tariff

Given that the majority of households in Ireland rely on oil or gas to fuel their main heating source, the majority of households that install heat pumps should consider switching their electricity tariff to reduce the cost of operating their heat pump. It should be noted that this action cannot be taken for granted. Many households may fail to switch their tariff after installing a heat pump or fail to even consider a different electricity tariff.

Avoiding turning the heat pump on/off and overuse of the boost function

Studies suggest that heat pumps work most efficiently when set to run continuously at a steady temperature. Changing the temperature constantly or 'boosting' the output of the system, as is

common with oil boilers, can significantly reduce the efficiency of heat pump systems. While operating the system, if efficiency is their main consideration, the householder should therefore try to avoid changing temperatures frequently or using boost functions.

Learning how the heat pump system operates

To maximise the savings realised from their heat pumps, householders should take the time to learn about efficiently operating their heat pump. This usually involves understanding the heat pump's controls, but also understanding how the system works as a whole. For example, as heat pumps operate more efficiently by maintaining a constant temperature, households should learn to avoid leaving windows and doors open when the heat pump is in operation.

Barriers

Throughout the customer journey, multiple barriers prevent householders and contractors from considering the installation of a heat pump.

Low awareness of heat pumps

Surveys conducted by Mukherjee, Meles and Ryan (2020) showed very low awareness of heat pumps among the general population in Ireland. If householders are not aware that heat pumps exist and of the benefits of the technology, then they cannot decide to install the technology.

Poor understanding of heat pumps and how they work

A recent energy literacy survey conducted by SEAI (2019) showed that only 33% of the population could correctly define what a heat pump is. Interviews conducted by Mukherjee, Meles and Ryan (2020) indicated low levels of knowledge of heat pumps and how they worked. Previous studies have shown that familiarity and understanding of heating systems are key to adoption.

Narrow focusing during distress purchases

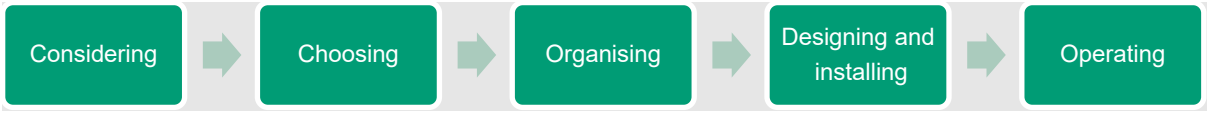
When householders make a distress purchase decision to repair or replace their boiler, their focus is on restoring the heating system as quickly as possible. This means that they may not explore all available alternative heating systems and may place a higher weight on how quickly the system can be replaced compared to the long-term running cost of the system. If one of the main drivers for replacing heating systems is boiler breakdown, most householders will not be willing to consider installing a heat pump which will take longer to design/install.

Contractors often report low demand for heat pumps from consumers and so may not offer them

Pinkse and Dommisse (2009) interviewed large contractors in the Netherlands. Contractors' surveys of their customers showed that most of their customers did not demand energy-efficient technologies as part of their construction projects. If contractors do not perceive a demand for heat pumps from their customers, they will be slow to build the capacity to provide them.

Regret aversion

Qualitative interviews with people who installed heat pumps as part of a small (n=12) field trial in the UK indicated that one person reported feeling concerned and ambivalent after making the decision to install a heat pump (Owen, Mitchell and Unsworth, 2013). Most Irish householders are not familiar with heat pumps. They may be reluctant to make the choice to install one fearing that they will later regret that choice if their bills increase or the system doesn't perform well. People prefer to avoid situations that might induce regret, and this may reduce willingness to adopt heat pumps.



Present bias

Results from discrete choice experiments in Italy, surveys conducted in Ireland, and agent-based modelling in Ireland indicate that one of the major barriers to heat pump adoption is the relatively large up-front costs to install the technology (Troiano *et al.*, 2019; Mukherjee, Meles and Ryan, 2020). People often overweigh up-front costs and heavily discount potential future running costs savings. This means that even if a heat pump is economically advantageous over longer time periods, people will not choose to install them because the up-front cost is much higher compared to alternatives like oil and gas boilers.

Risk aversion

Surveys have shown that both contractors and householders perceive heat pumps to be a newer, less familiar and thus a riskier technology (Caird and Roy, 2010). Evidence from behavioural economics shows that people will take action to avoid uncertain investments and behaviours (Berger, Bleichrodt and Eeckhoudt, 2013). Heat pump technology is seen as new and therefore perceived as being less reliable. People may also place too much emphasis on low probability risks associated with heat pumps such as Legionnaires' disease from poorly controlled systems and the risk of being without heat in a blackout.

Status quo bias

Discrete choice experiments in Germany (Michelsen and Madlener, 2011) (Madlener, 2011) and interviews with Irish consumers (Mukherjee, Meles and Ryan, 2020) reveal that householders are much more likely to stick with a heating system they are already familiar with than to install a new type of heating system. When a person's heating system breaks down or when they are choosing a new heating system, people are much more likely to simply replace their heating system with a newer model of the technology they had previously installed. Status quo bias tends to be quite strong and usually requires significant intervention to overcome.

Lack of finance

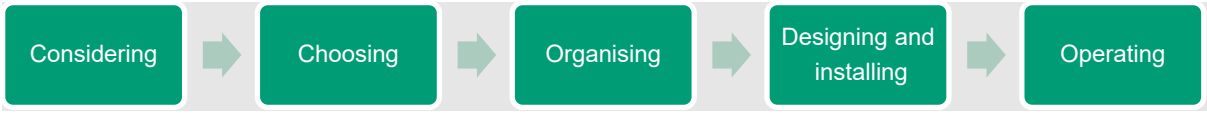
Nationally representative surveys carried out by SEAI on a bi-annual basis shows that the largest barrier to any retrofit works, including the installation of a heat pump, is the householder's inability to finance the project. The median household savings in Ireland according to the CSO are €5,000 while the median household savings for a family with two adults and two children is €3,900 (CSO, 2017). Most households need access to low-cost finance to fund the installation of a heat pump, especially if insulation work is also required to reduce the home's heat loss.

Concerns about noise of heat pump

Field trials from the UK (Caird, Roy and Potter, 2012) as well as other international surveys and interviews have shown that noise and vibration can be a cause of concern for both installers and householders. If installers or householders are concerned that the heat pump system will cause noise or vibration that may disturb them, or their neighbours, they are likely to be less willing to install a heat pump.

Concerns that heat pumps are slow to heat rooms

Survey work conducted in the UK (Caird, Roy and Potter, 2012) of both those who took part in a field trial and those who adopted a heat pump independently, found that a number of householders reported that their heat pump was slow to heat rooms compared to their old gas/oil boiler. Social housing residents who had their heating system replaced by a housing body were more likely (40% vs. 7%) than private housing residents to report this problem. Two of the most important factors that householders consider when investing in a heating system are comfort and reliability. Heat pumps



work differently to gas/oil boilers, maintaining a constant warm temperature rather than providing temperature boosts. If householders do not understand this and operate their heat pumps like a gas/oil boiler they will increase their bills and lower their comfort levels.

Potential for heat pumps to delay installation due to system complexity

Case studies from eight large-scale renovation projects in The Netherlands showed that installing heat pumps as part of renovation projects can lead to delays, especially when installers are not familiar with heat pumps (Hoppe, 2012). While the European industry has developed further since the early 2010s, the Irish market is still in an early stage of development. Project delays can be costly for contractors/installers as contracts often include incentives to finish projects on time. Tenants often also demand compensation when inconvenienced for longer than expected. If heat pumps are more likely to lead to project delays, contractors will be less willing to install them as part of renovation projects.

Disruption of installation process is seen as a hassle

Modelling results from the UK estimate the 'hassle costs' associated with installing a heat pump to be £315 (three days' time at £14 per hour) (Snape, Boait and Rylatt, 2015). Field trials in the UK also showed that some potential applicants chose not to install a heat pump, even though they saw the economic benefits, because they perceived the hassle costs to be too large (Owen, Mitchell and Unsworth, 2013). Heat pump installations can involve hassle for the householder. Resizing of radiators can make it necessary to redecorate after install. Installing underfloor insulation can mean some rooms will not be accessible for a number of days. Ground source heat pumps can involve digging large holes in the property's garden. Some people are not willing to accept such hassles even if the economic benefits of a heat pump are clear to them in the longer term.

Bad experiences with installing heat pumps

Contractors who have a bad experience installing heat pumps are likely to be dissuaded from installing heat pumps again in the future, as seen in a Dutch review of eight renovation projects (Hoppe, 2012). If a contractor has had a previous bad experience installing heat pumps, they are less likely to recommend heat pumps in future projects.

Negative reviews and feedback from previously poorly designed/installed heat pumps

Recommendations from others are powerful motivators, but negative feedback from peers can deter people from choosing to install a heat pump. If heat pumps are installed poorly and people experience an increase in their bills as a result, their negative feedback to others may slow adoption. For example, if heat pumps are undersized or installed in poorly insulated homes, people's bills may increase, and this may lead to heat pump attracting a negative reputation as 'expensive technology'.

Hassle factor of pre-survey and technical assessment

To qualify for existing grants, a technical assessment and survey of the home is required to make sure the home is heat-pump-ready, meaning it is sufficiently insulated. The householder may have difficulty in finding a technical assessor and organising a time for them to complete the technical assessment. In some cases, the technical assessment is conducted by a technical assessor not linked to a heat pump installation service and the householder must communicate with each party.

Loss aversion with technical assessment fee

A technical assessment can cost between €250 and €700 euro. SEAI provides householders with a €200 rebate grant conditional on installing a heat pump. Kahneman and Tversky (1979) show that

people are less likely to take a risk for an uncertain gain than to take a risk to avoid an uncertain loss. The technical assessment fee, and the rebate could be viewed as a risk of paying €250–€700 for the chance of gaining the heat pump grant. This up-front cost may deter people from installing a heat pump.

Lack of tenant support for installing unfamiliar technology in rented properties, especially in social housing

Case studies from eight large-scale renovation projects in The Netherlands showed that tenants are often reluctant to accept new and unfamiliar technologies due to concerns over increased costs, potential delays to retrofit works, and 'teething problems' common to new technologies (Hoppe, 2012). Tenants may be reluctant to install a heat pump if they believe that it will cost more or cause a delay to the upgrade of their property.

Aesthetic preferences trump energy-efficient design

An evaluation of the UK Government's Renewable Heat Premium Payment (RHPP) scheme highlighted that "radiator sizing analysis indicates that 'star rating oversize factors' as described in the Heat Emitter Guide (HEG) published by the Microgeneration Certification Scheme (MCS) may be inadequately understood or ignored due to practical and aesthetic considerations of size and location" (Lowe *et al.*, 2017). Decisions made by the householder and the contractor to limit the aesthetic impacts of a new heat pump system may reduce the system's efficiency, resulting in increased energy use.

Designers use rules of thumb when designing systems

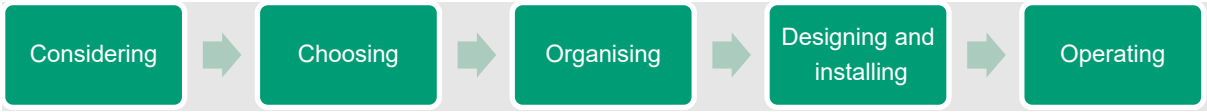
An evaluation of the UK Government's Renewable Heat Premium Payment (RHPP) scheme found that "at the time of the trials, installers predominantly assessed 'net capacity' as manufacturers' nominal capacity and not at the site-specific design conditions." The report stated that "the poor agreement between measured and estimated energy use may be due to mild winters during the trial or may suggest that calculation procedures were too complex". If the designers and installers of heat pump systems rely on rules of thumb that are not site specific, such as generic guidelines from manufacturers, default U-values, and subjective assessments of factors like ventilation, heat pump systems are likely to be incorrectly sized. When heat pumps are over-sized they are less efficient, and when under-sized systems can reduce householder comfort.

Complexity of design and install

Evidence from a small area-based scheme in the UK involving users, installers and area-based scheme facilitators suggests that the perceived complexity of the technology is a barrier to adoption among users and installers (Owen, Mitchell and Unsworth, 2013). An evaluation of the UK Government's Renewable Heat Premium Payment (RHPP) scheme also suggested that the calculation methodology used to design heat pump systems may have been overly complex, resulting in poor heat pump system design in some cases. Heat pumps are a new and relatively complicated technology compared to oil and gas boilers, which are well understood by installers. The calculation methodologies and design procedure are complicated, and this makes it easier for designers and installers to make mistakes. Additionally, the cost and efficiency implications for heat pumps are greater for errors in the calculated heat loss compared to boilers, meaning design decisions have a bigger impact on the efficiency of the system.

Low numbers of qualified heat pump installers

Early estimates suggest that an additional 1,600 FTE heat pump installers will be required to meet the target of installing 600,000 heat pumps by 2030 (Department of Communications Climate Action and



Environment, 2019). In Ireland, there may be some reluctance among existing tradespeople to retrain to become a heat pump installer. There will be a need to strike a balance between setting appropriate qualification standards for heat pump installers and avoiding introducing unnecessary barriers to entry to the profession. With too few installers, the target number of installations will not be achieved. If attention is not paid to ensuring installers are well-skilled, energy savings will not be fully realised.

Negative experiences during the installation process can create high levels of dissatisfaction (peak-end rule)

Interviews from a small area-based scheme in the UK seemed to indicate that if the installation process was not a good experience for the householder, this was reflected in the householder's assessment of the heat pumps efficacy (Owen, Mitchell and Unsworth, 2013). "One household had a long list of reasons why they were unhappy with the installation: radiator silt leaking out of removed radiators, vinyl flooring raggedly cut, removal of a thermostat including cutting a door architrave, and a flood overnight during installation". Householders use the quality of the installation process itself as a heuristic to determine their overall satisfaction with the heat pump and its performance. Negative events during the installation process are likely to reduce the chance someone will recommend the system to others even if the system performs well after installation.

Over-use of boost function and supplementary heating

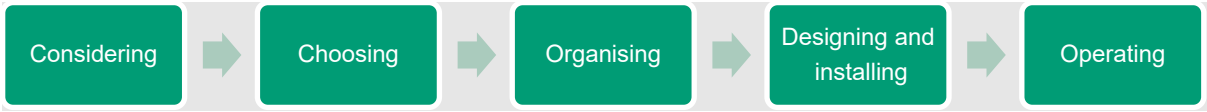
Owen, Mitchell and Unsworth (2013), and Caird, Roy, and Potter (2012) highlight that householders are likely to demand supplementary heaters and the ability to boost their heat pump systems in climates similar to Ireland's and the UK's. One participant from a UK study was described as "a user who was used to an oil system expected a rapid response, conceptualising the heat pump as a boiler. She did not allow the ASHP to run for long periods, partly due to concern about the cost of electricity if the system was on throughout the day". People rely on the mental model of how an oil/gas boiler works when interacting with their new heat pump system, which leads them to overuse the 'boosting' functionality, making the heat pump much less efficient and increasing their energy bills.

Increased need for maintenance and customer complaint management

Pinkse and Dommisse (2009) report on case studies of building contractors in the Netherlands. Contractors there report that they can find it hard to convince local authorities to install heat pumps because it makes future maintenance more complex. The authors also report that in cases where sufficient advice wasn't given to householders that poor system operation led to an increase in householder complaints. An increased need for maintenance relative to gas/oil boilers may deter householders and local authorities from installing heat pumps. Similarly, if the installation of heat pump systems is likely to lead to an increase in the number of complaints made, local authorities are likely to be more reluctant to install them.

Recharging the refrigerant in heat pumps may be forgotten by homeowners or made difficult by changing regulations

The refrigerant gases used in heat pumps needs to be replaced every 10 to 15 years. This replacement time period is similar to the usual lifespan of a heat pump which is about 15 years. Given the long-time span between installation and replacement, it is likely that homeowners may forget to replace the refrigerant when required, meaning the heat pump will become less efficient/may stop working. Further research and discussion will also be conducted to minimise any potential unintended consequences of future regulation of f-gases.



Installers may not see training the homeowner on how to use the heat pump as part of their role

A number of studies suggest that heat pump installers often fail to provide sufficient training to householders on how to operate their heat pump system. One contractor from a small case study in Yorkshire (Owen, Mitchell and Unsworth, 2013) described the extension of the technical skill set to include communication skills as "almost off-putting, really". If householders are not properly trained on how to use their heat pump system, they are likely to experience higher bills, lower comfort levels, and frustration. This will lower their willingness to recommend heat pump systems to others, slowing diffusion.

Poor design, and understanding of, heat pump heating controls

A number of studies reported that householders found heat pump heating controls difficult to use. Caird, Roy, and Potter (2012) report that the main source of dissatisfaction among users in their field trial was understanding and using the heating controls. Previous research by BEIS (2013) into the usability of regular heating controls also indicated that the majority of participants in experiments could not successfully complete simple tasks to set heating schedules or change temperature due to the poor design of heating control interfaces. A poorer understanding of a heat pump's heating controls is likely to be associated with higher bills, lower levels of comfort, higher emissions, and lower householder satisfaction. If householders are dissatisfied with their heat pump due to the complexity of its controls, they will be less likely to recommend a heat pump to others, slowing adoption.

Lack of one-stop-shop support for householders

A small case study examining the use of heat pumps to reduce fuel poverty in Yorkshire highlighted the need to provide one-stop-shop installation services to avoid the need for customers to coordinate multiple contractors or take responsibility for the quality of the installation (Owen, Mitchell and Unsworth, 2013). Without a project manager, householders can find it difficult to manage the installation of complex systems like heat pumps. Often multiple contractors and sub-contractors are involved in plumbing, design, and installation. If there is no central coordinator, contractors may assume that someone else will train the homeowner how to use the system resulting in the householder never receiving training on how to correctly operate their system.

Drivers

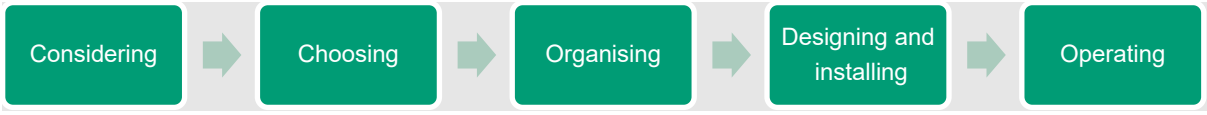
Throughout the customer journey, multiple drivers influence the likelihood that a householder or contractor will consider the installation of a heat pump.

Moving into a home that's in poor condition

A study by (Purcell, 2019) found that heat pump adoption was 1.8 times more likely when the ownership of a house changes. The author also shows that installation of energy-efficient technology is more likely at the point of change of ownership when the house is older and in poorer condition. People are more likely to improve the energy efficiency of a new home as they are in the process of making other changes to the home already. Encouraging people to consider a heat pump when the move into a new home, especially if it is an older poorer condition property may encourage adoption.

Boiler breakdown

While distress purchases can be difficult to influence, boiler breakdown still provides a window of opportunity to encourage householders to consider an alternative heating system like a heat pump. If one of the main drivers for replacing heating systems is boiler breakdown, it represents an opportunity to convince householders to consider installing a heat pump.



Case studies of pilot projects with good outcomes

Pinkse and Dommisse's (2009) interviews of Dutch contractors showed that contractors who had previous bad experiences with installing heat pumps were reluctant to consider installing them in the future. As heat pumps are still considered a relatively new technology in Ireland, contractors and housing bodies may be reluctant to install them. Highlighting positive case studies can provide assurance that heat pumps are effective and reliable.

Peer effects from heat pump installations in the local neighbourhood

There is a large evidence base showing that the first installations of solar PV panels in a neighbourhood leads to greater and quicker adoption of solar panels in that neighbourhood. This effect is strongest when solar panels are street facing and clearly visible to other homes on the street (Rode and Müller, 2019). Heat pumps installed in publicly visible areas are most likely to lead to increased rates of adoption in the neighbourhood. Similarly, highlighting local heat pump installations with signage or badges may help to boost peer effects.

Trust as a rule of thumb

Rather than weighing up the likely probability that a given contractor will incorrectly design or install their heat pump, based on the contractor's percentage of previously incorrectly installed systems, consumers use trust as a rule of thumb to assess the contractor's quality. Contractors' level of trustworthiness will influence the likelihood that a householder will adopt a heat pump.

Up-front subsidies

The evidence on the effectiveness of subsidies to increase heat pump adoption is mixed. There is some evidence to suggest that reducing up-front costs can increase adoption, especially in areas where households have access to cheap gas supplies (Troiano *et al.*, 2019). However, evidence from Canada suggested large amounts of free-riding and limited additional uptake in the face of generous up-front subsidies (Jensen, 2015). One of the largest barriers reported by households to adopting a heat pump is the large up-front investment required. Subsidies, if shown to be additional, can reduce up-front costs, encouraging more people to adopt heat pumps.

Operating cost subsidies

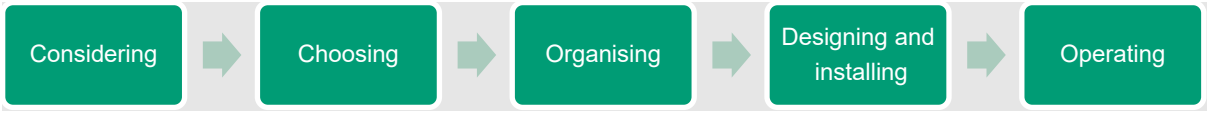
A study which tried to draw lessons from Finland's success in driving heat pump adoption and apply them to the UK suggested that providing both an up-front subsidy and an operating cost subsidy could increase heat pump adoption in the UK (Hannon, 2015). The evidence on the success of such measures is early and so should be interpreted carefully. When cheap gas is available, heat pumps may be more expensive to run for certain households. An operating cost subsidy can reduce costs and make heat pumps more competitive, potentially encouraging adoption.

Recommendations from friends, family, and contractors

Recommendations from trusted sources have been shown to be important in influencing consumer purchasing decisions in a range of domains (Ismagilova *et al.*, 2020). People rely on recommendations from others to assess the quality, riskiness, and value of a product. A study by Element Energy for DECC (Snape, Boait and Rylatt, 2015) estimated the benefit of recommendations from friends and tradesmen to be worth up to £1,700. Recommendations are likely to increase adoption.

Social proof/demonstrator projects

A number of studies have shown that familiarity with heat pump technology is an important determinant of willingness to adopt. It has been found in community renewable energy studies elsewhere in the UK that a lack of visible success or a project not being clearly rooted in local



concerns, issues and knowledge may inhibit further participation (Walker and Cass, 2007; Rogers *et al.*, 2008; Allen, Sheate and Diaz-Chavez, 2012). There is a low level of awareness of heat pumps in Ireland. Low awareness, a lack of familiarity with heat pumps, and low levels of understanding of heat pumps reduce the likelihood that households will install a heat pump. Households often report a need to see new technologies working in situ to increase their confidence in the technology.

Reliability of heating system

Studies have shown that heating system reliability is important to installers (Burely and Pan, 2010), housing agencies, and householders. Installers often perceive newer renewable technologies to be more unreliable. Households who are less familiar with heat pumps are also more likely to perceive them as being more unreliable (MacAdam, 2019). If people are not familiar with heat pumps and do not have confidence that they are a reliable heating source, less people will choose to install them. Policymakers and heat pump sellers should do more to highlight the reliability of heat pump systems.

Environmental concerns

Choice experiments (Troiano *et al.*, 2019), surveys (Mukherjee, Meles and Ryan, 2020) and field trials have shown that for a small segment of consumers the environmental credentials of a heating system are important for homeowners when determining which heating they choose to install. A small portion of the population (~20%) will be more likely to adopt heat pumps if they can be shown that heat pumps are an environmentally friendly option. **It should be noted that this is a minority of people and that the majority of people prioritise comfort, reliability, and lower up-front costs.**

Seeking comfort

The primary reason people install and replace their heating system is to maintain a level of comfort in their home. This is why when heating systems break down, especially during cold periods, people prioritise their replacement/repair. In well-insulated homes, heat pumps can provide consistent warm temperatures efficiently. People will be more likely to invest in a heat pump if they are confident that heat pumps can offer a higher level of comfort than an oil/gas boiler.

Motivated project manager passionate about installing heat pumps

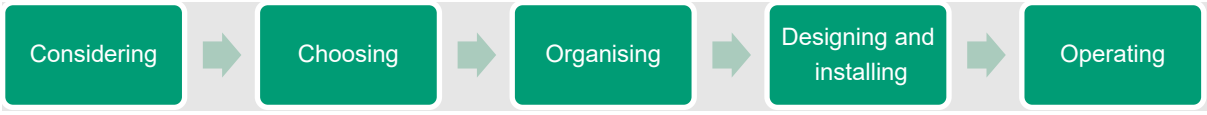
Interviews with stakeholders involved in eight large retrofit projects in the Netherlands showed that ensuring the installation of heat pumps in public authority housing requires a motivated project leader within the housing association who has strong social connections with a special interest in installing heat pumps (Hoppe, 2012). Heat pumps are still perceived as a relatively new technology in Ireland. Without the support of motivated individuals in local authorities and approved housing bodies, it is likely that status quo bias will lead to the continuation of installing oil and gas boilers.

Feasibility study grants

Case studies from the Netherlands suggest that feasibility study grants for heat pumps may encourage local authorities and housing bodies to consider installing heat pumps (Hoppe, 2012). Integrating newer technologies into large building or retrofitting projects can lead to additional costs for installers/contractors. Providing feasibility study grants can incentivise contractors to install new technology while also providing them with the opportunity to upskill members of their team.

Technologically sophisticated early adopters

It is widely accepted in the technology adoption literature that a small percentage of the population can be classified as 'technologically sophisticated early adopters'. These people tend to have an interest in technology and often enjoy being the first in their social network to adopt a technology. By



targeting people who are more likely to be early adopters, it is possible to increase the rate of adoption of heat pumps.

Desire to achieve energy bill savings and to avoid large bill increases

A survey by Mukherjee, Meles and Ryan (2020) showed that Irish households' main stated reason for purchasing any renewable technology including heat pumps was reducing energy consumption and making savings on their energy bills. It is important to note that other survey work has shown that while households may be initially motivated by potential savings, that households undertaking projects for comfort benefits are more likely to complete the installation process (Cloona, 2019). Factors such as familiarity, reliability, comfort, install time, and up-front costs are likely to be more influential on purchasing decisions than energy savings. Communicating energy bill savings from the installation of a heat pump should be considered carefully. If bill savings are the sole focus of communication efforts, they may have limited success in converting households to heat pumps. At the same time, bill savings are a motivator and accurate personalised estimates should help to attract household's attention.

Feedback on energy use from the heat pump system

Multiple studies show that providing feedback to households on their energy use is effective. Feedback is most effective when it is delivered in real time with appliance-specific breakdowns by time-of-use (Asensio and Delmas, 2016) and when energy use is communicated in broadly understood units (like euros instead of kwh), along with tips on how to save energy (Mills and Schleich, 2012). Caird and Roy (2010) and Caird, Roy and Potter (2012) report that half of the 83 users in their study were satisfied with the feedback they get from the heat pump system's controls on the energy and money they are saving, and a fifth were strongly dissatisfied. The main improvements desired were controls that provide the user with feedback on fuel and cost savings (68%) and system efficiency (58%) to help them operate their heat pump more efficiently.

Factors that influence adoption

Some people are more likely than others to install a heat pump. Understanding the socio-demographic, psychographic, and environmental factors that make some people more likely to install a heat pump will help to target communications. For example, those with higher educational attainment and socio-economic status are more likely to install heat pumps. Similarly, those living in large homes off of the gas grid relying on oil boilers are more likely to install heat pumps given the larger potential for energy bill savings. *Table 1* shows the factors that influence the likelihood that a household will install a heat pump and highlights which group within each factor is most likely to adopt a heat pump.

Table 1: Factors that influence the likelihood that a household will install a heat pump

Factor	More likely to adopt if:
Age	Younger (under 35) (Mukherjee, Meles and Ryan, 2020) Older (Retired 65+) (Roy, Caird and Abelman, 2008)
Current heating system and fuel type	Oil or electricity (Caird and Roy, 2010; Michelsen and Madlener, 2011; Jensen, 2015)
Size of house	Larger (Caird and Roy, 2010; Michelsen and Madlener, 2011; Owen, Mitchell and Unsworth, 2013; Purcell, 2019)
Disposition to technology	Positively pre-disposed to new technology (Caird and Roy, 2010; Mukherjee, Meles and Ryan, 2020)
Building energy rating of building	Lower for those moving home (Mukherjee, Meles and Ryan, 2020)

	Higher for those in existing dwellings (Purcell, 2019)
Educational attainment	Higher (Michelsen and Madlener, 2011; Mukherjee, Meles and Ryan, 2020)
Socio-economic status	Higher (Mukherjee, Meles and Ryan, 2020)

Factors that influence the realisation of savings

The realisation of both energy and monetary savings are influenced by a number of factors. It is important to understand how each of these factors contribute to the realisation of savings as it is important for the homeowner who wants to save money on their energy bills and for the realisation of national carbon emission reduction targets.

Installation quality

The installation quality of a heat pump can vary from dwelling to dwelling and from contractor to contractor. For example, pipework may be poorly insulated. If installation quality is poor, the level of savings realised will be lower.

Heat pump system design

The design of the system, such as the distance of the system from obstructions, or the sizing of the system for the heat demand of the home can affect the system's performance. If the system is not designed correctly, the level of savings realised will be lower, and if the system is undersized over-use of auxiliary heating sources can significantly increase the cost of operation.

Type of heat pump installed

There are multiple types of heat pumps available for homeowners to install; air to water, ground source, water to water, exhaust air to water, and air to air. The specific type of heat pump installed will influence the cost of the system installed and the savings produced.

Homeowners' energy tariff

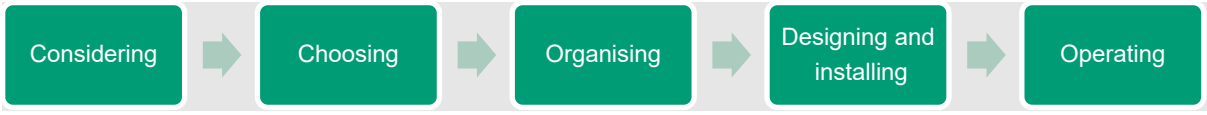
Energy tariffs determine how much homeowners pay for energy. Tariffs also determine how homeowners are charged for using energy. For example, specific heat pump tariffs are now available for homes with heat pumps that offer discounted electricity rates for both daytime and night-time use to suit the heating schedule of a heat pump. Previous studies have shown that the level of financial savings achieved by households is strongly influenced by the energy tariff they are on when using a heat pump.

Previous fuel used by homeowner for heating

The level of carbon emissions reduced from the installation of a heat pump will be partially determined by the previous fuel used by the homeowner for heating. The largest savings will be produced in homes that previously relied on electricity, solid fuel, oil and gas, in that order.

Homeowner behaviour

Homeowners interact with their heat pump system in multiple ways that affect their performance. For example, people in the home may choose to use the boost function, set higher temperature levels, change the heat pump's heating schedule, or turn the system off regularly. All of these behaviours can increase the amount of energy used and reduce the system's efficiency.



Potential solutions

From the evidence reviewed above, a number of potential solutions emerged. These potential solutions require further action/research before being implemented. Meeting the goal of installing 600,000 heat pumps, 400,000 in existing homes, will require substantial action across Government, local authorities, communities, and private businesses.

Encourage the development of 'heat as a service' providers

The offering of 'heat as a service' products in the UK creates new incentive structures between energy providers and customers that encourage decarbonisation (Catapult Energy Systems, 2019). Under the heat as a service model, consumers specify how much heat they require for different activities at specific times and pay a service provider to deliver their heating requirements. Under this model, the supplier has an incentive to deliver the heating requirement as efficiently as possible to maximise their profits. Suppliers then have an incentive to encourage the consumer to install efficient technologies like heat pumps, which can help overcome the status quo bias usually associated with consumers' heating system choices.

Encourage more frequent boiler servicing and replacement

While boiler breakdown may potentially be an opportunity to encourage homeowners to install a heat pump, narrow focusing at a time of stress often reduces the options homeowners are willing to consider. Encouraging utilities to provide boiler loans that allow people to install a temporary boiler on loan while they consider their replacement options may increase the number of people installing heat pumps. It is likely that more people could be persuaded to consider installing a heat pump during boiler servicing rather than at a time when their boiler has completely broken down. Encouraging more frequent boiler servicing and providing more intensive interventions to encourage heat pump adoption during boiler servicing may increase heat pump adoption.

Investigate the potential effectiveness of alternative heat pump financial subsidy designs

SEAI currently provides subsidies to encourage heat pump adoption, ranging from €600 to €3,500. These subsidies helpfully reduce the up-front cost of the heat pump which has been shown to be an important barrier to tackle. However, it is worth considering whether there is scope for additional subsidies or to make changes to the current subsidy to increase adoption rates further. For example, in the UK, homeowners were offered a time limited voucher to replace their heating system as part of a boiler scrappage scheme which aimed to encourage people to replace their boiler sooner than they otherwise would have (Brown *et al.*, 2020).

There is also evidence from other technologies such as solar PV and solar thermal panels that following the first installation of a solar panel in a neighbourhood, the rate of adoption among other households increases significantly (Bollinger and Gillingham, 2012). To encourage first movers to install a heat pump, a tapered incentive that provides a greater subsidy to first movers may help create local peer effects. Similarly, the use of referral incentives, where those who refer another household to install a heat pump receive a bonus subsidy, could help boost local peer effects. Further research and modelling are required to determine the suitability of such subsidies.

A number of countries have introduced operating cost subsidies where homeowners receive ongoing payments after installing a heat pump. For example, in the UK households can benefit from the domestic Renewable Heat Incentive (RHI) which provides homeowners who install a heat pump (or other form of renewable heat) with quarterly cash payments for seven years. Further research should

be conducted to determine whether operating cost subsidies could provide additional heat pump adoption in Ireland.

An innovative approach from behavioural science to using subsidies to encourage heat pump adoption also warrants further research. A paper published by Spencer (2020) outlines the theoretical case for applying insights from prospect theory to design lottery-based incentives that might encourage more people to consider installing new technologies. Spencer outlines an example applying to a residential furnace replacement programme in Canada:

> *"SaskEnergy is a natural gas company in Saskatchewan. It currently offers Saskatchewan residents a $650 rebate when they replace an existing natural gas furnace with a high-efficiency natural gas furnace. A typical high-efficiency natural gas furnace costs at least $3000. Thus, with the rebate, programme participants buying the cheapest possible high-efficiency furnace pay $2350.*
>
> *Consider an alternative option whereby participants could choose to enter a lottery where they could end up paying $3000 with a 78.3% chance but have a 21.7% chance of getting the new furnace for free. The expected value of this lottery is equivalent to the current $650 rebate, but, plugging these numbers into Tversky and Kahneman's (1992) model, we see that people should prefer this lottery option".*

Further research is required to determine whether lottery-based incentives such as those described by Spencer (2020) would be effective and practical to implement but they present an attractive policy design that may encourage more people to consider installing a heat pump.

Consider reducing the search costs associated with installing heat pumps

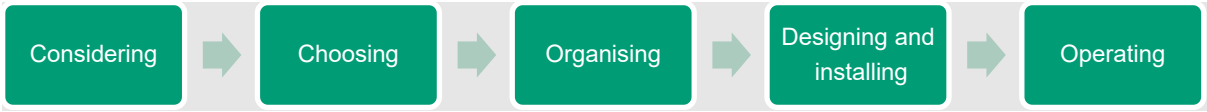
Both homeowners and contractors incur search costs when considering the adoption of a new technology like a heat pump. For example, homeowners are required to pay for a technical assessment to determine whether they are eligible for the heat pump grant. Contractors/builders considering installing heat pumps as part of a renovation project would need to determine the suitability of heat pumps for the given property type. In both cases, the provision of services that make these decisions easier, and subsidies which reduce search costs, could make heat pump adoption more likely. For homeowners, an up-front grant that reduces the cost of technical assessments may be useful. For contractors/builders/local authorities feasibility grants could help to subsidise the cost of researching the appropriateness of heat pumps for a renovation project.

Provide guidance on the design and installation of heat pump systems to minimise noise and vibration

A number of case studies from the UK found that noise and vibration can be an annoyance for residents if heat pumps are placed too close to living space or not fitted correctly (Caird, Roy and Potter, 2012). Providing guidance to heat pump installers on how to design and install heat pump systems to minimise noise and vibration could help to improve customer satisfaction, increasing the likelihood that homeowners recommend heat pumps to others.

Simplify heat pump heating controls

A number of studies have shown that homeowners find heat pump heating controls difficult to use (Caird, Roy and Potter, 2012). Simplifying the heating controls on heat pump systems will help to maximise operational efficiency while also increasing savings and customer satisfaction. Further research is needed to identify how improvements could be made. However, previous research has shown that homeowners repeatedly ask for the ability for heating controls to clearly indicate when the booster function is on/off and to provide feedback on the running costs of their current settings.



Provide additional training on heat pump system design and installation

To maximise the energy-efficiency savings from the adoption of heat pumps, it is important that systems are well sized for each home's heating demand and installed correctly to minimise energy loss. Providing training to heat pump installers on good design and installation will help to improve system quality. In particular, there should be a focus on avoiding under-sizing systems which can create dependencies on auxiliary heating systems. Ensuring that homes are well insulated and that they have an appropriate level of air tightness will also be important. Heat pump suppliers should be encouraged to develop technical support teams that can provide expert advice to installers on how to correctly design and size heat pump systems.

Consider further checks and balances for key heat pump design decisions

To ensure that heat pump systems are designed correctly, automatic check and balance systems should be implemented to highlight when highly irregular values are entered for key heat pump design variables. These could be similar to those used in the dwelling energy assessment procedures when the non-default design flow temperature is used. Standardised decision aids, checklists, and customer questionnaires should also be developed to simplify heat loss calculations for heat pump sizing and to ensure that heat pumps are designed efficiently in line with the customer's needs.

Introduce an annual award for local project coordinators who install a high number of heat pumps

Annual awards should be given to project coordinators who install large numbers of heat pumps. This will incentivise project coordinators in local authorities and in Better Energy Community projects that install heat pumps.

Use community-based social marketing to encourage adoption

Community-based social marketing is a coordinated form of marketing founded upon research in the social sciences. It demonstrates that behaviour change is most effectively achieved through initiatives delivered at the community level which focus on removing barriers to an activity while simultaneously enhancing the activity's benefits.

Heat pump adoption could be increased in Ireland by conducting community-based social marketing in areas where there is a large number of large-sized homes off the gas grid. These efforts should encourage peer-to-peer referral through the use of referral cards, garden signs, open-door events, and community meetings. These events should be supported by localised marketing (leafleting and door to door calls) as well as a national awareness campaign that builds consumer awareness and understanding of heat pumps. Simple explainer videos could help to improve consumer understanding of heat pumps.

Marketing efforts should focus on emphasising the economic savings, comfort benefits, and environmental benefits[1] of heat pumps, in that order. The outcomes of successful local projects should also be promoted among other local contractors, housing bodies and local authorities to build acceptance of the technology among all of these key stakeholders.

Establish a register of qualified recommended professionals

Given the importance of trust in a homeowner's decision to install a heat pump, it is recommended that a register of qualified recommended professionals is established. This list would feature

[1] Including improvements in local air quality where oil/solid fuel is being displaced.

professionals that consistently deliver high-quality service. Professionals on the list should be able to differentiate themselves with a logo or brand.

Create a role for an assigned certifier

To ensure that homeowners receive high quality training on how to operate their system and that the system has been installed correctly, an assigned certifier role should be created. The assigned certifier would be responsible for signing off on the final system installation. This will help to provide assurance for the homeowner and to maximise operational efficiency.

Create a registered quality mark for heat pump installers along with an independent redress board

Given the skilled nature of heat pump design and the potential for operational inefficiency if systems are poorly designed or installed, it is recommended to create a registered quality mark and independent redress board to protect homeowners. The registration process could be similar to that which exists for gas installers.

Encourage the development of energy tariffs for heat pumps

Heat pumps operate most efficiently while maintaining a consistent temperature throughout the day and night. Given that households with a heat pump are likely to have different load profiles to households with other forms of heating, the creation of energy tariffs that incentivise homeowners to operate the heat pump consistently at lower temperatures will help ensure that homeowners operate their heat pump efficiently. While one energy supplier in Ireland currently offers a heat pump tariff, it would be beneficial to encourage other energy suppliers to develop energy tariffs specifically for heat pump owners.

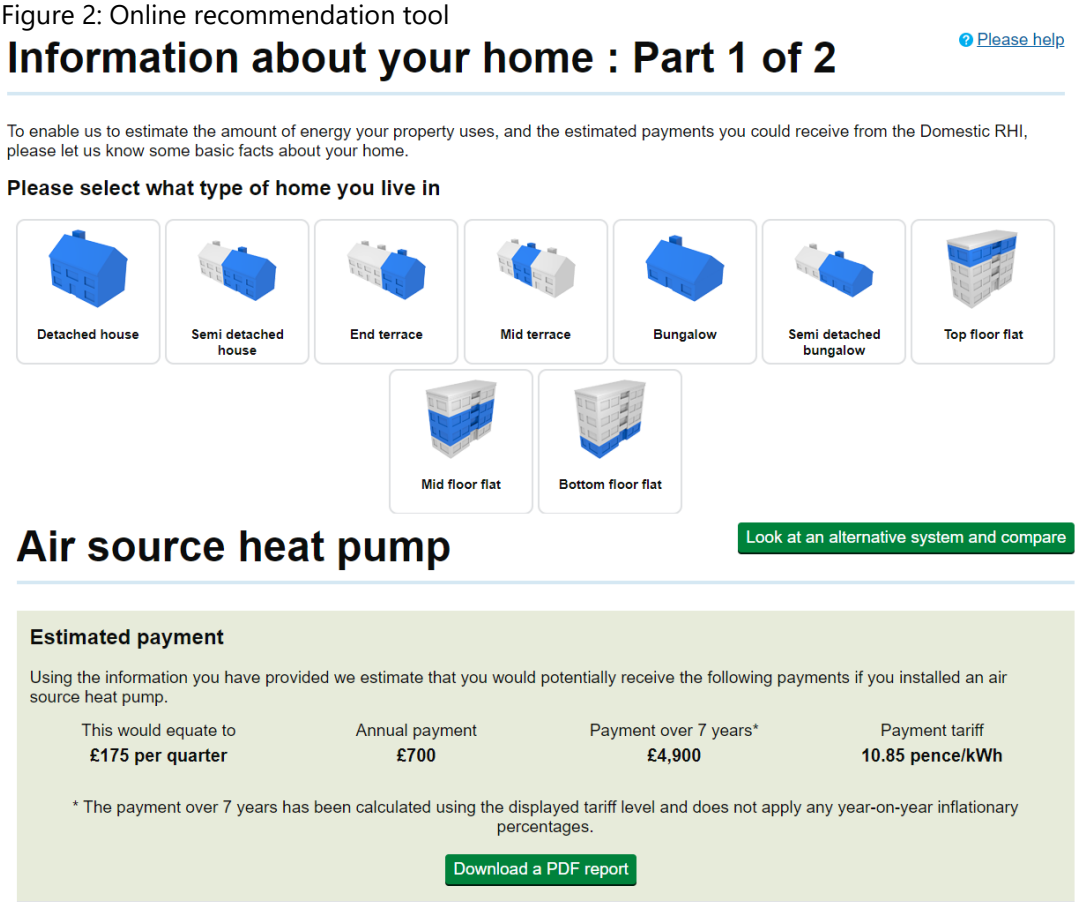
Recommendations

Based on the findings of this report, it is recommended that a number of actions be undertaken.

Develop online recommender tools

While an in-house assessment is often required to finally determine the suitability of a property for the installation of a heat pump, online tools can help people make initial decisions about whether they should consider installing a heat pump. Cost calculators and online recommender tools allow homeowners to enter basic details about their home and receive personalised advice about how much a heat pump might cost, how much they might save by installing one, or to determine if a heat pump is suitable for their home in the first place. In the UK, the renewable heat calculator allows homeowners to use their EPC data, or an online self-survey, to estimate the costs and benefits of installing a heat pump (see *Figure 2*).

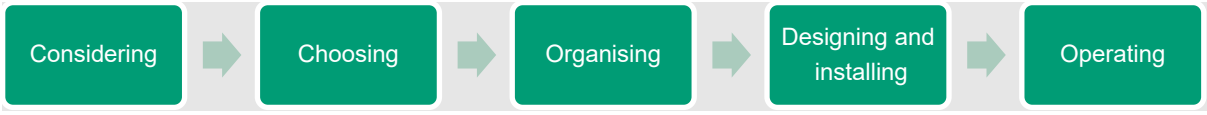
Figure 2: Online recommendation tool



Conduct research to further inform policies that could spur further heat pump adoption

There are a number of areas where further research is required to further inform policymaking. These include:

- Field studies investigating the relationship between heat pump design and operational performance;
- Field studies and modelling exercises exploring the potential for alternative financial subsidies to spur further heat pump adoption;



- Surveys and interviews investigating whether there are barriers to entry for tradespeople upskilling to become a heat pump installer;
- Lab and field studies investigating how best to train householders to operate heat pumps; and
- Lab studies to understand the design elements that help and hinder understanding of heating controls.

Work with the Environmental Protection Agency to consider the implications of changes to regulations on refrigerant gases to heat pump adoption

Future regulation of refrigerant gases may have implications for heat pump design, heat pump maintenance, and ultimately heat pump adoption. Government bodies, including SEAI, and heat pump manufacturers should work with the Environmental Protection Agency to anticipate the impact of potential changes in this regulatory area.

Introduce requirements for the provision of householder training on grant schemes

Given the consistent finding across a number of field studies that homeowners often struggle to fully understand how to operate their system correctly, and the large impact this can have in reducing efficiency savings, it is recommended to update the requirements of the heat pump grant to require that training for homeowners is provided by heat pump installers.

Encourage the development of one-stop-shops

One-stop-shops are designed to provide a single point of contact that can help simplify the customer journey of installing a heat pump for homeowners. One-stop-shops should focus on helping homeowners identify quality installers, access low cost finance, review the design of the proposed heat pump system, provide training on how to operate the heat pump efficiently, and help homeowners choose the best electricity tariff for their situation.

Provide networking events for project managers from local authorities and approved housing bodies

Networking events provide project managers with an opportunity to meet with heat pump installers, learn about positive case studies of successful heat pump commissioning and to become aware of all the supports available for heat pump installation. Events could feature speakers providing advice on how to maximise savings or maximise tenant satisfaction during heat pump installations, for example.

Provide training to BER assessors, home surveyors, boiler repairers, and heat pump installers on how to recommend a heat pump to householders

Running a number of workshops for BER assessors, home surveyors, boiler repairers, and heat pump installers on the benefits of heat pumps, and how to describe them to homeowners could help increase the number of opportunities homeowners have to learn about heat pumps. Given that homeowners report high levels of trust in the advice they receive from these experts, it will be important for plumbers and heating engineers to actively promote heat pumps.

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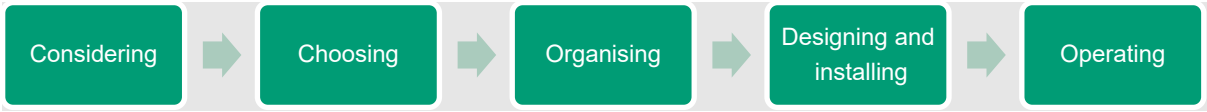

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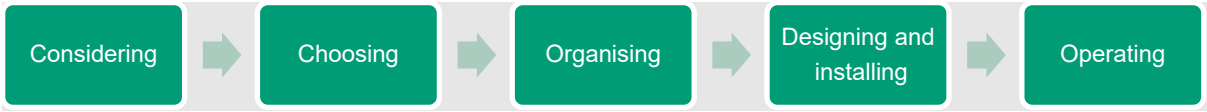

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