Department for
Business, Energy
& Industrial Strategy

# EVIDENCE GATHERING – LOW CARBON HEATING TECHNOLOGIES

## Gas driven heat pumps

September 2016

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## Gas driven heat pumps

Prepared for BEIS by:

The Carbon Trust and Rawlings Support Services

The views expressed in this report are those of the authors, and do not necessarily reflect those of the Department for Business, Energy and Industrial Strategy. This report was commissioned to inform BEIS's evidence base for future policy development.

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# Acronyms

| | |
|---|---|
| CCC | Committee on Climate Change |
| COP | Coefficient of performance |
| BEIS | Department for Business, Energy and Industrial Strategy |
| DHW | domestic hot water |
| ErP | Energy related products (Ecodesign) |
| GUE | Gas utilisation efficiency |
| GWP | Global warming potential |
| LPG | Liquefied petroleum gas |
| MCS | Microgeneration Certification Scheme |
| NCV | Net calorific value |
| NDA | Non-disclosure agreement |
| PER | Primary Energy Ratio |
| SAP | Standard assessment procedure |
| SCOP | Seasonal coefficient of performance |
| SPER | Seasonal primary energy ratio |
| SPF | Seasonal performance factor |
| SSHEE | Seasonal Space Heating Energy Efficiency |
| VRF | Variable refrigerant flow |
| VDI | Verein Deutscher Ingenieure |

# Contents

# 1. Executive Summary

## Introduction

Most low carbon pathways suggest that heat pumps will play a significant role in decarbonising the UK economy. The Committee on Climate Change (CCC) has suggested that the overall cost-effective uptake of heat pumps in UK homes could reach 2.3 million by 2030[1].

This study was undertaken by the Carbon Trust for the Department for Business, Energy and Industrial Strategy (BEIS) to inform their evidence base on gas driven heat pumps. The purpose is to help explore the role gas driven heat pumps may play in the market and inform future UK policy intervention relating to low carbon heating technologies.

This study was conducted from September 2015 to December 2015 using desk-based research, interviews with experts and stakeholders, and a stakeholder workshop. Experts from 37 organisations were interviewed across both the demand and supply side.

## The Technology

Gas heat pumps are at a relatively early stage of deployment for domestic applications. Gas heat pump technology can be split into sorption heat pumps and gas engine driven heat pumps. Sorption heat pumps can be split into two types – adsorption and absorption.

Sorption units use a thermal compressor to heat the refrigerant, whereas gas engine driven heat pumps use a mechanical compressor (similar to electric heat pumps) but where the energy source is gas. Gas driven heat pumps still use some electricity, although this is a small amount in comparison to electric heat pumps.

Absorption heat pumps can reach higher temperatures than standard electric heat pumps, typically up to 65˚C. Adsorption heat pumps are smaller, and can reach high temperatures of up to 75˚C. Domestic gas absorption and adsorption products are expected to enter the UK market in 2016

Gas engine driven heat pumps can reach temperatures of 65˚C. They are usually focused on commercial and industrial applications.

[1] Sectoral scenarios for the Fifth Carbon Budget, Technical report, *Committee on Climate Change, 2015*

Innovation is underway for this technology to develop more appropriate product capacities for domestic use, improve efficiencies, and reduce unit size.

## Current State of Market and Future Market Potential

There are no gas driven heat pumps available for the domestic market in the UK, but a domestic scale absorption heat pump is available in Europe. Commercial scale products are available in the UK. The UK sales for commercial absorption heat pumps is estimated at around 100-200 units per year. There have been significant developments to produce domestic products, as gas heating has very good familiarity in the UK.

There is a wide range of potential applications as 10-18kW products become available. Efficient, gas absorption heat pumps can reach high temperatures and therefore are suited to the retrofit market as they can be used with existing high temperature distribution systems (e.g. existing radiators), and produce domestic hot water. They could become a suitable alternative for most gas boiler replacements, subject to space requirements.

Gas driven products can also be suitable for installation in new build properties. In the medium term, they may be particularly suitable where the widespread use of electric heat pumps would require significant upgrades to local electricity supplies.

The estimated potential annual market is 100,000 to 210,000 units.

## Costs and Performance

There are few gas driven heat pump products available and the capital cost is currently higher than for electrically powered heat pumps.

An 18kW absorption product due to hit the UK market in 2016 (which is suitable for larger domestic properties) is expected to cost from £9,000 installed when launched, although costs could reduce by 20-30% or more with sufficient market growth.

The operating costs for the commercial scale 38kW absorption products have been found to be around 60-80% of an equivalent gas boiler, and the smaller version has a better seasonal space heating energy efficiency (SSHEE).

Adsorption products are now being made available in Europe and may be launched in the UK. The cost of these is likely to be considerably higher than absorption units; £17,000 upwards for the product and ground source installation.

Product costs have been reported for air to air gas engine driven heat pumps ranging from £15,000 to £30,000 for outdoor units which range in size from 25kW to 81kW. Additional equipment (including indoor units and controls) can cost from £5,000 upwards. These are used within the commercial and industrial market.

Limited performance data is available for domestic gas heat pumps as there are not currently any products on the market. In the Heat4U trial of the Robur 18 kW absorption heat pump[2], the efficiency for space heating was 132% and for heating hot water was 128%. The calculated energy savings compared to a gas condensing boiler were 30%.

## Barriers and Drivers for Deployment

The main advantage of gas heat pumps nationally is that, even if deployed widely, they would not constitute a significant burden on the electricity grid. If the scenario of heat pump uptake in 2.3 million homes by 2030 was realised through electric heat pumps, generation and grid network capacity would need to increase significantly. An extensive gas infrastructure is already in place in the UK. Because of this, gas heat pumps may have a role to play.

A number of barriers exist to large scale uptake of heat pumps, however gas driven heat pump technology can help to mitigate some of the traditional barriers.

Consumers may be more amenable to a 'gas heating system' than an electric heat pump due to their familiarity with gas boilers. Output temperatures over 60°C are generally achievable so products can be used to provide domestic hot water as well as space heating. They can potentially be used with existing high temperature radiator systems although, as for any heat pump system, to maximise efficiency the output temperature for heating should be as low as possible.

However, gas heat pumps have some additional barriers to overcome compared to standard heat pumps, such as high cost (for some product types), and a lack of measured performance data and proven track record.

## Gap Analysis

In general, confidence in the information collected is good. Stakeholders have been willing to share information across the full range of topics considered, and this information has been cross-checked against previous studies (with reasonable consistency across different sources).

As these technologies are new to market, there is limited published performance information available, and in situ verified results are limited and site specific and, for some domestic scale products, are based on prototypes.

However, the SSHEE at standard conditions is now published for all products, as required by Ecodesign (see section 0).

Further trials and modelling would be helpful to more accurately determine the potential cost and carbon savings across the range of different property types in the UK. This information may also help to stimulate demand (by convincing the demand side about real-world performance).

[2] Gas Absorption Heat Pump solution for existing residential buildings, *HEAT4U, 2013*

# Conclusions

Currently domestic gas driven heat pumps are not on the market in the UK but are expected to be launched in 2016. Presently, gas absorption heat pumps are the most competitive type of gas driven heat pumps for the UK as they offer the lowest installed cost. Adsorption products may also have a role to play if the cost can be reduced.

Gas driven heat pumps offer some advantages to combat barriers faced by standard heat pumps, but it is not clear whether these advantages are currently sufficient to lead to wide scale uptake.

Although gas heat pumps may help to overcome consumer inertia (as consumers are already familiar with gas boilers and may associate gas heat pumps as being a similar product), there are still a number of barriers to widespread deployment (such as high cost and their large size).

# 2. Introduction and Context

This study for the Department for Business, Energy and Industrial Strategy (BEIS) serves to inform their evidence base on Gas Driven Heat Pumps, including sorption (absorption and adsorption) heat pumps and gas engine driven heat pumps, to help inform future UK policy intervention relating to low carbon heating technologies. It has been carried out by the Carbon Trust, who has consulted widely with demand and supply side stakeholders.

Specifically, this report seeks to:

- Give an overview of the current state of the art
- Review the current UK market and future market potential
- Review relevant technical standards
- Gather information on system performance (rated and in-use)
- Gather evidence on current costs and the potential for future cost reduction
- Discuss the barriers to deployment
- Identify where major gaps in evidence currently exist and measures to fill these gaps

The above topics form Chapters 4 to 10 of this report.

## Scope

**Geographical scope**

The focus of the study was on products that are already available in the UK market. However, as this is a relatively new technology application, we also considered products that are available in Europe. In our literature review we examined sources from across the world to inform our research approach, particularly uptake in the European market.

**Technology scope**

The technology category addressed by this project is gas driven heat pumps up to 45kW, with a focus on domestic use.

A heat pump is a device that can transfer heat from a low temperature source, such as ambient air, water, the ground or waste heat, and raise it to a higher useful temperature.

**Gas driven heat pumps**

For the purposes of this study, gas driven heat pumps have been defined as air and ground source gas sorption (absorption and adsorption) heat pumps and gas engine driven heat pumps. For both technology groups, systems of less than 45kW capacity are within scope. The focus has been on products which can or may in future be suitable for use in domestic properties.

Efficient, gas driven heat pumps are capable of reaching high temperatures and therefore can be used with existing high temperature distribution systems (e.g. existing radiators), and to produce domestic hot water (DHW). Natural gas is a familiar fuel, used in approximately 85% of British households[3], therefore switching from a gas boiler to another heating technology with gas is a smaller step change for consumers than switching directly to electric heating. For these reasons, gas driven heat pumps could provide a viable alternative to boilers in the retrofit market.

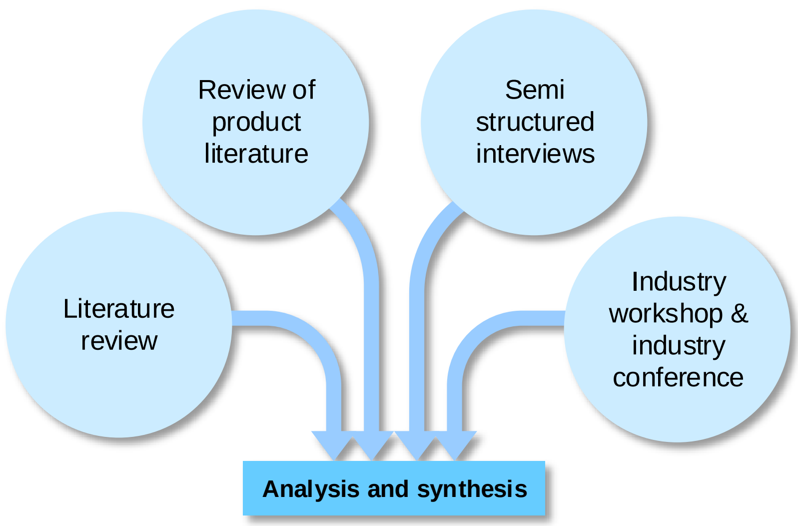
[3] RHI Evidence Report: Gas Driven Heat Pumps, *2014, DECC*

# 3. Methodology

## Research and Analysis

Our approach to this study was to divide the work into four activity streams. We began with a desk-based literature review to gather insights from published material. We also undertook an in-depth study of supplier product information (sales material and technical data). We then spoke to key stakeholders in a series of semi structured interviews. This was followed up with an industry workshop to present the initial findings and seek feedback. Using these different sources of information allowed the project team to triangulate the findings and strengthen the confidence in the resulting project findings. Figure 1 summarises the research process.

**Figure 1 Summary of the research process**




The four activity streams were used to inform the main study areas defined by BEIS which can broadly be summarised as:

- State of the art
- Market potential
- Technical standards
- System performance
- Costs
- Barriers

- Gap analysis

Figure 2 summarises the activities employed in the research stages and which key study areas they informed.

**Figure 2 An outline of the key activities and focus areas for each research method**

| | Desk based research | Review of product literature | Semi structured interviews | Industry workshop |
|---|---|---|---|---|
| Activities | • Extract publicly available information<br>• Review academic research<br>• Access current and applicable standards<br>• Source field trial information | • Access manufacturer's websites and catalogues and Ecodesign information | • Talk to key stakeholders from the supply side, demand side and other stakeholders | • Present interim findings to key stakeholders<br>• Encourage discussion between manufacturers and end users |
| Key study areas | • Technical standards<br>• Barriers<br>• Technology | • Technology<br>• System performance<br>• State of the art | • Barriers<br>• Costs and market<br>• System performance | • Market potential<br>• Barriers<br>• Gap analysis |

Evidence gathering process

### Literature review

We reviewed over 150 documents relating to both gas driven heat pumps and general heat pump technology. These provided information on the technology variants, claimed performance, market information and standards. The amount of information specifically relating to gas driven products was limited, but we have extrapolated from general heat pump information where appropriate.

### Product review

We also collated product information and performance data from supplier sales brochures, technical and installation brochures, and technical data sheets. These were obtained from manufacturer and supplier websites, and from direct contact with suppliers.

During the course of the project the deadline for manufacturers to publish technical performance information under the Ecodesign (ErP) regulations passed (see section 0). We therefore hoped to be able to obtain standardised manufacturer Primary Energy Ratio (PER) and Seasonal Space Heating Energy Efficiency (SSHEE) data from manufacturer websites. However, this information was difficult to locate, and often not immediately accessible through manufacturer websites. In many cases it was necessary to identify and speak to relevant people within the organisation to find the information.

The relevant performance information was manually extracted from manufacturer technical specifications and data fiches and analysed to indicate the level of product performance and consistency across product types.

## Semi-structured interviews

The Carbon Trust interviewed 37 key stakeholders for this study. In the interviews we critiqued our findings from the literature reviews and collected commercial information (e.g. product costs, sales), and data on in-use performance. We also discussed the current status of the market and potential for gas driven heat pumps.

The interviews were structured to examine each of the key study areas. Figure 3 shows an outline topic guide for the demand side and supply side interviews.

**Figure 3 Example of interview structure according to the stakeholder's experience with the technology**

| Supply side<br>(e.g. manufacturers; installers) | Demand side<br>(e.g. housing developers) |
|---|---|
| Products on sale and in the pipeline | Discussion of experience with heat pumps in general |
| Lab and in situ performance | In situ performance |
| Installation process | Installation process |
| Product maintenance schedules | Product maintenance schedules |
| Costs | Costs, running costs and payback periods |
| Market structure and demand | Barriers |
| Innovation and R&D | Discussion of specific experience with the technologies |
| Barriers | |

We interviewed a wide range of stakeholders including manufacturers, installers, trade associations, utilities companies and housing associations (seen in Figure 4). Our sampling was structured, using existing Carbon Trust contacts and establishing contacts with manufacturers that have relevant heat pumps in the UK or international markets. We particularly sought out stakeholders that had supplied, installed or carried out field trials of gas driven heat pumps.

**Figure 4 The distribution of 37 interviews carried out**

| | | Interviewees |
|---|---|---|
| **Supply side** | Installers | 11 |
| | Manufacturers | |
| | Distributors | |
| **Other stakeholders** | Test houses & standards bodies | 10 |
| | Utility companies | |
| | Researchers/academics | |
| **Demand side** | Local authorities | 16 |
| | Housing associations | |
| | Housing developers | |
| | *Total* | 37 |

## Stakeholder workshop

At the workshop we brought together supply and demand side stakeholders from across the heat pump sector to present our interim findings and sought to capture their feedback. The workshop was attended by 14 stakeholders.

As stakeholders were aware that the final outputs from this study could inform future policy there was a risk of gaming and bias from the participating stakeholders. To mitigate this, all figures provided have been sense checked, and compared with published information e.g. market studies, performance data, price lists etc. We sought opinions from a wide variety of stakeholders to ensure triangulation of the feedback.

# 4. Current State of the Art

## Gas heat pumps are at a relatively early stage of deployment for domestic applications, with domestic gas absorption units, and potentially adsorption units, entering the UK market in 2016

- **Gas heat pump technology can be split into sorption heat pumps and gas engine driven heat pumps. Sorption heat pumps can be split into two types – adsorption and absorption.**
- **Efficient, gas driven heat pumps can reach high temperatures and therefore be used with existing high temperature distribution systems (e.g. existing radiators), and produce domestic hot water.**
- **There have been significant developments to produce domestic scale products, as gas heating has very good familiarity in the UK.**
- **Absorption heat pumps can reach higher temperatures than standard electric heat pumps, typically up to 65˚C. An 18kW product is soon to be launched in the UK.**
- **Adsorption heat pumps can reach high temperatures of up to 75˚C. However, it is recommended that they operate at a flow temperature of 40-45˚C. Domestic scale products are already on sale in Europe.**
- **Gas engine driven heat pumps can reach temperatures above 65 ˚C. They are usually focused on commercial and industrial applications.**
- **Innovation is underway for this technology to develop more appropriate product capacities for domestic use, improve efficiencies, and reduce unit size.**

## Available Systems and System Diagrams

Within this section we describe the design and operation of the main categories of gas driven heat pumps, along with their typical configurations and applications, and pros and cons. The principle of heat pump operation is described first, using a standard electric heat pump to illustrate.

## Standard heat pumps

A heat pump transfers heat from a low temperature source such as ambient air, water, the ground or waste heat, and raises it to a higher useful temperature. Most heat pumps use a mechanical vapour compression cycle with the compressor driven by an electric motor. They make use of the fact that:

- When a substance evaporates it absorbs a large amount of energy which is then emitted as it condenses
- The temperature at which a liquid boils increases as the surrounding pressure increases
- The amount of energy required to transfer the heat is relatively small compared to the total energy transferred. Heat pumps can therefore provide an energy efficient, low carbon form of heating

Standard vapour compression heat pumps work by alternately evaporating and condensing a refrigerant. The main components are shown in Figure 5 and include: an evaporator, a compressor, a condenser, an expansion valve and a refrigerant such as R410A. Standard electric heat pumps are able to efficiently provide water flow temperatures of up to 55°C.

The performance of a heat pump is limited by the source and output temperatures which respectively need to be as high and as low as possible to minimise the amount of temperature lift the heat pump has to provide. For example a heat pump system using the ground as a source (which has a higher average temperature than the air in winter) and supplying underfloor heating at an output temperature of 35°C will have a higher efficiency than one using ambient air as the source and supplying radiators at an output temperature of 55°C.

The steady state performance of a heat pump is measured by the coefficient of performance (COP) which is the ratio of the heating capacity to the effective power input of the unit. The COP is measured in terms of delivered electricity. For gas heat pumps, Primary Energy Ratio (PER) is used as a performance measure. This is the ratio of the effective heating capacity to the total primary energy input (before any conversion or delivery losses, for example electricity generation losses). Dividing the coefficient of performance (COP) of an electric heat pump by the average generation efficiency (2.5 is used as a standard value) gives the PER, allowing the performance of the two technologies to be compared.

The SSHEE is a measure of performance averaged across a defined load profile, which is designed to represent real life use[4]. SSHEE is also measured in primary energy terms which allows comparison of different technologies using different energy sources.

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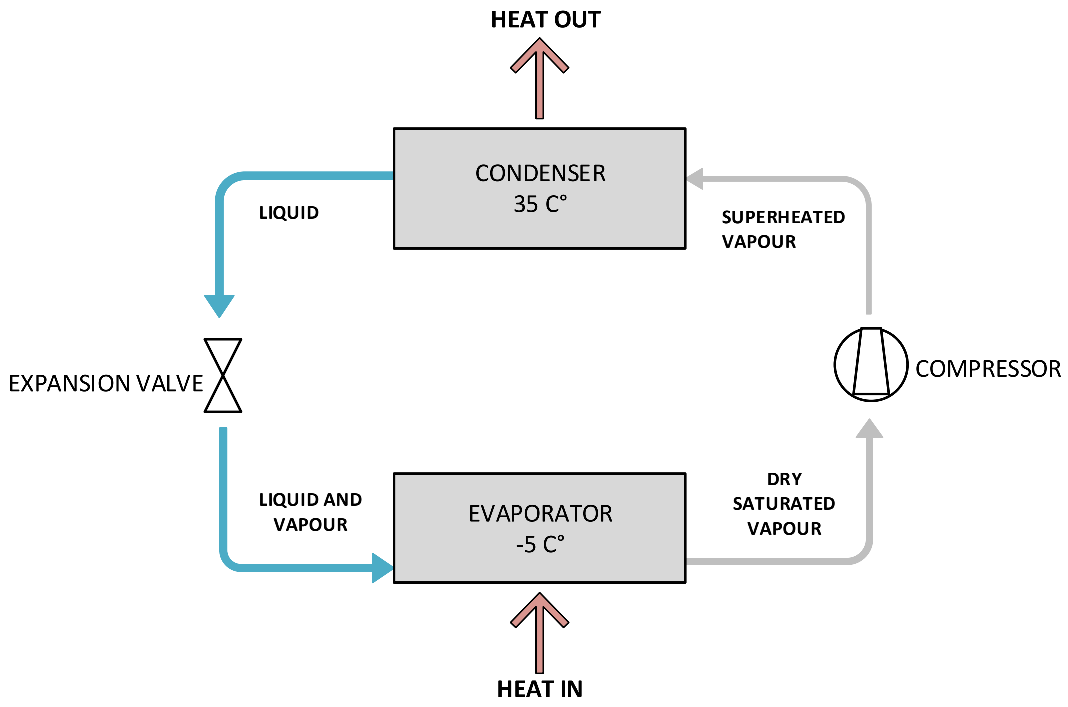
[4] As explained in Commission regulation (EU) No 813/2013, accessed November 2015, available here: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0813&from=EN

**Figure 5 Standard vapour compression heat pump circuit**




## Gas driven heat pumps

Three gas driven systems are currently available in the European market under two technology types: sorption (absorption and adsorption) heat pumps and gas engine driven heat pumps.

## Sorption

The term 'sorption' encompasses both **ab**sorption and **ad**sorption heat pumps. In a sorption cycle the mechanical compressor (as used in a standard electric heat pump described above) is replaced by a thermal compressor. The useful energy delivered by a sorption heat pump is a combination of the heat output from the condenser and heat recovered from the burner exhaust gases. Sorption heat pumps can use air, ground and water as their heat source.

In the UK, the only commercially available sorption systems are absorption units, and these are primarily focused on the commercial market (larger than 30kW in size). They are used to produce hot water for space heating and/or DHW. A smaller model targeted at the domestic householder market is expected to be available in the UK from spring 2016.

Gas adsorption heat pumps are not currently available in the UK, but are just being introduced in Europe as small water or ground source packaged units for providing domestic low temperature space heating.

### Absorption

As well as some of the key components of a standard electric heat pump (condenser, expansion valve and evaporator), an absorption system incorporates a thermal compressor which consists of an absorber, a pump and a generator, as can be seen in Figure 6.

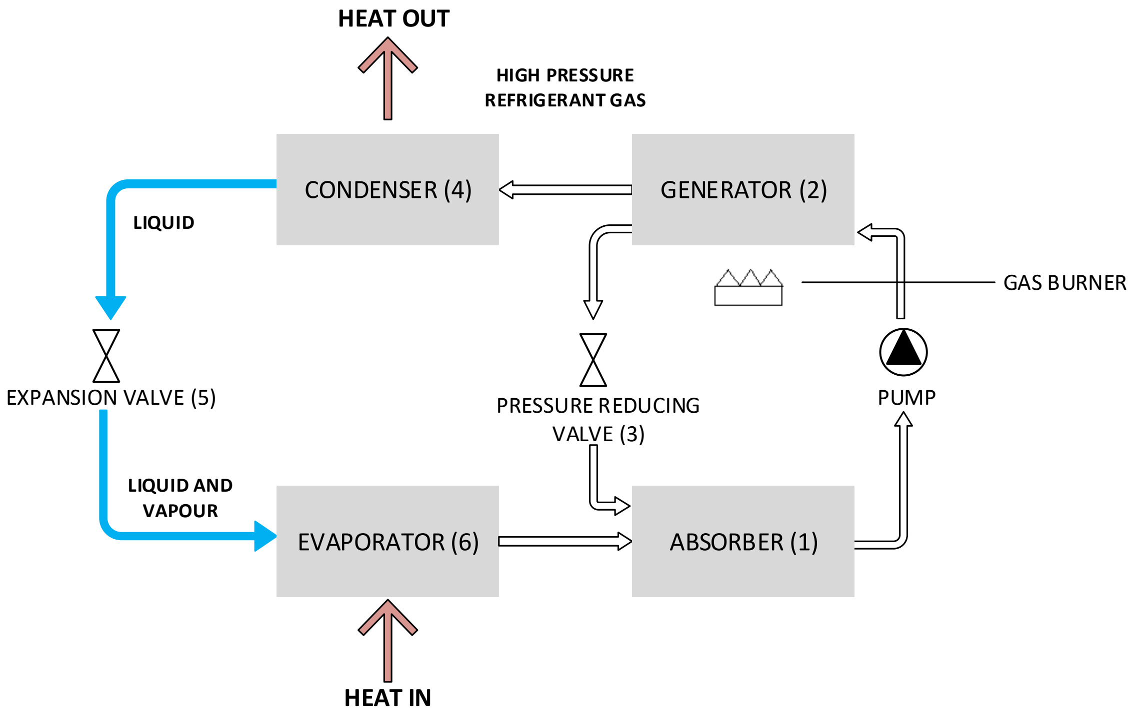
A working pair of refrigerant and sorbent is used instead of the single refrigerant used in a standard heat pump. In an absorption cycle, refrigerant vapour is drawn into a liquid sorbent in the absorber (1), allowing them to combine chemically. The resulting solution is then pumped up to the condenser pressure and the refrigerant driven out of the sorbent in the generator (2) by direct heating. The sorbent then flows through a pressure reducing valve (3) and returns to the absorber. The high pressure refrigerant vapour from the generator is condensed in the condenser (4) providing heat for the heating system. The refrigerant liquid then flows through an expansion valve (5) which reduces the pressure and temperature. The cool, low pressure refrigerant liquid enters the evaporator (6) where it absorbs heat from the ambient source and evaporates and the cycle can start again.

Ammonia and water are often used as the gas/liquid working pair. Using ammonia as the refrigerant allows the heat pump to draw in ambient heat from below freezing temperatures, making it suitable to use air as a heat source in the UK.

Absorption heat pumps can reach higher temperatures than standard electric heat pumps, typically up to 65˚C. This compares to 55˚C for standard electric systems. The output temperature and capacity is much less sensitive to reductions in ambient air temperature.

An advantage of the absorption cycle compared to a vapour compression cycle is that the pumping power to raise the pressure of the refrigerant is much lower, so the amount of electricity used by the pump in an absorption system is very small. However, there is difficulty in scaling down and keeping these products cost effective and, until now, the main product in the market has been a 38kW commercial scale unit - but a domestic scale unit is now on the market in Europe.

**Figure 6 Absorption cycle system diagram**




## Adsorption

An adsorption cycle again uses a thermal compressor, however the refrigerant vapour is adsorbed onto the surface of a solid sorbent instead of into a liquid. The refrigerant and sorbent do not combine chemically. As the sorbent cannot be pumped from the absorber to the generator, the sorbent is secured on or in a heat exchanger, which alternately heats the sorbent to drive off the refrigerant and then cools it back to a medium temperature to adsorb new refrigerant in a batch process. The heat pump usually uses a double cell reactor with the two cells running in counter phase as shown in Figure 7.

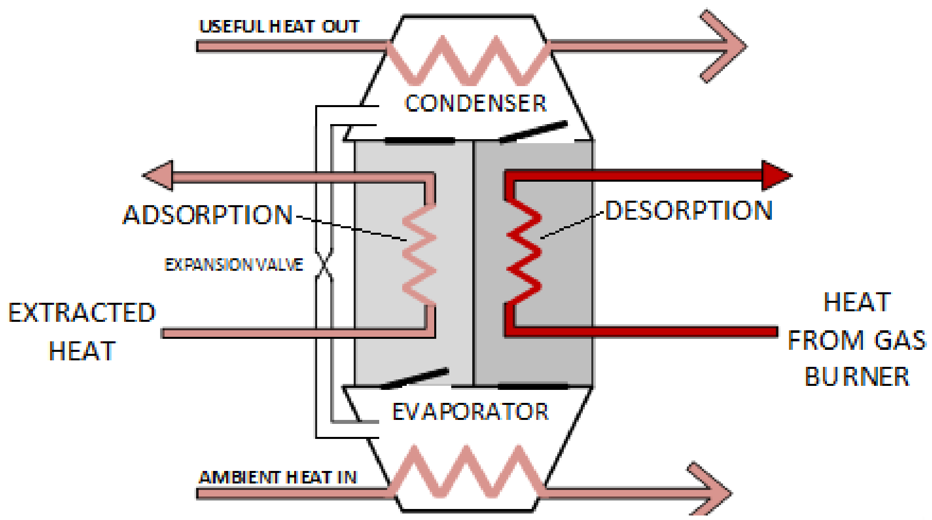
Low pressure liquid refrigerant enters the evaporator and is evaporated using heat from an ambient source. The vapour is drawn into the left hand cell and adsorbed. This process produces heat which is removed by the heat exchanger. At the same time the sorbent in the right hand cell is heated to a high temperature to drive off the refrigerant vapour it adsorbed on the previous cycle. The high pressure refrigerant vapour enters the condenser and is condensed, transferring heat to the heating system. The liquid refrigerant then flows back to the evaporator via an expansion valve to reduce the pressure. When the left hand cell cannot adsorb any more refrigerant the roles of the two cells are reversed. Some adsorption models use a three cell configuration, which allows the system to act in a more continuous process.

Adsorption systems tend to use water and zeolite as the liquid/solid working pair. Zeolites are highly porous aluminosilicate minerals, which can adsorb relatively large quantities of water vapour.

Whilst high temperatures of up to 75˚C can be attained with adsorption technology, it is recommended that the current water zeolite models operate at a flow temperature of 40-45˚C. This is lower than other gas driven heat pump technologies and is comparable to a standard electric heat pump.

It is difficult to scale up adsorption cells because the sorbent is a solid and the refrigerant is adsorbed onto its surface. The surface area increases to increase the capacity and the cells become too big. Additionally adsorption products operate at a very low pressure (millibars). This level of pressure is difficult to maintain, especially as the system gets larger.

**Figure 7 Operation of the adsorption system (cells)**




## Gas engine driven

The gas engine driven heat pumps currently available in the UK are air to air variable refrigerant flow (VRF) products with capacities from 20 to 120 kW, used to provide heating and cooling in commercial buildings, particularly where there are limitations on electricity supply. They can also provide DHW in heating mode when the air temperature is above 7°C, or by using recycled heat from the engine during cooling mode.

Gas engine driven heat pumps use standard components found in an electric heat pump: a compressor, condenser, expansion valve and evaporator. The primary difference is that in gas engine driven heat pump systems, the compressor is powered by the gas engine rather than by electricity, and heat is generated both through the refrigerant cycle and from the waste heat given off by the gas engine.

Gas engine driven heat pumps still use a small amount of electricity, although in many models the gas engine is also used to drive a small generator, offsetting the additional power required to run the heat pump.

The majority of gas engine driven systems are VRF air to air, but they can also provide domestic hot water with the addition of a hydrobox (which contains a heat exchanger to transfer heat from the refrigerant to the water circuit) to allow use with a water based heating system.

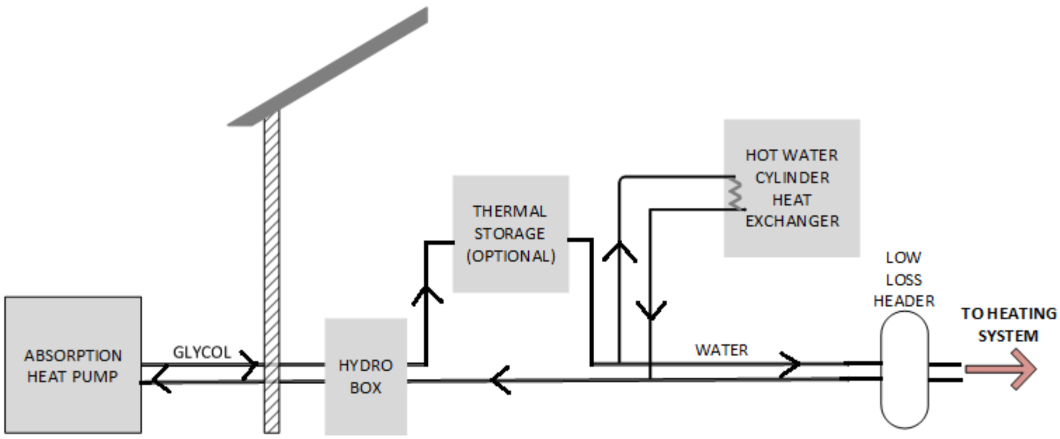
# System Applications

## Absorption system application

The application of absorption heat pump systems is primarily commercial, due to the size of the currently available absorption products (generally >30kW). This may change in 2016 with the introduction to the UK of a product sized for the domestic market. Absorption units may be installed individually or several units may be connected together to form a cascade system. The units can be connected to different heat source technologies, depending on whether air, ground or water is used as the ambient heat source. A basic absorption system is shown in Figure 8. The heat pump is usually mounted externally as it contains ammonia, and the heat is transferred to and from the building using water with antifreeze (glycol) added to provide protection from freezing. Inside the building a hydrobox containing a heat exchanger provides hydraulic separation between this glycol circuit and the hot water heating distribution circuit.

Due to the ability to produce high output flow temperatures, gas absorption heat pumps can be retrofitted to an existing high temperature heating distribution system, without the need to replace radiators or install underfloor heating. They can also provide domestic hot water.

**Figure 8 An air source absorption heat pump system**

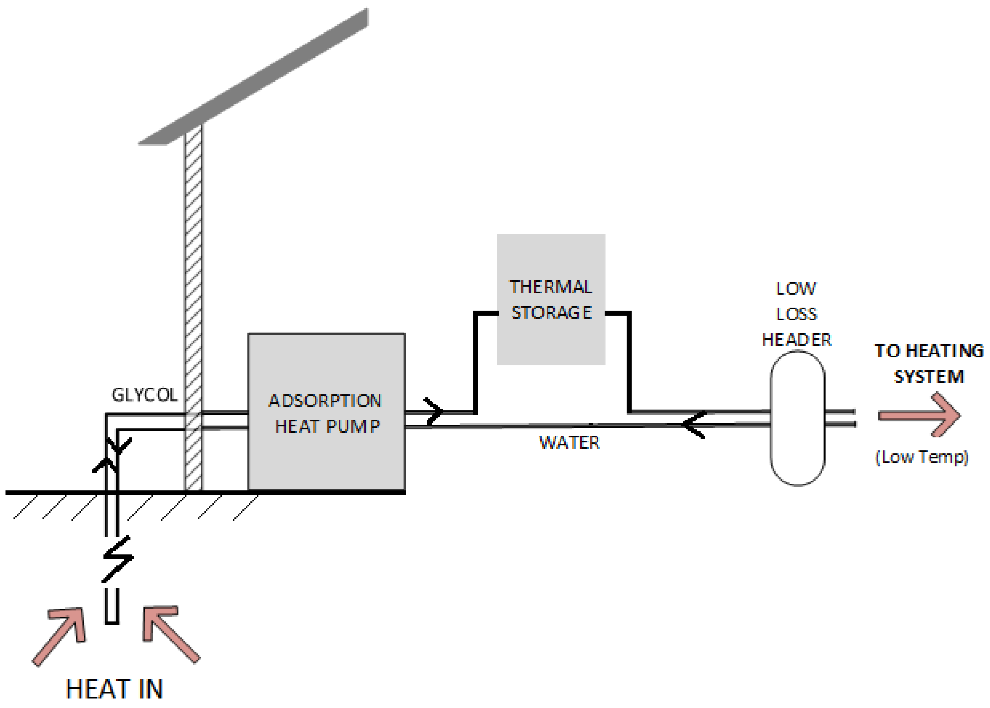


## Adsorption system application

Adsorption heat pumps are most commonly installed in domestic properties due to their size constraints. Unit kilowatt capacities of adsorption heat pumps tend to be below 15kW and, due to difficulties in linking several adsorption units in a cascade system, they are generally installed as single units. Because the refrigerant is water, to avoid the risk of freezing, the source temperature has to be above 5°C. Therefore they cannot use air as a heat source; they use ground or solar thermal energy. This requires boreholes or horizontal collectors for the former, and a solar collector for the latter. A basic adsorption system is shown in Figure 9.

As adsorption heat pumps are recommended for operation at lower temperatures, they are potentially better suited to new build properties with a low temperature heating distribution system, or those in which it is feasible to upgrade at least some of the heat emitters (radiators).

**Figure 9 A ground source adsorption heat pump system**

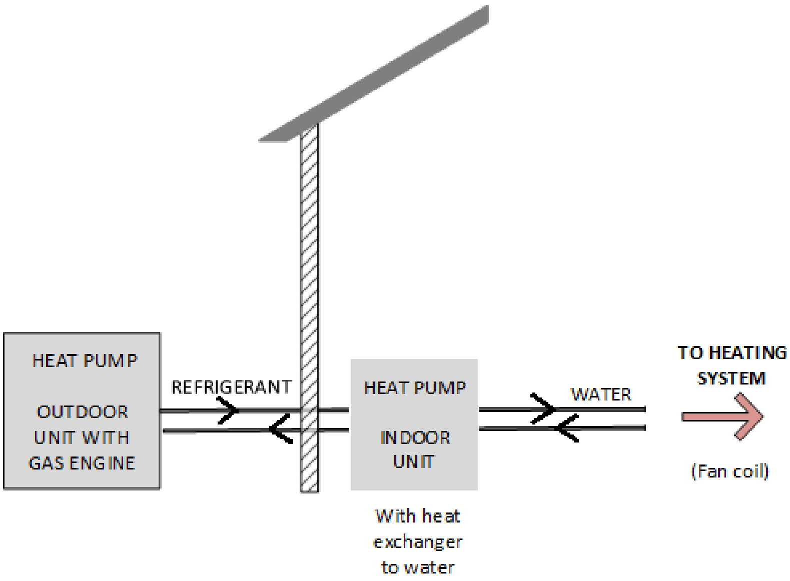



## Gas engine driven system application

Gas engine driven heat pumps are most commonly used for commercial buildings, and, to a lesser extent, for industrial applications. In order to reach the required scale for large buildings, multiple units are frequently installed in a single system, using a cascade structure. The gas engine driven cycle can be used as standalone equipment to replace a gas boiler or another distribution system, or alternatively it can work in combination with these. To fulfil hot water as well as space heating needs, a hydrobox can be fitted to the system to enable domestic hot water production and to allow use with water based heating systems. Due to the high temperature operation of gas engine driven heat pumps, they can be retrofitted to most existing conventional heating distribution systems, without the need to replace high temperature heat emitters, although the use of low temperature radiators or fan coils will be more efficient.  A basic gas engine driven system is shown in Figure 10.

Gas engine driven products are best suited to buildings with high demand for heating and cooling and long running hours. For this reason, they are unlikely to be suitable for the domestic market in the short to medium term.

**Figure 10 An air source gas engine driven system diagram**



## System Variations

Table 1 explores the relative advantages and disadvantages of different types of gas driven heat pumps.

**Table 1 Advantages and disadvantages of different types of gas driven heat pumps**

| System variation | Advantage(s) | Disadvantage(s) |
|---|---|---|
| **Absorption** | • Can be used in large premises<br>• Can reach high temperatures<br>• Established technology in the UK<br>• Use of ammonia which is a natural refrigerant with no global warming potential. | • Difficult to reduce size to suit domestic properties<br>• Use of ammonia as the refrigerant which is toxic, although it is a sealed unit and meets relevant safety regulations. Specialist training is required to handle ammonia. |
| **Adsorption** | • Can have a smaller ground loop than other ground source heat pumps<br>• Environmentally friendly, non-toxic and low cost refrigerant (commonly water) | • Difficult to increase size to suit larger properties<br>• Not a continuous process and may need thermal storage<br>• Current products require a ground loop which is expensive and needs space (cannot use air as a heat source) |
| **Gas engine** | • Air to air systems can provide both heating and cooling<br>• Can output at high temperatures<br>• Retains efficiency well as outside temperature falls | • Designed for air distribution systems so requires a separate hydrobox to be able to function as air to water for wet heating systems |

## Potential Innovation

Recent technical developments have been seen in gas driven heat pump technology for the domestic market. A smaller, 18kW absorption cycle heat pump suitable for domestic application is expected to enter the UK market in 2016, supplied by Robur. The reduced size of this product from both a power and physical space requirement perspective will allow absorption technology to be installed in a single domestic property, whereas previously this was only feasible for groups of properties or commercial buildings.

Adsorption cycle heat pump design has also been optimised to suit UK heating demand patterns and single phase voltage requirements. Whilst adsorption products are not yet available in the UK, this design optimisation allows them to be introduced in the future.

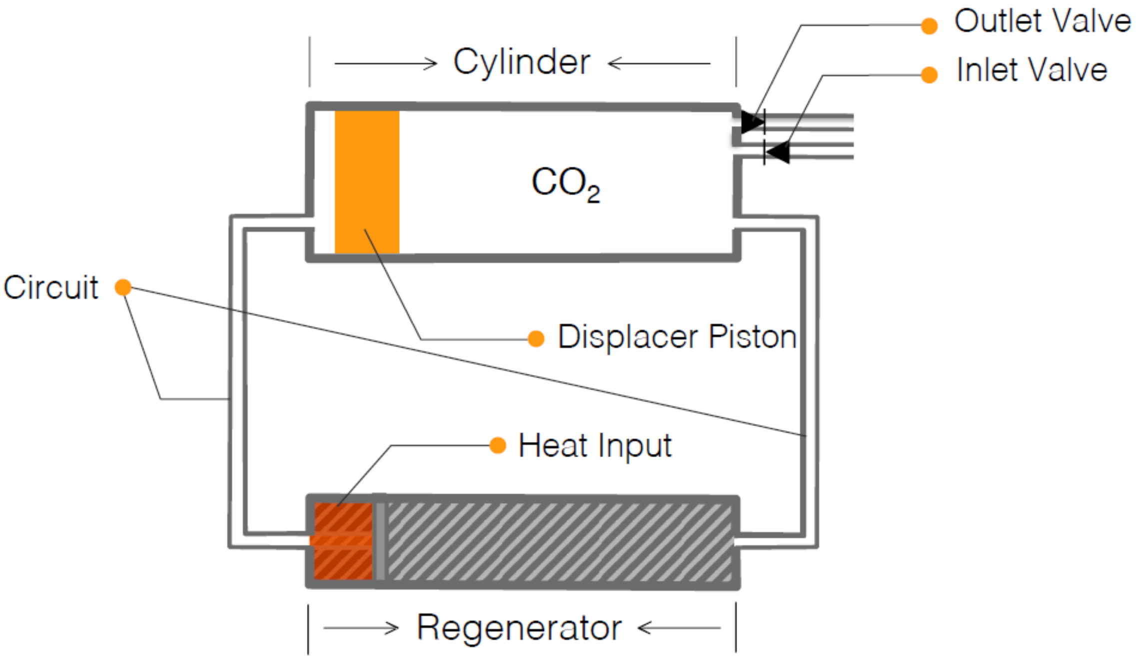
Several areas of innovation may be realised within 18 months. A trend is not just to improve efficiencies but also to reduce the space requirements of products.

The first of these is a water/zeolite adsorption product is being developed by Stiebel Eltron and Sortech which uses a modified adsorbent surface containing fibre mats to make the unit more compact.

Secondly, boostHEAT is the development of a heat pump boiler due for release in approximately 2017. This technology uses a specially designed thermal compressor to operate an air to water $CO_2$ heat pump as seen in Figure 11. It is a reciprocating machine which uses thermal energy from a burner to increase the pressure of the working fluid, carbon dioxide. boostHEAT aims to address one of the key problems faced by current heat pump technology, namely to provide the same high performance achieved in space heating when supplying domestic hot water. This product is reported to reach a COP of 1.65, whereas most of the gas driven products reach around 1.3. The recommended applications will be relatively small, predominantly in the domestic sector and small offices.

Thirdly an absorption cycle using a salt and water as its working pair is being developed by ClimateWell. This technology is based on lithium chloride, a solid that adsorbs water vapour. It has the potential to perform well in lower outdoor temperatures, and it also allows an element of energy storage. It is not currently being incorporated into any commercial products.

**Figure 11 The boostHEAT system schematic**




Source: boostHEAT

Other techniques that are being developed in the longer term include an adsorption product using an ammonia/carbon working pair led by Sorption Energy. This is a small model at 10kW, and has the advantage of being no larger than a gas boiler, therefore allowing box for box replacement. The product is being developed at Warwick University and focuses on reliability and compactness at an acceptable efficiency. In order to be brought to market as a viable product, an industrial partner would be needed to build a complete heat pump system, as Sorption Energy is only developing the thermal compressor.

A novel heat pump using a reciprocating machine, based on the Vuilleumier cycle which is being developed by Thermolift in the USA has demonstrated high efficiencies but is at an earlier stage of development.

# 5. Market and Product Review

## There are no gas driven heat pumps available for the domestic market in the UK, but a domestic-scale absorption model is available in Europe, and is due to be released in 2016

- **We have highlighted six manufacturers of gas driven heat pumps that currently operate in the UK, or may do so in the near future.**
- **Absorption and adsorption products that are suitable for domestic use have been developed and trials undertaken.**
- **Sales of commercial scale absorption products are estimated at around 100-200 units per year.**
- **There is a wide range of potential applications as 10-18kW products become available. They could become a suitable alternative for most gas boiler replacements.**
- **In the medium term, gas driven products may be particularly suitable where the widespread use of electric heat pumps would require significant upgrades to local electricity supplies.**
- **Gas driven heat pumps are suited to the retrofit market as they can make use of the existing high temperature heating distribution systems, sometimes with modifications. They can also be suitable for installation in new build properties.**
- **We have estimated the potential annual market at 100,000 to 210,000 units.**

## Product Review

There are relatively few gas driven heat pump products currently available on the market in the UK. Several additional models are available in the European market. A sample of the manufacturers and products can be found in Table 2. Where possible we have included the range of PERs at A7/W55 (ambient air source of 7°C and output water at 55°C) for sorption products or A7/A20 (ambient air source of 7°C and output air temperature at 20°C) for gas engine driven products, and the SSHEE at 55°C under average climatic conditions for each product range.

**Table 2 Manufacturers and product ranges**

| Manufacturer | Product range | System type | Working pair or refrigerant | Rated output range (kW) | Max temp - space heating | Monobloc or split | Ground or air source | PER (A7/W55; A7/A20)* | SSHEE range (%)** | Additional information |
|---|---|---|---|---|---|---|---|---|---|---|
| **Robur** | GAHP Series | Absorption | Ammonia/ water | 38 (18 to be introduced to UK in 2016) | 60-65°C | Monobloc | Air, ground or water models available | 1.1 – 1.28 for 38kW, 1.38 for 18kW | 103 - 127 | Several manufacturers including **Worcester Bosch, Remeha and Lochinvar** offer modified/rebranded versions of the 38 kW Robur product. |
| **Vaillant** | ZeoTHERM VAS | Adsorption | Water/ zeolite | 10, 14 | 75°C | Not given | Solar collector | Not given | 112-115 | The range is currently available in parts of Europe, but not in the UK. |
| **Viessmann** | Vitosorp 200F | Adsorption | Water/ zeolite | 10, 14 | 75°C | Monobloc | Ground or solar collector | Not given | 109 | A UK launch has been planned but an expected release date has not yet been declared. |

| Manufacturer | Product range | System type | Working pair or refrigerant | Rated output range (kW) | Max temp - space heating | Monobloc or split | Ground or air source | PER (A7/W55; A7/A20)* | SSHEE range (%)** | Additional information |
|---|---|---|---|---|---|---|---|---|---|---|
| **Aisin/ Tecnocasa** | GHP E Series | Engine-driven | R410A | 25, 31.5, 40, 50, 63 & 80 | 47°C | Monobloc | Air | 1.73 – 1.83 | Not applicable (for W55 output) | Available in the UK as air to air, or air to water heat pumps. PER refers to air to air product supplied in UK with heat recovery (@A7/A20) |
| **Panasonic** | Eco G | Engine-driven | R410A | 30, 50, 63, 80, 95 | 75°C | Not given | Air | Not given | Not given | Eco G products are all air to air. |
| **Yanmar** | Eco Compact Series | Engine-driven | R410A | Not given | 60°C | Not given | Air | Not given | Not given | There are plans to introduce this model to the UK, and a model adapted to better suit UK requirements and climate is currently under development. |

* Primary Energy Ratio (PER) is at the standard rating condition measured according to EN 12309 for sorption heat pumps, and according to EN16905 (when published) for gas engine driven heat pumps. PER Is quoted at A7/A20 for air to air products and at A7/W55 for air to water products
** Seasonal Space Heating Energy Efficiency (SSHEE) is for an output water temperature of 55˚C and average climate conditions measured according to EN12309 (for sorption heat pumps) or EN16905 (when published) for gas engine driven heat pumps)

# Market Review

## Market size and potential

In the UK the overall domestic heat pump market is still small. The heating market is dominated by boilers (which make up 85% of the market[5]), and by far the most widely installed type of boiler is the gas condensing boiler. Heat pumps have gained more traction in other countries. According to the European Heat Pump Association heat pump sales (of all types) in key European markets in 2014 were [6]:

- France – 193,100 units
- Sweden – 95,500 units
- Germany – 68,400 units
- UK – 18,700 units

The current UK heat pump market suffers from high capital cost, a low awareness of the product and some mistrust in the technology, especially when the competing technologies are so well established.

Currently there are very few gas driven heat pumps available and sold in the UK market and very little market data. Sales figures are available for commercial applications.

In 2011 there were estimated to be 150 gas absorption sales a year[7]. Carbon Trust research in 2015 estimated sales of absorption products at 100-200 per year. Gas engine driven products are currently available from two manufacturers in the UK, and sales figures are confidential. Compared to other heat pump technologies, the current gas driven heat pump market in Europe is small, estimated in 2014 to be 15,000 – 20,000 sales per year across the continent.[8]

Gas heat pumps are currently particularly suited to a niche market – where a homeowner might have to pay to upgrade their local electricity grid connection to install an electric heat pump, because their electricity capacity is restricted by their supplier (e.g. in rural areas at the end of a distribution line). There is currently a very small application of gas driven heat pumps in new build developments. In interview, a design engineer described how they had installed several gas absorption heat

[5] RHI Evidence Report: Gas Driven Heat Pumps, *2014, DECC*

[6] European heat pump markets and statistics report, *Thomas Nowak, EHPA, 2015*

[7] UK Market Update, BSRIA, *Abdel Eljidi, 2011*

[8] Carbon Trust estimate, *2015*

pumps in their developments over the past four to five years. They were specified for new build projects, motivated by obligatory renewable energy targets.

**Market potential**

BSRIA figures estimate that total heat pump sales are around 18,700 units a year in the UK[9]. BSRIA estimates that around 10% of these sales are commercial, so the total commercial sales are approximately 1,500-2,000 units per year. As stated earlier, sales of gas absorption heat pumps in 2014 were estimated to be between 100 and 200. Taking the average of 150, then gas absorption heat pumps accounted for approximately 10% of the commercial heat pump sales.

Assuming that they could capture a similar proportion of the domestic market (i.e. 10%), and assuming a current domestic market of roughly 17,000 units per year, the gas driven heat pumps market could be around 1,700 units per year in the short term.

The potential market in the UK as a replacement for a gas boiler is substantial because of nature of the UK's housing infrastructure (85% of homes have a gas boiler[10]). The key to the growth of this market is for this technology to become a cost effective consumer choice for gas boiler replacements. As discussed in section 8, the cost for all types of gas driven heat pumps is several times higher than for gas condensing boilers. Significant cost reductions may be possible with higher deployment rates, but achieving wide uptake is also likely to require education of consumers to persuade them that gas driven heat pumps provide more efficient heat, and are a feasible alternative to gas boilers. The technology is relatively straightforward to retrofit, and it can be suitable for use with standard high temperature radiators.

However, stakeholders felt that financial incentives and/or regulation are also likely to be required to achieve widespread uptake in the medium term, in order to overcome the high capital cost, and consumer inertia.

There is also potential in new build properties, again as an alternative to a conventional gas condensing boiler, although this potential market is around eight times smaller than the retrofit market.

HEAT4U predicted the future market split between existing and new dwellings to be 38% for new builds and 62% for existing dwellings[11].

**Estimate of effective market potential**

In order to estimate the potential size of the market opportunity for heat pumps, we undertook a high level assessment of the impacts of property type, property age (i.e. to create an estimate driven by property physical space limitations), and the

[9] Heat pump market UK, *Socrates Christidis, BSRIA, 2015*

[10] RHI Evidence Report: Gas Driven Heat Pumps*, 2014, DECC*

[11] Gas Absorption Heat Pump Solution for Existing Residential Buildings, *Heat4U, 2014*

composition of annual heating replacements in the market. Given the coarse nature of this assessment we sought to establish a range of possible outcomes.

There are approximately 27 million domestic dwellings in the UK (excluding NI) and in approximately 23 million (85%) of these, gas boilers are used to provide heating and/or hot water[12]. Heating and hot water for the remaining dwellings are supplied through off-gas-grid means such as solid fuel, oil or electricity.

Our analysis suggests that between 3.4 and 7.3 million domestic dwellings may be suitable for hybrid or gas driven heat pumps when gas availability and internal or external property space limitations are taken into account. Advances in technology that reduce heat pump equipment size or reduce the noise emitted from outdoor units are likely to steadily increase number of dwellings for which heat pump technology could be used.

The annual market for domestic heating replacements is approximately 1.67 million units[13] of which 1.5 million units are of gas boilers[14]. Comparison with the total stock of UK domestic dwellings gives an annual replacement rate of 6.5% of the installed base. However, analysis of research undertaken by Ipsos MORI and the Energy Saving Trust[15] on drivers for homeowners' desire to purchase a new heating solution (e.g. distress purchases, replacement parts hard to find for existing solution, refurbishment) indicates that only 44% of the time would the heat pump supply chain be likely to meet the customer's needs.

Factoring in the annual replacement rate and the drivers for heating system purchases, to the size of the addressable market gives annual market potential of between 97 and 210 thousand dwellings per annum.

This potential is shared between gas driven and hybrid heat pumps, which mostly share a common target market. The likely relative uptake of the two technologies will depend on a variety of factors. Some of these are explored in the summary report[16].

### Product availability

There are currently no domestic gas driven heat pumps available in the UK market (with an 18kW gas absorption heat pump suitable for large domestic properties due to be released to the market in 2016).

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[12] Sub-national consumption statistics, *DECC, 2014*

[13] Report IEA HPP Annex 42: Heat Pumps in Smart Grids. Task 1 (i): Market Overview United Kingdom, *Delta Energy & Environment, 2014.*

[14] Gas driven heat pumps: Market potential, support measure and barriers to development of the UK market, *R.E Critoph Warwick University, 2013*

[15] Homeowners' Willingness To Take Up More Efficient Heating Systems, *Ipsos MORI and the Energy Saving Trust, 2013.*

[16] Evidence Gathering – Low Carbon Heating Technologies, Domestic High Temperature Heat Pumps, Hybrid Heat Pumps and Gas Driven Heat Pumps: Summary Report, DECC, 2016

## Market segmentation and competition

Small or micro combined heat and power (CHP) units could be a future competitor for gas driven heat pumps; these are close to market. The systems can be powered by gas and generate a small amount of electricity as they are used. They have the benefit of being similar in size, appearance and function of a standard gas boiler and are currently eligible for a financial incentive.

Hybrid heat pumps are also direct competition for gas driven heat pumps. Table 3 shows a basic comparison between gas sorption heat pumps and gas boilers, and other heat pump types.

**Table 3 Gas sorption heat pump competiveness versus existing technologies**

| | Gas boiler | Gas driven absorption | Gas driven adsorption | Domestic hybrid heat pump | Low temp electric air-source heat pump |
|---|---|---|---|---|---|
| Capital cost | Low cost | High cost | Highest cost | Moderate cost | Fairly high cost |
| Installation cost | Low cost | Moderate cost | High cost (as ground source) | Moderate cost (may need to upgrade some radiators) | Fairly high cost (often need radiator upgrade and new hot water cylinder) |
| Running costs | Fairly low cost, dependent on gas prices | Lower cost than gas boiler or hybrid heat pump depending on relative gas/electricity prices | Lower cost than gas boiler or hybrid heat pump depending on relative gas/electricity prices | May be lower cost than gas boiler depending on relative gas/electricity prices | Often higher cost than gas boiler depending on relative gas/electricity prices |
| Consumer familiarity | High familiarity and favourability | Not yet available in the UK at domestic size | Not yet available in the UK | Low familiarity | Some familiarity |

# 6. Standards Review

## UK and EU performance standards are available to determine the performance of sorption heat pumps, and are at an advanced stage for gas engine driven products

- **BS EN 12309 defines the conditions for measuring performance of sorption products.**
- **A standard is being developed for measuring performance of gas engine driven heat pumps: prEN16905**
- **There are also standards governing the design and performance measurement of systems as a whole, as well as specific aspects such as safety and noise.**
- **All products must now meet the requirements of the Ecodesign Directive (2009/125/EC), notably the Ecodesign and Energy labelling requirements for space heaters and, where relevant, water heaters. This includes publishing information on seasonal space heating energy efficiency, and meeting a minimum energy performance standard.**

## Overview of Standards

Gas driven heat pumps are covered by some existing British standards, most of which are also European Standards. A detailed study of available performance standards was carried out as part of IEA HPP Annex 34 Thermally driven heat pumps for heating and cooling[17] and this identified a number of gaps and inconsistencies in the standards covering sorption heat pumps. Many of these are currently being addressed. Revised performance standards for gas sorption heat pumps have recently been published and performance standards covering gas engine driven heat pumps have been drafted and are likely to be approved in the near future. There are still some gaps however as the sorption standard only covers products with hydronic heating systems and the standard for gas engine driven heat pumps covers space heating and cooling but not water heating.

There is little specific guidance on system design and installation although sorption heat pumps are included in the Microgeneration Certification Scheme.

Products are included in certification schemes in the UK and Europe.

[17] IEA HPP Annex 34 Final Report, Report No HPP-AN34-1, *Heat Pump Centre, 2014*

## Current UK and EU standards

### Rated and seasonal performance and safety of gas-fired sorption appliances

BS EN 12309: 2014/2015 Gas-fired sorption appliances for heating and/or cooling with a net heat input not exceeding 70 kW.

This standard covers rated and seasonal performance. It also considers safety and includes provisions for hybrid appliances. The test conditions for four heating modes are specified: low temperature (35˚C), medium temperature (45˚C), high temperature (55˚C) and very high temperature (65˚C). The standard covers air to water, water to water and brine to water heat pumps, and is relevant for absorption and adsorption technology.

### System efficiency

BS EN 15316-4-2:2008 Heating systems and water based cooling systems in buildings. Method for calculation of system energy requirements and system efficiencies. Part 4-2. Space heating generation systems, heat pump systems.

This standard is relevant for absorption heat pumps and combustion engine driven vapour compression heat pumps. It details how to calculate the energy efficiency of a heat pump heat generating system. This standard is being revised to cover hourly and monthly calculation.

The Verein Deutscher Ingenieure, VDI 4650-2: 2013, Simplified method for the calculation of the annual coefficient of performance and the annual utilisation ratio of sorption heat pumps - Gas heat pumps for space heating and domestic hot water.

This standard was developed by the Association of German Engineers and the calculated performance is used as the basis for German Federal support schemes.

## British and European standards under development

### Rated and Seasonal performance of Gas-fired endothermic engine driven heat pumps

PR EN16905: Gas-fired endothermic engine driven heat pumps.

This standard covers the requirements, test methods and test conditions for rating and performance calculations of gas-fired endothermic engine driven heat pumps not exceeding 70 kW at standard rating conditions using air, water or brine as the heat transfer medium and used for space heating and cooling. It is still under development and of drafts of parts 1, 3, 4, and 5 inviting comments were published in September.

## Ecodesign for energy related products directive (ErP)

All products must meet the requirements of the Ecodesign Directive (2009/125/EC). The directive requires manufacturers to produce products that meet minimum performance standards and that these products are clearly labelled using a standard methodology. This is implemented through specific Ecodesign regulations and the Energy labelling regulations. The regulations covering gas engine driven heat pumps are:

- Commission regulation (EU) No 813/2013 Ecodesign requirements for space and combination heaters setting minimum performance requirements for heat pumps for water based space heating up to 400 kW.
- Commission delegated regulation (EU) No 811/2013 Energy labelling of space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device setting requirements for energy labelling and product data for heat pumps providing water heating up to 400 kW
- Commission regulation (EU) No 814/2013 Ecodesign requirements for water heaters and hot water storage tanks setting minimum water heating energy efficiency requirements for products with a rated output up to 400 kW and hot water storage tanks with a volume up to 2000 l.
- Commission delegated regulation (EU) No 812/2013 Energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device setting requirements for energy labelling and product data.

These regulations came into force on 26th September 2015.

Reversible heat pump products that can also provide cooling will also need to meet minimum performance requirements for cooling. These come under Lot 21 of the Ecodesign regulations and the final draft of these regulations has been sent out for public consultation. It is proposed that they come into force on the 1st January 2018. Details of the current and proposed requirements are given in Table 4.

**Table 4 The minimum energy performance requirements that gas driven air to water, water to water and ground to water heat pumps need to meet**

| Date implemented | Minimum heating Requirement SSHEE | | Minimum cooling requirement SSCEE | |
|---|---|---|---|---|
| | Low temperature* | Other | GWP>150 | GWP≤150 |
| 26 Sept 2015 | 115% | 100% | | |
| 26 Sept 2017 | 125% | 110% | | |
| 1 Jan 2018 | | | 149% | 134% |
| 1 Jan 2021 | | | 161% | 145% |

*Low-temperature heat pump means a heat pump space heater that is specifically designed for low-temperature application, and that cannot deliver heating water with an outlet temperature of 52°C at an inlet dry (wet) bulb temperature of -7°C (-8°C) in the reference design conditions for average climate.

## Building Regulations

There are no specific requirements with respect to heat pumps in the Building Regulations but recommendations on heat pumps are provided in the Domestic Building Services Compliance Guide. This recommends that the supply water temperature for radiators should be in the range 40 – 55˚C for air to water, water to water and ground to water heat pump systems.

The Standard Assessment Procedure (SAP) provides default values for efficiency for gas driven heat pumps and the Product Characteristics Database or SAPq allows the use of specific product performance data. This is currently being updated to accept Ecodesign data and to use the methodology proposed in the revised version of EN 15316-4-2 which proposes an hourly calculation method rather than the current bin method. The changes are likely to be implemented early in 2016. It is also being revised to incorporate hybrid heat pumps. Changes to the default values in the main SAP calculation will not be considered until the next revision of SAP.

## Microgeneration Certification Scheme (MCS)

MCS was set up to provide assurance on microgeneration technologies used to produce electricity and heat from renewable sources, and on the standard of installation of these technologies. It provides product certification for heat pumps not exceeding 45 kWth and installer individual and company certification. Participation is voluntary and fees are charged. There are initial fees for the assessment of product eligibility, and initial and annual fees for assessment of installers. The assessment is carried out by an independent accredited certification body. The product certification scheme includes absorption and adsorption heat pumps and products have to meet the minimum energy performance requirements set by Ecodesign.

**Gas engine driven heat pumps are not currently included**

MCS requires manufacturers to use a spreadsheet they have developed to calculate the seasonal coefficient of performance (SCOP) and SSHEE, and products must have weather compensation. Evidence of actual testing to determine the rating and performance at defined conditions must be provided[18].

MCS has developed an installer standard for heat pumps in collaboration with industry. This standard covers supply, design, installation, set to work, commissioning, and handover of heat pump systems.

## European Product Certification Schemes

### Eurovent Certita

This scheme is voluntary and fee-based covering a range of HVAC products including heat pumps.  Eurovent product certification is based initially on self-verification but then subject to independent surveillance. It covers gas engine driven heat pumps and absorption heat pumps (since 2014).  Eurovent provides both the Eurovent Certification mark and NF Heat Pump mark and a Euro Heat Pump programme was started in 2015.

### CEN Heat Pump Keymark

The European Heat Pump Association agreed in December 2015 to set up the Heat Pump Keymark, a product certification scheme which is expected to be recognised throughout Europe. It will initially cover heat pumps included in Ecodesign Lot 1.

[18] MCS007 Product  Certification Scheme Requirements – Heat  pumps, Microgeneration Certification Scheme, accessed November 2015, available here: http://www.microgenerationcertification.org/admin/documents/MCS%20007%20-%20Issue%202.1%20Product%20Certification%20Scheme%20Requirements%20-%20Heat%20Pumps%202011.10.26.pdf

# 7. System Performance

## Limited in-situ data is available for domestic gas heat pumps as it is an emerging market, with domestic absorption units due to the reach the UK market in 2016

- **The standardised testing and reporting of performance information required by Ecodesign should make it easier to draw comparisons between gas driven heat pumps and electric heat pumps and gas boilers.**
- **Gas fired systems generally require both thermal and electrical energy, so the efficiency is measured in terms of the Primary Energy Ratio (PER), which is the ratio of the useful heating and/or cooling energy in relation to the primary energy input.**
- **In the Heat4U trial of the Robur 18 kW absorption heat pump[19], the efficiency for space heating was 132% and for heating hot water was 128%. The system was very reliable.**
- **Data from in-situ trials is limited because products have only recently been placed on the market in Europe.**

## Laboratory-Tested Performance

The steady state performance of heat pumps is measured as the COP, which is the rate of heat transfer in relation to power input and is useful for product specification and labelling. The rated performance of sorption heat pumps is tested according to BS EN 12309. The test conditions for air to water heat pumps are shown in Table 5.

[19] Gas Absorption Heat Pump solution for existing residential buildings, *HEAT4U, 2013*

**Table 5 Standard rating test conditions for air to water heat pumps (heating mode)**

| Heat pump type | Outdoor heat exchanger | | Indoor heat exchanger | |
|---|---|---|---|---|
| | Inlet dry bulb temperature °C | Inlet wet bulb temperature °C | Inlet temperature °C | Outlet temperature °C |
| **Air to water, low temperature** | 7 | 6 | a | 35 |
| **Air to water, medium temperature** | 7 | 6 | a | 45 |
| **Air to water, high temperature** | 7 | 6 | a | 55 |
| **Air to water very high temperature** | 7 | 6 | a | 65 |

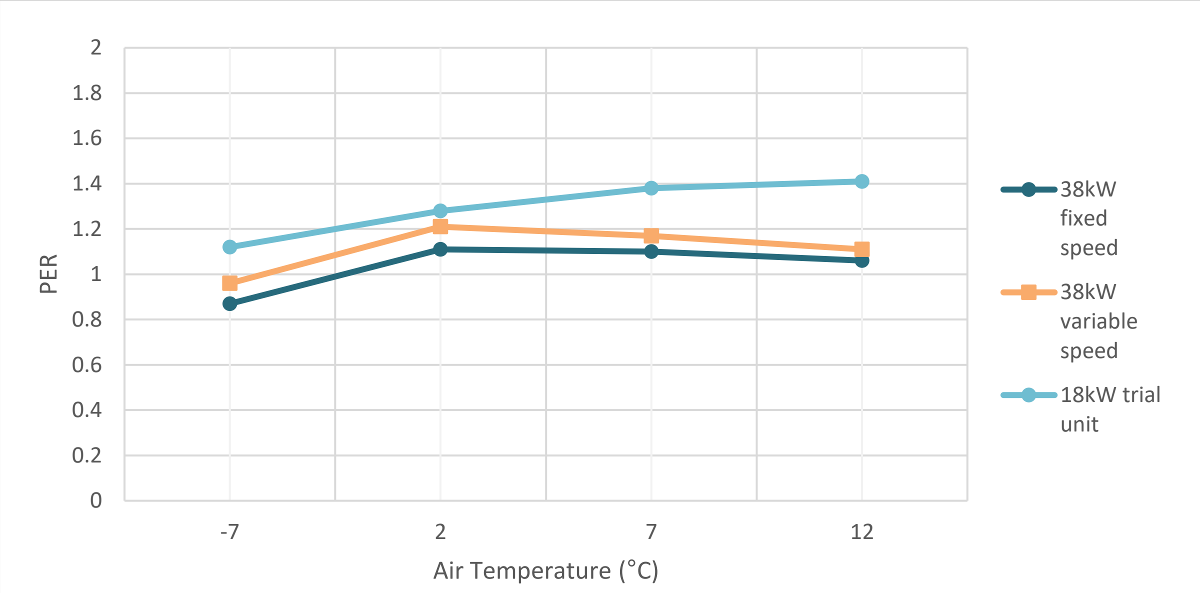
a: All tests shall be carried out with nominal flow rates indicated in the instructions in cubic meter per second, provided that the difference between the inlet and outlet temperatures at the indoor heat exchanger is lower than a maximum temperature difference ($\Delta T_{max}$) calculated using the formula ($\Delta T_{max}$) = 7+ ($T_{out}$ – 35)/30 x 10

Ground to water heat pumps and water to water heat pumps are tested with the same indoor heat exchanger temperatures as for air to water heat pumps but the outdoor heat exchanger temperatures differ. For ground to water heat pumps the outdoor heat exchanger temperatures are inlet temperature 0°C and outlet temperature -3°C and for water to water they are inlet temperature 10°C and outlet temperature 7°C.

The efficiency of a gas driven heat pump can be given as the Gas Utilisation Efficiency (GUE) which is the declared effective heating capacity to gas input ratio with the gas input expressed in gross calorific value (i.e. the total amount of heat released on combustion including the heat provided by condensing any water vapour produced). However gas driven heat pumps generally also use a small amount of electrical energy so the efficiency is often given in terms of primary energy; where the Primary Energy Ratio (PER) is the ratio of the useful heating and/or cooling energy in relation to the primary energy demand.

The capacity and efficiency of gas driven heat pumps is not as adversely affected by falling ambient air temperatures as electrically driven air to water heat pumps. This can be seen in Figure 12, which shows the efficiency of three absorption products. The figure also shows how a variable capacity product is more efficient than a fixed capacity one, and how the trial 18kW absorption heat pump is more efficient than the current commercial 38kW product.

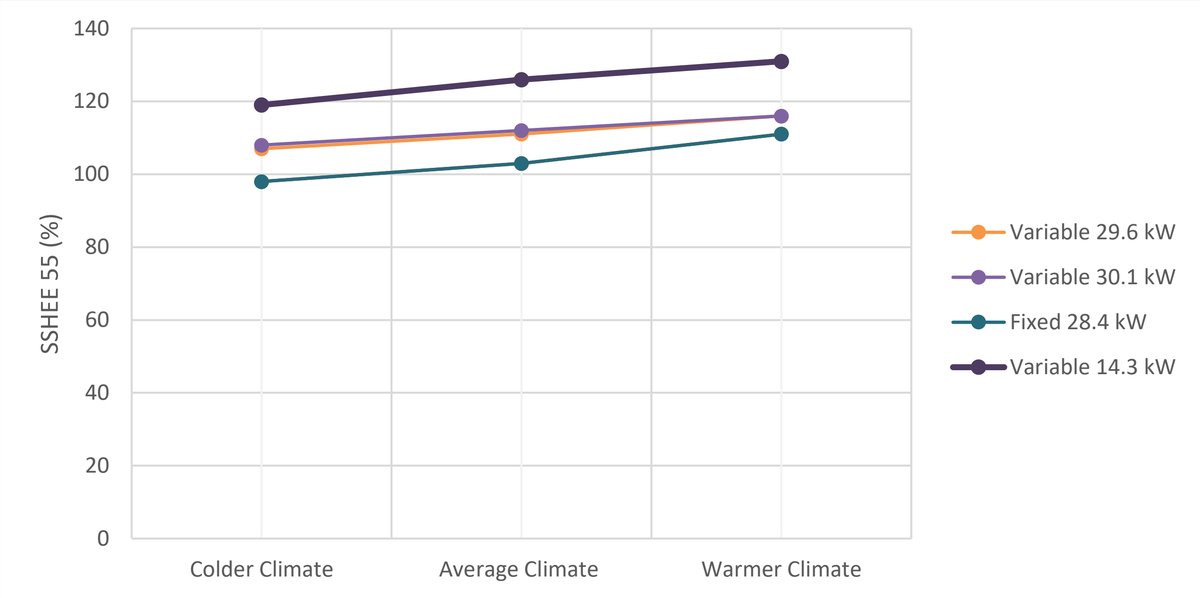
**Figure 12 PER values[20] for air source absorption heat pumps at different ambient air temperatures with an output temperature of 55°C**




The Ecodesign legislation setting minimum performance and labelling requirements came into force on the 26th September 2015. This requires manufacturers to provide data on the seasonal performance of gas driven heat pump products measured as the seasonal space heating energy efficiency (SSHEE), according to BS EN 12309 for sorption heat pumps. Seasonal performance provides a more accurate measure of actual performance than measurement at a single rating condition. Figure 13 shows the SSHEE at an output temperature of 55°C for absorption products (distinguishing those with fixed and variable capacity). The published SSHEE at 55˚C output temperature and average climate for the 38 kW Robur products vary from 103% for the fixed speed product to 113% for the variable speed product. The value of the 18kW product (shown as 14.3 kW output on the chart) is considerably improved at 126%.

[20] Note that the values plotted are part load PERs taken from the manufacturer's Ecodesign fiche data

**Figure 13 SSHEE for air source absorption heat pumps**




Robur has spent several years developing the 18kW model, which has recently been launched in Europe although it is not yet available in Britain. This product underwent extensive testing during its development as part of the Heat4U project including laboratory testing according to EN 12309 at Polimi and Fraunhofer ISE. The performance in terms of measured gas utilisation efficiency (GUE) is shown in Table 6. The GUE is the effective heating capacity divided by the gas input. The GUEs in Table 6 are given in terms of net calorific value i.e. $GUE_{(NCV)}$ (dividing them by 1.1 gives the $GUE_{(GCV)}$ based on gross calorific value). The testing was also used to evaluate the EN12309 test methods.

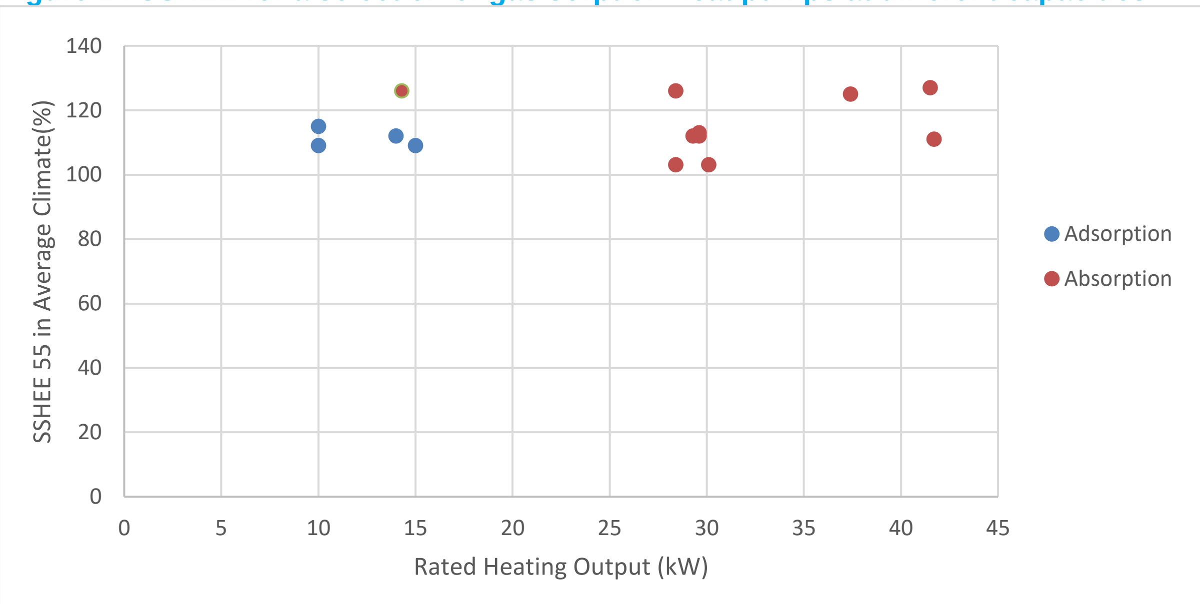
**Table 6 Performance of Robur 18kW air to water absorption heat pump measured at Fraunhofer Institute**

| $T_{air}$ | $T_{w\ out}$ | $Q_h$ | Part load ratio | $GUE_{(NCV)}$ achieved |
|---|---|---|---|---|
| 7.0 | 50.0 | 16.89 | 100% | 1.53 |
| 7.0 | 35.0 | 19.15 | 100% | 1.74 |

Source: Heat4U[21]

Figure 14 shows the SSHEE values for all the gas sorption heat pumps analysed in this study. Seasonal performance for the larger air source absorption products and the adsorption products are comparable, whilst the performance of the smaller and ground source absorption units are higher.

**Figure 14 SSHEE for a selection of gas sorption heat pumps at different capacities**




[21] Gas Absorption Heat Pump solution for existing residential buildings, *HEAT4U, 2013*

## In-Use Performance

### Absorption heat pumps

Data for in-situ performance for gas driven heat pumps in the UK is very limited. The 38kW Robur unit has been available in the UK since 2009 but there is very little quantitative performance data although qualitative feedback is positive. A heating system using four Robur absorption heat pumps with heat from 13 x 100 m borehole ground collectors, installed in a sustainable new-build development at the Open University in Milton Keynes has reached peak efficiencies of 169% and reduced energy costs and carbon emissions by over 40% compared to gas condensing boilers.

Another installation where two absorption heat pumps were installed as a hybrid system with gas condensing boilers in a care home has achieved seasonal efficiencies of 140% and reduced energy costs and emissions by about 30%. The care home had a high demand for domestic hot water.

The best documented trial has been of the new Robur 18 kW absorption heat pump. This was carried out as part of the Heat4U project which trialled units at five sites across Europe (France, Germany, Poland, Italy and the UK) for one year. British Gas carried out the UK trial which was started in October 2013 and was extended to cover a second year.

The heat pump was installed in a 1950’s semi-detached house which had a heat loss of 12 kW and the heating system comprised high temperature radiators with a set point of 65°C. The system was controlled using weather compensation and the maximum temperature required for comfort was actually 52-53°C (but both winters were relatively mild).

The Gas utilisation efficiency based on net calorific value $GUE_{(NCV)}$ for space heating was 1.32, while the $GUE_{(NCV)}$ for heating hot water was 1.28 (or 1.20 and 1.16 based on gross calorific value). The calculated energy savings as compared to a gas condensing boiler were 30% and the system was found to be very reliable during the course of the trial. The efficiencies across other counties were France, Germany, Poland and the UK were very similar. The efficiencies were 7% higher in Italy for space and water heating, which may be expected due to the warmer climate.

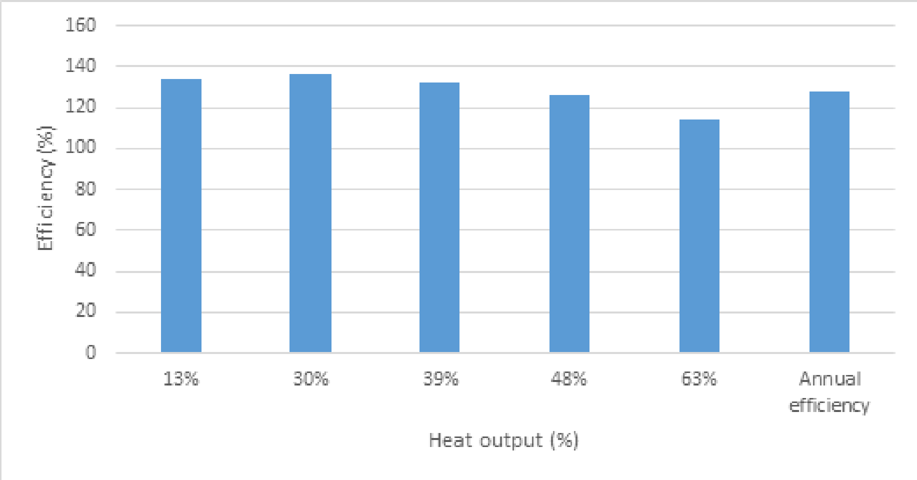
### Adsorption heat pumps

Adsorption heat pumps are not available in the UK yet so there is no UK in-situ performance data available, however trials have been carried out in Europe. The Gas Heat Pump Initiative which ran from 2008 to 2012 was a collaboration between Bosch, Vaillant, Viessmann and Robur and eight gas suppliers with the aim of developing sorption heat pump technology, through laboratory testing and field trials. Over 250 gas heat pumps were installed at locations throughout Germany. A prototype adsorption heat pump developed by Viessmann was extensively trialled and the results are shown in Figure 15.

The graph shows the product performance as gas utilisation efficiency based on net calorific value.

The product combines a compact zeolite heat pump (output 1.8 to 4.8 kW) and gas boiler (i.e. it is a hybrid product). It uses a 50m ground collector or a solar thermal system as the heat source and provides heating at up to 40°C. The system was installed in 15 houses and resulted in efficiency improvements of 27% compared to a gas condensing boiler. The product was placed on the market in 2014 and a larger version is now planned.

**Figure 15 The measured performance ($GUE_{NCV}$) of Viessmann VITOSORP[22] at B5/W35**




Source: Recreated from Viessmann data

Field trials of the Vaillant ZeoTherm adsorption heat pump gave a $GUE_{(NCV)}$ of around 1.3 when delivering heat at 35°C to underfloor heating. The product was also laboratory tested according to the German standard VDI 4650-2 which gave a $GUE_{(NCV)}$ of 122% at output temperatures of 35°C, and 113% at output temperatures of 55°C. The product was field trialled with both ground collectors and solar collectors.

Both of these products are available commercially in Europe. They are recommended for use with low temperature heating system, such as underfloor heating.

## System Sensitivities

Correct design and application is very important to ensure that the product can efficiently meet the heating requirements. For a gas heat pump however, output temperatures can be boosted by heat recovery from the exhaust gases so output is not quite so sensitive to the source temperature. Table 7 summarises the main system sensitivities for gas driven heat pumps.

[22] Source: Eon: Trigger for efficient use of renewable heat, *E.on presentation, Promelle et al, 2013*

**Table 7 System sensitivities for gas driven heat pumps.**

| Sensitivity | Description | Import -ance | Comment |
|---|---|---|---|
| Design | Overall performance will be determined by initial design. | *** | There is very little training available for gas driven heat pumps except from manufacturers, however sizing not quite as critical as for electric heat pump as gas engine/burner usually has spare capacity<br>For adsorption heat pumps the ground collector is only about one third of the size of that for an equivalent electric ground source heat pump. Correct use of buffer storage can significantly improve performance. |
| Installation | Quality of installation is very important | ** | All installations will require Gas Safe qualification. For sorption heat pumps the gas installation will be similar to that for a gas boiler. Gas engine fired products are split systems so will require F-gas qualification. |
| Controls | Correct control is important | ** | Control not as major as for electric driven heat pumps |
| User interaction | Level of user interaction required quite low | ** | Performance more similar to a gas boiler so less user intervention required than an electric heat pump. |
| Maintenance | Maintenance requirement is similar to a gas boiler | * | Gas absorption – low maintenance<br>Gas adsorption has no moving parts, is sealed and has no maintenance but the gas burner will need servicing.<br>Gas engine – major engine service every 10,000 to 30,000 running hours (2-5 years) |

Key: *** = performance very sensitive to variable *=little sensitivity to variable

# Expected Technology Lifetimes

Adsorption heat pumps have no moving parts, and absorption products just include a small fluid pump, and therefore lifetimes are expected to be longer than standard electric heat pumps. The refrigeration units are hermetically sealed but adsorption units using zeolite and water operate at low pressures so maintaining the seal is critical. As adsorption heat pumps use a batch process their life is measured in terms of the number of cycles (absorption and desorption) completed. Lifetimes of around 20 years are expected, but the technology is relatively new so there is limited experience available to verify this.

Technology lifetimes for gas engine heat pumps are expected to be more comparable with electric heat pumps. They would be likely to be around 15 years for a domestic application. However, their lifetime when used in commercial and industrial application will depend on the application and annual hours of operation.

# Energy and Carbon Performance

The energy extracted from an ambient source can be considered as renewable. What fraction this forms of the delivered heat will depend on the efficiency of the gas driven heat pump.

Considering just the gas absorption heat pumps reviewed in this study, the range of published SSHEEs is 103-126%. The Seasonal Primary Energy Ratio (SPER) has been assumed to equate to the SSHEE[23].

If it is assumed that the electricity used by the heat pump is generated using fossil fuels, then the fraction of delivered heat that will be renewable will be given by (1-1/SPER).

Therefore the Seasonal Primary Energy Ratio (SPER) is 1.03-1.26.

Therefore the proportion of space heating energy supplied which can be considered renewable ranges from 3-21%.

## $CO_2$ and cost savings

In order to estimate indicative $CO_2$ and cost savings, we have developed a generic scenario, and considered two possible counterfactuals – a gas condensing boiler, and an electric air to water heat pump.

The potential $CO_2$ reduction can be found by comparing the $CO_2$ emissions for two products to meet the annual space heating and water load for a typical building.

### Assumptions

For this example we have assumed 12,000 kWh space heating and 2,000 kWh domestic hot water. Based on a typical load factor of 17%, this would require a heat

[23] We have used SPER = SSHEE as an approximation. The SSHEE value includes other functions such as full pumping power and a controls effect. The difference is around 3%

pump of 10kW or larger. The output water is assumed to be medium temperature (as defined by Ecodesign regulations), as we have used SSHEE at 55°C as the performance measure.

Carbon conversion factors and energy prices are shown in Table 8, taken from BEIS Green Book guidance[24]

The simplified £/t$CO_2$ calculation has been calculated assuming an average installed cost of £10,500 for a gas driven heat pump and £2,300 for a gas boiler counterfactual. For simplicity, a product lifetime of 15 years has been assumed for both. Variations to annual running costs have not been included due to uncertainties over future energy prices.

**Table 8 Carbon conversions and energy prices from BEIS green book guidance[24]**

| **Carbon conversion factors:** | | |
|---|---|---|
| Gas* | 0.185 | kg$CO_2$/kWh |
| Burning oil | 0.247 | kg$CO_2$/kWh |
| Electricity** | 0.333 | kg$CO_2$/kWh |
| **Energy prices:** | | |
| Gas* | 4.11 | p/kWh |
| Burning oil*** | 3.61 | p/kWh |
| Electricity | 14.83 | p/kWh |

* Fuel factors and prices based on kWh calculated based on gross calorific value

** Long run marginal factor used for electricity

*** Calculated from an oil price of 37.1p/litre

We have also assumed that the gas absorption heat pump can provide 100% of the space heating and DHW demand, and so can the gas boiler, but that the standard electric heat pump only provides 80% of the hot water, with the rest provided by direct electric back-up (because it will not reach the temperatures required to protect against legionella bacteria)

[24] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, Data tables 1-20: supporting the toolkit and the guidance, DECC, 2016, Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/483282/Data_tables_1-20_supporting_the_toolkit_and_the_guidance.xlsx

As a simplification, we have assumed that SSHEE is all allocated to the primary fuel (e.g. we have not accounted separately for the electricity use by the gas boiler or heat pump)

The SSHEE and also Water Heating Energy Efficiency (WHEE) data in Table 9 has been extracted from our review of heat pump products, and a brief survey of a sample of gas and oil boilers.

**Table 9 Min, Max and average SSHEE and WHEE values across a range of heat pumps and boilers (from survey of Ecodesign fiche data)**

| | Minimum | Maximum | Average |
|---|---|---|---|
| **SSHEE55 (%) / SPF** | | | |
| **Gas absorption heat pump** | 103 | 126 | 112 |
| **Gas boiler** | | | 92.5 |
| **Oil boiler** | | | 90 |
| **Standard electric heat pump** | | | 119 |
| | | | |
| **WHEE (%) / SPF** | | | |
| **Gas absorption heat pump** | 103 | 126 | 112* |
| **Gas boiler** | | | 82 |
| **Oil boiler** | | | 76 |
| **Standard electric heat pump** | | | 101 |

* No data available – assume the water heating efficiency is the same as space heating

### Energy use and savings

In Table 10 below the energy use, cost and carbon emissions are calculated for gas absorption heat pumps, based on the range of SSHEEs and WHEEs found in our survey of available products).

The equivalent results for a gas boiler counterfactual and a standard electric heat pump counterfactual are also shown. The savings for the gas heat pump relative to the counterfactual are also shown. The ranges of savings relate solely to the range of gas heat pumps efficiencies used. All other variables (such as the counterfactual efficiencies) are averages, and are constant. Negative values denote that the savings are greater for the counterfactual.

**Table 10 Energy use, carbon emissions and savings for gas absorption heat pumps versus gas boilers and standard electric heat pumps**

| | Gas absorption heat pump | Condensing gas boiler counterfactual | Standard electric heat pump counterfactual |
|---|---|---|---|
| **Total space heating consumption, kWh/yr** | 9,520 to 11650 | 12970 | 4030 |
| **Total water heating consumption, kWh/yr** | 1,590 to1,940 | 2,440 | 1,030 |
| **Total energy consumption kWh/yr** | 11,110 to 13,590 | 15,410 | 5,070 |
| **Total carbon emissions, kg/$CO_2$/yr** | 2,050 to 2,510 | 2,840 | 1,690 |
| **Total energy cost £/yr** | 460 to 560 | 630 | 750 |
| | | | |
| | | Savings using a gas heat pump: | |
| **Energy saving kWh/yr** | | 1,820 to 4,300 (12 to 28%) | -8,520 to -6,040 (-168 to -119%) |
| **Carbon saving, kg$CO_2$ /yr** | | 340 to 790 (12 to 28%) | -820 to -360 (-49 to -21%) |
| **Cost saving £/yr** | | 70 to 180 (12 to 28%) | 190 to 290 (26 to 39%) |
| **Simple £/t$CO_2$ saved relative to counterfactual** | | 1,020 | |

Nb indicative values only, subject to rounding errors

In the modelled scenario the gas heat pump results in savings in cost, energy and emissions of between 12% and 28% against a gas boiler.

There are cost savings of between 26% and 39% compared to a standard electric heat pump because of the price differential between gas and electricity. However, energy consumption and carbon emissions are higher for the gas driven heat pump in this case.

A simple carbon abatement cost £1,020/t$CO_2$ has been calculated i.e. the additional cost of purchasing a gas absorption heat pump compared to a gas boiler, per tonne of $CO_2$ saved over the product lifetime.

It should be noted that the carbon emissions factor for electricity is expected to fall in subsequent years, and so the carbon emissions associated with the standard electric heat pump are likely to come down over time.

# 8. Costs

## There are few gas driven heat pump products available. The costs of some domestic versions may be comparable to electrically powered heat pumps when launched.

- **The most established product, the 38kW gas absorption heat pump, which is offered by several suppliers including rebadged versions, costs £12,000-£20,000 fully installed. This is aimed at the commercial market.**
- **An 18kW absorption heat pump, suitable for larger domestic properties, is expected to cost from £9,000 installed when launched, although costs could reduce by up to 30% according to stakeholders.**
- **Adsorption products are also expected to be launched in 2016. The installed cost could be upwards from £17,000, as this is a ground source product.**
- **Innovation is underway in this area, and with good market uptake it is likely that the significant cost reductions of 20-30% or more could be achieved.**

## Heat Pump Costs

Gas driven heat pumps tend to comprise single units – but they often require additional components such as buffer tanks or DHW tanks. Typical components are shown in Table 11.

**Table 11 Typical gas driven heat pump components**

| Capital cost | Installation cost | Running costs |
|---|---|---|
| • The heat pump itself<br>• For a split system, the refrigerant pipework between the units<br>• A domestic hot water tank – if needed<br>• Controls and meters<br>• Pipework, insulation, pumps etc. associated with any heating and hot water system<br>• For ground source heat pumps, the ground collector | • System design<br>• Installation of the heat pump<br>• Installation/replacement of hot water tank – if needed<br>• Installation of pipework. Electrical connection<br>• For ground source heat pumps, the ground works (trenches etc.) | • Annual maintenance<br>• Gas and some electricity cost |

Various components of costs have been identified, but it has not been possible to accurately break down the costs for all the various components separately, given the data collected. Nevertheless, the typical overall product and installation costs identified within this study, are described below in Table 12 and described further in the following section, based on a combination of published costs and stakeholder feedback.

**Table 12 Typical overall product and installation costs**

| Product type | Capacity (kW) | Product cost (£) | Product cost (£/kW) | Installation cost (£) | Other capital costs / accessories (£) | Total installed cost (£) | Total cost (£/kW) |
|---|---|---|---|---|---|---|---|
| Absorption 38kW | 38 | 9.5k – 14k | 250-400 | 1,8k-5k | 600-1k | 12k-20k | 300-530 |
| Absorption 18kW (predicted) | 18 | 6k | 330 | 2k-5k | 500-1k | 9k-12k | 500-650 |
| Adsorption (predicted) | 10-15 | 10.5k | 700 | 4k-7k | 2,5k | 17k-20k | 1,100-1,300 |
| Gas engine driven | 25 - 81 | 15k – 30k+ | 500-1000 | Not provided | 5k+ | >20k +installation | 1000+ (estimated) |

## Comparison with other studies

The cost of installing gas sorption heat pumps was obtained from discussions with stakeholders. The installed costs shown for 38kW absorption heat pumps (£12,000) start a little lower than those mentioned in the BEIS RHI Evidence report[Error! Bookmark not defined.] (£13,000).

The costs for gas engine driven heat pumps above were based on the estimates made in the RHI report, although they have all been corroborated by discussion with stakeholders.

It should be noted that the price premium for capital costs and installation costs for larger products is relatively low.

Variations in cost per kW relate more to the range of products sizes available than to the variations between product types. For this reason, cost per kW is a rather poor indicator for comparing performance across types. Care should be taken when comparing cost per kW for different product sizes – and indeed when comparing cost data from different sources.

# Operating Costs

The ongoing operating costs comprise the gas used to drive the heat pump, and also a little electricity used in the absorption and gas driven products for fans and pumps. For adsorption there will only be a pump for the ground collector but no electricity is used in the unit itself. In addition, there are annual maintenance costs.

### Reported cost savings

According to stakeholders, the operating costs for the 38kW absorption products have been found to be around 60-80% of an equivalent gas boiler.

Trials of the 18kW absorption product also showed energy and cost savings of around 20%.

Note that the cost savings would be greater for a gas driven heat pump which replaced a boiler running on LPG, due to the relative prices of gas, liquefied petroleum gas (LPG) and electricity. This could lead to an additional 20% cost saving.

### Maintenance

Maintenance must be carried out by somebody qualified to service gas equipment. Only technicians with proof of competence are permitted to work on ammonia refrigerant systems.

For the absorption products the annual maintenance check is similar to a gas boiler, and costs around £200 per year. A full service is needed every 2-3 years at a cost of around £350, including parts.

Maintenance costs for adsorption heat pumps will be similar or lower as the heat pump has no moving parts. The ground collector requires very little maintenance except occasional replacement of the antifreeze.

For the large gas engine driven air to air heat pumps, maintenance charges may be between £1,200 every 2-3 years for smaller units and £5,000 per year[Error! Bookmark not defined.] for a set of four large units.

## Opportunities for Cost Reduction

Standard electrically powered heat pumps are a relatively mature technology, although market penetration to date has been limited, especially in the UK. However, the technology is well established and many observers believe that scope for cost reduction is limited in the short to medium term to somewhere in the region of 10-15% (see for example Delta-ee report[25] and CCC report[26]).

However gas driven heat pumps, although the technology is not new, have so far achieved very limited penetration, and there are few manufacturers operating in the market. None currently offer a domestic scale product in the UK aimed at the mass market. The UK would be one of the key markets in Europe for such products due to relatively low gas prices, and the extensive gas infrastructure.

As a result, there has not yet been the opportunity for cost reduction which occurs with economies of scale, or which can be stimulated by expectation of a significantly increasing future market.

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[25] Potential Cost Reductions for Air Source Heat Pumps, *Delta-ee for DECC, 2014*

[26] Fourth Carbon Budget Review - technical report, *Committee on Climate Change, 2013*

Stakeholders have predicted that significant cost reductions could be achieved in the products suitable for domestic properties:

In the short to medium term they estimated that the cost of a new 18kW absorption unit, expected to start at around £9,000 installed, could come down by between 20-33%, or as low as £6,000. This would bring the products in line with or below electrically powered heat pumps, and within range of some hybrid gas heat pumps with boilers. Other manufacturers are known to be developing absorption products as well, which should increase cost competition.

Stakeholders claimed that with significant market uptake this scale of cost reduction is possible. However, it should be noted that at this price, the technology would still be around twice the price of a typical gas condensing boiler installation.

The adsorption units are relatively new technology, only recently launched, or about to launch, to the domestic market in Europe. They are likely to be significantly more expensive than electrically powered heat pumps, and even absorption heat pumps. This is particularly the case as they are restricted to ground or water source, which itself brings substantial additional cost. As a new technology there is scope to significantly reduce the product cost. However, in the foreseeable future, several stakeholders did not see adsorption technology being competitive in the UK market.

It is unlikely that gas engine driven air to air heat pumps, used to produce hot water for wet heating systems will be developed at scale for domestic use in the short to medium term, and so their cost reduction opportunity has not been considered further.

# 9. Barriers and Drivers to Deployment

## Gas heat pumps have notable advantages over electric heat pumps, but major barriers (such as high cost) still exist

- **Gas heat pumps may help overcome consumer reluctance to install heat pumps, as they retain the security of having a gas heating system. Absorption products may be used with existing heat distribution systems, thereby reducing cost.**
- **Gas heat pumps do not constitute a significant burden on the electricity grid. Because of this gas heat pumps may have a role to play, at least as a transitional technology.**
- **However, gas heat pumps have some additional barriers to overcome compared to standard heat pumps, such as high cost (for some product types) and a lack of measured performance data.**

This section first gives a brief overview of the drivers for the uptake of this technology, and then discusses the barriers to uptake.

Research showed that many of the same barriers which prevent the rapid uptake of standard heat pumps are also applicable to this technology. The findings on barriers are therefore presented first in terms of barriers that are unique to gas heat pumps, then in terms of the well-known barriers to standard heat pumps, as well as the impact of gas technology for each barrier (i.e. whether it mitigates or exacerbates this barrier).

This section was compiled from a review of literature, along with discussions with all of the stakeholders.

## Drivers for Deployment

Gas heat pumps have a number of advantages over standard heat pumps that mean they could find a market in the UK. These strengths include:

- Efficient, gas driven heat pumps can reach high temperatures and therefore can be used with existing high temperature distribution systems (e.g. existing radiators), and produce domestic hot water.
- They do not place a significant burden on the electricity grid – if a significant amount of the UK's heating requirement was electrified, generation and grid capacity would need upgrading.

- Natural gas is a familiar fuel for domestic heating, so the barrier to heat pump acceptance may be easier to overcome.
- The savings relative to a gas boiler are clear because there is no need for price comparisons and carbon conversions.
- Gas prices are relatively cheap in the UK, which can be advantageous compared to electric heat pumps.
- There is a reduced requirement for defrost cycles compared to electric heat pumps.

## Summary of Key Barriers

Standard heat pump barriers are summarised in Table 13 which gives a brief summary of the barrier, and the impact of gas technology on that barrier, along with an indication of the strength of the barrier. The barrier strength is our assessment based on a combination of expert opinion, how frequently the barrier was mentioned by stakeholders and how frequently it was highlighted in the literature search.

Our assessment of the impact of gas technology relative to standard heat pumps is colour coded, where green shading designates a positive impact, and red a negative impact. Items shaded blue mean that the barrier is not significantly different for gas heat pumps compared to standard products.

The barriers where gas heat pumps have an impact compared to standard heat pumps (red or green) are then discussed further in the following sections, segmented into consumer, technical, installation, and market barriers. It should be noted that some barriers may fall across one or more of these categories. Further details of the other barriers (blue) are shown in Annex B.

## Table 13 Summary of standard heat pump barriers and the impact of gas driven heat pumps

Key:

Technology's impact on standard heat pump barrier: **Green - positive impact; blue - no impact; red - negative impact**

Barrier Strength: * - Minor barrier; * * - Moderate barrier; * * * - Major barrier

| Barrier | Description | Technology's impact on standard heat pump barrier | Barrier strength |
|---|---|---|---|
| High upfront cost | High up-front cost is the major barrier for demand | Gas heat pumps tend to be more expensive than electric HPs. Absorption HPs are roughly 3-4 times as expensive for the installed cost as gas boilers. Adsorption and gas engine driven HPs are significantly more expensive. | *** |
| Consumer inertia | Consumers are reluctant to move away from the convenience of gas boilers | Consumers may be more comfortable with a gas heat pump as they are already comfortable with gas boilers. They are sometimes marketed as "heat pump boilers" | *** |
| Low technology awareness | Low level of knowledge / awareness about heat pumps on the demand-side | Interviewees indicated that awareness around gas heat pumps in the UK is poor | *** |
| Lack of confidence | Lack of robust / comparable performance data and previous negative experiences with heat pumps | Similar to electric heat pumps, although there is even less experience /performance data for domestic scale gas products | *** |
| Aesthetics | Aesthetics are a major barrier for consumers | Similar to electric heat pumps | *** |

| Barrier | Description | Technology's impact on standard heat pump barrier | Barrier strength |
|---|---|---|---|
| **Space constraints and planning permission** | Space constraints (for the heat pump unit and hot water tank), including planning requirements | Gas absorption units tend to be bigger and therefore more difficult to site.<br>Planning issues are similar to standard electric heat pumps. | *** |
| **High electricity price / low gas price** | A relatively large differential between electricity and gas per unit of energy reduces potential savings compared to other countries | The low cost of gas means the running cost is competitive with electric heat pumps. However the cost of running a gas boiler is also low. | * |
| **Uncertainty over performance / savings** | Current performance metrics are not reflective of in-use performance and it is difficult to calculate savings | Gas heat pump performance data is scarcer and the small number of products means comparison is difficult | ** |
| **Shortage of necessary skills** | Lack of skilled and experienced technicians / engineers to install and maintain systems | Compared to split air to water heat pumps gas heat pumps can be easier to install. They should be no more difficult to maintain than a gas boiler. | * |
| **Speed of installation** | Heat pumps take considerably longer to install than gas boiler | Similar to electric heat pumps – although adsorption products need ground or solar source. | * |
| **Number of players in supply chain** | Given the large number of players in the supply chain, it is not clear who is incentivised to ensure proper installation | Similar to standard heat pumps | ** |

| Barrier | Description | Technology's impact on standard heat pump barrier | Barrier strength |
|---|---|---|---|
| **Thermal efficiency of housing stock** | The UK's existing housing stock includes a significant proportion of thermally inefficient properties | Gas heat pumps can reach high temperatures, so heat loss in thermally inefficient properties is less significant than for electric heat pumps.<br>However, adsorption products may have limited capacity. | * * |
| **Noise** | Heat pumps can be noisier than other heating types such as gas boilers | Absorption/adsorption units are quieter than electric heat pumps as they do not have a pump | * |
| | | For similar heat outputs to standard HPs, gas engine driven HPs are noisier due to the slight engine noise | * |
| **Low replacement opportunities** | Existing gas boilers have long useful lives of 10-15 years. | Similar to electric heat pumps | * |
| **Network electricity capacity** | Heat pumps will add significant demand to the electricity network | Gas heat pumps do not provide a significant burden on the electricity grid | * |
| **Suitability of incumbent heating distribution systems** | Widespread use of heating distribution systems with high flow / return temperature which are not suitable for heat pumps is a barrier for retrofit | Gas heat pumps can reach high temperatures, so should be more suitable for retrofit to incumbent high temperature heating systems than electric heat pumps. | * |
| **Lack of sufficient financial incentives** | Stakeholders stated that there are no financial incentives for gas heat pumps. | There are currently fewer incentives for gas heat pumps compared to electric heat pumps | * |

| Barrier | Description | Technology's impact on standard heat pump barrier | Barrier strength |
|---|---|---|---|
| **Lack of appropriately sized products** | There is a lack of choice of capacities so it may be difficult to match demand efficiently. | Currently only 38kW and 18kW absorption heat pumps are available. It is difficult to produce smaller capacities. For adsorption units the largest units are about 10 kW although a 15 kW unit is planned. It is difficult to increase the capacity because of the high surface area of absorbent and difficulty in maintaining the low pressures needed.<br>Gas engine driven heat pumps are currently aimed at the commercial market. | * |

Key:

Technology's impact on standard heat pump barrier: **Green - positive impact; blue - no impact; red - negative impact**

Barrier Strength: * - Minor barrier; * * - Moderate barrier; * * * - Major barrier

# Consumer Barriers

## High up-front cost

In general, high up-front cost compared to gas-condensing boilers is a **major barrier** for standard heat pumps, especially when considered alongside uncertainty on in-use savings. However, the effect of cost varies depending on the market segment considered:

- **Housing developers** – cost is a major barrier for housing developers. The cost of a heat pump is not fully reflected by a proportionate increase in the value of a property. For this reason, housing developers are more likely to install gas-condensing boilers to maximise their return. Housing developers told us that there can be other more cost-effective ways for architects/engineers to increase the score in the Standard Assessment Procedure (SAP) or meet other building regulations, such as improving the building fabric and solar.
- **Buy-to-let landlords** – cost is a major barrier for landlords due to the landlord-tenant divide. Landlords are not incentivised to pay the high up-front cost as the tenant will be the financial beneficiary (through lower heating bills).

- **Homeowners** – cost is a major barrier for homeowners, although they do benefit from the ongoing savings.
- **Housing associations** – cost is also significant for housing associations, however, they are often eager to reduce the ongoing cost of living for occupiers.

Gas heat pumps are significantly more expensive than standard electric heat pumps. There has been little opportunity for gas heat pumps to reduce in cost, as their market penetration has not been significant. Planned domestic scale absorption products may be cost competitive with electric heat pumps, especially if costs reduce as scale increases.

Electric heat pumps can be cost-competitive for properties off the gas grid due to the high cost of connection to the gas grid. LPG adsorption heat pumps could access this market.

### Consumer awareness, confidence and trust

Consumer awareness of heat pumps in general is very low and is therefore a **major barrier**. In a survey of householders, 12% had heard of air source heat pumps and understand what they are, with the figure being 28% for ground source heat pumps[27]. Similar scales of awareness have been found in other studies[28].

Feedback from manufacturers is that they do not have enough funding to run an awareness raising campaign themselves. In Germany, for example, utilities have been very successful in driving awareness[29].

Our interviews suggested that few people are aware of gas driven heat pumps, and there is less experience and performance data than for electric heat pumps.

### Consumer inertia

Consumer reluctance to switch from the familiarity and convenience of incumbent technology (mainly gas boilers) is a **major barrier** to the uptake of standard heat pumps. This reluctance is reinforced by the ability of gas boilers to quickly heat a home and provide hot water on demand. Consumers are often concerned about the ‘quality’ of the heat from standard heat pumps (i.e. a concern that low heat levels are insufficient to heat a home). The complexity of some heat pump control systems compared to gas-condensing boilers adds to this inertia. Research has suggested that for the choice of system the ‘key determinant was the technology itself (dictating 54% of choices)’[30].

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[27] Pathways to High Penetration of Heat Pumps, *Frontier Economics,* 2013

[28] Homeowners’ willingness to take up more efficient heating systems, *Ipsos MORI and the Energy Saving Trust, 2013*

[29] http://www.delta-ee.com/images/downloads/pdfs/2015/ARTICLES_HPT_Jan15.pdf, *Delta-ee, 2015*

[30] Homeowners’ willingness to take up more efficient heating systems, *Ipsos MORI and the Energy Saving Trust, 2013*

Several stakeholders felt that current messaging around heat pumps would benefit from highlighting convenience benefits (such as longer product lifespans and lower maintenance requirements) alongside potential cost savings.

Consumers are comfortable with the concept of heating systems that use natural gas as the fuel, and so may be more comfortable with gas heat pumps, especially if marketed as a gas heating system.

### Uncertainty over performance/savings

Laboratory performance metrics can never be fully reflective of in-use performance and it is difficult for consumers to calculate savings. This is a **moderate barrier**. Since 26th September 2015, the Ecodesign Directive has stipulated that seasonal performance data for heat pump units must be published and readily available to consumers. However, currently we have found this data is difficult to locate and the level of technical knowledge required to use this performance data is high.

As there are fewer gas driven products available on the market, it is also more difficult to compare performance between manufacturers to find the best performing product.

## Technical Barriers

Lack of appropriately sized products.The choice of capacity is currently limited and this may make it difficult to match demand efficiently. Absorption heat pumps are only available as 38 kW and 18 kW units and reducing the size further is technically difficult. Adsorption units have the opposite problem with it being difficult to increase the capacity beyond about 10 kW because of the larger surface area needed for the sorbent, and the very low pressures that need to be maintained if water and zeolite are used. Research into new working pairs and sorbent materials should help to extend the capacity ranges.

### Noise

The noise produced by heat pumps has been a significant barrier, however considerable work has been carried out to reduce noise levels, and regulations are in place to limit the decibel output. With good design and effective siting, this is now considered to be a **minor barrier**.

Noise is likely to be less of a barrier for gas absorption and adsorption heat pumps as there are fewer moving parts and no compressor and any fans or pumps on the source side will be considerably smaller than for electric heat pumps. For engine driven heat pumps, noise levels are higher due to the slight engine noise.

## Installation and Maintenance Challenges

According to a number of the stakeholders interviewed, poor installation of standard heat pumps in the past had a very negative impact on their reputation in the market, although a number of demand-side stakeholders such as housing associations have reported to us that this issue has decreased over the last five years. To avoid a similar situation with gas heat pumps, it is important that similar poor installation is avoided as the market grows.

### Shortage of necessary skills

There has been a lack of capacity of trained installers for electric heat pumps[31]. This is a **minor barrier** that could hold back supply once demand grows. Given the importance of installation quality on in-use performance[32], poor performance of early installations could be a barrier to further uptake of heat pumps (as previously was the case with electric heat pumps). Consumers may also be concerned about a skills shortage for maintenance.

The skills shortage has improved and many manufacturers run training courses or have special relationships with groups of installers. However, some stakeholders still raised this as an issue during interviews for this research.

Existing gas qualified heating installers can legally and safely install gas driven heat pumps, therefore the large number of gas boiler installers in the UK could also install gas driven heat pumps without additional safety training. The Renewable Energy Skills Forum working through Summit Skills should help ensure that if any additional training required it is incorporated into courses. Training on the specific products is required however. Manufacturers of electric heat pumps have set up training centres, and run training courses to increase the number of capable installers and at the same time to increase awareness of the technology. With time and support from suppliers of gas heat pumps, this barrier may lessen.

## Market Barriers

### Readily accessible and low-cost gas network in UK

The extensive gas network and relatively high cost of electricity per unit of energy compared to gas in the UK is a **major barrier** for electric heat pumps as it means that that in-use cost savings from heat pumps are potentially lower compared to other countries[33]. Volatility around energy prices adds to uncertainty around savings.

Gas heat pumps have an advantage over electric heat pumps in this regard. Their running costs tend to be 60 – 80% of those of gas condensing boilers.

### Suitability of incumbent heating distribution systems

Widespread use of heating distribution systems with high flow / return temperature which are not suitable for heat pumps is a **minor barrier** for retrofit of standard heat pumps[34]. Heat pump suppliers commented that a high proportion of customers are reluctant to change their radiators to low temperature alternatives.

Gas heat pumps can reach high temperatures, so can be retrofitted without updating the existing heating distribution system. This mitigates this barrier.

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[31] Pathways to High Penetration of Heat Pumps, *Frontier Economics, 2013*

[32] Expert interviews

[33] IEA HPP Annex 42: Heat Pumps in Smart Grids – Market Overview, *Delta-ee, 2014*

[34] The Future of Heating: Meeting the Challenge, *DECC, 2013*

### Electricity grid constraints

This is a **minor barrier** for electric heat pumps that may limit deployment with increased uptake. This barrier can be a constraint on both the capacity of a local grid connection, as well as a longer term constraint due to limitations on total electricity generation capacity if a significant proportion of the UK's heating demand were electrified. In addition, the single phase supply in the UK means that many international products designed for three phase supply are unsuitable. The single phase supply also places a maximum on the heat pump capacity that can be installed so that in some situations not all of the load can be met.

Gas heat pumps only have very small electrical usage and do not have a significant impact on the electric grid, and so have an advantage over electric heat pumps in this regard.

### Thermal efficiency of housing stock

The UK's existing housing stock includes a significant proportion of old properties, which tend to be thermally inefficient. In 2012, nearly 60% of dwellings were built before 1964, and over 20% before 1919[35]. Heat pumps work best in well insulated, thermally efficient properties, so maintenance work to increase the efficiency of a property is often carried out before fitting one. This adds cost and disruption to the project, and so is a **moderate barrier**.

Gas heat pumps, particularly absorption products, help overcome this barrier, as they are able to reach high temperatures. Where high temperatures can be produced, the thermal efficiency of the property is less of barrier to uptake, as the heat pump is still able to sufficiently heat the property despite heat losses (although at some expense of efficiency).

### Planning and space

Planning constraints exist but are not insurmountable, therefore this is a **minor barrier**. For an installation outside[36], the space used must not exceed $6m^3$, noise level restrictions apply and there are regulations stipulating how close to a boundary line the unit can be sited. For listed properties, more stringent regulations apply.

Lack of space can be a **major barrier** depending on the property type and location**.** External space is usually required for the heat pump unit, as well as internal space for a water tank. The effect of this barrier will vary by property type. Non-urban properties are less likely to have space restrictions than high-density urban dwellings.

Lack of space may be a more significant barrier for gas heat pumps, as the space requirements for these units are generally higher.

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[35] English Housing Survey Headline Report 2010-11, *DCLG*, *2012*

[36] Planning portal, accessed November 2015, available at: www.planning portal.gov.uk/permission/commonprojects/heatpumps

## Financial incentives

A number of interviewees commented that the lack of financial incentives for gas driven heat pumps has restricted the introduction of domestic scale products in the UK. They drew attention to the availability of incentives for other heat pumps. However, some products are still planned for launch. This is therefore considered a **moderate barrier**.

# 10. Gap Analysis

Information has been collected across the full range of issues requested by BEIS. In general confidence in the information is reasonable to good. However, performance information is limited and site specific, and for some domestic scale products is based on prototype products.

- **Stakeholders have been willing to share information across the full range of topics considered.**
- **Stakeholder information has been cross checked against previous studies, and published information and data, and there is good consistency.**
- **As these technologies are new to market, there is limited published performance information available, and in situ verified results are limited. However, SSHEEs are published for all products, as required by Ecodesign.**
- **Further trials and modelling would be helpful to more accurately determine the potential cost and carbon savings across the range of different property types in the UK.**

At the outset of this study a wide range of questions were provided by BEIS, and a key aspect of the research was to identify where gaps exist in the available information, or where information is available, but not to a good level of confidence. Recommendations for filling these gaps through further study were also requested.

We have therefore assessed below each of the key sections above to examine the data quality and gaps.

### State of the art

As this is a relatively new type of heat pump technology, manufacturers are keen to explain how the technology works, and the various applications and configurations in which it can be used.

Therefore there is good information on the current status of technology, and in general suppliers have been open about product developments that are expected to reach the market in the next 1-2 years.

For some novel technology solutions, such as boostHEAT, only high-level details have been provided on how they work. BEIS may wish to engage directly with the supplier, maybe under a non-disclosure agreement (NDA), to understand exactly how the technologies work.

## Product review

We have carried out a comprehensive review of products available in the market and included a description of the key features of each, along with a spreadsheet containing more comprehensive information on each product, including operating temperatures, single vs 3 phase, refrigerant type, PERs and SSHEEs. A few data points appear to be unexpected, but confidence in the data generally is high.

Only a very few products exist which are marketed in the UK. We have therefore examined products from across Europe which are or may be scheduled for launch in the UK. A further review of these products post-launch may be needed to determine the details of the final commercial product marketed in the UK.

## Market size review

As these are new products, there are currently no sales of domestic scale models in the UK. Some data is available for sales of commercial scale models.

## Standards review

Good information has been available regarding current standards and those under development, and this is presented within the report. Confidence in this information is high.

## System performance

It has not been possible to obtain PER values for the adsorption products, and it is not compulsory for manufacturers to publish them. It is likely that manufacturers would know these values, and approaches from BEIS may yield further data.

Field trials have been carried out for the prototype 18kW Robur absorption product (although only one property in the UK), and the Viessmann adsorption product (not in the UK). Comprehensive monitoring was carried out, however the total number of properties studied is small. The results give a detailed assessment of the operation and results in specific circumstances. They give good qualitative information on the factors (control etc.) which affect performance. But the results are specific to properties/users concerned, and it may not be realistic to extrapolate the results to the wider market.

The monitoring results are unlikely to be sufficient to evaluate the accuracy of the published PER/SSHEE data across the range of conditions.

More detailed field trial information is available for the 38kW absorption product, and gas engine driven products are a well-tested technology, with good field trial information. Detailed trial information is not included in this report, as the trials relate to commercial rather than domestic installations.

If BEIS wishes to obtain better data regarding the in situ performance of gas driven products then they could firstly seek to obtain direct access to the monitoring data for trials that have been / are being carried out, under NDA if appropriate. Secondly, in order to better quantify the difference between the published seasonal performance indicators, and actual in use performance, further, more comprehensive trials, based in the UK, with detailed monitoring are likely to be needed, across a wider range of property types, and conditions. Field trials of adsorption products in particular would be useful as there haven't been any to date in the UK.

## Costs

Good data has been collected on the cost to the end user across the range of product sizes and types, although currently the costs are predictions for the domestic products, which have not yet launched in the UK. In addition the cost of extras and accessories, including controls, has been identified, along with typical installation costs for both air and ground source systems. Typical maintenance costs have also been identified. Confidence in capital and maintenance cost data is good. Confidence in the average cost of extras and accessories and installation is reasonable, however in order to confirm the potential range of these costs, a number of detailed scenarios could be created, and installers could be asked to provide guidance and pricing for the best and most likely options against these scenarios.

Whilst an indication of the cost savings has been provided, this is clearly very dependent on the individual property concerned. Therefore detailed analysis of the profile of potential cost savings for different product types has not been undertaken. This could be carried out either through modelling of housing stock, heat demands and scenario analysis to determine the potential of different solutions.

Or, alternatively, an exercise could be undertaken to identify a range of real properties (maybe with the help of manufacturers, installers and other stakeholders), document their characteristics (type, fabric, current heating system, current energy use/spend) and then model the impact of the technology options on this range of real properties.

## Barriers to deployment

Good information has been collected and reported on the wide range of barriers to the increased uptake of heat pumps in general, and gas driven heat pumps in particular.

# Annex A – List of standards

This section provides an extensive list of relevant technical standards.

| Standard/Regulation | Comment |
|---|---|
| BS EN 14511:2013 Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers using electrically driven compressors. | Topic: Rated performance (steady state)<br>Coverage: Electrically driven heat pumps for space heating and/or cooling, using air, water or ground heat sources.<br>Four parts: 1.Terms and conditions 2. Test conditions 3. Test methods 4. Operating requirements, marking and instructions.<br>Currently under revision - projected date for publication 2017 |
| BS EN 14825: 2013 Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling. Testing and rating at part load conditions and calculation of seasonal performance. | Topic: Seasonal performance. Coverage: Electrically driven heat pumps for space heating and/or cooling, using air, water or ground heat sources.<br>Currently being revised to align with ErP legislation and to include new calculations of seasonal performance and fossil fuel back-up.<br>Publication imminent |
| BS EN 12309: 2014/2015 Gas-fired sorption appliances for heating and/or cooling with a net heat input not exceeding 70 kW. | Topic: Rated and seasonal performance and safety<br>Coverage: Sorption heat pumps including use in hybrid appliances.<br>Seven parts: 1 Terms and definitions 2. Safety 3. Test conditions 4.Test methods 5. Requirements 6. Calculation of seasonal performance; 7. Specific provisions for hybrid appliances. |
| prEN 16905: Gas-fired endothermic engine heat pumps | Topic: Rated and seasonal performance and safety<br>Coverage: Gas-fired endothermic heat pumps<br>Five parts: 1. Terms and definitions; 2. Safety; 3. Test conditions; 4. Test methods; 5. Calculation of seasonal |

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|---|---|
| | performances in heating and cooling mode.<br>Currently under development - projected date for publication 2017 |
| BS EN 16147:2011 Heat pumps with electrically driven compressors. Testing and requirements for marking of domestic hot water units. | Topic: Performance for water heating<br>Coverage: Electrically driven heat pump water heaters<br>Currently being revised to align fully with ErP legislation.<br>Projected date for publication 2017 |
| BS EN 15450:2007 Heating systems in buildings. Design of heat pump heating systems. | Topic: Design of heat pump heating systems. Probably need updating.<br>Coverage: Air, water and ground source. |
| BS EN 378:2008+A2:2012 Refrigerating systems and heat pumps. Safety and environmental requirements | Topic: Safety and environmental requirements mostly related to refrigerants<br>Four parts: 1. Basic requirements, definitions, classification and selection criteria 2. Design, construction, testing, marking and documentation 3. Installation site and personal protection 4. Operation, maintenance repair and recovery.<br>Currently being revised - close to publication |
| BS EN 12102:2013 Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling. Measurement of airborne noise. Determination of the sound power level. | Topic: Noise measurement<br>Coverage: electrically driven heat pumps |
| BS EN 15316-4-2:2008 Heating systems and water based cooling systems in buildings. Method for calculation of system energy requirements and system efficiencies. Part 4-2. Space heating generation systems, heat pump systems. | Topic: System efficiency (SPF)<br>Coverage: All heat pump types.<br>Currently being revised to provide hourly and monthly calculation. |
| BS EN 13313:2010 Refrigerating systems and heat pumps. Competence of personnel. | Topic: Competence requirements |
| Commission regulation (EU) No 813/2013 Ecodesign requirements for space and combination heaters | Topic: Sets minimum seasonal space heating energy efficiency (SSHEE, $\eta_s$) requirements and requirements for product |

| | |
|---|---|
| | data<br>Coverage: Products with an output ≤ 400 kW. No minimum performance requirements are set for sorption heat pumps. Only covers products providing water based heating. |
| Commission delegated regulation (EU) No 811/2013 Energy labelling of space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device | Topic: Requirements for energy labelling and product data<br>Coverage: Heat pumps≤70 kW |
| Commission regulation (EU) No 814/2013 Ecodesign requirements for water heaters and hot water storage tanks | Topic: Sets minimum water heating energy efficiency requirements and requirements for product data.<br>Coverage: Heat pumps with a rated output ≤ 400 kW and hot water storage tanks with a storage volume ≤ 2000 l. |
| Commission delegated regulation (EU) No 812/2013 Energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device | Topic: Requirements for energy labelling and data fiche<br>Coverage: Heat pumps ≤70 kW with an integral or separate storage volume ≤ 500 l |
| Number not available - Ecodesign requirements for air heating products, cooling products and high temperature process chillers energy related To be added latest details of Lot 21 | Topic: sets minimum seasonal space cooling energy efficiency requirements<br>Coverage: Heat pumps with a rated heating capacity up to 1 MW and a rated cooling capacity up to 2MW.<br>Currently awaiting approval with implementation in January 2018 |
| Microgeneration Certification Scheme (MCS) Guidance | MIS 3005 Installer standard for heat pumps<br>MCS007 Product Heat pump standard<br>MCS 026 - SCOP and SSHEE Calculator<br>MCS 027 - SPER and SSHEE Calculator<br>MCS 028 - DHW Calculator |
| Ground Source Heat Pump Association (GSHPA) Guidance documents | Shallow ground source standard<br>Vertical borehole standard<br>Thermal pile standard<br>Thermal Transfer Fluid Standard (under development)<br>Open Loop Standard (under development). |

# Annex B – Standard heat pump barriers

In this Annex we list the barriers identified for standard heat pumps (See section 9) which are also relevant for gas driven products, with a similar level of relevance and magnitude.

## Consumer Barriers

### Aesthetics

Aesthetics are a **major barrier**. Feedback from demand-side interviewees suggested that real-world buyers care more about aesthetics than marginal energy savings. This can be less of an issue in the countryside or for properties with more space, where units can potentially be concealed behind bushes or fences, or further away from buildings.

The impact of the aesthetics barrier is little different for gas heat pumps.

## Installation and Maintenance Challenges

Poor installation of standard heat pumps had a very negative impact on their reputation in the market. To avoid a similar situation with gas driven heat pumps (if the market is even able to distinguish between them), it is important that similar poor installation is avoided as the market grows.

### Speed of installation

When the boiler is a 'distress' purchase, speed of installation forms a significant part of the purchasing decision for a replacement. The gas boiler market is mature, with a number of experienced heating engineers in the market which would allow a boiler to be bought and installed in under a day[37]. Installation of a gas driven heat pump will typically take a similar amount of time to a standard product, however there is less likely to be a need to alter the heat distribution system or radiators, which can shorten overall system installation time. This is a **minor barrier.**

As the unit can be connected in the same way as a gas boiler can, installation of gas driven heat pumps should take a similar length of time as a gas boiler.

### Number of players in the supply chain

Feedback from interviews was that there are too many players in the supply chain, often resulting in poor specification or installation. A number of interviewees questioned why manufacturers are not involved in the design and installation of

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[37] The Future of Heating: Meeting the Challenge, *DECC, 2013*

units. There was confusion as to why a manufacturer would not perform a health check post-installation. This is a **minor barrier**.

Gas heat pumps do not differ to electric heat pumps for this barrier.

### Low replacement opportunities

Gas boilers have long useful lives of 10 – 15 years, and consumers are reluctant to replace them unless they are coming to the end of their life. This is a **minor barrier** that is not limiting the market.

There is no difference to electric heat pumps for this barrier.

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**Department for Business, Energy & Industrial Strategy**
3 Whitehall Place, London SW1A 2AW
www.gov.uk/beis