Avoiding heat pump failure

For decades now, heat pumps have proved to be a highly effective and sustainable source of heating and hot water for thousands of people around the globe.

In the UK, however, heat pumps are still a slightly unknown quantity, despite the fact that sales are now at a record high (more than 26,000 installations in 2022 according to the Microgeneration Certification Scheme).

Much of this impetus has been driven by the government's belief that heat pumps can help decarbonise the UK's housing stock. It has sought to fast-track growth in the sector through financial incentives such as the BUS Grant to help lower the cost of heat pump installations and bring them on a par with gas boiler installations. Ministers' stated aim is to reach 600,000 heat pump installations across Britain by 2028.

Achieving this ambitious target isn't just about lowering the cost of heat pumps, however; it's also about educating homeowners about heat pump efficacy and efficiency. In other words, it has been recognised that there needs to be a concerted effort to convince existing boiler-owners that heat pumps are a good investment in reliable technology, which will keep them warm in the depths of winter and lower their energy bills.

We specialise in the design specification, commissioning, and maintenance of heat pumps integrated with our underfloor heating systems and other emitters where appropriate, e.g. radiators. As engineers with decades of experience in the heating sector, we can testify that heat pumps are more efficient than boilers at turning low grade energy into useful heat inside the home providing carbon friendly heat, even in sub-zero conditions. Plus, the technology it relies on is tried and tested - as far back as the earliest days of refrigeration. It's unfortunate, therefore, that we're seeing heat pump installations that are failing to deliver the expected reliability or warmth. However, almost all these reported "heat pump" issues have been caused not by a failure of the technology, but by other factors such as poor design specification, installation, and commissioning.

In other words, most problems that we're seeing have been mainly due to a lack of expert knowledge, little or no installer training, and poor regulatory oversight.

To work effectively, a heat pump needs to be:

- Sized correctly in the design specification
- Installed and commissioned to run efficiently
- Maintained in line with the manufacturer's guidelines

If a heat pump system is not specified, installed, and commissioned correctly, homeowners are likely to struggle with problems that include cold or over and under heating, no hot water, inflated system price, escalating running costs, and a heat pump that may be prone to breaking down.

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What are the common reasons for "heat pump failure"?

1. Insufficient insulation

Our starting point when creating a design specification is to calculate the potential heat loss through the building fabric.

Good insulation in the loft and walls, along with double-glazing, will reduce running costs because the heat pump won't have to work as hard, and therefore consume as much electricity.

If cavity wall insulation isn't possible because a property has solid walls (as seen in many older cottages, Graded/ Listed properties) then the house will require a much greater amount of heat and a long time to heat up. In this instance, We have to be honest here that a heat pump may not be the best solution. If a heat pump still remains a customer preference then the best option is probably to install a hybrid system where the heat pump heats the property for the majority of the year but has a back-up boiler for the very cold days (note, this system is not eligible for a BUS grant, which requires 100% heating from the heat pump).

2. Sizing a heat pump

We can't emphasise this enough: a heat pump must be correctly sized in the design specification.

The size of the unit has a huge impact on its cost, the efficiency of the system, ongoing running costs, and the level of heat output.

Incorrect calculations (or even guesswork) can add significantly and entirely unnecessarily to the heat pump cost. For example, the difference in cost of a 7kW heat pump vs a 12kW unit is several thousands of pounds! By contrast, increasing the size of a boiler by as much as 10kW adds only a few hundred pounds to its price.

There is no room for estimates or guesswork when it comes to sizing a heat pump. The system needs to be designed and sized accurately in a formal design specification process by an expert in heat pump technology, based on careful heat loss calculations (U-values, elevation etc).

3. System flow rate - sizing

A heat pump system's performance relies on good system flow rates for the delivery of heat. So, sizing the system's pipework correctly at the design specification stage is also crucial to the efficiency of the system.

3.1) Pipe Sizing & Delta T: the size or diameter of the pipes used throughout the heating system are a key determinant as to whether the system will be able to achieve the correct temperature differential (or Delta T) required by the heat pump and specified by the manufacturer.

The temperature differential is the difference between the temperature of the water flowing from the heat source to the emitters, versus the water temperature on the return leg.

Temperature differentials for radiators can be as much as 20°C, while we would expect a heat pump to have a smaller differential (typically c.5-10°C as specified by the manufacturer).

If the pipework is too narrow, it will slow the speed of the water around the system and the returning water will drop too much in temperature.

3.2) Pipe Sizing & Flow Rates: it's a fallacy to believe a heat pump can work efficiently with the narrow pipework that typically serves a boiler and radiator system.

A 7kW heat pump needs a flow rate of approximately 14-21 L/min (2–3 times the model rating) and in this case we would normally suggest a minimum of 28mm diameter pipework to deliver sufficient heated water at a good flow rate to all the emitters (underfloor heating or radiators) around the property. If the pipework is too narrow, the system will be noisy, and the heat pump will have to work much harder which will increase its running costs.

Flow rates and pipe sizes are therefore critical to the effective running of the system (although see Buffer Tanks below).

4. Insufficient or incorrect flushing and filling

An all-too-common problem!

If too little attention is paid to flushing and filling the pipework when the system is first installed, and the cleaning is less than optimal, it can cause sludge to form in the pipes, filters to block, flow rates to drop, and the temperature differential to rise.

Inevitably, it means the heat pump will have to work harder than it needs to, which will therefore, once again, increase its running costs. Using a good quality pre-mixed antifreeze with demineralised water and inhibitor will also help to maintain good performance of the heating system.

5. Buffer tanks

Buffer tanks aren't routinely mentioned in heat pump systems, but they play a very important role in ensuring the smooth and effective running of the unit, reducing the likelihood of breakdowns, and in many instances extending the heat pump's operational life.

A buffer tank is typically designed to contain 25 or 50 litres of water. It is connected on one side (by flow and return pipes) to the heat pump and on the other side, through separate pipework, to the heating system and hot water cylinders.

There are two reasons for installing a buffer tank:

5.1) To keep the heat pump working effectively: heat pumps work harder when they are in "hot water" mode in order to heat the water to c. 55°C (for space heating, the required water temperature is lower, c. 35-45°C).

In winter, in hot water mode, it is perfectly normal for the front of the pump to freeze, at which point the unit will automatically defrost. The defrosting process sends the water stored in the buffer tank through the unit to melt the ice, and this water is then dispersed either into the ground or down a drain.

We've seen examples of apartments where a buffer tank hasn't been installed because of a lack of space (they take up c. 300mm diameter x 700mm high). By leaving the buffer tank out, the heating system does not have sufficient water volume to defrost the heat pump. So, on the coldest of days, the pumps just stopped working.

5.2) To keep the heat pump working efficiently: where existing pipework is narrower than would be optimal for a heat pump (see Pipework Sizing above), installing a buffer tank can help because it can act as an effective hydraulic separator.

This means that the heat pump only needs to pump water the relatively short distance to the buffer tank. It's possible to then attach a second hydraulic pump to boost the flow rate to all the emitters.

6. Incorrectly installed 3 port mid-position valves

We also see problems caused by an incorrectly installed 3 port mid-position valve, which causes the heating to run at too high a temperature and means the householder has no hot water.

Simply put, a 3 port mid-position valve directs the water output from heat pump to two ports leading to either the heating or hot water system. A motor within the valve operates either or both ports.

If the electrician and/or the installer fails to follow the manufacturer's schematic, then water which should be directed towards the hot water cylinder, will instead be wrongly directed to the emitters. So, the heating will run at 55°C instead of the correct 35-45°C and what should be hot water will instead be cold.

7. Hot water cylinder sensor

The hot water sensor in a cylinder should be placed around a third to halfway up the tank, depending on the cylinder's size.

We often see it placed too low in the cylinder, which means water at the top of the cylinder will be far hotter than the bottom; effectively, the heat pump will be working too hard and running costs will, once again, be a lot higher than they should be.

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What is the optimal level of efficiency for heat pumps?

Correctly sized and well-designed systems with the right pipe diameter and flow rates will have a heating co-efficient of 1:3 (for every 1kw of electricity, the pump produces 3kw of heat).

A system that has a heating co-efficient of 1:2 or less because it has been poorly designed and/or installed, requires higher levels of energy and will ultimately be expensive to run.

Can heat pumps be installed on multiple plots?

Yes, heat pumps can and should be installed in houses on multiple-plot sites.

Unfortunately, problems with these installations are particularly common and therefore we see a lot of issues in this kind of development during our remedial work.

It usually transpires that the contractors chose not to sub-contract the work to the Microgeneration Certification Scheme (MCS) accredited installers, consequently, the systems were incorrectly installed, tested and commissioned.

For example, we have seen instances in larger sites where the external pipework of heat pump systems have not been insulated, nor has glycol/anti-freeze been added. This resulted in frozen pipes.

We've also seen problems with system immersion heaters. Hot water cylinders contain immersion heaters, both as a system back-up and as an important factor in lowering the risk of legionella (by raising the temperature in the DHW cylinder once a week). Immersion heaters are powered by electricity and are fairly energy intensive - typically using around 3kW per hour. We've been called out to systems that hadn't been commissioned correctly so the immersion heaters were generating all the heating and hot water. In fact, the heat pumps weren't working at all, and the running costs were...astronomic!

There is some good news, though, for multiple-plot sites; Local Authority Building Control (LABC) has announced that all heat pump system designs on multiple plots must meet MCS standards. This should eliminate poor practices.

If you want to know more about OMNIE and our underfloor heating and heat pump systems, call us on 01392 363605. If you have a project in mind, you can send your plans to customer.service@omnie.co.uk

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