How to Guide for Installing an Air Source Heat Pump

In July 2022 we replaced our old gas boiler with an air source heat pump (ASHP) as part of a general desire to reduce our carbon footprint as far as possible. Here are the key things we learnt during the process which we think might be useful for you.

We have mentioned a few products and companies, on the basis that we did some research to find them and they worked for us – they may not be the best available, and they may not work for you.

Our house: a medium-sized 1880s mid-terrace solid brick Victorian home, now 4 bedrooms via a loft conversion

Motivations

A number of considerations led to our decision to move to an ASHP:

- Our gas boiler was 17 years old, getting noisy and a bit unreliable, so we knew it would need to be replaced soon.
- We wanted to reduce our carbon footprint and cut out gas for heating
    - The average UK household's gas consumption in a year creates carbon emissions of 2300 kgCO2e, which approximates to a return flight from London to New York
    - Our gas consumption was higher than average, producing 4500 kgCO2e
    - By insulating well and moving to an ASHP, we have reduced our CO_2 emissions for heating and hot water to less than 2 tonnes per year
    - As the UK electricity supply gets greener, our emissions will drop even further – to near zero when the large majority of generation is renewable.
- ASHPs are reliable, quiet and very efficient
    - They have been used for decades in Europe
    - It is well-understood technology
    - The heat energy transferred into the house is a multiple (3 – 5 times) of the electrical energy consumed
    - ASHPs have got much quieter than they used to be.
- [Alternatives and add-ons which we decided weren't for us:
    - Ground source heat pumps are even more efficient, but the groundworks are very expensive and would destroy a large part of the garden (temporarily)
        - GSHPs are the right way to go for new-builds with underfloor heating
    - Solar panels could be used to generate some of the electricity to run the ASHP, but our roof space is not suitable, and there is the problem of most power being needed in the evenings and in the winter, so ideally you would install batteries as well
    - Heat storage batteries can be added to the system to allow more power consumption at off-peak times, but this seems to need a less efficient, higher-temperature ASHP
    - Infra-red heaters may be a good low-cost choice where there is no existing hot water central heating system to replace.]

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- There was a sizeable a government grant of £5,000 available in 2022 – now £7,500 – under the Boiler Upgrade Scheme
- We were not expecting to save money immediately, as the cost of electricity is set to 4 times the price of gas per kWh
    - The electricity price is tied to the gas price at present – but this is likely to change
    - Increased use of renewables in electricity generation will reduce the cost
    - **BUT** – as the ASHP is so energy efficient, and as our house is now better insulated, we are paying several hundred pounds less per year than we would have done with gas.

Insulation First: "Retro-fitting" your House

The first step in reducing the cost and carbon footprint of heating your home must be to make sure, as far as possible, that you are not throwing heat away. A well-built new house may be up to scratch already, but the average modern house and almost all older houses will have a lot of room for improvement. A Victorian house like ours usually leaks heat like a sieve.

If you do this the wrong way round and install an ASHP first, the best that can happen is that you spend too much on too large a heat pump; the worst, that you are cold during winter and regret the whole business.

Installing an Air Source Heat Pump

What is an ASHP?

It takes heat energy from the air outside your house and uses it to heat water for your radiators and to provide hot water inside the house. It works even when the air is much colder outside than inside. (If you want to know how it does that, see the technical appendix.)

- The main unit is a big box which sits outside your house, but close to it
- Two well-insulated pipes carry hot water into and out of the house back to the unit
- This hot water then circulates in your radiators and is piped in a coil inside your hot water tank, just like water heated by a gas boiler.

Inside the house, everything is much the same as gas central heating, but with more complicated controls.

https://cat.org.uk/info-resources/free-information-service/energy/heat-pumps/

https://energysavingtrust.org.uk/advice/air-source-heat-pumps/

Key Considerations

There are a number of things to think about before you get started.

- The state of your insulation – see separate how-to guide.
- Your current heating source:

    - If you are heating with oil, coal, wood burning or direct electrical heating, then economically and environmentally, the decision should be very easy
    - Gas is a bit more marginal, but increasingly going the right way as the electricity supply decarbonises
    - If you have recently fitted an efficient condensing gas boiler, it is better for the environment not to scrap it right away.
- Where will the outdoor unit go?
    - It is a large box – ours is about 1m x 1m x 0.5m
    - Plus, it needs a small gap behind (0.5m) and a large space in front (2-3m)
    - It should not be within 8m of a neighbour's bedroom, unless shielded
    - The shorter the distance for the pipe run back to the hot water tank, the better
    - Delicate plants may not survive the blasts of chilled air from the unit.
- Do you have room for a larger hot water tank, plus all the extra kit?
    - Apart from the tank, there is a control box, control panel, two pumps, wider (28mm) piping, water filter, a mysterious pre-mixing unit on the central heating…
    - We have lost most of our airing cupboard, while gaining the boiler space in the kitchen
    - An alternative to a large hot water tank may be a heat battery e.g. https://sunamp.com/hot-water-thermino-overview/ but these are still sizeable and heavy, expensive and only compatible with some ASHPs.
- You need an up-to-date EPC rating (done within the last 10 years), with no outstanding recommendations re loft or cavity wall insulation, in order to get your grant.
- Costs
- And other eligibility criteria – see https://www.gov.uk/apply-boiler-upgrade-scheme/check-if-youre-eligible.

Costs

A typical installation may cost £14,000, reducing to £6,500 as the government grant is now £7,500.

- The heat pump itself costs £3,000 - £6,000, depending on the power level
- A lot of the cost comes in the other pieces of kit needed – the new extra-large water tank (which is super-insulated), pressure vessels, mixers, controllers, the copper pipework etc.
- Another chunk of cost comes in the labour needed – a good 3-4 days for a plumber, plus electricians and project managers etc.

Our heat pump is by Mitsubishi (one of the leading makers) and is very quiet – the Ecodan PUZ-WM112VAA, which can run up to 11.2kW heat output. If we hadn't done all the insulation work, we would probably have needed the larger 14kW model.
https://les.mitsubishielectric.co.uk/homeowners/our-heat-pumps

The overall cost of our installation in 2022 was £13,350 so we paid £8,350 and the government paid £5,000 (the grant available in 2022).

Choosing an Installer

- They must be accredited to the Government's Boiler Upgrade Scheme (i.e. MSC Certified). They do all the paperwork for you in applying for the grant; there is a clear process for doing the work well and for resolving any issues
- Expertise in your chosen heat pump – these are not ordinary plumbers! They are specially trained as they have very sophisticated kit to put in and set up well
- Be local to you – vital! Then technicians can pop in to sort out any issues/check on progress.

Find an installer on https://mcscertified.com/ and get more than one quote. We chose Sustain Homes as they are experts in Mitsubishi Ecodans (and Sunamp heat batteries) and are based in Watford. They were very professional, friendly, responsive, and efficient.

https://sustainhomes.co.uk/heat-pumps#overview

Getting an EPC

Find a local EPC assessor on the official register https://www.theepcregister.co.uk/epc-register and book an appointment. They will inspect every aspect of your house and want to see and photograph all insulation and energy usage (including low energy light bulbs) currently in place. They will also want to see all your receipts and guarantees, with dates on. This all goes into the spreadsheet and then your house gets given an official energy performance rating. The EPC cost us £80 (depends on size of house).

They may make recommendations, which you must meet (and demonstrate with invoices/receipts) in order to get the ASHP grant. However, they cannot recommend very expensive work – usually it will just be extra loft insulation.

After all the insulation work we had done, we were put into the C band with no recommendations for further action, whereas the average Victorian home is a Band E or F.

The Design Stage

There are a number of decisions to sort out with your installer before installation:

- The capacity in kW of the ASHP needed for your house, which determines how big the box is
- The best site for the ASHP – it needs space around it, it blows out cold air, it makes some noise, ideally a short pipe run to your hot water tank
- The size of the hot water tank – because the water is cooler, you probably need a larger tank
- Where the hot water tank will go – hopefully it will fit where the old one was, along with the control box and more pipework
- The route the water pipes need to take through your house to the hot water tank
- The route the electric wiring needs to take from your fuse box to the ASHP
- The number of radiators to be replaced - bigger, double-panel radiators may be needed to warm a room as the water inside them will be cooler.

For a more technical explanation, see the appendix to this case history

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Impact of Installation on the House

- The installation meant some sections of carpets coming up and then being put back, a small section of stud work being removed and then put back, and the demolition of a cupboard in our kitchen. There was a bit of touch-up repainting to be done.
- Our old gas boiler and all its pipework was housed in a kitchen cupboard so we had to take out the cupboard so they could take away the boiler. We bought a new cupboard carcase, worked very hard to jam it back into the space and then put back the cupboard doors. We now have a useful new cupboard where the boiler was
- Our old airing cupboard had many shelves. These all had to be removed to fit in the new bigger water tank and kit. We have now created a mini airing space with removable baskets.
- As the installer wanted to go for the easy option of just boxing in the new wiring for the ASHP, and as we also wanted a new cable for our induction hob, we paid for our own electrician to put the 2 new cables under the floorboards (£550).
- Several of our radiators were already large enough, and double-panelled. In the end we only replaced 5 radiators, £150 each, plus a new towel rail for the shower room which they fitted for us.
- Definitely stay in the house while the installation is taking place – you're on hand to spot issues and be consulted.

Settings

We can programme and control the heating timing in 3 ways: via the controller beside the hot water tank, via the handset which can be placed in any room (rather than having a fixed thermostat in the hall), or via an app on our phone.

There are a lot of possible settings, and they are not very clearly explained. It is worth reading the guides, talking to the installers during commissioning, and trying things out before they leave.

For a more technical explanation, see the appendix to this case history

The Success Story

- It is so quiet! Outside and inside the house. No more clanking, wheezing boiler.
- Heating the house – it all works fine, and we were nice and warm in the winter. It is a slower heating process than gas – you have to get used to the settings.
- It heats the water very effectively – we set the water to 45 degrees centigrade, and we have plenty of hot water whenever we need it, just as before with gas.
- We have lower energy usage/bills now, as the ASHP is so energy efficient compared to a gas boiler, and as our house is far better insulated.
- If we ever have a technical issue, we can ask Sustain Homes to monitor what is going on remotely – as can Mitsubishi.
- We saved 2.5 tonnes of carbon in the 12 months following installation, and every year to come, and even more as electricity becomes greener.

Technical Appendix

How does an ASHP work?

An ASHP is just like a fridge, which uses electricity to pump heat out of the fridge, make the inside of the fridge cooler and the area behind the fridge hotter. An ASHP uses electricity to pump heat into the house making the air outside colder.

In detail, the process works like this:

- The main unit contains a refrigerant fluid (for example R32 or propane), which can be converted between liquid and gas at convenient temperatures and pressures
- The refrigerant is circulated in a closed loop, driven by a compressor (a special pump)
- When the refrigerant evaporates from liquid to gas, it absorbs a lot of heat and gets much colder – a similar (but much bigger) effect to a spray can nozzle getting cold
- The very cold gas/liquid is circulated through the narrow pipework with fins that you can see around the back of the unit, behind the fan
- The fan keeps relatively warm air flowing over the pipes, so that the refrigerant is warmed up, and the air itself gets colder
- Then the refrigerant is passed through the compressor, which compresses it back to liquid, and that makes it much hotter – hotter than it was when it started the circuit, because of the heat gained from the air
- The hot refrigerant is used to heat the hot water which will flow back into the house
- The cooled liquid refrigerant is now back at the start of the cycle.

It takes much less energy to pump the heat from outside in this way than to create heat directly by burning gas or putting an electric current through a resistor. The multiple, called the "Coefficient of Performance" or COP, can range from around 3 up to 5 or more, meaning that 1kWh of electrical energy consumed can provide 3-5kWh of heat energy to the house. This depends partly on the quality of the ASHP itself, but also on the external temperature, the temperature you are trying to reach with your water or heating system, and the details of your particular installation.

To account for this variability, you will see the term "Seasonal Coefficient of Performance" or SCOP, which reflects changing air temperatures across the year, together with the average pattern of heat need – more in winter, when the COP is lower, than in summer. So, the SCOP may be more useful than the COP, and will be a lower number. When a SCOP rating is given, it should also specify the water temperature achieved at that rating.

Most ASHPs are connected to your plumbing system and deliver the heat to the house via hot water. There are ASHPs which heat and cool air instead, but those are not compatible with "wet" central heating.

Heating the Water

ASHPs run most efficiently (highest COP) when they heat the water to a moderate temperature e.g. 45°C, and most will not heat water above 50-55°C. This is in contrast to a gas boiler, which will normally heat water to 65°C or more. There are two important consequences:

- Water at 45°C is perfectly hot enough for normal use for washing, but the lower temperature means you won't need to mix it with as much cold water, and so the hot water tank will run down quicker. You will probably need a new hot water tank anyway, but you will be advised to get a bigger tank than your current one.
- A lower temperature in the heating system means that radiators will deliver heat more slowly. You will be recommended to replace any radiator which is not large and double-panelled with double fins inside. The ideal is underfloor heating, but that is very expensive to retro-fit.

https://cat.org.uk/info-resources/free-information-service/energy/heat-pumps/

https://energysavingtrust.org.uk/advice/air-source-heat-pumps/

The Design Stage

A very detailed, room-by-room survey will be undertaken by the installation company. For each room, the floor, ceiling and all walls and windows will be assessed for thermal properties, plus what is on the other side of the walls. The aims of this are to:

- Calculate the overall heat loss of the house in order to determine the size of ASHP needed
- Calculate which radiators will need to be upgraded, and to what size
- Determine what size of hot water tank is needed.

It is worth reviewing the resulting spreadsheet with care to check that all the details are correct, because out of hundreds of measurements you can't expect perfection the first time. We agreed at least a dozen changes, some to do with errors, and some low estimates for the quality of our double glazing, or the insulation in the loft, for example. In one room we decided that a slightly small radiator would be adequate given the usage of the room. In another we went for a larger radiator because we know how cold that (attic) room gets.

There are some odd official standards. For example, in a terraced house, where a wall is shared with a neighbour, the neighbour's house is assumed to be kept at a mere 10°C. There are also mysterious multiplying factors for uncontrolled ventilation (i.e. draughts).

The survey also determines a suitable location for the heat pump, the hot water tank and controller, and the routing of pipes and electrical cabling. This should be a collaborative process, because there are many possible options, and only you can judge what you prefer.

The ASHP needs a direct 30A electrical connection to your fuse box, and an isolator switch.

Having no teenage children, we decided that our hot water requirement was lower than the standard calculation, so our new tank is smaller than it might have been. If we have visitors, we can press a button at any time to reheat the water – it takes half an hour.

Operating Settings

For **heating**, the recommendation is not to let the house get too cold at any time, because of the work and time needed to bring the temperature back up to a comfortable level when needed. (With our gas boiler, we always had the heating switched off at night, then a big burn in the morning when we got up. During the day we would turn the thermostat up and down according to how we felt.)

The controls for the ASHP are more sophisticated, and you can set both the times at which heating is possible, and a profile of changing thermostat temperatures across the day. You can set different profiles for the days of the week. You can even have two separate sets of profiles for different months of the year, but that seems unnecessarily complicated - we will probably just switch the heating off in late Spring. Our current setup for the colder months, which works well for us, is:

- Heating available 24 hours a day
- Same profile for all days of the week (we are normally at home every day)
- Thermostat set to 15°C at night, 18°C in the morning and early afternoon, 20°C+ in the late afternoon and evening, and back down to 15°C an hour before bedtime.

We sometimes also adjust the target temperature manually via the portable room controller/thermostat. For example, we moved the controller into the colder dining room in the afternoon when we wanted to make sure that would get comfortable for the evening. (The individual radiator thermostats also need to be set carefully for that to work - or else you may find most of the extra heat going into the main living areas.)

For **hot water,** you can use the settings to tailor the timings and temperature to suit you, saving energy and reducing noise in the nighttime.

- Our installation engineer set the target hot water temperature to 55°C, but we find that 45°C works well for us (and is much more efficient, because getting to 55°C is likely to require the immersion heater for the last 5°C).
- The recommendation was to have water heating set to come on whenever the temperature in the tank dropped far enough, but we prefer to have it come on at a fixed time.
- We were recommended to have that time be the middle of the night, but we don't have a special night-time tariff, and so we have it set for early evening, when the outside air is likely to be warmer.
- It reaches the right temperature in the hot water tank in just 30 minutes.

A legionella cycle is a special safety cycle run once a fortnight. This bacterium can survive in the hot water tank unless you heat it to 60°C occasionally.

