Analysis: Running costs of heat pumps versus gas boilers

by Jan Rosenow

Misinformation is derailing common understanding of how much it costs to heat homes with heat pumps. This analysis shows that if they are designed and installed well, heat pumps can be cheaper than gas boilers, the main home heating technology used in the UK.

Key finding

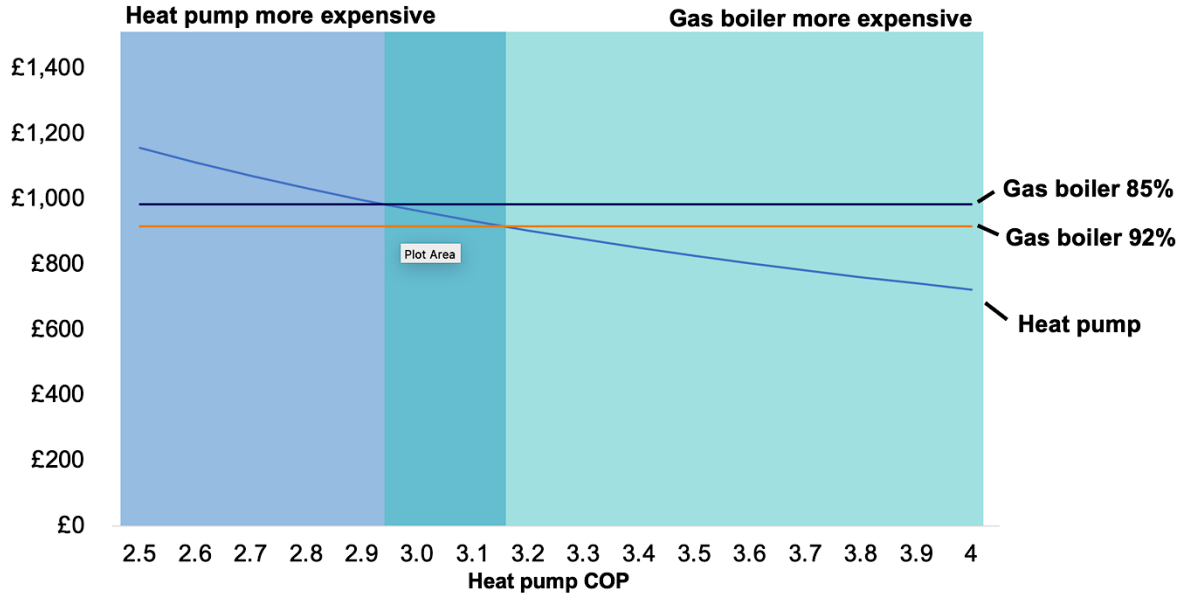
Household gas prices are on the rise and are expected to increase by another 84% in April. Electricity prices have risen too, but not as much as gas. This means that renewable heating technologies such as heat pumps are now much more competitive. The analysis below shows that, with an efficient heat pump, households can now save up to 27% on their heating bills compared to a gas boiler. Heating with an average gas boiler will cost households £984 per year, up from £579. A very efficient heat pump will only cost £723 per year, up from £536 per year. For an average household, this is a saving of £261 per year. With government looking to shift green levies from electricity to gas, heat pumps will become even more financially attractive.

The most important parameters that determine the running costs of a heating system are the overall heat demand, the efficiency of the system and the price paid for fuel.

Following Ofgem's price cap announced in February, domestic gas and electricity prices will increase significantly in the UK in April. The maximum unit costs for gas will increase by 84% and electricity by 35% (£0.07kWh for gas and £0.28/kWh for electricity, up from £0.04/kWh and £0.21/kWh, respectively). Electricity prices will be four times higher than gas whereas, under the current price cap, electricity is about five times more expensive than gas. This has clearly affected the running costs of heat pumps compared to gas boilers.

Analysis shows that, with an efficient heat pump, people can save up to 27% on their heating bills compared to a gas boiler: Heating with a gas boiler will cost households £984 per year, up from £579. A very efficient heat pump will only cost £723 per year, up from £536 per year. For an average household this is a saving of £261 per year.

Using the most recent figures available, the graphic below shows when it is cheaper or more expensive to heat with a heat pump compared to a gas boiler. The figures are based on the coefficient of performance, or COP, a measure of the ratio of electricity used to the heat extracted from the environment. A COP of 3, for example, means that you get three units of heat from one unit of electricity. The data shows that, with a COP of about 3, a heat pump starts to become cheaper to run than a gas boiler, which in most cases runs at an efficiency of about 85% as explained below. In the past, a COP of around 3.7 was required to achieve the same running costs as a gas boiler.



Assumptions: Heat demand: 10,204 kWh; Cost gas: 7.37p/kWh; Cost electricity: 28.34p/kWh; Gas standing charge: £0.27/day

Field monitoring data for existing buildings shows that a COP of 3 is easily achieved by air source heat pumps and 4 or above is possible for ground source heat pumps. When heat pumps underperform this is often the result of poor design, installation and maintenance.

The data shows that statements such as “heat pumps are more expensive to run than gas boilers” or “heat pumps always save consumers money” are misleading. A more correct statement is that “heat pumps can save consumers money if designed and installed well to achieve high enough efficiency.” This is more easily attained with the change in domestic gas and electricity prices.

Detailed assumptions used

Heating costs can be calculated using a simple formula (the standing charge for gas does not apply to heat pump systems):

$$heating\ costs = heat\ demand\ x\ \frac{1}{\substack{efficiency \\ of\ heating\ system}}\ x\ fuel\ price + gas\ standing\ charge$$

I made the following assumptions for each parameter:

Heat demand: We can assume space and water heat demand for a typical household to be around 10,204 kWh per year using a boiler efficiency of 85% (see below) and median annual gas consumption of 12,100 kWh, excluding the 2.4% of gas used for cooking.

Gas boiler efficiency: The minimum standard for new gas boilers is 92% efficiency set by the Energy-related Products Regulations. The efficiency of a gas boiler, however, varies significantly and depends on whether the flow temperature, the temperature of the water pumped around the house to the radiators, is low enough

for the boiler to condense — most boilers do not condense. In the UK, boilers are typically oversized, which affects efficiency as does the extent to which there are appropriate controls for the boiler. Detailed in-situ monitoring studies of condensing boilers showed an average measured efficiency of 82.5% for combination boilers and 80.3% for heating-only boilers. The study concluded that "the in-situ performance of the boilers is significantly less than the rated […] seasonal efficiency". It is therefore more realistic to assume that, in most cases, 92% efficiency is not being achieved. For the calculations, I thus use both a 90% boiler efficiency and a lower 85% efficiency.

Heat pump efficiency: The effective efficiency of the heat pump depends on the coefficient of performance explained above. Getting three or more units of heat for one unit of electricity is possible because the heat pump extracts thermal energy from the ambient air, ground or water. Because the performance varies across the year, the seasonal coefficient of performance should be used for cost analysis. Further details are available in several non-technical explanations of how a heat pump works.

Similar to a boiler, the efficiency of a heat pump varies and depends on multiple factors. An important parameter is again the flow temperature: the lower the flow temperature, the higher the COP. A COP of 3 appears to be feasible for air source heat pumps, as long-standing field monitoring studies by the Fraunhofer Institute in Germany shows. Note that outliers with particularly good COPs in fully renovated houses were not included in the calculation. Ground source heat pumps can deliver a COP of 4 or higher. It is important to point out that some installations fall short of achieving such high COPs. Previous field studies in the UK have shown that poor design and installation sometimes resulted in lower efficiencies. However, this can be avoided by appropriate design, installation and maintenance of the heat pump.

Fuel price: The fuel price assumed for a comparison is the energy price cap in the UK. Ofgem announced a new energy price cap in February 2022, resulting in a unit rate of £0.07kWh for gas and £0.28/kWh for electricity up from £0.04/kWh and £0.21/kWh respectively.

Standing charge: There is a standing charge for both electricity and gas. However, homes heated by gas always pay the electricity standing charge and electrically heated homes with no gas connection do not pay a standing charge for gas. It is therefore reasonable to ignore the standing charge for electricity, as households using gas boilers and those with a heat pump pay it regardless of the type of heating system used. For gas, official figures by Ofgem assume a standing charge of £0.27/day.

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