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# P4_3 Pumping Heat

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**Abstract**

We explored the feasibility of using air to air heat pumps as an alternative heat source in an average UK home. An ideal heat pump was calculated to be up to five times as efficient as electric heaters at temperatures as low as $-20^oC$. Heat pumps were calculated to be the cheapest and the most planet friendly source of heat for homes compared to gas boilers and electric space heaters.

## Introduction

The primary sources for heating in the UK are gas fired boilers and electric space heaters which are a major source of $CO_2$ emissions. We investigated the viability of heat pumps by calculating their ideal Coefficient of Performance (COP) and how replacing conventional heat sources with heat pumps would impact the costs and $CO_2$ emissions associated with domestic heating.

## Theory

Most modern boilers only reach an efficiency of up to 94% [1]. While electric heaters are thought to be 100% efficient, the effective performance of heat pumps can be much higher, since they move heat from one place to another instead of converting energy to heat. The performance of a heat pump is given in terms of its COP. The maximum COP a heat pump can achieve is given by:

$$COP = \frac{T_H}{T_H - T_C}, \tag{1}$$

where $T_H$ is the hot side temperature and $T_C$ is the cold side temperature.

Real heat pumps will have a lower COP due to inefficiencies associated with its operation. In this article we will be using Samsung EHS Mono Air source heat pump as a reference which has an average seasonal COP of 4.21 [2] which is equal to an effective efficiency of 421%. The cost per kWh of thermal energy generated can be calculated by:

$$Cost = \frac{cost\ per\ kWh\ (fuel)}{Efficiency}. \tag{2}$$

## Results

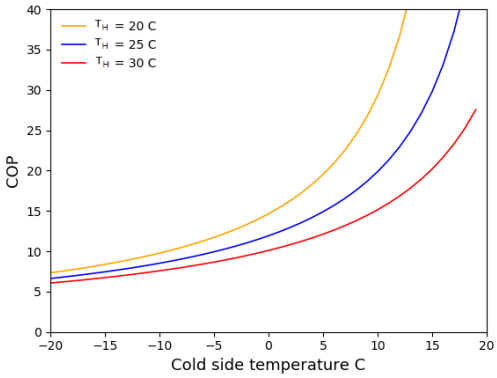


**Figure 1:** Theoretical values of COP for a heat pump

As shown in Figure 1, a lower $T_H$ value re-

| Heat source | Efficiency | Cost per kWh (pence) | $CO_2$ emitted per kWh of heat (kg) |
|---|---|---|---|
| Samsung EHS heat Pump | 421% | 3.14 | 0.067 |
| Gas Combi boiler | 90% | 4.2 | 0.230 |
| Electric heater | 100% | 14.37 | 0.284 |

**Table 1:** Cost and $CO_2$ emission comparison of heat sources

sults in a higher COP, but a sufficiently hot $T_H$ will be needed to ensure a reasonable heating rate. We can see that ideal heat pumps can achieve a COP of above 5 even at temperatures as cold as $-20^oC$, with COP reaching values of 10 or above for typical winter UK temperatures of about $0^oC$.

The average cost of fuel in the UK in 2019 is 14.37 p and 3.80 p per Kwh for electricity and gas respectively [3]. The energy mix of the UK consisted of 39.5% of gas, 5.1% coal and 55.4% non directly $CO_2$ emitting sources in 2018 [4]. Coal and Gas emit 1.14 and 0.57 kg of $CO_2$ per kWh of electricity respectively [5]. Therefore 1 kWh of electricity emits 0.28 kg of $CO_2$, while gas boilers emit about 0.23 kg per kWh of energy [6]. Emission figures in Table 1 were calculated by dividing these emission rates corresponding to the fuel used by the efficiency of the heat source.

## Discussion

Considering the ideal performance of heat pumps, they are capable of performing about 5 times more efficiently compared to an electric heater at temperatures as low as $-20^oC$.

They were also calculated to be the least $CO_2$ emitting heat source at 0.067 kg per kWh of heat generated. Given an average space heating requirement of 9000 kWh [7], an average home can cut their $CO_2$ emissions by up to 2 metric tons per year. Variance in COP due to temperature changes wasn't considered in this estimate.

Heat pumps appear to be the most planet friendly heating solution, emitting about 3-4 times less $CO_2$ than gas and electric heat sources. The main obstacle in its adoption can be the high cost associated with such units and their installation which can range from £7000 - £ 11000 for an average home [8] .

## Conclusion

Air to air heat pumps were found to be the most efficient and cost-effective way to heat a home. As the UK moves towards a more carbon neutral future heat pumps can play a vital role in cutting down carbon emissions and helping the UK meet its emission targets.

## References


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[4] DUKES 2019, page 89

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[6] https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0523

[7] https://www.thegreenage.co.uk/how-much-energy-does-my-home-use/

[8] https://householdquotes.co.uk/air-source-heat-pump-prices/