HOW THE PACE OF RESIDENTIAL HEAT ELECTRIFICATION IMPACTS THE ENERGY SYSTEM?

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Overview

Heating buildings is the source of nearly a quarter of UK emissions (UK Gov. 2021a). Thus, meeting net zero will involve virtually all heat in buildings to be decarbonised. In their Heat and buildings strategy, the UK Government (2021b) set out its plans to deliver at least 600,000 heat pump systems per year by 2028. This will involve significant changes to the energy system - including the upgrade of the energy networks and increasing renewable energy generation capacity - alongside the installation of new heating systems in people's homes. Understanding how these costs are distributed, where benefits might accrue and how the wider economy might be impacted will be key. These questions are set within a quickly changing policy environment where for example, surging global gas prices have driven a significant increase to the energy price cap for GB energy consumers. Although the significant increase in international gas prices has markedly narrowed the gap between the cost of electricity and gas, this price differential - where consumers currently pay significantly more per unit of energy for electricity - remains an important factor for understanding how different decarbonisation options will affect the affordability of heating systems.

Many studies have been developed to analyse the impact of heat electrification. However, most of them do not consider different heat pump adoption pathways and normally they only analyse the implications of a large penetration of heat electrification in the power sector, not considering, for example, the changes on emissions, energy use and consumer costs. The work developed in this paper aims to provide insight on this issue, analysing the implications of the electrification of residential heat under different adoption pathways, using the UK TIMES energy system model. Preliminary results show that the speed in which heat pumps are rolled out can have important impacts on energy use, emissions and the level of network investments, and thus higher costs for the final consumer.

Methods

In this paper, two electrification scenarios are analysed using the UK TIMES model. TIMES is a bottom-up techno-economic energy system-wide model, which considers all the processes of the energy system, and produces future energy scenarios based on a cost minimisation objective function. The two analysed scenarios are based on recent UK Government policy targets as set in the the Heat in Buildings strategy (UK Gov. 2021b), stating that 600,000 heat pump systems are to be installed per annum from 2028 and 1.9 million per year by 2035, this will translate to arounf 11 million of households using heatpums by 2035. The difference between these scenarios is the pace in which electrification is adopted until 2050 (see figure 1). The quicker electrification scenarios roughly follows the UK Government target, whereas the slower electrification scenario is assumed to have a slower uptake, not meeting the 2035 target, but ramping up adoption after this and reaching a similar total heat pump uptake by 2050.

The results of the different scenarios are compared across one another and with a base case where no heat electrification takes place. The impact of the residential heat electrification pace of adoption is analysed in terms of network investments, energy use changes and emission reductions.

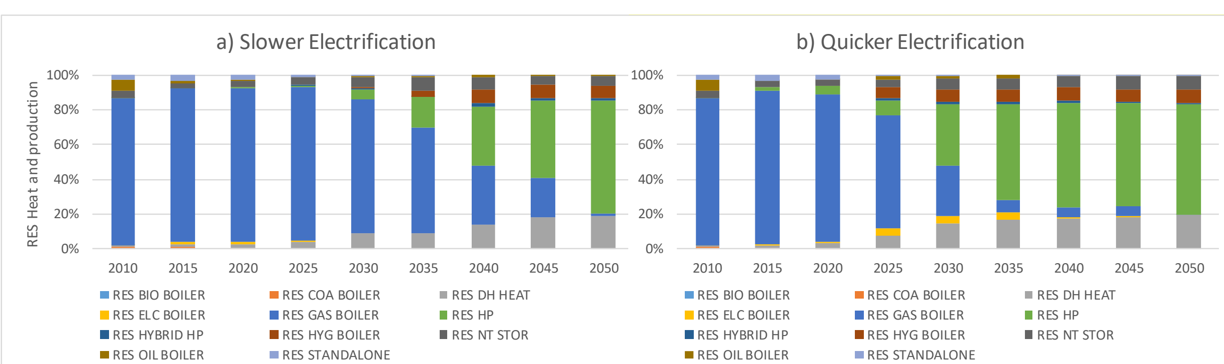

Figure 1. Residential heat technology mix: slower and quicker electrification scenarios.

Results

Preliminary results show that these residential heat electrification pathways produce different results in terms of the timing and the level of fuel switching and energy reductions. For example, Figure 2 shows the changes in residential energy use for heat relative to the base case. It can be noted that the quicker electrification drives energy savings earlier. However, the 2050 energy use point is similar in both cases and achive almost 40% energy reduction in relation to the base case. These energy reductions are caused by the higher efficiency from heat pumps. However, price differential between residential electricity and gas is key in translating these energy use savings into reduced costs for households. For instance, recent costs in the UK put each kWh of electricity to be around 4 times more expensive than gas. This higher price per unit of energy can completely offset any cost savings from the higher efficiency.

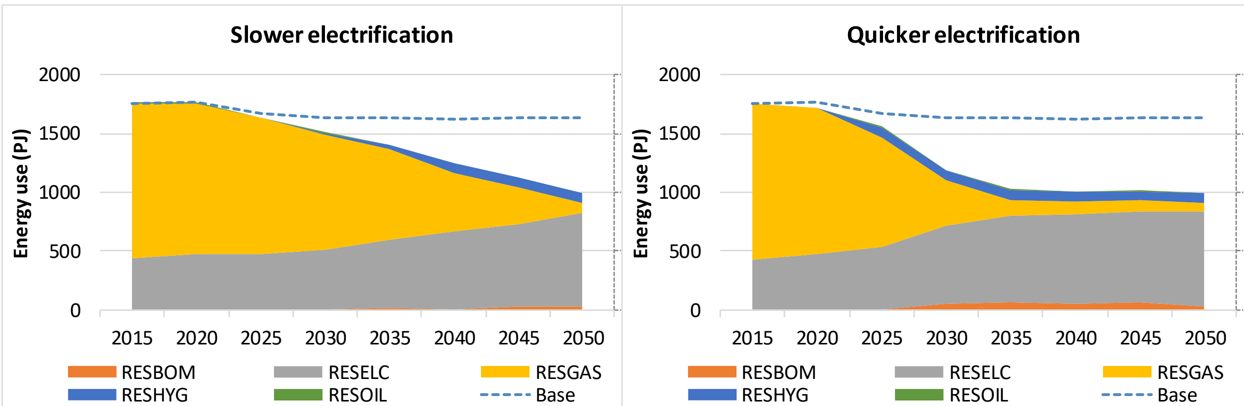

Figure 2. Energy use for residential heat in the slower and quicker electrification scenarios.

Additionally, the heat electrification pathways involve the expansion of generation and network capacity, and the investment patterns can change significantly in the different scenarios. Further to this, the network investment costs are transferred to consumers as an increase in marginal costs (energy prices), and heating costs can be significantly different across scenarios. These and other relevant policy outcomes, such as emission reductions, are also important to take into account while designing energy tariffs and heat decarbonisation policies.

Conclusions

Our initial analyses highlights key issues, such the importance of the market price differential between gas and electricity and how that may interact with other factors to impact the wider economy consequences of electrifying heat. We anticipate almost 40% energy savings for heating, largely due to the higher efficiency of heat pumps compared to gas central heating systems. However, where the electricity price is high relative to that of gas, monetary savings in delivering heat/hot water services can be significantly offset or completely eliminated. Such net impacts on bills must also be set in the context of the upfront and/or financing costs of purchasing and installing a new heating system.

In addition to this, the timing and level of network investments as also affected under the different scenarios. This could have important implications for the economy, as large investments concentrated in a short period of time could create adverse effects in the economy due to labour and/or capital scarcity (Alabi et al., 2020). We believe that these scenarios provide a range of outcomes that may help policymakers and network operators to plan and find solutions that do not overburden consumers and facilitate the transition to low carbon heat.

References

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