EPRG WORKING PAPER NON-TECHNICAL SUMMARY

UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

An overview of the electrification of residential and commercial heating and cooling and prospects for decarbonisation

EPRG Working Paper 2037

Cambridge Working Paper in Economics 20120

Mathilde Fajardy and David M Reiner

Heating and cooling are responsible for 54% of the world's final energy consumption, and 42% of global CO_2 emissions.[1] Owing to the highly dispersed nature of these emissions at the building level, efforts to lower heating and cooling demand and associated emissions are relatively recent, compared to other sectors such as power and transport. In the building sector, heating and cooling make up 58% of the sector energy demand. In the last twenty years, space and water heating demand has remained relatively constant, owing to significant efficiency improvements balancing the 65% global floor area increase. However, little effort has been made to assess how this demand is met. Heating in buildings is still heavily fossil fuel dominated, with direct emissions from buildings totalling 3 $GtCO_2$. Added to this base energy demand and emissions are those associated with an increasing demand for cooling services: in the same period, cooling energy demand almost tripled, and buildings indirect emissions (which include the carbon footprint of electricity) increased from 4.8 to 6.5 $GtCO_2$.

With an increasingly decarbonised electricity grid, the electrification of heating, through high efficiency household- and district-level heat pumps, offers one potential alternative to the incumbent heating system. Only 11% of buildings heat demand is

[1] Unless noted otherwise, the data presented refers to 2017, the most recent year available.

electrified, mainly using conventional electric heaters. Renewable heating alternatives, which include heat pumps, solar thermal, biomass boilers and renewable powered district heating and cooling networks only make up 10 per cent of current heating supply. While sales of these alternatives expanded over the last twenty years – from 2% to 3% of sales for heat pumps, and 4 to 6% for renewables, a much faster transition is required to meet global decarbonisation ambitions.

Global decarbonisation scenarios foresee a rapid decarbonisation of the buildings sector, with direct and indirect CO_2 emissions from the building sector dropping by 88% in the 2°C IEA Faster Transition Pathway to 2050. By 2050, residential heating demand is expected to be met with bioenergy and solar thermal (85% of installed heating capacity), heat pumps and natural gas, which still meets 15% of heating demand. While these scenarios are already very ambitious, the adoption of more stringent economy-wide net-zero targets will require even deeper and faster changes to the sector.

In this context, this study explores the challenges and opportunities to decarbonise heating in the buildings sector through electrification. Four key challenges and associated actionable levers were identified to unlock the potential role of electrification to decarbonise heating.

Driven by temperature rise and an increasing populating in emerging economies, cooling, (as well as demand for other electricity services) in buildings has significantly increased in last twenty years. Measures to mitigate this increase include improving appliance efficiency (via standards and technology performance labels), increasing building performance (via regulation and incentives), and exploiting the coincidence of solar PV production and cooling peak demand.

To this increasing demand must be added the electricity demand curve and peak demand impacts resulting from the electrification of a seasonal heat demand with high hourly variations, which could pose considerable balancing challenges to the grid. Opportunities to alleviate these impacts include synergies with alternative technologies (distributed solar PV, district heating and large-scale heat pumps), enhancing flexibility with thermal storage, and shifting peak demand to off-peak hours with smart meters and dynamic electricity pricing.

There is a high uncertainty around the adoption of higher cost heating technologies, efficiency improvements and flexible demand behaviours at the household level. Incentivise the purchase and operation of renewable heating technologies at the household level with support mechanisms, reducing the cost of new systems with market-based measures and economy of scale and highlighting the all-year thermal comfort benefits of reversible heat pumps are examples of measures which could boost adoption of technologies and demand-side measures.

Finally, costs associated with power infrastructure expansion (both generation and transmission) and decommissioning of an underutilised gas network are substantial. Improving efficiency of gas appliances, repurposing the gas grid with greener gas (hydrogen, biomethane or carbon-neutral synthetic fuels), and encourage hybrid heat pumps which can deliver better performance are three key levers to avoid the need for radical shift and stranded gas assets costs. In addition, electricity supply security standards play a key role in electricity generation and transmission capacity expansion and revising standards such as the Value of Lost Load (VoLL) could reduce the system's costs associated with a higher electricity and peak demand. Finally, as these costs dramatically increase with the tightening of decarbonisation targets, such as mid-century net-zero targets, quantifying the potential for CO_2 removal to offset residual emissions is another crucial lever to consider.

Contact m.fajardy@jbs.cam.ac.uk
Publication December 2020
Financial Support EPSRC Grant EP/P026214/1