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Achieving net zero goals in residential buildings

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Abstract: This paper discusses recent evidence of a large, unrealised energy savings potential in the UK residential sector. It discusses authoritative policy reviews critiquing the Net Zero Strategy and the Heat and Buildings Strategy as well as the economic literature on the energy-efficiency gap. These sources point to four main potential explanations for the lack of progress towards net zero in residential buildings in the UK: 1) historical and current untargeted subsidies to energy prices (e.g., energy price guarantee); 2) poor scheme implementation and lack of workforce training; 3) regulatory barriers such as planning restrictions and lack of policy coordination across stakeholders; 4) split incentives. To overcome these barriers, the paper recommends better access to data to foster evidence-based policy-making and support for innovative, local-authority-led projects.

Keywords: Energy-efficiency gap, energy price guarantee, planning restrictions, policy coordination, scheme implementation, residential buildings.

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Introduction

With the passing of the Climate Change Act in 2008, the United Kingdom became the first G7 nation to bind itself to statutory targets to reduce greenhouse gas (GHG) emissions. Responding to the 2015 Paris Agreement,[1] the government amended the Act, changing the commitment for an 80 per cent reduction in the UK's net carbon account compared to 1990 levels to a full 100 per cent decrease. Achieving this target would make the UK a 'net zero' carbon emitter.[2] In a second ambitious change, the government pledged to the UN that national GHG emissions would be reduced by at least 68 per cent by 2030 compared to the 1990 baseline.[3]

These targets have been characterised as technically possible but very difficult to achieve.[4] How to realise them was until February 2023 the responsibility of the Secretary of State for Business, Energy and Industrial Strategy (BEIS), upon whom the Climate Change Act placed a statutory duty to set a carbon budget every five years and present a report to Parliament on the strategies for meeting that budget.[5] BEIS was abolished in Prime Minister Rishi Sunak's first reshuffle and its energy responsibilities were transferred to a new body, the Department for Energy Security and Net Zero (DESNZ). DESNZ has an explicit mission to 'Ensure the UK is on track to meet its legally binding Net Zero commitments'.[6]

2021 saw the first carbon budget and associated strategy explicitly committed to achieving the new, net zero goal. *Net Zero Strategy: Build Back Greener*, laid before Parliament on 19 October, is an umbrella strategy outlining pathways to reduce emissions across all sectors of the UK economy.[7]

This discussion paper focuses on one of these sectors: residential buildings — and specifically those existing buildings which, according to analysis from the BRE Trust, a building science research centre, will represent 80 per cent of the 2050 UK housing stock.[8] In 2020, residential building emissions accounted for about 16 per cent of greenhouse gas emissions in the UK.[9] Moreover, this sector saw the smallest reductions in emissions since 1990, together with agriculture, despite decades of policies described more in detail below.[10]

[1] United Nations (2015)
[2] UK Government (2008)
[3] UK Government (2008)
[4] Committee on Climate Change (2019)
[5] UK Government (2008: Section 4)
[6] His Majesty's Government (2023)
[7] BEIS (2021a)
[8] BRE Trust (2017)
[9] BEIS (2022a)
[10] BEIS (2022b)

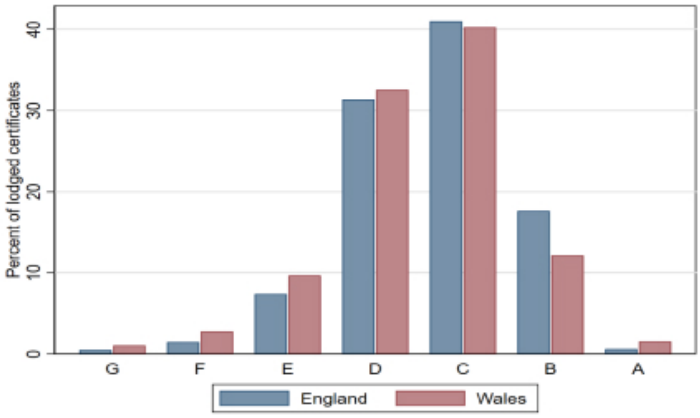

Figure 1. This chart shows the breakdown of EPC ratings for residential housing in England and Wales, where A is most efficient and G least. See https://epc.opendatacommunities.org/

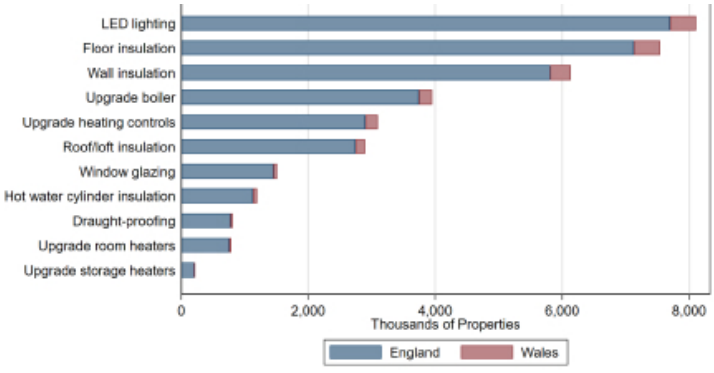

Figure 2. The number of properties that could benefit from simple energy-efficiency measures, as revealed by analysis of building Energy Performance Certificates (EPCs). See https://epc.opendatacommunities.org/

Specifically, retrofits and energy-efficiency investments have stalled.[11] Because the UK housing stock is one of the oldest in Europe,[12] these low retrofit rates imply a large untapped energy savings potential in existing UK buildings. One way to measure this potential is to use Energy Performance Certificates (EPCs), which include estimates of the energy performance of each building, as well as recommended energy performance improvements, and are required for each property being sold, constructed, or rented.

Figure 1 shows the percentage of properties with a lodged EPC by energy performance rating. With 41 per cent of properties with EPCs in England and 46

[11] DESNZ (2023)
[12] BRE Trust (2017)

per cent in Wales below C grade (that is with ratings D, E, F, or G), this chart gives a sense of the scale of effort still required to improve energy efficiency to a minimum of an EPC Grade C, the government's target.[13]

According to EPC data, even homes with a C or higher rating could still benefit from energy-efficiency investments. Virtually all 15 million properties in England and Wales that have a certificate lodged could improve their energy performance by adopting one or more simple energy-efficiency measure. Figure 2 shows the number of properties in England and Wales that could benefit from different measures, with insulation (including floor, wall, and roof/loft) and LED lighting making up the lion's share.

This paper discusses analysis by economists at the University of Warwick which asks why such a large energy savings potential has not been exploited (Fetzer *et al.* 2022). The authors find that the UK home energy savings potential is located in relatively affluent areas, suggesting that many homeowners might have been able to pay for improvements to unlock this potential, but so far have not. This finding qualifies results from the literature of correlations between energy efficiency and some socio-economic factors at the district level. For example, Ahlrichs *et al.* (2022) show that local authorities with more vacant homes, more households living rent free, and older households have lower energy efficiency.[14] As such, the geography of home energy savings potential warrants reflections on what policies can deliver a net zero transition that is also equitable. This paper presents novel insights from outreach to local governments who are already creatively designing and sharing best practices on low-cost, bottom-up solutions. Two of these potential solutions are highlighted in boxes below.

The finding of a large untapped energy savings potential in the UK relates to the notion of an energy-efficiency gap, that is an apparent underinvestment in energy efficiency given estimated savings on energy bills net of investment cost. Yet, the size of this gap and its determinants are not yet fully understood. Gerarden *et al.* (2017) review the economic literature on these determinants and divide them in three broad categories: (1) market failures, (2) behavioural explanations, and (3) modelling flaws.[15] The authors remark that the empirical evidence on these determinants has varying degrees of robustness and further research is needed.[16] Yet, in another review of the economic literature, Allcott and Greenstone (2012) find limited evidence of underinvestment from an individual perspective.[17] In other

[13] Department for Levelling Up, Housing and Communities (2023)
[14] Ahlrichs, J. *et al*. (2022)
[15] Gerarden, T.D. *et al*. (2017)
[16] Gerarden *et al.* (2017)
[17] Allcott, H. & Greenstone, M. (2012)

words, according to the studies included in the review, households did not seem to suffer from significant behavioural or information biases that would imply they were making mistakes. As energy-efficiency investments become cheaper over time, this conclusion might change if households fail to update their information and decisions.

Clarity on these mechanisms is crucial to assess the effectiveness of the UK strategy on net zero for buildings. This paper examines the extent to which the current policy landscape, as it relates to residential buildings, will enable the transition to net zero. Particular attention will be given to describing the status quo of the residential building stock and policy framework at the national and local level, building on existing quantitative and qualitative analysis.

Policy context

Historically, the UK government has used a variety of policy tools to promote building retrofits to 'decarbonize heat' (Mallaburn & Eyre 2014).[18] However, these policies have not delivered the required improvements and emissions reductions due to a lack of coordination in several dimensions.

First, frequent programme changes undermined programme success, reducing both the demand for energy-efficiency investments and the ability of firms to meet this demand.[19] On the demand side, early termination sends the signal that the scheme is flawed. On the supply side, ever-changing schemes hinder the ability of firms to plan, for instance by hiring or training skilled labour or by securing supply chains. One example of this policy short-sightedness is the case of the Green Homes Grant, introduced as a stimulus measure in October 2020, providing homes with vouchers to cover much of the cost of energy-efficiency improvements using accredited suppliers. However, this scheme ended in March 2021 with a significant underspend, as accreditation for the scheme proved costly and complex, and businesses did not scale up their operations and train new staff for a short-lived programme.[20]

Second, policies have lacked coordination across domains of government, leading to contradictory policies and gaps, for example in funding schemes for different market segments (e.g., rental).[21] Lack of coordination between levels of

[18] Mallaburn, P. & Eyre, N. (2014)
[19] Rosenow, J. & Eyre, N. (2016)
[20] Adam, S. *et al*. (2021: 378–9)
[21] Shrubsole, C. *et al*. (2014)

government has meant that top-down schemes have been ill equipped to address the needs of each local authority. Because both housing stock and population demographics vary extensively across the country, a one-size-fits-all approach is likely to fail.

The Net Zero Strategy attempts to provide a long-term vision across sectors of the economy. For example, while illustrating plans to decarbonise buildings, it also discusses implications for the levelling-up agenda, through the creation of 175,000 green skilled jobs. A package of policy papers further focuses on emissions arising from energy use in buildings, including the Heat and Buildings Strategy, released on the same day the Net Zero Strategy was presented to Parliament.[22] However, like the Net Zero Strategy, the Heat and Buildings Strategy lacks clear, well-defined steps. Indeed, lack of detail was one of the grounds on which the High Court deemed the Net Zero Strategy unlawful in summer 2022, following a legal challenge from a coalition of climate concern groups.[23]

Several independent reviews note similar shortcomings and call for more precise strategies and timelines. I discuss two important reviews below. The Climate Change Committee (CCC), an independent, statutory body established under the Climate Change Act 2008, is required to report to Parliament on the government's plans and progress towards its emissions targets. It issued an independent assessment of the Net Zero Strategy in October 2021, a separate review of the BEIS Heat and Buildings Strategy in March 2022, and a Report to Parliament on Progress in reducing emissions in June 2023.[24] With respect to decarbonising residential buildings, its critique highlights (1) underfunding and poor targeting,[25] and (2) lack of coordination and enforcement.[26]

Another independent review of the Net Zero Strategy is *Mission Zero* by the Rt. Hon. Chris Skidmore MP, published in January 2023.[27] The review discusses the following shortcomings of the Net Zero Strategy both from an individual and from a local government perspective:

[22] BEIS (October 2021b)
[23] Friends of the Earth, Client Earth, Good Law Project v Secretary of State for Business, Energy and industrial Strategy [2022]
[24] CCC (2021)
[25] CCC (2022)
[26] CCC (2022)
[27] Skidmore, C., Rt. Hon. (2023)

(1) Lack of policy certainty and clarity, including on funding.[28]
(2) The need for clear data and communications on:
    (a) information on co-benefits associated with net zero, for example air quality,
    (b) information on public attitudes towards net zero,
    (c) changes in household energy bills thanks to net zero investments.[29,30]
(3) Accessibility gaps.[31]
(4) The need to allow for changes in planning approaches to codify net zero goals in a legal duty or requirement for local authorities to act on climate change.
(5) The need to shift levies to disincentivise fossil fuels: Unlike in other European countries,[32] levies are disproportionally applied to electricity rather than fossil fuels, which makes low-carbon heating technology less appealing.[33] A study by the Institute for Fiscal Studies (IFS) finds that for domestic users, the implicit tax on emissions through gas consumption is negative as a result of the preferential 5 per cent rate of VAT charged on household energy bills.[34] Furthermore, starting in January 2023 the government applied a new, temporary levy on returns from low-carbon electricity generation to contribute to cost-of-living support.[35] Because an attempt to tax fossil fuel energy sources had already failed in the 1990s, the IFS proposes that such a reform be accompanied by a compensation package.[36] The government has committed to implementing a rebalancing of electricity and gas prices by March 2024.[37]

These reviews highlight the need to go beyond the Net Zero Strategy and address past policy failures in spurring energy-efficiency investments. The next section discusses published and novel economic research, shedding light on the potential implications of these policy gaps for the transition to net zero in residential buildings.

[28] Skidmore, C., Rt. Hon. (2023)
[29] Skidmore, C., Rt. Hon. (2023)
[30] Skidmore, C., Rt. Hon. (2023)
[31] Skidmore, C., Rt. Hon. (2023)
[32] Skidmore, C., Rt. Hon. (2023)
[33] CCC (2022)
[34] Adam, S. *et al*.(2021: 378–9)
[35] Office for National Statistics (2022a), HMRC (2022)
[36] Adam, S. *et al*. (2021: 378–9)
[37] CCC (2023)

How can UK policy enable the transition to net zero in the residential sector?

This section presents research outlining the extent and distribution of the energy-efficiency gap in the UK. It then discusses theories and recent empirical evidence in the economic literature on the potential determinants of this energy-efficiency gap in light of the UK policy context. Specifically, it focuses on issues of 1) implicit and explicit incentives faced by homeowners; 2) implementation processes; 3) regulatory barriers; and 4) market failures, such as split incentives. Alongside current policy gaps, this section also proposes solutions highlighted in boxes.

The UK energy-efficiency gap

Fetzer *et al.* (2022) characterise the distributional consequences of the ongoing energy crisis and show how its effects relate to the energy efficiency of the housing stock in different areas. Their analysis shows that 30 per cent of aggregate energy consumption, totalling £10–20 billion, could be saved if buildings were upgraded to higher energy-efficiency standards.[38] Moreover, these potential energy savings are largely concentrated in the wealthiest parts of England and Wales.[39]

This analysis uses data from EPCs covering over 15 million properties in England and Wales — about half of the housing stock. This imperfect coverage reflects the infrequent nature of EPC updates, which is tied to housing market events. Acknowledging that EPCs provide only engineering estimates of actual and potential consumption if all energy-efficiency recommendations are adopted, the authors calibrate the EPC data using granular data on actual energy consumption. This approach is in line with the recommendations of the CCC review.[40] However, it is important to note that further advances in data coverage, for example through a complete smart meter rollout, would improve the accuracy of this type of analysis.

What can explain the energy-efficiency gap highlighted by Fetzer *et al.* (2022)? The classification by Gerarden *et al.* (2017) outlined in the Introduction, identifies market failures, behavioural explanations, and modelling flaws as potential determinants of the energy-efficiency gap. In addition, the economic literature, discussed more in detail below, has identified implementation processes, rational responses

[38] Fetzer, T. *et al*. (2022)
[39] Fetzer, T. *et al.* (2022)
[40] CCC (2022)

to explicit and implicit economic incentives (as opposed to behavioural responses), and regulatory barriers.[41]

Importantly, most of these factors relate to the individual calculation of whether to take up investments in one's home. In other words, while households take into account their own costs and benefits to decide whether to invest, they do not take into account the carbon externalities. One role for governments is to aggregate individual preferences and take into account all social costs and benefits to find the socially optimal level of investment, and then devise policies to incentivise adoption up to that level.

Decomposing energy-efficiency gaps from a weather-proofing programme in Illinois across some of these factors, Christensen *et al.* (2023) find that 41 per cent of the gap is attributable to flawed engineering estimates, 43 per cent to heterogeneity in workmanship, and 6 per cent to rebound in energy use, that is households using more energy after retrofits have made it effectively cheaper.[42] This decomposition suggests that low-cost policies like behavioural nudges might have limited scope to make a difference for decarbonising buildings, especially when directed at households who have already chosen to invest in energy efficiency. By contrast, investments in workforce training appear sorely needed, as well as better data on individual buildings. The next subsections discuss evidence in favour of or against each mechanism.

Modelling flaws

Engineering assessments of the benefits of energy-efficiency measures might be flawed due to mismeasurement or heterogeneity in building characteristics. This critique also applies to EPC data that underlies the analysis in this discussion paper, highlighting the need for granular data on actual use linked to up-to-date measures of building quality, as discussed in both reviews of the Net Zero Strategy outlined in the Policy Context section.

Demand responses to economic incentives

This subsection discusses the monetary incentives to invest in energy efficiency that are implicit in energy prices, and how the current UK energy policy affects them. Then, it discusses additional non-monetary incentives households might face, emphasising the role of coordination and collective action at the local level.

[41] Gerarden *et al*. (2017)
[42] Christensen, P. *et al.* (2023)

The main monetary incentive to invest in energy efficiency is determined by the expectation of lower energy bills in the future. As such, expectations about future energy prices play a key role in determining take-up of energy-efficiency investments. Moreover, households base future expectation on current price trends when they make energy-efficiency investment decisions (Myers 2019).[43] As such, energy policy that changes consumer-facing prices can facilitate or hinder energy-efficiency investments. Fetzer *et al.* (2022) find that current policies, such as the UK's energy price cap, weaken incentives for households to invest in energy-efficiency upgrades by muting the price signal.[44] Moreover, these incentives are weakened precisely for those households that are able to pay and have high energy use.[45]

Beyond the monetary trade-offs implied by the delayed repayment through lower energy bills, households might also incur non-monetary costs and benefits due to energy-efficiency investments. In conversations with the author, an installer described the 'homeowner journey to net zero' as a long and complex process. For example, households might incur search costs in finding the right contractor and technology, scheduling costs for appointments, hassle costs to fill out paperwork. Similarly, households might experience non-monetary benefits from improved energy efficiency, such as increased comfort and health, or a *warm glow* from participating in something that benefits the environment. Allcott and Greenstone (2017) find that these non-monetary costs and benefits drive a lot of the variation in take-up of energy-efficiency investments. In fact, when looking only at monetary net benefits, households appear to make the 'wrong' investments: 40 per cent of households in their sample did not take up an investment with an internal rate of return (IRR) greater than 20 per cent on the dollar; while 36 per cent took up investments with a negative IRR — i.e, that actually cost them money. This suggests that non-monetary factors, such as increased comfort or a sense of 'doing one's bit', also drive decisions.[46]

Such a high degree of heterogeneity highlights the importance of targeting policies to the right people. Indeed, Knittel and Stolper (2019) find that differences in baseline consumption and income are significant predictors of the effectiveness of policies to reduce energy use among US households.[47] Ignoring these differences leads to weaker overall policy effects relative to more targeted approaches.

[43] Myers, E (2019)
[44] Fetzer, T. *et al*.(2022)
[45] Fetzer, T. *et al*.(2022)
[46] Alcott, H. & Greenstone, M. (2017)
[47] Knittel, C.R. & Stolper, S. (2019)

However, it is important to note that targeting might increase the complexity and delivery costs of a policy.[48]

One particular set of non-monetary costs relate to searching for the right solutions and coordination at the local level. As highlighted in the reviews of the Net Zero Strategy discussed above, the government strategy focuses on individual action rather than community or local authority action. Gregório and Seixas (2017) hypothesise that a neighbourhood-based strategy might yield better outcomes than a strategy targeting individual properties in historic urban centres in Portugal. In particular, they develop an aggregate Urban Energy Renovation Index that could be used to target at-scale retrofits, that evaluates the energy renovation capacity of a community, based on: 1) vacant dwellings, 2) ownership, 3) building age, 4) buildings with repair needs, and 5) energy savings potential based on EPC data.[49]

A UK Government Community Energy strategy was launched in 2014 and abandoned a few years later. Despite the lack of official support, such schemes are gaining a foothold[50] — local, bottom-up initiatives to organise bulk purchases of solar panels are sprouting throughout the country. However, these efforts rely on local champions, and not every neighbourhood or district has people willing and able to take matters in their own hands. Professor Thiemo Fetzer and Dr Ludovica Gazze at the University of Warwick are recruiting local authorities to learn about their existing efforts towards net zero. Through these conversations with 16 local authorities, arising in response to targeted outreach conducted in Autumn 2022, local authorities have shared the challenges they face:

(1) The lack of coordination even at local level: Remits concerning low-carbon housing are split between offices, and officers do not have time or resources to respond to inquiries about available schemes.
(2) The lack of technical capabilities for impact evaluation and targeting.
(3) Short-lived funding and electoral cycles do not incentivise contractors to invest in training and inventory.

Implementation process

Practical implementation of energy-efficiency investments matters both on the intensive margin, that is how the retrofits are carried out, and on the extensive margin, that is what homes get retrofitted. For example, Blonz (forthcoming) finds that

[48] Allcott, H. & Greenstone, M. (2012)
[49] Gregório, V. & Seixas, J. (2017)
[50] IPPR (2021)

BOX 1: EFFECTIVELY TARGETING LOW-CARBON HOUSING POLICIES IN THE UK

Fetzer (2022) suggests one policy alternative to the current energy price guarantee (EPG).[1] The suggested policy is a two-tier tariff such that the standing charge is fixed at the level of the October 2021 price cap, as are unit prices for the first 9,500 kWh of natural gas consumption and the first 2,500 kWh of electricity consumption. As 50 per cent of UK households consume less than 12,100 kWh of natural gas and 2,900 kWh of electricity, this threshold would limit energy price increases for the majority of households. The second tier of the tariff would be set at steeper levels. For example, a second-tier unit price of 20 pence per kWh for natural gas and 60 pence per kWh for electricity, together with the first tier described above, would have a similar cost to the government as the EPG. An alternative policy with stronger energy conservation incentives would involve a two-tier tariff where the first-tier threshold is set as a fraction of previous year's (or estimated) consumption, as implemented in Germany where the threshold is set at 80 per cent starting in March 2023.[2]

Importantly, more complex tariffs might require better targeting and data checks to ensure, for example, that households with medical needs are not overburdened by energy costs. Data that allow for targeting exist, but appear to be housed in different government departments and are not currently linkable.[3] For instance, appearing before the Treasury Select Committee in November 2022 the Chancellor of the Exchequer indicated that the government is working towards introducing a social discount or social tariff approach, better targeting energy subsidies, but only starting in Spring 2024 due to these data gaps: 'That means a lot of complicated work to marry the information held by HMRC with the information held by DWP on benefits. That is a very big operational challenge, but that is the direction of travel we want to go in.'[4]

The 2023 Spring Budget addressed one element of inequality, requiring utility firms to allow customers on prepayment meters to access the same tariffs as other customers; and extended the EPG; but did not announce any further steps towards the social tariff.[5]

[1] Fetzer, T. (2022)
[2] Sgaravatti, G. et al. (2021)
[3] Norman, A. et al. (2023)
[4] House of Commons (November 2022) Treasury Committee
[5] HM Treasury (2023)

contractors paid per number of replacements of energy-inefficient refrigerators intentionally misreport information about these refrigerators to inflate the number of qualified replacements.[51]

Contractors, installers, and energy companies have a big role to play, often representing the first point of contact for homeowners. The reviews discussed in the Policy Context section emphasise the need for coordination both across government levels and with industry. For example, energy suppliers have Energy Company Obligations (ECOs) to provide retrofits to fuel-poor customers, but these funds

[51] Blonz, J.A. (forthcoming)

BOX 2: DESIGNING AND TESTING LOCAL AND COMMUNITY-BASED STRATEGIES

Many local authorities are already implementing innovative practices. Enhancing knowledge exchange among these local actors could facilitate the diffusion of best practices, including low-touch, data-driven interventions, and the fine-tuning of schemes to the needs of different areas. For example, locally initiated examples, such as the Carbon Coop in Manchester (https://carbon.coop/), of one-stop shops that engage with supply-chain actors, consumers, and training providers have been successful and appreciated. Moreover, some districts are experimenting with providing buy-in options to private owners next to council homes when retrofits are carried on council estates.

Another district, Burnley, is leveraging data on rental properties from their selective licensing programme to flag rental homes with below-standard EPC ratings. Through incentives based on the licensing and accreditation programme, they have been able to bring most properties to compliance. This approach is in line with the recommendation by the CCC[1] that the government look at regulatory options around key points in the lifecycle of homes such as point of sale, remortgaging, refinancing, and permit requests for other repairs or improvements.

Another approach could leverage publicly available data on the energy performance of buildings, energy use, and demographic characteristics to identify clusters of homes in need of similar energy efficiency investments. Councils would then host community meetings in these clusters to inform the public about available schemes, showcase model homes, facilitate interactions with local contractors, organise buyer groups, and promote lotteries and competitions among energy savers. These community-level forces have been found effective to encourage investments (Bollinger *et al*. 2022),[2] and group discounts were part of popular schemes such as Solar Together.[3] Encouraging knowledge exchange and partnerships at the neighbourhood level is something that has also been proposed in the independent review by the Rt. Hon. Chris Skidmore MP in the form of champions or Local Net Zero Heroes.[4] For example, households who save the most could be entered into lotteries or be publicly recognised.

These proposals leverage the convening power and facilitating role of local authorities, as recommended by the independent reviews discussed above. Moreover, such policies could be delivered at a relatively low cost, although some councils are sceptical that they can affect take-up without promising grants. Notably, even if these interventions are relatively low-cost, local authorities need the necessary funding and staff resources, as well as regulatory authority to engage in these activities and to share findings and challenges among each other.

[1] CCC (2022)
[2] Bollinger, B. *et al.* (2022)
[3] Solartogether.co.uk (2023)
[4] Skidmore, C., Rt. Hon. (2023)

used to be underspent before the energy crisis.[52]

Ongoing research at the University of Warwick Department of Economics led by Dr Arun Advani and the author includes surveys and telephone conversations

[52] House of Lords Environment and Climate Change Committee (February 2023)

with heat pump installers to understand their perspective on barriers to take-up. The Net Zero Strategy relies heavily on heat pumps to replace gas boilers, but little is known about the market for heat pumps. 59 heat pump installers (out of over 200 firms contacted) responded to a survey highlighting the following areas of friction that jeopardise achieving the goal of 600,000 installations a year:

(1) High electricity prices. To incentivise heat pump installation, a specific electricity tariff at lower supply cost might be needed.
(2) The lack of tax incentives. For example, the European Union recommends that member states apply lower VAT rates for higher efficiency heating systems and building insulation.[53]
(3) The lack of funding for fabric-first approaches. According to most contractors, as much as half of the UK housing stock is currently unsuitable for heat pumps due to poor insulation.
(4) The lack of installer and maintenance training, exacerbated by brand specificity.
(5) Administrative burdens for accreditation, government schemes, and installation applications, including payment delays.

Crucially, different installers have different views on what homes are better suited for heat pumps, and what configurations work best. Yet, homeowners receive most advice from installers when they are shopping for options to either replace old boilers or retrofit homes. Therefore, these differences in views mean that who customers talk to will determine whether they choose to install. Moreover, installers lament low 'conversion rates' in terms of the number of installations relative to calls for interest that they receive, with some mentioning only 5 or 10 per cent success rates from inquiries. Because these installers perform home evaluations before any contract or decision is made, these represent losses for them.

As such, it useful that councils and energy companies are setting up advice services for free, either in the form of one-stop shops, or as on-demand programmes that customers can request. More awareness and information are sorely needed on these products. Yet, some councils feel that they would overstep their role by recommending certain products or businesses. Therefore, it is important that the national government steps in to provide this education on new products and to restore trust.

[53] European Commission (2022)

Regulatory barriers

As highlighted in the Policy Context section, the status of the UK housing stock is the result of failed past energy and housing policies, as well as of well-intentioned policies responding to different, sometimes conflicting, mandates. One crucial example, mentioned also by the independent reviews discussed above, is the mandate for local councils to preserve the character of neighbourhoods, defined as conservation areas. Conservation areas have increased permitting requirements, and these extra hurdles have important consequences.[54] A property inside a conservation area uses 5–15 per cent more energy (especially gas for space heating) than an identical property just outside the boundary of the conservation area. Overall, this extra consumption costs around £104–314 million per annum, at the price cap as of February 2023. From an environmental standpoint, this extra consumption generates 3–4 million tonnes in avoidable CO_2 emissions per year.[55]

Another potential source of friction on retrofitting action due to legacy policy is the chequered nature of social vs. private housing resulting from Right-to-Buy incentives. The fractionalised and inconsistent nature of ownership within, for example, a row of terraced homes, created by Right-to-Buy schemes might hinder the fruition of economies of scale and scope that might arise when retrofitting larger estates. Indeed, former council homes exhibit wider variation in conditions: while they are generally in better condition, some of them require relatively high-cost repairs.[56] Right-to-Buy schemes also interact with issues generated by leaseholds, such that service charges liability and lower resale values might disincentivise home improvements.[57] Moreover, it is unclear whether it is the council as the freeholder who is responsible for retrofits, or if that should fall to individual leaseholders. Mixed tenure is also a challenge for housing associations to leverage their bargaining power. Exploring regulatory changes and legal instruments that might solve this coordination problem could lower costs by distributing fixed costs among many project owners, for example by having joint ownership of converters and meters for solar power generation.

[54] Fetzer, T. (2023)
[55] Fetzer, T. (2023)
[56] Cole, I. *et al.* (2015)
[57] Cole, I. *et al.* (2015)

Market failures: split incentives across landlords and tenants

One final barrier in terms of misallocation of incentives for energy-efficiency investments that is often discussed at the property level, rather than at the neighbourhood level, is split incentives across landlords and tenants. Because tenants pay the bills but cannot decide on energy-efficiency investments, rental homes might see lower investments in energy efficiency and might have higher carbon emissions per square foot than owner-occupied properties, other things equal. For example, Petrov and Ryan (2021) and ONS (Office for National Statistics) analysis (2021) show that rented homes are generally less energy efficient than owner-occupied homes in England and Ireland (although these properties also differ on other dimensions).[58] However, recent research in the United States could challenge the widely held view that rental properties generate more carbon emissions by noting that rental properties are 9–20 percentage points more likely than owner-occupied properties to have electric heat, electric hot water heating, an electric stove, and an electric dryer.[59] The gap is largest for electric heating, with 49 per cent of US renters and only 29 per cent of US homeowners heating their homes primarily with electricity.

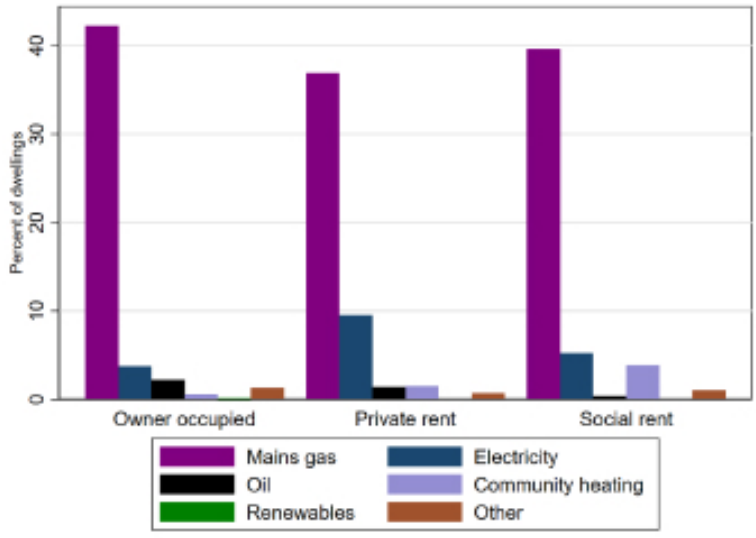

Figure 3. The main source of heating or method of heating used in central heating by tenure, England and Wales. See https://www.ons.gov.uk/releases/energyefficiencyofhousinginenglandandwales2022

[58] Petrov,I. & Ryan,L. (2021); ONS (2021)
[59] Davis, L. (2022)

The same general patterns hold for England and Wales as shown in Figure 3, although notably over a third of rental properties are still heated with gas.[60] One plausible explanation for this gap is that electric appliances are less capital-intensive and cheaper to install. As such, rental properties might be ahead of the curve on the path to electrification and net zero. This fact suggests that shifting levies from electricity to gas might favour some renters. However, it is important to note that the electric appliances installed in rental properties might be less energy efficient than average.[61] Thus, more research is needed to shed light on this issue.

Conclusion and policy recommendations

The government needs to spur action to decarbonise homes across several temporal horizons and domains. Short-term action is needed to ensure that different policy objectives do not jeopardise longer-term net zero efforts, for example when mitigating the effects of increased international energy prices on families' expenditures. At the same time, coordination and planning are required to put in place holistic, enabling policies that leverage low-hanging fruit, such as investments by the able-to-pay segment, while preparing a path for everyone to realise energy savings investments.

(1) In the short term, the government can:
   (a) Promote savings with behavioural measures and price signals while supporting energy-poor households (Alcott & Rogers 2014).[62] A two-tier, or social, tariff could achieve both energy conservation and equity goals as shown in other countries.
   (b) Create a database of local innovative initiatives and encourage knowledge exchange. Given the reliance of local councils on national and regional government schemes, the national government could leverage mandatory scheme reporting to compile such a database. Convening workshops and roundtables including representatives of different levels of government before, during, and after the launch of such schemes can enable a deeper understanding of local needs and specificities, including feedback on what works and what does not.

[60] Data from ONS (2022b)
[61] Souza, M.N.M., (2018)
[62] Allcott, H. & Rogers, T. (2014)

(2) In the medium term, the government needs to:
   (a) Encourage investments by the able-to-pay (Hahn & Metcalfe 2021).[63] A first step towards investment is empowering consumers to understand costs and benefits, for example by promoting awareness of how behaviour translates into energy bills.[64] To do so, a fast and mandatory rollout of smart meters is paramount (Bhattacharjee *et al*. 2022). Yet, a recent online experiment shows that, without subsidies, stated willingness to adopt a smart meter is still too low at 22 per cent.[65] Information on the social benefits of these meters has similar effects in terms of increasing adoption by about 18 per cent of a small £10 subsidy.
   (b) Facilitate evaluation of local and national solutions, including 1) facilitating efficient and GDPR (General Data Protection Regulation)-compliant data sharing across governments, businesses, and researchers and 2) adopting an agile experimentation mentality such that schemes can 'fail fast' or be adopted at scale. Relatedly, a complete smart meter rollout will provide at least part of this sorely needed data infrastructure.

(3) In the long term, the UK government needs to solve structural issues, including:
   (a) Resolve supply-side material and skill shortages by securing robust supply chains and promoting workforce training.
   (b) Provide adequate funding with continuous, reliable schemes co-designed with industry and local councils to ensure ease of access and maximise uptake.
   (c) Remove regulatory barriers, including grid bottlenecks and permitting red tape. Regulatory harmonisation across levels of governments will require coordination and careful revision of existing laws and regulations, but is key to ensuring net zero objectives become a true priority across the UK.

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[63] Hahn, R.W. & Metcalfe, R.D. (2021)
[64] Bhattacharjee, A. *et al.* (2022)
[65] Gosnell, G. & McCoy, D (2023)

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