UNIVERSITY OF BIRMINGHAM | BIRMINGHAM ENERGY INSTITUTE

ERA ENERGY RESEARCH ACCELERATOR

At the forefront of energy transformation

PATHWAYS FOR LOCAL HEAT DELIVERY

NET-ZERO AND RESOURCE EFFICIENT BY 2050

Decarbonising Domestic Heat

FOREWORD

To reach net zero and reduce its dependancy on natural gas, the UK has to stop using gas as its source of domestic heat.

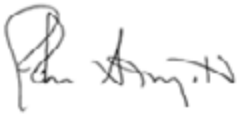
This study, led by Professor Martin Freer of Birmingham University, examines the scale of the challenge at a national level and how, as an example, an urban area such as East Birmingham might address that challenge.

85% of UK domestic property uses natural gas for heating and the majority of homes are inadequately insulated. To change this will be expensive and will require effective government leadership and delivery support, both financially and administratively. This study has drawn on the expertise of industry, academia, regulators, financiers, central and local government, and independent agencies.

It examines the challenge from a technical, financial, planning, and governance perspective in detail, and makes clear recommendations for a way forward.

As Chair of the Commission, I would like to thank all those who have given their time and expertise and commend the report to all those with an interest and responsibility for meeting this urgent and major challenge on our road to net zero.

Sir John Armitt, Policy Commission Chair



ABOUT BIRMINGHAM ENERGY INSTITUTE

The Birmingham Energy Institute (BEI) is the focal point for the University of Birmingham and its national and international partners, to create change in the way we deliver, consume and think about energy. Bringing together interdisciplinary research from across the University of Birmingham and working with government, industry and international partners, the BEI is developing and applying the technological innovation and original thinking required to create sustainable energy solutions.

Our global community is consuming more energy than ever. As we run out of time to contain climate change, the BEI is upscaling their innovative technology solutions for applications across the globe and influencing and shaping policy on critical issues such as waste management, materials supply, and decarbonisation of heat to shape the energy solutions of tomorrow.

The UK government is committed to bringing all greenhouse gas emissions to net-zero by 2050. The Midlands region is renowned for its ability to drive technology revolution and its nationally leading manufacturing and engineering base. The Birmingham Energy Institute is working with business, industry and policy stakeholders across the region to realise the transition to net zero.

ABOUT ENERGY RESEARCH ACCELERATOR

The Energy Research Accelerator (ERA) draws on the expertise and world-class facilities of the Midlands Innovation group of universities – Aston, Birmingham, Cranfield, Keele, Leicester, Loughborough, Nottingham and Warwick, plus the British Geological Survey.

ERA is funded by Innovate UK, which has invested £60 million in 23 state-of-the-art facilities, with an additional almost £120 million of co-investment provided by a range of industrial partners who are working with ERA on a range of projects across the Midlands.

The purpose of the Energy Research Accelerator (ERA) is to work with UK government, industry, and the higher education sector to undertake innovative research, develop the next generation of energy leaders, and demonstrate low-carbon technologies that help shape the future of the UK's energy landscape.

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GLOSSARY

ASHP	Air source heat pump
BCC	Birmingham City Council
BEIS	Department of Business, Energy and Industrial Strategy
BUS	Boiler Upgrade Scheme
CCC	Climate Change Committee
CfD	Contract for Difference
CFP	Committee on Fuel Poverty
CHP	Combined heat and power plant
DNO	Distribution network operator
DSO	Distribution system operator
ECO	Energy Company Obligation
EIZ	Energy Innovation Zone
EPC	Energy Performance Certificate
FiTs	Feed-in Tariffs
GSHP	Ground source heat pump
HUG	Home Upgrade Grant
KfW	German infrastructure bank
LAD	Local Authority Delivery scheme
LAEP	Local area energy planning
NCDH	National Centre for the Decarbonisation of Heat
RdSAP	Reduced Standard Assessment Procedure (for EPC)
RHI	Renewable Heat Incentive
ROCs	Renewable Obligation Certificates
SAP	Standard Assessment Procedure (for EPC)
SMETERS	Smart Meter Enabled Thermal Efficiency Ratings
UKIB	UK Infrastructure Bank
WHD	Warm Homes Discount
WMCA	West Midlands Combined Authority

Note on geographical coverage:

Most of the policies in the Heat and Buildings Strategy cover England only, although some apply to Great Britain. Our report makes no specific recommendations for policy in Scotland, Wales or Northern Ireland, but much of its analysis is broadly relevant to the whole United Kingdom.

Disclaimer:

This report represents the consensus view reached by the policy commission, but individual commissioners may not agree with every point.

HIGHLIGHTS

Decarbonising domestic heat is the big remaining challenge of climate policy. Progress on heat lags that of electricity and transport. We need to cut emissions from heat more in the next eight years than we have in the past 30. There is not a moment to lose.

The soaring price of gas makes heat decarbonisation yet more urgent – not less. The clue is in the name: the answer to a gas crisis is not to increase our vulnerability to the fuel, as some propose, but to reduce it. Our climate, financial and energy security imperatives are now aligned.

Decarbonising domestic heat is the key to achieving many of the government's biggest challenges: energy security; air quality; health; jobs and skills; fuel poverty and Levelling Up. Lifting the legacy policy costs off the electricity bill, for example, would support all these aims.

Current policy is too complicated, too centralised and underfunded. The targets are vague, policies come and go, and now we have a patchwork of schemes trying to solve essentially one problem. This cannot continue. The government must simplify, devolve and – in the short term - fund.

It need not cost the earth: Germany's successful KfW scheme has catalysed investment of €480 billion and essentially paid for itself from the extra VAT this generated. It will cost the earth if we fail to galvanise heat policy right now.

We have all the technologies we need and they work. Already, 10 million homes could fit a heat pump without additional insulation, a massive market in which competition will bring costs down. If the government introduces the right policies now, heat pumps could be cheaper to buy and run than a gas boiler – without subsidy – by the end of the decade.

The government is trying to solve this problem largely through national schemes, but heat is by definition local. Local and regional authorities must play a central role.

Heat resources and patterns of demand differ from place to place, pushing each neighbourhood towards one or other of the main technology options – heat pumps, heat networks, and possibly hydrogen near industry clusters. Building infrastructure to supply all three everywhere would be extremely expensive. Each area will need to choose which technology or combination of technologies suits it best.

Local authorities will first have to oversee local area energy planning (LAEP) to map and zone their area by technology. The government must create the institutional framework and empower and fund councils to start immediately. This local planning and engagement must start now, with proven technologies, if we are to achieve the 2050 target.

To galvanise progress, the government should fund **at least three pathfinder projects to decarbonise entire neighbourhoods of 10,000 homes each within the next five years.** The costs of decarbonising heat will not come down if we simply stare at the problem. They can only come down if we start to tackle it, build the market, and learn. A series of at least three clean heat pathfinders would start that journey.

INTRODUCTION

Until recently, most people never thought about their gas boiler unless it broke down. But 2021 changed all that. Soaring wholesale gas prices sent domestic energy bills through the roof, driving almost 30 suppliers out of business and millions more households into fuel poverty.[1] Suddenly the gas boiler had everyone's attention.

Expense should not be the only reason. Gas boilers are also a major problem for the climate. Heat for buildings causes 23% of Britain's total greenhouse gas emissions, and for housing alone causes 17% of emissions. Unless we replace 24 million gas boilers, we will never reach net zero.

The chancellor's emergency measures in February softened only £350 of the predicted £1,700 increase in this year's average energy.[2] They do nothing to tackle the underlying cause of emissions, soaring costs and energy insecurity: our overwhelming dependency on gas. The Energy Security Strategy published in April 2022 included new higher targets for low carbon electricity but no new measures on domestic heat or energy efficiency.

There is no doubt that decarbonising heat is a serious policy challenge. Whereas electricity emissions can be reduced in ways that are largely invisible to consumers, and transport emissions by selling them sexy new products, tackling heat demands the government intervene in every home in the country. Naturally, ministers are cautious.

The government has no shortage of policies. The Heat and Building Strategy, published in September 2021, lists dozens – covering every housing sector and every technology. But this follows a decade of chopping and changing, and the over-riding impression is still one of tentative and incremental steps. Broadly, current policy is too complicated, too centralised and underfunded. This cannot continue.

The good news is that all the tools we need are at our disposal. District heating networks have been operating for decades and could provide almost a fifth of our home heating economically by 2050. Heat pumps are also well-established and spectacularly efficient: turning 1 unit of electricity into 3 or 4 of heat. Like wind and solar a decade ago, these technologies need only be installed at scale to bring costs down.[3] Hydrogen might also play a part near industrial clusters but it could be a decade before the evidence is clear.

Analysis by the Climate Change Committee shows there are 10 million homes that could fit a heat pump without additional insulation – an enormous potential market. EON says that if the government introduces the right policies now, heat pumps could be cheaper to buy and run than a gas boiler – without subsidy – by the end of the decade.

What's more, galvanising its heat policy will help the government achieve many of its other goals:

Energy security: a faster roll-out of renewables and nuclear can reduce our exposure to high and volatile gas prices, but will eliminate that exposure only if we electrify domestic heating. Heat pumps in a smart grid will also help manage the intermittency of renewables. At the end of 2021, electricity from Britain's newest offshore wind farms cost a fixed price of £57.50/MWh while the volatile price of gas-fired electricity was over four times higher – £245/MWh.[4]

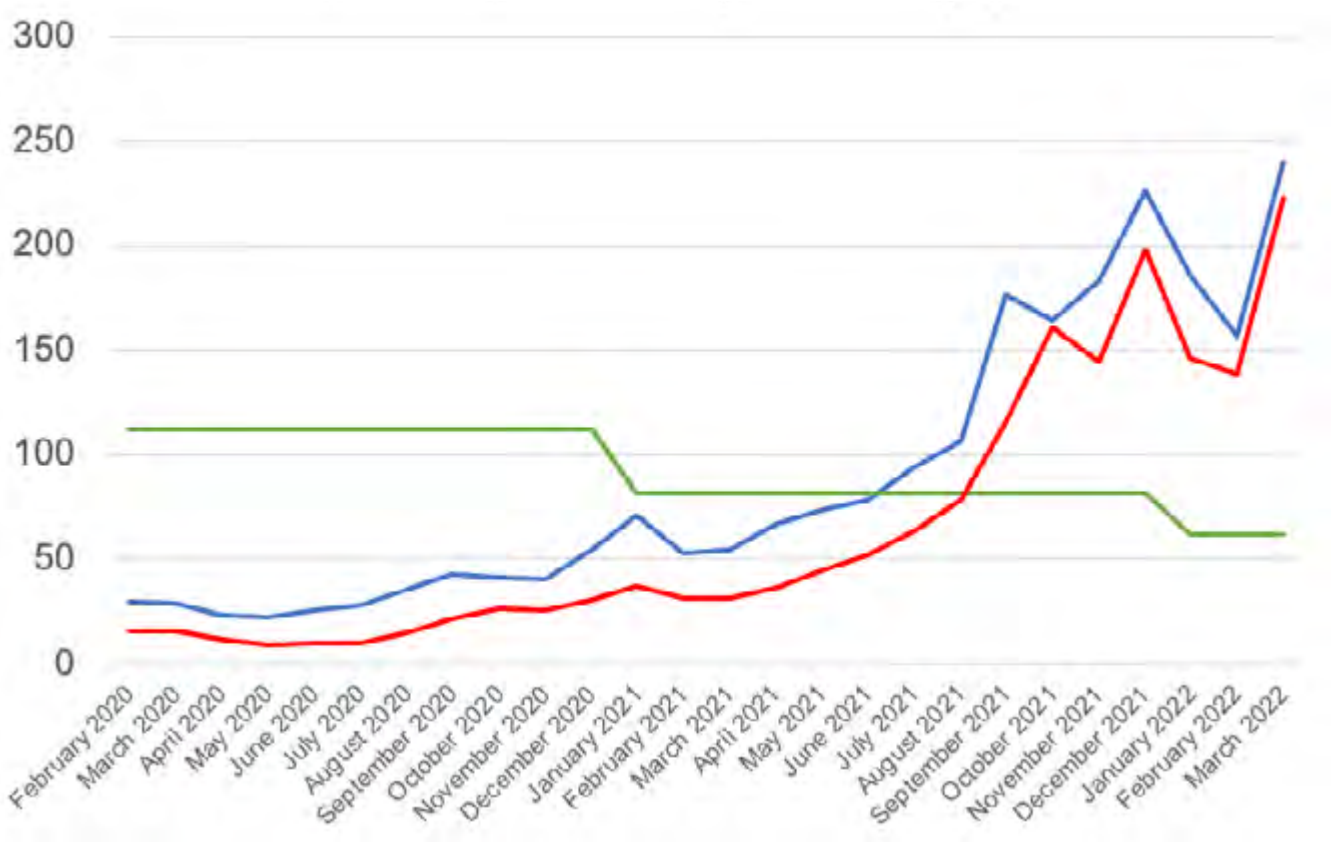
Air quality: the gas boiler emits not only CO2 but also nitrogen dioxide, which causes asthma and other respiratory diseases. Boilers produce around a fifth of the NOx in London and other big cities[5], and on current trends the government will miss its 2030 UK NOx target. Decarbonising heat would help put that right.

Health: gas boilers make people ill not only through the pollution they emit, but also when people can't afford to turn them on. Living in cold homes kills 27,000 people each year and costs the NHS £1.4-£2 billion annually in England alone.[6]

Jobs and skills: we need to train over 50,000 heat pump engineers by 2030[7], and 500,000 professionals and trades-people to install insulation and other retrofit measures, manage projects and provide consumer advice, and yet more in manufacturing.[8]

Fuel poverty and Levelling Up: fuel poverty is caused by a combination of low incomes and poorly insulated homes, now exacerbated by sky-high gas prices. Decarbonising heat and raising efficiency will help with both. A once in a generation renewal of Britain's housing stock will create warm, thermally efficient homes, and provide hundreds of thousands of good jobs (see above). It is hard to imagine another programme that could simultaneously deliver so much of the government's Levelling Up agenda.

FIGURE 1: SOARING FOSSIL GAS PRICES DRIVE UK ELECTRICITY TO FOUR TIMES THE PRICE OF OFFSHORE WIND



Notes: Wholesale electricity prices (blue line) are overwhelmingly driven by the wholesale price of gas, which is typically burned in CCGT power stations at average efficiency of 48.5% (red line). By contrast, the price of electricity generated by offshore wind (green line) is fixed by auction before the wind farm is built, with prices for successive wind farms driven down by innovation and economies of scale.

Sources: Various[9]

One aspect that needs particular attention is the role of place. All the newer technologies will need expensive new infrastructure: heat networks, electricity upgrades and possibly hydrogen grids. It would be extremely expensive to build all three everywhere, and in most neighbourhoods, local resources and patterns of demand will naturally favour one or another. There is a broad consensus that these choices should be made by local or regional authorities – in the context of a national framework. But the government has yet to decide who will carry out local area energy mapping and planning (LAEP), how it will be funded and how to secure the consent of local communities.

Resolving these local issues could transform heat policy. Councils and regional authorities are closer to their communities and often more trusted than remote Westminster. Empowering and funding them to carry out local area energy planning, with support from the Regional Energy Hubs and a new National Centre for the Decarbonisation of Heat, is a pivotal reform. Launching at least three mass clean heat pathfinder projects to decarbonise 5,000-10,000 homes in each area is another. Along with some important changes to the national framework, these reforms could turn heat decarbonisation from a seemingly intractable problem into a once-in-a-generation renewal of the nation's housing.

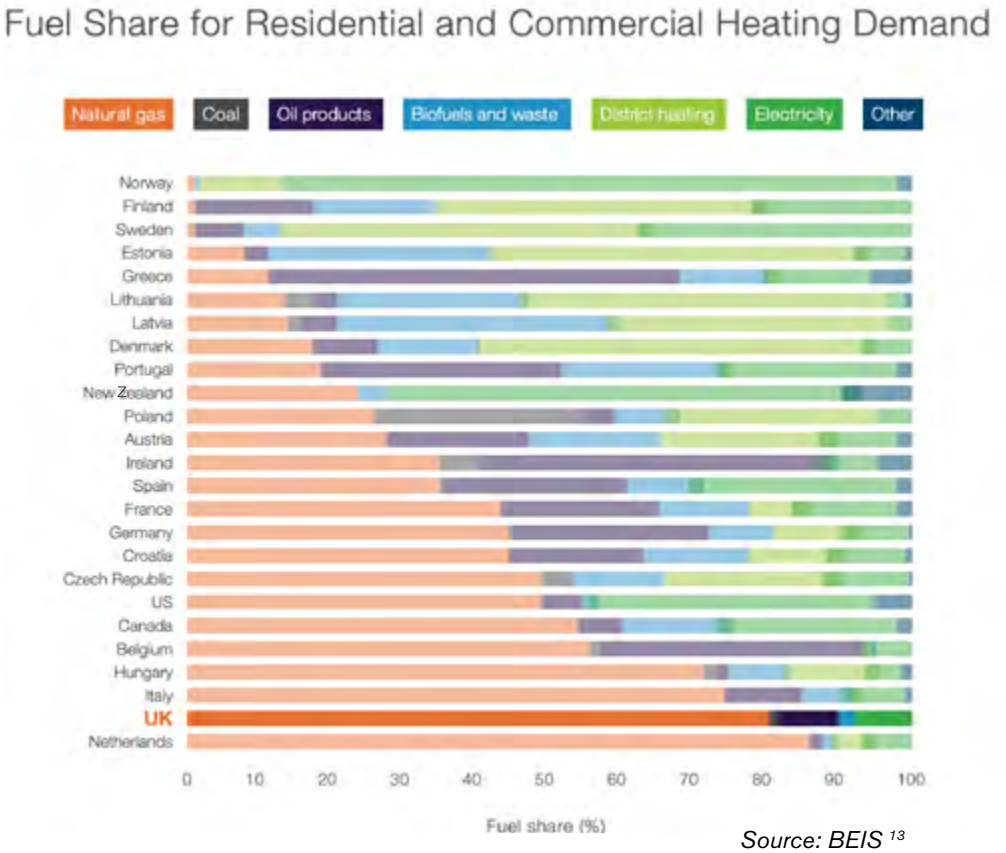
Most people have little interest in the geekery of low carbon heating. They may or may not care about their emissions, but what everybody wants is a warm home that doesn't cost too much to heat. That is entirely consistent with decarbonisation. Contrary to some recent press coverage, with the right policies, people will not end up 'colder and poorer'[10], but warmer, healthier and – through lower energy bills – better off.

EXECUTIVE SUMMARY
THE CLEAN HEAT CHALLENGE

There is no doubt that decarbonising Britain's heat is a major challenge. Building heat emissions have fallen only 19% since 1990 compared to 42% for the entire economy and far more for electricity generation.[11] Building heat emissions now need to shrink 24% by 2030 to get back on track for our legally binding 2050 net zero target.[12] In other words, we need to cut emissions from heat more in the next eight years than we have in the past 30.

In Britain, 24 million (85%) homes heat with natural gas, which makes us more dependent on gas for heating than any other OECD country bar the Netherlands (Figure 2). For Britain, replacing the gas boiler with low carbon heating is the central task.

FIGURE 2: FUEL SHARE FOR RESIDENTIAL AND COMMERCIAL HEATING BY OECD COUNTRY



Source: BEIS [13]

Britain has some of the worst insulated homes in Europe, which means bills and emissions are higher than they should be, even with current heating systems. To convert to low carbon heating, many homes will need to install further insulation to keep running costs down – although 10 million are already heat-pump ready. Partly because of our poor housing stock, and now worsened by sky-high gas prices, Britain also has some of the highest levels of fuel poverty in Europe.

All of which means the challenge of decarbonising building heat is greater in Britain than many other countries, but then so are the co-benefits. Heat-sieve homes, fuel poverty and 27,000 cold-related deaths per year should have been banished long ago, and if cutting emissions forces us to confront them now, so much the better for Levelling Up.

The good news is that there are no technological barriers to decarbonising building heat. Heat networks are widely used in Europe but currently provide only around 2% of Britain's residential heat. The Climate Change Committee (CCC) estimates they could cost-effectively provide 10% by 2030 and 18% by 2050.[14]

Heat pumps are also well established and highly efficient. A recent government-funded study installed heat pumps in 750 homes and found that there is no property type or age of building that is unsuitable for a heat pump. Although much of Britain's housing stock is poorly insulated, the CCC has found that 10 million homes are 'heat pump ready', a huge potential market in which competition should bring costs down.[15] (Traditional electric heating, though less efficient, would be easier to install and could also play a part). EON says that if the government introduces the right policies now, heat pumps could be cheaper to buy and run than a gas boiler – without subsidy – by the end of the decade.[16] Hydrogen boilers may also play a part, but probably limited to areas where the gas is needed for high-temperature industries such as steel making.

It is already clear that no single technology is likely to work for the entire UK. Heat resources and demand patterns differ between areas. To build three sets of infrastructure in every area would be needlessly expensive, so neighbourhoods will need to choose predominantly one. There is a broad consensus that these choices should be made by local and regional authorities. But the government has yet to decide who will carry out local energy planning (LAEP), how it will be funded and, crucially, how to secure the consent of local communities.

The urgency of decarbonising heat implies that we should concentrate on proven technologies. We think the approach taken by the London Olympic games is instructive. Given an absolute deadline and zero-tolerance of failure, the Olympic Delivery Authority decided to constrain innovation and rely on proven technologies – and delivered a successful games on time.[17]

For heat decarbonisation, this means planning to work largely with heat networks and heat pumps.[18] It also means not relying on the assumption that hydrogen will prove economic. If it does, so much the better and plans can be adjusted, but if not, the target and deadline can still be met on the basis of existing technologies and plans.[19]

The huge rise in gas prices during 2021–2022 has made decarbonising Britain's heat yet more urgent – not less. Some politicians and sections of the press have claimed that the reason energy bills are now unaffordable is the fault of green policies, and that the answer is to produce more gas.[20] This is simply wrong. Social and environmental charges add around £140 to the average energy bill, while the jump in gas prices has added £700 in the spring of 2022 and forecast to add another £1,000 in the autumn.[21] In any event, any new gas fields would take years to come on stream, and the price of their output would be set by international markets. Following Russia's invasion of Ukraine, gas prices are likely to stay permanently high at worst or highly volatile at best. The clue is in the name: the answer to a gas crisis is not to increase our vulnerability to the fuel, but to reduce it. Our climate, financial and energy security imperatives are now aligned. The government has no shortage of

Current policy and some alternatives

targets, policies and schemes to decarbonise heat. In 2021, it published a flurry of papers including the prime minister's 10 Point Plan, the Heat and Buildings Strategy and a slew of consultations about specific measures. We recognise the government's work in this thorny area, but by tackling the problem piecemeal it has created a patchwork that is now too complicated, too centralised and underfunded.

The government is clearly nervous of heat decarbonisation. Many of its targets are weaker than those proposed by the Climate Change Committee and others are vaguely worded – in high contrast to the sharply defined targets elsewhere:

- 'We aim to phase out the installation of new natural gas boilers beyond 2035'
- 'We will [...] ensure the UK housing stock is on track to meet EPC band C by 2035 *where practical, cost-effective and affordable'*
- 'Sales of new petrol and diesel cars to end in the UK by 2030'[22]

It is the clarity and absolute nature of the third bullet that has galvanised carmakers and sent EV sales soaring.[23] The heating industry has no such clarity and little incentive to invest until it gets it.

Many of the government's targets are measured against the Energy Performance Certificate (EPC). Unfortunately, the EPC is misleading because it was designed to rank the affordability of a home's energy bills rather than its energy efficiency or emissions. Because gas is cheaper than electricity – even today – this means the certificate favours a gas heated home with poor insulation over one that is well insulated and heated by electricity.[24] Some landlords have reportedly spent tens of thousands of pounds on energy efficiency measures and electric heating only to find their EPC ratings *falling* by several grades.[25] The government needs to reform the EPC to make it an accurate gauge of thermal efficiency - ideally by direct measurement, not modelling - and do it soon.

As for funding efficiency improvements, the government has developed several different schemes to help the poorest families living in the coldest homes. There is one scheme for homes heated by a gas boiler (Local Authority Delivery, LAD), another for those heated with other fuels (Home Upgrade Grant, HUG), and another (Sustainable Warmth Competition) to make the first two work together.[26] Yet another scheme, the Public Sector Decarbonisation Scheme, funds retrofits for schools, hospitals and council offices, and yet another (the Social Housing Decarbonisation Fund) covers council homes and housing trusts. For owner-occupiers, the Renewable Heat Incentive has recently been replaced by the less generous Boiler Upgrade Scheme. Since the closure of the short-lived Green Homes Grant, the government has offered no subsidy for insulation in the 60% of homes that are owner occupied and not-fuel poor. This is a gaping hole in an otherwise complicated picture. We are not sure why the government has created so many different schemes to tackle essentially one problem.

Likewise, the government has three programmes intended to ameliorate fuel poverty, but as the Committee on Fuel Poverty (CFP) has shown, these are poorly targeted. Taken together, these schemes spend £2.6 billion a year, but of that, only £0.4 billion (15%) reaches the fuel poor and only 22% goes on energy efficiency measures.[27]

The government has a statutory target that by 2030 all fuel-poor homes in England should have a minimum energy efficiency rating of EPC band C where 'reasonably practicable'.[28] But one recent analysis suggests that under current policies, of the 3.2 million households in fuel poverty in 2019, 80% would still be fuel poor in 2030. To reach the 2030 target under current policies, the government would need to spend another £18 billion.[29]

But now the gas crisis has made the problem even deeper. Charities have calculated the average annual bill of £2,000 in spring 2022 will push the number of households in fuel poverty to 6.5 million, and that if the average bill rises to £3,000 in October 2022, as forecast by some analysts, fuel poverty will rise to 8.5 million households.[30]

The one-off measures introduced by chancellor Rishi Sunak - a temporary discount of £200 on each energy bill, to be repaid over 5 years, and £150 rebate on council tax for homes in bands A to D – soften only half of the £700 rise in average bills in spring 2022. They fail to address the further rise coming in the autumn, which could prove long-lasting if not permanent following Russia's invasion of Ukraine; the underlying problems with policy on fuel poverty; and heat decarbonisation.

This was a missed opportunity. Since the chancellor has shown a preference for flat-rate rather than progressive interventions on energy, he would have done better to replace part of his measures (or added to them) by lifting legacy environmental costs off the electricity bill. This would have given around £100 to every household and lowered heat pump running costs, taking them closer to boiler parity.

Although the government has developed too many schemes, it is spending too little – around £2.2 billion per year. As Table 1 shows, the figures are tiny compared to – for example – the estimated cost of decarbonising only London's four million homes, or the estimates of the net cost of reaching net zero.

At £450 million, the Boiler Upgrade Scheme (BUS) will fund only 90,000 installations, or just 30,000 per year until 2025[31], far too few to allow the industry to scale up. It is also completely inconsistent with the Climate Change Committee's balanced pathway milestone of 450,000 installations in 2025 and the government's target of 600,000 per year by 2028. We fear that the 30,000 per year limit is so low it will suppress rather than support the market: heat pump sales in 2021, when the more generous Renewable Heat Incentive was still in force, are estimated at around 52,000.[32] The BUS per-home limit of £5,000 may also be too tight compared to the cost of installing a heat pump - £11,000 or more.

In this context, government spending on heat decarbonisation – the big outstanding challenge of climate and energy policy – seems inadequate even for pump priming.

TABLE 1: MAIN HEAT DECARBONISATION SCHEMES IN CONTEXT

	TOTAL £ BILLION	ANNUAL £ BILLION
ECO	4	1
Home Upgrade Grant	0.95	0.19
Social Housing Decarbonisation Fund	0.8	0.23
Boiler Upgrade Scheme	0.45	0.15
Public Sector Decarbonisation Scheme	1.425	0.48
Heat Network Transformation Programme	0.338	0.11
Totals	**8.0**	**2.2**
London boroughs domestic NZ 2030 (1)	98	N/A
Net cost of net zero, CCC (2)	321	N/A
Net cost of net zero OBR (3)	344	N/A
Financial crisis banks bailout (4)	137	N/A
COVID-19 (5)	331	N/A

Sources [33]

As serious are the stop-start nature and short time-horizons of many of the government's schemes. These have had a chequered history since the launch of the Green Deal in 2013, which stalled the number of homes being insulated. More recently the government hoped its ill-fated Green Homes Grant would disburse £1.5 billion to 600,000 homes in just six months – giving the supply chain almost no time to develop - but the scheme closed having spent only £314 million including £50 million on administration.[34] In the public sector, the delivery of government funding has improved in some respects but are still extremely complicated - illustrated by BEIS' online guidance for applicants.[35]

The shortcomings of UK policy on heat decarbonisation are not inevitable. Germany seems to have solved all these problems with a single simple and more generously funded scheme administered by the KfW infrastructure bank (Figure 11). The 'Efficiency House' or BeG scheme:

- Applies to all sectors: residential, public sector and commercial buildings; new-build and retrofit; owner-occupiers, social landlords, private landlords; and even energy savings contractors. The simplicity makes it easy for everyone to understand and the bank to run
- Covers all aspects of thermal efficiency and low carbon heating, and the size of the loans and grants depends on the degree of improvement compared to a reference standard
- Provides the homeowner with a low interest loan to pay for the retrofit; once completed and signed off, a significant chunk of the loan turns into a grant
- Has been running continuously since 2006 and its budget continues to rise

The KfW offers much to emulate. A single simple scheme applies to all types of buildings and ownership, in contrast to the myriad and complicated British funding pots. It covers all necessary measures, whereas the UK offers no support for insulation in the 60% of UK households that are owner-occupied and not fuel poor.[36] There is continuity – a single scheme has run for over 15 years - rather than endless chopping and changing. It is well funded: the German scheme provided more funding for thermal efficiency in 2006 than Britain does today; in 2020, Germany spent five times more (Figure 3). Not only is the overall budget much higher than in Britain, so too are the funding ceilings for individual projects.

FIGURE 3: GERMAN GRANT SPENDING ON BUILDING THERMAL EFFICIENCY AND ITS ECONOMIC BENEFITS

Source: KfW [37]

As generous as the KfW scheme appears, it has cost government very little. Since 2006 it has funded work on 6 million homes, secured roughly as many jobs, and KfW lending of €180 billion (of which only a part converts into a government grant) has triggered total investment of €480 billion. The extra VAT generated by this investment almost matches government spending on the programme.[38] In 2016, for example, the government spent €1.7 billion on subsidies, which triggered total investment of €10 billion, which in turn raised VAT of €1.6 billion.[39] In other words, the entire scheme, which now generates carbon savings of 12 million tonnes per year, has cost the German taxpayer next to nothing.[40]

And as successful as the KfW scheme has been, Britain will need to do even more. KfW has retrofitted 6 million homes over 15 years – an average of 400,000 per year. But the UK needs to upgrade 28 million homes and at the KfW rate that would take 70 years. To hit our legally binding 2050 deadline, Britain now needs to work almost three times faster than Germany has done so far – with funding to match. To develop the supply chain sustainably, we would need to start slower than that average rate and end faster. It is a huge challenge but one we cannot shirk.

We think the government should apply the key principles of the KfW scheme in Britain. Alternatively, it could offer state-backed wholesale guarantees to retail banks to provide 'green mortgages' for retrofit work, as proposed by E3G.[41] Green mortgages are already commercially available but the market is still small. State-backed guarantees would protect lenders from the risk of default and therefore allow them to offer better terms or commit larger volumes or both. This would follow the example of the successful National Loan Guarantee Scheme launched in 2012. Guarantees could also be offered to back big retrofit loans to social landlords.

Discounted green mortgages backed by state guarantees could be buttressed by three further reforms to incentivise energy efficiency improvements at or around the point of house sale. Mortgage portfolio efficiency reporting (on which the government has already consulted) would oblige mortgage lenders to report each year how much the EPC rating of the properties in their portfolio has improved. Sliding stamp duty would reward those who bought a higher EPC rated property, or who made EPC improvements within two years, with a rebate on their stamp duty.[42] Building Renovation Plans (or 'building passports') would provide a digital logbook containing all information relevant to the energy efficiency of a building, which would have to be provided at the point of sale.[43] The government may prefer to reform the EPC than introduce an entirely new certificate. In any case, none of these measures should be carried out without reforming the EPC.

Local authorities and local area energy planning

Local authorities must play a central role in decarbonising heat because heat is by definition local. Heat resources – heat from geothermal or mine-water, waste heat from industry or EfW plants – vary from place to place. So, too, do patterns of heat demand: industrial; dense and urban; suburban; or dispersed and rural. Existing energy infrastructure also differs by location.

These local traits will tend to push an area towards one or another of the main technology options: heat pumps, traditional electric heating, heat networks and possibly hydrogen. Any one of them would need huge investments in infrastructure – heat networks, electricity grid reinforcement, possibly upgrading the local natural gas grid to hydrogen - and to build all three everywhere would mean unnecessary and costly duplication.

Each area will need to map and analyse its probable future energy landscape through local area energy planning (LAEP). For each property, there will probably be one or possibly two technologies that suit it best. It is clear that the choices of individual homes will be influenced by those of the wider area: is there a heat network, for example? We will need independent technical bodies to advise on the options.

The overall plan, however, needs to be led by the local authority. Councils are more likely to carry local communities with them than remote Westminster – particularly those that may be isolated by language or distrust authority[44], and public consultation is an essential part of LAEP. Councils are the natural bodies to undertake this work since they are democratically answerable to local voters for the decisions they make.

Councils are also central to heat decarbonisation because they own 7% of the country's housing stock or (around 1.6 million homes in England) and many municipal buildings.[45] With the right policy support, they could commission huge numbers of retrofits to grow supply chains and bring costs down. They also have important regulatory powers over new and existing buildings: planning permission; building control; and energy efficiency standards in the private rented sector. In practice, this role has often been stymied by budget cuts and loopholes in the national rules.

Budget cuts have damaged councils' capacity even to bid for competitive funding – meaning funds have been unevenly distributed. This makes no sense to us. Homes need retrofitting everywhere, not just in those areas where the council has the wherewithal to bid.

Councils need increased funding to perform their existing roles in energy efficiency and heat decarbonisation and will need more to take on LAEP. Yet the Heat and Buildings Strategy is, according to the CCC, 'vague on the role for local area planning'.[46]

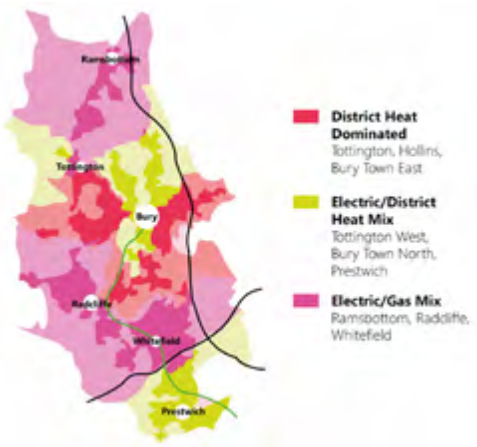
Local area energy planning

Local area energy planning is a methodology to discover the locally preferred and most cost-effective means of decarbonising local transport and heat in any given place. For heat the process includes:

- Mapping buildings and their levels of insulation; energy grids and their capacity; and any heat resources such as mine water, geothermal, waste heat from industry or EfW
- Technical modelling of the data to compare scenarios and reveal options and costs
- Re-mapping the area into heat zones that reflect the most cost-effective options: heat pumps in one neighbourhood; heat networks in another; priority areas for retrofits
- A social process to engage communities and other stakeholders so the decisions truly reflect the local area, the people and their choices

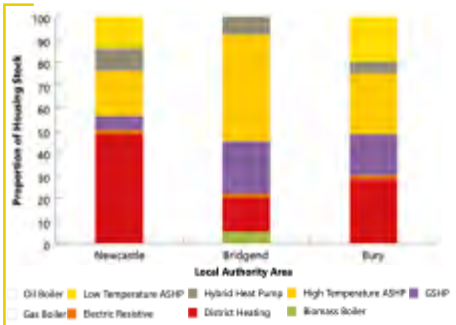
Ofgem commissioned the Centre for Sustainable Energy (CSE) and the Energy Systems Catapult (ESC) to develop the LAEP methodology. ESC has piloted the approach in Newcastle, Bridgend, and Bury in Manchester. The pilots divided each area into zones suitable for different types of low carbon heating technologies (Figure 4). The balance of technologies across the three shows how different areas can be. In Newcastle, the LAEP found that roughly half the homes could be heated by a heat network, whereas in Bury it was less than 30%, and in Bridgend 15% (Figure 5). In Bridgend, a far higher proportion of homes would need to be heated with high temperature heat pumps to save on the extra expense of retrofitting insulation in its poorer quality housing stock.

FIGURE 4: LAEP LOW CARBON HEAT ZONES IN BURY



Source: Energy Systems Catapult [47]

FIGURE 5: LOW CARBON HEATING TECHNOLOGY BREAKDOWN BY LAEP PILOT AREA



Source: Energy Systems Catapult [48]

The social element of LAEP is vital. This is the way to engage local communities in decisions about what are bound to be large and potentially disruptive changes in their lives, develop a shared understanding of the options and trade-offs, and foster consent through local, democratically legitimate bodies.

Another important aspect is that under LAEP 'zoning' is thoroughgoing rather than piecemeal. BEIS is currently running a desk-based zoning pilot project with 28 councils, but this covers only heat networks. By contrast, the LAEP process characterises all neighbourhoods within the area according to the most suitable technology or combination of technologies (Figure 3). The LAEP could define neighbourhoods as heat network zones, heat pump zones, urgent retrofit zones and possibly hydrogen zones. This kind of approach is already under way in Amsterdam.[49]

Defining neighbourhoods in this way should provide certainty for stakeholders in the area, leading to all sorts of benefits:

- Gas and electricity network operators can target their infrastructure investments where most needed and avoid stranded assets – so helping to limit the rise in energy bills – and Ofgem and the local authority can resolve any disputes between network operators
- Councils now know where to develop heat networks, and social landlords can identify homes that need the most urgent retrofits
- Social landlords, private landlords and owner-occupiers realise which low carbon heating technology they need to prepare for
- All this encourages local supply chain companies to invest in premises, staff and equipment – confident that the local market will develop

Each of the three LAEP pilot areas now has a detailed map and plan to guide their future projects, but these are taking too long. LAEP should be rolled out to all councils quickly. This local planning and engagement must start now, with proven technologies, if we are to achieve the 2050 target.

The clean heat pathfinder

Britain urgently needs at least three large-scale pathfinder projects to start the decarbonisation of building heat. We are long past the time when pilot projects of tens of homes, or even a few hundred, could tell us much that is useful. We need to learn how to decarbonise thousands of homes in a single place at once. The way to find out is to start doing it.

We need the pathfinders to learn how to retrofit and decarbonise at scale, and to develop an approach that can then be applied to neighbourhoods up and down the country. We also need it because at this point the costs look colossal, and the only certain way to bring them down is to massively increase the number of retrofits we carry out. At some point we have to commit; that time is now.

A pathfinder's goal is to decarbonise the heat of all buildings within its boundaries within five years. The area should cover between 5,000 and 10,000 homes, include all forms of tenure, deploy only proven technologies, trial new business and funding models, and come with a government backstop so that no resident would end up worse off for taking part. It would measure both energy and social outcomes.

The local economic benefits of each pathfinder could be transformational. Various nationwide estimates suggest we need to train over 50,000 heat pump engineers by 2030[50], and 500,000 other professionals and trades-people to retrofit 28 million homes – double the existing workforce.[51] In a deprived area, the impact of potentially hundreds of good new jobs, along with new businesses and manufacturing capacity, could do a great deal for Levelling Up.

Policy on heat decarbonisation is underfunded and too complicated. The pathfinders would need to solve both problems. The government should fund it more generously than under existing policies, through a single KfW-style scheme, which would also draw on low-cost lending from the UK Infrastructure Bank or similar. The purpose of this higher public funding is to get things moving and to discover how such spending can be offset by private lending, new business models, future energy savings, and by the cost reductions achieved by scaling up.

The pathfinders may also need powers to waive or flex some national regulations around energy bills – with agreement of BEIS, Ofgem and the Treasury. For all these reasons, it would need to be established under an Energy Innovation Zone. The EIZ would be led by local and/or regional authorities with support from local gas and electricity distribution network operators, the Regional Energy Hub, the Energy Systems Catapult and local universities. Government would need to fund the local and regional authorities to staff and resource their new role.

Local area energy planning will depend heavily on support from the Distribution Network Operators (DNOs), which manage the regional distribution gas and electricity grids. Information about the local capacity of their grids will be an important factor in deciding which technology zone is established in each neighbourhood. The grid operators will then need to invest in any extra capacity needed to put those zones into practice.

The network owners themselves cannot lead the LAEP process, however, since it will involve making choices that favour either gas or electricity in each neighbourhood. LAEP will need to include a mechanism that balances these competing interests, which could be trialled in the clean heat pathfinders. Ofgem is consulting the industry on the potential to create newly independent Distribution System Operators, including taking on some key planning functions from the DNOs.[52] This might resolve any conflicts of interest and provide a centre for whole system energy planning to inform LAEP.

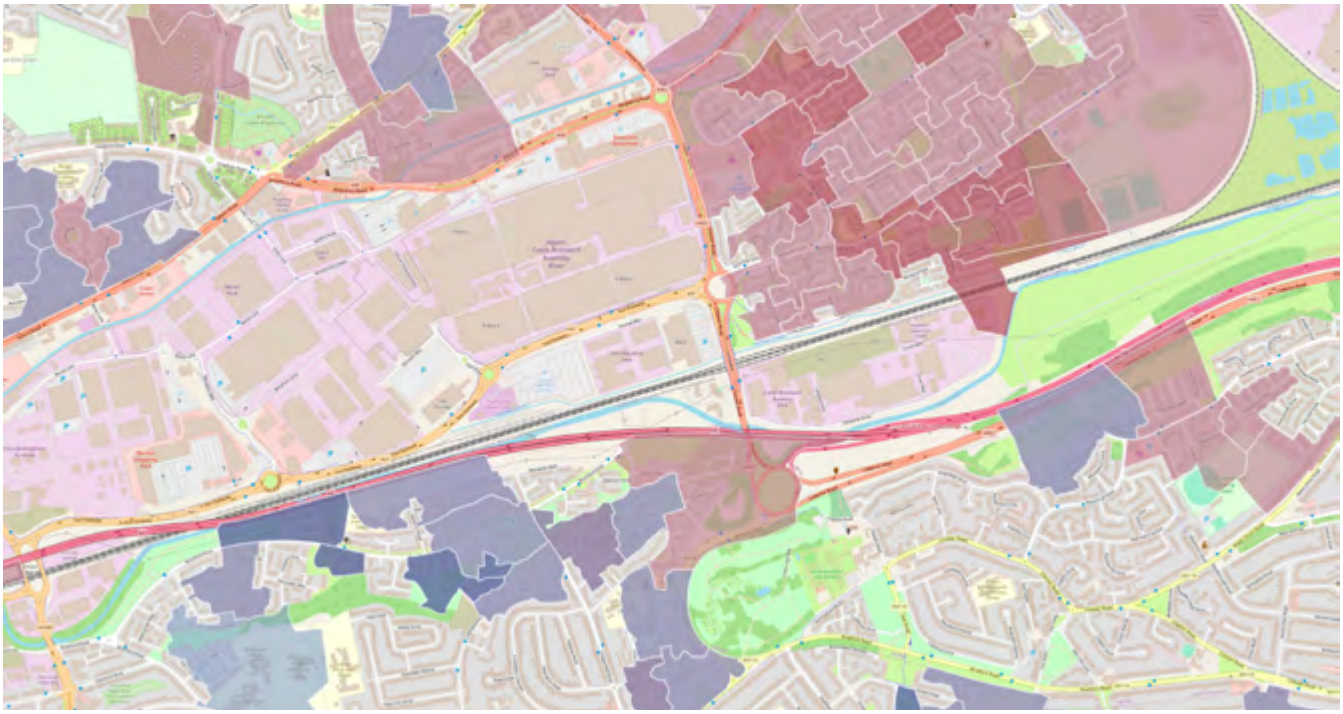
Location

There are many places in England that could host such a pathfinder, such as the three areas that have already prepared local area energy plans under the Energy Systems Catapult pilot. Another candidate could be East Birmingham, a community of 230,000 people, that combines nationally representative housing stock, excellent local heat resources and some of the highest rates of fuel poverty. Its local and regional authorities and universities are already pursuing clean heat projects which could be combined and expanded into a pathfinder.

Within East Birmingham, recent work by the Birmingham Energy Institute has identified several 'energy deprived' areas

where actual consumption was lower than theoretical demand. These include Castle Vale, which lies just north of the M6 near the junction with the M42 (Figure 6, top right) and neighbouring Bromford (bottom left). Roughly half the 4,300 homes in Castle Vale are owned by a social landlord, the Pioneer Housing Group, and many of Bromford's 3,500 homes are owned by Birmingham City Council (BCC). Both areas have high levels of unemployment and fuel poverty. In Castle Vale, Pioneer employs 170 people including 20 who work on retrofitting its properties.

FIGURE 6: COUNCIL AND SOCIAL HOUSING IN BROMFORD AND CASTLE VALE



Castle Vale is top right, Bromford bottom left.
Red shading indicates a higher proportion of council housing; blue shading a higher proportion of non-council social housing.

Source: Contains public sector information licensed under the Open Government Licence v3.0

Taken together, Castle Vale and Bromford represent almost 8,000 plus homes with a good mix of council housing, non-council social housing and privately owned homes, many of them owned by low-income families. This would be a good size and mix for a heat decarbonisation pathfinder. The housing stock largely mirrors the national stock in terms of the proportions of different housing types and building ages.

The high proportion of social housing in these neighbourhoods is an advantage because it reduces the number of landlords needed to work with the pathfinder, making things simpler. Another reason is that housing trusts and councils tend to own many homes of the same type, which allows retrofitters to standardise and reduce costs. Yet another is that the levels of insulation in social housing are often higher than in the private sector. Once a good range of building archetypes have been retrofitted under the pathfinders, it should open the way to cheaper retrofits for the rest of the country's four million homes owned by social landlords.

These neighbourhoods are also close to large and untapped waste heat resources, mostly concentrated at the Tyesely Energy Park. These include the 25MW Veolia EfW plant, which burns the city's black-bag waste, and a 10MW waste wood biomass plant. The waste heat from these facilities could be captured to extend the city's existing heat network or to power a new one. Generating capacity at the site is due to expand to 60MW, almost doubling the waste heat resource.

What would a clean heat pathfinder look like?

We need to show what zero carbon heating looks like in an entire neighbourhood and how it can be achieved - within five years. Naturally, this means the pathfinder would have to work with proven low carbon heating technologies only. It is not intended to demonstrate technologies so much as process and policy. The EIZ would be led by WMCA and BCC with support from local gas and electricity network operators, the Regional Energy Hub, the Energy Systems Catapult and local universities. Its boundaries would be set around Castle Vale and Bromford.

The pathfinder would then:

- Prepare a Local Area Energy Plan (LAEP) for all of East Birmingham
- Include formal arrangements that effectively turn the local gas and electricity network operators into a single distribution system operator (DSO) within the pathfinder – informed by Ofgem's current consultation on the future role of DSOs
- Establish zones within the pathfinder area for heat network, heat pump, urgent retrofit
- Engage with local communities
- Provide a platform for:
  - 'comfort as service' trials by energy, insulation and retrofit suppliers
  - time-of-day electricity pricing and grid balancing payments (real or synthetic) to homeowners and tenants
- Receive a greatly expanded budget compared to existing heat decarbonisation policies (see below) and through a single pot rather than having to apply to many different funds
- Disburse funding through one-stop-shop KfW-style low-cost financing and grant scheme – a single pot to replace the various government schemes - and blend in low-cost lending from UKIB or similar
- Waive environmental charges on electricity bills or secure government funding to equal value as a proxy
- Apply carbon pricing to support the capital expenditure or secure government funding to equal value as a proxy
- Fund a retrofit skills academy to train retrofit assessors, insulation and heat pump installers, and builders
- Mandate direct measurement of building performance before and after retrofit to prove and compare the performance of competing approaches
- Measure social benefits including economic growth; job creation and increased tax revenue; improvements in health; and reductions in child and fuel poverty
- Receive a government backstop behind service-level contracts to ensure that no resident is worse off for having taken part

Funding

Government funding for existing initiatives falls far short of what is needed for a clean heat pathfinder. A more realistic idea of the retrofit costs of a pathfinder can be judged by extrapolating from recent and ongoing projects. Table 2 shows a straight-line extrapolation of various recent estimates and future targets, and the results are eye-watering. The point of the pathfinders, however, is to render these numbers obsolete.

TABLE 2: NATIONAL COST OF RETROFIT WITH LOW-CARBON HEAT

	AV £ COST / HOUSE	PATHFINDER	EAST BIRMINGHAM	UK
Number of homes	N/A	8,000	125,000	28,000,000
KfW max grant	£45,000	£360,000,000	£5,625,000,000	£1,26,000,000,000
Energiesprong short-term target	£55,000	£440,000,000	£6,875,000,000	£1,540,000,000,000
Energiesprong long-term target	£35,000	£280,000,000	£4,375,000,000	£980,000,000,000
EBCHT average cost	£19,770	£158,160,000	£2,471,250,000	£553,560,000,000

Notes:
1. Straight-line extrapolation from current estimates or targets.
2. The average costs in this table include both insulation and low carbon heating system. But the Climate Change Committee estimates that 10 million homes are already well-enough insulated to fit a heat pump without further insulation. To that extent, the grossed-up totals for 28 million UK homes in this table are an overestimate. *Sources*[53]

The government will not need to fund these kinds of numbers because:

- The pathfinders will build the volume of the retrofit market, first locally and then nationally. By creating a huge economic opportunity it will draw in suppliers and build the supply chain. Competition and learning by doing will see to the rest
- These numbers represent the investment cost not the net cost. Energiesprong says its break-even is somewhere between £35,000 and £45,000. If retrofit costs can be competed down to these levels, the retrofits pay for themselves, and it is simply a question of developing long-term financing mechanisms
- A study by the East Birmingham Community Heat Taskforce has shown that a mid-range low-carbon for the 4,300 homes in Castle Vale would cost £60-£85 million.[54] If the EIZ sets the right conditions, however, much of this investment could be provided by comfort-as-service providers
- As the KfW example shows, a well-designed scheme can generate almost as much in tax receipts as it costs in subsidy

The solutions developed under the pathfinders could then be scaled regionally, further reducing retrofit costs and providing wider economic and social benefits. Birmingham, for example, has 61,000 council homes, and its Three Cities Housing Retrofit proposal covers 166,000 council and social homes across Birmingham, Coventry and Wolverhampton. Together with Birmingham's other Levelling Up Accelerators, the Council estimates this could create almost 75,000 jobs, swell the economy by £9 billion per year and help reduce relative child poverty of around 40%.[55]

Other support measures

The EBCHT study of Castle Vale highlights how a shift towards electric heating combined with existing pricing and taxation of gas and electricity would in fact increase heating bills and could raise fuel poverty by 60% (expensive hydrogen would have the same effect). The results of the study suggest the pathfinders should:

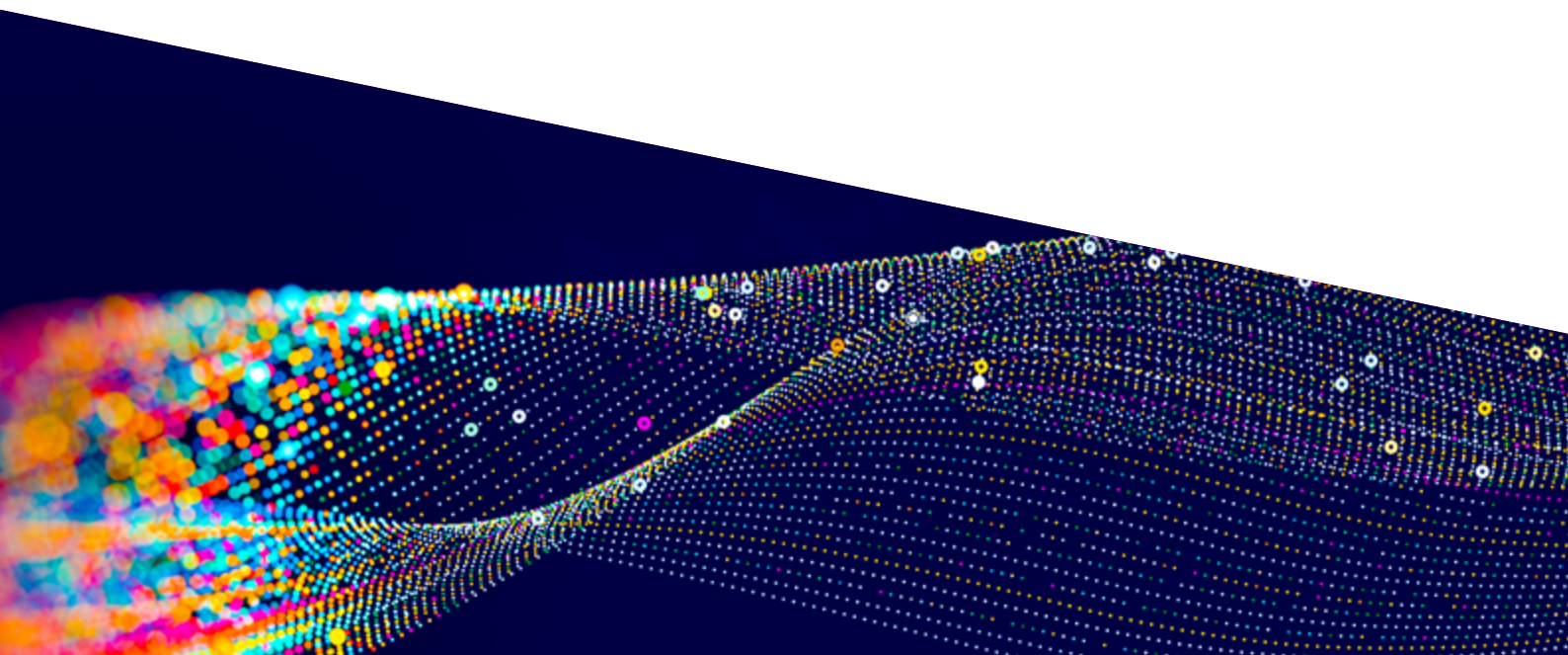
- Waive legacy environmental levies and possibly VAT on electricity bills, and integrate ECO work by energy suppliers
- Apply a carbon price of £75/tCO2 to building retrofits, which could repay the cost installing low-carbon heating through carbon savings alone within 20 years

The study also found that economic benefits of retrofitting Castle Vale would include employment of 1,200 job-years in an area of high unemployment. The EIZ would need to ensure the supply chain and skilled workforce by setting up a skills academy, or by working in tandem with the proposed National Centre for Decarbonisation of Heat (NCDH) at Tyseley Energy Park in East Birmingham.

The NCDH proposal is supported by the Manufacturing Technology Centre, Energy Systems Catapult and the Energy Research Accelerator. It would enable manufacturing, skills and low-carbon retrofit programmes to grow quickly and create tens of thousands of skilled jobs.

Wherever the government chooses to establish the pathfinders, within five years, each will have decarbonised the heating of an entire neighbourhood of mixed tenures through a variety of business models. Each will have produced a mass of data and learning about process and outcomes. Together they will have shown what levels of support are needed from government and how they can be minimised; how to secure consent from the community; and a fuller understanding of the economic and social benefits.

In short, the costs of decarbonising heat will not come down if we simply stare at the problem. They can only come down if we start to tackle it, build the market and learn. A series of at least three clean heat pathfinders would start that journey.



RECOMMENDATIONS

British policy on heat decarbonisation needs a reset. The keys to this are simplicity, place and – in the short to medium term - funding. We believe that by streamlining the national arrangements and, crucially, by defining and funding the role of local authorities, the government could galvanise action on heat decarbonisation. The way to get things moving is through several – at least three - large-scale pathfinder projects.

Targets

First, the government needs to set a clear course. The language of its current targets is vague, meaning much of the supply chain is reluctant to invest. The government must therefore set targets for clean heat as strong and clear as those it has set for EVs. We suggest:

- '*The sale of natural gas boilers will be banned in the UK by 2035*'

This simple change in language would tell the industry that a market of 28 million homes is coming, giving it the confidence to invest in production capacity and staff. The targets should be buttressed with a series of interim targets – as with the UK's carbon budgets – to keep us on track.

The government already has statutory target ensure all fuel-poor homes should have a minimum energy efficiency rating of EPC band C by 2030 where 'reasonably practicable' - but is badly off-course.[56] Independent analysis suggests that under current policies 80% of the 3.2 million households that were fuel poor in 2019 will still be fuel poor in 2030. And now the gas crisis has plunged millions more households into fuel poverty. The government must therefore:

- Reaffirm its fuel poverty target and explain how it will achieve it. Doing so will probably cost tens of billions of pounds rather than the low-single digit billions currently being spent – but this would be a major down-payment on heat decarbonisation
- Reduce the taxpayer burden by legislating its proposed minimum energy efficiency standards (MEES) for private landlords (see Table 5, main report), and fund local authorities to enforce them
- Honour the Conservative Party's 2019 election manifesto pledge to spend £2.5 billion on HUG; the Heat and Building Strategy commits only £950 million
- Make its fuel poverty target more effective by reforming the EPC as suggested below

Bills

The chancellor should lift at least the legacy environmental costs (ROCs and FiTs) off the electricity bill and take them into general taxation. This would reduce the average electricity bill by almost £100 and bring heat pump running costs closer to boiler-parity.

Environmentally, these charges pay for schemes that help decarbonise electricity that have been highly successful. Heat from a heat pump already emits far less carbon than that from a boiler. It is perverse to keep loading these costs onto the cleaner fuel – electricity – which the government wants to encourage us to use for heating. Removing these charges would begin to rebalance the effective subsidy received by domestic gas, which pays no carbon tax, compared to gas burned in a power station, which does. It would also reduce the level of intervention needed elsewhere in the market to encourage low-carbon heat.

Another way to reduce electricity prices would be to reform the power markets to reflect increasing share of renewables and eliminate marginal pricing driven by gas, as suggested by Dieter Helm's Cost of Energy Review[57], or similar. Suppliers such as EON agree that current market arrangements prevent the full benefits of low-cost renewables being passed on to customers and must be reformed. The company says 'this work needs to start now'.[58] Since gas prices look set to stay permanently high at worst and volatile at best, we agree. The government has committed to review market reform, and the Climate Change Committee says it should complete this by 2023. Again, we agree.

In the short term, government should investigate ways to clear any barriers in the wholesale market arrangements that may deter electricity suppliers from offering their customers half-hourly tariffs. These tariffs would allow households that install a heat pump to avoid peak prices, so reducing their running costs. Octopus Energy argues that the way network charges are levied (many of them at a flat rate per electricity meter) muffles the high and low price signals that would encourage this kind of behaviour.[59] The company says that if government lifted policy costs from electricity bills and reformed the energy market to allow proper time-of-use tariffs, heat pump running costs would be lower than those of a gas boiler.

Other funding

The government is investing too little in low carbon heat. Both the overall budgets and – for some schemes – the per-home spending limits are too low. There are also important holes: the government has no scheme to support insulation work in the 60% of UK households that are owner-occupied and not fuel poor, for example.[60] The government has not yet funded local and regional authorities to develop the capacity they will need.

The government could learn a lot from Germany, where the KfW Efficiency House scheme has been highly successful. It is a model of simplicity that covers all necessary works and applies equally to all sectors. It has triggered investment of €480 billion in 15 years. The VAT raised by that investment has paid for most of the subsidies. In other words, the entire scheme has cost the German taxpayer next to nothing.

We recommend the government should urgently:

- Introduce a single simple open-ended KfW-style scheme to cover insulation and clean heat for all sectors and tenures. We recognise that this is a fundamental 'year zero' reform, and should therefore be demonstrated in large-scale pathfinder projects
- Amalgamate all existing energy efficiency and heat decarbonisation funding pots into the scheme, double it and improve targeting on the fuel poor
- Recapitalise the UK Infrastructure Bank to provide the necessary low-cost lending or set up a state-backed guarantee scheme to allow retail banks to fill this role
- Alternatively, either UKIB or the Treasury should offer wholesale guarantees to Britain's retail banks to provide green mortgages for retrofit work, following the example of the National Loan Guarantee Scheme launched in 2012, and as proposed by the Green Finance Initiative

- Strengthen incentives to retrofit at the point of house purchase:
  - Sliding stamp duty[61]
  - Building Renovation Plans[62] (or reform EPC as below and integrate key features of Building Renovation Plans over time)
  - Mortgage portfolio efficiency reporting
- Increase heat network funding tenfold to £3 billion. Based on work by the Climate Change Committee and the IPPR think tank, this could stimulate private investment of up to £22 billion to provide 10% of Britain's heat through cost effective heat networks by 2030

Technical

Many of the government's targets on heat decarbonisation rest on Energy Performance Certificate (EPC) ratings. But the EPC is the wrong metric. For various reasons, it does not provide an accurate measure of thermal efficiency and sends perverse incentives; it is a roadblock.

BEIS and the Ministry of Housing accepted in 2020 that 'EPCs will need to move from a reflection of the features of a building (fabric, services and installed improvement measures) to a true measure of "in use" building performance.'[63] This reform is fundamental and now urgent.

The government should:

- Reform the EPC to measure and rank properties by thermal efficiency – as measured, not modelled
- Over time, incorporate the key elements of the proposed Building Retrofit Plans ('building passports') into the EPC

Making a thermal efficiency rating mandatory for all property sales would be a powerful lever. We need to insulate around 13,000 homes per week[64], comfortably below the number of homes sold each week pre-COVID.[65] If buyers used the document to haggle the price of energy-inefficient homes down (and vice versa), it would send a strong signal and might reduce the amount of subsidy required to incentivise retrofits.

Local and regional authorities

The government accepts that local and regional authorities will be central to decarbonising heat, especially in local area energy planning (LAEP). Most councils lack the necessary capacity — some even to bid for competitive funding. Amid tight budgets, climate spending is squeezed out by statutory duties such as social care.

The government should therefore:

- Set up a clear framework defining the role and responsibilities in heat decarbonisation of local and regional authorities. This should cover all potential technologies and include standard-setting, planning methodologies, provision of independent technical advice and local decision making
- Give councils a statutory duty to reach net zero and make it a factor in council executives' performance pay
- Give councils a statutory duty to undertake LAEP and make it a factor in council executives' performance pay
- Define the role of councils, combined authorities and Regional Energy Hubs in LAEP and fund them to build the capacity to carry it out. Funding should be allocated non-competitively, as recently demonstrated by Midlands Energy Hub on LAD2
- Widen the focus of zoning. The government's current pilot covers only heat networks. To save time the different types of zone (heat pump, urgent retrofit, possibly hydrogen) should be defined simultaneously as part of LAEP
- Legislate its proposed minimum energy efficiency standards (MEES) for private landlords (see Table 5, main report) and fund local authorities to enforce them
- Legislate to oblige landlords to register all rental properties with their local authority
- In the short term, ensure all councils have the necessary staff and capacity to access current funding schemes to eliminate postcode inequality

Pathfinder

The government should urgently set up at least three large-scale pathfinder projects to start the decarbonisation of building heat, as outlined above.

Institutions

As well as the pathfinder projects, government needs to create some new permanent bodies and/or give new responsibilities to existing ones. The government should fund:

- A new National Centre for the Decarbonisation of Heat (NCDH).[66] This would combine several functions but the most critical are:
  - *Skills Academy*. The Heat Pump Association says we need to train over 50,000 heat pump engineers by 2030.[67] Most of Britain's heating engineers are self-employed and therefore not covered by employer training schemes. The skills academy would train the trainers, provide training courses and set standards for other providers.
  - *Standards and Verification*. Set and verify standards for technologies and processes such as thermal efficiency measurement.
  - *Innovation*. It will also include a manufacturing accelerator, business incubator and a Building Integration and Living Lab, all to help drive down costs
- Independent consumer advice centre. The government should fund a respected independent body such as the Energy Savings Trust to provide simple and authoritative advice about heat decarbonisation to residents, householders and small landlords. This would build on the Simple Energy Advice website but go much further, providing expert home visits and properly tailored advice. The body will need the capacity to deal with millions of enquiries
- The government should also launch a national conversation to raise awareness of low carbon heat, with messaging tailored not only to the population at large but also to communities that may be isolated by language and perhaps mistrust of authority. Local authorities should be responsible for local awareness-raising and consultation

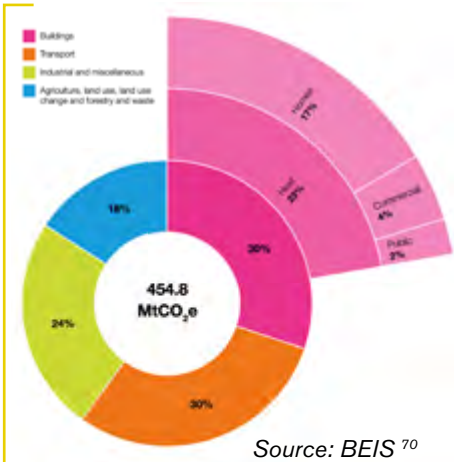
MAIN REPORT
1. THE CLEAN HEAT CHALLENGE

There is no doubt that decarbonising Britain's heat is an enormous and complicated challenge. It combines poor housing stock, high levels of fuel poverty, unfamiliar technologies (for Britain, at least), eyewatering infrastructure costs and the need to intervene in 28 million homes. Now it is exacerbated by the gas crisis and Russia's invasion of Ukraine, which could push the average annual energy bill to £3,000 and the number of households in fuel poverty to 8.5 million.[68] All of these problems make it more urgent – not less – to decarbonise heat.

Emissions

Heat is the single biggest emitter of greenhouses gases in the UK. Heating for buildings causes 23% of Britain's total emissions, and housing alone causes 17% (Figure 7). According to the Committee on Climate Change, building heat emissions now need to shrink 24% by 2030 to get back on track for our legally binding 2050 net zero target.[69] In other words, we need to cut emissions from heat more in the next eight years than we have in the past 30.

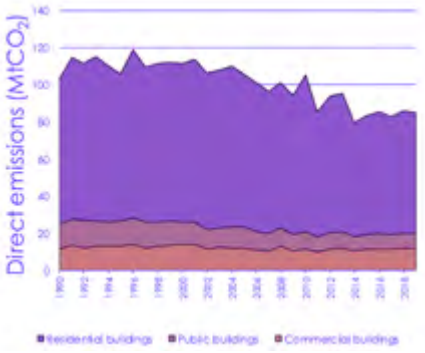
FIGURE 7: UK EMISSIONS FROM HEATING BUILDINGS



Source: BEIS [70]

Britain's overall emissions have fallen 42% since 1990, but this is largely due to the decarbonisation of electricity generation. By contrast, progress on heating emissions has been poor. Direct emissions from buildings have fallen 19% in that time, due to the introduction of condensing boilers and (now discontinued) insulation schemes, but since 2015 progress seems to have stalled (Figure 8).[71] Much of the apparent improvement has been due to warmer winters rather than increased efficiency. When this effect is stripped out, direct emissions from buildings in 2017 were only 9% lower than in 1990.[72] Heating needs to catch up.

FIGURE 8: DIRECT EMISSIONS FROM BUILDINGS SINCE 1990



Source: Climate Change Committee [73]

The vast majority of the country's households (24 million or 85%) heat with natural gas, while only 5% heat with electric storage heaters, 4% with oil and 2% with heat networks.[74] Replacing the gas boiler with low carbon heating is therefore the central task. As shown in Figure 9, the UK's gas dependence is greater than any other OECD country, bar the Netherlands.

FIGURE 9: FUEL SHARE FOR RESIDENTIAL AND COMMERCIAL HEATING BY OECD COUNTRY

Source: BEIS [75]

Gas boilers have a lifespan of around [15 years], meaning there are only two boiler replacement cycles between now and 2050, and are often replaced as a 'distressed purchase' when the heating fails in winter. Both facts have profound implications for heat policy.

Low carbon heating technologies

There are three main low carbon contenders: heat pumps, heat networks and hydrogen boilers.

Heat pumps

Heat pumps are a well-established technology and work like a fridge in reverse. They are highly efficient, since 1kW of electricity input produces 3kW heat on average. But installing one today is expensive – at around £11,000 for an air-source heat pump (ASHP) and £18,000 for a ground-source heat pump (GSHP).

Costs are expected to fall as the market develops. The technology is already mass produced in Europe and the Far East, so it is not clear how far or fast manufacturing costs can fall, but supply chain margins and the installation process look ripe for rationalisation.

Some energy companies say they are confident that heat pumps could soon become competitive. When the new Boiler Upgrade Scheme (BUS) subsidy starts in April 2022, Octopus Energy plans to launch a heat pump offer that it says will cost 'roughly the same' as a gas boiler after the £5,000 subsidy. EON says that the total cost of owning a heat pump (installation and running costs) could match or undercut those of a boiler by the end of the decade, even without subsidy, provided the government removes the environmental levies from electricity bills and grows the market so that industry can reduce installation costs through innovation and competition.[76]

Heat pumps operate most efficiently at low flow temperatures and therefore need homes to be reasonably well insulated – an additional challenge given Britain's poor-quality housing stock (see below) – although the CCC has found that 10 million homes are already heat pump-ready.

The good news is that there is no property type or age of building that is unsuitable

for a heat pump, according to a recent government-funded study. The Energy Systems Catapult led the project to install 750 heat pumps in homes across three regions of Great Britain – from Scotland to southeast England – and in all property types including almost 40 flats. It found that the challenges were manageable even in pre-war homes.[77]

Widespread uptake of heat pumps would make it necessary to greatly expand electricity generating capacity and strengthen electricity distribution grids.

Traditional electric heating, although less efficient that heat pumps, may be less disruptive to install in some circumstances, and could therefore also play a role.

Heat networks

Heat networks are an efficient way to provide heat for large buildings in city centres and areas of dense housing. Inside the building, the equipment consists of a heat exchanger to transfer heat from the piped supply to the building's own heating system. One disadvantage is that heat networks require investment in expensive underground pipe networks up front – before any revenue is generated.

Although most heat networks are powered by gas-fired combined heat and power (CHP) plants, they have traditionally been seen as low carbon because the systems are efficient. That low-carbon status is increasingly undermined by the falling carbon intensity of grid electricity, however, which can make single-building heat pumps the greener option. But heat networks can become net-zero compatible by replacing CHP as a heat source with large scale heat pumps or waste heat. Heat networks currently provide around 2% of residential heat, but the Climate Change Committee estimates they could cost-effectively provide 10% of Britain's heat by 2030 and 18% by 2050.

Hydrogen

Manufacturers are testing hydrogen boilers that burn hydrogen just as conventional boilers burn natural gas. And if commercialised, they should sell for around the same price. If there were no other considerations, simply swapping one for the other would make life easy for the homeowner – although, since hydrogen fuel is likely to remain expensive, homes would need to be well-insulated to mitigate high fuel bills.

But already a consensus is starting to emerge that hydrogen is unlikely to become a mass market application for domestic heating because:

- The inefficiency of 'green' hydrogen production by electrolysis means that hydrogen heating would need five times more wind turbines than heat pumps would to supply the same final heat, greatly increasing infrastructure costs
- There is unlikely to be any spare renewable electricity to make green hydrogen for decades because of growth of EVs and heat pumps
- High temperature industries like steel and cement, where there are few alternatives, need hydrogen more than domestic heating does, and will therefore outbid for supplies

All of which makes it unlikely the gas grid will be repurposed in a reasonable timeframe – as some contend – as a national hydrogen grid. It seems more likely that hydrogen heating will be limited to areas where the gas is needed for high-temperature industries such as steel making.

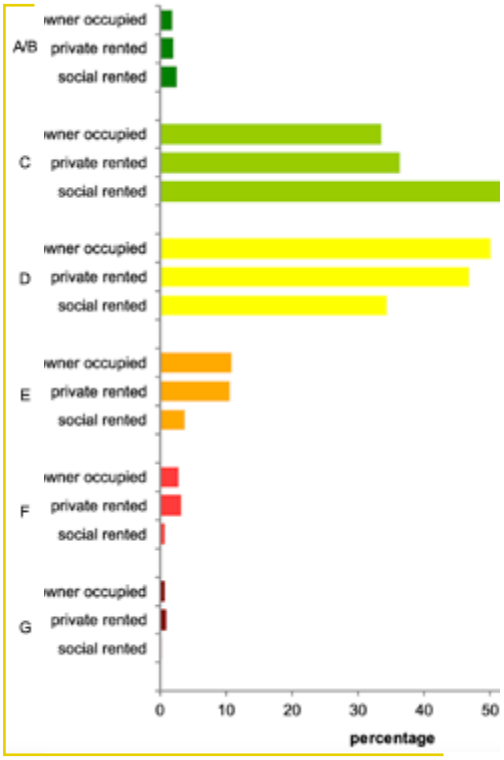
Housing stock

Britain has some of the least thermally efficient housing in Europe. A study in 2015 found that, compared to 10 other European countries, the UK ranked between 7th and 11th on a range of housing thermal efficiency measurements.[78] That means bills and emissions are higher than they should be, even with current heating systems, and that many homes will need further insulation — although 10 million will not — before converting to low carbon heating.

The average energy efficiency of homes in England, as measured by the government's Reduced Standard Assessment Procedure (RdSAP) and the Energy Performance Certificate (EPC) based on it, has improved significantly in the last 20 years. The average SAP score has risen from 45/100 in 1996 to 65/100 in 2019.[79] And in the EPC ranking of A to G, most properties now rank C or D (Figure 10).

It is widely recognised, however, that the RdSAP and EPC scores do not tell the whole story. Their original purpose was to rank the affordability of a property's energy bills rather than energy efficiency or emissions. This affects the built-in assumptions of the RdSAP model and its outputs. As a result, because a kilowatt of electricity has historically cost around four times more than one of gas, it is possible to achieve a high EPC score in a home with poor insulation simply by installing photovoltaic solar panels on the roof. Likewise, a well-insulated home with electric heating can score lower than a poorly insulated one with a gas boiler. Some landlords have reportedly spent[81] tens of thousands of pounds on energy efficiency measures and electric heating only to find their EPC ratings falling by several grades.[82]

FIGURE 10: EPC BANDS BY TENURE, 2019

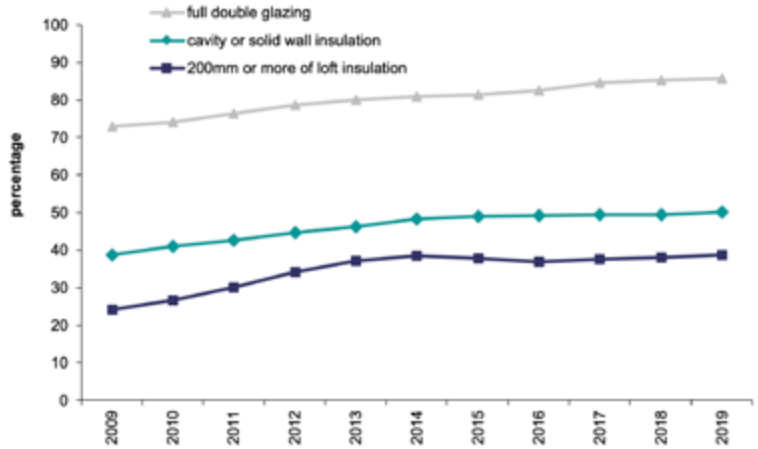


Source: MHCLG [80]

Despite rising EPC ratings, most homes are still badly insulated. As shown in Figure 11, only 50% of homes have cavity or solid wall insulation, and less than 40% have 200mm or more of loft insulation.[83] Despite the huge amount of insulation yet to be installed, the graph also shows how progress has slowed in recent years.

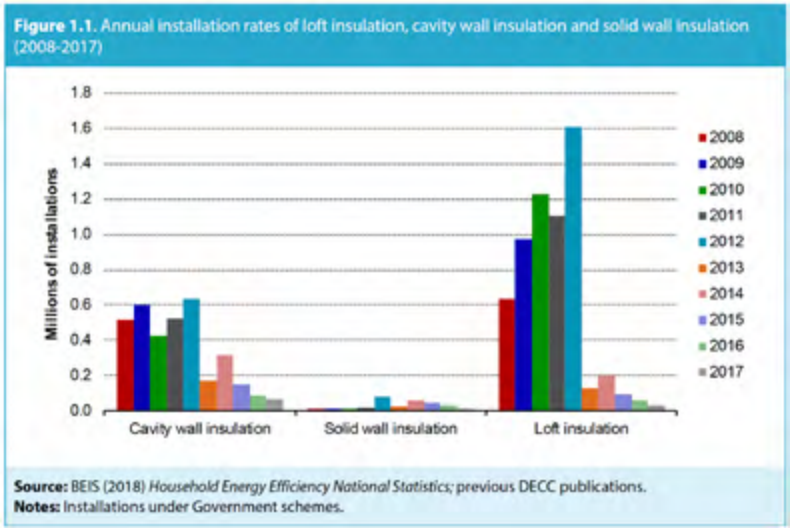
Figure 12 shows how annual insulation rates slumped in 2013 after the introduction of the Green Deal and changes to the ECO schemes and have

FIGURE 11: INSULATION MEASURES, 2009-19



Source: MHCLG [85]

FIGURE 12: ANNUAL INSTALLATION RATES FOR INSULATION 2008-17



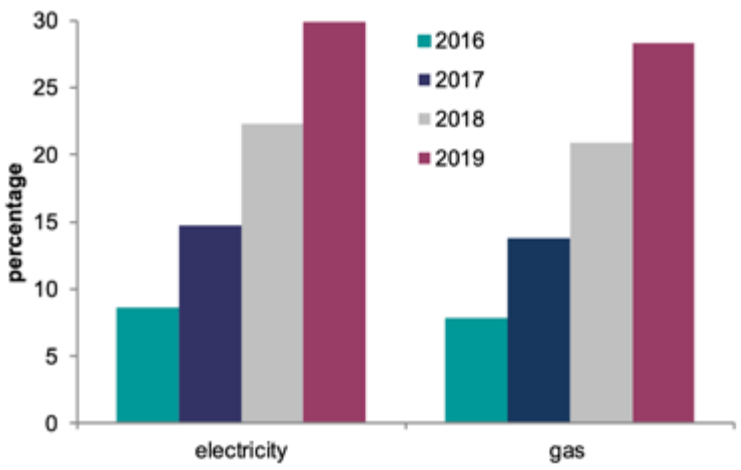
Source: CCC [86]

not recovered. It also shows how the easier and cheaper insulation measures – loft and cavity wall – have far outweighed the more intrusive and expensive solid wall insulation. In 2019, only 11% of houses with predominantly solid walls had installed wall insulation.[84]

Although much of Britain's housing stock is poorly insulated, the Climate Change Committee has found that 10 million homes are already well enough insulated to be heated with heat pumps, which is a huge potential market in which competition should bring costs down.[87] It says a further 10 million could be made heat-pump ready with more insulation.

One way to improve our understanding of the thermal efficiency of individual homes housing would be to introduce some form of direct measurement, or new modelling techniques that integrate real energy consumption data from smart meters (see chapter 2). By 2019, however, only 30% of homes had been fitted with smart meters (Figure 13).

FIGURE 13: SMART METER INSTALLATIONS

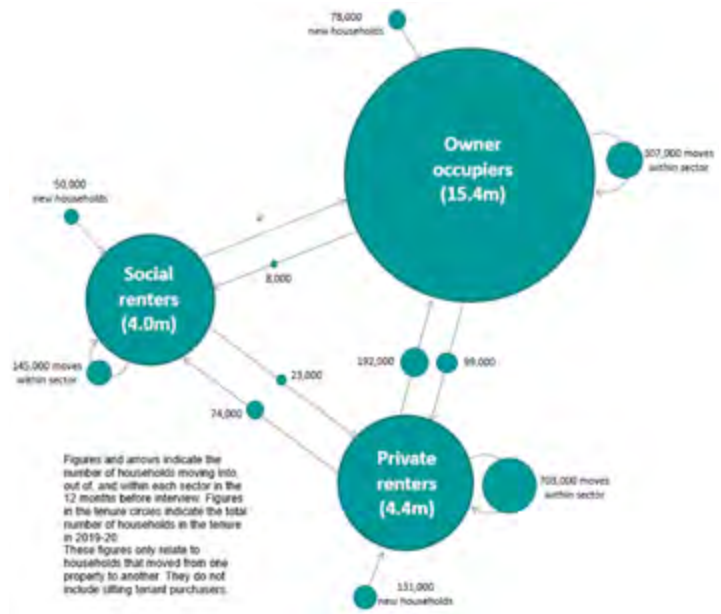


Source: MHCLG [88]

Housing tenure

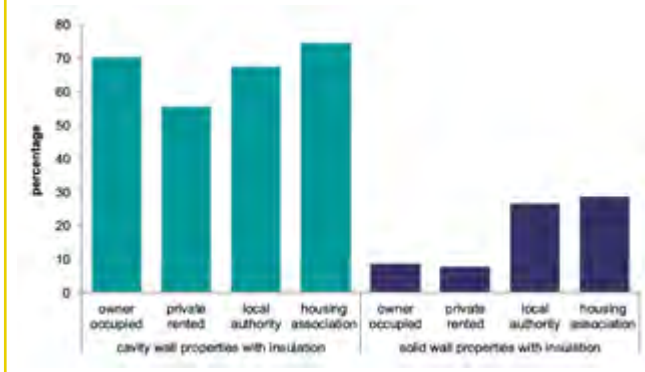
Tenure affects both the current energy efficiency of housing and the owner's ability to improve matters. As shown in Figure 14, there are 15.4 million owner-occupied homes in England (64%), 4.4 million privately rented (19%) and four million socially rented (17%, of which 10% housing association and 7% council). In general, social housing has a higher EPC rating than private sector housing, but more importantly, given the reservations noted above, is also generally better insulated (Figure 15).

FIGURE 14: ENGLISH HOUSEHOLDS BY TENURE



Source: MHCLG [89]

FIGURE 15: ENGLISH WALL INSULATION, BY MAIN WALL TYPE AND TENURE, 2019



Source: MHCLG [90]

The social sector is often seen as in a good position to drive heat decarbonisation. It controls four million homes, including many of the same type, which favours standardisation, and its levels of insulation are generally higher than in the private sector. Both councils and housing associations should be able to secure capital against their housing stock given a supportive statutory framework. Both are often closer to and more trusted by their tenants than is remote Westminster.

After 10 years' austerity, however, councils lack capacity to make strategic decisions and funding to see them through. They also face the problem of engaging communities – even if they are better placed than central government to do this – and sometimes of gaining access to their properties to carry out works.

Housing associations, meanwhile, have been put off by past experience of low carbon heating projects and, like councils, have a long list of competing priorities including the Building Safety Act, the Fire Safety Bill, and white papers including housing, energy and planning. Housing associations are extremely nervous of the heat decarbonisation agenda.

Private landlords control some 4.4 million properties but most hold only small portfolios. As shown in Figure 16, almost 60% own fewer than four and 15% own only one. Access to further capital may be a problem for many buy-to-let landlords. And as noted above, landlords face the conundrum that while the government has proposed (but not yet legislated) a minimum EPC rating of C for new lettings by 2025 and all lettings by 2028, investing in low carbon electrical heating can in fact send EPC ratings down.

Owner-occupiers control almost two-thirds of English homes, and have the greatest interest in improving the thermal comfort of the home they live in. But they have little personal incentive to invest in low carbon heating. Many lack the capital at current installation costs and subsidies, and 1.2 million homeowners were fuel poor even before the gas crisis. Many of those who can afford it might prefer to spend their money elsewhere. Almost certainly the majority are confused about what they could do or where to find tailored advice on whole house retrofits.

It is also true, however, that around 20,000 homes are bought and sold each week in the UK[92], when the sums of money exchanged usually dwarf the sums needed to install insulation and low carbon heating, making house sale a powerful potential regulatory trigger point. Others include one million boilers replaced each year and 1.2 million mortgages taken out or refinanced.[93]

Fuel poverty

The poor thermal efficiency of its housing means the UK also has some of the worst levels of fuel poverty. Ranked in 2015 among 16 European countries for fuel poverty, Britain came 14th – worse than all but Slovenia and Ireland.[94] The same relationship is shown regionally in Figure 17, where the West Midlands scores worst on both housing efficiency and fuel poverty.

The latest statistics show that in 2020 3.2 million or 13.2% of the households in England were fuel poor.[95] But these numbers predate the sharp rise in gas prices in 2021, and the further surge following Russia's invasion of Ukraine in 2022. Charities have calculated that the near doubling of the average annual bill to £2,000 in spring 2022 will push the number of households in fuel poverty to 6.5 million. If the average annual bill rises to £3,000 in October 2022 as forecast by some analysts, fuel poverty will rise to 8.5 million.[96]

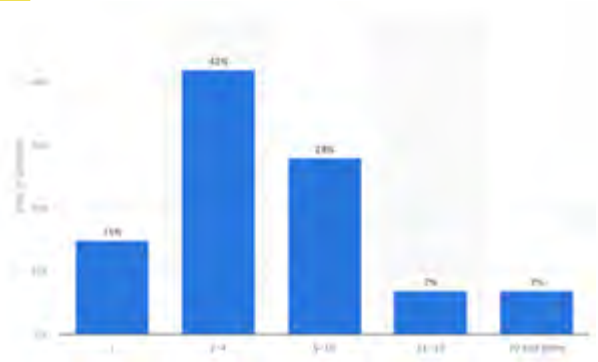
The average fuel poverty gap in 2020 – the amount by which energy bills would need to fall to lift the household out of fuel poverty – was £223 in 2020. But since bills are set to double or triple this year, the fuel poverty gap is also bound to soar.

In contrast to the stereotypes, only 22% of the fuel poor are pensioners and 46% do not receive benefits.[97] This makes it difficult to target help for the fuel poor since some of the schemes are designed around gateway benefits for which almost half the fuel poor are either ineligible or do not claim. According to the Committee on Fuel Poverty, the government's official advisor, of £2.6 billion annual spending on relevant programmes (Winter Fuel Payments, Warm Home Discount and Energy Company Obligation) only 15% is targeted on the fuel poor. And only 22% of the money is spent on energy efficiency measures rather than energy bill rebates or income supplements.[98]

In 2019, almost 27% of private tenants were fuel poor, over 18% of social tenants and 8% of owner-occupiers.[99] Households that heat with electricity (21%) are far more likely to be fuel poor than those that heat with gas (13%). Those that heat with electricity make up only 7% of households in England, but 12% of all fuel poor households.[100]

Since electricity tariffs are much higher than those for gas, and environmental charges on electricity are also much higher (see below), shifting to electric heating without introducing counterbalancing policy measures is likely to raise energy bills and worsen fuel poverty.

FIGURE 16: UK PRIVATE LANDLORDS BY NUMBER OF PROPERTIES OWNED, Q1 2019



Source: Statista [91]

FIGURE 17: FUEL POVERTY CORRELATES WITH POOR HOUSING EFFICIENCY.

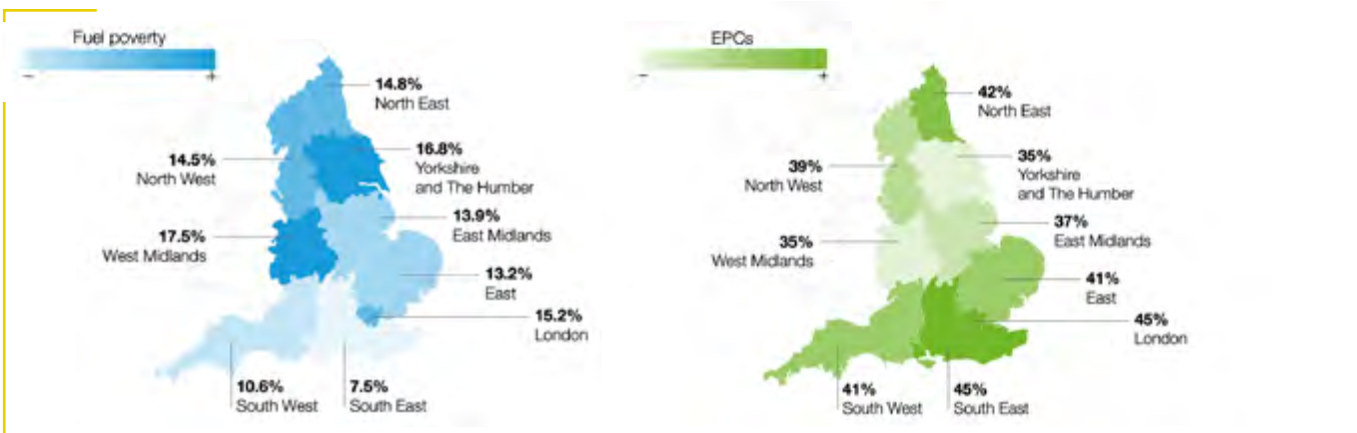


Figure 4 shows that the proportion of households living in fuel poverty varies across England.[145,146] Additional support for low income and fuel poor homes can help to level up different regions across the UK.

Figure 5 shows that the energy efficiency of building also varies by location.[147,148] Therefore, upgrading the efficiency of buildings in specific regions can help level up the region.

Source: BEIS [101]

Energy bills and tax

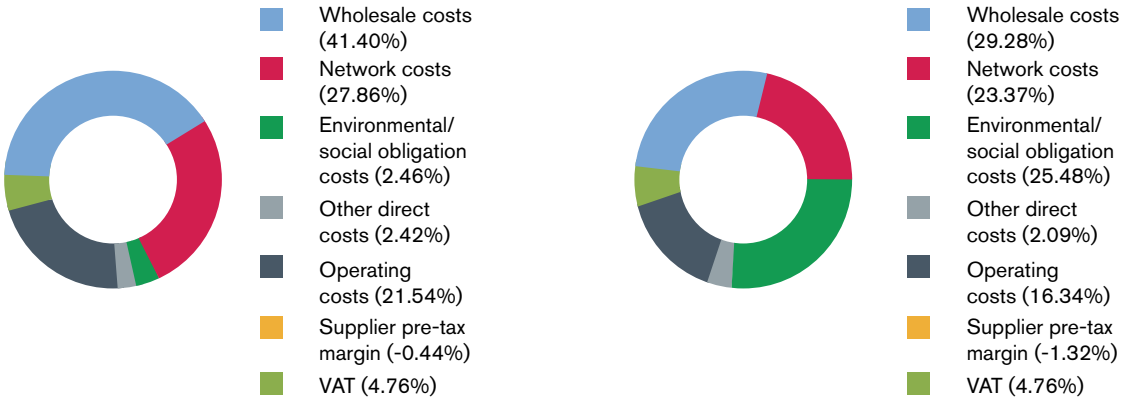
Low carbon heating systems currently cost households more to install, and will cost society huge amounts for new infrastructure (see below) to supply them. Some technologies such as heat pumps also have higher running costs, but this is largely because of the way fuels are taxed.

As shown in Figure 18, in autumn 2021 social and environmental charges (subsumed within the energy suppliers' tariffs) inflated the average gas bill by 2.5% and the average electricity bill by 25.5% - 10 times as much.

The electricity charges cover the costs of the Energy Company Obligation (ECO), which funds energy efficiency improvements in fuel poor households; the Warm Homes Discount for pensioners; the contracts for difference (CfD) mechanism, which smooths the income of off-shore windfarms but is not a subsidy over the longer term; and feed-in tariffs (FITs) and renewable obligation certificates (ROCs), which fund now-discontinued subsidy schemes.[102]

The effect of paying for these charges is regressive – bearing most heavily on the poorest. The electricity bill is also inflated by carbon tax paid by gas fired power stations, whereas gas burned in a domestic boiler suffers no carbon tax, meaning it is effectively subsidised.

FIGURE 18: GAS AND ELECTRICITY BILL BREAKDOWN AUTUMN 2021



Source: Ofgem [103]

TABLE 3: SOCIAL AND ENVIRONMENTAL LEVIES ON ANNUAL ELECTRICITY AND GAS BILLS, AUTUMN 2021, ROUNDED

ELECTRICITY	£	GAS	£	ELECTRICITY ROC + FIT ONLY	£
RO	72	ECO	17	RO	72
FiT	20	WHD	7	FiT	20
CfD	22	GGL	0	Total	92
ECO	13	Total	24	VAT at 5%	5
WHD	7	VAT at 5%	1	**Total**	**97**
AAHEDC	1	**Total**	25		
Total	135				
VAT at 5%	7				
Total	**142**				

Sources OFgem[104]

In autumn 2021, these social and environmental charges amounted to £142 on electricity and £25 on gas (Table 3). As a result, in the second half of 2021 one kilowatt hour (kWh) of heat from an ASHP cost 45% more than one from a gas boiler despite emitting less than half the CO_2e – even at current grid carbon intensity (Table 4). Homeowners are therefore doubly penalised for installing low carbon heating: both capital and running costs are higher. The current arrangements are therefore bad for the fuel poor and bad for the climate.

TABLE 4: IMPACT OF ELECTRICITY POLICY CHARGES ON HEATING COSTS, AUTUMN 2021

ELECTRICITY	GAS	ELECTRICITY	RATIOS
Average energy tariffs July-Dec, £/kWh	0.039	0.189	4.85
Carbon intensity of fuel, kgCO2e/kWh	0.184	0.233	1.27
Boiler efficiency, %	90	N/A	N/A
ASHP efficiency, %	N/A	300	N/A
Carbon intensity of heat kgCO2e/kWh	0.20	0.08	0.38
Cost of heat, £/kWh	0.04	0.06	1.45
Cost of heat if electricity policy costs removed	0.04	0.05	1.08

Sources BEIS[105]

Note: At average tariffs in the second half of 2021, one kilowatt-hour of electricity cost almost five (4.85) times as much as one of gas, and at that stage British electricity was 27% more carbon intensive than natural gas. But because heat pumps are so much more efficient than boilers, the heat they produce emits less than half (38%) the CO2/kWh emitted by a boiler. The higher efficiency of the heat pump also improves the cost comparison: whereas electricity costs almost five times as much as gas, the heat produced by the heat pump costs only 45% more than heat from a boiler. In July-December 2021, social and environmental charges inflated electricity tariffs by 25%. If those costs were removed and shifted to general taxation, heat pump heat would cost only 8% more than heat from a boiler.

Table 4 also shows how removing the social and environmental costs from electricity bills and into general taxation would bring the cost of low-carbon heat much closer to that of a high-carbon boiler. Heat from a heat pump would then cost only 8% more than that from a boiler, down from 45% previously.

Fuel poverty campaigners worry, however, that removing ECO and WHD from the electricity bill would deny these programmes a guaranteed and politically secure source of funding. It would also interfere with the existing delivery mechanism through the energy suppliers. If ECO and WHD remained on the electricity bill, and only ROCs and FiTs were lifted into general taxation, it would still reduce the average electricity bill by £97 (Table 3) and take the cost of heat from a heat pump significantly closer to boiler parity.

Shifting ROCs and FiTs into general taxation can be justified on both social and energy grounds. As things stand, these charges are regressive – bearing heaviest on the poorest. Under general taxation the burden would be spread more fairly. Removing them from the bill would give every household almost £100. This flat rate approach is not well targeted on the fuel poor, but it would have the benefit of reaching the 46% of the fuel poor who do not receive benefits – just like the chancellor's emergency measures in February 2022.

Unlike the chancellor's emergency measures, however, this reform would also remove a perverse disincentive to install low-carbon heating. ROCs and FiTs pay for schemes that have helped cut electricity emissions sharply, so much so that heat from a heat pump already emits far less carbon than heat from a boiler. It is perverse to keep loading these costs onto the cleaner fuel – electricity – which the government wants to encourage us to use for heating. Removing these charges would begin to rebalance the effective subsidy received by domestic gas, which pays no carbon tax, compared to gas burned in a power station, which does. It could also reduce the level of intervention needed elsewhere in the market to encourage low-carbon heat.

Another way to reduce electricity prices may be to reform the power markets to reflect the increasing share of renewables and eliminate marginal pricing driven by gas, as suggested by Dieter Helm's *Cost of Energy Review*[106], or similar. Suppliers such as EON agree that current market arrangements prevent the full benefits of low-cost renewables being passed on to customers and must be reformed, and the company says 'this work needs to start now'.[107] The government has committed to review market reform, and the Climate Change Committee says it should complete this by 2023.

In the short term, the government could also investigate ways to clear any barriers in the wholesale market arrangements that may deter electricity suppliers from offering their customers half-hourly tariffs. These tariffs would allow households that install a heat pump to avoid peak prices, so reducing their running costs. Octopus Energy argues that the way network charges are levied (many of them at a flat rate per electricity meter) muffles the high and low price signals that would encourage this kind of behaviour. Octopus already offers a synthetic half-hourly time of use tariff but has had to subsidise it so far.[108] It says that if the government lifted policy costs from electricity bills and reformed the energy market to allow proper time-of-use tariffs, heat pump running costs would be lower than those of a gas boiler.[109]

Infrastructure

Each of the main low carbon heating technologies implies investment not only in every home but also in the upstream infrastructure need to generate and distribute the energy.

A future dominated by heat pumps, for example, would require huge amounts of additional renewable generation and major upgrades to electricity distribution networks. One dominated by hydrogen boilers would require renewable generation and electrolysers to produce the fuel, or an entirely new carbon capture industry, and the upgrades to the natural gas grid. To build or expand a heat network means digging up the streets and laying hot water pipes.

Estimates of what each pathway would cost differ widely. Various studies by E4tech and Imperial College have investigated three broad pathways – electricity, hydrogen and hybrid. The results for each pathway can differ by £100 billion or more. Similarly, modelling by the Energy Systems Catapult for Ofgem implies a best to worst case scenario range of £100 billion to £450 billion for heat decarbonisation – although it was based on locally mixed rather than nationally determined technology pathways.

We believe it would be folly to base policy on such modelling. The modellers themselves admit that the scenarios rest on technical assumptions to 2050 provided by technology developers - which should perhaps be treated with caution - and that tweaking those assumptions changes not only the values but also the relative ranking of the pathways.

The broader point is that heat is local and therefore so are decarbonisation pathways. Instead of making a top-down decision based on highly contingent modelling, it makes more sense to pilot local solutions at full speed and mass scale (several locations, thousands of homes each), and then deduce the infrastructure required. This almost certainly implies a hybrid approach – although the balance of that hybrid will differ greatly from place to place.

Given the extreme urgency of decarbonising heat, it also implies that we should concentrate on proven technologies. We think the approach taken by the London Olympic games is instructive. Given an absolute deadline and zero-tolerance of failure, the Olympic Committee decided to constrain innovation and rely on proven technologies – and delivered a successful games on time.[110]

For heat decarbonisation this means planning to work largely with heat networks, which have been operating for decades, and heat pumps, which the government's Electrification of Heat project has proved suitable for all types of home.[111] It also means *not* relying on the assumption that hydrogen will come through. If it does, so much the better and plans can be adjusted, but if not, the target and deadline can still be met on the basis of existing technologies and plans.[112]

It is already clear that no single technology is likely to work for the entire UK. Heat resources and demand patterns will differ between regions and neighbourhoods. For example, heat networks make sense in city centres and areas of dense housing, but not rural areas where the cost of laying the pipework would be disproportionate. Hydrogen home heating might make sense in areas where the fuel will be produced in bulk for industrial purposes such as steel making but not further afield. Heat pumps look the default option everywhere else.

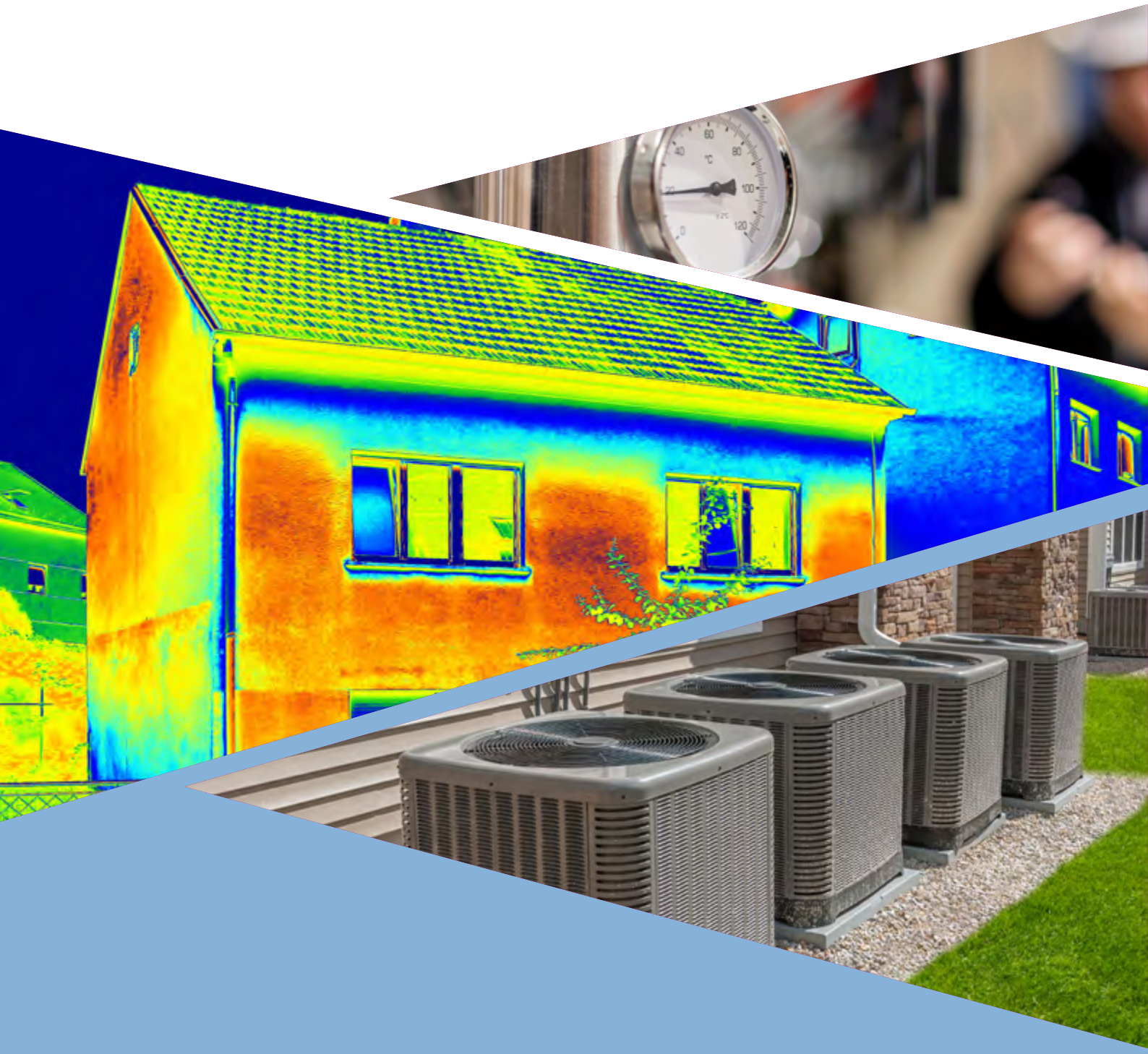
To build three sets of infrastructure in a single area would be impractical, so regions and neighbourhoods will need to choose predominantly one. There is a broad consensus that these choices should be made by local or regional authorities: at this scale, data can be gathered affordably; consultation can lead to consensus; and the transition can be supported through partnerships between DNOs and private developers. But the government has yet to decide who will carry out local energy mapping and planning, how it will be funded and, crucially, how to secure the consent of local communities. The other major issue, of course, is who pays for the local and regional infrastructures and how.

Communities

Most people have little or no interest in their heating until it stops working, so heat decarbonisation is a difficult sell. For some (able-to-pay owner-occupiers) it will mean upfront expense that may take years to 'pay back'; for others (tenants) it may mean disruptive work on their home and higher energy bills; and for some it may mean both. For those whose homes were warm enough to start with, it's hard to answer the question 'what's in it for me?'

Some groups will be particularly hard to reach. For the millions in fuel poverty, especially those forced to choose between heating and eating, decarbonisation will be the last thing on their minds. Other communities may be isolated by language and perhaps mistrust of authority. To have any chance of decarbonising heat, the government should launch a national conversation and frame policies and messaging to reach all these groups. It also needs to empower and fund those most likely to be able to reach them, which in many cases will be local and regional authorities rather than central government.

2. CURRENT POLICY AND SOME ALTERNATIVES



There has been no shortage of policy activity around decarbonising heat. In 2021 the government published a flurry of papers including the prime minister's 10 Point Plan, the Heat and Buildings Strategy, the Net Zero Strategy, the UK Hydrogen Strategy and many consultations about specific measures.

The Heat and Buildings Strategy, published in October 2021, after some delay, is naturally the most comprehensive statement of current and future policy so far. Its policies touch all the main technologies and housing sectors, new building standards and fuel poverty. Although the document runs to 200 pages, its main elements are easily summarised.

Housing sectors

Most of the government's spending on heat decarbonisation comes through a series of schemes that support the installation of energy efficiency improvements and low carbon heating in low-income households, social housing and public sector buildings. Most run for three years from 2022.

The Home Upgrade Grant (HUG) aims to help poorest families living in the least energy efficient homes – those rated EPC bands D–G – that are not connected to the gas grid. For low-income energy inefficient homes that are connected to the gas grid, there is the separate Local Authority Delivery (LAD) scheme. More recently the government has set up a third scheme, Sustainable Warmth, to make the first two work together.

The biggest single scheme is not funded by the taxpayer but by energy customers. The Energy Company Obligation (ECO) mandates energy suppliers to help low-income families heat their homes more affordably by installing insulation and new boilers. The energy companies are expected to spend £1 billion per year for the next four years, funded through a charge on energy bills (more detail below).

LAD, HUG and ECO are the main policies by which the government hopes to reach its 2030 fuel poverty target by when all fuel-poor homes should have a minimum energy efficiency rating of EPC band C where 'reasonably practicable'.[113]

The Social Housing Decarbonisation Fund is available to councils and housing trusts and worth £800 million in total. Social housing is generally more energy efficient than private homes – as measured by the EPC – but the scheme aims to raise a 'significant amount' of the remaining inefficient stock to EPC band C.

The Public Sector Decarbonisation Scheme is worth just over £1.4 billion and funds major retrofits for public buildings such as schools, hospitals and council offices. One secondary school in Derbyshire, for instance, has received almost £700,000 to install a modern insulated roof and replace coal-fired boilers with air source heat pumps.

Rather less support is available to owner-occupiers. The Boiler Upgrade Scheme (BUS) launched in April 2022 provides a capital grant of up to £5,000 to home-owners who install an air-source heat pump, which might cost £11,000 or more. Since the funding is capped at £450 million, the scheme will support 90,000 installations at most.

The BUS replaces the Renewable Heat Incentive, which was more generous but paid the subsidy annually over seven years rather than on installation, and the short-lived Green Homes Grant. Unlike the GHG, the BUS does not cover insulation work, even though this may be sensible before installing a heat pump. This is a gaping hole in an otherwise complicated picture. We are not sure why the government has created so many different schemes to tackle essentially one problem.

As for homes built from now on, the government plans to introduce a Future Homes Standard by 2025 to make sure all are energy efficient and fitted with low-carbon heating.

Technology

The largest technology-specific scheme is the Heat Network Transformation Fund, worth £338 million over three years from 2022, of which £270 million is earmarked for the Green Heat Network Fund. The programme provides 'gap funding' — capital grants to heat network projects that would not otherwise be economic — to build the market and bring down costs through standardisation. To gain funding, projects must meet benchmarks on carbon intensity, pricing and social benefits.

The government also plans to support heat networks by introducing zoning. This means local authorities would be empowered to identify areas suitable for heat networks and, once built, to compel certain types of buildings to connect. Those buildings would include large public-sector and commercial buildings, blocks of flats already heated by communal systems and all new-builds. The government is currently running a desk-research pilot project with 28 local authorities including Birmingham City Council. Since heat networks are monopoly suppliers, the government also plans to introduce rules to protect customers.

For heat pumps, the government recently funded a £15 million project to test the feasibility of large-scale roll-out of heat pumps by installing them in 750 homes across three regions. The project reported at the end of 2021 and found there were no types or ages of building for which heat pumps were not suitable.[114]

The biggest remaining barrier to heat pumps is the cost of installing one. The government has earmarked £60 million of its Net Zero Innovation Fund to support research and development to reduce their capital cost. The government is consulting on a possible market-based mechanism to oblige boiler manufacturers to produce an increasing proportion of heat pumps — similar to the EU rules for car makers.

Since heat pumps have long been mass-produced in Europe and the Far East it is not clear how much manufacturing costs can be reduced. The heat pump itself typically accounts for less than half the total cost of an installation, so there may be more potential to reduce costs by streamlining the installation process. Installers would be more likely to achieve that if there were support for a large-scale roll-out.

To help reduce the running costs of heat pumps, the government has said only that it 'will look at options to shift or rebalance energy levies away from electricity to gas over this decade'.

On hydrogen, the government will fund small scale pilot projects to test safety and feasibility, including a 'hydrogen neighbourhood' of up to 300 homes at Levenmouth in Fife in 2023, and a hydrogen village from 2025. If these succeed, it may support a hydrogen town by 2030. It is also supporting work to investigate the blending 20% hydrogen into the natural gas supply and plans to decide on this in 2023.

The government is co-investing £240 million through its Net Zero Hydrogen Fund to develop hydrogen production capacity, which it hopes will reach 5GW by 2030. It is also investing £60 million through the Low Carbon Hydrogen Supply competition, and £1 billion to support the development of carbon capture. An earlier project, Hy4Heat, spent £25 million developing and demonstrating hydrogen ready boilers and other appliances.

Fuel poverty

The government spends £2.6 billion on three programmes intended to ameliorate fuel poverty through income support. But unfortunately these schemes do little to support decarbonisation and are not even well targeted on the fuel poor.

Under the Winter Fuel Payment scheme, for example, anyone born before 1955 receives payments of between £100 and £300 without needing to claim and regardless of income.[115] This does very little to alleviate fuel poverty since even the richest pensioners receive it and only 22% of the fuel poor are pensioners.[116] Nor does it improve energy efficiency.

The Warm Homes Discount (WHD) is a one-off payment of £140 paid to pensioners who receive Pension Credit or certain means tested benefits.[117] This is better targeted at those on low incomes but not the fuel poor, since 46% of them are ineligible for benefits or fail to claim them. Most of the WHD goes to pensioners on pension credit (49% of recipients) and those on disability benefits (35%). Since the scheme is funded by a charge on energy bills, it is doubly unfair: the two million (pre-gas crisis) fuel poor households that receive neither benefits nor the WHD pay for those who receive both. Again, this scheme does nothing to improve energy efficiency.

The Energy Company Obligation (ECO) is a long-running scheme that forces energy suppliers to carry out insulation work and boiler replacements for poor customers in cold homes.[118] The government has recently raised the obligation to £1 billion a year. This scheme clearly has improved the thermal efficiency of the 2.3 million homes treated since 2013, but again is not well targeted on the fuel poor since eligibility depends on claiming benefits. Like the WHD, ECO is funded through a charge on energy bills, and so is paid for even by those it is meant to help.

Taken together these schemes spend £2.6 billion a year, but of that only £0.4 billion (15%) reaches the fuel poor, and only 22% goes on energy efficiency.[119] The Committee on Fuel Poverty has long argued the government should reform these schemes to reduce the energy bills of the fuel poor by means of thermal efficiency improvements. Together with the Climate Change Committee, it has shown that if the Winter Fuel Payment were focused on those most in need, it would free up £800 million for extra energy efficiency measures for the fuel poor and contribute to decarbonising heat.

The one-off measures introduced by chancellor Rishi Sunak — a temporary discount of £200 on each energy bill, to be repaid over five years, and £150 rebate on council tax for homes in bands A to D — soften only half of the £700 rise in average bills in spring 2022. They do not address the further rise of £1,000 coming in the autumn, nor do anything to improve the targeting of help for the fuel poor, nor support heat decarbonisation.

What we think

We recognise the government's efforts in this thorny policy area. The problem is both extremely complicated and politically difficult. BEIS has identified most of the key challenges for the main technologies and housing sectors and has developed and funded schemes it hopes will tackle them. And it continues to fund research into vital technical issues where innovation is required. We agree with many of its guiding principles: act now to develop markets; accelerate no-and-low-regrets actions now; target support for the most needy; work with the grain of consumer behaviour. The direction of travel is broadly clear even if there is no detailed programme of delivery.

In the context of this challenge, however, we question the scale and urgency of the government's ambition. Compared to electricity and transport, the government seems particularly nervous of the politics around heat decarbonisation. The over-riding impression is one of extreme caution and incremental steps. Unlike electricity and transport, for heat decarbonisation the government has set no hard deadline.

The government rightly worries about how policies to decarbonise heat could affect bills, the fuel poor and its Levelling Up agenda, and more broadly about the politics of intervening in 28 million homes. It has also been stung by the recent failure of its Green Homes Grant scheme. All this has led it to tread too warily. As a result, the targets are too weak, there's not enough money and there remains some important policy gaps. Heat policy needs to strengthen and accelerate: We need to cut emissions from heat more in the next eight years than we have in the past 30.[120]

The truth is that the soaring price of gas makes heat decarbonisation yet more urgent — not less. The answer to a gas crisis is not to increase our vulnerability to the fuel, as some propose, but to reduce it. Our climate, financial and energy security imperatives are now aligned. The government should view the gas crisis, which will double or treble the average energy bill in 2022, as an opportunity to intervene decisively — not just to ameliorate bills, but also to incentivise low carbon heating.

As the evidence of climate crisis worsens by the day, and as COP26 made clear, there is no time left for half measures.

Targets too weak

Many of the government's targets are weaker than those recommended by the independent Climate Change Committee, and it is hard to understand why the government has chosen to dilute them. The government's gas boiler phase-out starts two years later than the CCC's; its 2028 heat pump installation target is a third lower; and its 2035 district heating targets 40% lower.[121]

The government's caution is also evident in its language throughout the Heat and Buildings Strategy. Many of the targets (listed in Table 5) are vague or weakened by caveats. The government 'aims' or 'intends' to 'phase out' the installation of new natural gas boilers 'beyond' 2035. Its energy efficiency targets apply only where 'reasonably practicable' or 'practical, cost-effective and affordable'. The government commits to 'look at' options to shift or rebalance energy levies 'over this decade'.

The vagueness of the boiler phase-out and building stock energy efficiency targets is particularly troubling. They are in stark contrast to the clarity of the government's position on petrol and diesel cars:

- 'We *aim* to *phase out* the installation of new natural gas boilers *beyond* 2035'
- 'We will [...] ensure the UK housing stock is *on track* to meet EPC band C by 2035 *where practical, cost-effective and affordable*'
- 'Sales of new petrol and diesel cars to end in the UK by 2030'[122]

The third bullet declares a hard deadline beyond which certain polluting products cannot be sold in this country. It is precisely the clarity and absolute nature of the deadline that has galvanised the car-makers and sent EV sales soaring.[123] The heating industry has no such clarity and little incentive to invest until it gets it.

We suggest the following:

'The sale of natural gas boilers will be banned in the UK by 2035'.

This simple change in language would tell the industry that a market of 28 million homes is coming. It would give it the confidence to invest in production capacity and to hire and train staff. It would signal that the government means it and there is no going back. A roadmap of interim targets would make the policy even more powerful.

TABLE 5: HEAT DECARBONISATION TARGETS

YEAR	
2020	Private rented homes must meet EPC band E
2023	Hydrogen neighbourhood trial
2025	Private rented homes to meet EPC band C for new lettings (consulted, not yet legislated)
2025	'Clear ambition for industry' to cut heat pump costs by 'at least 25-50%'
2025	Fuel poor homes to meet EPC band D - or as many as 'reasonably practicable'
2025	Future Homes Standard — all new homes to be energy efficient and fitted with low-carbon heating
2025	Hydrogen village trial
2026	Strategic decision about the role of hydrogen
2028	Private rented homes to meet EPC band C for all lettings (consulted, not yet legislated)
2028	UK heat pump manufacturers to produce 300,000 units per year (up to 10,000 in 2021)
2028	UK to install 600,000 heat pumps per year — or at least have the capacity to do so
2030	10 GW low carbon hydrogen production
2030	Private rented commercial buildings to meet EPC band B
2030	Manufacturers to ensure heat pumps are no more expensive to buy and run than gas boilers
2030	Possible hydrogen town trial
2030	Fuel poor homes to meet EPC band C - or as many as 'reasonably practicable'
2035	Gas boiler phase out ('we aim to phase out the installation of new natural gas boilers beyond 2035')
2035	UK Housing stock to meet EPC band C where 'practical, cost-effective and affordable'
2035	UK to install 1.7 million pumps per year
2037	Public sector buildings to cut direct emissions 75% against 2017

Sources BEIS[124]

The wrong metric

Table 5 also makes clear how much of the government's heat policy is judged against Energy Performance Certificate (EPC) rankings. But as we noted in chapter 1, the EPC is the wrong metric.

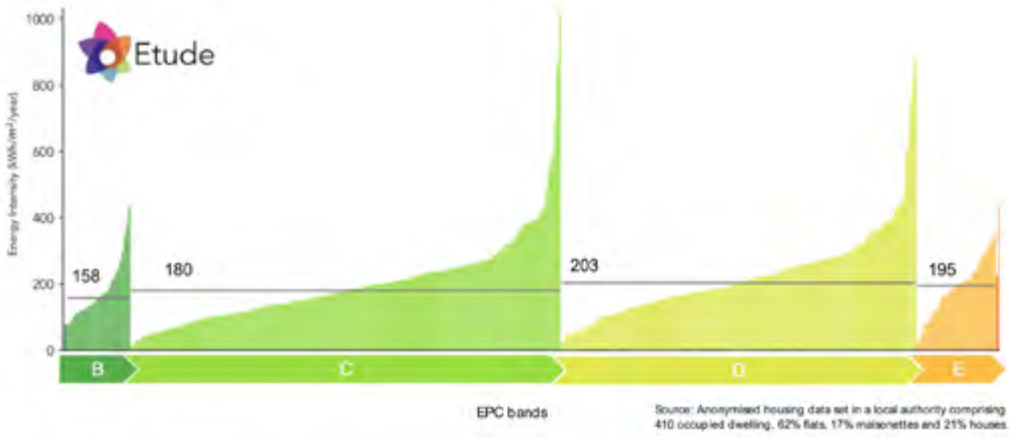
The EPC can mislead for several reasons. First, it takes no account of the home's location (and therefore real average weather conditions). Second, the Reduced SAP model (RdSAP) used to generate most EPCs locks in certain assumptions about the building fabric that depend on its age, which may not be accurate. Third, and most importantly, the whole purpose of the EPC is to judge the affordability of a home's energy bills rather than its energy efficiency or emissions.

Part of the problem is that gas tariffs — even after prices soared in 2021 – are far cheaper than those for electricity, and likely to stay so. That means the affordability-focused EPC penalises electric heating even in a well insulated home and rewards gas heating even in a poorly insulated one.

A study by the Passivhaus Trust has shown how a home with the minimum insulation and gas heating could rank EPC band A while a highly insulated one with direct electric heating would rank EPC band C — despite emitting scarcely a third as much CO2 in 2020 and scarcely a quarter in 2030.[125] In the real world, some landlords have reportedly spent tens of thousands of pounds on energy efficiency measures and electric heating only to find their EPC ratings falling by several grades.[126]

The same study reports a survey of 410 council properties that shows how EPC bands correlate only poorly to energy consumption (the bulk of which is gas not electricity). Figure 19 shows how the best performing band E property consumes less energy than the best performing one in band B.

FIGURE 19: NON-CORRELATION OF EPC BANDS AND ENERGY CONSUMPTION



Note: Illustration of disconnect between EPC bands and actual energy consumption in the domestic sector: Energy intensity of 410 homes across a local authority in England, by EPC rating. Each bar represents a single dwelling's energy intensity over the course of a year (credit: Etude). Anonymised housing data set in a local authority comprising 410 occupied dwelling, 62% flats, 17% maisonettes and 21% houses.

Source: Passivhaus Trust [127]

For the purposes of heat decarbonisation, the EPC asks the wrong question. If the government wants to incentivise homeowners to insulate their homes to a standard compatible with low carbon heating, it needs find a way to measure and rank homes by thermal efficiency. We can see three potential solutions.

One is simply to reform the EPC. Even critics of the full SAP model (SAP rather than RdSAP) accept that it can produce a passably accurate estimate of a home's thermal efficiency. It is just that this measurement does not appear on the EPC certificate or in policy targets. The government could therefore change the basis of the A-G rankings from affordability to thermal efficiency, or it could add a second, parallel ranking to reflect thermal efficiency.

The only way to be certain of a home's thermal efficiency, however, is not to model but to measure it directly. Companies such as Veritherm and BuildTestSolutions already provide this service, which can be unobtrusive and cheap (see Box 1). The results can be expressed as a single metric — Watts per Kelvin (W/K) — which shows how much energy the home requires to keep itself 1C warmer than outside. A simple calculation then tells you whether the home could be affordably heated with a heat pump, or whether it needs more insulation. The results can be presented in an easy-to-read traffic light system similar to the EPC.

Another option would be to find clever ways to measure a home's thermal efficiency remotely by combining publicly available datasets such as land registry, EPC and weather. BEIS is already investigating this approach through a project called SMETERS: Smart Meter Enabled Thermal Efficiency Ratings (see Box 1).

Box 1: Measuring thermal efficiency

Measuring how quickly a home loses heat can be done in several ways.

One approach takes only a few days to get a result. On a winter's evening, Veritherm installs electric heaters and digital thermometers in every room, and another thermometer outside, all connected by Wi-Fi to a laptop. It then heats the home to around 30C until midnight when the heaters switch off automatically, and the laptop then records the rate at which the temperature inside falls until morning.

The company now knows the dimensions of the house, the amount of energy it put into it, the external temperature, and the rate at which internal temperatures fell. From this it calculates the thermal efficiency of the building and the amount of energy it needs to keep internal temperatures at (say) 21C when the outside temperature drops to -2C. The advantage of this technique is that it produces accurate results quickly; the disadvantage is that the residents need to find somewhere else to spend the night.

Another approach is less intrusive but takes longer. BuildTestSolutions installs small Wi-Fi enabled thermometers around the house and a device to record the energy flowing through the property's gas and electricity smart meters. Over a period of several weeks it measures the energy coming into the property, and the internal and external temperatures, and uses this data to calculate the building's thermal efficiency. Whereas Veritherm provides an 'Instamatic' snapshot, BuildTestSolutions develops a longer-term picture under varying conditions with no need for the family to move out.

A third method is to try to model the energy efficiency of the home using publicly available datasets, such as land registry, EPC and local weather, without any direct measurement in the home. The BEIS-funded SMETERS research project — Smart Meter Enabled Thermal Efficiency Ratings — has compared some of these 'remote only' techniques to others that include some 'in-home' monitoring (as above). Eight companies including EDF, Knauf Energy Solutions (a subsidiary of the insulation manufacturer) and the Building Research Establishment took part.

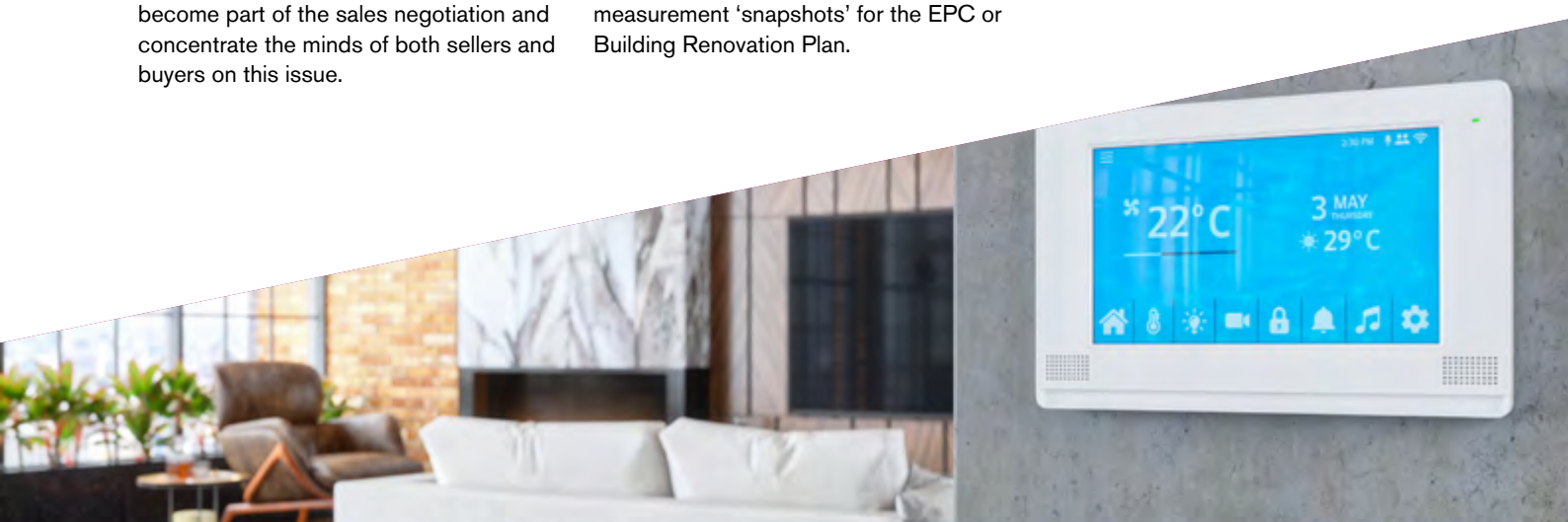
The best results were achieved by 'in home' monitoring, but 'remote only' techniques may prove useful nevertheless. If an energy supplier needs only to find out which of its customers live in the 20% most efficient homes and which in the 20% least efficient homes, for example, a remote only approach might be accurate enough. The company could then tailor offers on heat pumps to the former and insulation to the latter. On the other hand, a comfort-as-a-service provider would need accurate and continuous monitoring both before and after any retrofit to demonstrate and guarantee building performance.

BEIS has now extended the SMETERS research to cover 5,000 homes — although this second stage will not compare results to directly measured performance.

On balance we favour direct measurement of thermal efficiency: it is widely and rightly seen as the gold standard and can be provided cheaply. We believe this should be added to a reformed EPC, or to a new mandatory Building Renovation Plan (or 'green building passport', see the end of this chapter). Whichever document the government chooses to carry the thermal efficiency measurement, it should oblige homeowners to produce an up-to-date version when selling their property. Thermal efficiency would then become part of the sales negotiation and concentrate the minds of both sellers and buyers on this issue.

If any of the SMETERS methods proves accurate enough, however, it would offer the advantage of low-cost continuous measurement, rather than a single snapshot. This in turn would help energy suppliers provide 'comfort as a service' (see Box). This could galvanise the retrofit and low-carbon heating market. It would also allow landlords and even owner-occupiers to pay retrofit installers by results. There is nothing to stop suppliers and installers offering these services even if the government mandates direct measurement 'snapshots' for the EPC or Building Renovation Plan.

Any of these options would be an improvement on the current EPC, and the government should decide soon. BEIS and the Ministry of Housing accepted in 2020 that 'EPCs will need to move from a reflection of the features of a building (fabric, services and installed improvement measures) to a true measure of "in use" building performance'.[128] This reform is fundamental and urgent. The EPC asks the wrong question and sends perverse incentives; it is a roadblock.



Box 2: Comfort as a service

Most people have little interest in the geekery of low carbon heating. They may or may not care about their emissions. But what everybody wants is a warm home that doesn't cost too much to heat. The problem with low carbon heating is that it requires large upfront investments in insulation and unfamiliar technologies that may be quite disruptive to install. Worse, in the throes of the gas crisis, which some in the industry expect to last at least into 2024[129], many families are worried stiff about how they will pay their next energy bill — never mind go green.

Comfort-as-a-service could be one solution. The basic idea is that a company assesses your home and works out what draft-proofing, insulation and other measures are needed to make it heat-pump ready. It then installs those measures and the heat pump for which it charges a fixed monthly fee on a long-term contract. Instead of buying units of gas each month, the tenant or homeowner pays a fee to receive a guaranteed level of comfort – perhaps 21C.

The company, which could be an energy supplier or an independent contractor, would claim any relevant subsidies and might earn income from solar panels installed on the roof, or from network fees for operating heat pumps at times that avoid peak periods. These should help reduce costs to homeowners but may depend on new legislation and energy market reforms.

The comfort fee may or may not include the cost of the electricity needed to run the heat pump. If the electricity heating cost were included, the supplier would need to hedge its wholesale costs rather better than the almost 30 suppliers that have gone bust in the gas crisis — and presumably the comfort fee would change periodically to reflect the price of electricity.

If heating costs were not included, the resident would still be exposed to changing energy tariffs and the comfort fee would in effect represent a hire-purchase agreement for the retrofit measures. Either way, the agreement for the capital element would need to stay with the property when sold, or somehow be bought out at that point.

In principle comfort-as-a-service should work with all forms of property tenure. For now, providers have tended to work with social landlords, which typically control lots of properties, can access public subsidy and have maintenance budgets that can help the economics. See Boxes 3 and 4 on Energiesprong and Knauf Insulation Services below.

Box 3: Energiesprong

Energiesprong is both a building standard and a funding model first developed in the Netherlands. It aims to make houses net-zero-energy by adding thick external insulation and a new roof with integrated solar panels, along with new energy equipment such as heat pumps. The capital cost is paid by the building's owner — typically a council or other social housing provider — and recouped over 30 years from several sources. These include residents' energy payments, income from renewable energy generation, and avoided maintenance costs.

The ideal is that residents' total energy-related payments should be lower than their previous energy bills. Tenants continue to pay for their own electricity, which now drives the heat pump. In place of their old gas bill, they now pay a comfort fee to the landlord to help cover the capital costs of the retrofit. This might be set at (say) a 5% discount to their previous average gas bill and then rise in line with general inflation rather than gyrating with the gas price.

It is important to remember that tenants are still exposed to changes in their electricity tariff — which for now is still driven by the wholesale price of gas. The comfort fee covers the costs of the retrofit, including insulation and (probably) heat pump, which will reduce the amount of energy needed to heat their homes. This and the stability of the comfort fee should limit their exposure to future shocks and make their energy-related costs more predictable.

A key feature of the Energiesprong approach is that the external insulation and new roof are manufactured remotely, and then fitted by crane in less than a week, with little disruption to tenants. This both increases the efficiency of the process and creates work for local manufacturers.

Energiesprong UK carried out a pilot with Nottingham City Council covering ten homes in 2017, for which the insulation and roofs were manufactured by LoCal Homes in West Bromwich.

Energiesprong UK says the capital costs of its retrofits will fall with rising volumes. It is now in the final stages of agreeing a series of further pilots with eight councils in London, each covering 30-50 houses, in which it expects each retrofit to cost £75,000. If successful, each pilot will lead to a larger demonstration of 150 homes, where the capital costs should fall to £55,000. The company says the business model would break even at this level if social landlords were spending enough to keep their properties properly maintained. But since they generally cannot afford to, the real-world break-even is somewhere between £35,000 and £45,000.

Box 4: Knauf Insulation Services

Knauf Insulation Services is a subsidiary of a Belgian manufacturer and charges its customers not for its insulation products, nor even for the work of installing them, but for 'measured fabric improvement'.

What that means is that the company first measures the thermal efficiency of the home, devises a retrofit plan to improve it, installs the insulation and then measures the efficiency again — and invoices on that basis. The company has already completed projects for three social housing providers in Belgium and now has a pipeline of future projects worth €10 million.

Knauf's eventual aim is to make homes so well insulated that heat pumps can be used to help balance the electricity grid and avoid expensive grid reinforcements. With adequate insulation, the heat pump can pre-heat the home in off-peak hours when electricity is cheaper and then turn off — while the home remains warm - during expensive peak periods. For this to work in Britain, the energy markets would need to be reformed so that owners receive payments for this kind of behaviour (which could be controlled automatically by smart thermostats). These payments would defray some of the capital cost of the insulation and heat pump.

But for all of this to work in Britain, Knauf says the fundamental reform is to change the EPC from modelled to measured thermal efficiency. Only then can the supply chain unburden home-owners of the upfront cost — repaid by instalments over the long term — and risk involved in investing large sums in insulation and a heat pump. The company argues this is the only way that millions of homes can be decarbonised quickly.

Time and money

Aside from weak targets measured by the wrong metric, the government is also spending too little. Total planned government spending on heat decarbonisation amounts to around £2.2 billion per year. As Table 6 shows, the figures are tiny compared to – for example – the estimated cost of decarbonising only London's four million homes, or the estimates of the net cost of reaching net zero. In this context, government spending on heat decarbonisation – the big outstanding challenge of climate and energy policy – seems inadequate even for pump priming.

The limits on individual subsidies may also be too tight. The LAD3 scheme pays local authorities a maximum of £10,000 towards a whole-house retrofit[130], but external insulation alone for an end-terrace or detached house can easily cost double that. We think this limit and the total budget should double.

The Boiler Upgrade Scheme pays £5,000 towards the installation of a heat pump, less than half the total cost of around £11,000. There may be enough well-heeled early adopters consume the budget of £450 million, but 30,000 installations per year for three years is nothing like enough for the industry to scale up and bring costs down — so what is the point? The government should keep a close eye on take-up and raise the individual subsidy if necessary. It should raise the total budget regardless.

The Heat Network Transformation Programme in particular seems underfunded. The IPPR has argued that the government needs to extend current programmes beyond their current closure date of 2022 and increase funding between six and tenfold. The think tank's starting point is that the Climate Change Committee estimates that cost-effective heat networks could provide 10% of Britain's heat by 2030, representing 33TWh to 54TWh under various scenarios. Based on previous HNIP deals and some assumed cost reduction towards Scandinavian levels, the IPPR calculates this would require investment of between £13 billion and £22 billion, and that this could be catalysed by HNIP funding of between £1.8 billion and £3 billion.

On fuel poverty, the government has a target to make sure all fuel poor households are living in homes rated at least EPC band C by the end of 2030 where 'reasonably practicable'.[131] But its progress and funding appear a long way off track. A recent analysis by Gemserv and Agility Eco suggests that under current policies, of the 3.2 million households in fuel poverty in 2019, 80% would still be fuel poor in 2030. To reach the 2030 target under current policies (which are not well targeted), the government would need to commit another £18 billion.[132]

Fuel poverty charities point out that the government's projected HUG funding of £950 million falls far short of the Conservative Party's 2019 manifesto commitment of £2.5 billion.[133] But if the Gemserv analysis is correct, even the manifesto commitment is an order of magnitude too small. And the gas crisis has now pushed the government's target even further out of reach: charities estimate that soaring gas prices could raise the number of fuel poor households to 8.5 million in 2022.[134]

Just as serious are the stop-start nature and short time-horizons of many of the government's schemes. These have had a chequered history since the launch of the Green Deal in 2013, which stalled the number of homes being insulated. More recently the government hoped its ill-fated Green Homes Grant would disburse £1.5 billion to 600,000 homes in just six months — giving the supply chain almost no time to develop - but the scheme closed having spent only £314 million including £50m on administration.[135] The current Boiler Upgrade Scheme runs until 2024/5, but it will fund only 30,000 installations a year — far too small to allow the industry to scale up — and then what?

TABLE 6: MAIN HEAT DECARBONISATION SCHEMES IN CONTEXT

	TOTAL £ BILLION	ANNUAL £ BILLION
ECO	4	1
Home Upgrade Grant	0.95	0.19
Social Housing Decarbonisation Fund	0.8	0.23
Boiler Upgrade Scheme	0.45	0.15
Public Sector Decarbonisation Scheme	1.425	0.48
Heat Network Transformation Programme	0.338	0.11
Totals	**8.0**	**2.2**
London boroughs domestic NZ 2030 (1)	98	
Net cost of net zero, CCC (2)	321	
Net cost of net zero, OBR (3)	344	
Financial crisis banks bailout (4)	137	
COVID-19 (5)	331	

Sources[136]

In the public sector, the delivery of government funding has improved in some respects. For example, in the first stages of Green Homes Grant Local Authority Delivery (LAD) scheme, which funds energy efficiency improvements for poor households, councils had to bid for funding. This meant gambling scarce staff time and resources with no guarantee of success; if the council made a mistake the application would be rejected without appeal and all that effort would be wasted.

In later stages the funding was channelled through Regional Energy Hubs, which allocated the funding in advance. This meant the councils knew what they could expect to receive, and the Hub guided them through the application process. The councils could then use some of the eventual funding to cover their initial costs. As a result, in the Midlands, while LAD1a funding reached only 30% of councils, LAD1b reached 50% and LAD2 95%. Midland Energy Hub has now won £82 million for the Sustainable Warmth programme and will distribute it by the same process.

But the funding arrangements are still extremely complicated, which is clearly illustrated by BEIS' online guidance for applicants.[137] Sustainable Warmth draws from two pots, LAD3 and HUG1 divided into 19 different cost caps — and crucially funds are still ladled out 1-year at a time.[138]

Charities that work with councils to identify and support fuel poor families through the process of retrofitting their homes say this seriously harms their work. Once funding is announced it takes several months to recruit any new staff and probably six more to train them properly, after which there are just three months of funding left. 'We can never be sure that one programme will roll into another. LAD2 might not become LAD3'.[139] Recruitment is made harder since the employer can offer only short-term contracts.

Suppliers suffer the same problem. It takes time to hire and train heat pump installers and retrofit managers — who are then often poached by larger competitors. The history of support schemes has led to boom-and-bust in the supply chain and has bred caution. The main lesson of the Green Homes Grant is that supply chains take time to develop and the government was too optimistic about what the market could deliver in so short a time. Cutting off such support too early leaves lasting scars. The charities report that some small local firms are reluctant to take on this work.

International best practice

The shortcomings of UK policy on heat decarbonisation are not inevitable.

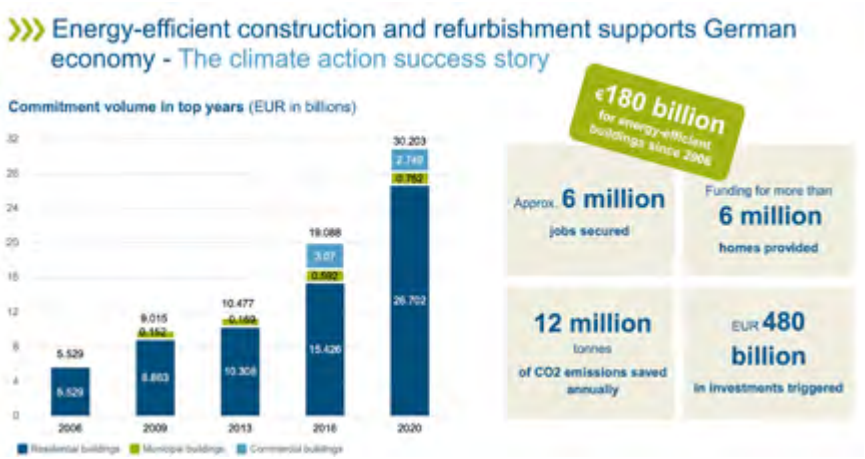
Germany seems to have solved all these problems with a single simple and more generously funded scheme administered by the KfW infrastructure bank (Figure 20). The 'Efficiency House' or BeG scheme:

- Applies to all sectors: residential, public sector and commercial buildings; new-build and retrofit; owner-occupiers, social landlords, private landlords and even energy savings contractors. The simplicity makes it easy for everyone to understand and for the bank itself to administer, making it more successful
- Covers all aspects of thermal efficiency and low carbon heating, and the size of the loans and grants depends on the degree of improvement compared to a reference standard
- Assures that retrofits are effective because projects must be designed and signed off by independent energy experts — whose costs are covered by the grant
- Provides the homeowner with a low interest loan to pay for the retrofit; once completed and signed off, a significant chunk of the loan turns into a grant
- Also supports single measures, which homeowners can carry out step by step, guided by a renovation roadmap, which attracts an extra 5% subsidy
- Has been running continuously since 2006 and its budget continues to rise

FIGURE 20: GERMANY'S BUILDING THERMAL EFFICIENCY SCHEME

Source: KfW [140]

FIGURE 21: GERMAN GRANT SPENDING ON BUILDING THERMAL EFFICIENCY AND ITS ECONOMIC BENEFITS



Source: Source: kfW [142]

The KfW scheme offers much to emulate. A single simple scheme applies to all types of buildings and ownership, in contrast the myriad and complicated British funding pots. It covers all necessary measures, whereas the UK offers no support for insulation in the 60% of UK households that are owner-occupied and not fuel poor.[141] There is continuity — a single scheme has run for over 15 years - rather than endless chopping and changing. It is well funded: the German scheme provided more funding for thermal efficiency in 2006 than Britain does today; in 2020, Germany spent five times more (Figure 21).

Not only is the overall budget much higher than in England, so too are the funding ceilings for individual projects. A retrofit which reduces energy consumption to 40% of the reference standard can receive a low-cost loan of up to 120,000 euros, of which 54,000 may convert to a grant (Table 7). By contrast, in the UK, LAD3 retrofit funding for retrofits to low-income homes is limited to an average of £10,000.

As generous as the KfW scheme appears, it has cost government very little. Since 2006 it has funded work on six million homes, secured roughly as many jobs, and KfW lending of €180 billion (of which only a part converts into a government grant) has triggered total investment of €480 billion.

The extra VAT generated by this investment almost matches government spending on the programme.[143] In 2016, for example, the government spent €1.7 billion on subsidies, which triggered total investment of €10 billion, which in turn raised VAT of €1.6 billion.[144] In other words, the entire scheme, which now generates carbon savings of 12 million tonnes per year, has cost the German taxpayer next to nothing.[40]

And as successful as the KfW scheme has been, Britain will need to do even more. KfW has retrofitted six million homes over 15 years – an average of 400,000 per year. But the UK needs to decarbonise 28 million homes and at the KfW rate that would take 70 years. To hit our legally binding 2050 deadline, Britain now needs to work almost three times faster than Germany has done so far – with funding to match. To develop the supply chain sustainably, we would need to start slower than that average rate and end faster.

TABLE 7: KFW LOAN AND GRANT RATES

EFFICIENCY HOUSE LEVELS AND SUBSIDIES AT A GLANCE

WE SUPPORT YOU WITH A LOAN WITH A REPAYMENT GRAND OR AN INVESTMENT GRANT.

EFFICIENCY HOUSE	(REPAYMENT) GRANT IN % PER HOUSING UNIT	AMOUNT PER HOUSING UNIT
Efficiency house 40	45% of max. €120,000 loan amount/eligible costs	up to €54,000
Efficiency house 40 renewable energy class	50% of max. €150,000 loan amount/eligible costs	up to €75,000
Efficiency house 55	40% of max. €120,000 loan amount/eligible costs	up to €48,000
Efficiency house 55 renewable energy class	45% of max. €150,000 loan amount/eligible costs	up to €67,500
Efficiency house 70	35% of max. €120,000 loan amount/eligible costs	up to €42,000
Efficiency house 70 renewable energy class	40% of max. €150,000 loan amount/eligible costs	up to €60,000
Efficiency house 85	30% of max. €120,000 loan amount/eligible costs	up to €36,000
Efficiency house 85 renewable energy class	35% of max. €150,000 loan amount/eligible costs	up to €52,500
Efficiency house 100	27.5% of max. €120,000 loan amount/eligible costs	up to €33,000
Efficiency house 100 renewable energy class	32.5% of max. €150,000 loan amount/eligible costs	up to €48,750
Efficiency house monument	25% of max. €120,000 loan amount/eligible costs	up to €30,000
Efficiency house monument renewable energy class	30% of max. €150,000 loan amount/eligible costs	up to €45,000

WITH A RENNOVATION ROADMAP, YOU RECEIVE AN EXTRA 5% SUBSIDY

TOGETHER WITH AN ENERGY EFFICIENCY REPORT, YOU CAN DRAW UP AN INDIVIDUAL RENOVATION ROADMAP. YOU THEN HAVE A MAXIMUM OF 15 YEARS TO RENOVATE STEP BY STEP AND ACHIEVE THE DESIRED EFFICIENCY HOUSE LEVEL. THEN YOUR (REPAYMENT) GRANT INCREASES BY 5%.

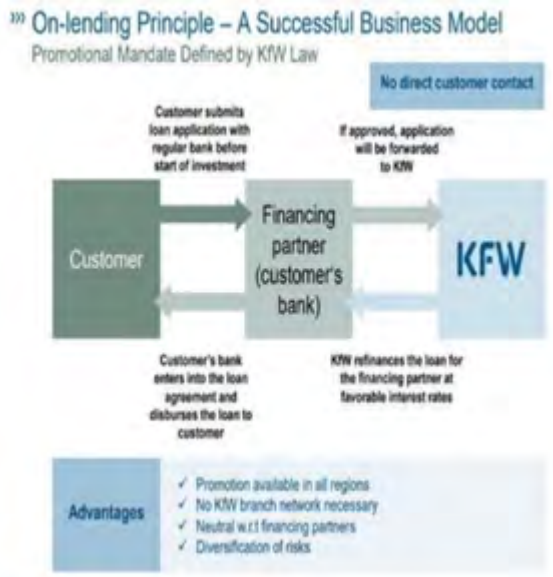
Sources kfW [145]

NB Retrofits are graded by the amount of energy a home consumes compared to a reference building. 'Efficiency house 70' consumes only 70% of the reference and receives lower subsidy than 'Efficiency house 40', which is almost twice as efficient. Installing renewable heating increases the subsidy, as does working to a 15-year renovation roadmap.

Applying international best practice in the UK context

One big advantage of the KfW scheme is that much funding comes in the form of low-cost loans, which draw in private capital and multiply the impact of the grants. For that you need a policy bank with real financial muscle. One problem with applying the German example in Britain is that KfW, established after WWII to fund reconstruction, is now colossal, whereas our nearest equivalent is a relative minnow. The recently founded and state-owned UK Infrastructure Bank (UKIB) has £22 billion to lend[146], which is dwarfed by the investment needed to decarbonise Britain's building heat. KfW's resources are 150 times larger relative to its country's GDP than UKIB is to Britain's.[147]

FIGURE 22: THE KFW MODEL: ON-LENDING OF CONCESSIONARY FINANCE



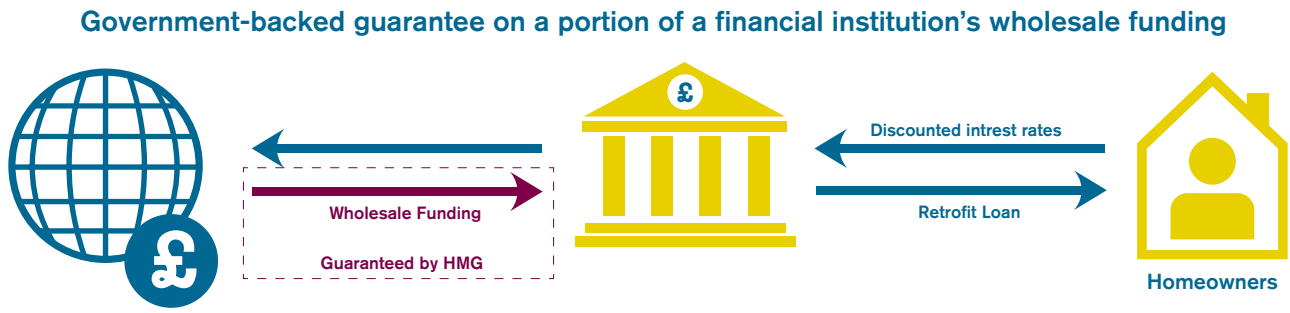
Source: KfW

One answer might be to cut-and-paste the German scheme and progressively recapitalise UKIB by raising its borrowing limits. This would also mean changing UKIB's remit from backing a few large-scale infrastructure projects to potentially millions of small ones.

Another approach would be to support low-cost lending for retrofits and clean heat through 'green mortgages' from retail banks backed by state guarantees.

Green mortgages are already available with over thirty products on offer according to the Green Finance Institute's tracker.[148] Lenders offer a discount to borrowers who meet various conditions such as meeting a particular EPC rating or carrying out specified efficiency upgrades. But the market is still small. State-backed guarantees would protect lenders from the risk of default and therefore allow them to offer better terms or commit larger volumes or both.

FIGURE 23: GREEN MORTGAGES WITH STATE-BACKED GUARANTEES



Guarantees are in some ways more powerful than grants because they can unlock funding greater than their initial size and can sometimes be recycled. For example, a guarantee achieving a leverage ratio of 3:1 would mean £100 million in guarantees could lead to £300 million of lending. When the initial loans come up for re-financing — in the mortgage market this is typically once every five years — the guarantee may no longer be necessary, allowing the guarantee to support additional new lending.

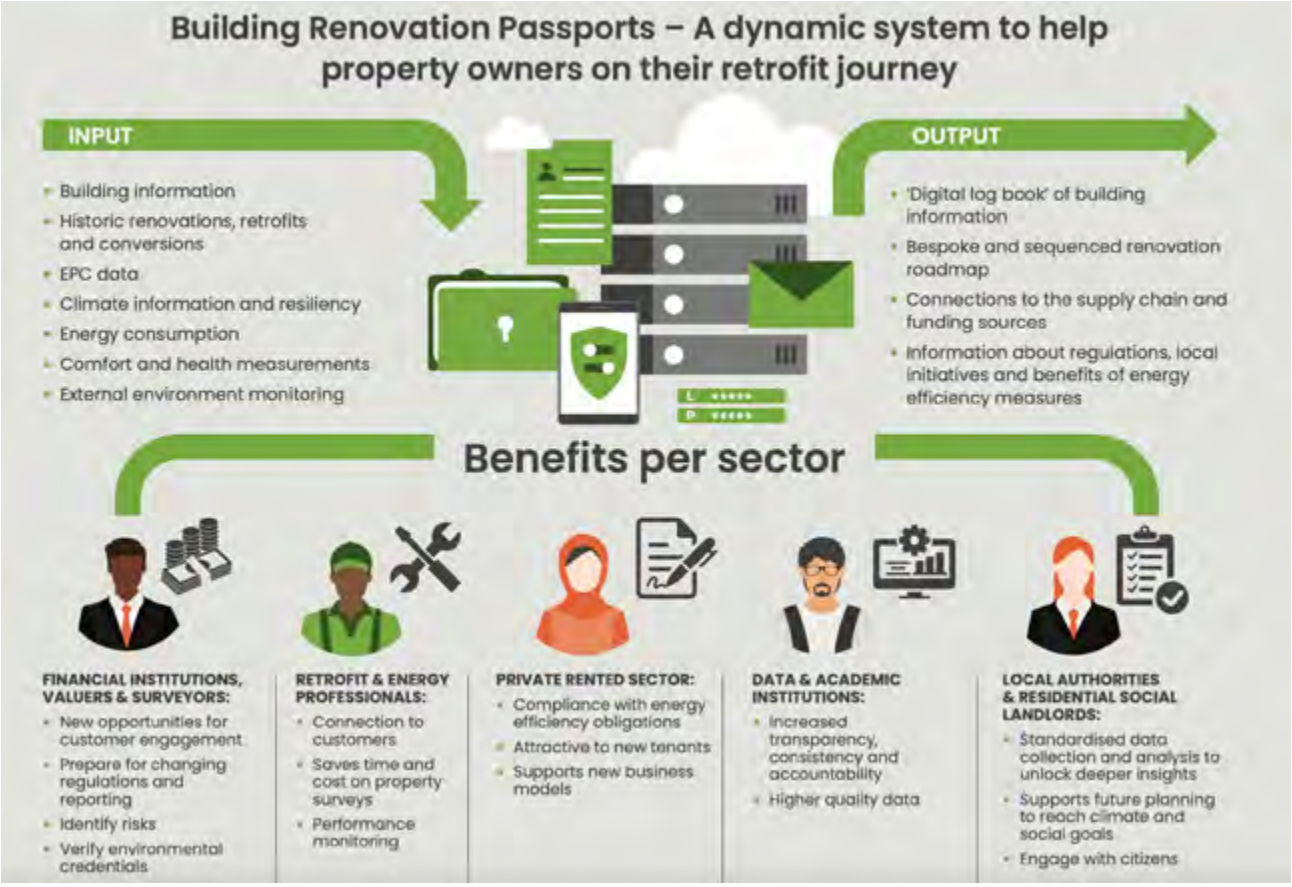
A guarantee scheme would follow the successful National Loan Guarantee Scheme launched in 2012, which backed 28,000 loans discounted by 1% worth over £5 billion in total. Guarantees could also be offered to back big retrofit loans to social landlords as well as to private homeowners. The guarantees could either be provided by a recapitalised UKIB of by the Treasury.

Green mortgage guarantees could be reinforced with three more reforms to incentivise energy efficiency improvements at or around the point of house sale:

- *Mortgage portfolio efficiency reporting*. BEIS consulted in 2021 on proposals to force lenders to report a yearly breakdown of the EPC ratings of their mortgage portfolios and the value of their lending for energy efficiency improvement works. Many of the responses pointed out that this could encourage lenders to lend only against higher EPC rated properties to shun lower rates ones. The Green Finance Institute and others argue that a better approach would be to report how much the portfolio's properties had improved their EPC ratings that year
- *Sliding stamp duty*. The UK Green Building Council has argued that stamp duty rates should be adjusted to reward higher energy efficiency homes and penalise lower energy efficiency ones when homes are bought and sold.[149] The GBC proposes (with support from the Green Finance Institute[150]) that those who buy a higher EPC rated property, or who make EPC improvements within two years, should receive a rebate on their stamp duty, whereas those who buy lower rated homes and make no improvements would pay marginally more. The scheme could be revenue neutral for the Treasury

- *Building Renovation Plans.* Otherwise known as building passports, the idea is to create a digital logbook containing all information relevant to the energy efficiency of a building.[151] This would include physical details of the layout and construction, EPC data, energy consumption, a record of all energy efficiency upgrades made so far and bespoke renovation roadmap to guide future work. The seller would have to provide this for the buyer during the sale, and the document could be consulted and updated by experts and contracts as further upgrades take place. Germany already has such a scheme, and homeowners who follow a renovation plan receive 5% additional subsidy from KfW

FIGURE 24: BUILDING RENOVATION PLANS



Source: Green Finance Insitute [152]

Infographic showcasing the recommended data inputs and outputs of a Building Renovation Passport and the benefits such a tool could bring to different sectors.

All three measures could be powerful levers, with the caveat that all rely to some degree on the EPC rating, which is not a reliable measure of thermal efficiency (see Targets too weak, above). Basing financial rewards and penalties on the EPC rating would only strengthen the effect of its perverse incentives.

If the government were to opt for these measures in place of a simpler KfW-style scheme, it should only do so on the basis of a reformed EPC that reflects the real-world thermal efficiency of buildings. Alternatively, all three reforms could be predicated on a new measure of real thermal efficiency to replace the EPC rating.

3. THE ROLE OF LOCAL AUTHORITIES

One particular weakness in current policy is the part to be played by local authorities. The government has acknowledged that councils will have a central role but so far has neither defined nor funded it. We believe this work is urgent and would help break the current log-jam.

The fundamental problem, we believe, is that heat decarbonisation is simply too complicated to solve 'on paper' at a national level. Because heat is by definition local, solutions will differ from place to place. The way to find out what works is through local area energy planning (LAEP) and we believe councils should carry out this work.

Because they are responsible for smaller areas — often with distinct local characteristics — councils shrink the problem to a more manageable size. In contrast to the current top-down approach, we need to start finding out what works at the local level and then roll those solutions out to similar areas across the country.

The issues around councils and heat decarbonisation have been thoroughly explored by the Climate Change Committee (CCC), the National Audit Office, the UK100 coalition of local authorities, and the Green Alliance. The Energy Systems Catapult has successfully piloted local area energy planning in Newcastle, Bury and Bridgend. Yet the Heat and Buildings Strategy is 'vague on the role for local area planning' according to the CCC.[153]

It is time to stop debating these measures and start putting them into practice in local mass demonstrations of entire low-carbon heat plans in one place.

Why councils are central

Councils will be central to decarbonising heat in buildings — if for no other reason — because they own 7% of the country's housing stock or (around 1.6 million homes in England).[154] They also own many municipal buildings such as offices, libraries and leisure centres.

Local authorities must therefore decarbonise in bulk. With the right level of funding and policy support, they could commission huge numbers of retrofits, which would help grow supply chains for insulation and low carbon heating. This could also encourage housing trusts, which own a further 10% of Britain's homes and have been reluctant to invest in heat decarbonisation so far, to follow suit.

Councils could also play a critical role because of their regulatory powers over new and existing buildings: planning permission; building control; and energy efficiency standards in the private rented sector. In practice, their exercise of these powers has often been undermined by budget cuts and loopholes in the national rules. In future, it may be further weakened by proposals in the 2020 planning white paper, although these are now under review. But with a more supportive framework, councils could use these kinds of powers to drive energy efficiency improvements and heat decarbonisation in the private sector.

The single most important reason councils should lead on heat decarbonisation, however, is that heat is local. Heat resources — heat from geothermal or mine-water, waste heat from industry or EfW plants — vary from place to place. So too do patterns of heat demand: industrial, dense and urban, suburban, or dispersed and rural. Existing infrastructure — heat networks, the strength of gas and electricity grids – also differs by location.

These local characteristics will tend to push an area towards one or another of the main technology options: heat pumps, heat networks and possibly hydrogen near industrial clusters. Any one of them would need huge investments in infrastructure — heat networks, electricity grid reinforcement, possibly upgrading the local natural gas grid to hydrogen - and to build all three everywhere would be extremely expensive. Each area will need to choose which technology or combination of technologies suits it best.

Each area will need to map and analyse its probable future energy landscape through local area energy planning (LAEP). For each property there will probably be one or possibly two technologies that suit it best. It is clear that the choices of individual homes will be influenced by those of the wider area: is there a heat network, for example? We will need independent technical bodies to advise on the options.

The overall plan, however, needs to be led by the local authority. Councils are more likely to carry local communities with them than remote Westminster — particularly those that may be isolated by language or distrust authority[155], and public consultation is an essential part of LAEP. Councils are the natural bodies to undertake this work since they are democratically answerable to local voters for the decisions they make.

Why councils are hobbled

Although local and regional authorities are the obvious candidates to lead the decarbonisation of building heat, they face formidable barriers. After a decade of austerity, most councils lack the money, staff and skills to take the initiative; their existing powers are constrained in practice; and the government, although it acknowledges councils will play an important role, has not yet defined or funded it.

Council funding

Council budgets shrank 23% per head in the decade to 2019/20 due to cuts in central government funding and council tax freezes. Since local authorities have a statutory duty to provide social care the cuts fell heaviest on unprotected budgets. Spending on the environment fell by almost a quarter, and on housing and planning by more than half (Figure 25).

These spending cuts have had a scarring effect on councils' capacity. Although a handful of local authorities such as Nottingham and Bristol do have sizeable climate teams, most do not and some lack even a single sustainability officer. A survey in 2020 found that 88% of councils thought lack of staff was a barrier to tackling climate change and 78% thought the same of a skills shortage.[157]

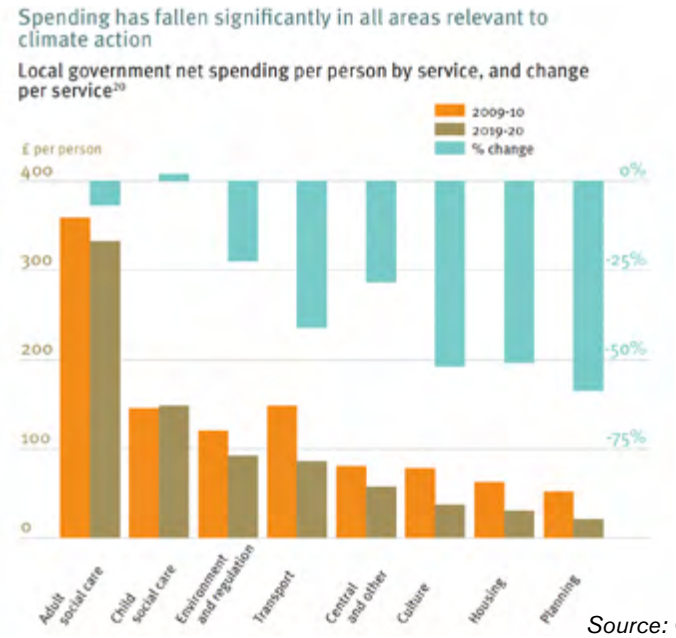
Government spending on building efficiency also fell sharply over the same period from over £1.3 billion in 2009/10 to just £425 million in 2017/18. Spending on efficiency and decarbonisation has now recovered to £2.2 billion a year (chapter 2), which we welcome but believe is still inadequate.

Worse, the funding has come in several different funding pots, each of them short-term and — until recently — awarded through competitive bids. This has favoured those councils that have the staff and skills to bid and discriminated against those that lack them, meaning funding has been not just inadequate but also highly uneven across the country (Figure 26).

The NAO has found that that a total of £1.2 billion in 21 separate funds was available to councils for net zero projects, 17 councils received more than £20 million each while 37 got less than £2 million each. Put another way, 14 councils gained £50 per head or more, and 67 less than £12.50. In the West Midlands, only Warwickshire made it into the top group, and most of the rest of the region was in the lowest.

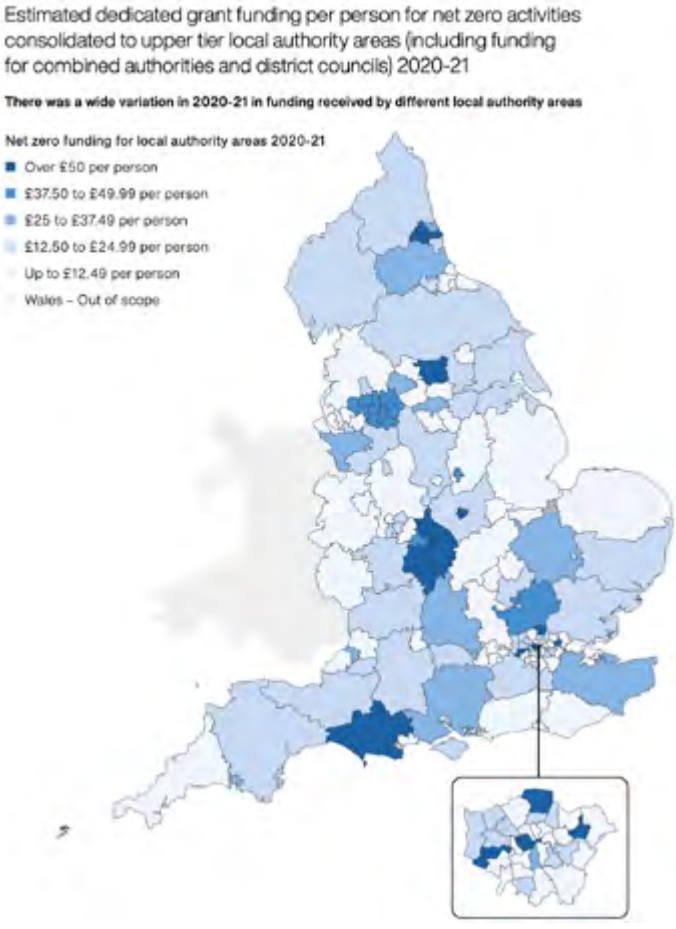
This makes no sense to us. Homes need retrofitting everywhere, not just in those areas where the council has the wherewithal to bid for short term competitive funding.

FIGURE 25: COUNCIL SPENDING 2009/10 – 2019/20



Source: Green Alliance [156]

FIGURE 26: NET ZERO FUNDING BY LOCAL AUTHORITY



Source: NAO [156]

Council powers

Planning issues

Existing regulatory powers held by local authorities could in principle help drive heat decarbonisation in the private sector. But in practice councils' exercise of those powers is often stymied.

In planning permission, for example, councils can in theory insist that developers build to a higher standard of energy efficiency than mandated by national regulations. In practice, house builders hold a trump card called the 'viability test', enshrined in planning law, which means they must be allowed to recover all their costs and make a 15-20% return before any conditions are imposed.[159]

Builders can often depend on another get-out and build homes to the outdated, inferior building standards in force at the time planning permission was granted, often many years before. In 2018, for example, 62% of the homes built by Persimmon, Britain's largest house builder, were to standards that pre-dated the most recent of 2013, according to a report of the Business, Energy and Industrial Strategy Committee (the BEIS Select Committee).[160] This grandfathering of older efficiency standards then gives the developer the right to rate its design using out-dated SAP/EPC modelling which flatters the building and misleads its buyer.

Even with all these loopholes, house builders often build homes that fail to meet the outdated standards to which they were designed — known as the 'performance gap'. Sometimes newly built homes lose twice as much heat as claimed. The Climate Change Committee has calculated this could cost the buyer up to £260 per year (pre gas crisis) in heating bills.[161] It also means hundreds of thousands of recently built homes will need to be retrofitted at great expense to accommodate low carbon heat.

The BEIS Committee report in 2019 suggested simple reforms that would fix these problems, but there was no mention of them in the government's Planning for the Future white paper published in 2020. Following a public outcry about the white paper's plans to limit local planning powers — which played a part in the government's loss at the Chesham and Amersham by-election — the government is now reviewing its proposals.[162]

Councils would not need to insist on higher-than-national standards if the national standards themselves were adequate. The government plans to introduce a Future Homes Standard mandating low carbon heating and "world-leading" levels of energy efficiency for new homes by 2025.[163]

We welcome this commitment but note that it should never have been necessary. The government planned to impose a similar standard called Zero Carbon Homes from 2016 but scrapped it at the last minute after lobbying from house builders. In the wasted decade between Zero Carbon Homes and Future Homes Standard, England will have built around 1.6 million homes to inadequate standards that will soon need to be retrofitted at great cost to accommodate low carbon heating.[164]

Persimmon was one of the companies that lobbied the government to scrap the Zero Carbon Homes standard, as it admitted in evidence to the BEIS Select Committee.[165] The Committee found that by the company's own figures it could have raised all the homes it built in 2018 to zero carbon standards for around £165 million. The Committee noted this was small proportion of the £600 million Persimmon paid in bonuses to its senior managers that year.[166] The regulations should not — and need not — have allowed it. The government should legislate the Future Homes Standard immediately.

Energy efficiency in the private rented sector

Since 2018, councils have also had a duty to enforce the rules on minimum energy efficiency standards on private landlords, but evidence to the Policy Commission and other inquiries suggest this has had little impact.

The rules have mandated a minimum EPC rating of E for new tenancies since 2018 and all tenancies since 2020. But there is no obligation for landlords to register their rented properties with the local authority and no central register of rented properties' EPC certificates. This makes it hard for councils to investigate, particularly since their budgets are so tight. In 2018, there were 124,000 privately rented homes in England with EPC ratings of F or G.[167] But by July 2020, a Freedom of Information responses from 268 councils showed that only 17 fines had been issued.[168]

Evidence presented to the BEIS Select Committee suggested the standards were not being enforced by councils 'due to a systemic lack of capacity'. The committee concluded 'there is weak enforcement of the regulations by local authorities, making them effectively valueless'.

BEIS has recognised this problem and in 2021 made £2 million available to help councils build their capacity to enforce the MEES rules. Many more councils applied than expected – over 100 applied for £8.5 million in total.[169] BEIS increased the pot to £4.3 million, scarcely half the demonstrated demand, and again, the fund was competitive and supported only 59 councils of 375 across England and Wales.[170]

Local area energy planning

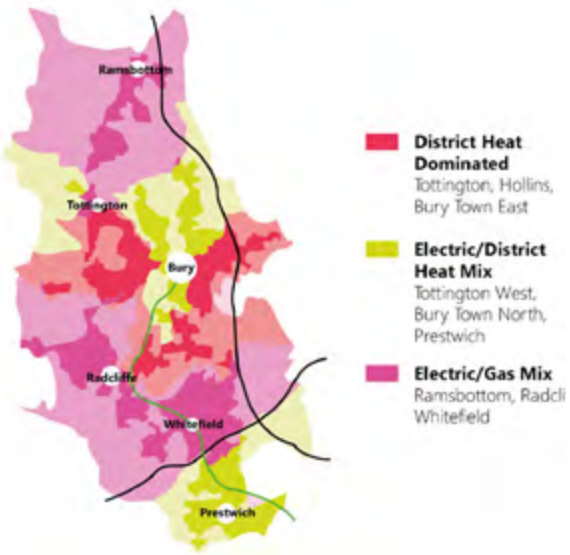
Local area energy planning is a methodology to discover the locally preferred and most cost-effective means of decarbonising local transport and heat in any given place. For heat the process includes:

- Mapping buildings and their levels of insulation; energy grids and their capacity; and any heat resources such as mine water, geothermal, waste heat from industry or EfW
- Technical modelling of the data to compare scenarios and reveal options and costs
- Re-mapping the area into heat zones that reflect the most cost-effective options: heat pumps in one neighbourhood; heat networks in another; priority areas for retrofits
- A social process to engage communities and other stakeholders so the decisions truly reflect the local area, the people and their choices

Ofgem commissioned the Centre for Sustainable Energy (CSE) and Energy

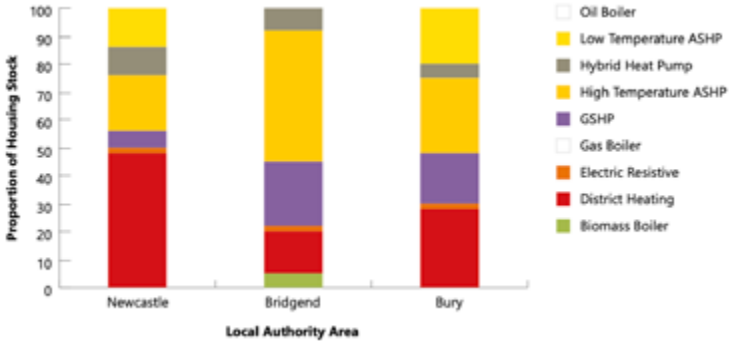
Systems Catapult (ESC) to develop the methodology for LAEP. The ESC piloted it in Newcastle, Bridgend, and Bury in Manchester. The pilots divided each area into zones suitable for different types of low carbon heating technologies (Figure 27). The balance of technologies across the three shows how different areas can be. In Newcastle the LAEP found that roughly half the homes could be heated by a heat network, whereas in Bury it was less than 30% and in Bridgend 15% (Figure 28). In Bridgend a far higher proportion of homes would need to be heated with high temperature heat pumps to save on the extra expense of retrofitting insulation in its poorer quality housing stock.

FIGURE 27: LAEP LOW CARBON HEAT ZONES IN BURY



Source: Energy Systems Catapult [171]

FIGURE 28: LOW CARBON HEATING TECHNOLOGY BREAKDOWN BY LAEP PILOT AREA



Source: Energy Systems Catapult [172]

TABLE 8: LAEP HEAT DECARBONISATION PILOT COST ESTIMATES

DISCOUNTED COSTS 2015-2050 £ BILLION	TOTAL COST[48]: BUSINESS AS USUAL[49]	TOTAL COST: DEEP DECARBONISATION	DIFFERENCE: DEEP DECARBONISATION VERSUS BAU
Newcastle	£10.4	£11.8	£1.4
Bridgend	£6.6	£7.4	£0.8
Bury	£7.1	£8.2	£1.1
Total 3 areas	£24.1	£27.5	£3.4

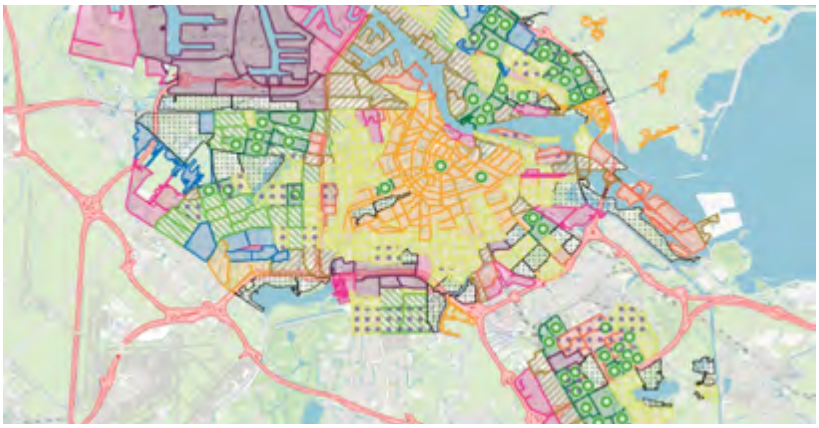
Sources Energy Systems Catapult [173]

The LAEP pilots showed the net costs of heat decarbonisation would be large, amounting to £3.4 billion for 620,000 people, less than 1% of the UK population (Table 8). From best to worst case assumptions, this implies a range of £100 billion to £450 billion for the whole country.[174] The average annual heating bill would be £100-£300 higher in 2050 compared to business as usual.
The LAEP exercise itself cost £570,000 in Bridgend, but costs would fall to less than £250,000 if scaled up, the study found. The exercise can extract savings that far outweigh its costs; in one pilot, the most efficient pathway was 17% cheaper than the least.[175]

The social element of LAEP is vital. This is the way to engage local communities in decisions about what are bound to be large and potentially disruptive changes in their lives, develop a shared understanding of the options and trade-offs, and foster consent through local, democratically legitimate bodies. Without such a process the LAEP is unlikely to be carried through — and all the more so in areas where communities may be isolated by language or mistrust of authority. It's for these reasons that the LAEP must be owned and led by regional and local authorities.

Another important aspect is that under LAEP, 'zoning' is thoroughgoing rather than piecemeal. BEIS is currently running a desk-based zoning pilot project with 28 councils, but this covers only heat networks. By contrast, the LAEP process characterises all neighbourhoods within the area according to the most suitable technology or combination of technologies (Figure 27). There would be no need for each council to reinvent the wheel every time; the LAEP zones could soon be reduced to a short menu of architypes: heat network zones, heat pump zones, urgent retrofit zones and possibly hydrogen zones. This kind of approach is already under way in Amsterdam (Figure 29).[176]

FIGURE 29: LOW CARBON HEAT ZONES IN AMSTERDAM



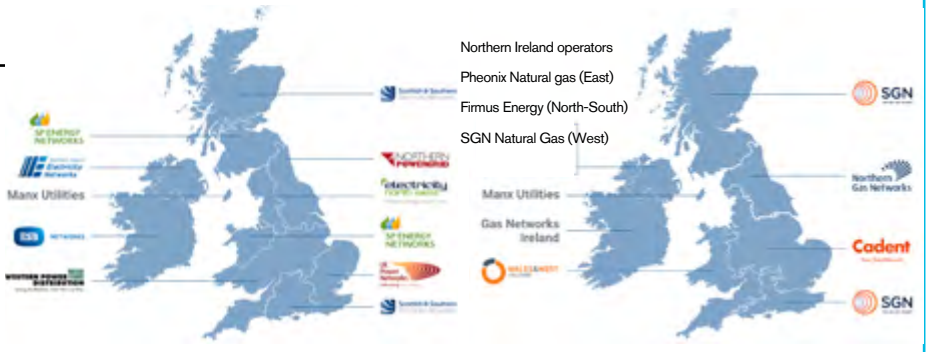
The dotted areas show where work has already started.

Source: Gemeente Amsterdam[177]

LAEP will depend heavily on the Distribution Network Operators (DNOs), which manage the regional gas and electricity grids (see box 5).

Box 5: The role of DNOs and DSOs

Local area energy planning will depend heavily on support from the Gas Distribution Networks (GDNs) and electricity Distribution Network Operators (DNOs), which manage the regional distribution gas and electricity grids. The gas and electricity grids are owned by separate companies within each region, and the boundaries between gas regions and electricity regions differ (see maps on right). [178]



Source: Energy Networks Association[179]

Historically, the role of GDNs and DNOs has been to take supply from the national gas and electricity transmission grids and pass it on at lower pressure or voltage to end consumers, meaning energy flowed in one direction only.

But now the job of GDNs and DNOs is increasingly complicated. With growing amounts of 'distributed' renewable generation (solar panels, wind farms, green gas), energy now flows both ways. GDNs and DNOs must not only expand capacity to accommodate new forms of demand (EVs, heat pumps) and potentially far higher peak loads, but also actively balance supply and demand — just as the transmission grids do at a national level.

And whereas gas and electricity distribution grids were previously entirely separate systems, in future they could be more closely integrated. Hybrid heat pumps, for example, which combine a gas or hydrogen boiler with a heat pump, could help manage electricity peaks by shifting heating load onto gas at peak times, and so reducing the investment needed in new electricity distribution capacity.

To manage all this, GDNs and DNOs are evolving to take on the role of Distribution System Operators (DSOs), which actively balance supply and demand using storage, third party services and smart meter data.

Local area energy planning (LAEP) will depend heavily on information from GDNs, DNOs and DSOs about the capacity of — and any bottlenecks in — their grids. This will be an important factor in deciding which technology zone is established in each neighbourhood. The grid operators will then need to invest in any extra capacity needed to put those zones into practice.

The operators themselves cannot lead the LAEP process, however, since it will involve making decisions that favour either gas or electricity in each neighbourhood. We will need to create a mechanism within LAEP to resolve these competing interests, which could be trialled in the clean heat pathfinders. Ofgem is consulting the industry on the future arrangements surrounding DSOs.[180]

Defining neighbourhoods in this way should provide certainty for stakeholders in the area, leading to all sorts of benefits:

- Gas and electricity network operators can target their infrastructure investments where most needed and avoid stranded assets — so helping to limit the rise in energy bills — and Ofgem and the local authority can resolve any disputes between network operators
- Councils now know where to develop heat networks, and social landlords can identify homes that need the most urgent retrofits
- Social landlords, private landlords and owner-occupiers realise which low carbon heating technology they need to prepare for
- All this encourages local supply chain companies to invest in premises, staff and equipment — confident that the local market will develop
- And this in turn helps change the low carbon heating transition from a few individual efforts into if not a collective endeavour, then normal community-wide behaviour

Each of the three LAEP pilot areas now has a detailed map and plan to guide their future projects. Bridgend, for example, is developing two heat networks, one of which may exploit heat from water trapped in an abandoned coal mine.[181] And Greater Manchester is now developing a city-wide LAEP covering all its 10 districts.[182] So far, however, these projects are still largely piecemeal and are taking too long.

Nevertheless, we believe that LAEP can unblock the decarbonisation of building heat.

To do so, the government could adopt two new policies:

- Fund at least three pathfinder mass demonstration projects which compress the entire LAEP process — both planning and execution — into a period of five years. Each pathfinder should cover an area large and varied enough to demonstrate the main locally viable technologies and the target should be to decarbonise all building heat in that area. Government would need to guarantee the projects so that no resident would be left worse off, or at least offer inducements similar to previous heat decarbonisation pilots.[183] These pathfinders would provide a beacon showing all other local authority areas what can be achieved and how the process works. They would also generate a huge amount of learning. Both factors should greatly accelerate heat decarbonisation across the country

- At the same time, give every local authority the duty and funding to produce its own LAEP, with support and co-ordination through the Regional Energy Hubs. The methodology[184] is now ready to roll out, there is no advantage in delay, and the LAEP process would begin the vital community engagement without which heat decarbonisation is likely to fail. By the time these plans have been completed, the pathfinders should be starting to demonstrate the rest of the process. Aggregating the results of these LAEPs will generate invaluable insights for electricity generators, network operators and policymakers

Both policies could follow organisational and funding approaches of which the government already approves. The difference here is that these pathfinders would not primarily be designed to demonstrate whether the technology is safe, but how to combine and install a variety of proven technologies quickly and throughout an area. This would help build consumer confidence in unfamiliar technologies and grow the market enough to make it attractive to industry.

Funding for the LAEP roll-out should follow the approach BEIS has chosen for LAD2 (see previous chapter) in which funds are allocated not competitive. Once completed, a council's LAEP plan would pre-qualify it to apply for the funds to execute it. This would follow the model already used for heat network funding. Here the council applies for small amounts of funding to develop a plan, and once the plan has been approved applies for larger sums to build it — from government and private investors.

In summary, councils need government to give them both the powers and funding they currently lack to perform their existing duties around heat decarbonisation. But if local and regional authorities are to play a central role in the shift to clean heat, one that no other organisation can really fill, those duties and that funding must be expanded to cover local area energy planning. A few councils will need to run major pathfinder projects to light the way.

4. THE CLEAN HEAT PATHFINDER

Britain urgently needs some large-scale pathfinder projects to start the decarbonisation of building heat. We are long past the time when pilot projects of tens of homes, or even a few hundred, could tell us much that is useful. We need to learn how to decarbonise thousands of homes in a single place at once. The way to find out is to start doing it.

We need the pathfinder to learn how to retrofit and decarbonise at scale, and to develop an approach that can then be applied to neighbourhoods up and down the country. We also need it because at this point the costs look colossal, and the only certain way to bring them down is to massively increase the number of retrofits we carry out. At some point we have to commit; that time is now.

The pathfinder's goal is to decarbonise the heat of all buildings within its boundaries within five years. The area should cover between 5,000 and 10,000 homes, include all forms of tenure, deploy only proven technologies, trial new business and funding models, and come with a government backstop so that no resident would end up worse off for taking part. It would measure both energy and social outcomes.

The local economic benefits of each pathfinder could be transformational. Various nationwide estimates suggest we need to train over 50,000 heat pump engineers by 2030[185], and 500,000 other professionals and trades-people to retrofit 28 million homes — double the existing workforce.[186] In a deprived area, the impact of potentially hundreds of good new jobs, along with new businesses and manufacturing capacity, could do great for Levelling Up.

We have argued in this report that policy on heat decarbonisation is underfunded and too complicated. The pathfinder would need to solve both problems. The government should fund it more generously than under existing policies through a single KfW-style scheme that applies to all tenures. The scheme would also draw on low-cost lending from the UK Infrastructure Bank or similar. The purpose of this higher public funding is to get things moving and to discover how such spending can be offset by private lending, new business models, future energy savings, and by the cost reductions achieved by scaling up.

The pathfinder may also need powers to waive or flex some national regulations around energy bills — with agreement of BEIS, Ofgem and the Treasury. For all these reasons, it would need to be established under and Energy Innovation Zone. The EIZ would be led by local and/or regional authorities with support from local energy system operators, the Regional Energy Hub, the Energy Systems Catapult and local universities. Government would need to fund the local and regional authorities to staff and resource their new role.

There are many places in England that could host such a pathfinder such as the three areas that have already prepared local area energy plans under the Energy Systems Catapult methodology (see previous chapter). But for this report we use East Birmingham to illustrate the necessary ingredients and how they might be combined to develop a place-based approach to clean heat that can then be applied more widely.

East Birmingham

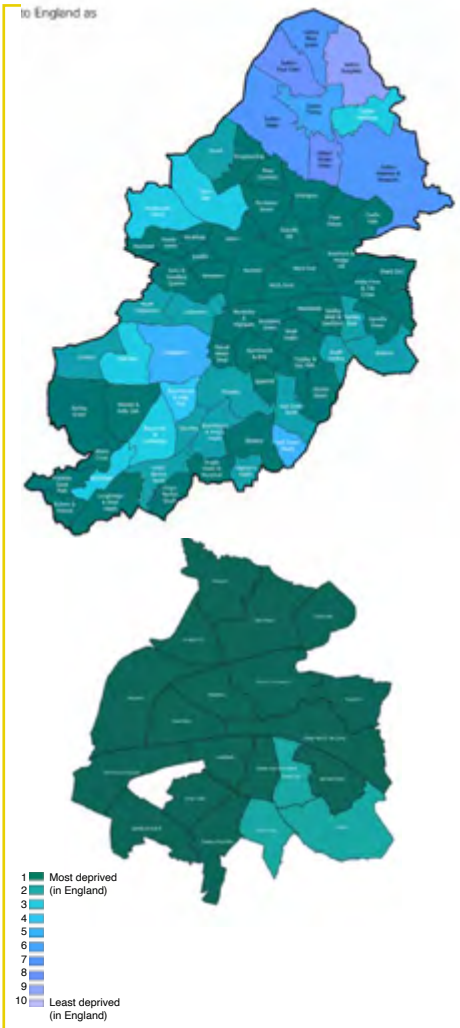
East Birmingham is a good starting point for several reasons. It is a community of 230,000 people that combines some of the highest rates of fuel poverty, nationally representative housing stock, and excellent local heat resources. Its local and regional authorities and universities are already pursuing clean heat projects which could be combined and expanded into a pathfinder.

We saw in chapter 1 how the West Midlands combines some of the lowest housing efficiency and highest fuel poverty in England. Deprivation in Birmingham is worse and in East Birmingham worse still — after years of under-investment (Figure 30).[187] If anywhere deserves to level up through energy efficiency retrofits it is East Birmingham.

Aside from the need to reduce fuel poverty, there are several positive reasons that an area like East Birmingham would work well as a clean heat pathfinder.

First, the housing in East Birmingham is a good proxy for the country as a whole: it largely mirrors the national stock in terms of the proportions of different housing types and building ages. A fifth of the homes were built pre-1919, which is mainly found in Small Heath, the area

FIGURE 30: DEPRIVATION IN BIRMINGHAM AND EAST BIRMINGHAM

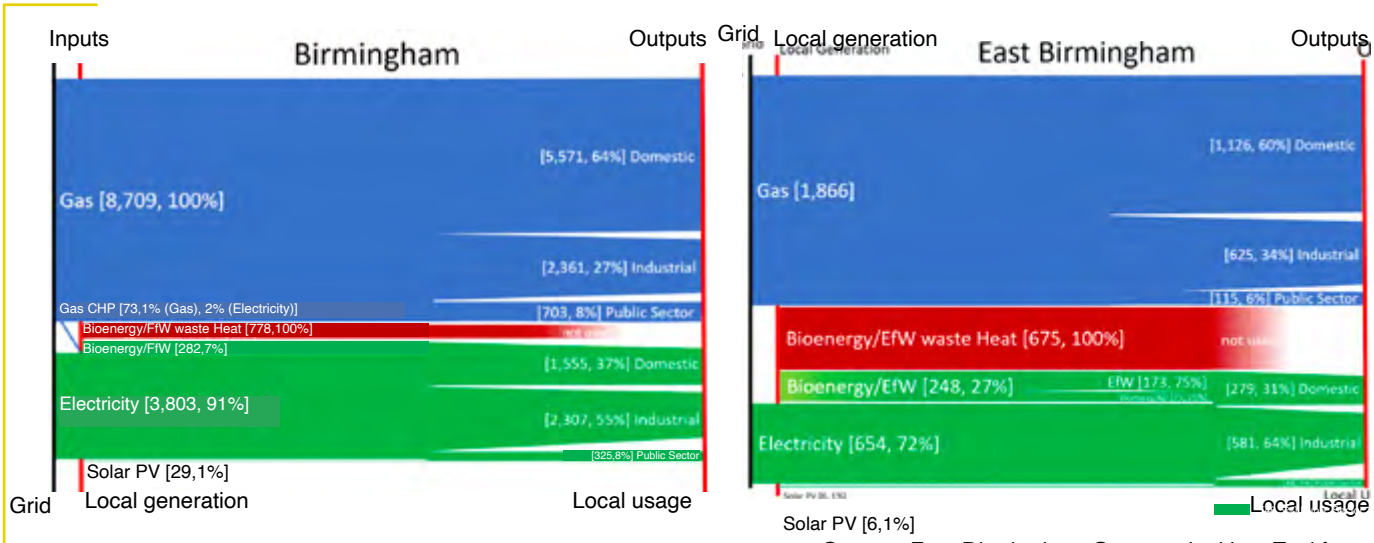


Source: Birmingham City Council [188]

around Tyseley Energy Park and Hodge Hill. As a result, the average EPC rating is D. In areas with a higher share of social housing, such as Castle Vale, West Saltley and Shard End, the EPC ratings are typically higher – also matching the national picture.

Second, East Birmingham has significant energy production facilities and a large untapped waste heat resource (Figure 31), largely concentrated at the Tyesely Energy Park. These include the 25MW Veolia EfW plant, which burns the city's black-bag waste, and a 10MW waste wood biomass plant. The waste heat from these facilities could be captured to extend the city's existing heat network or to power a new one. Generating capacity at the site is due to expand to 60MW, almost doubling the waste heat resource. The Severn Trent sewage plant at Minworth near Castle Vale injects biomethane into the natural gas grid.

FIGURE 31: ENERGY INPUTS AND OUTPUTS IN BIRMINGHAM AND EAST BIRMINGHAM



Source: East Birmingham Community Heat Taskforce

Third, the combined authority, local councils and local universities are all pursuing clean heat projects which could be combined and expanded into a clean heat pathfinder. The WMCA and Birmingham City Council, for example, has the Net Zero Neighbourhoods programme, to fund heat decarbonisation in small pilot projects of around 300 homes each. The Birmingham Energy Institute has led the East Birmingham Community Heat Taskforce to map the area and analyse the costs of heat decarbonisation. More broadly, BCC's Levelling Up Strategy proposes a three cities housing retrofit of 166,000 council and social homes across Birmingham, Wolverhampton and Coventry.[189]

Relevant programmes and organisations based in the West Midlands include:

- West Midlands Combined Authority (WMCA) Net Zero Pathfinder
- WMCA Net Zero Neighbourhoods, with £1.65 million to fund retrofit demonstrator projects[190]
- Birmingham City Council (BCC) East Birmingham Inclusive Growth Strategy
- BCC Levelling Up Strategy
- BCC East Birmingham Zero Carbon Heat Innovation Zone
- East Birmingham Community Heat Taskforce
- Tyesely Energy Park
- Energy Capital
- Midlands Energy Hub
- Energy Systems Catapult

Locations

Within East Birmingham, recent work by local initiatives has identified two adjacent neighbourhoods we think could combine to host an effective clean heat pathfinder.

Castle Vale

Work by the Birmingham Energy Institute has identified several 'energy deprived' areas where actual consumption was lower than theoretical demand. One of these was Castle Vale, which lies just north of the M6 near the junction with the M42 (Figure 32, top right). The population of around 10,000 is predominantly white working class with high unemployment following automation at nearby factories such as Jaguar Land Rover.

There are around 4,300 homes of which roughly half are social housing managed by the Pioneer Housing Group; most of the rest are owner-occupied. The housing stock is a mixture of poorly insulated 1960s housing and better insulated housing built more recently in the 1990s. There is also a high street, a trading estate with around 20 Units, sporting facilities including a swimming pool and a football stadium, areas of open green space and heavy industry.

FIGURE 32: COUNCIL AND SOCIAL HOUSING IN BROMFORD AND CASTLE VALE

Source: Birmingham City Council

Blue areas represent council homes and red areas social housing. Bromford is bottom left, Castle Vale top right.

Pioneer Housing employs 170 people including 20 who work on retrofitting its properties. Like many social landlords, it is struggling to adapt to the low carbon agenda because of the many other challenges it faces: COVID-19 recovery; building safety act; fire safety bill, and the white papers on housing, energy and planning. It is risk averse and says it cannot be 'an expensive guinea pig' for pilot schemes.

Nevertheless, Pioneer is one of the reasons we believe Castle Vale would be a good place to host a pathfinder:

- Pioneer's predominance means Castle Vale community is more organised than others
- The high share of social housing means that energy efficiency is higher than the East Birmingham average and fuel poverty is average, making the area an easier proposition for investment than some others
- The mix of social and owner-occupied homes means both tenures can take part and be assessed
- The East Birmingham Community Heat Taskforce has already studied the area (see below) and developed relationships
- High unemployment means the pathfinder would also be valuable for the jobs it creates and skills it develops

Bromford

Just next door to Castle Vale is Bromford (Figure 32, bottom left), a deprived area of roughly 3,500 council, social and privately owned homes with high levels of fuel poverty.

Taken together, Castle Vale and Bromford represent almost 8,000 plus homes with a good mix of council housing, non-council social housing and privately owned homes, many of them owned by low-income families. This would be a good size and mix for a heat decarbonisation pathfinder.

What would the clean heat pathfinder look like?

The task is urgent and the purpose is to galvanise action both in the pathfinder zones and then across the country. We need to show what zero carbon heating looks like in an entire neighbourhood and how it can be achieved. The target should therefore be low carbon heating in all buildings within the zone within five years.

Naturally this means the pathfinder would have to work with proven low carbon heating technologies only. It is not intended to demonstrate technologies so much as process and policy. The pathfinder will therefore need to be set up in an Energy Innovation Zone (EIZ) to allow energy market rules and taxation to differ from national policies — with the agreement of Ofgem, BEIS and the Treasury.

The EIZ would be led by WMCA and BCC with support from local energy system operators, the Regional Energy Hub, the Energy Systems Catapult and local universities. Its boundaries would be set around Castle Vale and Bromford.

The pathfinder would then:

- Prepare a Local Area Energy Plan (LAEP) for all of East Birmingham
- Include formal arrangements that effectively turn the local gas and electricity network operators into a single distribution system operator (DSO) within the pathfinder — informed by Ofgem's current consultation on the future role of DSOs
- Establish zones within the pathfinder area for heat network, heat pump, urgent retrofit
- Engage with local communities
- Provide a platform for:
  - 'comfort as service' trials by energy, insulation and retrofit suppliers
  - time-of-day electricity pricing and grid balancing payments (real or synthetic) to homeowners and tenants
    Receive a greatly expanded budget compared to existing heat decarbonisation policies (see below) and through a single pot rather than having to apply to many different funds
- Disburse funding through one-stop-shop KfW-style low-cost financing and grant scheme — a single pot to replace the various government schemes - and blend in low-cost lending from UKIB or similar
- Waive environmental charges on electricity bills or secure government funding to equal value as a proxy
- Apply carbon pricing to support the capital expenditure or secure government funding to equal value as a proxy
- Fund a retrofit skills academy to train retrofit assessors, insulation and heat pump installers, and builders
- Mandate direct measurement of building performance before and after retrofit to prove and compare the performance of competing approaches
- Measure social benefits including economic growth, job creation and increased tax revenue, improvements in health, and reductions in child and fuel poverty
- Receive a government backstop behind service-level contracts to ensure that no resident is worse off for having taken part

Funding

Government funding for existing initiatives falls far short of what is needed for the clean heat pathfinder. A more realistic idea of the retrofit costs of a pathfinder can be judged by extrapolating from recent and ongoing projects. Table 9 shows a straight-line extrapolation of various recent estimates and future targets, and the results are eye-watering. The point of the pathfinder, however, is to render these numbers obsolete.

EAST BIRMINGHAM PATHFINDER
100,000 HOMES

Neighbourhoods in pathfinder zoned by technology (heat pump, heat network, urgent retrofit etc).

Fund a retrofit skills academy to train retrofit assessors, insulation and heat pump installers, and builders.

Disburse funding through one-stop-shop KfW-style-low-cost financing and grant scheme – a single pot to replace the various government schemes – and blend in low-cost lending.

CITY CENTRE

Birmingham City Council EfW plant and Tyseley Energy Park 150 MW of waste heat.

Waive environmental charges on electricity bills and apply carbon pricing to capital expenditure — or government funding to equal value as a proxy.

Severn Trent Minworth Wastewater Treatment Plant

Biogas and 100 MW of waste heat.

‘Comfort as service’ trials by energy, insulation and retrofit suppliers and time-of-day electricity pricing and grid balancing payments (real or synthetic) to homeowners and tenants.

BIRMINGHAM INTERNATIONAL AIRPORT

Engage with local communities.

Measure social benefits including economic growth, job creation and increased tax revenue, improvements in health, and reductions in child and fuel poverty.

Prioritisation Decile

- 1st
- 2nd
- 3rd
- 4th
- 5th
- 6th
- 7th
- 8th
- 9th
- 10th

TABLE 9: NOTIONAL COST OF RETROFIT WITH LOW-CARBON HEAT

	AV £ COST/HOUSE	PATHFINDER	EAST BIRMINGHAM	UK
Number of homes	N/A	8,000	125,000	28,000,000
KfW max grant	£45,000	£36,000,000	£5,625,000,000	£1,260,000,000,000
Energiesprong short-term target	£55,000	£440,000,000	£6,875,000,000	£1,540,000,000,000
Energiesprong long-term target	£35,000	£280,000,000	£4,375,000,000	£980,000,000,000
EBCHT average cost	£19,770	£158,160,000	£2,471,250,000	£553,560,000,000

Notes:
1. Straight-line extrapolation from current estimates or targets.
2. The average costs in this table include both insulation and low carbon heating system. But the Climate Change Committee estimates that 10 million homes are already well-enough insulated to fit a heat pump without further insulation. To that extent, the grossed-up totals for 28 million UK homes in this table are an overestimate. *Sources*[191]

The first point is that by building the volume of the retrofit market, the pathfinder will reduce costs. By creating a substantial economic opportunity it will draw in suppliers and build the supply chain. Competition and learning by doing will see to the rest.

The second point is that these numbers represent the investment cost not the net cost. The Energiesprong model, for example, aims to recoup all the outlay from various savings and income streams over thirty years (see Box 3). If social landlords were spending enough to keep their properties properly maintained, the company says the model would break even at up-front costs of £55,000. Since social landlords often cannot afford to spend as much as they should, Energiesprong says the break-even is somewhere between £35,000 and £45,000. If retrofit costs can be competed down to these levels, the retrofits pay for themselves, and it is simply a question of developing long-term financing mechanisms.

A study by the East Birmingham Community Heat Taskforce has shown that a mid-range thermal efficiency programme for the 4,300 homes in Castle Vale would cost £45 million, to which low-carbon heating would add a further £15-£40 million, giving an overall cost of £60-£85 million.[192] If the EIZ sets the right conditions, however, much of this investment could be provided by comfort-as-service providers.

The cost to the government would therefore be far lower than these notional totals, but spending would need to be significantly higher than existing programmes. The average retrofit payment under LAD3 is £10,000, for example, which is probably less than half what is needed at this stage. There are also administrative costs for the councils, regional authorities and others.

The solutions developed under the pathfinder could then be scaled regionally, further reducing retrofit costs and providing wider economic and social benefits. Birmingham, for example, has 61,000 council homes, and its Three Cities Housing Retrofit proposal covers 166,000 council and social homes across Birmingham, Coventry and Wolverhampton. Together with Birmingham's other Levelling Up Accelerators, the Council estimates this could create almost 75,000 jobs, swell the economy by £9 billion per year and help reduce relative child poverty of around 40%.[193]

Other support measures

The EBCHT study highlights how a shift towards electric heating combined with existing pricing and taxation of gas and electricity would in fact increase heating bills and could raise fuel poverty by 60% (expensive hydrogen would have the same effect). This crucial point is often missed: that thermal efficiency measures by themselves are not enough to compensate for the (current) higher cost of electricity compared to gas. This is why the pathfinder EIZ should waive environmental levies and possibly VAT on electricity bills in the pathfinder zone.

The study also shows how applying a carbon price to building retrofits could transform the economics. Assuming a carbon price of £75/tCO2, and assuming capital costs at the lower end of the modelled range, the cost of fitting low-carbon heating in the 4,300 homes is repaid by carbon savings alone within 20 years. No such scheme exists at present, but the EIZ would be the place to trial one. Alternatively, the effect of a carbon price could be replicated by government funding to equivalent value.

The study found that economic benefits of retrofitting Castle Vale would include employment of 1,200 job-years in an area that suffers high unemployment. The EIZ would need to ensure the supply chain and skilled workforce with by setting up a skills academy, or by working in tandem with the proposed National Centre for Decarbonisation of Heat (NCDH) at Tyseley Energy Park in East Birmingham.

The NCDH proposal is supported by the Manufacturing Technology Centre, Energy Systems Catapult and the Energy Research Accelerator. It would enable the rapid scaling up of manufacturing, skills and deployment of heat solutions and create new programmes designed to enable the rapid growth of promising

technologies and business models, in turn creating tens of thousands of skilled jobs.

Wherever the government chooses to establish the pathfinders, within five years each will have decarbonised the heating of an entire neighbourhood of mixed tenures through a variety of business models. They will have produced a mass of data and learning about process and outcomes. They will have shown what levels of support are needed from government and how they can be minimised; how to secure consent from the community; and a fuller understanding of the economic and social benefits.

In short, the costs of decarbonising heat will not come down if we simply stare at the problem. They can only come down if we start to tackle it, build the market and learn. A clean heat pathfinder — or several — would start that journey.

5. RECOMMENDATIONS

We believe British policy on heat decarbonisation needs a reset. The keys to this are *simplicity, place and funding.*

As we have seen, low-carbon heat is an inherently local problem. Decisions about which technology to use and which infrastructure to build will vary by neighbourhood. There is broad consensus that councils are best placed to lead this process, but the government has yet to define and fund their role.

At the same time, the national arrangements have grown too complicated as government has grappled with various aspects of the problem.

We believe that by streamlining the national arrangements and, crucially, by defining and funding the role of local authorities, the government could galvanise action on heat decarbonisation. The way to combine place, simplicity and funding to get things moving is through at least three large-scale pathfinder projects.

Targets

First the government needs to set a clear course. The language of its current targets is vague and hemmed around with caveats meaning much of the supply chain – scalded by previous policy reversals - is reluctant to invest. The government must therefore set targets for clean heat as strong and clear as those it has set for EVs. We suggest:

- *'The sale of natural gas boilers will be banned in the UK by 2035'*

This simple change in language would tell the industry that a market of 28 million homes is coming. It would give it the confidence to invest in production capacity and to hire and train staff. It would signal that the government means it and there is no going back. The targets should be buttressed with a series of interim targets — as with the UK's carbon budgets — to keep us on track.

'Clean heat ready' would be defined by a thermal efficiency standard — such as Watts per Kelvin (W/K) or annual kWh/m2 — that is measured not estimated (see 'Technical' below). The standard should be set at level that means each home is well-enough insulated to be affordably heated with a heat pump — whether or not that technology is eventually installed.

The government already has statutory target ensure all fuel-poor homes should have a minimum energy efficiency rating of EPC band C by 2030 where 'reasonably practicable' — but is badly off-course.[194]

Independent analysis suggests that under current policies 80% of the 3.2 million households that were fuel poor in 2019 will still be fuel poor in 2030. And now the gas crisis has plunged millions more households into fuel poverty.
The government must therefore:

- Reaffirm its fuel poverty target and explain how it will achieve it. Doing so will probably cost tens of billions of pounds rather than the low-single digit billions currently being spent – but this would be a major down-payment on heat decarbonisation
- Reduce the taxpayer burden by legislating its proposed minimum energy efficiency standards (MEES) on private landlords (see Table 5) and fund councils to enforce them
- Honour the Conservative Party's 2019 election manifesto pledge to spend £2.5 billion on HUG; the Heat and Building Strategy commits only £950 million
- Make its fuel poverty target more effective by reforming the EPC as suggested below

Bills

The government must reset its clean heat policy in the throes of a gas crisis that is pushing millions more into fuel poverty. Whatever else it does to soften the impact on consumers, the government must also lift legacy environmental policy costs from electricity bills into general taxation. This would reduce the average bill by about £100 and help on heat decarbonisation, fuel poverty and the government's Levelling Up agenda.

In social terms, this reform would turn a regressive levy that hits the poorest hardest into a more progressive tax. It would also be more effective than some other proposed changes to benefits. By cutting bills, it would put money directly into the pockets of the 46% of fuel poor households that currently cannot or do not claim any benefits. It would particularly help those who already heat with electricity and are 50% more likely to be fuel poor than those who heat with gas. This reform would also begin to resolve the policy contradiction in which people are subsidised to install a heat pump and then penalised for running it. In autum 2021, a kilowatt hour of low-carbon heat from a heat pump cost 45% more than one of high-carbon heat from a gas boiler (Table 3). Removing policy costs would bring the cost of clean heat from a heat pump closer to boiler parity and would reduce the level of intervention needed elsewhere in the market.

Another way to reduce electricity prices would be to reform the power markets to reflect increasing share of renewables and eliminate marginal pricing driven by gas, as suggested by Dieter Helm's *Cost of Energy Review*[195], or similar. Suppliers such as EON agree that current market arrangements prevent the benefits of low-cost renewables being passed on to customers and must be reformed, and the company says 'this work needs to start now'.[196] Since gas prices look set to stay permanently high at worst and volatile at best, we agree. The government has committed to review market reform, and the Climate Change Committee says it should complete this by 2023. Again, we agree.

In the short term, government should investigate ways to clear any barriers in the wholesale market arrangements that may deter electricity suppliers from offering their customers half-hourly tariffs. These tariffs would allow households that install a heat pump to avoid peak prices, so reducing their running costs. Octopus Energy argues that the way network charges are levied (many of them at a flat rate per electricity meter) muffles the high and low price signals in that would encourage this kind of behaviour. Octopus already offers a synthetic half-hourly time of use tariff but has had to subsidise it so far.[197] It says that if government lifted policy costs from electricity bills and reformed the energy market to allow proper time-of-use tariffs, heat pump running costs would be lower than those of a gas boiler.

Other funding

Generally speaking, the government is investing too little in low carbon heat. Both the overall budgets and some of the per-home spending limits are too low. The patchwork collection of schemes through which funding is provided is bewilderingly complicated. Most schemes are funded annually and, until recently, awarded by

competitive bidding, which is difficult for under-resourced councils. There are also important holes: the government has no scheme to support insulation work in the 60% of UK households that are owner-occupied and not fuel poor, for example.[198] The government has not yet funded local and regional authorities to develop the capacity they will need.

We think the government could learn a lot from Germany. The KfW Efficiency House scheme has been highly successful. It is a model of simplicity that covers all necessary works and applies equally to all sectors: residential, public sector and commercial buildings; owner-occupiers, social landlords, private landlords and even energy savings contractors. It triggered investment of €480 billion in 15 years generating almost enough VAT to cover the scheme's subsidies.

We recommend the government should urgently:

- Introduce a single simple open-ended KfW-style scheme to cover insulation and clean heat for all sectors and tenures. We recognise that this is a fundamental 'year zero' reform, and should therefore be demonstrated in a large-scale pathfinder project (see below)
- Amalgamate all existing energy efficiency and heat decarbonisation funding pots into the scheme, double it and improve targeting on the fuel poor
- Recapitalise the UK Infrastructure Bank to provide the necessary low-cost lending or set up a state-backed guarantee scheme to allow retail banks to fill this role
- Alternatively, either UKIB or the Treasury should offer wholesale guarantees to Britain's retail banks to provide green mortgages for retrofit work, following the example of the National Loan Guarantee Scheme launched in 2012, and as proposed by the Green Finance Initiative
- Strengthen incentives to retrofit at the point of house purchase:
  – Sliding stamp duty[199]
  – Building Renovation Plans[200] (or reform EPC as below and integrate key features of Building Renovation Plans over time)
  – Mortgage portfolio efficiency reporting
- Increase heat network funding tenfold to £3 billion. Based on work by the Climate Change Committee and the IPPR think tank this could stimulate private investment of up to £22 billion to provide 10% of Britain's heat through cost effective heat networks by 2030

Technical

Many of the governments targets on heat decarbonisation rest on Energy Performance Certificate (EPC) ratings. But as we show in chapters 1 and 2, EPC is the wrong metric. For various reasons it does not provide an accurate measure of thermal efficiency. The EPC asks the wrong question and sends perverse incentives; it is a roadblock.

BEIS and the Ministry of Housing accepted in 2020 that 'EPCs will need to move from a reflection of the features of a building (fabric, services and installed improvement measures) to a true measure of "in use" building performance.[201]' This reform is fundamental and now urgent. The government should now:

- Reform the EPC to measure and rank properties by thermal efficiency – as measured, not modelled
- Over time, incorporate the key elements of the proposed Building Retrofit Plans (building passports) into the EPC

Making a thermal efficiency rating mandatory for all property sales would be a powerful lever: we need to decarbonise about 20,000 homes per week until 2050, which is roughly the number of homes sold each week. If buyers use the document to haggle the price of energy-inefficient homes down (and vice versa), it will send a strong signal and may reduce the amount of subsidy required to incentivise retrofits

Local and regional authorities

The government accepts that local and regional authorities will be central to decarbonising heat and especially in local area energy planning (LAEP). A few local authorities have managed to build a sizeable climate/clean energy team, but most have no capacity and no means of funding it. After a decade of austerity, councils have been forced to concentrate on their statutory duties and cut back on other areas including climate and clean energy. Until recently, councils have had to bid competitively for funding in this area, meaning those who already have the wherewithal to bid win more funding while those without fail or don't even try.
The government should therefore:

- Give councils a statutory duty to reach net zero and make it a factor in council executives' performance pay
- Give councils a statutory duty to undertake LAEP and make it a factor in council executives' performance pay
- Define the role of councils, combined authorities and Regional Energy Hubs in LAEP and fund them to build the capacity to carry it out. Funding should be allocated not competitive, as recently demonstrated by Midlands Energy Hub on LAD2
- Widen the focus of zoning to cover not only heat networks but also heat pumps, urgent retrofit and possibly hydrogen zones. At the moment the

government is piloting zoning but only for heat networks. To save time the different types of zone should be defined simultaneously rather than one after another
- Legislate its proposed minimum energy efficiency standards (MEES) for private landlords (see Table 5), and fund local authorities to enforce them
- Legislate to oblige landlords to register all rental properties with their local authority
- In the short term, ensure all councils have the necessary staff and capacity to access current funding schemes to eliminate postcode inequality

Pathfinder

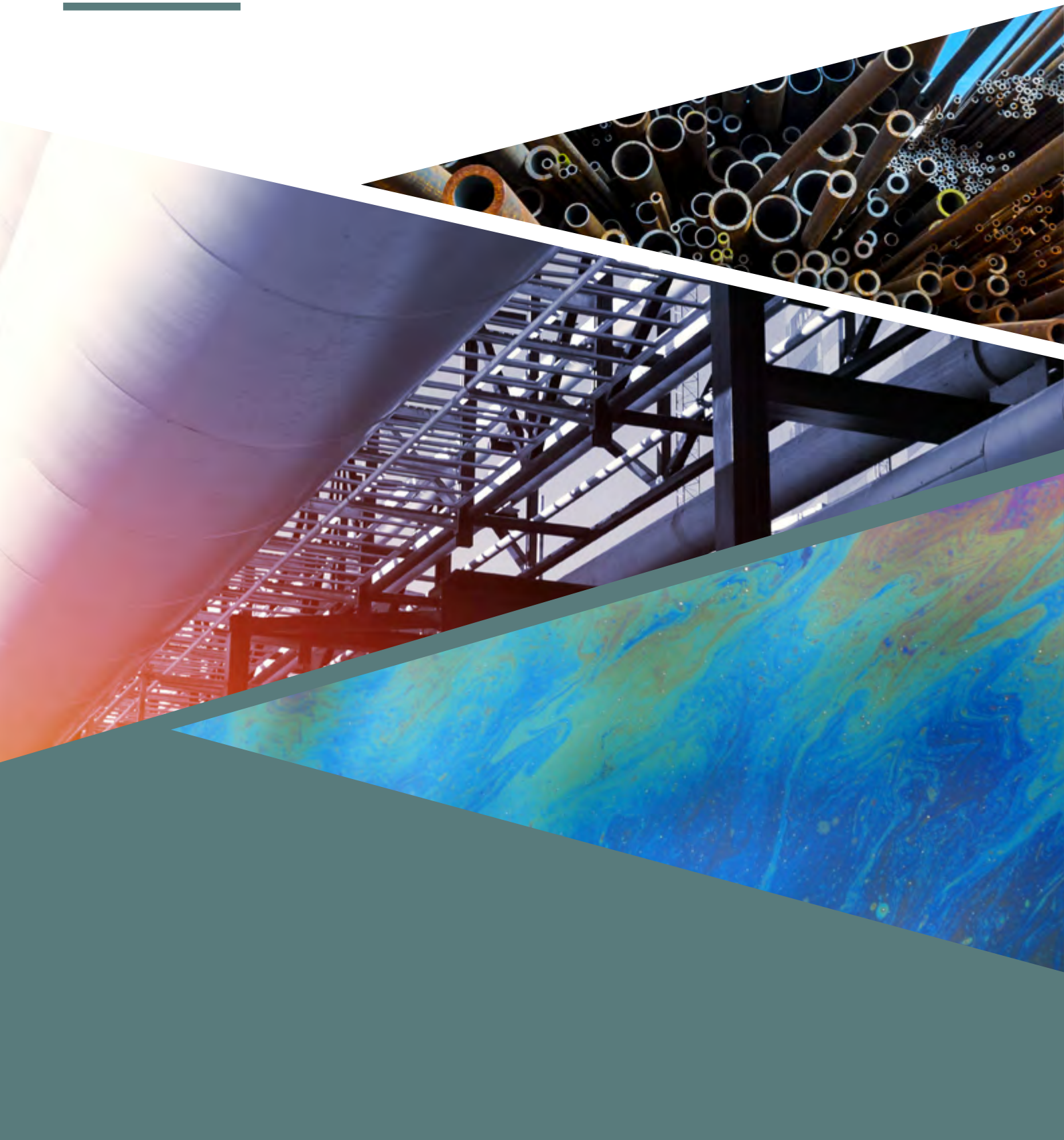
The government should urgently set up at least three large-scale pathfinder projects to start the decarbonisation of building heat, as outlined above.

Institutions

As well as the pathfinder project(s), government needs to create some new permanent bodies and/or give new responsibilities to existing ones.
The government should fund:

- A new National Centre for the Decarbonisation of Heat (NCDH).[202] This would combine several functions but the most critical are:
  – Skills Academy. The Heat Pump Association says we need to train over 50,000 heat pump engineers by 2030
  – The UK has 130,000 gas safe engineers and 50,000 F-gas engineers[203] , most of whom are self-employed and therefore not covered by employer training schemes (Octopus Energy plans to train 1,000 a year). The skills academy would provide training courses and set standards for other providers
  – The Energy Systems Catapult is working with several partners including BEAMA and TrustMark to build on existing skills and training capabilities to support the new academy and the Manufacturing Technology Centre has a well-developed programme and facilities to provide apprenticeship training across several sectors
  – Co-ordinate between local, regional and national plans to resolve any overlap or conflict
  – Standards and Verification. Set and verify standards for technologies and processes such as thermal efficiency measurement
  – Innovation. It will also include a manufacturing accelerator, business incubator and a Building Integration and Living Lab, all to help drive down costs
- Independent consumer advice centre. The government should fund a respected independent body such as the Energy Savings Trust to provide simple and authoritative advice about heat decarbonisation to residents, householders and small landlords. The body will need the capacity to deal with millions of enquiries
- The government should also launch a national conversation to raise awareness of low carbon heat, with messaging tailored not only to the population at large but also to communities that may be isolated by language and perhaps mistrust of authority. Local authorities should be responsible for local awareness-raising and consultation

APPENDIX 1
COMMISSION WORK PROGRAMME



SCOPING PHASE ACTIVITIES

- Developing the idea for the Policy Commission with Birmingham Energy Institute and Energy Research Accelerator
- Literature review of research and data in the public domain
- Appointing the commissioners
- Commissioners' initial roundtable to agree the terms of reference and decide which expert witnesses to approach for evidence

REVIEW AND WRITING PHASE

Activities included:

- Reviewing oral and written evidence submitted to the commission
- Commissioners' summary meetings to finalise the content and format of the report
- Finalising the findings and recommendations of the commission
- Desk research and writing by editor

EVIDENCE SESSIONS

Two evidence stakeholder focused sessions were held, followed by two commission summary meetings, to agree recommendations.

Session 1

Industry & Local Delivery View
13th October 2021
Institution of Mechanical Engineers, London

Session 2

Policy & Regulatory and Access to Finance View
3rd November 2021
Institution of Mechanical Engineers, London

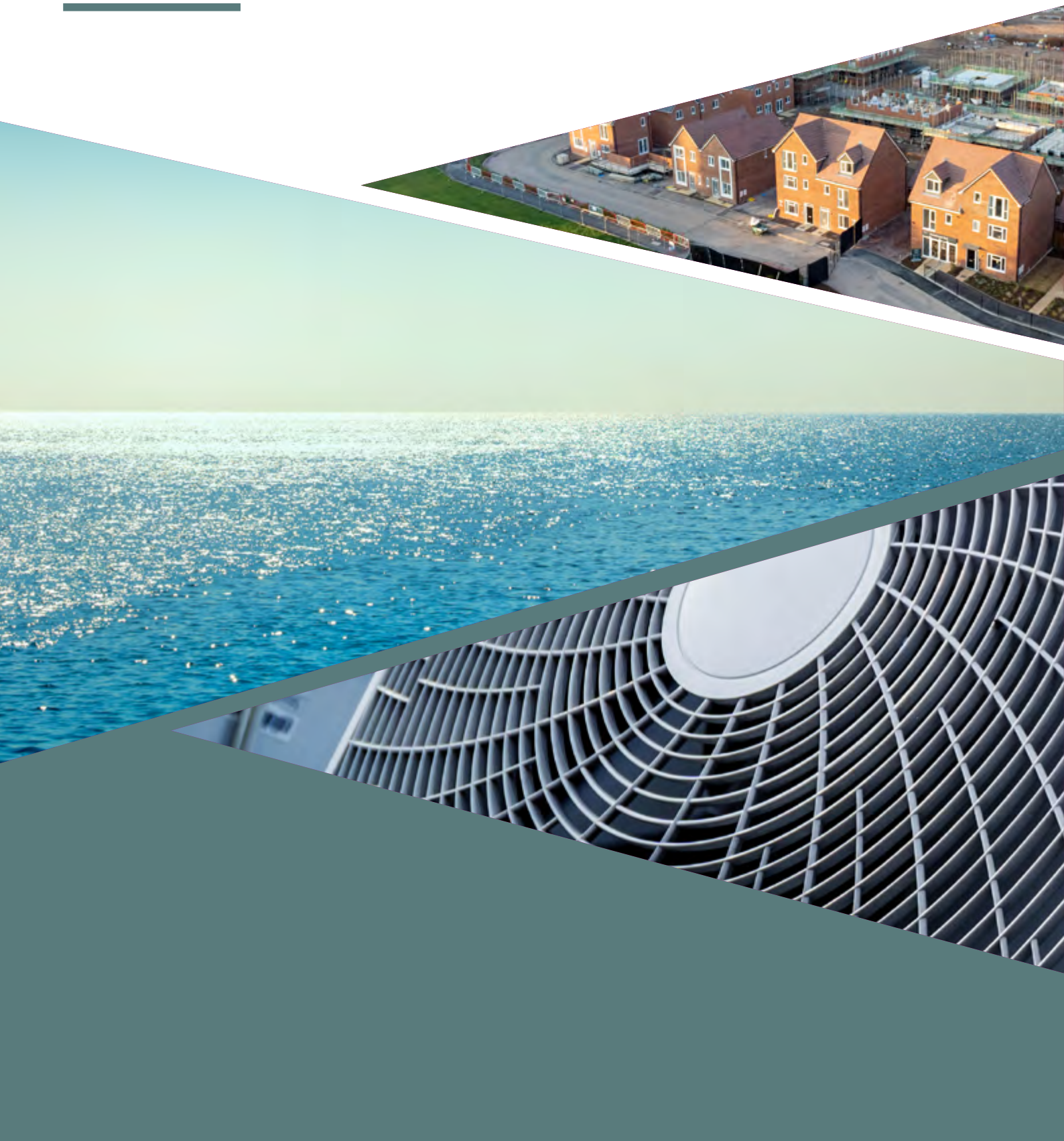
Commission Summary Meeting 1

Community & Housing View
23rd November 2021
Institution of Civil Engineers, London

Commission Summary Meeting 2

Local Area Energy Planning
10th February 2022
Birmingham Energy Innovation Centre, Tyseley Energy Park, Birmingham

APPENDIX 2
COMMISSIONERS' BIOGRAPHIES



COMMISSIONERS:

1. Sir John Armitt

CBE FREng FICE FCGI - Chairman, National Express Group and the National Infrastructure Commission

Sir John Armitt is Chairman of the National Express Group and the National Infrastructure Commission. Sir John is also on the Board of the Berkeley Group and Expo 2020.

In September 2013, Sir John published an independent review on long term infrastructure planning in the UK. The recommendations in the Armitt Review received widespread support and in large part have now been adopted by the current government, resulting in the National Infrastructure Commission.

After leaving John Laing PLC in 1993, where Sir John had been Chairman of Laing's International and Civil Engineering divisions, he became Chief Executive of Union Railways. In 1997, he became Chief Executive of Costain, a position he held until 2001. Sir John was Chief Executive of Railtrack plc from 2001–2002, Chief Executive of Network Rail from 2002–2007, Chairman of the Olympic Delivery Authority from 2007–2014, Chairman of the Engineering and Physical Sciences Research Council from 2007–2012, a member of the Airports Commission from 2012–2015, a member of the Board of Transport for London from 2012–2016 and a board member and later Chairman of the Thames Estuary 2050 Growth Commission from 2016–2018.

Sir John was President of the Institution of Civil Engineers from 2015–2016, he is a Fellow of the Royal Academy of Engineering, Institution of Civil Engineers and City and Guilds of London Institute and has received honorary doctorates from the universities of Birmingham, Imperial College London, Portsmouth, Reading and Warwick.

Sir John was awarded the CBE in 1996 for his contribution to the rail industry and received a knighthood in 2012 for services to engineering and construction.

2. Professor Martin Freer

BSc, PhD, FInstP – Academic Lead Director of the Birmingham Energy Institute (BEI), Director of the Energy Research Accelerator

Professor Martin Freer is a nuclear physicist, and Director of the Birmingham Energy Institute (BEI) at the University of Birmingham. He is also Director of the Energy Research Accelerator (ERA), which comprises eight internationally-renowned Midlands universities which are part of the Midlands Innovation partnership, together with the British Geological Survey.

Martin is former Director of the Birmingham Centre for Nuclear Education and Research, which he established in 2010. He has overseen the development of the BEI, helped establish Energy Capital and has co-led the establishment of the joint University of Birmingham–Fraunhofer Germany research platform. He led the development of the Birmingham Energy Innovation Hub and the co-development of Tyseley Energy Park in Birmingham.

In 2015 he co-led the BEI Commission 'Doing Cold Smarter' chaired by Lord Teverson, and in 2012 he led the Policy Commission 'Future of Nuclear Energy in the UK' chaired by Lord Hunt, he co-led the Policy Commission with Sir David King which saw the creation of Energy Innovation Zone in the West Midlands and in 2020 published a report on The Road to Low-Carbon Heat with the CBI chaired by Lord Billimoria. His main research area is the study of the structure of light nuclei, using nuclear reactions. He received the Friedrich Wilhelm Bessel Prize, Humboldt Foundation, in 2004 and the Rutherford Medal in 2010.

3. Philippa Eddie

Commercial Finance Specialist, Project and Structured Finance Group Infrastructure and Projects Authority

Philippa has worked in infrastructure finance for 30 years as an adviser, lender and principal; she is currently in the Infrastructure and Projects Authority which reports to Cabinet Office and HM Treasury. The combination of an extensive private sector career with eight years in central Government brings a dual lens to projects. Prior to joining HM Treasury in 2013, Philippa was a Partner at EY, and had previously been at Deutsche Bank/Morgan Grenfell for many years, having started her career at Morgan Stanley. While in the private sector, Philippa worked in many areas of infrastructure including health, education, emergency services, prisons, transport, water and energy.

In the IPA, Philippa advises Government departments on projects in the energy, transport, water and digital sectors. Philippa is currently focusing on the Government's Net Zero agenda, working with BEIS on heat networks, Carbon Capture and Storage, and hydrogen, and with OZEV on investment into electric vehicle charging infrastructure. Philippa is a regular speaker at conferences. As a strong supporter of developing talent, she is also a qualified Executive Coach and Mentor working with individuals both within and outside of the civil service.

COMMISSIONERS

4. Cheryl Hiles

Director, Energy Capital, West Midlands Combined Authority

Cheryl is Director of Energy Capital at the WMCA. She is driving the delivery of the West Midlands Regional Energy Strategy and energy devolution ask to Government, to ensure the West Midlands has the necessary tools, powers and resources to meet its green recovery and net zero ambitions. Cheryl pioneered the West Midlands Net Zero Pathfinder programme and is responsible for leading a variety of smart local energy system innovation initiatives. These form the evidence base that demonstrates the value of local solutions and part of a package of measures to achieve our national net zero objectives.

Prior to leading Energy Capital, Cheryl was the sector director for energy and environment at Pell Frischmann design engineering consultancy but spent the majority of her 20 year career at Regen, championing democratic, decentralised and decarbonised energy solutions.

5. Jenny Hill

Head of Buildings and International Action, Committee on Climate Change

Jenny leads the Committee's buildings work programme, alongside its international work in the run up to COP26. She has over 10 years' experience developing technical policy advice on decarbonisation, advising the UK Government, European Commission and UK Local Government. Her focus is low-carbon energy strategy and policy development, with specialisms on energy efficiency and heat technology, costs and policy.

In recent years, she has focussed in particular on how to design policy in a way which is fair and transparent, particularly for the more difficult to decarbonise parts of the energy system. She has led several CCC teams in recent years, including the work on industry and the team which produced the report Biomass in a low-carbon economy, which covers global land use and forestry projections, fuel-switching and carbon removals. She is a consultant by background, working across environmental policy and urban regeneration.

6. Ryan Jude

Programme Director, Green Taxonomy, Green Finance Institute

Ryan is the Programme Director for Green Taxonomy work at the Green Finance Institute, with a focus on advising the UK Government on implementing a UK Taxonomy — a common framework setting the bar for investments that can be defined as environmentally sustainable — through the Green Technical Advisory Group (GTAG).

Ryan also works with the Institute's sector-focused coalitions and initiatives, bringing together key stakeholders across the public and private sectors, academia and civil society in order to unlock barriers to the deployment of capital to deliver tangible economic outcomes. Ryan previously led the Institute's Zero Carbon Heating Taskforce, as part of the Coalition for the Energy Efficiency of Buildings (CEEB). Ryan co-hosts the Institute's Green is the New Finance podcast series, showcasing leading thinking on how to mobilise capital towards a greener, more inclusive and climate resilient global economy.

Before joining the Institute, Ryan worked in investment banking at Cantor Fitzgerald and Jefferies, specialising in power, energy and infrastructure, with a particular focus on renewable energy transactions. He has experience providing financial and strategic advice to leading clients on high-profile, global transactions, in both mergers and acquisitions and project finance.

7. Henry Lawson

Henry Lawson, Managing Partner at EcoPragma Capital

Henry is an entrepreneur and investor in the digitisation space. He has generated over $1billion of value growth for investors in media business systems as the industry underwent the same digitisation now being seen in new energy.

Henry Lawson is Co-Managing Partner and Founder of EcoPragma Capital, focusing on investing in companies contributing to the net zero transition, that are on the cusp of commercial growth, having already established product market fit and commercial value.

Henry started his career at Ricardo Consulting Engineers in engine research and development before strategy consulting with Monitor Company in the UK, Canada, Italy and the Netherlands. He lead a case with the leading US radio advertising sales house and they liked his proposals so much he was hired to implement them. Four years later, having digitised transaction processing and built a $100 million revenue new business unit from scratch he was hired by supplier, Donovan Data Systems to run its European operations.

Restructuring the operations, expanding in France and Germany and opening in Ireland, Henry was asked by the lead investor to become Worldwide President. At the time, leading technology companies were approaching with offers below $100 million, which the lead investor and rest of the team agreed should be rejected.

Over a 10 year period digital media grew from tenths of a percent to tens of percent of media spend and at the same time customer concentration increased from 30 to 6 customers making up 80% of revenues.

With three distinct technology transitions, including acquiring the technology of BrandOcean, innovative new business models and selected partnerships, the company was able to grow profitability tenfold and investor value by over $900m.

The company was later sold to NEA becoming MediaOcean.

Having watched data use explode as digital media grew, Henry left Donovan and joined Warburg Pincus as an Executive in Residence to pursue the thesis of combining privacy and personalisation by involving the consumer. Over two years, working with the TMT teams in London, New York and San Francisco, he found no companies of the scale required and ultimately chose to found a start-up with renowned Seattle investor Tom Huseby and technologist Brian Roundtree to pursue his thesis.

AutoGraph has 17 international patents awarded, won multiple awards and been featured on BBC News and Click, and in *Inc., Re/code, Geekwire, The New York Times, The Daily Telegraph, Marketing Week, Ad Age, TechCrunch, The Guardian, Mobile Marketing, PC Mag, Readers Digest, The Drum* and *Brand Republic*. Henry has also been recognised by *DataIQ* as one of the 100 most influential people in data.

In late 2020, Henry tied up with business school classmate Michael Liebreich to create EcoPragma Capital LLP. The partnership is initially investing in club deals before establishing funds.

In addition to his primary roles, Henry has been an active investor in multiple businesses. In 2001, he established Domaine Le Breil in South West France, employing a local team to plant vines more often seen in the Rhone valley. His calculation that climate change would make them viable was amply rewarded with excellent harvests of high quality grapes. The vineyard was sold for over 100% ROI in 2011.

Through his network in 2010, Henry uncovered the orphan BP business unit BP specialist fuels. He assembled an investor group lead by Oakfield Capital with a leadership team from Ricardo and over five years revenue quadrupled. The business was sold to Lyceum Capital with a 5x ROCE.

Henry also serves as a governor of Lancing College and past member of the London to Brighton Veteran Car Run Steering Committee, initiating the Regent Street Motor Show now attended by 250,000 annually. Henry was an exhibitioner in Engineering at Trinity Hall, Cambridge and a Baker Scholar at the Harvard Business School where he also ran the Prospectus, the Facebook of its day. Henry has three grown up sons and lives in West Sussex with his wife, two black labs and collection of classic cars. Once a year he is seen driving a veteran car from London to Brighton commemorating the new energy transition of 120 years ago.

8. Michael Liebriech

Chairman and CEO of Liebreich Associates

Michael Liebreich is Chairman and CEO of Liebreich Associates, through which he provides advisory services and speaks on clean energy and transportation, smart infrastructure, technology, climate finance and sustainable development. In early 2019, Michael joined Sustainable Development Capital LLP (SDCL) as a Senior Advisor and in September 2020, he became an official Advisor to the UK's Board of Trade.

Michael is Co-Founding and Managing Partner of EcoPragma Capital LLP, a Growth Equity investor, investing in companies on the cusp of strong commercial growth and contributing to the net-zero transition. He is a member of the UK Department for International Trade's Capital Investment Advisory Board, Visiting Professor at Imperial College's Energy Futures Lab and founding Chairman of the Liebreich Foundation and of Moving Mountains.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COMMISSIONERS

Michael founded New Energy Finance in 2004 and was Chairman and CEO until the sale to Bloomberg LP in 2009. He remained CEO of Bloomberg New Energy Finance, until 2014, then became Chairman of the Advisory Board; since 2018, he has been a Senior Contributor. Michael was also Board Member of Transport for London from 2012–2018.

Michael serves on a number of advisory boards, including the IEA's Global Commission for Urgent Action on Energy Efficiency, GreenMap Association, WWF Switzerland, The Hawthorn Club, (WiSER), the OECD Centre on Green Finance, Imperial College's Masters programme in Climate Finance and Management, Carbon Limiting Technologies Sustainable Technologies Fund, Ignite Power, and Equinor's International Advisory Board. In the past Michael has served on the high-level advisory group for the UN Secretary General's Sustainable Energy for All initiative, the World Economic Forum's Global Agenda Councils on Sustainable Energy, the Clinton Global Initiative Energy and Climate Change Working Group, and Business for Britain.

Michael earned his MA in Engineering with First Class Honours from the University of Cambridge, winning the Wyatt Prize for Engineering and the Ricardo Prize for Thermodynamics. He has an MBA from Harvard, where he was a Harkness Fellow and Baker Scholar.

Michael has won lifetime achievement awards from BusinessGreen and the UK Renewable Energy Association, and is a two-time Ernst & Young Entrepreneur of the Year finalist. Michael was a member of the British Ski Team from 1986 to 1993, British Moguls Champion in 1991, and competed in Europa Cup, World Cup and in the 1992 Albertville Olympics.

9. Peter Smith

Director of Policy and Research, National Energy Action

Peter has been at NEA since July 2010 and was appointed a director in 2016. He is responsible for overseeing the charity's policy and advocacy work; working with government, industry and other stakeholders to address the causes and impacts of fuel poverty.
He has particular interest and expertise in the field of domestic energy efficiency and decentralised energy policy. He also provides the strategic direction for NEA's Parliamentary engagement. Prior to joining NEA Peter played a leading role within the combined heat and power industry.

10. Jane Dennett-Thorpe

Head of Net Zero Transition, Ofgem

Jane is Deputy Director for the Net Zero Transition at Ofgem, the GB energy regulator. She led on Ofgem's 2020 Decarbonisation Action Plan, setting out for the first time the regulator's upcoming actions on decarbonisation, and is now helping to embed strategic focus on key issues for the Net Zero Transition across the organisation.

She has held a range of roles on energy and climate policy, including in the UK's Department of Energy and Climate Change as Head of Evidence, Deputy Head of Science and leading on industrial energy efficiency policies.

11. Tom Thackray

Director of Infrastructre, CBI

Tom Thackray leads the organisation's policy work on infrastructure and energy, aiming to improve business connectivity and ensuring the UK maintains a secure, affordable and low-carbon supply of energy.

In his time at the CBI, Tom has held a variety of roles including leading the CBI's Innovation and Enterprise teams, covering policy issues relevant to small and medium-sized businesses and the digital and creative industries. He is an experienced advisor to government and has contributed to Ministerial groups on research and innovation, cybersecurity and small business.

Prior to joining the CBI, Tom worked in public affairs consultancy in Brussels and London.

12. Lisa Trickett

Co-founder, Places in Common

Lisa Trickett has held leadership positions in the sphere of public policy in both a political and professional context for over two decades. Lisa has worked within the public, private and higher educational, sectors. She is a co-founder of Places in Common, a public policy co-operative working in the field of climate change and securing a just transition.

Whilst at the University of Birmingham, she developed the Leadership of Place programme, which sought to create long term sustainable and inclusive communities through organisations of every kind working together. Lisa is currently a Member of Birmingham City Council, Chair of the West Midlands Combined Authority's Overview and Scrutiny Committee and Chair of the Active Wellbeing Society — prior to this she served four years as the Cabinet Member for environmental and sustainability policy.

13. Nick Winser

CBE, FREng
Chairman, Energy Systems Catapult

Energy Systems Catapult Chair since 2015, Nick Winser was appointed Chair of the Advisory Board for the Energy Revolution ISCF programme in 2018 and served on the Advisory Panel for the Cost of Energy Review in 2017. He is also a member of a COP26 Advisory Group and the Net Zero Expert Group which advises the Secretary of State.

These appointments followed a 30-year career in the energy sector which included UK and European CEO of the Board of the National Grid, President of the European Network of Transmission System Operators for Electricity (2013-2015) and CIGRE UK Chair.

A member of the IET, serving as its President in 2017/18, Nick maintains a keen interest in the organisation's work and sits on the Nominations & Succession Committee. Chair of the MS Society and a former member of the Board of the Kier Group, Nick also has a professional interest in both the charity and construction sector.

14. David Strahan

Editor

David Strahan has been a professional writer for over 30 years. He learned his trade through the exacting discipline of writing for television, first as a reporter for Thames TV, and then as a business correspondent and producer-director at the BBC. For ten years he made investigative documentaries for *The Money Programme* and *Horizon* until leaving to write *The Last Oil Shock* (John Murray Ltd, 2007).

Since then he has worked as a writer and editor specialising in clean energy, including journalism for *Bloomberg New Energy Finance* and *New Scientist*, and commercial reports for clients such as Ricardo, the Energy Systems Catapult and the University of Birmingham Energy Institute. He also teaches clear writing for science, business and journalism, and provides a REF consultancy service for universities. **www.writefirstdraft.co.uk**


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APPENDIX 3
THE WITNESSES

THE WITNESSES

- Rachel Fletcher, Director of Regulations and Economics, Octopus Energy
- Charlotte Large, Strategy, Policy and Innovation Director, EQUANS/ENGIE
- Nathan Gambling, Plumbing Heating Lecturer/Consultant and Training Specialist (Betateach)
- Charles Abel Smith, Research Associate, UK100
- Zoe Guijarro, Senior Energy Policy Researcher, Citizens Advice
- Paul Barker, Infrastructure Programme Manager, Bristol City Council
- Mike Hemsley, Head of Analysis and Strategic Insights, Energy Transitions Commission
- Daniel Newport, Deputy Director, Head of Heat and Buildings Strategy, Department for Business, Energy and Industrial Strategy (BEIS)
- Patrick Allcorn, Head of Local Energy, Department for Business, Energy and Industrial Strategy
- Bruce Davis, Joint Managing Director, Abundance Investment
- Rufus Grantham, Managing Director, Bankers Without Boundaries
- Jenny Saunders CBE, DCL, Member, Committee on Fuel Poverty
- David Lomas, Co-Founder, Amberside Capital
- Maxine Frerk, Associate, Sustainability First
- Ian Hutchcroft, Director, Energiesprong
- Maria Dunn, Head of Development Policy, Birmingham City Council
- Richard Halsey, Director of Capabilities, Energy Systems Catapult

APPENDIX 4
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