Retrofitting housing:

translating net-zero commitments into actions and impacts

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Abstract

This study examines issues and challenges of retrofitting existing housing, which is a key step toward reaching net zero targets. We use Manchester City Council as a case study to highlight how incentive structure, asset management and investment approaches, and housing finance may need to work together in the context of climate change and relevant emerging national and local policies.

Even though the overall national approach to heating decarbonisation is ambitious, it lacks an understanding of what residents are motivated by and does not fully appreciate the implications and challenges of retrofitting at scale. Moreover, it is not based on solid evidence regarding financing retrofit or retrofits' actual carbon reduction efficiency. When comparing Manchester's approach to other local authorities' efforts, key distinctions and opportunities to establish and share excellent practices are identified.

Our analysis suggests decarbonising energy supply and applying market-based interventions may likely be more effective to reduce carbon footprints than focusing simply on domestic heating. We must also reconsider our beliefs about the climatic costs of economic progress, have a long-term perspective as well as shape stakeholders' behaviours effectively towards tackling climate change.

Glossary

ASHP – Air source heat pump

BEIS – Department for Business, Energy and Industrial Strategy

CCC – Climate Change Committee

CDM – Construction Design and Management Regulations

CH_4 - Methane

CO_2 – Carbon dioxide

COP – Co-efficient of Performance

EHS – English Housing Survey

EPC – Energy Performance Certificate

ESG – Environmental, social and governance

GRESB - Global Real Estate Sustainability Benchmark

GWh – Giga watt hour

GWP – Global warming potential

HEED – Home Energy Efficiency Database

kg - kilogramme

kt – Kilo tonne

kWh – Kilowatt Hour

MCC – Manchester City Council

MCCF – Manchester Climate Change Framework

mt – million tonnes

N_2O – Nitrous oxide

ONS – Office for National Statistics

PRS – Private rented sector

PV – Photovoltaic

SHDF – Social Housing Decarbonisation Fund

tWh – Tera watt hour

VAT – Value Added Tax

VOA – Valuation Office Agency

1. Introduction

There is an international agreement about the scale and likely effects of climate change over the next decades.

Since the 1880s, Earth's average temperature has risen by 1.1°C. The decade of 2011-2020 was the warmest on record, and the current trajectory is that the average temperature will be 2.7°C higher by the end of the 21st century (UN.org[1]). The consequences of global warming include droughts, water shortages, fires, rising sea levels, floods, and storms (UN.org). It is widely accepted that climate change and global warming are primarily driven by the increases in emissions of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)[2].

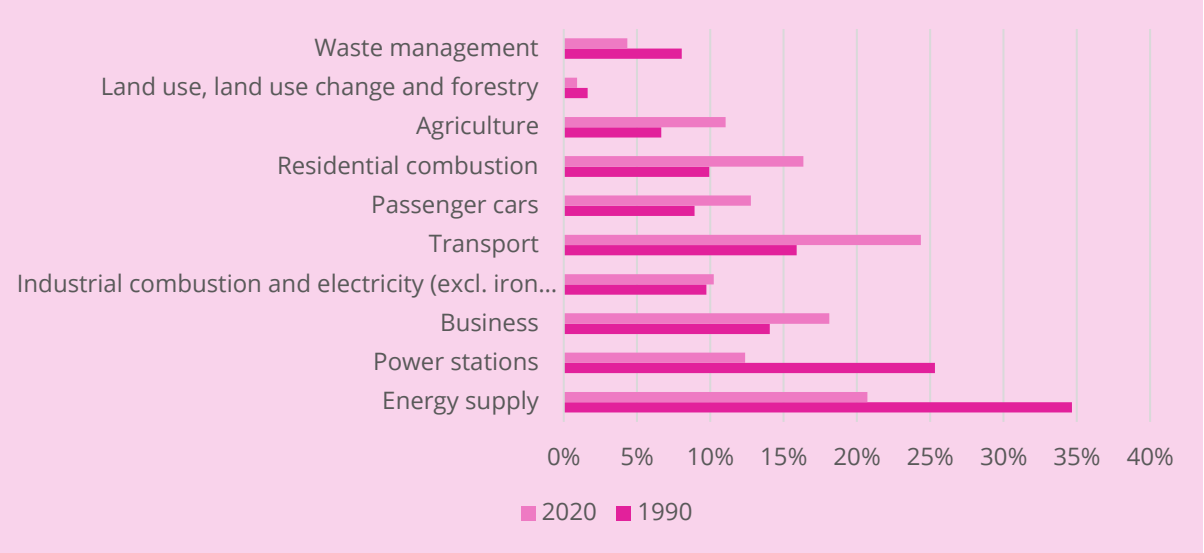
Between 1960 and 2018, world CO_2 emissions rose from 8 million kilo tonnes (kt) to 33 million kt, whilst the consumption of energy from renewables only rose from 17.0% in 1990 to 17.6% by 2018 (Worldbank[3]). The latest estimate for total emissions of CO_2 in the UK (BEIS, 2022[4]) stood at 405.5 million tonnes (mt) in 2020[5], with the residential sector emitting 65mt (16% of the total). The largest emitter of greenhouse gases is transport (98 mt), followed by electricity generation (78 mt), business (61.5 mt) and agriculture (5.5mt) (BEIS, 2022). Total global emissions of greenhouse gases were 37 billion tonnes in 2019, with the UK contributing a little under 1% of the total[6]. The questions are then: which sectors and areas should be looked at for reducing total carbon footprint? And, how that can be achieved with minimal economic and social disruptions?

The Climate Change Act 2008 commits the UK government by law to reducing greenhouse gas emissions to net zero by 2050[7]. Following the COP26 summit, the UK has committed itself to reducing carbon emissions by 78% on 1990 levels by 2035[8], with this meaning that by 2035 no coal or gas should be used as part of power generation and the sale of petrol and diesel engine road vehicles should be

[1] It is important to note that the global warming potential (gwp) of each gas varies greatly: the gwp of CO_2 is 1, CH_4 is 27 and N_2O is 273. Although CO_2 is the biggest source of global warming gases at around 80% of the total, CH_4 emissions average around 11% and N2O around 7%. Read.
[2] Read.
[3] Read.
[4] Read.
[5] The CCC report of 2022 records a figure of 447MtCO_{2e} for 2021, an increase of 4% (CCC, 2022 p.17). The report notes that emissions from surface transport and electricity generation were up by 10% on 2019 and emissions from buildings up by 6%, p18. The provisional greenhouse gas figures for 2021 are 424.5 mt – an increase of 5%. Residential had increased to 68 mt, transport had risen to 107.5 mt, electricity generation had increased to 81 mt, business 65 mt.
[6] Read.
[7] Read.
[8] Sixth Carbon Budget, June 202. Read.

banned by 2030[9]. The Government has also expressed an ambition that by 2025 no new gas boilers are fitted (Net Zero Strategy, 2021, p.135).

Figure 1: Share of total carbon footprint in UK by sector (1990 and 2020)



Source: UK National Statistics. Read.

Housing is a very significant part of the total carbon footprint of the built environment: the Climate Change Committee (CCC) has estimated that the UK's 29 million homes produce 20% of the total carbon emissions[10]. Figure 1 highlights the share of various sectors including residential combustion in 1990 and 2020. To fulfil COP26 commitments, the planning of housing developments, housing types, energy efficiency, choice of building materials for dwellings, green infrastructures and other built structures must all address their environmental impacts and long-run sustainability. While strict environmental standards are relatively easy to implement in new housing developments, the biggest challenge is to reduce the environmental impacts of existing dwellings. This is especially critical for the UK, which has one of the oldest housing stocks in Europe[11]. The retrofitting of our existing stock is an essential aspect of decarbonisation in the UK.

These environmental concerns also occur in the wider context of the severe demand-supply mismatch and affordability gaps in the UK housing market. The government must now reconcile two critical issues: housing supply and zero-carbon. However, tackling these two problems at the same time requires intensive cross-collaboration between government agencies that often work in silos. This is needed to deal with important financing resources and the challenges of large-scale retrofitting programmes.

[9] Read.
[10] Read. The base figure is 14% but excludes 6% from electricity consumption.
[11] Read.

Since 2008, the UK has mandated that all housing transactions must have an Energy Performance Certificate (EPC), ranging from A (best rating) to G (worst rating). This has led to a market for retrofitting existing units to improve their EPC ratings prior to transaction. However, the EPC requirement alone cannot achieve the net-zero targets: retrofitting at scale is needed, but for this to be achievable, issues around affordability and financing, programming at scale of delivery, which is without historic parallel, and the technology itself needs to demonstrate its efficacy.

Retrofitting the existing housing through thermal upgrading, the installation of air source heat pumps (ASHPs) and photo-voltaic (pv) power generation will be expensive, ranging from £15,000 per unit to £70,000 when ancillary repairs and upgrades are included. There are also affordability issues for low-income households, who often face poor housing conditions and prohibitive resource constraints, and the recent hikes in the cost of electricity and gas have made this situation much more acute and urgent.

The financialised state of the housing market and huge demand-supply imbalances also make investment in housing retrofit unattractive. These issues tend to be more severe in the private rented sector (PRS), with renters having no right to address poor housing conditions. In supply-constrained housing markets, landlords can ignore these issues, and the costs of upgrading are likely to be transferred to tenants through higher rents. Moreover, the current financing system for retrofitting and the housing market tend to focus on different and somewhat contradictory outcomes. Anchor institutions in place face dilemmas in terms of cross-collaboration as they compete for the same limited government resources. The CCC's latest report on progress notes major concerns around providing low-carbon heat in homes and energy efficiency in non-fuel-poor homes (CCC 2022, p.22, 25). The report also highlights concerns around the government's "reliance on untested approaches for buildings" (ibid, p29).

In this pilot project, we focused on Manchester City Council (MCC) to investigate the issues at a granular level. The MCC housing market has been rapidly expanding, especially in terms of PRS, and has attracted significant public and private investments. MCC's plan to become a zero carbon city by 2038 is set within the context of a complex local government operation within one of the UK's largest and most vibrant cities. Therefore, MCC provides an excellent testing ground for these issues. A key objective is to scale up to other regional markets in the UK as a follow-on project using the MCC case study.

The report explores the levers and powers local authorities can use to divert or disrupt the current flows of finance for retrofit to ensure effective delivery in terms of affordability, building local economic opportunity and delivering against net-zero targets. The project has helped to generate significant impacts by understanding ways and means of improving the carbon footprint of the housing sector. Also, the project will have a strong impact by working with the local government and influencing its policies in this area. This will be done through external collaborations.

The report starts by considering the broader issues around net-zero to ensure that the decarbonisation of domestic heating is properly located within the wider context of global and national emissions, and that the quality of the evidence and arguments for domestic decarbonisation are properly considered. The second part of the report describes the approach we took to the study, explaining the granular approach and the concern to identify the empirical evidence informing decisions. The next part of the study reviews the wider policy framework and highlights the tensions within any approach to the decarbonisation of the housing stock. We then review the specifics of the Manchester case study, drawing some comparisons with other similarly situated local authorities. The broader financial issues are then considered along with the structures of incentives for decarbonisation. After drawing key conclusions from our research, we provide recommendations for the Manchester area and offer observations on national issues.

2. The importance of housing retrofit in decarbonising the UK

It is estimated that the UK's 29 million homes emit around 65 million tonnes of CO_2 per year, an average of 2.2 tonnes per dwelling.

The UK, through the exploitation of North Sea gas, has a very high rate of domestic gas heating at around 86% (English Housing Survey, Energy Report, 2021): around 22 million dwellings. Whilst the efficiency of modern gas boilers has improved vastly, the carbon footprint of gas is relatively high. The average house is estimated to use between 8,000 and 17,000 kWh of gas per year (depending on size, occupancy, thermal efficiency, etc.). The CO_2 per kWh of gas is around 0.184 kg per kWh[12], so the range of CO_2 emissions from gas central heating will be from 1.5 tonnes to 3.1 tonnes per dwelling per year.

The basic ways of curtailing dwellings' emissions are to reduce the need for heating through additional thermal insulation, increase the efficiency of heating methods, and enhance the efficiency of other appliances. The recent and forthcoming hikes in the price of gas and electricity are intensifying the issues, with reports of fuel poverty and households cutting back on consumption.

The Government is committed to the electrification of heat, on the basis that ASHPs can replace gas-fired systems and potentially reduce dwelling emissions by up to two thirds. It is providing financial and policy support for the rapid expansion of ASHPs, hoping to install around 600,000 per year[13]. Although the production of electricity is not decarbonised as around 45% is produced through the burning of fossil fuels, giving a figure of 0.181 kg per kWh, it is hoped that the efficiency of ASHPs will massively reduce CO_2 emissions from domestic dwellings via their comparative efficiency. If ASHPs operate at a co-efficient of production (COP) of 3 kWh of heat per kWh of electricity consumed, then a smaller dwelling currently

[12] Read.
[13] Heating and Buildings Strategy 2021, p. 11

using 8,000 kWh of gas and producing 1.5 tonnes of CO_2 per year could reduce its CO_2 to 500 kg via switching to an ASHP. This is the key attraction of ASHPs and, given its pre-eminence amongst retrofit measures, this will be a significant focus of the study.

3. National policy frameworks

The broad framework for the retrofitting existing dwellings is embedded within a number of overarching policies and is most particularly addressed in the Heat and Buildings Strategy, 2021.

The Climate Change Act of 2008 contains the general legal foundation for net-zero, which was revised in July 2021 to add a goal of lowering greenhouse gas emissions by 78 percent from 1990 levels. The 2020 Ten-Point Plan for a Green Industrial Revolution included aims for greener buildings at Point 7. These objectives include the implementation of the Future Home Standard, the installation of 600,000 heat pumps annually by 2028, the extension of the Green Homes Grant, the provision of funding from the social housing decarbonisation fund (SHDF), and the strengthening of energy efficiency requirements for private landlords (BEIS, 2020, p.20). In addition, the Plan included commitments for the decarbonisation of power, transportation, and the development of green finance.

The Heat and Buildings Strategy (2021) prioritises the development of ASHPs and the improvement of residential thermal efficiency. Additionally, the policy seeks to deploy 13 million heat pumps by 2050 (p. 156). It also states an ambition to phase out the installation of natural gas boilers by 2035 (p. 9); a further "ambition of working with industry to reduce the costs of heat pumps by at least 25–50% by 2025 and towards parity with boilers by 2030" (p. 11); to make major strategic decisions regarding hydrogen as a heat source by 2026 (p. 11); to replace 1.7 million fossil fuel boilers annually by the mid-2030s; and to scale up low-carbon heat networks (p. 12). Prior to modifying the heating system, the plan emphasises "fabric first" approaches (p. 12).

The Heat and Buildings Strategy has five guiding principles: firstly, a whole-buildings and whole-systems approach; secondly, driving innovation; thirdly, accelerating no- and low-regrets actions; fourthly, balancing certainty and flexibility; and lastly, providing assistance to those with the greatest need (p. 12-13). The policy is connected to a variety of financial assistance for decarbonizing buildings. It includes: (a) £60 million Net Zero Innovation Portfolio supporting a

"Heat Pump Ready" Programme, (b) supporting the capital costs of installations through the Boiler Upgrade Scheme, (c) providing £5,000 grants for ASHPs and reducing the disparity between gas and electricity prices, and (d) expanding the supply chain of heat pumps and ensuring the electricity system can respond to increased demand (p. 16-17).

The overarching policy is further extended and updated in the Energy White Paper (2020), the Net Zero Strategy: Building Back Greener (2021), the British Energy Security Strategy (2022), and a number of additional specialised initiatives. The updated Building Regulations (Parts L, F, and O) also address energy efficiency, ventilation, and overheating concerns in new houses, while Part L1 applies to extensions and renovations of existing dwellings, including replacement windows, doors, and heating system upgrades[14].

3.1 General approach at the national level

At the most basic level, all carbon reduction strategies aim to reduce emissions through a combination of the following measures:

3.1.1. Switching from fossil fuels to carbon-neutral means of generating heat and power

This means phasing out natural gas, oil, coal, and their derivatives and using electricity generated through solar, wind, geothermal, hydro, tidal, or nuclear power to produce electricity and hydrogen as a fuel. Within domestic buildings, it is anticipated that heat will be generated, for the most part, by ASHPs for individual dwellings and district networks for dwellings located within larger buildings or complexes (e.g., purpose-built student housing and apartments).

3.1.2. Increasing the efficiency of sources of heat and power

The switch to condensing gas boilers was achieved several years ago and reported levels of efficiency are now much higher than they were 20 years ago. However, the

[14] Read.

requirement to reduce emissions is likely to lead to a phasing out of gas-fired central heating and after 2035[15] no new gas boilers should be installed.

3.1.3. Increasing the thermal efficiency of dwellings to reduce heating requirements

While this is relatively easy for newbuild, for older dwellings it usually entails upgrading thermal insulation and the reduction of heat loss through gaps in the structure. This is very expensive, with costs often exceeding £20k per unit. In addition, retrofitting requires a systemic approach and close attention to quality, as addressing one area without addressing others can create new problems, including interstitial condensation and cold bridging.[16]

3.1.4. More effective and usable control systems

At the highest level, this can involve changes to the national grid to control issues around intermittency of supply and mismatches between supply and demand (demand for electricity reduces greatly in the evening but wind turbines still generate). There are also some interesting examples of progress in relation to battery storage, although this is still very expensive, and capacity is very limited. In the domestic sense, control systems can be upgraded to ensure that heat is not wasted during periods of non-use or electricity is drawn when tariff costs are lower (e.g., the Economy 7 tariff). The roll-out of smart meters is also based on the assumption that providing timely and accurate information on costs and consumption may encourage people to use less energy. There have also been several experiments around smart tariffs and remote controls on heating systems.[17]

3.1.5. Increasing the cost of carbon-based fuel

This can encourage reduced demand but can exacerbate fuel poverty. Since the recent increases in the cost of gas and electricity, there have been many reports of households cutting their consumption.

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[15] There is some uncertainty about the date being 2025 or 2035. Read and read.
[16] Read.
[17] Read and read.

3.1.5. Energy security as an over-riding consideration

The storms which beset the UK in 2021 and 2022, alongside the increases in the cost of gas and oil following the COVID pandemic and the Russian invasion of Ukraine, have raised the importance of energy security. Energy security is not simply about ensuring that the supplies of the relevant sources of heat and power are secure; it also aims to preserve the integrity of distribution networks during periods of extreme weather. The government's recent announcements on its energy security policy indicate something of a retrenchment around the importance of fossil fuels.

Similarly, in 2021, the weather meant that contributions to the energy grid from renewables were much lower in that year than in previous years. According to Energy Trends, 2021, renewable energy decreased by 9.5% year on year to 121.9 tWh, while fossil fuel generation increased by 12% from 2020. As well as lower outputs from renewables, energy from nuclear sources also fell in the year.

The government has recently reasserted its commitment to nuclear power forming an important part of the energy generation mix in the UK going forward. The UK has five active nuclear reactors, with four of these due to cease operations between 2022 and 2028, and only Sizewell B operating past 2028. Hinckley Point C and Sizewell C are the only nuclear power plants due to open, and these have been subject to continuous delays and cost overruns. The government has recently announced £1.7 billion in funding towards the cost of new nuclear plants and expressed its confidence in small modular reactors, supporting these from the advanced nuclear fund of £210 million and stating that these should be deployable by the early 2030s.

Although nuclear power has accounted for around 20% of the energy mix, some forecast that this will decline to 10% by the end of the 2020's as most of the existing plants are decommissioned. Hinkley Point C was first announced in 2010, with construction starting in 2018. Its original cost was around £20 billion. Latest estimates are that it will cost nearer £23 billion, with an operational start in 2026. Sizewell C has been beset by many problems and is unlikely to start generating

power before 2031 at the earliest. It is important to note that the British Energy Security Strategy[18] (7/4/22) makes the following statements.

> Gas is currently the glue that holds our electricity system together and it will be an important transition fuel. We are taking a balanced approach to this unique subterranean asset. There is no contradiction between our commitment to net zero and our commitment to a strong and evolving North Sea industry. Indeed, one depends on the other.
>
> The North Sea Transition Authority plans to launch another licensing round in the autumn, taking into account the forthcoming climate compatibility checkpoint and the need for energy security. This will mean more domestic gas on the grid sooner
>
> Establishing Gas and Oil New Project Regulatory Accelerators to provide dedicated, named project support to facilitate the rapid development of projects – which could take years off the development of the most complex new opportunities

[18] Read.

4. Key issues and tensions around retrofitting housing

For many years, the UK's housing policy has prioritised the construction of new homes.

The renovation of existing owner-occupied housing has been mostly a question of owner preference and financial ability; for social landlords, expenditure on existing homes has been targeted at fulfilling decent home standards and addressing fire concerns; for private landlords, similar factors apply. The maintenance and improvement of individual residences has been a rather modest endeavour, punctuated by big contracts for complex or high-rise plans and the management of larger maintenance contracts. Little national funding has been allocated for retrofitting, and few large contracts have been awarded or completed.

Retrofit is a relatively new addition to the vocabulary used to describe the improvement of existing dwellings; formerly, refurbishing, rehabilitation, and renovation were commonly employed. Retrofit encompasses the process by which upgrades to existing stock significantly reduce $C0_2$ emissions; this is the essential, implied distinction. For instance, installing a new kitchen and bathroom, re-plastering, replacing an old gas boiler, and rewiring may not address decarbonisation. Given the age of the housing stock in the UK, the retrofitting of dwellings is expected to incur significant costs to address existing issues and improve occupants' comfort.

Renovating old housing provides unique issues compared to new construction. Existing properties entail risks and contingencies when problems arise on each site during renovations. There can be problems with the current fabric. In addition, the contractor may have to work around existing occupants and must get numerous permissions (e.g., Building Regulations, Construction Design and Maintenance Regulations, and the Party Wall Act). The dwelling's construction may pose challenges for external or interior insulation, and existing fittings will need to be disposed of properly. Ventilation, the avoidance of cold-bridging, and the filling of

gaps in walls and floorboards are typically important factors to consider while insulating older homes. Additionally, the required labour, skills, and organisational capacity for retrofitting compete with those needed for new construction.

As indicated earlier, approximately 95% of the current dwelling stock in the UK is heated by gas-fired central heating, oil-fired central heating, or older electric storage systems. Improving the thermal efficiency and installing electrified heating sources in 27 million homes within 13 years is an incredibly lofty and challenging goal, both logistically and financially.

There are other specific issues to consider on a national basis, and these are addressed below.

4.1. Energy Performance Certificates (EPCs)

These currently favour the installation and upgrading of gas central heating systems alongside insulation and energy efficiency measures. Furthermore, the limited utility and low impact of EPCs in influencing decision-making and behaviour, as well as their inaccuracy (see for example, Coyne and Denny, 2021), and lack of a relationship to actual living costs, are well-documented. The Government has published a 35-point action plan to improve EPCs in 2020, noting that only 3% of respondents to a consultation felt these were accurate and reliable, 73% feeling they were not effective in encouraging action and only 24% of buyers and renters stating that their decision was influenced by the EPC rating (BEIS, 2020b).

4.2. Heat pumps and enhanced insulation

In essence, ASHPs capture heat from outside air and transfer it to a liquid refrigerant, which is then compressed and heated using electricity. Then, a heat exchanger is utilised to circulate hot water to radiators and as the source of hot water for running taps. Consequently, the heat pump is only as carbon neutral as the electricity powering it.

A main issue is that the temperature of the hot water is far lower than that can be achieved by a gas boiler, necessitating larger and longer-running radiators, an additional system for hot water, and exterior placement of the pump. Installers of

heat pumps typically advise increasing insulation, installing larger radiators, and adding a secondary source of hot water heating.

The reviewed strategies acknowledge that, for the consumer, the cost-benefit calculations do not quite stack up in favour of installing ASHPs in comparison to gas central heating, and that the total installation costs are significantly greater than for replacement gas systems. Only 24% of owner-occupants, according to the CCC's 2022 Progress Report, would consider replacing a gas system with an ASHP. However, in 2021, only 3% of old gas systems were replaced with ASHPs (pp177). This indicates that convincing people to adopt this technology will be a difficult undertaking. The research also stated that, given the present ratio of gas to electricity prices, the operational cost of an ASHP would most likely be higher than that of an equivalent gas system.

4.3. Retrofit versus landlords' asset management strategies

All landlords need to protect the quality and appeal of their stock to ensure its long-term future and meet legal requirements. Social housing providers prepare 30-year business plans, which map out their income against various expenditure items, with lenders and the regulator requiring assurance around the adequacy of plans and provisions to safeguard the viability of their stock. Most asset management strategies aim to comply with obligations around fire, gas, electric, water and asbestos safety, as well as ensuring that the fabric, fixtures and fitments and quality of properties is maintained. Many of the obligations around fire and asbestos safety have increased and most social landlords have not included for fabric improvements and retrofit for zero-carbon (often estimated at around £20k to £60k per property) in their long-term business plans.

Private landlords will expect a reasonable return on their investment and expensive retrofit which does not enable them to charge additional rent is unlikely to be commercially attractive. The existing expectations around enhancing the EPCs of properties are also likely to demand further investment in properties. The PRS currently houses 28% of all fuel poor households (Heat and Buildings, which year, p. 80) and private landlords are expected to bring almost all their stock to EPC level C by 2025, with 3.2 million having a rating of D or below (BEIS PRS, 2020).

4.4. Rationality of individuals

A central issue in retrofit is that upfront costs are very high, with the potential monetary returns accruing slowly over a long period. In addition, the current differential in cost per kWh of electricity compared to gas means that replacing gas central heating with an ASHP will involve much higher up-front costs with the prospect of increased running costs. The situation is further complicated by the comparative complexity of controls and the limited responsiveness of heat pump-based systems. Given that 1.7 million new gas boilers are fitted every year, owners are likely to maximise the longevity of the asset and invest in short-term quick wins such as additional insulation, although even here there are compromises as many older homes will not be able to receive external cladding and owners may baulk at the reduction in usable space through internal insulation. As the earlier discussion showed, smart metres have failed to significantly impact on the behaviour of residents (Fredericks *et al*., 2020).

4.5. Potential for heat network zones

Heat network zones (sometimes known as district heating) supply heat from a central source to consumers via pipes carrying hot water (BEIS). The heat can be generated by excess heat from power stations, waste facilities, bio-mass, and geo-thermal, amongst other sources. It can be suitable for high-density housing, including purpose-built student housing, flats and apartments, and public buildings. Within the UK, there are around 14,000 schemes supplying around 450,000 homes[19]. Heat networks are not without problems, including reliability, cost to consumers, lack of choice of supplier for the consumer and the reliance of 50% of schemes on gas[20](Heath, 2021).

4.6. General awareness

While there is strong evidence that public awareness of climate change is high, there seems to be less knowledge of what net-zero commitments will mean at an individual level (Demski, 2021; Ipsos, 2021). Although Demski's research found that

[19] Read.
[20] Read.

only 39% of respondents had a fair amount of knowledge of net-zero, the Ipsos study found that 69% were aware of the term, only 20% were aware of the UK's commitments. Demski's study found that only 45% strongly supported action and only 16% were willing to adopt lifestyle change.

4.7. Complexity of the funding regimes

There are several ways to fund retrofit measures. The first source is the individual asset owner (either an owner-occupier, landlord, or institution), who may self-fund or seek borrowing. The Government has also announced a wide range of different funds and unravelling these can be difficult as they all have different eligibility criteria, timescales, bidding regimes, and targets.

5. Manchester's retrofit strategy: a comparative analysis

The city of Manchester has grown rapidly over the last twenty years, recovering from its population losses in the 1970s and 1980s through a combination of inward migration, huge increases in the number of students, and the development of new high-density housing within its inner core.

Despite its well-publicised economic strengths, it still contains large pockets of deprivation, and much of the housing stock consists of smaller terraced housing built in the pre-war years. The Mayor of Greater Manchester has committed the region to decarbonisation by 2038 and the RetrofitGM strategy forms the core of Manchester City Council's (MCC's) approach to tackling the decarbonisation of its existing housing stock.

5.1. Housing market profile of Manchester

5.1.2. The size of the housing stock

Although several sources suggest that the total housing stock is around 238,000, there are conflicting sources of evidence. Establishing a baseline of dwelling stock is also complicated by the sheer amount of student housing, which is not subject to council tax and therefore not recorded in many statistics. According to Valuation Office Agency (VOA) data in 2021, there were 238, 780 residential dwellings, of which 134, 790 (57%) were in band A, suggesting they are flats or smaller terraced houses. The Manchester Intelligence Hub records 228,786 households in 2021 and a population of 555,741 in 2020. The ONS 2020 record is 231,000 dwellings[21].

[21] Note, it is likely that this estimate may be somewhat different depending on various factors including time, geography and data definitions.

5.1.3. Tenure profile

The tenure profile is also complicated in terms of recording methods. The ONS 2020 records 72,000 PRS (31%), 67,000 social rented (29%) and 92,000 owner-occupied (40%). These figures differ somewhat from the housing profile of Manchester produced by MCC. The proportion of rented housing (60%) is considerably higher than the national average of 36% (ONS[22]).

5.1.4. Stock type

Flats represent the largest proportion of the stock at 39%, closely followed by terraced houses at 34%, with semi-detached houses, detached houses, and bungalows making up the remainder. Again, the proportion of flats and terraced houses is both considerably higher than the national average[23] - 23% and 26% respectively, with 73% of Manchester's stock being flats or terraced houses compared to 49% for England.

5.1.5. Energy performance

In terms of energy performance data from gov.uk has been used to produce the following profile of Manchester's housing stock:

Table 1: Comparison of EPC data in Manchester to England

EPC comparison								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**Total**
Manchester	130	10351	86985	90527	33857	6510	1937	230,297
England	11436	593139	5715953	8182973	3399168	858869	256757	19,018,295
%								
Manchester	0%	4%	38%	39%	15%	3%	1%	
England	0%	3%	30%	43%	18%	5%	1%	

Note: it is likely that this estimate may be somewhat different depending on various factors including time, geography and data definitions. Source.

The figures suggest that to ensure all properties are C or above, actions will need to be applied to around 132,000 dwellings. Interestingly, Manchester compares

[22] Read.
[23] Read.

favourably to the national average on EPCs, with 42% being C or above compared to the national average of 33%. This may reflect the age profile of the stock and the higher proportion of flats.

5.1.6. Fuel poverty

The Manchester Intelligence Hub records 228,786 households in 2021 and a population of 555,741 in 2020. It also records that 42,844 households are in fuel poverty. The Housing Strategy for Manchester records a population of 600,000 with 18.6% (41,000) of households in fuel poverty. These figures are likely to increase substantially in view of the recent rises in the cost of all types of fuel.

5.2. Policy frameworks

The key commitments around retrofitting the existing housing stock were originally contained in GM's 5-Year Environment Plan for Greater Manchester, which was adopted in 2019, and these have been further refined and extended in GM's RetrofitGM, adopted in July 2022 by the Greater Manchester Regional Partnership.

The GM 5-year plan sets out a series of ambitious targets for the region, including:

- For the city-region to be carbon-neutral by 2038
- Fully decarbonising how buildings are heated by 2038
- Reducing heat demand
- Ensuring that 50% of households have solar photovoltaic panels by 2040
- Reducing the number of homes with gas boilers to 35% by 2040
- Ensuring 60% of homes have low-carbon heating systems by 2040
- Completing 60,000 retrofits per year

The 5-year plan has been fleshed out and updated within RetrofitGM, which was approved by the GMCA in March 2022. The report acknowledged that the city region had already used the 2022/23 carbon budget and was on course to use the entire budget within six years (p. 4). It set a target of achieving 60,000 retrofits per year from 2030 onwards (a significant dilution of the commitment in the original 5-year plan). It conceded that it would be seven years before new homes would be carbon zero (p. 4) and estimated that for social housing alone, 138,000 dwellings

needed retrofitting, with plans to undertake 7,200 retrofits by 2024 (5% of the total in need).

The report appears heavy on the identification of problems and themes but light on setting stretching and measurable targets. It identifies four key challenges: lack of market demand; supply chain capacity; workforce skills; and the lack of financial products. The report strongly advocates the installation of air source heat pumps, enhanced insulation, and solar panels for the stock, estimating that these will reduce residential carbon emissions by 97% (p. 28).

The calculations within the report seems, at times, unclear and hopeful. For example, on page 23, it estimates that installing heat pumps plus enhanced insulation will cost £10,000 per property. However, on page 30 it records that social landlords intend to spend £118 million retrofitting 7,200 dwellings, giving an average cost of £16,400 per dwelling. Therefore, the cost of this could be between £8.9 billion and £14.5 billion. To complete this in a 16-year timeframe is extremely ambitious, and the timeframe would require annual expenditure of between £556m and £906m per year.

The aspirations of the combined authority have been cascaded into MCC's policy framework and are reflected in the council's Housing Strategy 2016-2021[24] and the Manchester Climate Change Framework 2020-25, adopted in February 2020. The key targets within these two documents are listed below:

Table 2: Ambitions within Manchester Housing Strategy and MCCF

Target	Source	Completion date
Achieve a zero-carbon city by 2038	MCCF	2038
50% reduction in CO_2 from homes	MCCF	2025
13,600 dwellings connected to low-carbon heat source	MCCF	
50% dwellings connected to so PV 16m2	MCCF	2024
11,500 retrofits per year	MCCF	
10,500 retrofits over 4 years	Housing Strategy	
20 social housing providers carbon-literate	MCCF, appendix 2	2025

[24] We understand this is to be updated by Autumn 2022.

Work with the PRS to encourage energy efficiency	Housing Strategy	
Improve heating and insulation in the PRS and social housing	Housing Strategy	

5.3. Comparing Manchester to other local authorities

MCC's strategies were compared to those in use at Liverpool, Leeds, Birmingham, and London on the basis that these were all major authorities with strong commitments to net-zero.

The primary observation is that there is a lack of commonality in the formats of strategies, making the process of comparison time-consuming and difficult. While all aim to reduce carbon emissions in their areas, the target dates differ and, in some cases, the words "net-zero", "zero carbon", and "decarbonizing" are used. Leeds and Greater London plan to be net zero by 2030; Greater Manchester plans to be zero carbon by 2038; Liverpool plans to decarbonize space and water heating by 2030; and Birmingham plans to be net zero by 2041.

Although the overall objective of each strategy is relatively clear, the policy documents for each area differ considerably in their layouts, aspirations, output targets, interventions, and financial inputs. Each area highlights challenges, some of which are common, and some particular to the area. Given that the journey to the decarbonisation of domestic heating is at an early stage, it is reassuring to see that each area is experimenting with different approaches. What does stand out is the need to attract considerable financial resources, implement a scale of intervention in the homes of individuals that is unprecedented in scope, and embrace technologies which are not mature and reliant upon a nascent structure of implementation. While some strategies identify some of the risks associated with such ambitious proposals, the ability of the individual authorities to manage the inherent risks within their programmes is uncertain.

Most strategies can be condensed into three simple sections: where do we stand; where would we like to be; And how will we reach our destination? Inherent in each of these categories are questions regarding who, when, how much it will cost, and how it will be resourced. The where are we now questions and information were covered in an earlier section of this chapter, suffice it to state that the quality and breadth of the evidence supporting each method differed considerably.

Despite the relative clarity of each strategy's overall objective, some strategies supported the overall objective with a succession of objectives or actions. In every instance, it was unclear how the proposed steps would accomplish the end goal. About retrofitting, there was a wide range of expectations regarding the installation of ASHPs: some had rather modest goals, and others had ambitious objectives. The aims for retrofitting should reflect a comprehensive understanding of the features of the stock and the conditions of its tenants and owners. This appreciation was not evident in a number of objectives.

There were a variety of opinions regarding the future of heating networks and hydrogen as a fuel. The enthusiasm for the installation of ASHPs may jeopardise a high level of premature engagement with a technology that has been implemented at an extremely low rate in the UK, which may hinder the future deployment of green hydrogen-based heating systems that can utilise the existing natural gas pipelines.

Some areas highlighted the difficulties associated with the increase in demand for electricity from the grid, the potential negative effects on fuel poverty, the inadequacies of the EPC in relation to carbon reduction, and the relative expense of ASHPs in relation to their contribution to decarbonisation. Several regions raised concerns over the existing cost estimates for ASHPs and retrofits. Greater London's policy was remarkable for its emphasis on the full building and promotion of building renovation passports as a means of generating a more sophisticated approach to retrofitting and facilitating better information management around stock and plans.

5.3.1. Monitoring, evaluation, and reporting

Both the combined authority and MCC have constituted specific committees to monitor progress, develop policy and consider the broader issues around decarbonisation. The meetings at the combined authority and MCC seem well-serviced, well attended and offer scrutiny. In this aspect, MCC’s compares favourably to the sample of other local authorities, as demonstrated in the heuristic analysis presented in Table 3.

Table 3: Heuristic assessment of environmental performance reporting

Reporting	Manchester	Liverpool	Leeds	Birmingham	Greater London
Dedicated committee	Yes	Yes	Yes	No	Yes
Frequency of meeting	Quarterly	Not yet met	Quarterly (no meetings since March)	No	Quarterly
Data dashboard	Yes	No	No (Roadmap approved March 22)	No	No
Reporting against targets	Yes	No	No	No	No
Benchmarking	No	No	No	No	No
Annual evaluation	Yes	No	No	No	Yes
Clear thread to strategic targets	Yes	No	Not yet	No	No
Number of clicks to access	4	4	6	Lots and registration	6
Combined authority link	Yes	Not apparent	Yes - 6 clicks	Yes	Yes
CA Committee	Yes	Not apparent	Yes	Yes	Not apparent
Ease of citizen scrutiny	Good	Poor	Fair	Very poor	Fair

Source: Strategies and policy documents of authorities.

The results show a wide range of practices and the near absence of comparable dashboard-based reporting and no benchmarking against other localities. Citizen scrutiny is mostly difficult, and reporting is often in written form located within the agendas of committees.

6. Financing retrofit

In essence, there are two conflicting and often complementary approaches to the challenges of decarbonisation and retrofit; the first involves a fabric-first prioritisation in which the thermal efficiency of dwellings is enhanced prior to installing electrified heat. The second relies on the capacity of ASHPs to replace gas-fired central heating using low carbon electricity to rapidly reduce carbon emissions.

The challenges around both approaches to relate to the capital expenditure (capex) and operational expenditure (opex) and the cost benefit ratio, in terms of carbon reductions but also the financial returns from capital expenditure. Retrofitting poorly insulated housing with ASHPs may reduce carbon emissions but it is highly likely to increase energy costs. However, addressing thermal efficiency issues, other related property upgrades and electrified heat can involve a magnitude of expenditure which makes both the carbon reduction per pound of expenditure and the absolute level expenditure involved poor value for money.

This section of the report focuses upon approximating the costs of decarbonizing our existing housing stock, considering the time scales for decarbonisation by 2030 or later and the potential means of financing retrofit.

6.1 The cost of retrofitting the UK's housing stock

A key primary issue is enhancing the thermal efficiency of stock prior to installing an ASHP. Other issues include grid capacity, the ASHP supply infrastructure and the operational costs borne by consumers. The capital expenditure of electrification of heat is very high, whilst the process of retrofitting is invasive and carbon-intensive as existing components are removed and new components fitted. Most reports suggest a minimum expenditure of around £11,000 per unit, and in cases where the dwelling is very poorly insulated or large, estimates of greater than £70,000 per unit are common. A further complication is the need to ensure that the supply of

electricity is boosted to accommodate the increases in demand from domestic heating and the electrification of transport. Despite an extensive literature review, we have been unable to locate a model for costing the improvements to the electricity grid on a per capita basis, nor have we encountered estimates of the decommissioning costs of existing infrastructure around gas supply to domestic dwellings.

In the review of local authority retrofit strategies, we noted that the majority aimed to achieve an EPC average rating of C for their stock, or to ensure that none of the stock was below EPC C. However, an EPC C is not carbon-neutral. Therefore, carbon neutrality must address the decarbonisation of electricity either prior to or in tandem with the electrification of heat.

Within Manchester, there are approximately 231,000 homes, of which 72,000 are privately rented, 67,000 social rented, and 92,000 owner-occupied. 56% are below EPC C, around 129,000 in total. Even assuming a low average retrofit cost of £25,000 per unit, this would produce a total cost (at current prices) of £3.25 billion to bring this stock to EPC C (note that this is not carbon neutral) or nearer £6.5 billion to achieve a nearer A rating. If a 10-year programme is followed, this would mean retrofitting 13,000 dwellings per year at a cost ranging from £194m to £647m per year.

Given the tenure split in Manchester, the table and figure below identify the financial and programme requirement for each sector:

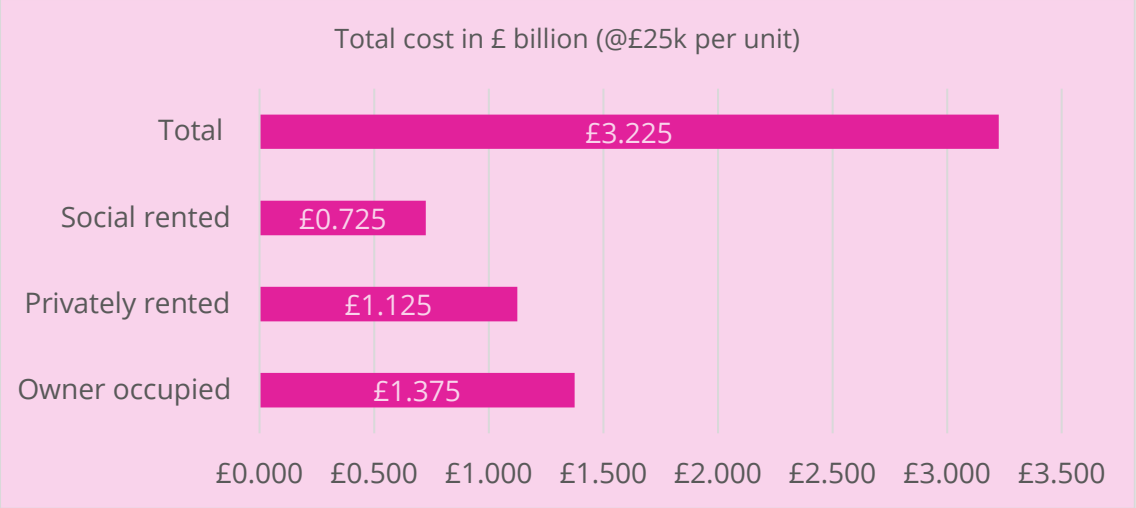
Table 4: Costs to achieve EPC C

	Total Number of housing units	Approximate Number of housing units with EPC D or less	Total cost in £billion (@£25k per unit)	Annual cost in £ million (£25k per unit)
Owner occupied	92,000	55,000	£1.375b	£137m
Privately rented	72,000	45,000	£1.125b	£112m

Social rented	67,000	29,000	£0.725b	£72m
Total	**231,000**	**129,000**	**£3.225b**	**£321m**

Note: The figures for EPCs below C in each tenure sector are based on the national average as quoted in the Buro Happold report.

Figure 2: Cost burden by sector



Expenditure of this magnitude would bring the stock to an EPC C but this would still not be carbon neutral.

6.2. Financing the cost

There are many factors to consider when discussing the financing of retrofit measures. The nature and timescale of the ambitions relating to decarbonisation are likely to cost hundreds of billions of pounds. However, we should not consider decarbonisation in isolation from other housing-related expenditures such as purchasing, maintaining, improving, and building new housing. The increase in house prices over the last two years as a quantum is likely to vastly exceed the annual cost of decarbonisation, but capturing this equity increase and directing it towards adding value to the existing stock, rather than becoming a source of wealth, is likely to challenge popular conceptions around the entitlement to tax-free gains through rising house prices.

6.3. Financial barriers to Decarbonisation

In the first instance, measures to decarbonize heating in existing dwellings are very expensive. The cost of an air source heat pump alone, with its associated radiators, pipe work, pumps, hot water storage and controls, can be around £11,000 for an average house, compared to around £2000 for upgrading an existing gas boiler system. For a heat pump to be efficient and save the householder money, extensive upgrading to the thermal installation of a property is usually required, with costs for this ranging from a minimum of around £5000 to around £60,000 for larger older properties.

Although not strictly financial barriers, there are issues around the technical performance of ASHPs as a product and uncertainties around the policy environment that can make actors reticent to invest. In terms of the technical aspects, the technology is changing rapidly and there is a likelihood that whatever is installed now may well be out of date within two or three years. In addition, the lack of an established infrastructure of ASHP installers and manufacturers means that a financial decision to retrofit housing involves issues of additional risk and timescale, as well as cost.

There are also technical challenges associated with the installation of decarbonized heat in certain property configurations and tenures. For example, high rise blocks and flats containing leaseholders will not be suited to individual ASHP-based systems. Similarly, landlords have different motives, incentive structures, regulatory contexts, and access to investment finance that will condition their propensity and capacity to invest in decarbonisation. Although social landlords have access to loan and bond based financial models, their primary duty to tenants is to ensure that their homes are safe and meet the relevant decent home standards. These requirements in themselves necessitate setting aside significant resources over the business planning periods, and there is little spare capacity for costly decarbonisation measures. Social landlords cannot increase rents to recoup the costs of decarbonisation, and, given the current cost of living crisis, any rent increases are unlikely to be accepted.

The situation of owner-occupiers will largely be conditioned by their intentions in relation to remaining in the property, their disposable income, and the equity they

have in the property. Although a significant proportion of owner-occupiers have considerable equity so far, there has been little enthusiasm to spend it on decarbonisation measures. This is linked to a key point relating to the product buy-in of householders and homeowners, with the evidence suggesting that there is little enthusiasm for decarbonized heat in the context of a strong likelihood that it will create an increase in the cost of heating.

The kWh costs of gas and electricity are an important consideration. Currently, the kWh cost of gas is around 10.5 pence, whereas electricity is around 34.5 pence per kWh. In addition, costs are currently loaded onto the electricity aspect of consumer bills for the construction of renewables, including nuclear power. Some estimate that the average household's electricity bill contains up to £153 per year to help fund renewable forms of heat and electricity[25]. Given the rising cost of energy and the massive market penetration of gas heating, it is unlikely that governments will fundamentally alter the pricing structure between gas and electricity. Hence the requirement for electrified heating to use much less energy than gas-fired central heating systems. Another complexity of the taxation environment is the fact that all home improvements, other than expenditure associated with heat pumps and energy efficiency, attract a VAT rate of 20%, whereas new construction is zero-rated.

6.4. Drivers of decarbonisation

The key drivers of decarbonisation can be considered in terms of factors which incentivize decision makers to decarbonize, the creation of regulatory and enforcement mechanisms which require decarbonisation, and mechanisms which enable decarbonisation to be funded. These three headings are used to consider the individual elements that will help finance decarbonisation.

6.4.1. Incentive structures

The government has recognised the high cost of decarbonisation and put forward a wide range of grants and subsidies. The grants and subsidies are available for a wide range of elements relating to the decarbonisation of heating, but they are

[25] Read based on the Ofgem figure available here.

mostly concerned with kickstarting the process rather than providing long-term stable funding for decarbonisation. As well as helping towards the installation and development costs of decarbonisation measures, subsidies have been offered in the past for micro-generation, including the feed-in tariff. Again, these measures have been subject to change and many of the grants offered to householders, including the green house grant, have suffered from very low levels of take-up. Governments have also recognised the disincentives created by tax treatments and, most recently, the government has suspended VAT on the installation of heat pumps as well as providing an up-front subsidy for their installation.

For individual homeowners, it is logical to seek a financial return on their investment. The promise of reduced heating bills is likely to be a key factor in the decision-making processes of homeowners and tenants who will endure considerable disruption if their landlord removes their gas central heating and replaces it with an ASHP. Homeowners and tenants will also expect any new heating system to provide advantages in terms of comfort as well as efficiency. The complexity of control systems and the need to leave ASHPs on permanently suggests that the incentives are weak. A further incentive may be linked to an owner's plans to upgrade the property, for example in the case of a major refurbishment.

6.4.2. Regulatory and enforcement mechanisms

The regulatory environment around the decarbonisation is relatively immature compared to that around new build. Whilst the building regulations govern most aspects relating to the construction of new housing and have been strengthened to incorporate zero carbon considerations, the updated Building Regulations have only recently encompassed retrofit[26].

The EPC is being promoted as a tool to enhance the energy efficiency of stock with the expectation that landlords bring all stock to EPC rating of C by 2030. In the absence of a national landlord registration scheme, it is difficult to see how this requirement will be enforced. The regulatory regime governing social landlords has not set out any clear requirements, however, the decent homes standard is under

[26] Read.

review, and this may well incorporate clear expectations relating to decarbonisation.

There are some developing mechanisms which may be useful in the future including: PAS 2035, PAS 2038 and building renovation passports. However, currently there is little in the way of regulation or enforcement to ensure that the owners of housing address the electrification of heat. In addition, the former Prime Minister has recently confirmed that homeowners will be able to replace gas boilers when they become obsolete or malfunction[27].

6.4.3. Enabling mechanisms

Given the issues noted earlier in terms of weak incentives and a relatively undeveloped regulatory framework, it is not surprising that the range of enabling mechanisms is also immature. The obvious and important mechanism is the provision of government grants to kick-start most aspects of decarbonisation. Whilst there is evidence of new products developing, such as green equity releases, green mortgages, bond issues and complex leasing schemes, there are fundamental problems in terms of how funding other than grants is repaid. Because the regulatory environment is insufficient to give equity-rich homeowners a push towards decarbonisation, then the burden is likely to fall upon social and private landlords. Until a means of raising rents to recoup these additional costs is found, landlords will simply see decarbonisation as another burden on their finances.

The sources of finance are strongly linked to tenure and ownership of stock. For owner occupiers retrofit may be financed from their own resources: perhaps linked to existing improvement plans or a change in ownership, dipping into any excess equity through raising additional loans on the property valuation or taking advantage of any government grants or subsidies such as the current boiler upgrade scheme. Private landlords may borrow in a similar manner but would hope to raise rents ultimately or enhance the valuation of their stock.

[27] Read.

Social landlords may finance improvements through the issue of bonds, raising additional loan finance or assigning specific resources from their existing asset management budgets. Under the current rent-setting regulations, social landlords will not be able to raise additional rents to finance retrofits; nor will landlords, social or private, be able to introduce arrangements whereby the energy-saving benefits which accrue to tenants are shared with the landlord.

6.4.4. Key programme risks

Thus far, the review has shown that there is a limited appetite for retrofit to decarbonize homes and that the financial mechanisms have not yet stimulated activity at the scale needed to achieve the 2030 ambitions. The introduction of generous grants and reduced VAT on heat pumps has attempted to address this reticence. Such grants and financial stimuli create a new set of risks around the promotion of an industry that is not mature, and the introduction of time-limited grant funding contains the risk of promoting a "gold-rush" mentality. The absence of a highly developed regulatory framework and a competitive market of producers and installers creates risks around cost inflation; poor quality work leading to subsequent poor performance; failure of the technology; and the attraction of fraudsters into the market so that they can claim subsidies.

The untested nature of ASHPs in the UK and the immaturity of the installation logistics also creates the risk that the new products will not deliver the promised energy efficiencies and lower energy bills, thus damaging the reputation of decarbonisation in the eyes of future purchasers. The nature of the electricity grid also creates wider risks: in the first instance the road towards full decarbonisation of the electricity grid is not at all clear and there are several estimates that by 2030 the electricity grid will still be reliant upon fossil fuels for between 25% and 40% of its output. The second key risk relating to the electricity grid is that it will take too long to put the necessary infrastructure on stream to be able to generate the level of electricity needed to power millions of heat pumps and millions of electric cars.

Within the rented sector, there is a risk that social landlords may decide to divest themselves of stock that is too expensive to retrofit, and this might fall into the hands of private landlords and other investors. The need to decarbonize the stock may push forward the obsolescence of older, smaller, terraced and flatted

accommodation. This may be a desirable outcome given the age of Britain's housing stock, but it will create a need for substantial public expenditure to clear obsolescent property and build new stock.

7. Conclusions

Although there is little debate about the need to reduce the UK's carbon emissions in accordance with the agreed-upon targets, the goals for decarbonizing residential buildings through retrofitting are incredibly ambitious and expensive.

Unfortunately, many reports attribute higher CO_2 emissions to residential housing than is actually the case, quoting amounts of 29 percent whereas the official figure for heating is 16 percent. At best, getting all residential properties in the UK to EPC level C will half these emissions at a cost of approximately £440 billion. Without concurrent and complementary activities pertaining to the other 84% of emissions, this will likely accomplish modest success at a very high cost and over a period of more than twenty years. Decarbonization of energy production and steps to cut emissions from highly polluting and inefficient cars are anticipated to be far more cost-effective and expedient to adopt.

This study illustrates the complexities, risks, and costs of programming 600,000 ASHPs and retrofits annually, which have been widely investigated in numerous previous works. There are not the necessary funds nor incentives to encourage investment from owner-occupiers or landlords on the required scale. Similarly, the cost per unit is significantly higher than that of gas-fired central heating, and the moral imperative alone will not be sufficient to convince people to bear these upfront expenses with such lengthy payback periods. The energy sector in the UK is already in a state of turmoil, and the recent price increases for gas and electricity are causing significant hardship for many people. While the huge grants offered to install heat pumps may entice the affluent, the poorer households will struggle to merely heat their houses.

According to a recent ruling by the High Court, the government's strategy, while extensive, does not appear to be entirely integrated. In many ways, it appears preferable to attain the highest levels of thermal insulation for our stock while decarbonizing the energy supply and then electrifying the heat in homes. Similarly,

the boiler upgrade programme is limited to 30,000 every year, and it is quite unlikely that this number would be exceeded because many will wait until the following grant period to make a decision.

There are, however, legal and financial changes that the government may implement to accelerate the electrification of heat.

A crucial prerequisite for any of these initiatives would be convincing decision-makers that decarbonisation is beneficial for inhabitants. Currently, there is a paucity of empirical research, but an abundance of anecdotal evidence indicating concerns with the installation of ASHPs and thermal efficiency measures, and there is little hope for decreased utility bills for homeowners. Consequently, there is little motivation for future buyers to pursue retrofitting. If there was a greater emphasis on constructing performance evaluations and better information regarding the outcomes, this may sway opinions.

Key regulatory interventions could include requiring a property to achieve EPC level C prior to sale or within a fixed period of sale; implementing a new lettable standard that applies to social and private tenants and requires a minimum EPC level C; creating a national register of properties linked to the Land Registry; and incorporating building renovation passports, similar to MOTs and vehicles.

In direct financial terms, the government may encourage greater retrofit by decreasing VAT to zero on all retrofitting components, bringing the treatment of retrofitting and new construction into parity. Furthermore, it seems highly illogical that ECO financing is still used to replace old boilers with new gas boilers, when this cash might instead be allocated to heat pumps (the fact that this is not the case may suggest a lack of confidence that heat pumps will result in lower utility costs). Similarly, the little sums paid for power generated by microgeneration offer households with little motivation to install photovoltaic panels. Fixing the kWh rate to half of the average cost of purchased kilowatt hours might be a game-changer for solar energy.

By taxing the equity of properties when they are sold, a substantial amount of funds might be obtained; this would help curb exorbitant housing prices and raise funds for retrofitting. Instead of the existing system of offering grants for heat pumps and help to buy with no income constraints, grant funding might be focused

at the poorest households with the least energy-efficient housing stock. When privately owned properties are sold, the grants may be recovered.

There are currently a multitude of privately funded sources that could facilitate retrofitting. However, their growth will be greatly contingent on convincing the public that retrofitting will result in tangible benefits. Likewise, the high transaction costs and complexity of private financing will limit its expansion.

The decarbonization of the housing stock will be a lengthy, expensive, and potentially multi-decade process. It constitutes a fundamental transformation that will affect all homes, and it is likely that a national coordinating organisation will be required for the coordination, regulation, funding, and management of such a programme. Currently, the funding arrangements are short-term and subject to frequent change, and the oversight and assurance of the entire programme are unclear.

7.1. Implications for Manchester

The city of Manchester has set extremely ambitious retrofitting goals for its housing stock. At this time, the city's ability to attain these goals is questionable, and its own monitoring reveals that it is slipping behind on its carbon reduction goals (Manchester Climate Change Agency, 2021). The report notes that a significant portion of the 2020 reductions were attributed to the pandemic and not policy. According to the same research, the annual carbon emissions per person were 5.6 tonnes, with only 0.9 tonne related to gas heating (ibid, p. 32). Again, this number demonstrates that addressing this factor on its own will not have a big impact, especially considering that flights and food and drink each accounted for 0.9 tonnes.

Manchester may wish to reconsider its overall strategic priorities, as well as its retrofitting method and goals. There are existing pilot programmes, which should be examined and monitored so that lessons can be learnt and knowledge captured. In determining specifics of a retrofitting requirement, the concerns of cost, performance, inequality, fuel poverty, public engagement, and compatibility for stock configurations will be crucial. The issue of fuel poverty is extremely pressing, and ASHPs may exacerbate the situation. Other local governments have adhered

to a stringent no-harm principle, and Manchester should assess how its policy stance compares.

Manchester is well-positioned to be an early user of the technological advancements that are entering the marketplace. Smart tariffs, building monitoring systems, improved heating controls, and engaging with institutional landlords and investment community based on environmental, social, and governance (ESG) criteria might provide an effective set of tools. If adopted, the ESG benchmarking approaches could facilitate international comparisons.

Understanding the conditions, objectives, resources, and stock suitability issues is a significant challenge for Manchester. Tens of thousands of students live in the city, and more than sixty percent of the housing stock is rented. This indicates that ASHPs and thorough retrofits will be difficult to sell to residents and landlords, but the turnover associated with a big rental sector provides an opportunity to intervene when people move out of their homes. This may seem less ambitious than a 60,000-per-year ASHP programme, but it is considerably more achievable.

Although the technology solutions are promising, Manchester's own data indicates that the journey to net zero will require a fundamental reassessment of lifestyles and expectations. The recent heatwave indicates that adaptation to weather extremes will require cooling as well as heating. As Manchester grows and becomes more densely inhabited, it will become more of a heat sink, influencing the microclimate. As the city is reshaped, it must use its opportunities to build and cultivate natural greening measures.

Selected data sources

BEIS Heat Pump Ready Programme: Stream 1 Phase 1 projects.
Read.

National energy efficiency data framework (NEED).
Read.

Renewable heat incentive (RHI) and renewable heat premium payments (RHPP) quarterly statistics.
Read.

English Housing Survey data on tenure trends and cross tenure analysis.
Read.

English Housing Survey data on energy performance.
Read.

English Housing Survey live tables.
Read.

How the population changed where you live: Census 2021.
Read.

UK Climate risk sector briefings.
Read.

IEA Oil 2021 Analysis and Forecast to 2026.
Read.

Gov.uk – Check if a heat pump is suitable for your home.
Read.

Ofgem Boiler Upgrade Scheme.
Read.

Daily energy generation statistics.
Read.

Policy platforms and performance comparisons.
Read.

Energy and emissions projections: Net Zero Strategy baseline.
Read.

Statistics on the stock of domestic properties by Council Tax Band and property attributes in England and Wales.
Read.

International comparisons on energy.
Read.

UK local authority and regional greenhouse gas emissions.
Read.

National Grid ESO.
Read.

Manchester Climate Change Agency.
Read.

Bibliography

Abid, M., Hewitt, N., Huang, M.J., Wilson, C. and Cotter, D., 2021. Performance Analysis of the Developed Air Source Heat Pump System at Low-to-Medium and High Supply Temperatures for Irish Housing Stock Heat Load Applications. Sustainability, 13(21), p.11753.

Ahern, C. and Norton, B., 2020. Energy Performance Certification: Misassessment due to assuming default heat losses. Energy and Buildings, 224, p.110229.

Association for decentralised energy, 2018. Heat Networks in the UK.

BEIS, 2020. Improving the Energy Performance of Privately Rented Homes in England
and Wales

BEIS, 2021. Heat and Buildings Strategy

BEIS. 2021a. Heat Pump Ready: Supporting Information.

BEIS, 2022. British Energy Security Strategy

BEIS, 2022a. Review of Electricity Market Arrangements Consultation Document

Burns, F., Strachan, S. and Clark, T., 2021. Heat pump use in Scotland: an evidence review.

Buro Happold, 2021. Retrofitting Social Housing: A funding roadmap. The Housing Finance Corporation.

Cantor, J., 2020. Heat pumps for the home. The Crowood Press.

Carbon Trust, 2020. Heat pump retrofit in London.

Carroll, P., Chesser, M. and Lyons, P., 2020. Air Source Heat Pumps field studies: A systematic literature review. Renewable and Sustainable Energy Reviews, 134, p.110275.

Chesser, M., Lyons, P., O'Reilly, P. and Carroll, P., 2021. Air source heat pump in-situ performance. Energy and Buildings, 251, p.111365.

Chesser, Michael et al. “The impact of extreme weather on peak electricity demand from homes heated by air source heat pumps.” Energy Sources, Part B: Economics, Planning, and Policy 16 (2021): 707 - 718.

Climate Change Committee, 2020. The Sixth Carbon Budget: The UK's path to Net Zero

Climate Change Committee, 2022. Progress in reducing emissions: 2022 Report to Parliament

Coyne, B. and Denny, E., 2021. Mind the Energy Performance Gap: testing the accuracy of building Energy Performance Certificates in Ireland. Energy Efficiency, 14(6), pp.1-28.

Demski, C. 2021. Net zero public engagement and participation: A research note. BEIS

Dixon, T., Lannon, S. and Eames, M., 2018. Reflections on disruptive energy innovation in urban retrofitting: methodology, practice and policy. Energy Research & Social Science, 37, pp.255-259
Energy and Utilities Alliance. 2021. The Upfront Cost of Decarbonising Your Home.

Energy Systems Catapult. 2021. Electrification of Heat Demonstration Project: Heat Pump Installation Statistics. BEIS

Fredericks, D., Fan, Z., Woolley, S., de Quincey, E. and Streeton, M., 2020. A decade on, how has the visibility of energy changed? Energy feedback perceptions from UK focus groups. Energies, 13(10), p.2566.

Gaur, A.S., Fitiwi, D.Z. and Curtis, J., 2021. Heat pumps and our low-carbon future: A comprehensive review. Energy Research & Social Science, 71, p.101764.

Greater Manchester Combined Authority, 2019. 5-YEAR ENVIRONMENT PLAN FOR GREATER MANCHESTER 2019-2024 https://www.greatermanchester-ca.gov.uk/media/1986/5-year-plan-branded_3.pdf

GMCA, 2022. RetrofitGM
https://www.greatermanchester-ca.gov.uk/media/6018/retrofitgm.pdf

Green Finance Institute (2020). Financing energy efficient buildings: the path to retrofit at scale. https://www.greenfinanceinstitute.co.uk/wp-content/uploads/2020/06/Financing-energy-efficient-buildings-the-path-to-retrofit-at-scale.pdf

Hårsman, B., Daghbashyan, Z. and Chaudhary, P., 2016. On the quality and impact of residential energy performance certificates. Energy and buildings, 133, pp.711-723.

HM Treasury, 2021. Net Zero Review: Analysis exploring the key issues

Hope, A.J. and Booth, A., 2014. Attitudes and behaviours of private sector landlords towards the energy efficiency of tenanted homes. Energy Policy, 75, pp.369-378.

House of Commons Business, Energy and Industrial Strategy Committee, 2022. Decarbonising heat in homes

House of Commons Environmental Audit Committee, 2022. Building to net zero: costing carbon in construction

House of Commons Library, 2022. Estimates Day debate: The Spending of the Department of Business, Energy and Industrial Strategy on action on climate change and decarbonisation

House of Commons Treasury Committee, 2021. Net zero and the Future of Green Finance

House of Lords Industry and Regulators Committee, 2022. The net zero transformation: delivery, regulation and the consumer

Ipsos, 2021. Reaching net zero – awareness and attitudes. Ipsos.com
Kempton, J., 2014. Asset Management of low-zero carbon technology in social housing. Structural Survey.

Lang, M., Lane, R., Zhao, K., Tham, S., Woolfe, K., & Raven, R. (2021). Systematic review:

Landlords' Willingness to Retrofit Energy Efficiency Improvements. Journal of Cleaner Production, 303, 127041.
Love, J., Summerfield, A., Biddulph, P., Wingfield, J., Martin, C., Gleeson, C. and Lowe, R., 2017. INVESTIGATING VARIATIONS IN PERFORMANCE OF HEAT PUMPS INSTALLED VIA THE RENEWABLE HEAT PREMIUM PAYMENT (RHPP) SCHEME.

Manchester City Council, 2016. A Housing Strategy 2016-2021

Manchester City Council, 2020. Manchester Climate Change Framework 2020-25

Manchester Climate Change Agency, 2021. Annual Report.

Manchester Combined Authority, 2022. Retrofit GM.

McElroy, D.J. and Rosenow, J., 2019. Policy implications for the performance gap of low-carbon building

Meek, C., 2021. Heat pumps and UK's decarbonisation: lessons from an Ofgem dataset of more than 2,000 domestic installations technologies. Building Research & Information, 47(5), pp.611-623.

Strong, D., 2018 Home Truths about Heat Pumps. Calor

Wang, Z., Wang, F., Ma, Z., Bai, M., & Liu, S. (2018). Experimental investigation and evaluation of the performance of air-source heat pumps for indoor thermal comfort control. Journal of
Mechanical Science and Technology, 32, 1437-1447.

Wickins, C., 2014. Preliminary data from the RHPP heat pump metering programme. DECC