Building fabric improvement and heat pump deployment: a set of policy conundrums

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Abstract

Minimum building energy efficiency standards and retrofit targets for fabric improvement have long been a cornerstone of effective policy for energy demand. However, there is increasing policy focus on residential heating (and cooling) being provided from renewable electricity via heat pumps. Do fabric standards matter anymore and, if so, why?

This paper looks at the trade-offs and policy complexity facing countries which are currently largely dependent on fossil fuel boilers for heating. What should the balance be between mandating building fabric improvement and heat pump deployment, what are the choice criteria, and who gets a say?

The paper examines building interventions through the concept of 'trigger points.' It evaluates a segmented market approach and proposes a policy framework that emphasises 'understanding first' as a strategy to facilitate informed decision-making, rather than imposing specific measures. For example, the mandate to replace all fossil-fired heating systems presents a new opportunity for policy intervention: transitioning to a new heating system can act as a trigger for at least minimal fabric improvements. The paper explores various tests associated with the 'understanding first' approach, discussing how to strike a balance between simplicity and complexity in policy. It also delves into practical considerations for implementing the 'understanding first' approach, including affordability, energy security, and fostering a just energy transition.

Understanding is identified as a necessary, but not sufficient, aspect of policy for the decarbonisation of heating. The paper concludes that while a deeper understanding is crucial, it must also translate into new narratives for different actors to enable tangible, measurable changes in the built environment. There is no one right answer – and policy needs the flexibility to recognise this. Setting minimum quality standards for deployment, and a policy framework which allows for local decision-making within nationally (and internationally) determined targets is likely to be part of the answer. This paper sets out the challenge for policy in devolution and coordination, providing a set of unresolved conundrums that future policy needs to meet. The discussion presented aims to enrich and provoke further debate, rather than offering conclusive solutions to complex problems.

Introduction

The buildings sector in Europe is a major contributor to the continent’s greenhouse gas emissions, accounting for 36% of energy-related emissions in the EU (European Council 2023). For new housing, it is already possible to build to a very high standard of fabric at little additional cost. Although countries differ in the precise efficiency and air-tightness standards they set, there is no disagreement that new homes must be designed to significantly reduce demand for space heating and cooling through a focus on fabric: the advent of low or zero carbon heating options has not altered this consensus. For existing housing – the focus of this paper – the picture is not so clear-cut.

The adoption of net zero targets has altered the urgency and the nature of change needed. When climate targets required less than 100% decarbonisation, there was a plausible logic that some fossil fuel would remain in the system long-term. But that changes with a 100% decarbonisation goal which necessitates universal adoption of zero carbon energy sources. When decarbonised energy is used for space heating, does fabric improvement and energy demand reduction still matter, and if so why?

The scale of the challenge is immense. Eradication of fossil fuels means that countries like the UK and Netherlands, where approximately 85% and 92% homes respectively are heated by natural gas, face the task of replacing nearly all home heating systems with a net zero option within 25 years, or sooner. There is a consensus that the most common domestic heating system replacement will be a heat pump powered by renewable or zero emissions electricity. This heating might be delivered through heat networks or individual heat pumps in each home, or a mixture of both. Even if the dominant net zero option were hydrogen as a replacement fuel in the gas grid, this would involve boiler replacements and other changes to the infrastructure, both inside and outside the home. For many Europeans, a heat pump will cost more to install, and may cost more to run, than their current fossil fuel system: this will not be a simple transition. In this paper, the focus is on hydronic heating systems; the possible switch from water to air as a carrier of heat (or cooling) is not considered.

The need to change heating systems across Europe is not in doubt; the question remains how much fabric improvement is needed in addition to heating system replacements. This is a profound shift in policy thinking. Previously, the energy efficiency community has worked on the assumption that all heating fuels emit CO_2 to some extent, and so all demand reduction equates to reduced emissions. But that assumption is being challenged. The prospect of cheap and abundant renewable electricity means that fuel switching alone could, in theory, be enough to reduce CO_2 emissions to zero. Fuel switching, in combination with the efficiency of heat pump technology, is a plausible route to full decarbonisation for building heating in at least some cases. The role of building fabric improvements is called into question, not because it is an inherently bad idea, but because it may not be universally needed to achieve the decarbonisation goal. Fabric improvements may still be desirable to achieve other objectives (notably the health and well-being benefits for residents; and to support local employment); but for climate change, the building fabric may be less important than previously thought. Is the previous focus on ‘fabric first’ a plausible, affordable or just route to meeting Net Zero? This is the question at the heart of this paper. It is explored using the UK as an example, addressing socio-technical, economic and environmental aspects.

The aim is not to provide definitive answers, but to advance the debate by presenting evidence and arguments to elucidate a number of detailed questions, including:

- In what circumstances are fabric improvements needed, if not everywhere?
- How ambitious do standards need to be for reducing heat loss with fabric improvements?
- Can different standards be defined for different circumstances, to be achieved through a coherent set of achievable policies?
- How can policy be designed to deliver the desired outcomes without entailing excessive cost or complexity?

The paper begins with defining key terms used, followed by a brief policy background on renovation and decarbonising the electricity sector. Then there is a targeted literature review which situates the debates about ‘fabric first’ versus zero carbon heating systems and summarises key areas of difference. Following this, a new way of managing these tensions, ‘understanding first’, is presented and developed in terms of policy approaches. Remaining policy conundrums are articulated. The paper closes with discussion and conclusions.

Defining our terms

For the purposes of this paper, we define key words and phrases, so that their meaning is clear.

‘Fabric first’ means an approach to improving the energy efficiency performance of buildings in which the design logic aims to reduce heat loss before addressing the efficient provision of building services. It typically promotes use of high-insulating individual components, low thermal bridging and well-controlled ventilation. The implications for energy use are most significant in the context of space heating (Eyre, Fawcett et al. 2023).

Retrofit is a process of making changes to buildings and technical systems in buildings so that energy consumption and associated carbon dioxide emissions are reduced, in line with energy and climate policy goals. The work involves reducing heat loss, installing low carbon heating systems such as heat pumps, as well as efficient lighting and appliances and building-integrated renewable energy technologies, such as solar panels (Killip, Fawcett et al. 2021). Different retrofit approaches exist, taking into account factors such as timing, e.g., one-off or staged interventions over time, and retrofit types, e.g., whole-house, fabric-first, single measure, deep or shallow retrofit (Fawcett and Topouzi 2019, Topouzi, Fawcett et al. 2019).

Policy background

Across Europe there is agreement, as enacted through policy, that both fabric improvements to the existing stock and replacement of fossil fuels for heating are vital to reach net zero in the building stock.

The EU and individual countries have been pursuing policies to reduce energy demand from new and existing buildings over many decades, with some notable successes (Economidou, Todeschi et al. 2020). At EU level there has been a shift from 'Nearly Zero Emission Buildings' to 'Zero Emissions Buildings' as the standard needed to meet carbon emission targets (Maduta, Melica et al. 2022). Most recently, the EU's Fit for 55 package is a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are in line with the climate goal of reducing net GHG emissions by 2030 by at least 55% compared to 1990 levels. Targets have been set for energy efficiency and the energy performance of buildings, as well as for renewable energy. The European Council and Parliament have reached provisional political agreement on a proposal to revise the energy performance of buildings directive (European Council 2023). The revised directive sets new and more ambitious energy performance requirements for new and retrofitted buildings in the EU and encourages member states to retrofit their building stock. The residential building stock will reduce the average energy consumption by 16% in 2030 and a range between 20-22% in 2035. 55% of the energy reduction will have to be achieved through retrofit of the worst performing buildings.

There are existing commitments to decarbonise electricity and to prevent new connections to gas networks and use of fossil fuels for heating at national and/or EU level. The energy price crisis of winter 2022/23 has given extra impetus to moving away from dependence on natural gas for energy security and affordability reasons (EPRS 2022). Table 1, gives a snapshot of key system characteristics and policy dates for several countries. Although national details vary, the direction of travel is the same. Setting dates to ban gas boilers in new or existing homes has proven politically contentious, with action in the UK, Germany and France being moved further into the future, primarily due to concerns about the costs to householders (Messad 2023). It is notable that the carbon intensity of electricity varies considerably by country – not only does this mean some countries have far more work to do in decarbonising electricity, it also means that the present carbon benefits of switching to electricity for heating vary. Whether that matters, when all countries have aims to move to zero carbon electricity, is open to question. Progress with electricity decarbonisation may influence the focus on fabric improvement, with countries closer to decarbonisation targets more likely to have capacity to add larger heating loads to the network.

Table 1: Decarbonisation of electricity and heating data, various European countries

	GHG intensity of electricity (CO2e/kWh), 2022/23	**Date for zero carbon electricity**	**Restrictions / bans on gas boilers**	**Net zero date**
UK	207	2035	Banned from 2025 in new homes & 2035 for all homes.	2050
Netherlands	321	2035*	New connections to network banned from 2018 all homes. Gas boilers banned from 2026 (hybrid heat pumps as minimum standard)	95% GHG reduction by 2050
France	68	2035*	Previous plans to ban boilers withdrawn. Focus on increasing HP uptake – various policies,	2050
Germany	366	2035*	Ban on gas boilers from 2026/2028 (previously 2024/25 proposed)	2045
Italy	252	2035	No date announced for gas boiler ban. Standards set for use of renewable energy in homes	2050

*Pledge by several European countries for their joint electricity network (Government of the Netherlands 2023)
Sources: GHG intensity, EU countries: (EEA 2023), UK (DESNZ and DEFRA 2023), Gas network & boilers information (Woollard 2023)

Literature review

Retrofit and fabric first

The term 'fabric first' was initially associated with Passive House standards, but 'fabric first' does not imply a defined standard. For example, in new housing where a 'fabric first' approach is taken across Europe, in some countries like Denmark and the Netherlands, building regulations are close to Passive House standards, whereas in the UK, current building standards (Part L) and proposed new Future Homes Standards are considerably less ambitious (Palmer 2020). For existing buildings, there have been many studies based on empirical evidence and modelling analysis suggesting what fabric standards for retrofit can or should be, and on what basis, whether

looking at conventional cost-benefits or taking account of multiple costs and benefits of retrofit. These often come to different conclusions. The campaign group 'Renovate Europe' call for energy demand reduction of 80% in the EU building stock by 2050 (www.renovate-europe.eu). By contrast, recent work on renovation of Germany's older building suggests that the costs of renovation are not offset by energy cost savings, even when renovating to only the most basic energy-efficiency standard, leading to questions about the value of current policy in favour of fabric improvements (Galvin 2024). Without resolving these differing analyses, this paper's assumption is that 'fabric first' means something closer to 'Renovate Europe's standards.

In addition to debating what 'fabric first' means in terms of fabric standards, it is also worth considering what 'first' means. It does not necessarily mean that fabric improvements *must* be done before installing zero carbon heating systems, rather that when considering how to reach net zero, decision-makers should first look at demand reduction options. Here, 'first' implies a priority of design intent, not necessarily a sequence in time.

Killip et al. (2021) investigate whether, and how, the market transformation approach that has been successful in many product markets could be applied to the market for repair and maintenance services. Their recommendations come under four broad headings: tighter regulation and compliance; finance and fiscal measures; improving retrofit quality and workforce competence; supporting innovative approaches. The report identifies several factors that make this service market challenging for policy to affect: complex supply chains with multiple stakeholders; and the existence of a large and mature market for mainstream renovation work, which dwarfs the market for energy retrofit.

Replacing fossil fuel heating with heat pumps

Across Europe countries differ considerably in the energy sources used to provide space and water heating, and the technical systems used to deliver warmth and hot water. In the UK and the Netherlands, heating is dominated by natural (fossil) gas used in boilers in individual homes, whereas in other countries there is a more mixed picture. In 2021, four EU countries relied more than 50% on natural gas for meeting residential heating needs: The Netherlands, Italy, Hungary and Luxembourg (Eurostat 2023).

Gas boilers have both low capital and running costs, and in countries with an extensive gas network provide the cheapest means of achieving space and water heating except in very well-insulated homes. This makes the transition to low or zero carbon heating particularly challenging. The cost of different fuel options is in part a function of government decisions around the level of taxes or levies placed on different energy sources. Across Europe, taxes and levies are 2-10 times higher on electricity tariffs than on gas, depending on the country (Rosenow, Thomas et al. 2022). In addition to capital and possibly running cost barriers, there are technical, social, supply chain and organisational barriers to the mass roll-out of heat pumps, whether deployed in individual homes or via district heat networks. Many of these challenges are similar in type to those in the retrofit sector. Current heat pump sales and new installations vary considerably by country, with for example, the Netherlands installing 7 times as many per head of population as the UK (the European laggard) in 2022 (Statistica 2023).

Lowes, Gibb et al. 2022 propose a policy toolkit for heat pump market transformation, based on coordinated action across three broad pillars: fiscal and economic context; financial incentives for installations; regulation. Their analysis of heat pump markets in five different countries shows a range of policies in place in six categories, organised here under three key themes (Table 2). In relation to building fabric improvements, the report suggests greater use of building codes for both new and existing buildings.

Table 2: Thematic grouping of proposed policies for heat pump market transformation

Thematic grouping (own analysis)	**Proposed policies (Lowes, Gibb et al. 2022)**
Enabling policy(ies)	Coordination, Communication, Installer training
Incentive policy(ies)	Tax changes, Subsidies and loans
Regulation	Minimum standards, labelling, technology bans

Other innovative approaches such as the 'Heat Pump Readiness Indicator' proposed by the Buildings Performance Institute Europe (BPIE, 2024) offer a solution to improve energy efficiency representation within Energy Performance Certificates (EPCs). By considering factors such as building location and envelope quality, the indicator should assist consumers in making informed decisions regarding building retrofits alongside their heap pump installation. This approach could be applied to residential buildings across the EU to assess their suitability for heat pump installation before and after retrofit. All these approaches aim to provide effective strategies to facilitate the implementation of heat pumps.

Debates about the role of heat pumps and fabric

Rosenow and Hamels (2023) argue that full decarbonisation requires some combination of action on both the supply side and the demand side. They support this position by arguing that action on only one side (supply or demand) is likely to entail unrealistically high cost. A combination of (relatively cheaper) actions for both supply and demand is likely to lead to the least-cost option, although exactly where the optimal least-cost figure sits is unclear. The authors cite a number of modelling studies that reach different estimates, suggesting that least-cost solutions are likely to be context-dependent, taking account of factors such as climate, initial building stock condition, existing energy supply infrastructure in place, etc. At the level of building stocks, the review of modelling studies suggests that the least-cost strategy might aim for an energy demand reduction of 30-50% from building fabric improvement, combined with heat pumps and fully renewable electricity supply. The same authors argue for a pragmatic approach to tackling this complexity, arguing that policy options need to be simple enough to be communicable and applicable. They suggest that 'efficiency first' may be a more suitable foundation for policy than 'fabric first'. The term 'efficiency' refers to both fabric measures and heat pumps, but it does not help differentiate between the two or evaluate the different possible combinations of fabric improvements and heating system replacements.

Eyre et al. (2023) follow the example of Rosenow and Hamels in questioning the validity of the 'fabric first' idea for existing buildings at two distinct levels of analysis: at the level of individual buildings, and at the level of building stocks. They suggest that 'fabric first' still makes sense for new construction. For retrofit they suggest 'understanding first' as a replacement for 'fabric first', emphasising the point that the decision-making process at any level needs to be well-informed. Eyre et al. make the case for cost-effective fabric measures to be implemented, but argue that heat pumps alone will suffice in many cases. They also identify non-cost reasons for making fabric improvements in retrofit, which may link to policy priorities other than energy, such as improved health and jobs. However, they do not set out in detail how decisions should be made to achieve the contingent choices they describe. At the level of an individual building, who should decide whether a heat pump is enough or some fabric measures are needed? At the level of building stocks, what combination of interventions is needed to achieve decarbonisation of heating in a way that is affordable, reliable and fair? And how can policy be designed to achieve the desired outcomes? The 'understanding first' approach needs to be more explicit about who needs to understand what, in what circumstances.

Fraboni et al. (2023) reviewed data about the environmental impact and the primary energy consumption of 27 space heating and cooling technologies for the residential sector as if they were adopted in 11 different European member states. The emissions of electricity-powered technologies, if not driven by the direct self-consumption of renewable energy systems, depend strongly on the region of adoption and the carbon intensity of its electricity supply. They conclude that "From a policy perspective, the incentivisation of the energy retrofitting of the building stock represents the first strategy to be implemented to create the prerequisites for heat pump installation." Their logic is that the deployment of energy conservation measures has been demonstrated to be an effective strategy to lower buildings' energy requirements and facilitate the adoption of electrical low-temperature systems. One important difference between Fraboni et al.'s approach, compared with the approach of Rosenow and Hamels, and Eyre et al., is that it considers current emissions from electricity supply, but does not mention the possibility of those supply-side emissions dropping further in the future. For Rosenow and Hamels, and Eyre et al., a dynamic interplay is anticipated between changes over time on both the demand and supply sides of the energy equation. It is known that emissions from electricity supply are not yet zero (Table 1), but in future that could change. The question then is, what might be a good balance of heating system electrification and fabric improvement in a future where all electricity is zero-carbon? Posed in this way, there is a shift in thinking needed for the energy efficiency community (including ourselves), to consider heating decarbonisation as a challenge that requires joined-up, future-focused thinking across both demand and supply (Lowe and Oreszczyn 2022).

Additional empirical data which is relevant to these debates will be collected for the UK via the Energy Demand Observatory and Laboratory (www.edol.ac.uk). This longitudinal evidence base, with smart energy meter, technical monitoring and social data from 2,000 representative households, plus additional detailed samples of heat pump and retrofit adopters, will inform modelling and future policy design. Such evidence is crucial for understanding market segmentation and identifying the narratives that can create new trigger point opportunities for retrofitting at scale, speed, and quality.

'Understanding first': concept and comparison

Introducing 'understanding first'

Following Eyre et al. (2023) the 'understanding first' concept is presented here for two different contexts and stakeholder groups: firstly at the level of individual retrofit projects, and secondly at the level of policy-making. For decision-making on individual retrofit projects 'understanding first' advocates for a nuanced perspective that goes beyond a simple binary choice between heat pumps and fabric improvements. Instead, it focuses on what is appropriate for each building, emphasising the need for a comprehensive understanding by various stakeholders—from homeowners to project teams (assessors, designers, installers, advisors, etc). This approach acknowledges that decisions related to renovation are multifaceted and complex (Wilson, Crane et al. 2015) and that homeowners' decisions have emotional and cognitive aspects (Bobrova, Papachristos et al. 2024). Building aspects considered include efficiency and optimal technical performance of the building and its systems (heating/cooling), but also indoor environmental qualities that achieve comfort, and resilience to extreme weather conditions. Evidence suggests that poorly chosen retrofit measures or installation sequences can lead to underperformance (CCC 2019). For homeowners, understanding their building's unique requirements, the necessary intervention sequence, and balancing trade-offs with cost, disruption, and other constraints are critical. The 'understanding first' approach is particularly significant at the early decision-making stage of individual building level retrofitting.

To effectively implement 'understanding first' in practice, a thorough building assessment and evaluation of its existing condition and services, as well as planning and post-improvement evaluation are essential (including quality assurance of installation and performance). Decisions for each home should be made on-site using an integrated design approach. While there are established metrics and assessment methods for 'understanding first', they are not yet mainstream and can be costly.

At the policy level, the challenge for national and local governments is to understand heating decarbonisation as a systems challenge at multiple scales, from regional and neighbourhood scale down to individual buildings. This requires fostering initiatives that support integrated approaches rather than single measures. In some instances, significant fabric improvements might be necessary, along with professional assessments to ensure homes are affordably heated, comfortable, and healthy. Such an approach allows for achieving decarbonisation and other goals at the required pace, avoiding excessive costs or inappropriate installations, which could undermine consumer confidence in technologies and market actors (Eyre, Fawcett et al. 2023).

Trigger points for retrofit

Opportunities to carry out retrofit work come at different times for different buildings, owners and occupants. These 'trigger points' are moments in time when circumstances offer better alignment between residents' choices, technical and market opportunities, and supply chain readiness (BPIE, 2017; Energy Saving Trust, 2011; Maia, Kranzl, & Müller, 2021). So, for example, the point of sale or rental can be a 'trigger point' for retrofit if furniture is being moved out of the way and/or renovation and improvement works are being planned to adapt the home to the new occupants' needs. In many cases, such trigger points can significantly reduce the costs and disruption of energy retrofit by doing the work in combination with other 'normal' renovation works. The birth of a child or having a relative move in can also be trigger point; the key is to coordinate relevant retrofit activity with other planned works. The works may be smaller than 'whole home' projects, but a room-by-room approach is valid, and can lead to significant savings if planned and followed through over time (Fawcett & Topouzi, 2019). The need to replace all fossil-fired heating systems creates a new intervention point for policy: the change of heating system can be the trigger for at least a minimum level of fabric improvements. Generally, the trigger is a market opportunity, and the theory behind the idea assumes that effective policies can be designed to make best use of these opportunities when they arise. This concept of 'trigger points' might be used more widely in policy based on 'understanding first' to facilitate informed decision-making rather than dictate specific measures. It can also help to differentiate or segment the market for mainstream renovation work and link it to retrofit.

Integrating 'understanding first' into the retrofit process

Linking ‘understanding first’ with the detailed process of retrofit enables more detailed consideration of the trigger points of various types which occur (

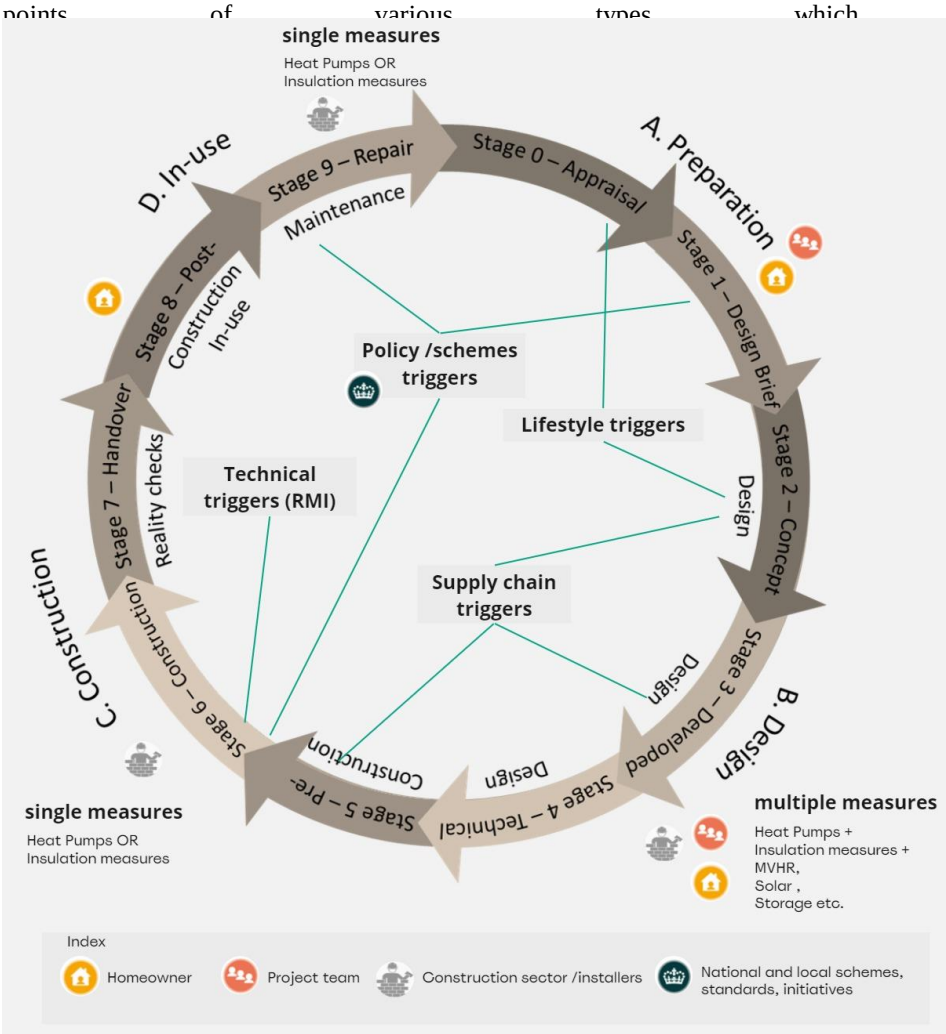

Figure 1). It also highlights the different actors involved in retrofit and the distinct markets which operate. Different markets offer different intervention opportunities – e.g. a low-income household needing to urgently replace a broken heating system needs different support and advice to make low carbon choices than the middle-income household on the point of retirement wanting to future-proof their home against rising energy and maintenance costs.

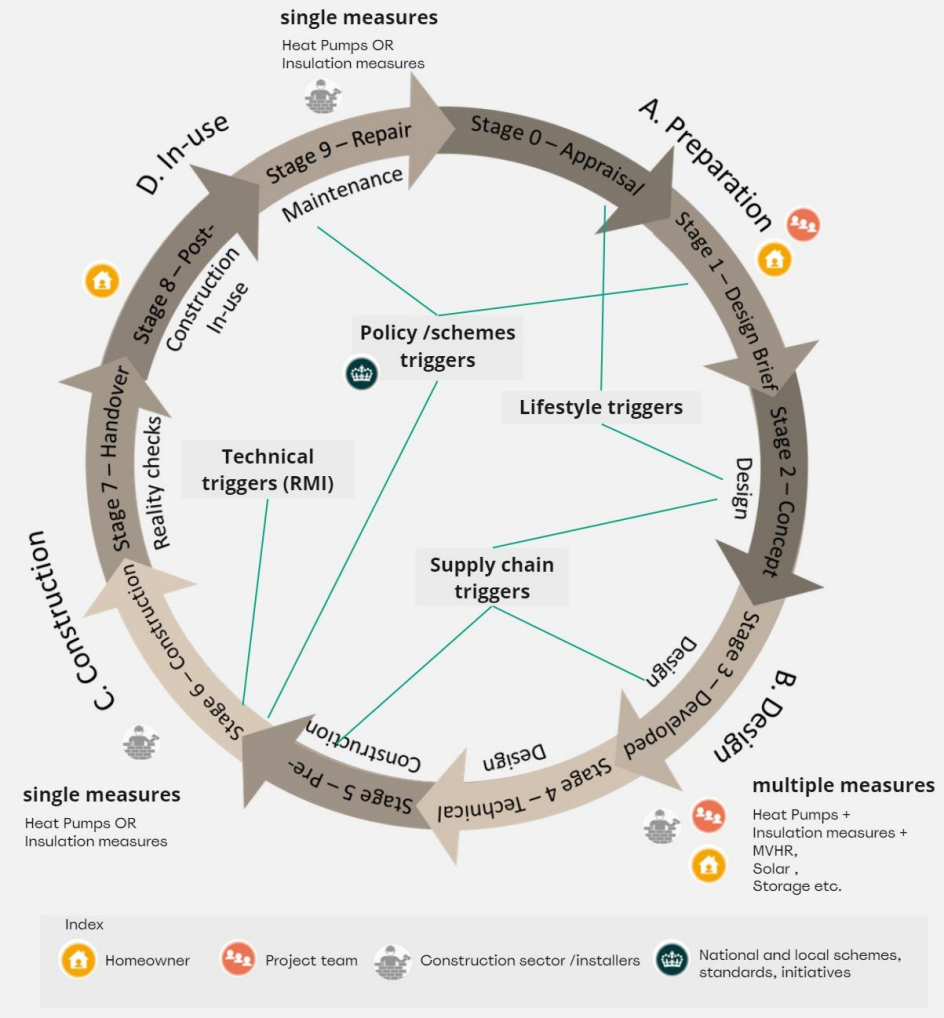

Figure 1: Trigger points within the retrofit process: stages, approaches, and actors involved. (Fig adapted from (Topouzi et al., 2019)

As illustrated in Figure 1, at project level trigger points can be activated by policy-driven financial incentives for specific measures (such as single measures like heat pumps and/or multiple measures that combine insulation and heat pumps). National and local policy triggers can be applied from the initial assessment and planning stages of a retrofit, through to construction, repair, maintenance, and improvement stages. For example, policy for heat pump deployment could include requiring a minimum EPC C rating for heat pump subsidies. This is similar to the UK government's 'Boiler Upgrade Scheme' existing subsidies for heat pump installation, which are only available to homes where certain insulation measures are installed (Ofgem 2024).

'Understanding first' can help create narratives for different actors that are essential in achieving optimal performance, especially in cases where retrofit interventions occur at the construction stage or during repair, maintenance, and improvement (RMI) projects.

This also implies a skills policy that supports the development of competence in conducting thorough whole-building assessments, producing quality designs, and ensuring proper installation. Supply chain triggers at the design and construction stages require the development of occupational standards that align with technical standards for building fabric and/or heating systems, possibly combined with incentives that reward higher fabric standards. Given the importance of details for technical triggers, this might mean, for instance, that higher fabric standards and quality of installation could lead to higher levels of retrofit grants. Lifestyle triggers can arise at any stage and be influenced by all other triggers, depending on the availability of schemes and the capacity of the supply chain and installers.

There is a noticeable gap in understanding the effect of these building level triggers and their impact on local and national retrofit policy. At the local level, energy plans have not focused on different trigger points or the needs of various actors involved (e.g., households, developers) to support their decision-making process, starting with

understanding, planning for short- and long-term interventions. Policy narratives for decarbonising heating systems at the level of region, city, or neighbourhood also mean integrating district-scale strategies to accommodate both demand- and supply-side changes, with design, operation, and emissions targets devolved to the local level. At the national level, this implies a push to incentivise higher quality, more detailed Energy Performance Certificates (EPCs) and Building Passports (GABC 2021; Volt et al., 2020; Sesana & Salvalai, 2018)– ensuring the necessary understanding is in place when retrofit or low carbon heating interventions are needed.

Comparison with other policy principles

Another way of considering the merits of 'understanding first' is to consider its pros and cons in comparison with other policy principles. Table 3 presents a first list of these, where pros and cons are in relation to meeting national decarbonisation goals (so a focus on environment, rather than affordability or energy security).

'Understanding first' is not the only alternative to 'fabric first' – other plausible approaches include 'efficiency first' - a fundamental principle already applied to policymaking, planning and investment in the energy sector - or a more targeted application of this principle via 'heating system efficiency first'. Both of these principles would have distinct benefits, but there is concern that the first is too general to help with policy dilemmas around how much improvement is needed to fabric (where and when) compared with efficiency improvements in heating systems delivered via heat pumps. Focusing only on the efficiency of the heating system, while potentially delivering good results and being relevant to all properties, would be equivalent to a declaration of 'fabric last' which this paper argues against. While a fossil fuel ban for heating is likely to be a part of any policy package delivering net zero (and is already being gradually introduced in places, see Table 1), it does not provide sufficient guidance on its own.

Table 3: Pros and cons of different policy principles in relation to meeting net zero goals

Approach	**Pros**	**Cons**
Fabric first	Beneficial, whatever the source of heat	Hasn't been achieved at significant scale Maybe becoming less relevant
Efficiency first	Covers both fabric and heating system	Doesn't differentiate; not specific enough
Heating system efficiency first	Measurable Universal coverage (all homes will need a heating system; not all homes will need fabric improvement)	Fabric may become ignored Good opportunities for fabric upgrades may be missed, not taken
Understanding first	New focus on quality of process by prioritising and planning the retrofit intervention for best performance	Requires more complex coordination of roles, skills and policy mix
Fossil fuel ban	Clear about what to stop. Likely to be an element of any policy package.	Unclear about what the replacement should be.

Discussion: Policy conundrums

There are a number of tests which arise for ''understanding first' - and indeed any proposed policy approach:

- Can the policy approach be implemented in a way which is simple enough to be effectively communicated?
- Can it be turned into a practical policy programme which will achieve decarbonisation goals in the building sector?
- How are trade-offs between providing affordable and secure energy at least environmental cost resolved? Will the policies implemented have acceptable levels of cost, reliability and fairness?

These are all complex issues which cannot be easily answered – the discussion below is just a beginning.

Balancing simplicity and complexity

There is a recurring tension between the understandable desire to keep policy simple and clear, versus the complex nature of the market transformation challenge of retrofit. The 'policy simplicity' argument would tend to favour a small number of policy interventions, with few concessions and exceptions. This is one of the characteristics of minimum standards, for example (although the process of negotiating minimum standards can be lengthy and complex). Following this logic, there is a case for supporting a policy focus on replacing fossil fuel heating systems with heat pumps. That policy might include a minimum fabric efficiency standard, but it could not be set too high because that would reintroduce more of the fabric measures – and complexity - that the policy is trying to avoid.

Segmenting retrofit market opportunities using trigger points

To move from the principle of 'understanding first' to practical and implementable policy, we need to start thinking about the policy packages which could be put in place. Different trigger points could align with multiple policies of different kinds, including regulations and financial incentives (Table 4 lists some examples).

Table 4. Possible policies for fabric improvements, based on segmentation of market opportunities

Market opportunity	**Possible policies**
Major retrofit	***Enabling policy & Regulate activity:*** Building regulations; Consequential works / consequential improvements/ conditions on permissions
Extension	***Regulate activity*****:** Building regulations
New kitchen or bathroom	***Incentivise policy:*** Financial incentives
Big maintenance and repair works	**Enabling policy & Regulate activity:** Building regulations; Consequential works / consequential improvements/
Small maintenance and repair works	***Incentivise policy:*** Financial incentives
Replacement heating system	***Regulate activity:*** Installation standards for new heating system; Minimum EPC rating

Many of the tools listed are familiar from the current policy landscape – and are known to be successful given the right context, policy mix, design and implementation. A less common approach, included in Table 4, is making use of contingent policy - 'if the situation is X, then the action should be Y'. This begins to enshrine the 'understanding first' approach at policy level. One specific example listed is 'consequential works', whereby retrofit requirements are placed on homeowners who are already investing in, say, a home extension above a certain size or value. Increasing the 'contingent' element of a policy mix also involves linking market opportunities with a variety of policy tools and new narratives. In terms of the scale of retrofit intervention, whether it involves deep (major) retrofit or significant maintenance and repair works, both cases can present opportunities for enabling policy implementation and regulation. While it is crucial to maintain simplicity in the retrofit process, it is also equally important to ensure regulatory compliance.

At least two drawbacks of this contingent policy approach can be highlighted. Firstly, the history of 'consequential works' in the UK shows that it carried high political risk, being characterised in the media as an unwelcome intrusion by the state in the private property of citizens and an attack on aspiration – a 'conservatory tax'.. The proposed legislation was quickly dropped (Mallaburn and Eyre, 2014). A second drawback is a potential misalignment between the policy intent and the interests of installers and others in the supply chain. For 'understanding first' to be effective, there needs to be a competent person (who understands) in a position to assess any given situation, advise the building owner, and act in the best interests of the building owner and the policy intent. In some cases, that may mean a market actor being expected to advise a potential customer away from commissioning a service that the market actor wishes to provide. This logic seems to lead to the need for an independent assessor/advisor to be the person who understands the market opportunity and the policy context, combining that understanding with the communication skills to explain a potentially complicated contingent policy to the resident or building owner.

Enabling a just transition

There are major questions about affordability, energy security and creating a just energy transition, whichever policy principles come to the fore. To be successful, implementing 'understanding first' at policy level in decarbonising heat also means taking into account the potential effects on inequality, especially among lower-income groups.

Questions of distributive, procedural and recognition justice are all relevant, and indeed other elements of energy justice too (Heffron, 2022). Key issues to be further investigated include:

- In policy around financing of retrofit and access to funding, who should pay (and for what)?
- Who decides a fair allocation of costs, based on what decision-making criteria?
- How can capital be made affordable and available?
- In terms of key roles, responsibility, and coordination of retrofit in decision making, who ensures that good decisions are made?
- How to ensure that actions taken on the ground are sufficient, and consistent with national policy and strategy on related topics?

Conclusions

The deployment of heat pumps, combined with the plausible decarbonisation of electricity supply in the future, calls into question the validity of a 'fabric first' approach. However, while 'fabric first' may no longer be an appropriate rule of thumb for all cases, that does not necessarily mean that it should be replaced with 'fabric last'.

'Efficiency first' may be better than 'fabric first' because it better reflects the potential of fuel switching and heat pumps in a future world where renewable electricity is cheap and abundant. However, it does not help differentiate between fabric efficiency and heating system efficiency. 'Understanding first' is an attempt to reflect the many contingencies and uncertainties in play at different levels of decision-making. However, it does not take us very far in terms of policy design for technology deployment. Better understanding may be needed, but it needs to be related to physical and measurable changes in the built environment. Understanding appears to be a necessary, but not sufficient, component of policy for heating decarbonisation.

More detailed analysis of market opportunities for retrofit could aid future policy-making, based on the idea that different combinations of regulation, information and financial incentives may be appropriate in different contexts. This does not mean that there should be no universal minimum standard for building fabric, but it does suggest that the standard may need to be less ambitious than the market or technical potential. It may also be less ambitious than previously assumed in the energy efficiency and sustainable buildings communities. Such a minimum standard could apply in combination with heat pump deployment. In parallel, where there are other market opportunities to achieve higher fabric standards, different approaches may need to be taken in order to achieve what modelling studies suggest is needed - the 30-50% demand reduction through fabric improvements.

The arguments in this paper are intended to inform and stimulate further debate, not to provide definitive answers. If, as we suggest, there is a need for greater understanding at project and policy level, then there is more work needed to map out the potential intervention points, and to work out the detail of policy design. The scope of the policy will need to integrate trigger points and develop new narratives for various actors, addressing topics such as skills training and quality assurance. Additionally, a greater understanding will be required to achieve policy coordination across ministries and at different scales.

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