TACKLING THE LOCAL RETROFIT CHALLENGE WITH WORLD-CLASS SOLUTIONS: HOW TO MAKE INNOVATION HAPPEN

A REPORT TO THE GREATER MANCHESTER COMBINED AUTHORITY

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Contents

Executive Summary

Most of the carbon emitted in Greater Manchester (GM) comes from the energy consumption across three sectors: transport, commercial and domestic. As part of the region's ambition to become carbon neutral by 2038, considerable emissions reductions must be achieved across all three. These are necessary to ensure that the city-region remains within the science-based carbon emissions limits set out by the Tyndall Centre for Climate Change Research. The GM preferred decarbonisation pathways are detailed in the 5 Year Environment Plan (5 YEP), which outlines core activities to be undertaken across the region to reduce its carbon footprint.

The following report focuses on the decarbonisation of the local housing stock, which emits 4 $MtCO_2$ to the atmosphere annually. In order to reduce the environmental impact of domestic energy consumption, the 5 YEP outlines the regional ambition of achieving significant energy efficiency improvements across a large portion of the local housing stock. The achievement of meaningful carbon reductions is pre-conditioned on retrofitting 61,000 local houses per year over the next five years. The region's environmental strategy also specifies the quality and sets the targets for the energy efficiency gains to be achieved, prioritising more comprehensive retrofit works. There are, however, considerable regional and national challenges hindering retrofitting to the required scale and quality.

The key barriers to deployment of deep retrofits are associated with the current policy landscape and its impact on the development of relevant capabilities. First, the government funding aimed at improving the energy efficiency of existing housing stock is limited and focuses on the deployment of cost-effective measures that deliver marginal energy efficiency improvements. Second, the energy efficiency policies are market-driven and rely on private sector to finance deployment and development of relevant innovations. Together, these translate into under-developed supply chains that are ill-positioned to deliver more comprehensive retrofits. At the same time, the available market offerings present lacklustre value for potential customers and are considered risky by potential finance providers.

The aim of this report is to provide a detailed analysis of these challenges and offer policy recommendations to the Greater Manchester Combined Authority (GMCA). The report outlines a potential pathway for coordinating a large-scale retrofit project that would address the identified barriers through a comprehensive policy mix. The report is based on a review of the academic literature, governmental reports, and white papers on the energy efficiency of existing housing stock. In addition, as part of the project, 15 interviews were conducted with Greater Manchester stakeholders from key areas of interest.

List of recommendations

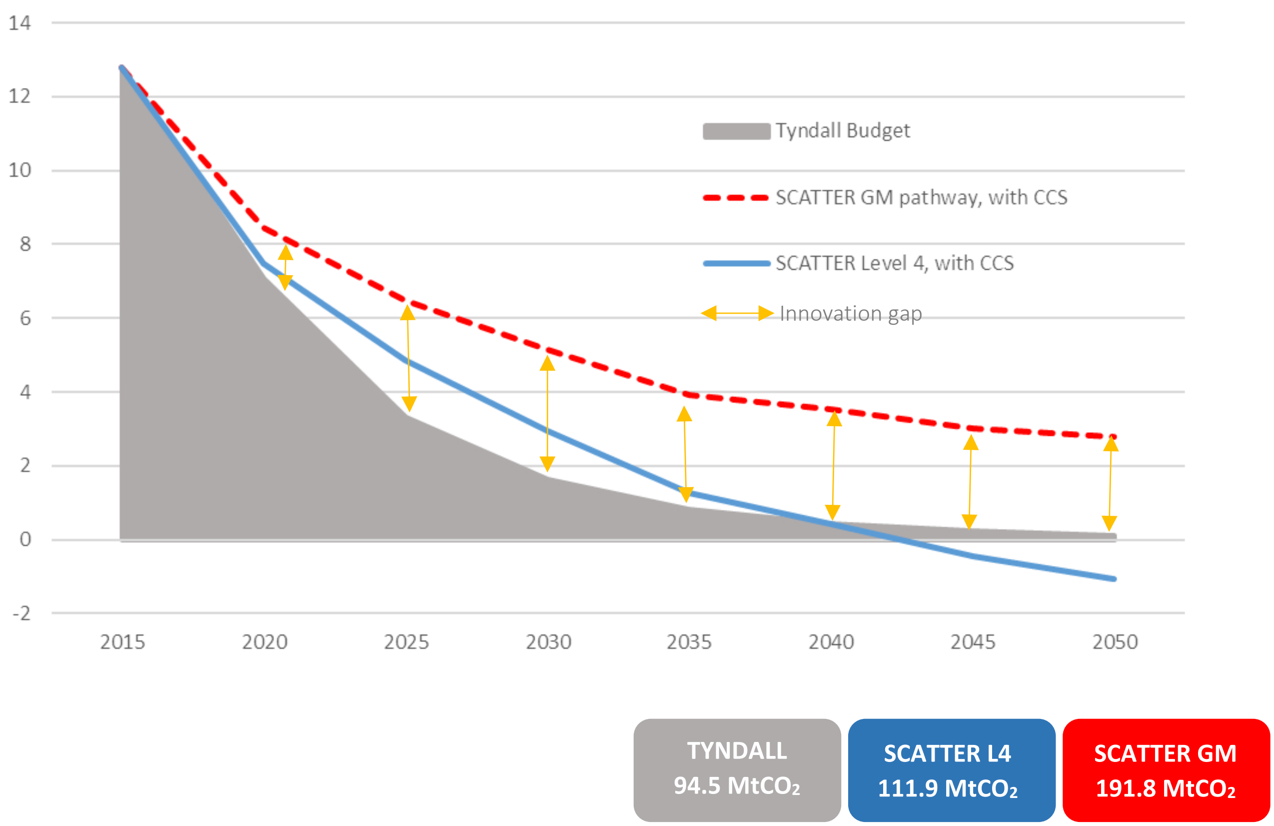
Social Landlords
Recommendation 1: Create a lead market by procuring deep retrofits of social housing stock at scale. **Recommendation 2: Enable standardization of practice and creation of technological trajectory.** **Recommendation 3: Innovate the procurement and the investment appraisal processes to enable further development of a lead market for deep retrofit and related innovations.**
GMCA
Recommendation 1: Facilitate collaboration between the graphene ecosystem, construction sector, and local manufacturers to enable effective exchange and integration of knowledge into retrofit-related innovations. **Recommendation 2: Work towards ensuring the availability of training and educational services to enable the development of relevant skills within the regional supply chain.** **Recommendation 3: Work towards establishing an Energy Service Company to disrupt the inefficient business model.**
UK Government
Recommendation 1: ECO scheme to shift focus from cost-effective retrofit measures to deployment of whole house retrofits. **Recommendation 2: Support large-scale retrofit projects in order for the supply chain to be mobilised to develop relevant capabilities, deliver cost/performance improvements and better value for customers.** **Recommendation 3: Amended the relevant regulation in order to address the barriers to large-scale deployment of whole house retrofits, and protect the emerging needs of the retrofit customers.**

1. Introduction

In March of 2019, Greater Manchester committed to the achievement of carbon neutrality by 2038. This target is aligned with the Paris Agreement commitments that aim to limit the global average temperature rise to well below 2° C. In support of achieving this goal, The University of Manchester's Tyndall Centre developed the baseline and assessed the possible pathways for achieving the carbon reductions needed. This includes a recommended budget that sets out the emissions limits of 71 $MtCO_2$ for the region (94.5 $MtCO_2$ if emissions from 2015-2018 are included).

The carbon budget for Greater Manchester is divided into 7 periods (first period: 2018 – 2022, last period: 2048 to 2100) with an underlying assumption of 50% reduction in emissions between each period (10%-20% year on year[1]). The emissions reduction targets are further embedded in the model developed using Setting City Area Targets and Trajectories for Emissions Reduction (SCATTER) tool (see Figure 1.).

Figure 1. Graph visualising the carbon reductions across two decarbonisation pathways against the Tyndall Centre's budget.



Source: SCATTER for GMCA – Technical Annex, June 2019

[1] GMCA, 2019. The 5 Year Environment Plan. Available at: https://www.greatermanchester-ca.gov.uk/media/1986/5-year-plan-branded_3.pdf

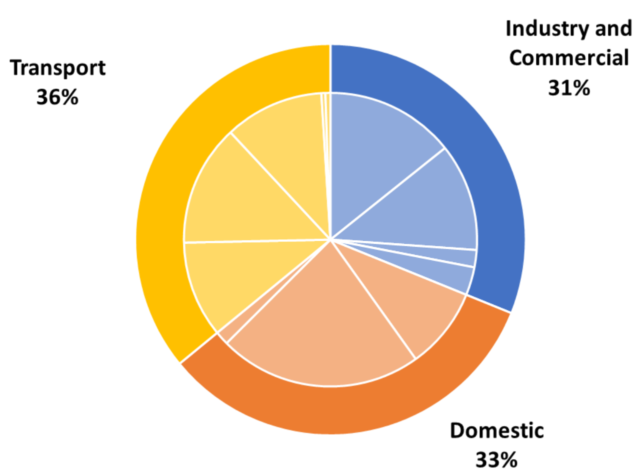
However, reducing current emissions to the levels recommended within the Tyndall Centre's budget is a major challenge. Based on the SCATTER modelling, neither the 'GM preferred' nor the 'Level 4' decarbonisation pathways align with the science-based emission limits[2].

The major challenge faced by the region is associated with the high carbon emissions levels. The achievement of significant emissions reductions requires complex and large-scale shifts across the *socio-technical systems* (see Box 1) that underpin key emitting sectors. Consequently, they require major changes in the behavioural, technological and regulatory dimensions akin to a system-level transformation.

Box 1. A *socio-technical system* describes the relationship between the society and a given technology/set of technologies. It incorporates both the individual and the institutional dimensions of how the technology is understood by its users and producers. These shared understandings include: the acceptable use cases, standard practices, and regulations. They also drive the path of technological innovation, with radical innovations associated with major shifts in societal perceptions.

According to carbon emissions data from the Department for Business, Energy and Industrial Strategy (BEIS)[3], in 2017 the three local sectors emitting large quantities of CO_2 into the atmosphere were transport, industry and domestic energy consumption (see Fig. 2), with roughly 4 $MtCO_2$ a year each. If the emissions are not reduced significantly, Greater Manchester will miss its yearly targets for the current period by an estimated 5 $MtCO_2$, or 25 $MtCO_2$ for the entire period, with total estimated emissions at more than 60 $MtCO_2$. Consequently, the final emissions limit set out for Greater Manchester for the next 80 years could be surpassed within less than a decade.

Figure 2. Carbon emissions by sector, source: UK local authority and regional carbon dioxide emissions national statistics: 2005-2017, BEIS 2019.



Transport
- **Minor roads – 11%**
- **'A' roads – 11%**
- **Motorways – 13%**
- **Transport 'Other' – 1%**

Domestic buildings
- **Electricity – 9%**
- **Gas – 22%**
- **Other fuels – c2%**

Industry & Commercial
- **Electricity – 14%**
- **Gas – 12%**
- **Large installations – 2%**
- **Other fuels -3%**

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[2] Anthesis, 2019. SCATTER for GMCA – Technical Annex.
[3] BEIS, 2019. UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2017. Available at: https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2017

With nearly 30% of the total UK energy usage[4] and 33% of the CO_2 emissions for Greater Manchester (GM) city-region[5], domestic energy consumption is one of the priority areas. If carbon reductions are to be divided equally between the most emitting sectors, the housing stock in Greater Manchester would need to reduce its carbon footprint by at least 97% (ie, to 0.12 $MtCO_2$ per year) by 2038 to remain within the science-based emission limits. Achieving such reductions requires a significant improvement of the energy efficiency of a huge portion of the local housing stock. The 5 Year Environment Plan outlines the regional objective of retrofitting 61,000 houses per year in the current budgetary period, as well electrifying the regional heating supply [6]. It also specifies the quality and sets the targets for the energy efficiency gains to be achieved, prioritising more comprehensive retrofit works that can deliver 57% - 75% reduction in the building's thermal leakiness[7].

There are, however, considerable regional and national challenges hindering retrofitting on the required scale and to the required quality. First, government funding aimed at improving the energy efficiency of existing housing stock is limited to the Supplier Obligation scheme (ie, Energy Company Obligations)[8].The scheme focuses on the deployment of single measures (deemed cost-effective), however, they deliver marginal energy demand reductions. Second, the policy framework for the achievement of higher Energy Performance Certificates (EPC band C)[9] is insufficient to create a self-sustaining market for energy efficiency. This is because EPC ratings do not translate well into energy demand reductions[10], and the policy relies on limited funding through ECO to achieve its objectives.

Furthermore, existing supply chains are ill-positioned to deliver more comprehensive retrofits. This is because supply chain actors are not sufficiently embedded within innovation systems that would enable them to develop retrofit related innovations. Third, the current market offering presents lacklustre value for potential public and private sector customers. As the cost-effective measures are deployed in isolation, the reduced energy demand is based on estimates rather than guarantees. Therefore, the retrofit is considered a risky investment for potential private investors as well as finance providers.

[4]Derived from the data set supporting the *Energy Consumption in the UK (ECUK) 1970 to 2018* report. Available at: https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

[5] BEIS, 2019. UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2017. Available at: https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2017

[6] GMCA, 2019. The 5 Year Environment Plan. Available at: https://www.greatermanchester-ca.gov.uk/media/1986/5-year-plan-branded_3.pdf

[7] Anthesis, 2019. SCATTER for GMCA – Technical Annex.

[8] Business, Energy and Industrial Strategy Committee, 2019. Energy efficiency: building towards net zero. Available at: https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/1730/1730.pdf

[9] UK Government, 2018. The Clean Growth Strategy. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

[10] Better Building Partnership, 2012. A Tale of Two Buildings. Available at: https://www.betterbuildingspartnership.co.uk/sites/default/files/media/attachment/BBP%20JLL%20-%20A%20Tale%20of%20Two%20Buildings%202012.pdf

The aim of this report is to provide a detailed analysis of these challenges and offer policy recommendations to the GMCA. The report outlines a potential pathway for coordinating a large-scale retrofit project that would address the identified barriers through a comprehensive policy mix. The report is based on a review of the academic literature, governmental reports and white papers on the energy efficiency of existing housing stock. In addition, as part of the project, 15 interviews were conducted with Greater Manchester stakeholders from key areas of interest.

1.1. The importance of energy efficiency

The bulk of emissions from domestic energy use is associated with gas and electricity consumption. In Greater Manchester, domestic electricity use accounts for around 9% of regional emissions[11], equal to 1 $MtCO_2$ emitted to the atmosphere each year. However, the highest proportion of domestic emissions comes from the gas consumed for heating and hot water. Gas used in local residential buildings emits nearly 3 $MtCO_2$ each year and accounts for 24% of regional year on year emissions. So far, efforts to reduce domestic carbon emissions have concentrated on decarbonising the UK's electricity supply through the deployment of low-carbon energy generation[12]. However, policy efforts are increasingly being targeted at the UK heating supply with focus placed on heat electrification and deployment of speculative technologies such as Carbon Capture and Storage (CCS)[13].

This, however, represents a major challenge to the electricity grid as it will result in significant increase in demand. This is because demand for energy from gas is four times as high as demand for energy from electricity; according to recent Ofgem estimates, between 1,800 – 4,300 kWh equivalent of electricity, and 8,000 – 17,000 kWh equivalent of gas is consumed annually by a typical UK household[14]. In addition, at the current rate of deployment of non-emitting energy generation, the UK will only be capable of supplying 60% of the 2050 estimated energy demand associated with electrification of other sectors (eg commercial, transport)[15].

Given that electrified heating will require a massive expansion of the national electricity grid, the Committee on Climate Change commissioned an analysis of the economic impacts of different pathways available to the UK[16]. The models developed by Imperial College London indicate that heat decarbonisation efforts will require the deployment of non-emitting energy generation at a scale of between 6 to 9 GW per year. That rate of deployment is necessary to

[11] BEIS, 2019. UK local authority and regional carbon dioxide emissions national statistics: 2005 to 2017. Available at: https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2017
[12] UK FIRES, 2019. Absolute Zero. Available at: https://www.repository.cam.ac.uk/bitstream/handle/1810/299414/REP_Absolute_Zero_V3_20200505.pdf?sequence=9&isAllowed=y
[13] BEIS, 2018. Clean growth: transforming heating - overview of current evidence. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766109/decarbonising-heating.pdf
[14] Ofgem, 2020. Typical Domestic Consumption Values 2020 Decision Letter. Available at: https://www.ofgem.gov.uk/system/files/docs/2020/01/tdcvs_2020_decision_letter_0.pdf
[15] UK FIRES, 2019. Absolute Zero. Available at: https://www.repository.cam.ac.uk/bitstream/handle/1810/299414/REP_Absolute_Zero_V3_20200505.pdf?sequence=9&isAllowed=y
[16] Imperial College London, 2018. Analysis of Alternative UK Heat Decarbonisation Pathways. Available at: https://www.theccc.org.uk/wp-content/uploads/2018/06/Imperial-College-2018-Analysis-of-Alternative-UK-Heat-Decarbonisation-Pathways.pdf

deliver the 130% - 450% increase (compared to current levels) in available renewable energy by 2050[17]. Given the variance in the renewable production, all considered pathways require large-scale deployment of costly nuclear power as well. As a result, the assessed heat decarbonisation pathways are estimated to cost £80bn to £120bn per year throughout the implementation period. This large expenditure is likely to translate into higher energy prices, which will put the most vulnerable members of the society at higher risk.

This problem is compounded by the poor state of the national housing stock, which has a considerable impact that goes beyond the environment and includes an array of social issues. For instance, an estimated 13% of GM residents struggle to cover their energy bills and live in fuel poverty[18]. Living in fuel poverty is associated with poorer mental and respiratory health[19] and contributes to 11,000 excess winter deaths[20]. While these social costs are hard to quantify, the health risk factors associated with poor housing quality have been estimated to cost the NHS around £1.6bn[21]. The investment at the levels modelled by Imperial College London are likely to increase the scale of the problem even further as they will translate into significant rise in the energy prices. This is particularly problematic if the decarbonisation efforts will focus on electric heating as electricity bills will rise sharply. According to the 2017 model by National Energy Action, a household's annual bills could rise as much as £250-£800 as a consequence[22].

Considering the issues identified above, a major improvement to the energy efficiency of the regional housing stock is necessary. First, reduced energy demand associated with improved energy efficiency is a pre-condition for cost-effective heat decarbonisation[23]. This in turn will reduce the impact of decarbonised heating supply on deprived communities and will support inclusive sustainable transition. In addition, energy demand reductions associated with improved energy efficiency will translate into reduced regional domestic emissions. This is because efficient low-carbon heating solutions can only be viably deployed if the building's thermal efficiency is optimised. Without improving the building's energy efficiency, such solutions will continuously rely on back-up heating from gas and electricity[24].

[17] Ibid.
[18] BEIS, 2020. Fuel poverty statistics. Available at: https://www.gov.uk/government/collections/fuel-poverty-statistics
[19] Institute of Health Equity, 2020. Health Equity in England: The Marmot Review 10 Years On. Available at: http://www.instituteofhealthequity.org/resources-reports/marmot-review-10-years-on/the-marmot-review-10-years-on-full-report.pdf
[20] E3G, 2018. UK has sixth-highest rate of excess winter deaths in Europe. Available at: https://www.e3g.org/docs/E3G_NEA_Cold_homes_and_excess_winter_deaths_Press_Release.pdf
[21] National Energy Action, 2018. Health & Housing Sectors Tackling Fuel Poverty and Cold-Related Ill Health Together. Available at: http://www.nea.org.uk/wp-content/uploads/2019/02/NEA-Under-One-Roof-FULL-REPORT-FINAL-Feb-19.pdf
[22] National Energy Action, 2017. Heat Decarbonisation: Potential impacts on social equity and fuel poverty. Available at: http://www.nea.org.uk/wp-content/uploads/2017/09/Heat-Decarbonisation-Report-2017.pdf
[23] Business, Energy and Industrial Strategy Committee, 2019. Energy efficiency: building towards net zero. Available at: https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/1730/1730.pdf
[24] BEIS, 2018. Clean growth: transforming heating - overview of current evidence. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766109/decarbonising-heating.pdf

1.2. Nature of the innovation gap

In the context of retrofit, two socio-technical systems need to be considered. The micro system (building-level) refers to retrofit technologies and their interactions with each other as well as the behaviour of occupiers. At this level, the biggest issue during retrofit works is related to the lack of adequate project coordination. In combination with limited consideration for the performance of the final retrofit design, this can lead to consequences that reduce the comfort of living at the retrofitted property. These unintended project outcomes have, over the years, damaged the public image of retrofit as a concept[25].

The delivery failures are a result of the imperfections within the macro (regional innovation) system, which lacks the capability to deliver whole-house retrofits to the desired standard. In addition, the focus on cost-effective measures deployed in isolation means that the regional ecosystem lacks the necessary capacity to deliver innovations that would target specific retrofit issues systemically. This lack of capacity to develop and acquire knowledge in turn translates into undeveloped supply chains and lack of skills.

In addition, trust issues exist on both sides of the market. The development of new capabilities requires significant financial and time commitment from businesses. The lack of well-articulated demand, and policy shifts that have detrimentally affected the market before take-off, means that retrofit has been an uncertain investment for years. While potential customers lack the trust in what the market has to offer, the supply chain actors lack the trust in what is demanded now and will be demanded in the future.

The next section (Section 2) briefly discusses the issues that impact the quality of comprehensive retrofits and positions them against existing standards. It demonstrates that, while relevant technologies and best practices already exist, diffusion is the key innovation gap. After providing an overview of what should be expected from local supply chains in Section 2, Section 3 diagnoses the reasons for the lack of regional skills and capacity.

[25]Pettifor, H., Wilson, C. and Chryssochoidis, G., 2015. The appeal of the green deal: Empirical evidence for the influence of energy efficiency policy on renovating homeowners. Energy Policy, 79, pp.161-176. Available at: https://doi.org/10.1016/j.enpol.2015.01.015

2. Micro (building level) system

Figure 3. Photos illustrate the outcomes from the retrofit project in Preston that affected 390 homes. The occupiers reported water penetration, damp and mould. Some of them were forced to vacate the property. Source: Passive House Plus, 2018[26].

A key challenge in retrofitting is addressing the thermal 'leakiness' of buildings. One of the most concerning issues associated with deployment of these measures is the interplay between the air quality and the fabric's air tightness. In recent years, several retrofit projects deployed in the UK have proven unsuccessful, with one government-funded project considered particularly detrimental to the retrofit brand (ie Preston retrofit project, see Figure 3)[27].

In order to alleviate these issues, it is important to consider each building as a socio-technical system where technological elements are in constant interaction with the behaviour of the occupiers. If this behaviour remains unchanged despite the improved thermal performance of the building, this may result in the rise of the internal temperature to uncomfortable levels. In addition, the improved air tightness in conjunction with the occupier's way of life could lead to higher levels of humidity and have a significant impact on the air quality.

These interactions are embedded in a systemic approach to retrofit that is at the core of several existing, albeit not widely adopted, retrofit standards (see Section 2.1 for overview). In addition, it is both adopted by important stakeholders in the GM city-region (eg Procure Plus)[28] and incorporated into GMCA implementation plans[29]. The underlying assumption of the concept is that, in order to reduce emissions, none of the retrofit measures can be deployed in isolation. At the very least, not without a detailed consideration of the way in which it will impact the property and the occupier. This in turn calls for a whole-house approach to retrofitting local housing stock.

The application of whole-house approach is only the first of many necessary steps, however. A review of the government initiative *Retrofit for the Future* offers further evidence for the limited consideration for air tightness and ventilation during installation of energy efficiency measures. Despite following whole-house principles, the occupiers reported reduced comfort of living associated with indoor temperature and air quality. In addition, the review identified performance-related issues, as only 3 out of the 45 assessed cases reached the 80% emissions reduction target[30].

The inconsistency across the delivered projects, in combination with widely accepted notion[31] that the UK construction sector lacks the necessary skills to rise to the challenge of retrofitting more than 24 million properties, triggered the *Each Home Counts* review in 2016. In order to address the skills and

[26] Passive House Plus, 2018. Disastrous Preston retrofit scheme remains unresolved. Available at: https://passivehouseplus.ie/news/health/disastrous-preston-retrofit-scheme-remains-unresolved
[27] Ibid.
[28] Procure Plus, 2020. Homes as Energy Systems. Available at: https://www.procure-plus.com/case-studies/homes-as-energy-systems/
[29] GMCA, 2019. Decarbonising Greater Manchester's existing buildings.
[30] Gupta R., Gregg M., Passmore S., Stevens G., 2015. Intent and outcomes from the Retrofit for the Future programme: key lessons. Building Research & Information, 43, 435–451. Available at: https://www.tandfonline.com/doi/abs/10.1080/09613218.2015.1024042
[31] Bonfield, P., 2016. Each Home Counts: Review of Consumer Advice, Protection, Standards and Enforcement for Energy Efficiency and Renewable Energy. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/578749/Each_Home_Counts__December_2016_.pdf

project coordination issues identified in the review, the UK government has moved towards developing a standard framework for the delivery of quality retrofit.

2.1. Existing standards for whole house retrofit

There are several standards that tackle the issues described above. These are characterised by an advanced mode of delivery that incorporates tools for accurate assessment of the retrofit outcomes. The consideration for interaction of technologies and risk-based project management means these represent a trusted offer that delivers quality and results on both the energy demand and carbon emission reductions. Since these standards focus on whole-house retrofit, they are also considered to represent a radical system-level innovation[32]. The most notable examples of retrofit standards are the EnerPhit and Energiesprong. While both offer considerable energy demand reduction with performance guarantees, there are, however, differences between the two.

EnerPhit builds on the *Passivhaus* standard for new build. It integrates the 'fabric first' model with a systemic approach that considers the interactions between the deployed measures and their impact on other elements within the system. The utilisation of the Passive House Planning Package as a tool for retrofit planning alleviates concerns around unintended consequences resulting from installation of single measures, and enables stepwise retrofit delivery to the desired quality. Considerable gains in energy efficiency are further capitalised by the deployment of on-site renewable energy generation, which in combination with heat pumps, solar thermal, and mechanical ventilation with heat recovery (MVHR), enable the EnerPhit-certified buildings to be self-sufficient (Fig. 4).

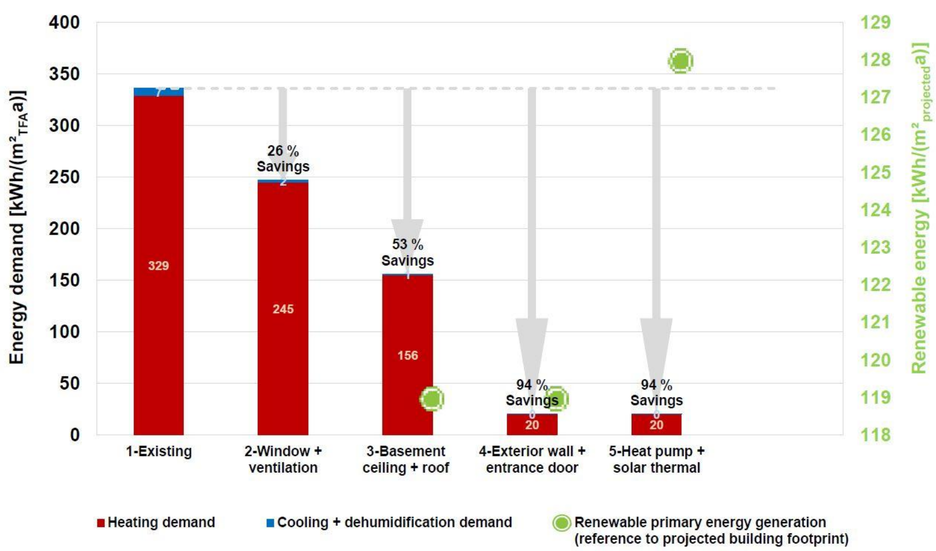

Figure 4. The energy demand reductions (kWh per m²) achieved at each stage of the retrofit. As the measures improve the building's thermal performance and ventilation, the energy demand for cooling and dehumidification decreases. From Stage 3, the retrofit also includes on-site renewable generation, which in combination with heat pumps and solar thermal can supply the total energy demand for the retrofitted building. Source: Passive House Institute, 2016. [33]

[32] Brown, D., 2018. Business models for residential retrofit in the UK: a critical assessment of five key archetypes. Energy Efficiency 11, 1497–1517. Available at: https://link.springer.com/article/10.1007/s12053-018-9629-5

[33] Passive House Institute, 2016. Step by step retrofits with Passive House components. Available at: https://europhit.eu/sites/europhit.eu/files/EuroPHit_Handbook_final_Optimized.pdf

The Energiesprong standard also focuses on reductions in thermal leakiness of buildings as well. The careful consideration of the system's elements enables the retrofitted buildings to significantly reduce energy demand while providing comfort to the occupier by improving air quality and internal temperature. The Energiesprong mode of delivery is significantly different to EnerPhit's, however, as it focuses on installation of modules that integrate the fabric of the building (Fig. 5).

Figure 5. Conceptualisation of the Energiesprong model for retrofit delivery.

This modular approach provides high levels of control for the thermal performance of the building as it is effectively 'enveloped' with a layer of new walls with integrated windows and doors. The integrated modules are manufactured off-site and transported onto the construction site. The same off-site manufacturing approach is also applied to the roof that integrates solar PVs, which – in combination with heat pumps and MVHR – enables the building to be energy independent. The model emphasizes one-off deployment and is possibly applicable to 42% of all houses in the UK[34]. Given its focus on industrial production of modules, the Energiesprong retrofit can be delivered within a week. However, the modules are currently only being manufactured in the Netherlands.

The whole-house approach has also been integrated with the recently released BSI project delivery standards (PAS2035) and retrofit technical specifications (PAS2030), which build on the Passive House Planning Package tool[35] to ensure careful consideration for the project outcomes. As an overarching framework that outlines specifications for the delivery of quality retrofit, the government's intervention in this area represents a major step towards facilitating the uptake of retrofit. Specifically, this intervention focuses on the lack of skills within the roles necessary for the delivery of retrofits by reducing uncertainty through soft touch regulation. In addition, the PAS2035 requirements written into project funded through ECO3 is likely to somewhat facilitate the uptake of the standard among the contractor-base[36].

Nonetheless, the policy surrounding the deployment of retrofit measures in the UK remains market-driven and its capacity to mobilise the sector to deliver the necessary energy demand reductions is dubious. More significantly, the largest funding scheme in England (Energy Company Obligation) is ill-suited to address the wider macro system failures, which manifests in a lack of capabilities and limited adoption of whole house retrofit standards.

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[34] Green Alliance, 2016. Reinventing retrofit: How to scale up home energy efficiency in the UK. Available at: https://www.green-alliance.org.uk/resources/reinventing_retrofit.pdf

[35] Retrofit Academy, 2019. PAS2035: What is it and what does it mean for you?. Available at: https://www.retrofitacademy.org/wp-content/uploads/2019/10/PAS-2035.pdf

[36] BEIS, 2019. ECO 3: Improving consumer protection consultation IA. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/822619/ECO3_Improving_Consumer_Protection_Consultation_Impact_Assessment.pdf

3. Macro (regional innovation) system failures

Box 2. The innovation system failures are embedded in wider systemic imperfections that result in limited capacity of the system to exploit, develop and transfer new knowledge. The inability of the system's participants to engage in these activities has a direct impact on the outputs of the system (i.e. products and services) as well as its capacity to change. The latter is crucial to ensure that new knowledge is effectively translated into relevant practices, new outputs and capabilities. Some of the key imperfections identified in the academic literature include:

- Capabilities failures
- Infrastructural failures
- Interaction or network failure
- Institutional failures

Source: Klein Woolthuisa, Lankhuizenb & Gilsing, 2005[37]

In context of comprehensive retrofits, multiple innovation system failures have been identified. These extend beyond the capabilities failures mentioned thus far and include all system imperfections conceptualised in the academic literature (see Box 2 for overview). This section describes the infrastructural and network failures present within the macro system and provides a brief analysis of the underlying reasons for their existence. In addition, it also touches on some of the soft and hard institutional failures that further hinder the transformation of the regional innovation system.

The capabilities failure results from the supply chain's inability to deliver whole-house retrofits reliably and consistently. Section 3.1 provides a brief overview of how existing capabilities have developed along the trajectories set by public funding schemes. Beyond deploying whole-house retrofits, supply chain actors are also incapable of delivering the innovations that would address cost/performance and retrofit-specific issues. Part of the reason for this systemic imperfection is related to the lack of a market for such innovations (see Section 3.2). However, it is also related to the wider characteristics of the UK construction sector. According to the UK Government reports, the construction sector has one of the lowest innovation[38] and productivity rates[39] out of all UK industries. The latter is indicative of two key infrastructural failures experienced within the industry.

The first infrastructural failure is associated with the limited availability of training and education providers that would facilitate the development of relevant skills. Specifically, in context of retrofit, these include project coordination, assessment, and design[40]. Training options are limited both on the national and the regional level, which can be attributed to two key factors. First, as the market demand has thus far been dominated by ECO funding focusing on single energy efficiency measures, there has been limited market for advanced training. Second, the dominant business model has not supported the diffusion of whole-house retrofit standards associated with advanced energy efficiency measures. The lack of standardization means that both educational providers and their customers experience uncertainty regarding the trajectory for the development of relevant skills and technologies. In addition, as the sector relies on low-skilled labour, this failure is further embedded in its wider characteristics and mode of operation. While the latter showcases the absence of infrastructure around the transfer of

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[37]Klein Woolthuis, R. J. A., Lankhuizen, M., & Gilsing, V., 2005. A system failure framework for innovation policy design. Technovation, 25(6), 609-619. Available at: https://www.sciencedirect.com/science/article/pii/S0166497203002037

[38] BEIS, 2020. UK Innovation Survey 2019: Headline findings covering the survey period 2016 – 2018. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/873740/UKIS_2019_Headlines_Findings.pdf

[39] Cast Consultancy, 2016. The Farmer Review of the UK construction Labour Model. Available at: https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2016/10/Farmer-Review.pdf

[40] Bonfield, P, 2016. Each Home Counts: Review of Consumer Advice, Protection, Standards and Enforcement for Energy Efficiency and Renewable Energy. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/578749/Each_Home_Counts__December_2016_.pdf

knowledge and diffusion of innovative practices, another failure exists that limits the capacity for the development of new knowledge.

Thus, the second infrastructural failure is associated with access to the infrastructure for the development and testing of new ideas. As a result, very few businesses from the industry advantage of the regional R&D infrastructures to develop innovations. Unlike the previous infrastructural failure, this failure is associated with the lack of collaboration between the construction and the education sectors (ie interaction or network failure). The necessary infrastructure is present and well developed, yet it remains underutilised. For instance, Greater Manchester is home to several strong universities and research centres with access to advanced science-technology facilities, yet such regional research strengths are not leveraged to their full potential. Additionally, the fact that the retrofit market primarily comprises independent contractors and small businesses amplifies these issues further. Sole traders and small-and-medium sized enterprises (SMEs) lack the necessary financial and time resources to invest in innovation and up-skilling – particularly if the outcomes of such activities remain uncertain.

Finally, it is also important to mention institutional failures. As a highly regulated industry, the scope for application of innovations is limited by the regulatory frameworks that outline the specifications for acceptable practices and permitted technologies. Consequently, diverting from the tried and tested trajectories carries significant risks that may outweigh any potential gains from deployment of innovation. Finally, the policy culture (ie a soft institutional failure) surrounding the retrofit has favoured market-driven approaches to addressing the energy efficiency issues of the national housing stock. Section 3.1 provides an overview of how this approach is likely to result in the UK missing its carbon budget targets. Section 3.2 provides an overview of how these failures translate into the dominant business model for the delivery of retrofits and ultimately stifles diffusion of advanced energy efficiency measures.

3.1. The market for retrofit so far

Section 2.1 showcased some of the relevant radical system-level innovations that could play a crucial role in reducing the carbon emissions from the regional housing stock by reducing its demand for energy. Nevertheless, the diffusion of said innovations is very limited – a situation that can be partially attributed to UK policy approach on the energy efficiency of national housing stock.

The UK Government's efforts to tackle housing stock inefficiencies and associated social and environmental challenges date back to early 2000s, with an implementation of energy efficiency policies such as the Warm Homes and Energy Conservation Act 2000, and the Utilities Act 2000. Subsequent years have seen further commitments to the reduction of energy demand embedded in the 2008 Climate Change Act targets, and an announcement of zero-carbon new built plans. Between 2002 and 2008, the sector has seen a considerable activity under the Supplier Obligation towards improving energy efficiency of the national housing stock.

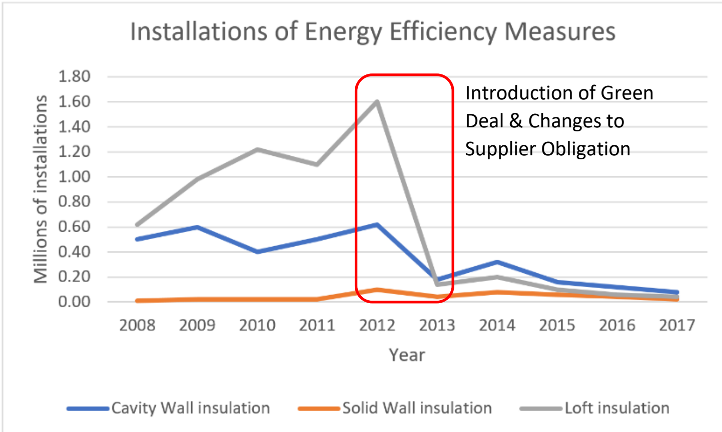

Figure 6. Installation rates of the energy efficiency measures in England under the goverment schemes. Source: Business, Energy and Industrial Strategy Committee, 2019[41].

While fighting climate change was deprioritised in the wake of the financial crisis, the upward trend in the adoption of energy efficiency measures persisted. The installation rates of energy efficiency measures funded by the government programmes had been steadily increasing from 2008 onwards and peaked in 2012[42]. Following the success of Supplier Obligation, the government decided to restructure the scheme and run it alongside the Green Deal programme targeted at 'able to pay' customers. As Supplier Obligation (managed as part of Energy Company Obligation from 2013) was reduced and the government has looked to the market to deliver investments through a pay-as-you-save repayment model, the installation rate of energy efficiency measures fell drastically (Fig. 6). As of 2017/2018 the installation rate was 95% lower than that for 2012[43] and remains nearly 90% below the levels required to meet the EPC Band C targets[44].

Effectively, the current market-based approach means that the low hanging fruit of 32% reduction in household emissions[45] is unlikely to be realised in the foreseeable future. Furthermore, the available funding schemes focus on single measures, while further emission reductions (going beyond the 32%) are associated with whole-house retrofits. Thus, the available schemes fail to create the market for more comprehensive retrofits that would drive the development of relevant regional capabilities and diffusion of relevant innovations. Most importantly, however, the focus on the single measures deployed in isolation should be considered as the key issue with uptake among 'able to pay' customers. Given the upfront cost of the retrofit measures (particularly the deeper ones) and the uncertain outcomes, the finance providers have seen little value in offering loans to retrofit customers. These issues are further reflected in the current business model that underpins the retrofit.

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[41] Business, Energy and Industrial Strategy Committee, 2019. Energy efficiency: building towards net zero. Available at: https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/1730/1730.pdf

[42] Committee on Climate Change, 2019. UK Housing: Fit for the future?. Available at: https://www.theccc.org.uk/publication/uk-housing-fit-for-the-future/

[43] Business, Energy and Industrial Strategy Committee, 2019. Energy efficiency: building towards net zero. Available at: https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/1730/1730.pdf

[44] BEIS, 2020. Household Energy Efficiency Statistics. Available at: https://www.gov.uk/government/collections/household-energy-efficiency-national-statistics

[45] Committee on Climate Change, 2015. The Fifth Carbon Budget—the next step towards a low-carbon economy. Available at: https://www.theccc.org.uk/wp-content/uploads/2015/11/Committee-on-Climate-Change-Fifth-Carbon-Budget-Report.pdf

3.2. Issues with the current business model

The most dominant business model for the delivery of comprehensive retrofit in the UK is the *atomised* business model[46]. Its atomised nature is related to the fact that the delivery of a comprehensive retrofit is associated with a stepwise and uncoordinated installation of energy efficiency measures (Fig. 7). According to Brown (2018)[47] and Brown et al. (2019)[48], this model reflects the ever-evolving nature of the UK housing energy efficiency policy and does not support integration or standardization. Policy shifts have targeted each aspect of energy efficiency separately, with some not being targeted by funding schemes at all. Consequently, retrofit measures are deployed in isolation, with the focus being placed on those measures that are deemed most cost-effective. This has several consequences for what the customer can expect from the retrofit.

First, this business model does not support a whole-house approach (see Section 2) and associated energy savings are uncertain. This uncertainty is embedded in the estimated rather than guaranteed energy efficiency gains and associated demand reductions, which do not translate effectively into the energy bill savings. Since the performance of installed measures is not guaranteed, customers lack incentives to invest in their property, particularly as the retrofit work may not translate into increased property value as well. In addition, this represents a major risk for potential finance providers offering capital under a pay-as-you-save repayment model. This has been identified as one of the pitfalls of the Green Deal[49] . In combination with the exclusion of more comprehensive retrofits from the programme, it resulted in a limited uptake among 'able to pay' customers. Second, the uncoordinated nature of project delivery can have unintended consequences (described in Section 2). This means that any deeper work carried out on the property may reduce the comfort of living to the occupier, thus failing to achieve the expected retrofit outcomes.

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[46] Brown, D., 2018. Business models for residential retrofit in the UK: a critical assessment of five key archetypes. Energy Efficiency 11, 1497–1517. Available at: https://link.springer.com/article/10.1007/s12053-018-9629-5

[47] Ibid.

[48] Brown, D., Kivimaa, P., Rosenow, J. and Martiskainen, M., 2019. Overcoming the systemic challenges of retrofitting residential buildings in the United Kingdom: a herculean task?. In: K. Jenkins and D. Hopkins, ed., Transitions in Energy Efficiency and Demand: The Emergence, Diffusion and Impact of Low-Carbon Innovation. New York: Routledge. Available at: Google Books

[49] Rosenow, J. & Eyre, N., 2016. A post mortem of the Green Deal: Austerity, Energy Efficiency, and Failure in British Energy Policy. Energy Research & Social Science. Available at: https://www.researchgate.net/publication/305409421_A_post_mortem_of_the_Green_Deal_Austerity_Energy_Efficiency_and_Failure_in_British_Energy_Policy

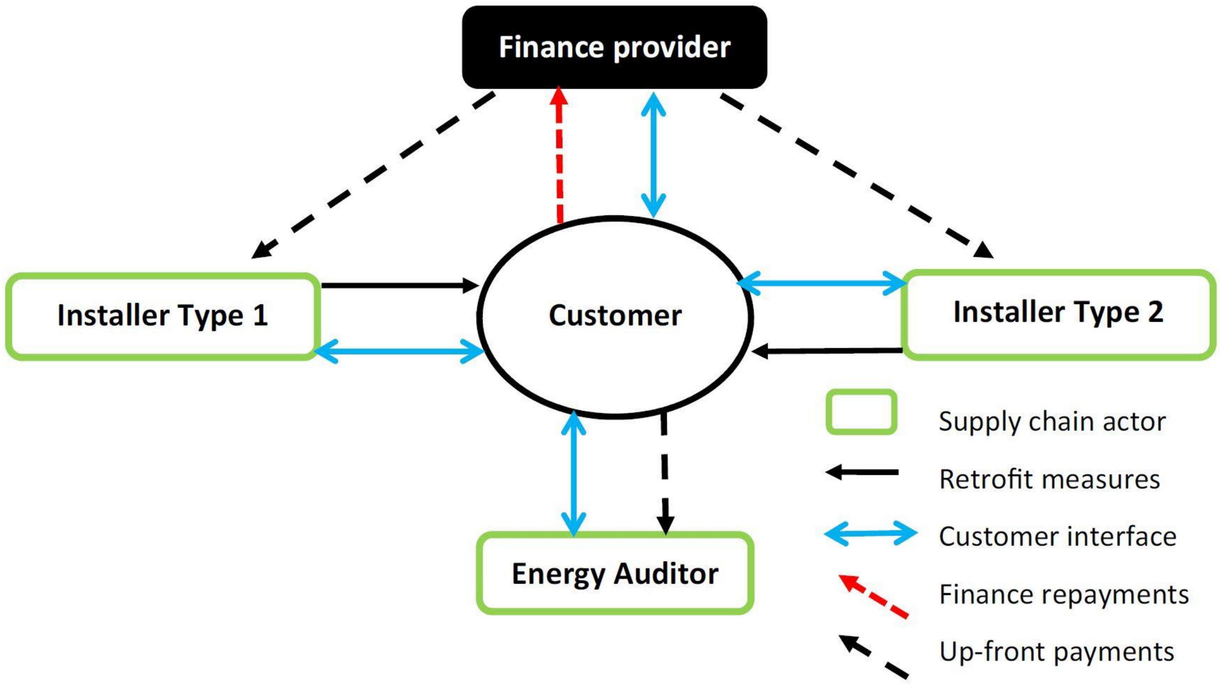

Figure 7. Conceptualisation of the atomised business model. Source: Brown, 2018[43].

This delivery model has further implications for the role of the customer during deployment. As each retrofit measure is installed by a separate contractor, the customer takes the responsibility for coordinating the entire project. This means that they act as the communication interface between each of the installers, and must deal with the complexities of the delivery of comprehensive retrofits. This can have further impact on the installation quality, particularly in relation to other measures deployed to the property. This is because factors such as the impact of air tightness on air quality are not taken into consideration due to the lack of direct coordination between installers. In addition, the delivery under this business model does not incorporate adequate assessment of the property and retrofit design. This is because both require tighter integration of the supply chain, as well as retrofit-specific roles (eg project coordinator, retrofit designed and assessor). Taken together, this translates into subpar retrofit outcomes and is associated with risk of unintended consequences materialising after the project's completion. Furthermore, this model of project coordination leaves little scope for accountability of contractors if things go wrong[50] as many of the negative outcomes are associated with the interaction of measures rather than the quality of deployment.

Finally, the delivery of retrofits under the atomised business model does not incentivise innovation aimed at cost/performance improvements. This is a result of split incentives between the finance providers and the installers. While, the latter would be better positioned to deliver such innovations, the former look to the energy bill savings to recuperate the upfront expenditure and generate profits. Under the atomised business model, the installers are unlikely to reap the rewards associated with innovations

[50] Bonfield, P, 2016. Each Home Counts: Review of Consumer Advice, Protection, Standards and Enforcement for Energy Efficiency and Renewable Energy. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/578749/Each_Home_Counts__December_2016_.pdf

while they would be responsible for investing in the R&D activity and learning. Consequently, the business model represents a major challenge to the diffusion of comprehensive retrofits as it is misaligned with the wider objectives of the whole-house approach.

4. Policy recommendations

The below section describes the policy recommendations that address the issues discussed throughout the report. At their core, these recommendations are designed to facilitate the transformation of the regional innovation system. Consequently, they target key elements that have been identified as hindering the development of regional capabilities for the delivery of whole-house retrofits. Beyond the deployment of the retrofit, these policy recommendations also address the issues associated with innovation. This is to tackle the key barriers in the diffusion of advanced energy efficiency measures, namely their upfront cost. In addition, the focus on innovation has been integrated in anticipation of maximising the economic value generated for the region that is associated with the large-scale retrofit deployment. The core objective of this exercise is to create a complementary policy mix with each of its elements acting to reinforce the impacts of the other.

4.1. The role of social landlords

The deployment of comprehensive retrofits in Greater Manchester is currently limited to small-scale demonstration and pilot projects that focus on 10s or, at most, 100-200 houses[51]. While proof of concept and demonstration projects are important to facilitate the development of relevant knowledge and best practices, they have a limited capacity to provide the local system with a new direction. This is because the market created through such endeavours has no critical mass that would attract financial and time commitments to develop relevant capabilities at scale. Consequently, articulating the demand for whole-house retrofit is the first step that will accelerate the development and diffusion of retrofit-related innovations. The high volume of properties to be retrofitted will reduce the uncertainty around the concept and will attract investments into the development of relevant capabilities. Hence:

Recommendation 1: Create a lead market by procuring deep retrofits of social housing stock at scale.

The scale of the market in this context is as important as the characteristics of the procured retrofit services. As shown in Figure 8, the Energiesprong UK estimates that it will be possible to deploy their standard in the UK without subsidies at the point where social landlords commission approximately 5,000 Energiesprong retrofits. This is since the market created by social landlords has the potential to mobilise the necessary economies of scale to drive the cost down to an estimated £50,000 with the goal of cutting it further to £35,000[52]. As social housing accounts for 22% of GM's housing stock (roughly 264,000 houses)[53], the number put forward by Energiesprong UK represents around 2% of the local social housing stock.

[51] GMCA, 2019. Decarbonising Greater Manchester's Existing Buildings.
[52] Green Alliance, 2016. Reinventing retrofit: How to scale up home energy efficiency in the UK. Available at: https://www.green-alliance.org.uk/resources/reinventing_retrofit.pdf
[53] GMCA, 2019. Greater Manchester Housing Strategy: Greater Manchester Doing Housing Differently.

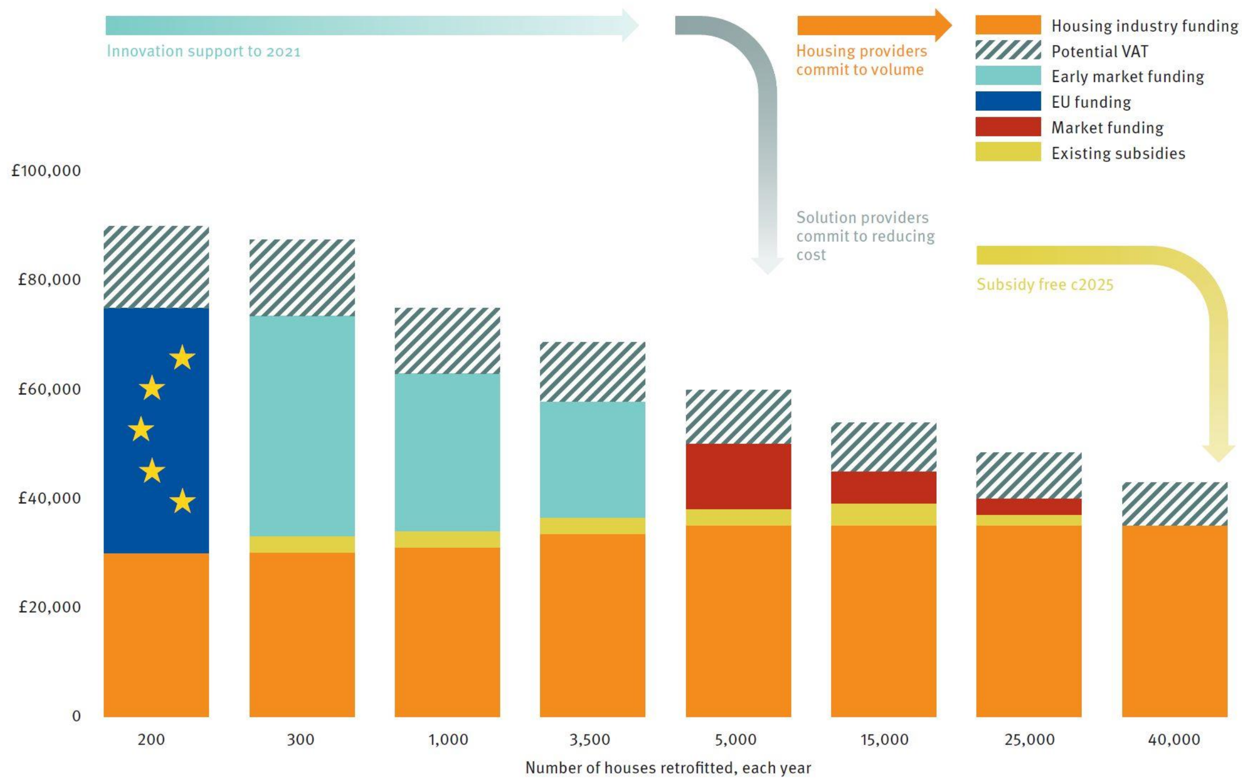

Figure 8. The Energiesprong UK model for cost reductions associated with the volume of retrofitted properties. Source: Green Alliance, 2016[54].

Regardless of which standard is adopted by the social landlords, leveraging economies of scale to drive the retrofit costs down will only be achievable if the created market facilitates standardization. The primary reason for that is associated with the fact that standardization provides a clear direction for the system. The focus on a specific standard also sends out a strong signal regarding the trajectory for expected technological and process innovations. In combination with substantial commitment, this reduces uncertainty to attract investments to build up the necessary capabilities that feed into the deployment of the supported standard. Hence:

Recommendation 2: Enable standardization of practice and creation of technological trajectory.

The two recommendations above are also associated with considerable innovations at the process level. This is because procurement will have to be used as a tool for facilitating the development of relevant regional capabilities. Hence, writing in the requirements for the standards supported by the UK Government (ie PAS2030 and PAS2035) will have to become the norm among social landlords. In addition, to leverage the suppliers' commitment to deliver the necessary innovations, procurement could be designed specifically to demand relevant innovations. Together, this will support both the diffusion of innovative technologies and practices by facilitating the uptake among the local supplier base, but also creates a market for retrofit-related innovations.

[54] Green Alliance, 2016. Reinventing retrofit: How to scale up home energy efficiency in the UK. Available at: https://www.green-alliance.org.uk/resources/reinventing_retrofit.pdf

Moreover, the costs associated with the deep retrofit of considerable portion of the social housing stock calls for further changes to the investment appraisal process. This is since the value from large initial capital expenditure can only be fully captured if the life cycle costs are taken into consideration. As a result, assessing the costs-benefits balance of deep retrofit both in terms of the value from reduced energy demand, but also reduced maintenance and repairs cost over time is necessary[55]. Hence:

Recommendation 3: Innovate the procurement and the investment appraisal processes to further enable the development of lead market for deep retrofit and related innovations.

4.2. The role of the GMCA

While the role of social landlords is primarily to create the demand for deep retrofits, the Greater Manchester Combined Authority (GMCA) will play a crucial role in creating optimal conditions for this demand to be met in a manner that delivers economic, social and environmental value for the local community. For this objective to be realised, the GMCA needs to facilitate the collaboration between stakeholders from the relevant sectors, work towards the development of the necessary knowledge transfer infrastructure, and facilitate the disruption of inefficient business models through introduction of new organisational structures. Thus, the recommendations are building further on the concept of directing the transformation of the regional innovation system, albeit on a more granular level

The Greater Manchester Local Industrial Strategy has identified several regional strengths[56] that are not fully utilised in context of whole house retrofit. Despite Greater Manchester being home to graphene, the local advanced materials ecosystem is yet to be engaged to assist in delivering relevant innovations to improve the financial viability and performance of whole house retrofits. This is despite graphene being touted as a material with significant potential to support energy efficiency gains across several product categories (see Figure 9).

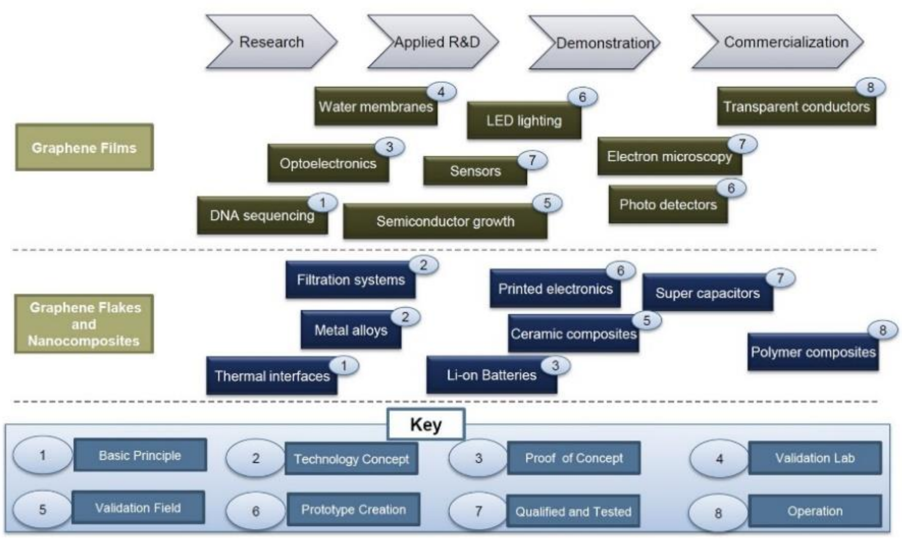

*Figure 9. Potential applications of graphene across the Technology Readiness Scale. Frost & Sullivan, 2018**

*Frost and Sullivan (2018, September 7). Industrial and Commercial Applications of Graphene. TechVision Opportunity Engines. Retrieved from Frost and Sullivan database, https://ww2.frost.com/

[55]Energiesprong, 2015. Transition Zero. Available at: https://energiesprong.org/wp-content/uploads/2017/04/EnergieSprong_UK-Transition_Zero_document.pdf

[56] GMCA, 2019. Greater Manchester Local Industrial Strategy. Available at: https://www.greatermanchester-ca.gov.uk/media/2132/gm-local-industrial-strategy-web.pdf

As graphene-related innovations are moving towards the commercialisation phase, the final steps of the process are associated with mobilising the relevant complementary assets that could enable effective market entry. This is associated with building up the manufacturers' capacity to adopt these innovations in the production of relevant goods. Consequently, Greater Manchester has already made a move towards intermediating between the local manufacturers and the advanced materials ecosystem by establishing the Graphene, Advanced Materials and Manufacturing Alliance (GAMMA). The integration of construction sector into the mix (particularly in context of the lead market created by social landlords) means that the ecosystem participants can target a considerable local market for innovation. Most importantly, the collaboration between the construction sector, local manufacturers and the graphene ecosystem has the potential to maximise the economic outcomes for the local area. This is because through such intermediation the relevant innovations are developed, designed and deployed in the region, thus ensuring that the bulk of the economic value from large public spending is captured locally. Hence:

Recommendation 1: Facilitate collaboration between the graphene ecosystem, construction sector, and local manufacturers to enable effective exchange and integration of knowledge into retrofit-related innovations.

As noted throughout the report, the supply chain lacks relevant skills to deliver quality retrofits. While inclusion of PAS2030 and PAS2035 compliance in the procurement requirements creates a drive for the development of relevant skills, this demand must be met by training and education providers. However, the availability of relevant educational services in this context is limited in the region and further afield. As part of the response to the issue, the GMCA is working towards establishing a Retrofit Accelerator (RFA), whose role would be to fill in the existing gap by acting as a knowledge repository and knowledge transfer facilitator[57]. Given the importance of RFA for the implementation of the regional retrofit strategy, the new organisational structure could facilitate the uptake of the standards supported by the UK Government by becoming an accredited training provider and certification body under the TrustMark Government Endorsed Quality scheme[58]. Regardless of whether this function will be fulfilled by RFA, the development of such training infrastructure is important as it further supports the point on the standardization of practices around the delivery of quality whole house retrofit. Hence:

Recommendation 2: Work towards ensuring the availability of training and educational services to enable the development of relevant skills within the regional supply chain.

Section 3.2 details some of the failures associated with the dominant business model for the delivery of comprehensive retrofits. There are several alternative business models that have been identified to successfully diffuse the whole house retrofit in various European contexts[59]. One of the key characteristics of the successful business models is the tighter integration of each of its elements (ie customer value and its delivery mechanisms). Starting from the value offered to customers, the retrofit customers can expect high energy efficiency gains, as well as improved comfort of living associated with internal temperature and air quality. In addition, this model emphasises the aesthetics of the final

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[57] GMCA, 2020. GMCA Retrofit Accelerator – Outline.
[58] BEIS, 2019. ECO 3: Improving consumer protection consultation IA. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/822619/ECO3_Improving_Consumer_Protection_Consultation_Impact_Assessment.pdf
[59] Brown, D., 2018. Business models for residential retrofit in the UK: a critical assessment of five key archetypes. Energy Efficiency 11, 1497–1517. Available at: https://link.springer.com/article/10.1007/s12053-018-9629-5

design to ensure that the deep retrofit increases the market value of the retrofitted building. Together, the energy bill savings and the increase in the property value offset the upfront cost of comprehensive retrofit delivered under this business model.

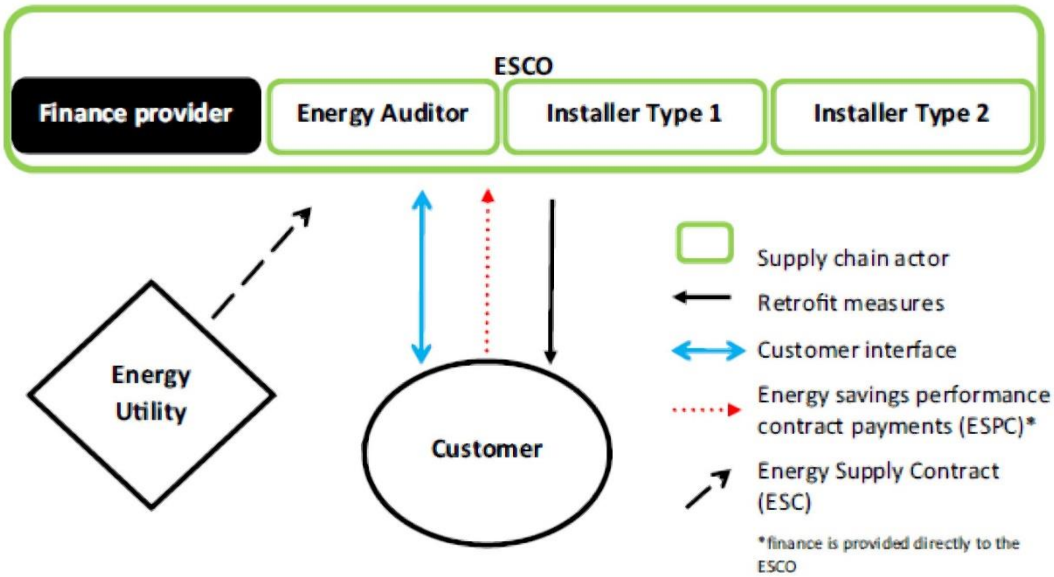

Figure 10. Conceptualisation of the fully integrated business model. Sources: Brown, 2018

At the centre of the integrated business model for comprehensive retrofits, is an Energy Service Company (ESCO). This organisational structure is responsible for ensuring the quality of the installation by providing technical assistance and oversight during implementation. This is associated with the tight integration of the supply chain, where ESCO takes the full responsibility for the project coordination and the delivery to the required standard. This should allow ESCO to offer performance guarantees, which are the pre-condition for this model's success. Energy bill savings are the ESCO's primary revenue source and any inefficiencies can compromise the organisation's ability to utilise the net-zero energy demand model. This model aims to ensure that the building produces as much energy as it consumes, thus becoming energy independent.

Under this business model structure, the occupier pays for energy as a service rather than for the commodity it is produced from, which is the case in the context of the traditional consumer-supplier relationships. The integrated business model creates an attractive offer for patient finance providers as well as for institutions with longer acceptable payback periods (eg social landlords). This is because energy bill savings accumulate over time, which allows for the capital expenditure to be recuperated. In addition, the existence of an ESCO has the potential to facilitate innovation as the organisation responsible for deploying energy efficiency measures is also the actor that reaps the rewards from cost/performance improvements associated with innovation. This, together with the integration of supply chain, creates optimal conditions for such innovations to materialise. Hence:

Recommendation 3: Works towards establishing an Energy Service Company to disrupt the inefficient business model.

4.3 The role of UK Government

Beyond the tools available to the GMCA and key stakeholders in the social housing sector, the implementation of the recommendations listed above may require the UK Government's intervention at the national level. Specifically, there are two key areas in which the national government could facilitate the diffusion of whole-house retrofit standards. The GMCA and social landlords have a role to play in lobbying for the below recommendations to be implemented by the central government.

The first recommendation is associated with the objectives of the UK Government's policy that supports the deployment of energy efficiency measures. As described in Section 3.1, the ECO scheme is ill-fitted to enable the supply chain to build up the necessary capabilities to deliver deep retrofits. Its focus on cost-effective measures also makes it insufficient to improve the energy efficiency of national housing stock significantly. A change of the ECO scheme's structure, as well as its objectives, should be considered as a pre-condition for improving the housing stock's energy efficiency at scale. Hence:

Recommendation 1: ECO scheme to shift focus from cost-effective retrofit measures to deployment of whole-house retrofits.

In addition to shifting focus from single measures to comprehensive retrofits, more funding must become available overall. The report from the Business, Energy and Industrial Strategy Committee[60] suggests that improving the energy efficiency of UK residential buildings should be treated as a major infrastructure project. Consequently, it requires similar levels of public sector investment. As it stands, the Committee on Fuel Poverty estimates that there is a £15bn gap in available funding to achieve the EPC band C targets by 2030[61]. Frontier Economics estimates the EPC band C targets funding gap to be as high as £4.5bn per year[62]. Crucially, the target of improving the energy efficiency of UK houses to reach EPC band C is nowhere near the energy demand reductions and the costs associated with comprehensive retrofits, which suggests an existence of even larger gap in this context. Hence:

Recommendation 2: Support large-scale retrofit projects in order for the supply chain to be mobilised to develop relevant capabilities, deliver cost/performance improvements and better value for customers.

There are also two key areas of UK regulation that have the potential to stifle the levels of investment from social landlords. The first one is associated with the Right to Buy[63], which poses significant risk to the social landlord's ability to recuperate the upfront cost of a deep retrofit. Under the Right to Buy regulation, council tenants can buy the property they occupy at a discount, which has the potential to cannibalise the increased property value associated with comprehensive retrofit delivered under the integrated business model. Similarly, Right to Switch[64] is considered particularly problematic in context

[60] Business, Energy and Industrial Strategy Committee, 2019. Energy efficiency: building towards net zero. Available at: https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/1730/1730.pdf

[61] Committee on Fuel Poverty, 2018. Third Annual report. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754361/Committee_on_Fuel_Poverty_Annual_Report_2018.pdf

[62] Frontier Economics, 2017. Affordable Warmth, Clean Growth. Available at: https://www.frontier-economics.com/media/2248/affordable-warmth-clean-growth.pdf

[63] UK Government, 2020. Right to Buy: buying your council home. Available at: https://www.gov.uk/right-to-buy-buying-your-council-home

[64] Ofgem, 2016. Switching Programme Design Principles. Available at: https://www.ofgem.gov.uk/system/files/docs/2016/06/switching_programme_design_principles.pdf

of a whole house retrofit delivered by an ESCO. This is since the consumer's right to switching energy providers is not compatible with a net-zero energy demand model. As the total energy demand of a building is supplied by on-site renewable energy generation, the energy service charges cover the capital expenditure repayments rather than the cost of energy production[65]. New regulation may be required to remove these barriers to deployment, while ensuring that the consumer rights are protected adequately. Hence:

Recommendation 3: Amend the relevant regulation in order to address the barriers to large-scale deployment of whole-house retrofits and protect the emerging needs of the retrofit customers.

[65] Brown, D., 2018. Business models for residential retrofit in the UK: a critical assessment of five key archetypes. Energy Efficiency, 11, 1497–1517. Available at: https://link.springer.com/article/10.1007/s12053-018-9629-5