The Domestic Retrofit Challenge

Delivering scalable and replicable low-carbon volume-retrofits: Lessons learnt from the European context

2020 CIBSE Ken Dale
Travel Bursary Report
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"We must creatively reimagine existing buildings as part of the solution to the climate crisis."

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Acknowledgements

I have the privilege of sharing this study with you all through CIBSE and the Ken Dale Travel Bursary. It has been an amazing experience and It would not have been possible without the much-appreciated contributions from a host of individuals, institutions and companies.

My journey through the application process, being granted with funding and researching through the *United Kingdom, Germany, Netherlands, Austria and France* have been a 'once in a lifetime' experience. For their time and valuable contributions, I would personally like to thank:

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→ Mr *Uwe Bigalke*, Head Market Development Team at *Energiesprong Germany.*

Executive summary

Climate change is perhaps the defining issue of our generation and those to come, and this is due to the effect of greenhouse gas (GHG) emissions from human activities. The UK government has made a commitment for at least 68% reduction in GHG emissions by the end of the decade (i.e., 2030), compared to 1990 levels. There is also an ambitious new emissions target setting the UK on the path to net zero by 2050. As our climate emergency escalates, prioritising the retrofitting of existing buildings, over carbon-intensive new-build construction, is a vital issue to consider, and there are many aspects to this conversation.

Retrofitting our existing buildings is our biggest challenge in getting to net-zero carbon in the built environment. We need to retrofit, on average, one home every thirty-five seconds between now and 2050. That is a massive challenge we are not even close to starting.

Refurbishing of existing buildings was low down the 'wish-list'. Thankfully, things have changed, and the re-use of the built environment is being increasingly championed. A key challenge is governmental policy, which currently makes retrofit harder than it should be, falls far short of promoting the reduction of consumption, and significantly levies 20% VAT on most refurbishments as against 0% on new builds[1], often making it more expensive to re-use than to build new. Retrofitting is also typically more complex and messier than erecting a new build, with more uncertainties and demands on the project team.

1. VAT for builders. retrieved from Gov.uk: https://www.gov.uk/vat-builders

Good retrofit is a collaborative effort, and the best retrofit projects come from architects, engineers, builders, clients, and potential future occupants working together early in the design stages.

This research work explores domestic retrofit, its benefits and challenges, and how to add value to the whole process. We must start by understanding more about the problem; we know the principles of retrofit but how far should we go? Do we go for different levels depending on the building type? How much is enough and how much will it cost? How to retrofit at scale? etc.

Pioneering case studies in the European context were further exploited. The chosen case studies fall under key pilot schemes being watched carefully by the social housing sector such as Energiesprong, Enerphit and others.

Below are some takeaways that emerged from this work.
Find out more on the key takeaways in pages 96-97.

→ Finance is a big barrier to retrofit – teams need to develop and demonstrate an investable pathway to net zero.

→ Political and leadership championing is key to making a net zero project happen. It will help enable funding and support from government bodies.

→ Stakeholders need to work collaboratively to drive economies of scale and should partner up to exchange knowledge and lessons learnt.

→ Get ready to act quickly once funding becomes available – this is a vital starting point for a net zero project.

→ The actors had to be agile, flexible, cooperate and communicate one with others to make processes more fluid and contribute to success. Tenants' involvement is key to a good retrofit project.

"Worldwide we use and waste a lot of energy much of which is used in our homes. At the same time, we pay high energy bills in order to live in houses that are actually often uncomfortable because of humidity, mold and drafts."

Energiesprong Explained (2019). Retrieved from https://vimeo.com/298156304

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Setting the Context

About CIBSE Ken Dale Travel Bursary

The Chartered Institution of Building Services Engineers (CIBSE; pronounced 'sib-see') is an international professional engineering association based in London that represents building services engineers, also commonly known as mechanical and electrical engineers, architectural engineers, technical building services engineers, building engineers, or facilities and services planning engineers. It is a full member of the Construction Industry Council, and is consulted by government on matters relating to construction, engineering and sustainability. It is also licensed by the Engineering Council to assess candidates for inclusion on its Register of Professional Engineers.

The Ken Dale Travel Bursary offers young building services engineers the opportunity to experience technical, economic, environmental, social and political conditions in other countries and to examine how these factors impact the practice of building services engineering.

The Ken Dale Travel Bursary has been established by CIBSE to commemorate Ken Dale's contribution to the Institution and the building services profession. The Ken Dale Travel Bursary makes awards available, up to £4,000, to CIBSE members in the developmental stage of their career who wish to spend up to four weeks outside their own country researching aspects connected to their field of work and which will benefit CIBSE, their employer, their clients and the profession. CIBSE is especially keen to encourage applicants to take up the award for research that articulates with CIBSE's concern for the environment.

For more information, please visit:

→ *www.cibse.org/*

→ *www.cibse.org/building-services/awards/ken-dale-travel-bursary*

About the Author

With over eight years of diverse professional experience, Joey shaped an interdisciplinary work approach which draws on insights into Architectural Design, Urban Energy Planning, Sustainability Consultancy and Environmental Engineering.

Joey Aoun joined Arup's Sustainability team as a *Principal Consultant* earlier in 2022. Previously, he worked within the *Environmental Engineering* team at *Foster + Partners.*

Joey built a diverse academic background, holding a master's degree in *Architecture* (2014), a postgraduate diploma in *Green Building Technology* (American University of Beirut, 2016), and an MSc in *Urban Energy Technology and Policy* (Newcastle University, 2018). Graduated with Distinctions, his academic work was awarded at *IBPSA-USA's Project StaSIO 2019*, won the prize for the *Highest Marked Postgraduate Dissertation* at *Newcastle University*, awarded a *TEMPUS Travel Grant* (Italy & Sweden, 2016), and co-represented Lebanon in the *Arab World Architectural Exhibition* (Morocco, 2014).

Joey is a registered *Architect* overseas (MOEA, Lebanon), a *Chartered Engineer* (CEng) in the UK through CIBSE (MCIBSE), and a RIBA Affiliate member currently pursuing full chartership. As well as gaining professional accreditations: $LEED_{BD+C}$ *AP* and *WELL AP.*

More on his community engagement, Joey is a *STEM Ambassador,* a contributor to the *LETI 2020 Retrofit Workstream* and a *Guest Tutor* delivering seminars on *Net-zero Carbon Urban Futures* to *Stage II Architecture* students at *Newcastle University.*

Joey's research interest is focused on zero-carbon futures emphasizing the potential of retrofitting the existing building stock. The latter ties well with his recently published research papers on *local area energy planning for domestic heat decarbonization.* He presented his work at *ASHRAE IBPSA-USA 2020 Building Performance Analysis & Simbuild* conference in Chicago, and at the *2nd IBPSA-Scotland uSIM* conference in Edinburgh.

Through his career impact, Joey achieved several accolades. He is the 1st runner-up for the *CIBSE Young Engineers Awards 2020, CIBSE ASHRAE Graduate of the Year* category. Joey is the winner of the *2020 Ken Dale Travel Bursary* and his proposal centers on delivering replicable *Net Zero Social Housing Retrofit* in the European context. Lately, he was Highly Commended for the *Newcastle University Alumni Achievement 2021 Awards, Rising Star* category.

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Acronyms

IBPSA	International Building Performance Simulation Association
StaSIO	STAndard SImulation Outputs
TEMPUS	Trans-European Mobility Programme for University Studies
CIBSE	The Chartered Institution of Building Services Engineers
RIBA	Royal Institute of British Architects
LEED AP	Leadership in Energy and Environmental Design Accredited Professional
WELL AP	The WELL Accredited Professional
CEng	Chartered Engineer with the Engineering Council in the UK
ASHRAE	The American Society of Heating, Refrigerating & Air-Conditioning Engineers
STEM	Science, technology, engineering, and mathematics
LETI	The London Energy Transformation Initiative

Research background

Domestic retrofit will support the government in tackling climate change as well as improving the thermal efficiency of our homes and quality of living. The aim of this research work is to encourage retrofitting of existing conventional dwellings into energy efficient, healthy, and eco-friendly homes. As well as bringing value to the local community, reducing operational cost and associated carbon emissions on the global and local environment.

The housing stock in the UK changes slowly, so modifying established domestic dwellings with updated technology and materials to reduce energy use and greenhouse gas emissions is crucial if the nation is to meet its international obligations.

Research Questions

There are many issues surrounding retrofit at scale in the UK. The route to introducing higher standards and the associated costs are relatively clear for new-build properties. For retrofit, it is much more complex, and several interrelated issues must be addressed, such as:

→ How can we legislate to ensure homes are retrofitted?
→ When should retrofit happen?
→ How far/deep should retrofit go?
→ How should it be financed?
→ How can we ensure retrofits are done to a good standard?
→ How do we make sure that a retrofit does not result in damage to the building fabric?
→ How to retrofit at scale?

Research objectives

1. To research strategies, frameworks, and interdependencies in the urban retrofit design.
→ Conducting a through literature review debrief.
→ Documenting strategies employed in different retrofit projects and revealing the rational behind those.
→ Elucidating the whole project retrofit perspective and urban systems interdependencies.

2. To capture industry-wide experience of the projects' stakeholders.
→ Meeting a wide range of experts (i.e., funders, developers, design teams, project managers, contractors and occupants).
→ Seeking answers on a priorly prepared low-carbon retrofit driven questionnaire inspired by established literature[1] (see the Appendix).

3. To divulge unforeseen 'opportunities' and 'threats', by gathering practical lessons learnt from different case studies.
→ Arranging site visits.
→ Contextualising low carbon volume retrofit measures in different development contexts.

4. To inspect the scalability and replicability of low carbon volume retrofit strategies and technologies.
→ Analysing the research findings and reflecting on multiple scales of intervention (i.e., from national policy scale to technical building detailing).
→ Share best practice, data, lessons learned, evidence, case studies, resources, approaches etc.

1. What are the Barriers to Retrofit in Social Housing? (2019). Retrieved from: https://www.gov.uk/government/publications/barriers-to-retrofit-in-social-housing

This document seeks to

This document is intended to help the industry understand and deliver net zero carbon domestic retrofit. It is specifically aimed towards developers/landowners, designers, policy makers, and the supply chain. This report offers insights and practical advice on low-carbon domestic retrofit, gathering lessons learnt form pioneering case studies in the European context.

This document seeks to:

- → Aid clients and developers in setting briefs and strategies both at organisational and project levels, which are required to develop net zero carbon buildings.
- → Support design teams with easy-to-follow best practice guidance on delivering net zero.
- → Outline to planners, policymakers, local and central government what to expect for the delivery and hence the policy framework needed to deliver net zero carbon domestic retrofit.

Report structure

The work includes sharing best practice, data, lessons learned, evidence, case studies, resources, approaches etc.

The introduction outlines in further detail the magnitude of the domestic retrofit challenge that the industry faces, as well as opportunities to overcome the barriers. Four chapters follow the introduction, delving into details on delivery and implementable solutions. Each chapter forms a key component of the journey towards a successful retrofit.

The following chapters forms the skeleton of this report.

0. Setting the Context
1. Introduction
2. Domestic Retrofit Overview
3. Case Studies
4. Holistic Retrofit Approach
5. Conclusion and next steps
6. Appendix

1

Introduction

Research Background

Buildings, in all their forms, have a huge impact on the environment. Globally, the United Nations (UN) Environment Program estimates buildings are responsible for 30–40% of all primary energy used.

In the UK, buildings are responsible for about a fifth of the greenhouse gas emissions and a third of the energy demand[1]. This presents a significant challenge as well as a valuable opportunity for the built environment sector to contribute to emissions abatement and mitigation.

UK's government ratified the Paris Agreement within the UN Framework Convention on Climate Change. This agreement implied pledging to work alongside other developed nations to achieve net-zero greenhouse gas emissions by 2050 (as per the 2019's agreement update). The existing housing stock (≈26 million homes) is unarguably a key area for decarbonization, and low-carbon housing is the way forward. Low-carbon domestic dwellings take a leading role to mitigate climate change, achieve long term sustainable goals and improve our living standards at the same time.

As the vast majority of the homes (≈80%) that will be occupied in 2050 have already been built, retrofitting existing stocks represents a larger opportunity for delivering low-carbon houses.

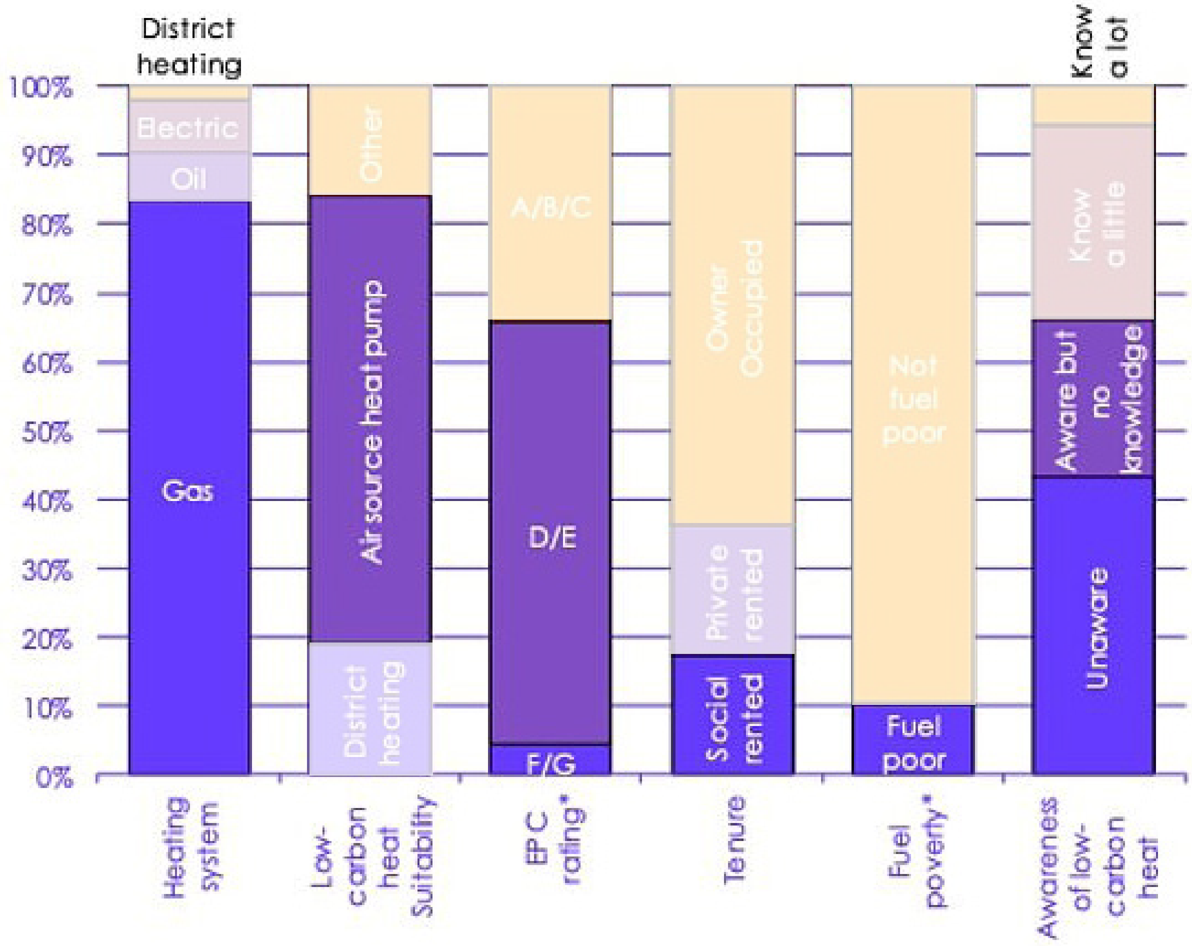
To upgrade 26 million homes by 2050, we need to deliver volume retrofits (i.e., retrofit at scale), quickly and cost-effectively and to ensure that any upgrades installed will need very few, if any, improvements in the future. Whilst the design of new zero-carbon housing developments has been researched, the potential for zero-emission retrofit in the UK is yet to be realised. Strategies, frameworks, and interdependencies in the urban retrofit design need to be researched further to meet the UK's ambitious climate change target. Curbing emissions from the built environment will play a central role.

Low carbon retrofitting of homes is not just a technical option, it is a lifestyle choice with overarching benefits!

1. Mitigating and adapting to climate change (2017). Retrieved from: https://www.ukgbc.org/news/blog-mitigating-adapting-climate-change-micro-content/

2. Retrieved from: https://www.thisismoney.co.uk/money/article-9080199/Is-property-market-facing-ticking-time-bomb.html

A breakdown of the UK's housing stock based on heating system, low carbon heat suitability, EPC rating, tenure, fuel poverty and awareness of carbon heat[2]



Sources:

- Heating system: Element Energy for CCC (2020);
- Low carbon heat suitability: Element Energy and UCL for CCC (2019);
- EPC Rating: MHCLG (2019);
- Tenure: MHCLG (2020), Scottish Government (2018), Stats Wales (2020), Department for Communities (2019);
- Fuel Poverty BEIS (2020a);
- Awareness of Low-carbon heat: BEIS (2020b).

Notes:

- EPC and fuel poverty statistics shown for England only.
- Low-carbon heat suitability reflects assessment undertaken for Net-zero advice and reflects the portion of the stock deemed suitable for air source heat pumps, net of those suitable for district heating.

COVID-19 Impact, a green recovery

Following the global COVID-19 outbreak, energy efficiency has been increasingly recognised as a vital component of achieving a 'green economic recovery'. Numerous reports have highlighted the potential for energy efficiency to deliver substantial local growth and green jobs.[1&2]

Investment in home renovation for net zero could help level-up infrastructure and opportunity across the UK, by supporting over 150,000 skilled and semi-skilled jobs to 2030. It would reduce household energy expenditure by £7.5 billion per year at today's prices.[2]

Modelling of a program to provide whole house retrofit for 9 million homes has estimated this would provide 117,811 new direct jobs in year one, rising to a peak of 382,885, in year four. This would be an average of 294,527 new jobs between 2020-2023/24, a 22% increase in total construction employment and a 162% increase in the renovation, maintenance, and improvement sector. This rises to an average of 515,157 when factoring-in indirect jobs. These measures would increase economic activity with annual Gross domestic product (GDP) 1.58% higher in 2023/24, compared with the level of economic activity otherwise expected.[1]

A focus on both local and regional growth has been central to discussions of how to drive an inclusive, green economic recovery in the wake of the pandemic. The government made 'levelling-up' the regions a key priority in the wake of the 2019 election and has continued to reiterate the importance of delivering both local growth and regeneration.

A group of 24 mayors and local leaders, representing 24 million people across the UK, have established a new 'Resilient Recovery Taskforce', calling on the Chancellor to commit to a 'New Deal for Green Skills and Growth', alongside a major push on infrastructure investment, public transport and retrofitting homes[3]. The local government association estimates that in England by 2050 there will be 1,182,197 direct jobs in the Low-Carbon economy – including those related to energy efficiency and low carbon heat. The report[4] also provides a regional breakdown of the direct jobs for all English single tier and district councils.

New research[5] from UK100 indicates that nearly half a million builders, electricians and plumbers will be needed to help meet the Government's objective of becoming Net Zero by 2050. It also shows that more than 3.1 million job posts affected by the shift to green jobs will need access to skills and training from government and industry.

1. Donal Brown, Hanna Wheatley, Chaitanya Kumar, Joanne Marshall, "A Green Stimulus For Housing: The Macroeconomic Impacts of a UK Whole House Retrofit Programme". Retrieved from: https://neweconomics.org/uploads/files/Green-stimulus-for-housing_NEF.pdf

2. EEIG, "Energy efficiency's offer for a net zero compatible stimulus and recovery". Retrieved from:https://www.theeeig.co.uk/media/1096/eeig_report_rebuilding_for_resilience_pages_01.pdf

3. UK100, "Resilient Recovery Task force". Retrieved from: https://www.uk100.org/wp-content/uploads/2020/09/Taskforce_UK100_A4_FINAL.pdf

4. LGA Research, "Local green jobs - accelerating a sustainable economic recovery". Retrieved from: https://lginform.local.gov.uk/reports/view/lga-research/estimated-total-number-of-direct-jobs-in-low-carbon-and-renewable-energy-sector?mod-area=E09000006&mod-group=AllBoroughInRegion_London&mod-type=namedComparisonGroup

5. UK100, "Call for Green New Deal as 1 in 10 jobs (3.1 million) needs reskilling as part of green recovery". Retrieved from: http://www.uk100.org/wp-content/uploads/2020/07/REVISED-FINAL-Resilient-Recovery-Taskforce-Launch-200702.pdf

"Building sustainability into the UK exit strategy from the pandemic is a win-win-win for the climate, public health and the economy."

A green Covid-19 recovery (2021). Retrieved from: https://theecologist.org/2021/feb/15/green-covid-19-recovery

2

Domestic Retrofit Overview

What is retrofit?

Retrofit can be defined as changes or upgrades that improve a building's efficiency or performance without significantly altering its bulk, scale, and form. It also includes changes to external features such as shading and landscaping.

Retrofit options are diverse; they have different installation difficulty and cost, as well as varying impacts on comfort levels and energy use. Examples range from simple fixes (i.e., changes to light fixtures, window coverings, door seals, etc.), to major modifications (i.e., solar photovoltaic panels, thermal mass, building envelope insulation, etc.). Substantial work that significantly changes the layout or use of the home, or any new home construction, falls outside the retrofit remit.

Retrofit should aim to get the most out of the building's best performance and aim for as close to new build net zero carbon performance as possible.

Deep whole-house retrofit

In the early years of retrofit, most retrofitting in the UK has involved installing small-scale standalone energy efficiency measures such as loft insulation or replacement windows. Whole-house retrofit takes a holistic approach to the property, aiming to improve the 'building fabric' (i.e., walls, windows, floors and roofs), the heating system and to install renewable energy (i.e., heat pumps, solar panels, etc.), where possible.

This approach is called 'deep retrofit' because it's a more intense holistic approach, aiming to cut carbon emissions way beyond a standard retrofit project.

Whole-house retrofit can provide huge financial, comfort, carbon and social benefits. A good retrofit also helps prevent health risks from damp and mould, reduces the risk of fuel poverty and generates local employment. The reductions in energy use and carbon emissions can be as much as 80%.

Insulation of roofs and walls, new windows and doors, small-scale renewable energy such as solar panels or district heating systems, are the basic techniques. But instead of deploying them piecemeal, as in the past, the government should start a system of "deep retrofits", by which each dwelling would receive a one-off refurbishment covering all the needed improvements and future proof people's homes.

Improving the building fabric*

Fabric First is an approach to retrofitting homes that aims to reduce demand for heat and power as far as possible, through insulation combined with adequate ventilation, before specifying services and renewables.

Improving the building fabric to minimise heat losses and maximise air tightness is sensible because insulation has a relatively low cost, a long-life and should only be required once before 2050 for most properties. Building services, by contrast, have a short life and will almost certainly need to be replaced every 10-15 years.

**Read more about building fabric retrofit measures in page 80.*

Improving building services*

It is building services that are actually responsible for using the energy in the home. Often, they are given insufficient thought and left to installers, which can result in inappropriate, oversized and poorly controlled solutions.

As a dwelling becomes better insulated and more airtight, the reduced load should result in simpler and smarter building services solutions.

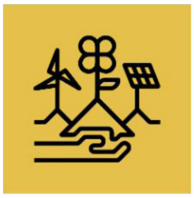
Integrating the technologies together can be a complex task and there are many opportunities for engineers and technicians, designers and installers to satisfy the demand for a holistic approach to designing, installing and maintaining the low carbon building services.

**Read more about building services retrofit measures in page 81.*

Possible retrofit solutions include:

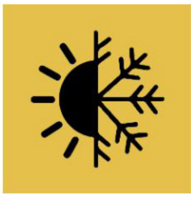

Insulation


Air tightness and ventilation


Renewable technologies


Water heating systems


Efficient lighting


Heating and cooling systems


Energy monitoring systems

Using locally generated green power

Why retrofit?

Retrofitting existing buildings must be our priority for the following reasons:

→ UK government commitments - on the path to net zero by 2050; the challenge is how we get there!

→ Over a quarter of current emissions are attributed to the existing 26 million homes in the UK.

→ Approximately 80% of the homes we live in today will still be in use in 2050. With the energy consumption of existing buildings accounting for around 35% of the UK's annual carbon emissions, we all need to be looking closer to home to make a bigger impact on reducing our carbon footprint.

→ Millions of homes were built before the revised UK building regulations and have low energy efficiency.

→ It's a good thing that all new build clients include net zero carbon in their developments, but the real challenge is how to go about reducing carbon emissions from our existing domestic dwellings. The question should not be whether to retrofit, but how soon can we start the retrofit programme and how far should retrofit measures go.

Large retrofit provides benefits to the city, owners, occupiers and the supply chain. The city gains important information about routes to net-zero, and significant improvements in the appearance and vitality of a poorer part of the city. Property owners see significant improvements in the energy efficiency, desirability, and value of the homes. Those living in the properties see improvements in comfort, cost, and wellbeing. The project can enable smaller SMEs to develop new products and services and to learn valuable lessons about this growing market.

It is essential to weigh-up the benefits of retrofit not just against the direct impact, but against all the other ripple impacts.

1. The Retrofit Toolkit - Helping Local Authorities to Kickstart Deep Retrofit 2020, page 4. Retrieved from: https://www.ukgbc.org/wp-content/uploads/2020/11/Local-Authority-Retrofit-Toolkit.pdf

The benefits of low carbon domestic retrofit are five-fold:

1. Protection against rising fuel prices, which recently rose by up to 60%.
2. Improved comfort in homes which are better insulated, better ventilated and draught-free.
3. Mitigation of climate change through improved energy efficiency and reduced carbon dioxide emissions.
4. Adaptation to climate change through reduced risk of summer overheating and improved resistance to more frequent extreme weather.
5. Improved market value and increases the global economy in skills and jobs.

The 2020-2050 National Retrofit Programme (NRP)1 outlines a series of benefits quantified in additional income or avoided expenditure that are eye-watering:

Economic

→ Increase government tax revenues by £163 billion by 2030.

→ Net government surplus of £60 billion by 2030.

→ £63.8 billion in energy bill savings, leaving more money in the pockets of residents.

Environmental

→ £15.3 billion in avoided CO_2.

→ £6 billion resulting from improved air quality.

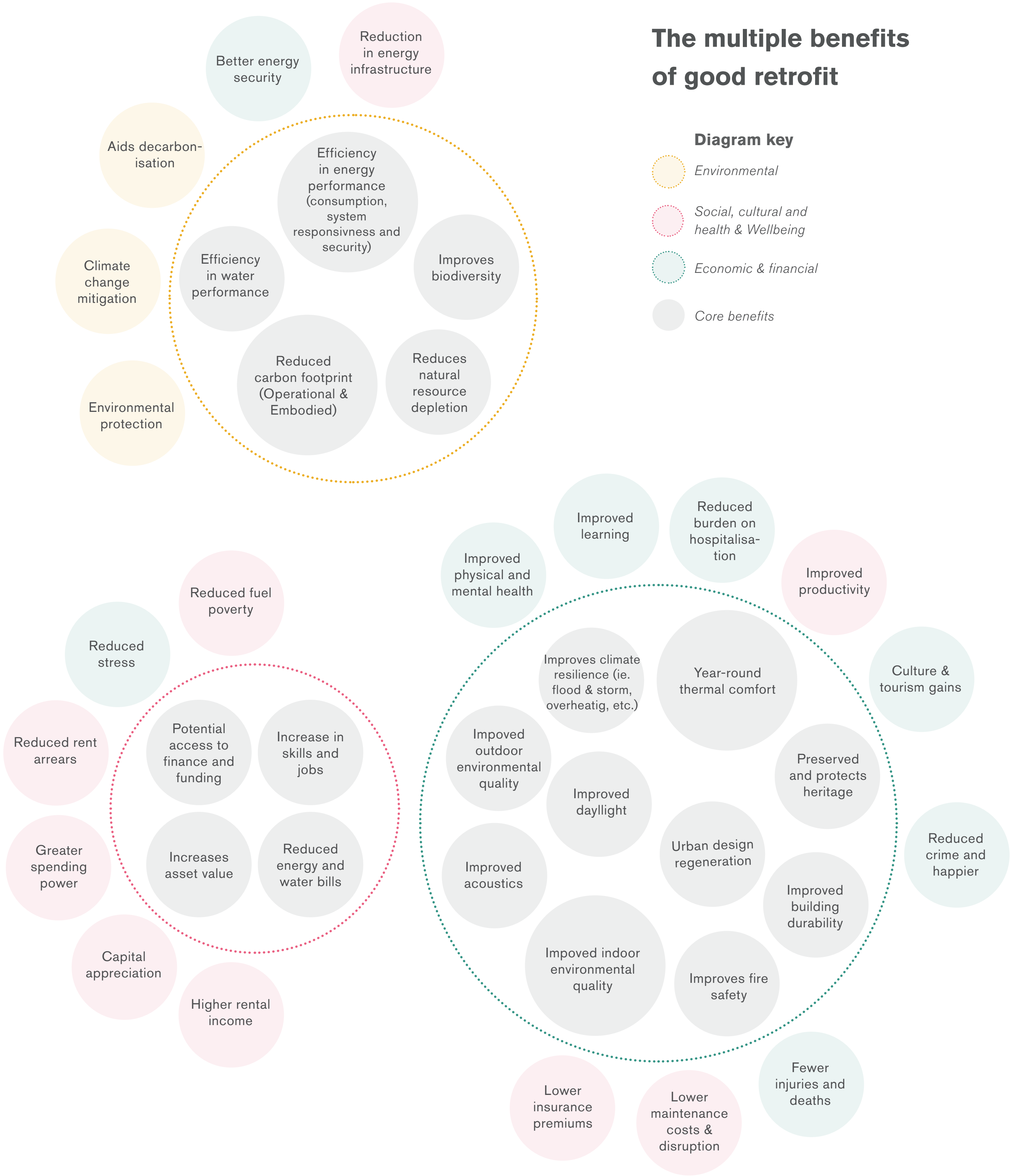
Social

→ £6.6. billion through improved health and a reduced burden on NHS and social care.

→ £6.6 billion through improved comfort and quality of life, enabling an aging population to live at home for longer.

→ In total, the NRP identifies: a) a combined £254 billion of undiscounted benefits by 2040. b) A cumulative ~298MtCO_2e, or 36% of the savings required for the 4th and 5th carbon budgets.

The multiple benefits of good retrofit



Volume retrofit

Comprehensive retrofitting to 2050 standards can be costly. *The Institution of Engineering and Technology* at *Nottingham Trent University* says large retrofit programmes for housing, which would reduce costs at scale, are still at the planning stage in the UK. The challenge is to scale-up retrofitting initiatives and to make them business as usual. The *Paris Climate Agreement* offers a clear time frame and clear target. Its implementation represents an opportunity to accelerate this scaling-up and to achieve the radical transformation of energy systems attempted by the reviewed initiatives.

Volume retrofit can be replicable at Scale. Let us innovate and scale it up so income and savings can fund the work!

Retrofitting all 26 million existing homes is undoubtedly a colossal challenge in transitioning the built environment to net zero. The sheer scale of this task is huge. It is one home to be retrofitted every 35 seconds between 2020 and 2050. If every retrofit takes 4 people 6 months, it's 500,000 simultaneous retrofits needing 2 million skilled people in the industry.

To retrofit the UK 26 millions home by the 2050:

35 seconds to complete each retrofit

500,000 simulteneous retrofits will be required

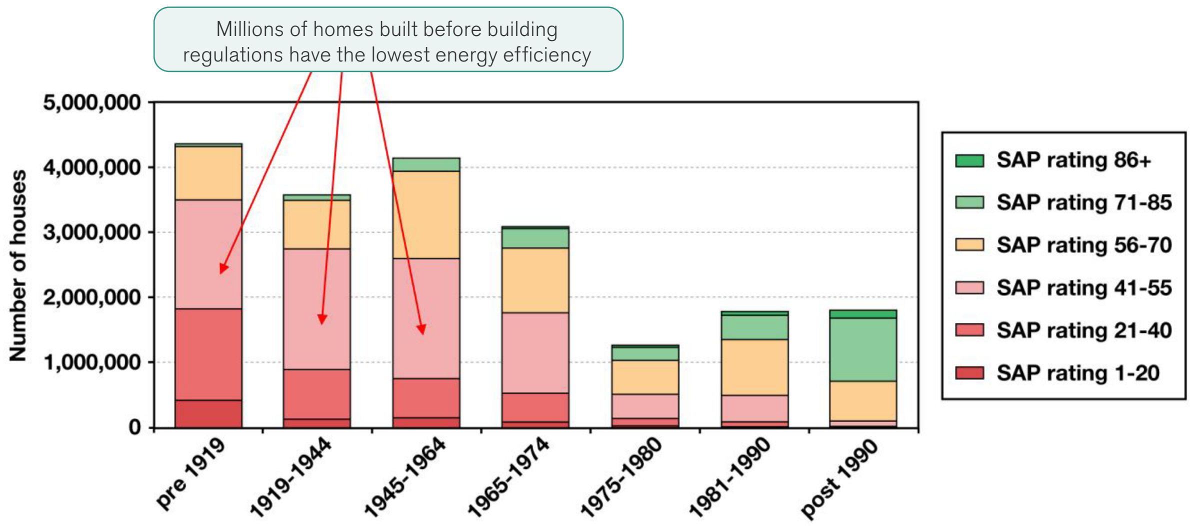
2,000,000 skilled people needed in the retrofit industy (currently 135,000)

According to the Sustainable Energy Association, a combination of deep retrofit of existing social housing, far greater standards in new-builds and rapid market growth of low carbon heating systems is now required. It's also a complex undertaking. Every home is different which means some efficiency measures that work on one project may not be appropriate for another. Get it wrong and you could end up with damp and rot. Getting the right contractor with the right skills and experience is also a worry for most homeowners.

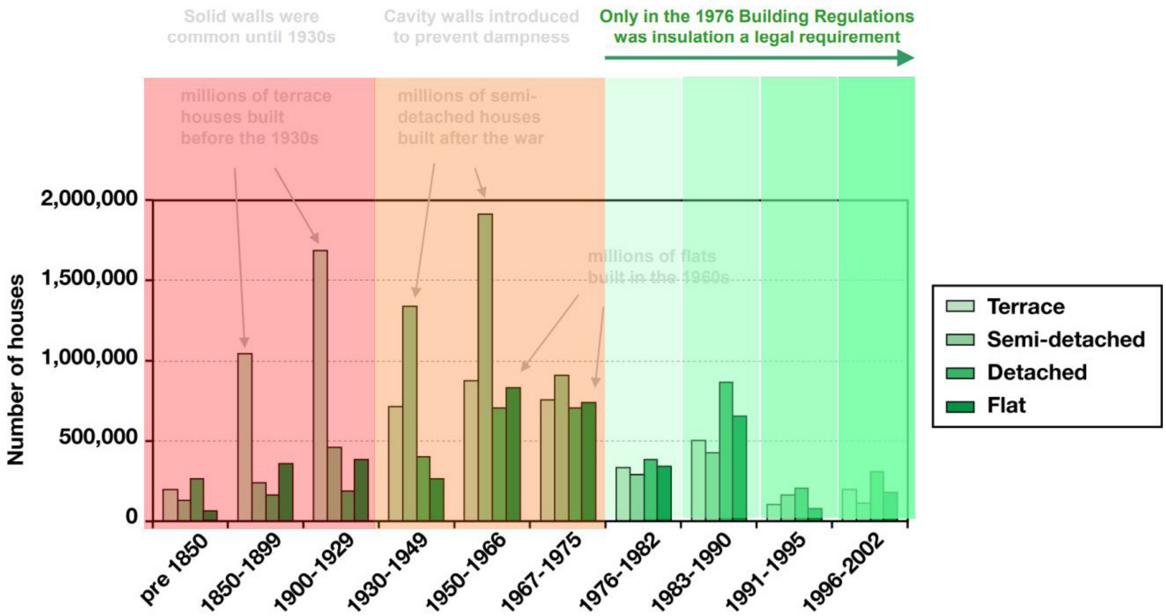
Most homes are owned by the volume housebuilders who have shown considerable reluctance to achieve the highest standards. The nation must turn to the social housing sector to set high standards and to take positive action to cut carbon emissions.

It is the housing associations who can and should take the lead in moving toward net zero carbon emissions from housing; leading by example.

Thermal efficiency of the existing building stock in the UK[1]



UK Housing Stock[2]



1. CLG. 2006. Review of sustainability of existing buildings, raw statistics available online.

2. CLG. 2001. English house condition survey - supporting tables, profile of the stock, table a1.3 dwelling type by age category, raw statistics available online.

UK's housing stock 'needs massive retrofit to meet climate targets'

by Fiona Harvey on October 11 2018

New research by the Institution of Engineering and Technology and Nottingham Trent University. The report's authors suggest starting with social housing, which makes up about 4.5m homes. By engaging a whole locality at a time, the costs can be brought down and retrofit schemes carried out more efficiently. It can cost about £17,000 to retrofit a standard house. The benefits go beyond emissions savings, also including lower energy bills, warmer homes and a much-decreased burden on the NHS, which currently spends about £1.4bn a year treating conditions that arise from poor housing.

Costs for ongoing maintenance, amounting to £5.2bn a year for social housing alone, would also be drastically cut or eliminated by a one-off "deep retrofit" for most residential buildings. Social housing tenants spend £4.2bn a year on energy, a big chunk of most household budgets, which would also be much reduced if their homes were insulated and fitted with renewables such as solar panels.

Retrieved from: https://www.theguardian.com/environment/2018/oct/11/uks-housing-stock-needs-massive-retrofit-to-meet-climate-targets

Cost of retrofitting social homes in UK to zero carbon to top £100bn

by Lucoe Heath on November 23 2020

Responses from 207 housing associations and stock-owning councils to Inside Housing's survey and Freedom of Information Act requests has shown the mean cost of decarbonisation per social home is £20,742.

Multiplied by the roughly five million social homes in the UK, that puts the total decarbonisation cost for the sector at £104bn. More than a fifth (i.e., 46) of the social landlords that responded to the survey could provide an estimate of how much it would cost on average to reach net zero with their housing stock, with answers ranging from less than £3,000 per home to £50,000 per home.

At £2,842 per home, London-based *Optivo* (a UK housing association) provided the lowest net zero cost, but this was largely due to the fact that the figure did not include planned investments such as roof and window replacements, as well as the sum for replacing gas heating with electric alternatives.

Retrieved from: https://www.insidehousing.co.uk/news/news/cost-of-retrofitting-all-social-homes-in-the-uk-to-zero-carbon-to-top-100bn-exclusive-research-reveals-68674

HOUSING TODAY

Announcement part of Rishi Sunak's £3bn green jobs fund

by Tom Lowe on July 7 2020

Chancellor *Rishi Sunak* has announced plans for a £50m fund to pilot innovative retrofit projects for social housing, as part of a £3bn fund for green jobs designed to jump-start the post-covid economy.

The £50m will be earmarked to pilot innovative approaches to retrofitting social housing "at scale" using heat pumps, insulation and double glazing to make social rented homes more energy efficient.

Priority will be given to the least energy efficient social housing in England, with the Treasury claiming the move could reduce annual energy bills for tenants of these homes by around £200.

Retrieved from: https://www.housingtoday.co.uk/news/chancellor-announces-50m-social-housing-retrofit-programme/5106864.article

SOCIALHOUSING

Social housing needs 'massive programme of retrofitting'

by Luke Cross on December 13 2019

Lord *Barwell,* who was housing minister for almost a year, said: "We are going to need a massive programme of retrofitting our housing stock in this country if we are going to deliver net zero. It's no good just focusing on new build housing – it takes far too long to replace the stock."

Mr *Kiely* also pointed to the challenge of being "carbon ready" while addressing fuel poverty, with the cost of energy set to rise. And he spoke of a major upskilling required across the sector and the supply chain.

Retrieved from: https://www.socialhousing.co.uk/news/news/social-housing-needs-massive-programme-of-retrofitting-64522

This is MONEY.co.uk
FINANCIAL WEBSITE OF THE YEAR

Property market faces energy-efficiency ticking timebomb: Two-thirds of UK homes will be unsellable by 2028 unless they insulate

by Ed Magnus on January 25 2021

→ The Climate Change Committee has proposed all homes for sale should attain an EPC rating of C from 2028
→ The CCC is advising the government on how to achieve its net zero carbon emissions target
→ Less than one third of UK properties have an EPC of C or higher

Retrieved from: https://www.thisismoney.co.uk/money/article-9080199/Is-property-market-facing-ticking-time-bomb.html

The Challenge

A barrier to large-scale retrofitting of the existing housing stock is that costs are currently too high, and that there is not a construction and supply chain with the capability and capacity to deliver in volume and at speed.

The key challenges affecting the whole retrofit market in the UK have been widely reviewed and discussed.

Discrepancies between predicted and actual savings[1].

→ University College London (UCL) modelled the predicted energy savings of 1,372 dwellings retrofitted with loft and cavity wall insulation. 49% energy savings were predicted across the stock. In reality the average savings were 10% in central heated homes and 17% in homes without central heating.

→ Combination of gaps in insulation and thermal comfort "take-back" (i.e., occupants raising the temperature of their homes after the refurbishment) reduced energy savings by up to 39%.

Industry does not have the capacity to retrofit all solid walled homes by 2050[2].

→ ~180,000 installations/year required to retrofit just 6.6 million out of the existing 26 million homes by 2050.

→ Energy Efficiency Partnership for Homes (EEPH) estimate the UK industry maximum capacity is 15,000-20,000 installations/year.

→ Capacity (and expertise) must increase 10-fold.

1 - Hong, S., Oreszczyn, T., Ridley, I., 2006. The impact of energy efficient refurbishment on the space heating and fuel consumption in English dwellings.
2- Energy efficient partnership for housing, 2008. The insulation industry, working in partnership with government to insulate the housing stock by 2050.
3 -Boardman B, Darby S, Killip G, Hinnels M, Jardine C and Palmer J. 2005. 40% house, University of Oxford, Environmental Change Institute, Oxford, UK.

Added cost, disruption, time, planning issues and technical expertise (e.g., moisture control) required to improve certain properties[3].

→ Up to 1.2 million homes are in conservation areas.

→ Up to 300,000 homes are listed.

Commerciality, and access to and availability of capital funds - whether they are provided by the owner, occupier or third party[4].

→ Lack of incentives for landlords (if tenants are reaping the benefits).

→ Uncertainty regarding capital costs & payback periods.

→ Not all properties and/or occupants qualify for grants.

→ Failure to provide a compelling and viable business case for investment in retrofit and the inherent split incentive between owners and occupiers. This includes how payment is made to service providers, how the cost is passed on to the occupiers, and how guarantees and risks are shared amongst the parties involved.

→ Retrofit programmes have not been packaged to be attractive to large investors. They compare poorly in risk and return with more established green infrastructure projects such as wind farms.

Lack of demand and current high costs of retrofitting.

→ Retrofit for energy efficiency is not attractive enough to homeowners, landlords or tenants. All buyers worry about the risks. They are not confident that the promised benefits will arrive, and worry about poor quality installation, defective equipment and uncontrolled costs.

→ With only a few properties undergoing deep retrofit, cost per unit is still high. This makes it difficult for an owner to create an economic case to invest. A small number of retrofitted homes mean no economies of scale; keeping costs high and suppressing demand.

A lack of both capability and capacity throughout the supply chain.

→ Lack of knowledge of the options available to upgrade buildings and issues associated with the implementation of specific retrofit activities, for example building constraints, occupier disruption, compatibility with existing systems, insufficient understanding of appropriate analysis and planning, payback periods and an endemic skills shortage in the built environment sector.

→ Buyers lack the knowledge and understanding to specify, select and manage retrofit projects.

→ There is a skills gap throughout the construction sector, but specifically in the new technologies required for deep retrofits.

→ There are few integrators; businesses that can design and deliver successful retrofits.

→ Both landlords and suppliers have limited knowledge about retrofit for energy efficiency.

Over a third of tenants in social homes are in fuel poverty, with households in the lowest income bands having the highest rates of fuel poverty[5].

→ Ensuring housing remains affordable in the round for social tenants requires a focus on addressing high energy costs, and ensuring that decarbonisation objectives do not cut across this critical social wellbeing agenda.

→ A further challenge is the amount of social housing that lies within mixed tenure blocks, in which many owners – some of whom will be private landlords – may be unable or unwilling to find their share of the costs of energy efficiency and associated improvement works.

No clear and consistent Government policy driving retrofit.

→ A lack of regulation or government intervention to stimulate the uptake of retrofit activity. There has been an insufficient focus by policy makers on the existing building stock compared to new build.

→ Government is not demanding deep retrofit of existing homes as part of the journey to net-zero. It is not being given priority. Experience of changing UK Government policies, such as the Code for Sustainable Homes and the Green Deal, makes both buyers and sellers reluctant to commit.

Social landlords face additional challenges specific to their sector.

→ Maintenance work and improvement work are usually separate budgets, often with framework agreements for delivery. These silos make it difficult to coordinate activities and make the most effective use of the combined budget.

→ Thermal retrofit can be a low priority for social landlords compared to other activities such as meeting Decent Homes standards or replacing and upgrading kitchens and bathrooms.

→ Some social landlords do not have accurate enough stock condition information to model the value of retrofit programmes.

→ Many social landlords feel that they have already carried out the easy upgrades for energy efficiency and now need to move on to more demanding solutions such as external wall insulation. They see this as expensive, complicated, and difficult to integrate into work programmes.

→ Many social landlords feel that they have already carried out the easy upgrades for energy efficiency and now need to move on to more demanding solutions such as external wall insulation. They see this as expensive, complicated, and difficult to integrate into work programmes.

4 -UKGBC. 2008. Low carbon existing homes, United Kingdom Green Building Council

5- DECC, 2015, Fuel Poverty Strategy for England. Retrieved on 02/11/2018 from: https://www..gov.uk/government/speeches/fuel-poverty-strategy-for-england

Barriers to retrofit[1]

Benefits of retrofitting – however small or gradual the improvement – are undeniable. But there's plenty standing in our way. Whether it's the social and income divide, or a lack of funds, policy, trust, and experts to carry out the work, it's still an uphill struggle to bring retrofitting to the fore. Regardless of any climate change commitments.

National level

- → Brexit - uncertainty
- → No national strategy - start/ stop policy
- → Lack of long term planning for funding
- → Over emphasis on 'top-down' policy
- → National Planning Policy Framework (NPPF) and building regulations do not adequately address retrofit
- → EPCs not fit for purpose

Cost and Finance

- → High upfront costs - hidden costs and uncertainties, dealing with existing buildings
- → Lack of finance mechanisms
- → Lack of coherent offering for instituitional investors
- → No fiscal incentives
- → Slow return on investment
- → Wealthier households might be bale to pay but are they willing to fund
- → Loan/ grant schemes have prioritised single measures which limit whole house approach and skew prioirities

Supply chain

- → Industry decimated by start/ stop policy
- → Skills and capacity lacking, training often prioritises new build
- → Loss of confidence in long term policy direction
- → Construction industry procurement focused on cost not quality

1- Re-interpreted from 'The Retrofit Playbook : Driving retrofit of existing homes – a resource for local and combined authorities' Version 2.1, published by UKGBC, February 2021.

City level

- → Lack of risk taking
- → Lack of long term strategy - short term funding and annual budgets
- → Lack of capacity
- → Limited coordination between local authorities

Tenure issues

- → Landlord and tenant split
- → Social housing has particular challenges - e.g., capped rents
- → Challenegs of multi tenure blocks/ streets/ areas

Householder offering

- → Failure to tap into householders's varied psychologies and motivations - poorly informed about braoder benefits of retrofit
- → Retrofit seen in terms of 'return on investment' rather than improving quality of life
- → Hassle factor
- → Lack of knowledge
- → Lack of trusted installers and third party advice

Technical

- → Complexity in getting whole house deep retrofit right
- → Performance gap - lack of measuring and monitoring
- → UK housing stock is diverse
- → Existing national grid cannot manage technological innovations
- → Heritage and conservation buildings issues
- → Fixed aspects of existing buildings (i.e., existing architecture, fixed form, orientation and windows locations)

How can we make it happen?

The challenge is multi-fold, however there are significant opportunities which the social housing sector is well placed to build on. Over half of social housing in the UK is already in EPC band C or better, compared to two-fifths in the private rented and owner-occupied sectors. Landlords have extensive experience of delivering projects to improve the energy performance of buildings as well as innovative solutions that work for tenants.

Social landlords can work together with government to attract investment, create good quality local jobs in the green economy, and improve the warmth and comfort of social homes to tackle both climate change and fuel poverty together.

What must change if social landlords are to invest in deep retrofit?

→ *Confidence* – buyers need to know that there is a solution for their specific properties, that it can be delivered and is robust. They need to trust both the solutions and providers.

→ *A good business case* – something that fits their strategic objectives and their investment criteria.

→ *Information and knowledge* – buyers feel that there is a lack of independent and trusted advice on retrofit options and methods. They feel confused. They also need access to a skilled knowledgeable supply chain.

→ *Policy and regulation* – unless Government is prepared to mandate retrofitting for energy efficiency and liveability, it is unlikely to make it to the top of social landlords' priorities.

→ *A better offer from suppliers* – solutions on offer are not tailored to the buyers' needs, both strategically and operationally. Retrofit needs to be fast and hassle-free.

Other considerations to overcome the barriers

→ Projects need careful risk management with contract terms and conditions that are attractive to investors, and to the finance and construction sectors.

→ The cost of technology will also affect the final decarbonisation cost for the sector, with landlords hopeful that the cost of items such as heat pumps will reduce as demand increases.

→ Costs will inevitably fall as volume increases, larger programmes emerge and supply chain capability grows with the result of making deep retrofit more economically viable.

→ Businesses will also need expert advice to overcome the contractual and regulatory obstacles that they will face.

→ Public perception of the value of insulation took a blow when the Grenfell fire, in which 72 people died, exposed the risks from flammable cladding on tower blocks. However, high-quality cladding and other retrofit technologies should be a priority, and a public information campaign to engage householders could allay people's concerns.

→ Retrofitting a typical house can take several weeks, but the residents can remain living there throughout. Many people are reluctant to take on the inconvenience and cost of such building work, but the government could offer incentives and subsidies, which along with the savings on energy bills could make the proposition more attractive.

→ Local authorities and RPs have a real opportunity to develop schemes that can act as a catalyst for urban renewal and economic growth, especially when they take advantage of planning across the project lifecycle including real estate, planning, construction, financing and operations, and compliance with the Renewable Heat Incentive and eligibility criteria.

To overcome the barriers, a planned approach is required!

1. Set clear corporate retrofit goals to include energy saving and carbon reductions, introduction of new technologies and accelerated replacement of inefficient services equipment.
2. Designate roles and define processes to ensure that a dedicated individual is given the responsibility and authority to assess retrofit opportunities across the property portfolio.
3. Prioritise buildings most suitable for retrofit by analysing portfolios against key selection criteria.
4. Engage occupiers to determine common goals, identify barriers and formulate solutions.
5. Agree transparent financing arrangements between owner and occupier using an exceptional expenditure clause to repay costs. For high cost projects third party finance may be sought.
6. Select appropriate technology best-suited to the constraints of the building and which minimise the level of disruption to the occupiers.
7. Delivery using a trusted supply chain with a performance guarantee.
8. Evaluate performance in-use to inform future internal retrofit projects as well as the wider market.

At what cost?

Any construction work is relatively expensive and for good reasons; we are physically changing our environment, and this should be carried out with thought, care and consideration. With existing buildings we have the additional risk - and therefore cost - of the unknown construction that has come before. This upfront cost can be high and may not 'pay back' the building's owner in simple terms (i.e., savings in energy bills) especially in the short term. However, many of the benefits highlighted previously in this report (pages 24-25) bring substantial cost benefits to both individuals and society.

Cost benefits to society

→ Reducing the need for and cost of energy generation and electrical infrastructure.

→ Reducing the need for and cost of carbon reduction measures such as carbon capture and storage.

→ Research from the Chief Medical Officer[1] estimates that every £1 spent on energy in homes gives 42p back to the NHS - because people are warm, they are less likely to fall ill, and their mental health and well-being is improved.

→ There is evidence[2] that every £1 spent on improving energy efficiency provides £3.20 in returns via gross domestic product (GDP) increases across the country.

→ Creating local jobs because retrofit is a labour-intensive activity that benefits the local economy. Could refer to CLC retrofit strategy here for estimated numbers, and these are spread throughout the country & include SMEs so even more beneficial to recovery & levelling up.

Cost benefits to society and individual

→ Reducing fuel poverty by reducing energy demand and therefore fuel bills.

→ Reducing the costs of poor health by improving winter thermal comfort, improving air quality and reducing the risk of summer overheating.

→ Extending the life of our housing stock and reducing long-term maintenance costs through major improvement, resulting in more durable buildings less prone to damp.

→ Reducing rent arrears and void periods by reducing energy demand and therefore fuel bills alongside providing more pleasant homes.

→ Improving productivity by creating healthy comfortable buildings.

→ Improving building capital by creating durable buildings that are more comfortable with lower energy bills.

It is essential therefore to weigh-up the costs of retrofit not just against the reduction in energy bills, but against all these other savings.

How much does retrofitting a house cost?

The cost of retrofitting a house will vary considerably, as every home has unique needs for improving its energy efficiency. Some properties will need to address all aspects of their home's energy consumption, including improving or installing insulation, glazing, draught-proofing, and replacing the boiler. The adjacent diagram illustrates an estimate of the average cost of retrofitting a house in the UK. The cost per m^2 includes the cost of materials and labour. Cost assumptions are retrieved from the *Department for Business, Energy & Industrial Strategy – 'What does it cost to retrofit homes'* [3].

See pages 86-87 summarising the outcome of some recent payback periods/ environmental impact studies for the different building retrofit measures.

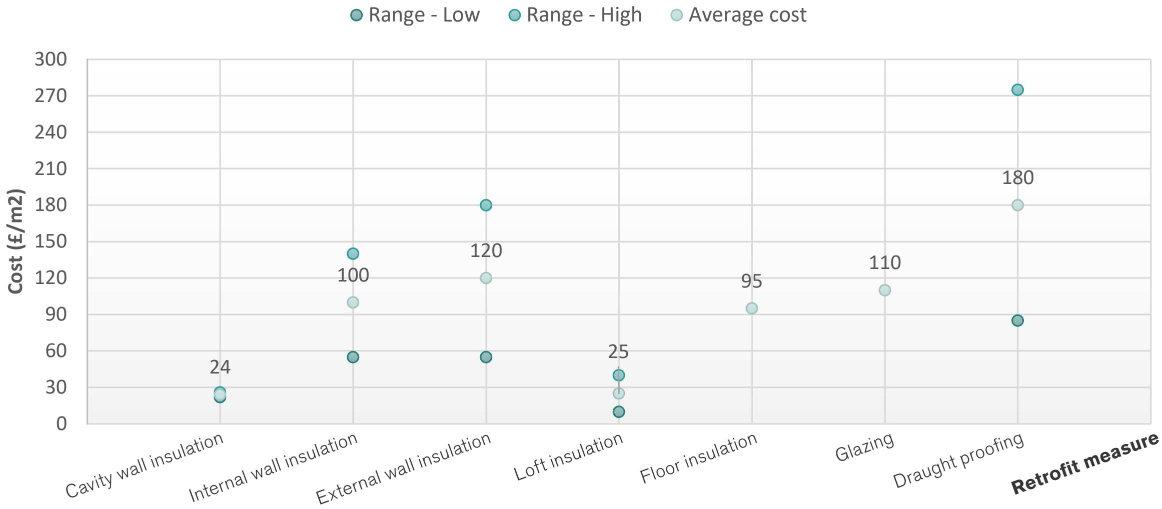
1- Chief Medical Officer Report 2019 (p31), Department of Health. Retrieved from: http://www.sthc.co.uk/Documents/CMO_Report_2009.pdf

2- Cambridge and Verco Economics, 2014, Building the Future: The economic and fiscal impacts of making homes energy efficienct. Retrieved on 18/03/19 from: http://www.energybillrevolution.org/

3 - Cambridge Architectural Research, 2017. "What does it cost to retrofit homes", Updating the Cost Assumptions for BEIS's Energy Efficiency Modelling. Retrieved from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/656866/BEIS_Update_of_Domestic_Cost_Assumptions_031017.pdf

The average expected costs (materials + labour) to pay to retrofit a typical UK house.[3]

See page 99 for the anticipated payback period for the different insulation measures.



Installation cost, energy savings cost and payback period of energy efficiency measures, by EER band in the UK, 2019[4]

In 2019, 40% of dwellings (9.9 million) were A to C rated; 47% (11.4 million) were D rated; 10% (2.3 million) were E rated and 3% (784,000) were F or G rated,.

a) If all eligible energy improvement measures, as defined in the Energy performance certificates (EPCs)[5] methodology, were to be installed in those dwellings, 98% of dwellings would fall into an Energy Efficiency Rating (EER) band A to C , and just 2% of dwellings would have an EER band of D or lower.

b) The average notional cost required to bring up all homes currently banded D or below to reach an EER band C would result in an average saving translating into a simple payback period.

a) Cost figures, if all eligible energy improvement measures, as defined in the EPC methodology, were to be installed

	installation cost	energy cost saving (annual)	simple payback (years)
EER band			
A to C	£8,506	£264	33
D	£14,558	£504	29
E	£19,974	£922	22
F or G	£25,804	£1,780	14

Base: all applicable dwellings

1) improvement costs of low and high cost measures at 2019 prices
2) underlying data are presented in Annex Table 3.6

b) Cost figures required to reach an EER band C, by EER band 2019

	installation cost	energy cost saving (annual)	simple payback (years)
EER band			
D	£6,472	£179	36
E	£13,285	£594	22
F or G	£18,858	£1,339	14

Base: all dwellings able to be improved to an EER band C

4 - English Housing Survey - Energy report, 2019-20. National statistics Ministry of husing, communities and local government.

5- https://en.wikipedia.org/wiki/Energy Performance Certificate (UK).

Financing schemes

Energy efficiency is a societal issue and should be seen as a national infrastructure priority. It should be funded not just by individuals, but by local and national governments. Systemic change in how retrofit is funded is required - from funding through health, infrastructure and economic recovery budgets, to green finance initiatives and tax schemes like VAT.

To take advantage of financial grants and incentives, social housing landlords need to develop an investment pathway to net zero. With strategies, investment plans and project programmes in place, they can respond rapidly to funding calls and be well positioned to secure support and promote net zero projects.

The following are some UK governmental financial and regulatory incentives for householders and landlords to retrofit their properties.

Energy Company Obligation (ECO)
ECO is a government energy efficiency scheme to tackle fuel poverty and help reduce carbon emissions. Under ECO, medium and larger energy suppliers fund the installation of energy efficiency measures in British households. Each energy supplier has an overall target based on its share of the domestic energy market in Britain. It is estimated that the ECO market is worth £1bn a year and delivers in the region of 180,000 – 200,000 measures per year. The ECO has been around since 2012 and has been delivered in 'rounds' lasting three to four years each. We are currently in ECO 4 which now support the whole house retrofit approach.

Home Upgrade Grant (HUG)
A £2.5 billion grant funding scheme targeted at fuel poverty alleviation, potentially shifting the focus away from the ECO. Plans are expected to be announced in the next 12 months but it is likely that private tenure households will be able to replace boilers, provide insulation and wholly replace energy systems providing an average annual saving of £750 a year.

Social Housing Decarbonisation Fund (SHDF)
A £3.8 billion SHDF focusing on improving insulation and introducing low carbon heat in 2 million social homes, reducing energy bills by an average of £160 a year. This investment has a target of achieving Energy Performance Certificate (EPC) Band C and above. The SHDF Wave 1 competition closed to applications in October 2021 and delivered £160m of funding in the first year. SHDF Wave 2.1 will allocate up to £800 million of funding, it is now launched in September 2022 with a delivery window running until 30 June 2025.

The Local Authority Delivery (LAD)
The Scheme aims to raise the energy efficiency of low-income and low EPC rated homes (those with Band E, F or G). This includes those living in the worst quality off-gas grid homes, delivering progress towards reducing fuel poverty, the phasing out the installation of high carbon fossil fuel heating and the UK's commitment to net zero by 2050. Local authorities in England can submit bids for funding to improve the energy efficiency of the homes of low-income households in their areas. A further £300m in 2022 was made available.

The Green Home Grant (GHG)
Homeowners and residential landlords can apply for a Green Homes Grant voucher towards the cost of installing energy efficient improvements to their property such as insulating houses or installing low-carbon heating. Homeowners and landlords must redeem the voucher and ensure improvements are completed by 31 March 2022. GHG is associated with a £2 billion investment to be spent in theory before the 31st of March 2020, as part of the economic stimulus package (£500 million in funding for local authorities through LAD).

Funding mechanisms

In their report[1], the Green Finance Institute CEEB (Coalition for the Energy Efficiency of Buildings) layout 21 demonstrator projects based on detailed profiling of the barriers to retrofit and other characteristics associated with owner-occupied, private rented and social rented homes. The demonstrators are aimed at bringing practical solutions to the market and fall into the following categories:

a) Data, digitalisation and enabling frameworks: Highlighting the vital role that reliable data and a quality assured supply chain will play in trust for both consumers and funding providers as well as exploring the role that 'Building Renovation Passports' could play in promoting these priorities and creating demonstrable value in house prices.

Example: Metered Energy Savings
A standardised savings calculation methodology to deliver rich data on real-time energy savings over the lifetime of a retrofitted building.

b) Tenancy agreements: Addressing the split incentive between landlord and tenant by allowing energy savings to be recovered through rental payments and promoting 'affordable living' measures that combine rent and energy costs.

Example: Green Leases
Green Leases with an 'Energy Alignment Clause' enable landlords to recover the cost of a retrofit, based on the predicted energy savings, and minimise the landlord-tenant split incentive.

c) Lending products: A number of loan mechanisms to make it easier and more attractive to fund retrofit through borrowing products appropriate to different homeowner circumstances.

Example: Property Assessed Clean Energy 'style' financing
Financial institutions provide long-term capital for retrofit projects, while local authorities or associated independent third parties collect repayments via an additional property charge that is passed through to the lender.

d) Saving and investment products: Aimed at both encouraging investment in homeowner's own properties and in investments that will provide the capital for larger scale retrofit schemes, for example Community Municipal Investments in the above case study.

Example: Energy Saving ISA (Individual savings accounts)
Energy bill savings from a retrofit project can be directed towards an ISA or savings product, to help tenants build up their savings for a mortgage deposit or other investments.

e) Energy service products: Unlocking the cash savings in energy efficiency savings to fund the initial investment on behalf of homeowners including insurance and guarantee backed mechanisms to provide confidence across all tenure types.

Example: Comfort as a Service
Financial mechanisms to unlock the cash savings in energy efficient and optimised homes, to support the investment case for housebuilders and homeowners to achieve high efficiency standards.

1 - Green finance institute, 2020. Financing energy efficient buildings: the path to retrofit at scale. Retrieved from: https://www.greenfinanceinstitute.co.uk/wp-content/uploads/2020/06/Financing-energy-efficient-buildings-the-path-to-retrofit-at-scale.pdf

Standards to help meet targets

Established standards provide guidance to support the development and delivery of upgrades to homes. They can help with achieving higher standards of upgrade works, ultimately leading to greater residential satisfaction, as well as the co-benefits from warmer, healthier, and more comfortable, environmentally friendly homes. Here are some examples of the key standards that apply to upgrading homes in the UK:

Building regulations: Part L1B

This sets out the minimum requirements to be achieved when undertaking works to existing dwellings. The requirement to comply with building regulations is triggered when certain building works are undertaken.

PAS 2035: 2019 & PAS 2030

Published by the British Standards Institute (BSI), Publicly Available Specification (PAS) 2035 creates a framework for deep retrofit projects that are high quality, safe and fit for the future. The document provides guidance and specification for the retrofit of existing dwellings, and lays down minimum standards of qualifications, roles and responsibilities, for anyone carrying out retrofitting.

PAS 2030 is another BSI standard which sets out the requirements for installing, commissioning, and handing over energy efficiency measures (EEMs) in domestic retrofit projects. It addresses areas including installation controls, equipment, inspections, handover and correction action procedures.

EnerPhit

EnerPHit (Quality-Approved Energy Retrofit with Passive House Components Certificate), is the Passivhaus standard for existing buildings.

Energiesprong

Energiesprong ("Energy Leap") is a new refurbishment standard developed in the Netherlands to massify high-performance energy refurbishments, starting with the social housing stock. The idea: long term net zero energy and high quality and comfort refurbishment (performance guarantee up to 30 years), with a minimum disruption for tenants thanks to the off-site construction of large components, and an overinvestment financed by the money saved on energy bills and maintenance. Originating in the Netherlands, this initiative is now launched in the UK, Germany, Italy and France.

LETI's Climate Emergency Retrofit Guide

The London Energy Transformation Initiative (LETI) was established in 2017 to support the transition of the capital's-built environment to net zero carbon, providing guidance that can be applied to the rest of the UK. LETI's Climate Emergency Retrofit Guide shows how we can retrofit our homes to make them fit for the future and support the UK's Net Zero targets. The guide defines energy use targets for existing homes and provide practical guidance on how to achieve them.

The AECB Retrofit Standard

The Association for Environment Conscious Building (AECB) retrofit standard allows for easy self-certification and increasing comfort & energy performance; it engages and upskills construction professionals to adopt and deliver higher performance targets for retrofit projects. The AECB Retrofit Standard encourages the UK construction industry to decarbonise and is primarily focused on improving the building fabric but access to low carbon heat needs to also be considered.

For more information, please visit:

- → ***www.gov.uk***
- → ***www.bsigroup.com***
- → ***www.trustmark.org.uk***
- → ***www.passivehouse.com***
- → ***www.energiesprong.org***
- → ***www.leti.london***
- → ***www.aecb.net***

Domestic retrofit standards and how do they compare

Retrofit Standards	APPROVED DOCUMENT L1B Conservation of fuel and power in existing dwellings	EnerPHit Certified Retrofit Passive House Institute	energiesprong uk	LETI
Overview	UK building regulation that sets the standards for the energy performance and carbon emissions of existing dwellings.	Independent Construction Standard for retrofit.	Housing process that encourages developers to consider real-world performance outcome.	Guidance for safe and effective retrofit.
Space heating demand (kWh/m²/yr)	N/A* **Provides minimum efficiencies for heating systems in existing dwellings (e.g. gas-fired or oil-fired, solid fuel appliance, etc.)*	<20-25 kWh/m²/yr	<40 kWh/m²/yr	*Best practice* <50 kWh/m²/yr (up to 60 when constrained) *Examplar guidance* <25 kWh/m²/yr
Energy Use Intensity (kWh/m²/year)	N/A* The target primary energy rate, in kWhPE/m2 per year: this is influenced by the fabric and fuel.	EUI equivalent* likely to be 35-45 kWh/m²/yr **Specific primary energy demand*: 120 kWh/m²/a	No EUI target, but scaled targets for hot water and appliance load.	*Best practice* <50 kWh/m²/yr (up to <60 when constrained) *Examplar guidance* <40 kWh/m²/yr
Fabric Max. U-value (W/m²K)	*Fabric* *New* *Existing* *Roof* 0.15 up to 0.35 *Wall* 0.18 up to 0.70 *Floor* 0.18 up to 0.70 *Window* 1.4 *Rooflight* 2.2 *Doors* 1.4	*Roof* 0.12 *Wall* 0.15 (external insulation) 0.30 (Internal insulation) *Floor* 0.12 *Window* 0.85 *Rooflight* N/A *Doors* 0.8	N/A* **Energiesprong specifies performance outcomes, which means development teams are not tied to any particular system or design.*	*Roof* 0.12 *Wall* 0.15 - 0.18 *Floor* 0.15 - 0.18 *Window* 0.8 - 1.0 *Rooflight* N/A *Doors* N/A
Compliance method	Two Buildings Regulations England Part L (BREL) report (design stage and another as-built) and photographic evidence should be provided.	Demonstrated by Passive House Planning Package (PHPP) modelling independently verified by PH Certifier.	Home owner or landlord enters into a contract which guarantees levels of performance specified. Thus compliance is by in-use assessment.	Demonstrated either by modelling or the constituent element method. No certification or QA scheme offered.

3

Case Studies

Rational for chosen places

To serve the purpose of this research work, a number of pioneering case studies in the European context were selected. The rational of the chosen places is illustrated in the below diagram. Site visits were arranged in 2022, with a total of one month spent travelling within the UK, then to the Netherlands, Germany, France and Austria. The aim was to capture industry-wide experience of projects' stakeholders, to explore local policies driven frameworks and to gather practical lessons learnt on site. Case studies were assessed looking at different aspects; lessons learned and legacy from each case study are summarised in this chapter.

Prior to and/or during the site visits, a questionnaire was circulated to a wide range of experts (i.e. funders, developers, design teams, contractors and occupants) involved in each case study (see the Apendix). The adjacent page captures industry-wide experience and summarises average responses received on four selected questions from the questionnaire.

Rational for the chosen case studies

Climate Zone
ASHRAE climate zones 4A or 5A (≡UK Climate).

Scale Development
Enriching range of typologies and scales.

Innovation & Pioneering
Award winning, 3rd party certified and/ or pilot projects.

Affordability
Financing scheme (e.g. local authorities, housing association, city council and real estate).

Policy Driven Initiatives
Countries with established national energy and climate plan.

Holistic Retrofit Lifespan
Inform a comprehensive retrofit plan of work (i.e. construction, retrofit, operation and post-occupancy).

Extracted questions from the circulated questionnaire	**Average answer from the different stakeholders interviewed**
a. What do you think are the barriers to achieving net zero carbon targets in projects? (1. The biggest barrier to 10. The least barrier).	**1.** It is too expensive to construct **2.** Lack of financial incentives **3.** Lack of Policies, guidance, and Standards **4.** Retrofit is Complicated. The industry is not there yet **5.** Skills Shortage. There isn't enough knowledge/ expertise **6.** Lack of occupants and landlord's awareness **7.** Products for the retrofit (eg. Windows/ MVHR/ Heat pumps/ Solar PV, etc) **8.** Project management **9.** It is too expensive to design **10.** There aren't enough built precedents/ benchmarks

b. Please rate the following factors to consider when deciding to retrofit a residential property.

	Not a factor	*minor factor*	*considerable factor*	*major factor*	*critical factor*
The age of the property				●	
The style of the property		●			
Whether retrofitting is a viable option				●	
The financing required					●
The time taken to retrofit			●		
The risk factors involved				●	

Others: Can tenants stay in the house during the renovation or not!

c. Please rate the following advantages of retrofitting residential properties in terms of importance.

	Not Important	*minor importance*	*Average importance*	*major importance*	*critical importance*
Long-term cost saving on energy bills				●	
Increase in property value		●			
A "Greener" household with lower energy usage and lower carbon emissions			●		
Increased comfort and well-being					●
Improvement of buildings appearance				●	
The preservation of cultural and heritage significance when retrofitting older buildings			●		
Renewing outdated components of a building					●

d. Please rate the following disadvantages of retrofitting residential properties in terms of importance.

	Not Important	*minor importance*	*Average importance*	*major importance*	*critical importance*
The cost implication of retrofitting					●
The long time return on investment				●	
The limitation of techniques available depending on the buildings style and age				●	
The complicated process of retrofitting				●	
Changes to original cultural and historical buildings			●		
Unknown risk factors involved			●		
The lack of available incentive schemes					●

Others: The problem is, that the tenants have the advantage of lower energy costs, but the house owner has to do the investment.

Wilmcote House, a 'whole building' EnerPhit standard retrofit

Residential block, Wilmcote House, had significant maintenance issues, and many residents were living in fuel poverty. Due to the rehousing, demolition costs and disturbance to residents, the Council decided against the demolition of Wilmcote House. Instead, an ambitious retrofit scheme was undertaken and the building lifespan is now extended by at least 40 years.

Passivhaus technology was used for all building components to achieve high levels of thermal efficiency, air tightness and energy performance. The thermal performance of the building fabric was radically improved, with the estimated space heating demand reduced by 80% from 188 kWh/m^2/yr to approximately 23 kWh/m^2/yr. Tenants' energy bills have fallen by an average of £700 a year (i.e., 40% reduction).

It was, at the time of completion, the largest residential EnerPHit delivered with residents in occupation in the world. The building process was difficult for residents, but most are happy with the retrofit and the Council's approach.

The case for retrofit

Wilmcote House is situated in the most deprived area of Portsmouth and is within the 10% most deprived area of England. The 11-storey block of flats built in 1968 had an average EPC SAP rating for the properties of 55 (Band D). The building was failing:

→ Residents were complaining about the excessive costs of the existing electric night storage heaters.

→ Maintenance of the building was costly with the windows and roof at the end of their serviceable life.

→ Restricted access doors were broken creating ineffective security.

→ Poor aesthetics, decorations were required throughout.

→ Water penetration issues existed within properties and communal areas.

Client	Portsmouth City Council
Architect	ECD Architects
Structural engineer	Wilde Carter Clack
Quantity surveyor and project management	Keegans
Contractor	Engie formerly Keepmoat
Contractor's design team	GSA Architects; Design Buro; Curtins Engineers
Space heating demand pre-retrofit (modelled)	188 kWh/m^2/yr
Space heating demand post-retrofit (modelled)	23 kWh/m^2/yr
Energy Use Intensity pre-retrofit (modelled)	341 kWh/m^2/yr
Energy Use Intensity post-retrofit (modelled)	87 kWh/m^2/yr

Somerstown, Portsmouth, England, UK

107 existing flats in three 11-storey interlinked blocks

1960s flats

Staggered completion of blocks during 2017-2018

£12.9 million (approx. £117,000 per flat)

Step-by-step EnerPHit

RICS South East Awards 2018

Winner - Design Through Innovation category

Winner – Regeneration category

Constructing Excellence Awards – Sustainability Category 2018

SHIFT Awards – Best large scale retrofit Project 2018

"This study exemplifies the tangible benefits in quality of life for residents who are experiencing fuel-poverty and can transition from living in cold, draughty, mouldy flats, to living in warm, comfortable and healthy homes." *Loreana Padron, Head of Sustainability at ECD Architects*

Site visit with the head of building maintenance at Portsmouth City Council

Pre-retrofit

Post-retrofit

Retrofitting focus

Demolish, refurb or retrofit? A financial appraisal at feasibility stage suggested that a fabric-first approach adopting a high specification of work would be more economical over a 30-year plan than to demolish, and replace the 3 blocks. Residents were kept in-situ whilst works were carried out, avoiding community displacement. A 'whole building' approach was taken within the extent of the £13M contract.

Improved building fabric:

→ Installation of fire rated composite entrance doors to properties.

→ Installation of Rockwool external wall insulation surrounding a self-supported steel frame (U-value - 0.14 $W/m^2.K$).

→ Replacement of existing windows with high performing triple glazed Ecohaus Internorm windows (U-value - 0.93 $W/m^2.K$).

→ Replacement of existing roof and additional Rockwool insulation (U-value - 0.13 $W/m^2.K$).

Improved building services:

→ New hot water cylinders, electric heating and electric showers (e.g., New smaller direct electric heaters replacing inefficient electric storage heaters).

→ Zehnder mechanical ventilation heat recovery (MVHR) units in each flat.

Improved living space:

→ Extension of living areas and creation of 'sunrooms'.

→ Enclosure of communal walkway with the creation of an additional entrance.

→ Structural concrete repairs and decorations to external/ communal areas.

→ Converting the existing office admin area at the ground floor to four new additional flats.

Building fabric works

Building fabric works

A fabric first approach

The three existing residential blocks were originally constructed as a concrete prefabricated structure in 1968, using a large panel 'Bison REEMA' variant system (LPS). The existing concrete wall panels included a very small amount of insulation (25mm), but this was ineffective, and alongside inefficient double-glazed windows and old electric storage heaters, the flats experienced high levels of heat loss.

The architect's thermal and airtightness strategy involved the simplification of the thermal envelope, with a new load-bearing steel frame erected on the garden-side elevation. This allowed the external corridors to be enclosed and allowed the living rooms to be extended to meet the new simplified external envelope. The existing stair cores were left uninsulated and outside the thermal envelope, which improved the building's form factor significantly.

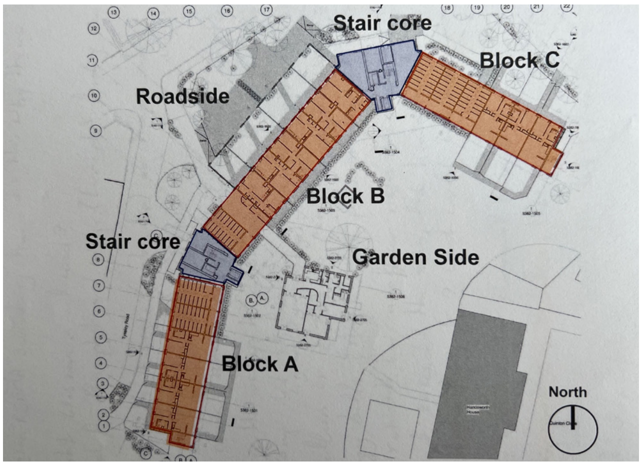
The new structure was attached to the façade which was having LPS typical 1960's construction. The LPS system is at risk of disproportional collapse with gas explosion. So, all gas was prohibited on site for decades now and was replaced by an electrical storage.

With the retrofit scheme, the three blocks are now externally insulated with 300mm non-combustible mineral wool insulation, which wrapped the entirety of walls and roofs. The retrofit included the installation of triple-glazed windows. The building has been cladded in high quality non-combustible mineral wool insulation and all flats have been fully compartmented thereby preventing the spread of fire between flats both internally and externally.

Building envelope	UK Building regulations U-values		Wilmcote House U-values
	Part L1B Refurbishment	Part L1A New Build	
Flat roof	0.18 W/m².k	0.13 W/m².k	0.13 W/m².k
Walls	0.30 W/m².k	0.18 W/m².k	0.14 W/m².k
Windows	1.6 W/m².k	1.4 W/m².k	0.93 W/m².k
Air tightness	N/A	3.0 m³/hr/m² @50pa	1.0 m³/hr/m² @50pa

Building envelope performance comparison

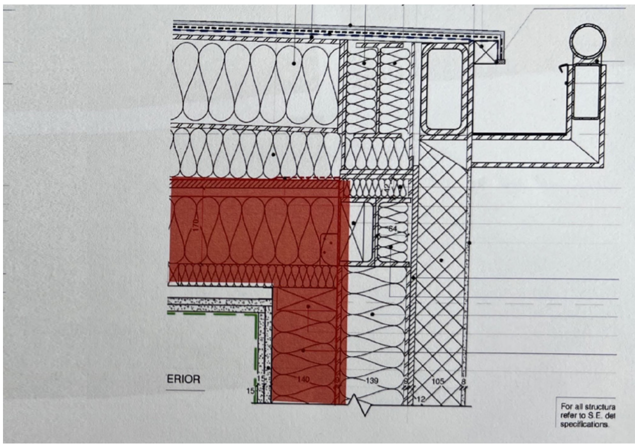
Building fabric works



Site plan

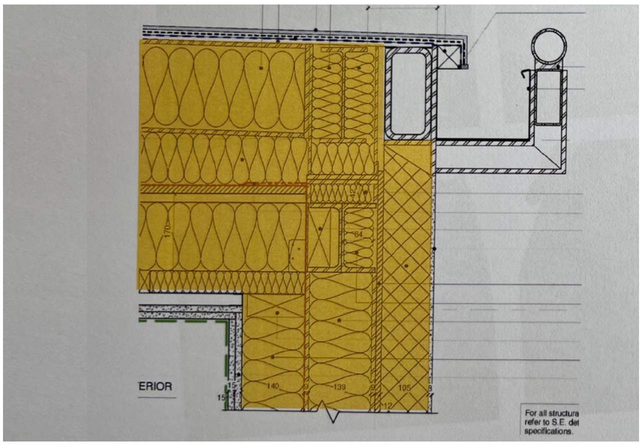
Project's timeline

- *Sep 2018* – Actual completion date
- *Nov 2016* – Planned completion date
- *Aug 2014* – Work commences onsite
- *Jan 2014* – Main contractor appointed
- *Apr 2013* – Planning approval
- *2012* – Resident liaison Officer appointed
- *Sep 2012* – Survey confirms Wilmcote House is structurally sounds
- *Feb 2012* – ECD Architects prepare feasibility report
- *2010* – Portsmouth City Council evaluation identifies window, roof and condensation issues



Roof replacement section detail - Part L 2016 equivalent (hypothetical)

The red hatch shows how little insulation would have been needed to only comply with the Building Regulations at the time, in comparison with the yellow hatch below showing the insulation as installed!



Roof replacement section detail - EnerPHit requirements (actual scheme)

How was it financed?

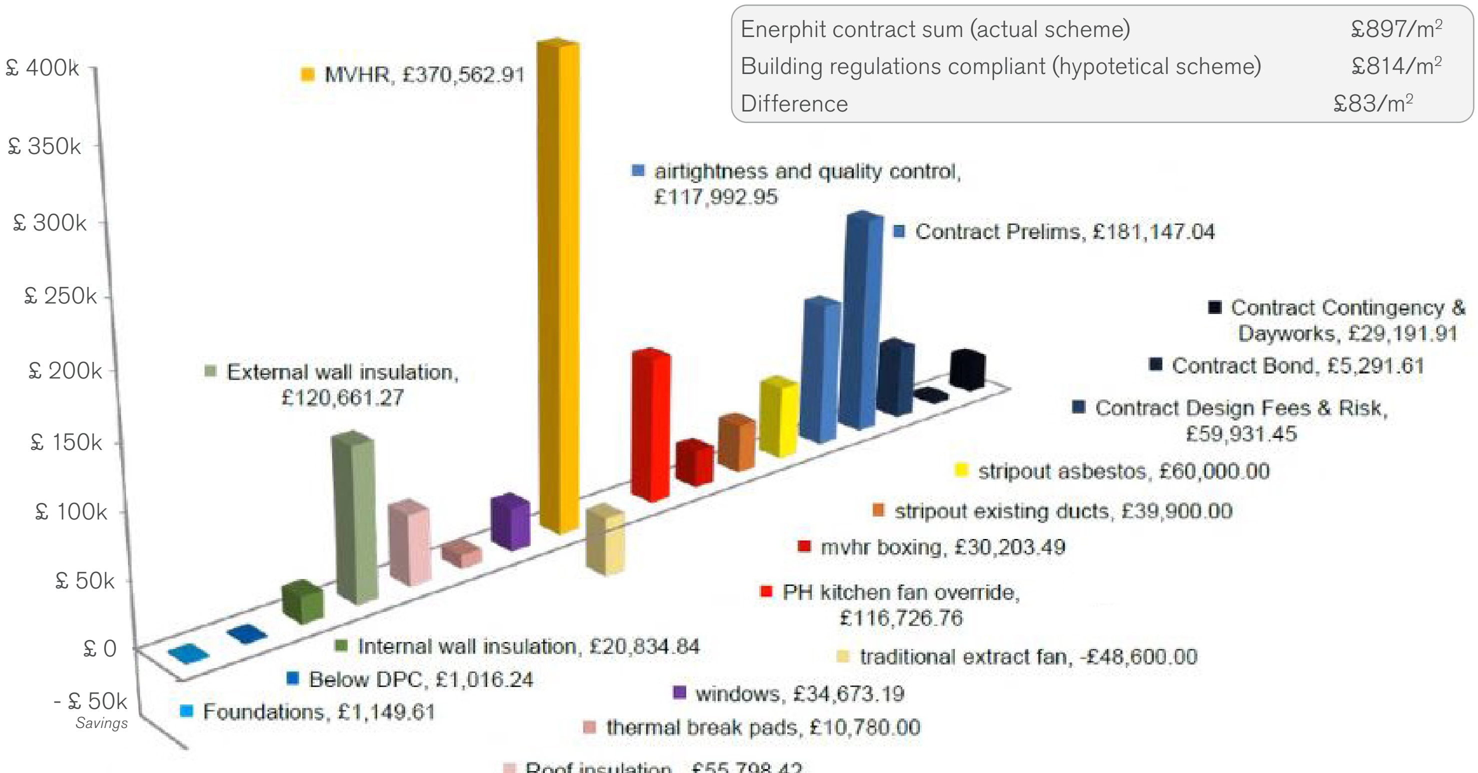
The scheme did not rely on UK government funding or private investment, it was fully funded by Portsmouth City Council. EuroPHit funding was secured to promote the project as a leading exemplar retrofit project, together with funding for project team training to help the scheme achieve EnerPHit standards. Wilmcote House was the only participating case study from the UK in the EU funded EuroPHit project. The EuroPHit is a Europe-wide programme aiming to retrofit a number of housing developments and commercial buildings to the EnerPHit standard using a 'step-by-step' approach.

The client partnered with the London School of Economics (LSE) in a research project which was funded by Rockwool Limited, UK's leading manufacturer in sustainable non-combustible stone wool insulation. Whilst the University of Southampton monitoring work was funded through a PhD fellowship. *More details on the research outcomes in the next page.*

"We engaged with the University of Southampton, who installed data loggers into a number of properties and the results were compelling: residents weren't heating their homes to World Health Organisation comfort levels. They were living in fuel poverty as they simply couldn't afford to heat their homes." *Steve Groves, Head of Building Maintenance at Portsmouth City Council*

Breakdown of estimated capital cost differences

Enerphit contract sum (actual scheme)	£897/m²
Building regulations compliant (hypotetical scheme)	£814/m²
Difference	£83/m²



*£1k = £1,000

Monitoring and Occupancy Surveys

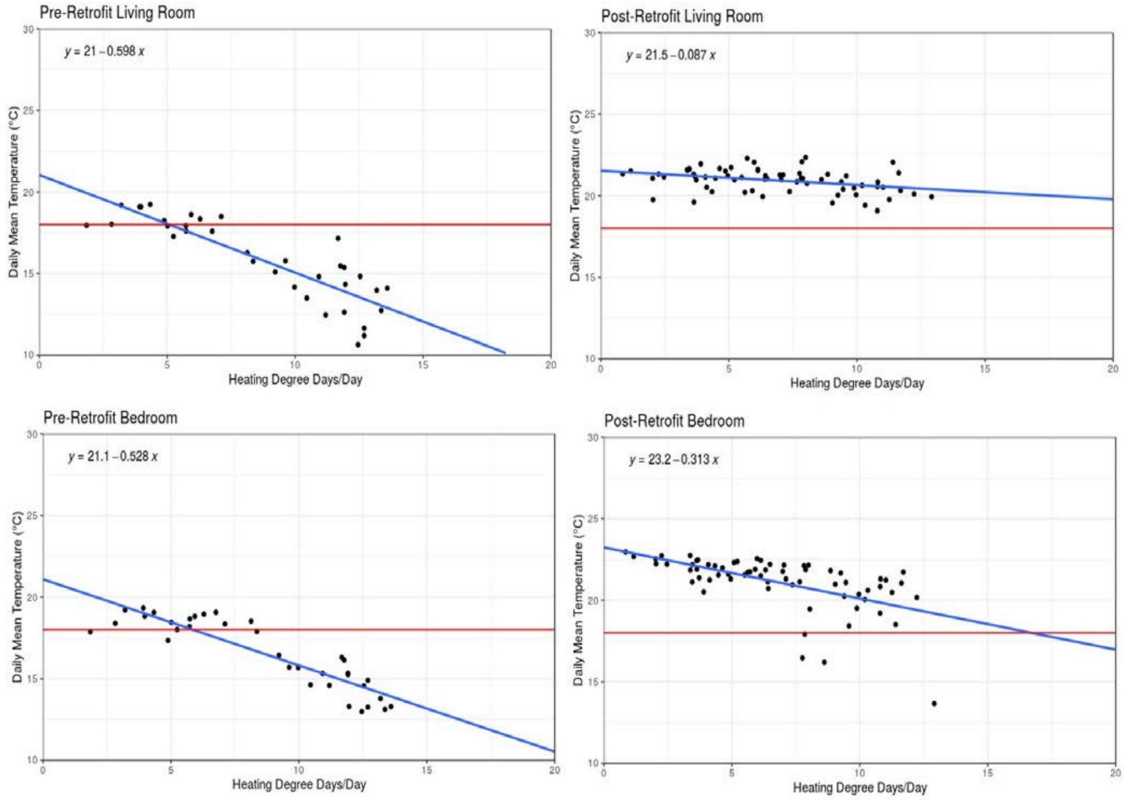
Pre-retrofit research carried out by the University of Southampton discovered many units had an EPC rating of band D/E and several residents could not afford to heat their homes to World Health Organisation (WHO) comfort levels. Without refurbishment it would be uninhabitable for residents, and costly to maintain in the short-term.

The University of Southampton continue to monitor the building post-construction to determine the impact of the works on winter fuel poverty and summer overheating risk. Preliminary feedback suggests the properties energy performance is much improved translating to lower fuel bills for tenants. Thermal comfort surveys conducted during the first round of monitoring after the insulation works were completed (2017-18) suggested a low heating usage amongst tenants, with 60% of participants utilising their heating less than once per week. Whilst 36% had not used their heating at all over the winter period.

The below graphs show a pre vs post-retrofit comparison of a dwelling (living room and bedroom only) where the residents did not use the heating in their home, possibly due to economic constraints. The point of intersection of the blue and red lines estimates a threshold for which some form of heating may be required in order to maintain a daily average of 18°C. The shift of point of intersection between pre vs post-retrofit indicates the Heating Degree Days threshold change. Prior to the retrofit, this dwelling would experience approximately 160 days annually that would require heating (in varying magnitudes) in order to maintain 18°C. Post retrofit, this dwelling in particular is able to maintain 18°C without the requirement for active heating.

The client also partnered with the London School of Economics (LSE) in a research project who have studied the social impact of the refurbishment of Wilmcote House on residents. Residents were interviewed before, during and after the works. The LSE concluded their final resident interviews and they published their final report in January 2019.

Scatter plots show a single dwelling (living room and bedroom) that are under-heated prior to the retrofit, and currently maintains siginficantly better internal temperatures utilising the same heating practice post retrofit.



Source: Stephen, J. (2020) Southampton University monitoring data and analysis (PhD work)

Main challenges

Before retrofit:

→ All solutions must be low cost.

→ Tenants must remain within their homes while the works are being undertaken.

→ Designing the retrofit to meet the demanding EnerPHit standard which involved a number of challenges:

- How to insulate the rear façade which featured integral but exposed walkways without introducing thermal bridges?
- How to provide appropriate and effective ventilation?
- How to provide cost effective heating in a building with limited space for communal services and where the use of gas is prohibited?
- How to overclad balconies and exposed walkways?

→ (A challenge identified and resolved at pilot stage) Tenants have asked for additional ventilation in kitchens as there is a serious issue of overheating now that the external walkways have been glazed over. Note that kitchens' high-level openings cannot open to the external walkways due to the fire regulation. This issue was addressed by designing in the cooker hood extractors.

During retrofitting:

→ Residents reported feeling uncomfortable in their homes and felt their quality of life had been affected. This was exacerbated by delays, last minute changes, missed appointments, miscommunication, instances of poor workmanship, etc.

→ Noise due to the building works.

→ The builders did not always show respect for the residents or their homes. Residents often missed work to give builders access into their homes, only to be let down.

→ For structural reasons, the existing reinforced concrete ground floor could not be broken-up to allow insulation to be installed beneath a new slab. The ground floors were therefore left uninsulated. This could be a future refurbishment step following any potential reduction in the cost of very thin, high-performance insulation.

Main successes

→ The Council's Resident Liaison Officer provided a vital line of communication with residents and was strongly praised by residents. Residents were comprehensively consulted on the refurbishment proposals through a combination of: Newsletters, community events, door-knocking, show flats, open days, etc.

→ Tenants had high expectations that their bills would go down, homes would be warmer, and the building would look nicer; all three expectations were met.

→ The project successfully showcases EnerPHit standards, and the advantages of refurbishment over demolition.

→ The project provided training to upskill contractors around Passivhaus construction, funded by EuroPHit.

→ A new steel structure has been designed to allow the envelope to be extended and to enclose the walkway between the maisonettes, improving safety and allowing easier detailing and installation of external wall insulation.

→ The external wall insulation not only improved the energy efficiency, but allowed refurbishment work to be carried out with the occupants in situ, minimising inconvenience for occupants and reducing temporary relocation costs.

→ Residents' concerns around inadequate and expensive electric heating and the lack of space for drying clothes were incorporated into the retrofit specification.

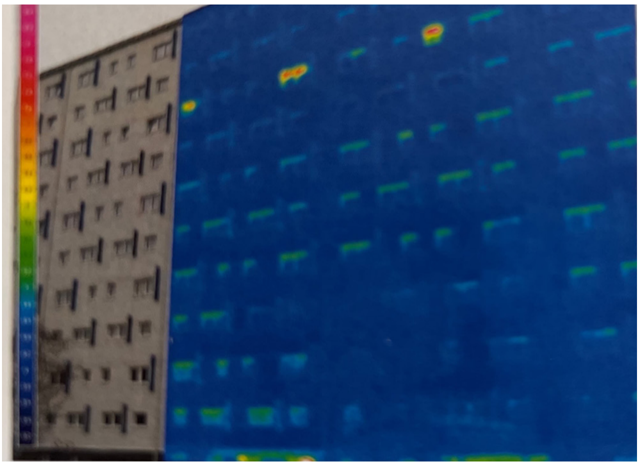
→ Retrofit works were sensible given in-situ residents:

- The contractor suggested Mast Climbers as an alternative to traditional scaffolding to reduce nuisance to tenants.
- Works were phased focusing on one block at a time.
- The communal garden and play area was used by the contractor during the project and was transformed into a car park after the works were completed. The play area was relocated to an adjacent area with general public access that benefited all local residents.

→ Engaging with academia:

- The University of Southampton to monitor the building pre vs post retrofit.
- The London School of Economics (LSE) to study the social impact of the refurbishment on residents.

Pre-retrofit



Post-retrofit

Lessons learnt

→ Portsmouth City Council have reflected on how they procure larger projects in future and their role as a client to manage similar refurbishment schemes, particularly the roles of resident liaison and clerk of works that were more effective when the council provided the roles directly.

→ The council realised that one on one consultations should be considered, as opposed to large consultations.

→ The council would reconsider the partial and phased works approach if they are to do it again.

→ Thermal imaging was a key tool to showcase heat loss before retrofit which were then massively reduced post-retrofit.

→ The project exceeded the anticipated timescale, partly due to the builders being unreliable and missing appointments with residents.

→ The EnerPHit standard drove quality in the work.

→ Implementing the EnerPHit technical requirements was the biggest challenge for the design team and contractor; they had to work together to overcome numerous issues and unforeseen works on site to achieve compliance.

→ Keeping residents in-situ, formed a constraint to complete the final air-test required by the EnerPHit standard. Thus, the certification was never fully achieved. The Architects suggested having a localised pre-arranged test in the future.

→ At design stage, an increase in the primary energy demand was noticed due to some existing storage heaters being retained and even the introduction of the new direct electric heaters. The future decarbonisation of the grid, alongside the future installation of PVs may allow for the primary energy values to be EnerPHit compliant.

→ The retrofit build cost was approximately £920/m^2. This is comparable with new-build housing to similar density and quality, providing a strong business case for upgrading existing concrete buildings at scale.

→ LSE post-retrofit interviews with occupants were done bit too soon after the works, so occupants were still tired from the retrofitting mess and the two years works delay. Some negative responses were noted on that basis. The Council have undertaken additional post retrofit interviews 2 years later with occupants more satisfised with the scheme

Sutton Eco6 Energiesprong retrofit

Sutton Housing Partnership (SHP) has begun work on transforming up to 100 homes using the Energiesprong approach as part of the Council's ambitious drive to cut carbon and give residents cleaner air, greener spaces and lower energy bills. Over 1,900 homes in Sutton are suitable for the approach. During the pilot phase, a total of six homes in St Helier, Sutton were transformed. These semi-detached houses dating from mid to late 1930s are of traditional construction, with uninsulated cavity and high energy bills for tenants.

This pioneering retrofit project provided:

→ For residents: Warmer, more energy efficient homes and lower energy bills (depending on their energy usage).

→ For the borough: A very useful learning opportunity for the extension of retrofitting opportunities across the Borough.

→ For the planet: Making a significant contribution to reducing the environmental impact of our housing stock by replacing fossil fuel heating systems with largely renewably powered systems.

How was it financed?

SHP has secured some significant funding to help get this project moving, from the GLA[1] (Mayor of London's Energy Leap programme), BEIS[2] (Whole House Retrofit Innovation) and ECO3i[3] (the energy companies obligation programme) via British Gas. The capital element that the Council had to fund is only 48% of the overall capital value.

1- The Greater London Authority
2- Department for Business, Energy & Industrial Strategy
3- The energy company obligation (ECO3) scheme is one of the mechanisms the Government has established to help achieve the goal of being carbon neutral. One of the things that the ECO3 scheme does is provide grants to fund energy efficiency upgrades to homes that reduce emissions, electricity and energy bills.

Client	Sutton Housing Partnership
Landlord	London Borough of Sutton
Employers Agent and Clerk of Works	Baily Garner
Contractor	Bow Tie Construction
Other delivery Partners	Greater London Authority British Gas via the energy companies obligation programme (Eco3i) The Department for Business, Energy & Industrial Strategy With project support from Energiesprong UK and Turner & Townsend
Post-retrofit predicted operational energy	4,743 kWh
Renewable energy generation	3,839 kWh

Sutton, London, UK

6, two stories properties (GIA 60-70 m² per property)

1930s semi-detached houses

Completion March 2022

Budget ≈£80k per property

PAS 2035

"It is better because before all this was old. We had draughts, condensation and mould everywhere but now because of the new windows that is gone, it is a lot better" Resident

Whole house 'Energiesprong' approach

The residual electricity import required will be zero carbon as the national grid decarbonises. If export is included in the carbon balance, the properties will be close to net zero carbon (or even carbon negative).

In accordance with the Energiesprong specification, all homes were brought-up to a minimum net-zero energy standard, creating warmer, more desirable places to live. Energiesprong performance specification contains outcome-based targets within which the installer has relative freedom to design the appropriate solution. The retrofit is guaranteed for in-use performance against design.

Retrofit measures included internal and external works, focussing on:

→ External walls: Enhanced cavity fill.

→ Roof: 400 mm loft insulation; roof integrated solar photovoltaic panels.

→ Windows: UPVC triple glazed windows.

→ Doors: UPVC insulated doors with triple glazing.

→ Heating/ hot water/ ventilation: Ventive Home-B, a fully integrated 4-in-1 module replacing traditional boilers, hot water cylinders and ventilation units.

→ Hot water storage: 200 litre insulated cylinder.

→ Space heating: Wet system retained, room thermostat and TRV (Thermostatic radiator valve) radiators.

→ Monitoring: Comprehensive monitoring system. Heat metering on heating and DHW (Domestic Hot Water) production.

Site visit with the Market Development lead at Energiesprong UK.

	Before retrofit	After retrofit	Saving
Energy costs	£1,300	£780	40%
Predicted energy use	18,000 kWh	3,000 kWh	83%
Carbon footprint	4.1 tonnes	1.1 tonnes*	73%

Pre vs post retrofit performance

** 2017 electricity grid carbon factor*

Post-retrofit

4-in-1 integrated energy module

Ventive Home-B is a fully integrated ventilation, heating and hot water system combining exhaust-air and air-sourced heat pump technologies, designed for both new dwellings and energy retrofits.

Replacing traditional boilers, hot water cylinders and ventilation units, Home-B allowed homes to move away from fossil fuels and benefit instead from clean renewable energy, reducing carbon footprint. The Heat Pump recovers heat from stale exhaust air to ensure maximum energy savings with intelligent connected controls. The 10kWh Thermal Store enables the Heat Pump to generate heat at night using off-peak electricity while keeping the house warm and Hot Water available.

Ventive Home-B performance criteria

- Ventilation rate: 20-100 l/s (demand responsive)
- Heat Recovery & Heating: up to 88% (at 40 l/s)
- Hot Water: up to 300l at 45°C
- Night time cooling: up to 2 Air Changes per Hour
- Daytime cooling: up to 2kW for free
- Heating: up to 6kW at 40°C

Ventive Home-B, a fully integrated 4-in-1 module: ventilation, heating, cooling and hot water system.

Main challenges & lessons learnt

Communication is key to a good retrofit project

Need for a strong joined-up tenant engagement and liaison strategy between landlord and contractor - from pre-contract to post-contract. This is essential to ensuring that tenants understand the scope of work. Also, keeping occupants informed and in-control of their environment (i.e., tablet display of consumption, temperatures and instructions for the tenant and control of radiators, box and connection.

Internal space limitation

The proposal involved an external 'porch pod' which houses the heating system and creates additional space for the resident, installed within permitted development rules.

Detailed pre-works surveys

are vital to identifying and fixing existing defects ahead of retrofit works, and creating archetype models for property peculiarities. Time and budget must be made available, especially as PAS2035 requires detailed condition survey.

PAS 2035 compliance

The retrofit followed PAS 2035 but was not strictly bound by it due to the specified innovative heating system not yet being registered by MCS, which certifies low-carbon energy technologies and contractors. The retrofit coordination role was done in house by the installer and the Energiesprong UK team.

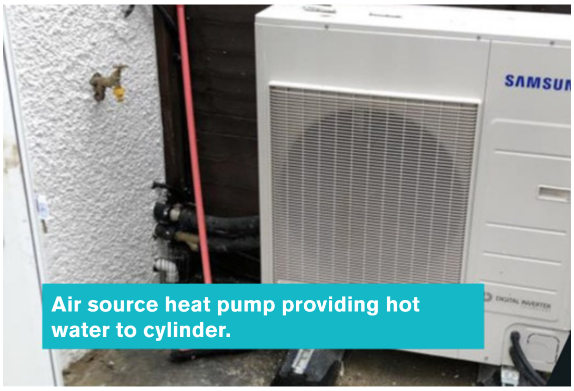
Offsite wraparound solutions

Challenge of procuring offsite wraparound solutions, cost and availability. Energiesprong UK identified a further 10 suppliers with this capability to prevent future bottlenecks.

Early market retrofit projects

are very demanding on housing and solution providers. Funder support was required to make sure future projects benefit from learning about new processes and products.

‘plant room’ with MVHR unit and PV controls and inverter.



Air source heat pump providing hot water to cylinder.

External ‘porch pod’ which houses the heating system and creates additional space.

Short delivery timeframe

Planning was avoided by focusing on high performance cavity wall insulation and airtightness, which was significantly more cost-effective than external wall insulation.

Single measure challenges *(Lesson learnt from Clockhouse Coulsdon, an earlier project phase)*

Due to COVID19, funding timescales and risk management, the project used single energy measures e.g., heat pump and a new water tank. These were situated inside the homes, rather than an integrated pod outside. These were more disruptive to tenants than acceptable, and cost reduction potential not evidenced. Integrated, offsite manufacturing solutions will be used for future phases. In this St Helier phase, a new external ‘porch pod’ houses the heating system and creates additional space *(See the adjacent images to the left: top two images from the Clockhouse Coulsdon phase and the bottom one from the St Helier phase).*

Resident in-situ

Works were planned to minimise disruption to tenants inside their homes (e.g., the exiting windows were moved back to expose the cavity wall frame from the outside).

Next steps

SHP is now a part of Energiesprong’s Innovation Partnership, which has been developed as part of the Mayor of London’s Retrofit Accelerator Homes programme, alongside Turner and Townsend. Upcoming project phases (i.e., scaling this up to 100 homes in Sutton) are underway and will draw on the lessons learnt from the pilot retrofits phase(s).

Strubergasse - Stadwerk Lehen, Salzburg

The re-development of the 'Strubergasse' neighbourhood (≈45,000 m^2) was strategically planned to deliver the vision of the wider city district 'Lehen'. The neighbourhood constitutes of 26 residential blocks (≈35,900 m^2) out of which 14 blocks (286 apartments) were retrofitted and 12 blocks (337 apartments) demolished and re-built. The re-development works included a new mobility concept, new green areas/ foot paths, and rethought the local energy supply system.

The 'Lehen' district vision was drafted in 2005, and the implementation plan for the 'Strubergasse' neighbourhood was drafted in 2009. The renovation works were concluded in 2013. The new buildings works started afterwards and were completed in 2018.

The redevelopment project was completed in December 2018 with a whole set of benefits delivered such as enhanced energy performance and supply, improved biodiversity (i.e., new green areas), and liveability (i.e., balcony for each apartment) and mobility (i.e., new bicycles storage and a better parking management system for motorized private transport), etc.

How was it financed?

Salzburg city council invested €7.8 million (≈£6,5 million) in the renovation of the 14 blocks. Most of the investment was funded by the housing subsidy scheme of the federal government of Salzburg. The EU Concerto program, contributed with €950k (≈£800k). The new houses were funded by 'GSWB', a non-profit housing association owned by the city of Salzburg and the federal state of Salzburg. The funds were gathered from the housing subsidies collected over the years for the realization of social apartments. For the planning and implementation of adapted green areas, the city council of Salzburg invested an additional €1 million (≈£840k).

Developer	Salzburg city council
Architect	Willi Lankmayr
Property management	Johann Steckenbauer
Site manager	Johannes Innerhofer
Moderation process management	Salzburger Institut für Raumordnung & Wohnen (SIR)
Energy specialist	Salzburg AG
Housing Specialist	Stadt : Salzburg - Housing department
City planning	Andreas Schmidbaur
Space heating demand pre-retrofit (modelled)	93-150 kWh/m^2/yr
Space heating demand post-retrofit (modelled)	27-35 kWh/m^2/yr

Salzburg, Austria

26 blocks (i.e., 623 living units)

1950's houses

The projevt was phased with the works completed in Dec 2018

≈ €7.8 million (invested to rennovate the14 buildings) + ≈€1 million invested in the green areas

Klimaaktiv Gold rating *(see page 66 for more information on the Klimaaktiv standard)*

"Quartierssanierung Strubergasse" has won the Autrian energy globe category Earth in 2019

"Whilst important to acknowledge there is no one-stop-shop fix for all retrofits, this case study offers a potential solution to roll out across a multitude of existing large-scale multi-story concrete tower blocks in disrepair." City council

Retrofitting focus

Over almost 10 years, the re-development of the 'Strubergasse' included the following:

→ 12 blocks were demolished and rebuilt; 14 blocks were thermally renovated with new balconies added. The number of apartments has increased from 623 to 636.

→ A new mobility solution (one-way streets and new public bus route), a public bicycle network and foot paths throughout the neighbourhood.

→ Rearranged car parking strategy with reduced capacity and dedicated bicycle parkings were introduced.

→ New green areas with community gardens, and waste collection points (underground),

→ A buffer tank serving the whole development is connected to the heat pump running on exhaust air from apartments /kindergarten and heat recovery from wastewater.

→ New energy supply with local district heating and integration of thermal solar energy.

A 'whole building' approach was taken within the budget of ≈£470k per building (≈£23k per apartment). The buildings retrofit scope included but is not limited to:

→ Envelope insulation (roof, external walls, floors, etc.).

→ Basement insulation.

→ Windows upgrade.

→ New/ replacement external doors.

→ Improved airtightness.

→ Upgrading fire protection.

→ Ceiling/pedestal fans.

→ New central heating system.

→ District heating connection.

→ Energy meters.

→ Reduced water demand (lower flow fittings).

Site plan


Strubergasse - Stadwerk Lehen


Site visit with the Salzburger Institut für Raumordnung & Wohnen (SIR) working group leader

Social support

The bad condition of the old apartments made it necessary to temporarily relocate the Strubergasse's residents (≈1,100 occupants in 286 apartments) to other apartments for the period of renovation. Four housing associations collaborated, flagging rehousing opportunities in nearby projects.

Strategical approach

The thermal renovation was completed in 2012-2013. The demolition of the first house started in 2013 after the tenants got the possibility to move to the new built apartments in the local neighborhood. After the first new house was finished, people could relocate & the next house(s) could be demolished.

Steering group

From 2012 to 2018 a steering group moderated the process. Individual solutions were developed, relocations organised and kept informed. The needs for the different age groups were taken into considerations. Adequate housing was found for all households during the transitional period.

Return possible

If desired, the tenants can sign a return agreement once the retrofitting works were completed. About 30% of the original residents have returned to the development, after an average two years of works per residential block. In some instances, the living conditions of the tenants changed, and this was taken into consideration (e.g., a family used to live in a three-bedrooms house with three children; now they want to return to a smaller flat as two of their children moved out).

Moving-in support

All households received a detailed handover file which serves as a comprehensive guideline for the tenants to make the most of their retrofitted homes.

Social bond secured

Strubergasse's social housing units are let at low rents, on a secure basis, to those who are most in need or struggling with their housing costs. Salzburg city council is closely monitoring the process of the flats' allocation giving the priority to those in most need every time an apartment is allocated.

Working and steering groups

A working group of specialists/ experts was formed at the start of the project including representatives of the city council, housing association, property management, energy supply company, SIR, a renovation specialist, and an architect. The group was moderated by SIR. This group worked out a strategy for the total renovation and drafted a feasibility study that was later submitted to inform the political decision.

After the political buy-in decision, a steering group was formed, led by the city council. The group had nearly the same members of the working group, in addition to the contractor and builders. This group met 24 times throughout the project timeframe to help make strategic decisions.

Quality agreement

Just from the beginning, SIR moderated the retrofit process and worked closely with the steering group to draft a quality agreement which was then signed and agreed with all the parties involved. The EU Concerto program requirements and the quality agreement provided a robust framework for the works. The quality agreement presented detailed performance targets and implementation strategies aligned with the project's vision. Compliance with the originally agreed quality agreement will be monitored and assessed over a period of two years post practical completion. The first year of occupancy was not considered indicative because the occupants are still learning on how best to use the systems; also, they are likely to be moving-in things continuously with the doors open most of times.

The quality agreement was a live document with different inputs, at different design stages, from the housing association, project management, site manager, and others closely involved. The quality agreement was structured around the Klimaaktiv standard categories. Klimaaktiv is an Austrian climate protection initiative and an integral part of the Austrian climate strategy. For more information on the Klimaaktiv standard, please see page 66 or alternatively visit:
https://www.klimaaktiv.at/english/

Net-zero carbon development

By law, 'Strubergasse' tenants are free to choose their energy provider, though it is assumed that most households will stick with the local provider 'Salzburg AG'. 'Salzburg AG' nationally has an energy mix accounting for 100% of renewable energy sources (86,5% waterpower, 8.3% wind energy, 5.2% other sources).

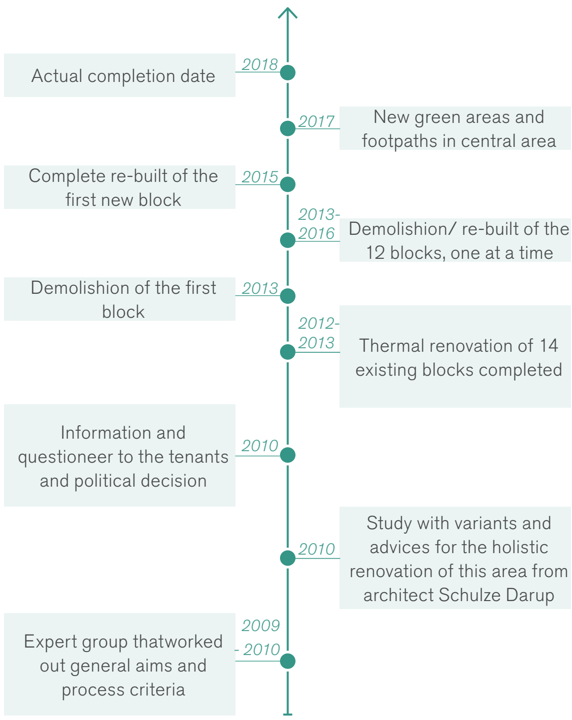
The target is to reduce overall energy demand, and optimise the neighborhood energy supply (25% solar thermal energy on-site and 75% connected to the local district heating). Given the local area limitations, the energy mix as of today consists of 40% biomass and industrial waste heat, and 60% natural gas.

For more information, please visit:
https://selectra.at/energie/anbieter/salzburg-ag/privat-ok

Pre vs post retrofit performance

	Refurbished	New build	Project total
Residential area (m²)	15,633	20,300	35,933
Heating demand before retrofit	93-150 (kWh/m²/a)	100-150 (kWh/m²/a)	4,119,200 (kWh/a)
Heating demand after retrofit	27-35 (kWh/m²/a)	20-25 (kWh/m²/a)	1,055,630 (kWh/a)
Hot water demand (kWh/a)	-	-	360,000
Electricity demand (kWh/a)	-	-	2,226,000 (636 flats * 3,500)
Operational energy cost (€/m²/a)	-	-	5.09 €/m² (inclusive 25% savings from solar renewable)
GHG emissions before retrofit (operational)	56.77 (Kg CO_2 eq./m²/a)	38.85 (Kg CO_2 eq./m²/a)	1,676,400 (kgCO_2 eq. /a)
GHG emissions after retrofit (operational)	8.31 (Kg CO_2 eq./m²/a)	3.30 (Kg CO_2 eq./m²/a)	197,000 (Kg CO_2 eq. /a)
Water demand	-	-	40(m³/per/a)

Project timeline



The buffer tank serving the whole development and connected to the heatpump running on exhaust air. The buffer tank features an interactive art work.

Pre retrofit

Post retrofit

Main challenges

→ Politicians want to target the low hanging fruit delivering short-term value in line within their governance. There is a lack of incentives for retrofit measures with long paybacks.

→ Different heating systems were installed in the existing old flats (e.g., single stoves for coal, wood or oil, single floor heating with gas, some flats were connected to the district heating, etc.). With the support of the local energy supplier and municipality, it was necessary to formulate a strategic approach to agree on one preferred system and invest in ways to transform the existing stock. In 2018, about 50% of the 636 apartments were connected to the district heating and there is a plan to progressively increase this number.

→ The Austrian building standard focuses on new buildings with a lack of awareness and guidance regarding retrofitting the existing building stock.

→ The traffic situation was not sustainable, and neither were the green areas. Car parking spaces where taking-up a significant amount of the public realm around the buildings, leaving no defined green public spaces. A new mobility strategy was proposed and the challenge was to gain the tenants buy-in as their lifestyle depends heavily on the use of private vehicular transport.

Main successes

→ The area of Strubergasse has become a modern living area: high living quality, improved building standards, new green area, sustainable mobility concept, new local facilities (e.g., supermarket, shops, medical services, social infrastructure), delivering value beyond the site's red-line boundary.

→ ≈88% saving in operational carbon: from 1,676,400 kg CO_2 eq./a (pre-retrofit) down to 197,000 kg CO_2 eq./a (post-retrofit).

→ ≈72% energy demand reduction from 2,180,400 kWh (pre-retrofit) down to 609,030 kWh (post-retrofit).

→ Largest roof integrated thermal panel collection in Austria 2,048 m^2. About 25% of all the development's energy demand is supplied from renewable sources (e.g., heat pump and solar photovoltaics).

→ The secured social bond allowed for a more diversified tenant mixture (e.g., working/ middle-class households, different age groups, etc.)

→ In 2019, 1 year post occupation, 88% of the tenants were satisfied with the retrofitting outcome and the new living standard in the Strubergasse's neighbourhood.

→ The project implemented a strategical approach for the tenants' relocation during the works (see page 60, Social Support section).

Retrofitted buildings - Strubergasse neighborhood

New buildings - Strubergasse neighborhood

Lessons learnt

→ The working group early workshops were key to assess the viability of the redevelopment scheme and helped in identifying the key opportunities and challenges (e.g., varied ownerships, tenancy, etc.). The steering group then helped informing the retrofit process bringing multi-disciplinary experts into the decision-making process.

→ The city council owned most of the apartments, thus, every decision is political. Political parties are usually interested in single retrofit measures as opposed to a deep whole house retrofit approach. They are interested in short term as opposed to long term outcomes, and this is to align with the election/ governance periods. A holistic feasibility study would be required at the forefront, building-up the case for the redevelopment scheme and presenting short-term and long-term value delivered. The EU Concerto external funding supported the decision-making process, endorsing the scheme and emphasising its importance.

→ Tenants' involvement is key – keeping them informed and understand what makes them feel more comfortable (e.g., for some tenants a balcony is more important than a floor insulation, some other tenants are after having a larger storage area in their homes, or an accessible green public playground for their kids, etc.).

Next steps

The first step of the Lehen district redevelopment was "Stadtwerk Lehen"; Strubergasse was a model project of the EU Concerto program. Lessons learnt from this project will inform other redevelopment projects and will help in delivering the Lehen district overall vision. Below are some influenced upcoming redevelopment projects:

→ Lehen 'Rauchmühle' area, Inhauserstrasse (on-going, site works started summer 2019), and Goethe Siedlung (on-going, currently at planning stage).

→ Aspern Seestadt, Vienna: one of the largest urban redevelopment projects in Europe.

→ Reininghaus Gründe, Graz, Austria: Between Gries, Wetzelsdorf and Eggenberg, a new district will be developed by 2025.

→ Haus der Zukunft plus Leitprojekte, varied locations: 'House of the Future Plus' programme is a multi-year, strategically oriented joint project with a focus on building associations, settlements and/or industrial and commercial areas - and on trend-setting modernisations of buildings.

ZeCaRe - Friedrich Inhauser Straβe

Built in 1985, the residential complex of 'Heimat Osterreich' suffered from poor accessibility, lighting, insulation and damaged balconies. This urged the city council to renovate the estate, to improve the local area and the tenants living standards. Phase 1 delivered the retrofit of the 'Heimat Osterreich' residential complex with phase 2 (retrofit of a nearby residential complex owned by another housing association) scheduled to start on-site early next year.

Phase 1 is now completed with 75 flats from 1980's (originally wood construction) being renovated and 24 new apartments delivered as part of the redevelopment scheme. The design works were informed by an advisory board of three international architects (two urban planners and a landscape designer) formed by the city council. For instance, they advised on keeping the identity of the old houses, with the existing sloped roofs being integrated in the new architectural concept.

How was it financed?

The bulk of the works was funded by the city council. To gather lessons learned and to influence future redevelopment projects, the council advised on having a research work running in parallel. The accompanying research projects 'Zero Carbon Refurbishment II' and 'ZeCaMo' were funded by the climate and energy fund of the *Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation & Technology.*

Developer	Heimat Osterreich
Architect	Christoph Scheithauer
Landscape Designer	Peter Aicher
Moderation process management	Salzburger Institut für Raumordnung & Wohnen (SIR)
Building services	ECA - Energy Consulting Austria
Social specialist	StadtLandBerg
Mobility specialist	Family of Power
Reserach body	FH Salzburg University

Salzburg, Austria

75 existing flats in four separate blocks

1980s flats

Completion December 2021

Confidential

Klimaaktiv Gold rating *(see page 66 for more information on the Klimaaktiv standard)*

2021 Sustainbaility Award
1st place in the research field

2021: OGUT environemntal award: Innovation and City category

2021 VCO Mobility Prize
Awaded as an examplary project

"I am enjoying growing my own veggies on-site and sharing the surplus with the neighbors" Resident

Retrofitting focus

One of the main drivers is to make multistorey houses as appealing as a private house where the space is more abundant. The buildings' retrofit scope included, but is not limited to:

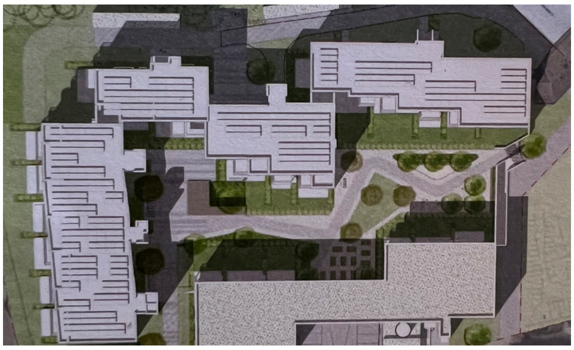
→ Envelope insulation (roof, external walls, floors, etc.).
→ Windows/ external doors upgrade.
→ Improved airtightness.
→ New balconies.
→ New central heating system.
→ Energy meters.
→ Reduced water demand (e.g., lower flow fittings).
→ 1 additional floor (24 new apartments in total).
→ A new mobility point on-site.
→ A new waste collection/ sorting on-site.
→ Public realm interventions such as communal gardens, food growing corner, kids playground, & seating furniture.
→ Communal spaces accessible by all tenants which can be privatly rented given prior notice (e.g., 1 communal guest room, 1 multipurpose room for private events, storage sheds, high beds for food growing, 1 workshop area).

Affordable housing

→ An additional 24 low rent apartments were created by increasing the number of apartments from 75 to 99.

→ Salzburg city council is closely monitoring the process of the flats' allocation giving the priority to those in most need every time an apartment is allocated.

→ Low rents were made possible with a grant provided by the city council to the Housing Association. Rent figures (Bills excluded) includes the service charge covering-up for the communal area maintenance and the mobility point facility access. The monthly subsidised rental costs for residents are about 8 €/m_2 (bills excluded). On the open market, typical asking rent will be 18.5 €/m_2 (bills excluded).



Masterplan

Pre-retrofit

Post-retrofit

Local waste collection point, on-site sorting.


The buffer tank and the mobility point.

Klimaaktiv building standard

klimaaktiv is the Austrian climate protection initiative and integral part of the Austrian climate strategy. It´s primary objective is to launch and promote climate-friendly technologies and services. In doing so, klimaaktiv focuses on high standards of quality, provides education and training of professionals, gives advice, and cooperates with a large network of partners. klimaaktiv certification scheme has three rating levels (gold, silver, bronze), and is structured around the following categories:

→ Management & coordination (early expert involvement, education & training, communication, partner management, municipalities).
→ Buildings (Low-carbon design and construction, waste optimisation, water reduction, and other holistic design strategies).
→ Energy systems and efficiency.
→ Mobility (promoting clean mobility).

The project scored 929 out of a possible 1000 points, thus achieved the gold standard for sustainable living and services by Kilmaaktiv. The certification scheme requirements were captured in a 'quality agreement' signed by all involved parties to showcase commitment towards meeting the 'gold' rating target.

For more information, please visit:
https://www.klimaaktiv.at/english/

Focus on mobility

For the first time in the city of Salzburg, a new mobility point is introduced in a residential context. The mobility point is operated by the Cooperatives Europe, under the European Power programme. The European Power programme was created in 2015 to help Europeans develop policy responses to the issues affecting the EU's capacity to act on the global scene. The on-site mobility point offers a wide range of sustainable transport options:

→ E-car sharing
→ Electric scooters
→ E-bikes
→ Cargo bike
→ Trolley boys

The team reduced the number of car parking spaces required for the new scheme and challenged the city council parking requirements for the additional 24 flats. The team argued that the new bicycle storage in the basement will cover-up for the shortcoming number of car parkings and will induce a new sustainable alternative way of transport for the tenants. The existing 68 car parking spaces are not permanently allocated to the residents, instead they can be rented on a daily basis.

The city of Salzburg has created a new guide for municipalities and property developers on this topic. For more information, please visit:
https://www.stadt-salzburg.at/smartcity/smarte-mobilitaet/mobility-points/

Site visit meeting with one of the residents.

Site visit with the Salzburger Institut für Raumordnung & Wohnen (SIR) working group leader.

Low-carbon approach

The aim of the comprehensive renovation was to reduce the CO_2 emissions of the residential complex, both operational and embodied. The following strategies have been implemented:

→ A buffer tank serving the whole development is connected to the heat pump running on exhaust air from apartments/ kindergarten and heat recovery from wastewater.

→ On-site photovoltaics and the heat pump cover up to 75-80% of the development's heating energy and hot water demand. The remaining 25-20% are covered with pellets heating in which wood pellets (i.e., small pellets from wood chips and sawdust) are combusted.

→ A targeted clean mobility concept aimed at reducing car use, thus, cutting down harmful emissions.

→ The use of ecological materials (e.g., timber construction having a low embodied carbon). Note that the Austrian building regulation allows for timber construction for up to 4 storeys with no additional fire risk requirements.

→ Construction materials selection was informed by the Ökoindex OI3 assessment tool which looked at the materials' global warming potential, acidification potential and reduced the need for non-renewable primary energy.

Materials impact assessment

Choosing the right building material is becoming increasingly important, as the amount of energy required to construct a building is about the same as it takes to heat a low-energy house for 50 years. Environmentally friendly construction takes into account the best possible thermal insulation, renewable energy sources and ecological building materials.

The Ökoindex OI3 assesses the ecological quality of all materials based on the environmental indicators global warming potential, acidification potential and the need for non-renewable primary energy. The Ökoindex OI3 can be calculated for building materials, constructions, and entire buildings. As a single figure, the indicator provides quantitative information on the potential for global warming, acidification of the environment and the consumption of non-renewable energy resources. The Ökoindex OI3 calculations are based on the IBO guideline value table for building materials and can be calculated using various computer programs, e.g., eco2soft. Detailed information on the balance border method as well as precise calculation rules are presented in the current OI3 calculation guide.

You can download the OI3 calculation guide and check the IBO guideline values for building materials, following the below links:

→ ***https://www.ibo.at/en/building-material-ecology/lifecycle-assessments/oekoindex-oi3/***

→ ***https://www.ibo.at/en/building-material-ecology/lifecycle-assessments/ibo-guideline-values-for-building-materials/***

E=0 Hem's Energiesprong Retrofit

The EnergieSprong approach was launched in France in March 2016, by GreenFlex, a firm specialised in helping organisations accelerate their social and environmental transition. GreenFlex has set-up a market development team of seven people to adapt and implement the EnergieSprong approach in France and works with local stakeholders to do so.

In the frame of the E=0 project, Vilogia, a social housing association in France, tested the EnergieSprong approach for the first time on 10 individual houses to demonstrate the replicability of the project. The pilot is composed of 2 groups of 4 houses and 1 group of 2 houses. They are typical northern brick houses with two floors and four rooms built in 1952, with an initial energy performance of E. This first refurbishment comes with a 25-years performance warranty on the energy performance.

Developer	Vilogia (Social housing association)
Main contractor	Rabot Dutilleul Construction
Architects	RedCat Architecture
Energy Consultant	Symoé
Prefabricated modules	Smart Module Concept
Structural engineer	Nortec
Design and installation of energy solutions	Pouchain
Pre-retrofit primary energy	301 kWh /m²
Post-retrofit primary energy	0 kWh /m²

Hem, France

10 terraced houses (840 m² in total)

1950s houses

Completion April 2018 (total 4 months of sites works)

€1,200,000 (€120,000 per house)

Energiesprong performance standard

Performance guarantee

Guaranteed performance is at the heart of the Energiesprong model. The net-zero operational energy (E=0) is guaranteed over 25 years under the normal conditions of defined use. The warranty includes energy equipment and facades. The only way to provide this guarantee is to closely monitor the energy consumption and other metrics after the project is complete.

If the project fails to perform as the design intended, the contractor (i.e., holder of the guarantee) is liable to a financial penalty to the housing association and the tenants. In this case:

→ *Rabot Dutilleul* (main contractor) is the bearer of the guarantee during the design and implementation phases.

→ *Pouchain* is the bearer of the performance guarantee during the operation phase.

Project timeline

Apr 2018	Actual completion date
Jan 2018	Work comencement
May 2017	Business case implementation
Nov 2016	Business case dialogue
Oct 2016	Entreprises shortlist
Sep 2016	Project launch

"In the long term, deep whole house retrofit is more economical than adopting modest fragmentary energy efficient works that can often cause unintended damage & underperform, locking in inefficiencies."
Architects

Retrofitting focus

The six-weeks retrofit works were non-intrusive, and there was no need for the resident to move out their homes. The retrofit scope included the following measures:

→ 40cm-external prefabricated façades were added. The initial façades were digitally scanned and then reproduced in utilities. The roof was insulated and triple-glazing windows were installed.

→ Kitchen and bathroom were refurbished.

→ A dual flow ventilation was installed enabling uniform heating during winter and a cooler house in heatwave periods.

→ A heat pump was installed to provide hot water.

→ Solar panels were installed on roofs to provide energy.

→ An energy 4-in-1 module *(Nilan Compact P)* was integrated in the façade which gathers heat, hot water, ventilation and cooling systems to facilitate maintenance.

→ Monitoring devices were installed with access to live coaching to help them follow, understand and master their energy consumption.

Meeting with the Project Coordinator at Energiesprong France.

Site plan

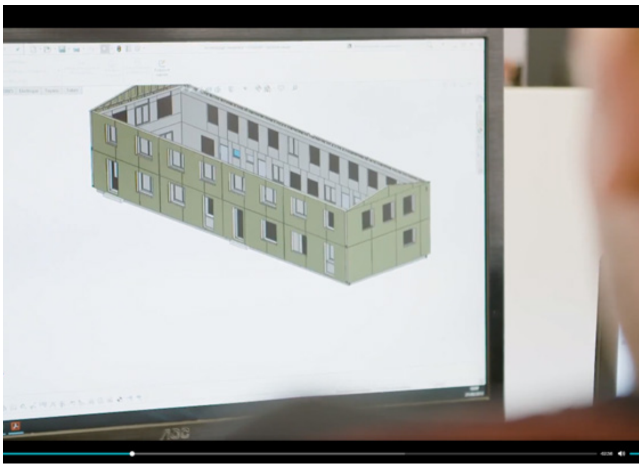
Post retrofit

Nilan Compact P technical 4-in-1 module

Step 3: On-site Integration and extensions of additional building elements.

Step 4: On-site Integration and extensions of additional building elements.

Step 2: Off-site manufacturing: prefabricated facades with triple glazed joinery.



Step 1: 3D scanning and prefabrication based on BIM modelling.

One-Stop-Shop

The Energiesprong approach aims to fully insulate homes using offsite manufactured wall and roof panels in conjunction with pre-assembled 'energy pods' - creating warmer, more desirable places to live that are partly financed by energy and maintenance savings. The retrofit package for the Hem project includes:

→ a prefabricated timber façade.

→ an integrated heat pump for centralised heating.

→ Roof integrated photovoltaic panels.

Prefabricated timber framed façade elements are used for the external thermal insulation of walls. The prefabrication enables the industrialisation of the manufacturing process, and reduce the duration of on-site works. The system also integrates windows and HVAC devices. In this refurbishment package, the prefabricated façade is combined with a heat pump that provides space heating and domestic hot water, and with a ventilation with heat recovery. Photovoltaic panels are also installed on the roof.

Find-out more about the one-stop-shop prefabrication approach in pages 82-83.

N.B. Prefabrication tends to involve the use of new raw materials for bespoke purposes (i.e., high embodied carbon). Project team should prioritise a circular economy approach when specifying materials, otherwise this can be classified as a threat. Energiesprong France are already exploring this route.

Step 5: The mounting of prefabricated modules exploring a new construction process.

Step 6: Integration of photovoltaic panels on the insulated roofs.

Whole house Energiesprong approach

Insulation

→ Facade: 831 m² of insulated façade and 90 joineries replaced, Rtotal = 7.08 (m². K) / W. Prefabricated panels, wood frame of 145 mm, filled with 60 mm of resolic foam (R = 3), external insulation supplement of 120 mm of polystyrene panel (R ≥ 2,09). Triple glazed PVC joinery (Uw=0.85 W/m²K). Roller shutters: aluminium blades, insulated interior box. Glass door (Uw=1 W/m²K) Cladding briquettes cladding (E=5mm).

→ Roof: 420 m² of insulated roof, Rtotal = 8.98 (m². K)/W. Sandwich panels 150 mm polyisocyanurate foam (PIR) (R≥ 6.82 (m². K)/W). Ceiling insulation 80 mm in rock wool (R ≥ 1.95 (m². K) / W), cut off-site.

→ Floor: 420 m² of insulated floor, Rtotal=4.2 (m².K)/W.

- On cellar space: Insulation underneath slab 15 cm of expanded polystyrene insulation (R≥4.15 (m². K)/W).
- On crawl space: Insulation 20 cm insulating TH50 (R ≥ 4.15 (m². K)/W). Doubling of the volume emerging on the ground floor and replacement of the entrance door of the cellar by an insulating door.

Renewable energy production

→ Roof integrated photovoltaic panels: 272 monocrystalline panels of 280 Wp or 81.6-76.2 kWp installed over 443 m².

→ Estimated energy production per year 1: 80,000 kWh, or 8,000 kWh per dwelling.

Energy module

→ Energy module: Nilan Compact P technical 4-in-1 module, air/air heat pump: dual flow ventilation, production of heating/air conditioning (blown air), cooling, and domestic hot water (180L). 2.76 < COPair/air < 3.81.

→ Additional heating transmitters: Auxiliary radiators in bathrooms and convectors in living rooms

→ Ventilation ducts: Double flow ventilation, Oblong Nilair VMC ducts incorporated on the façade and in a false ceiling, air intake grids on the façade.

Instrumentation

→ Sensors: counting of ECS, electrical consumption by use (General TD, Kitchen, Radiators, energy module, lighting) and PV production.

→ Orders: Tablet display of consumption, temperatures and instructions for the tenant and control of radiators, box and connection.

Supplementary works

→ Asbestos removal: Removal of asbestos “Eternit” plates as well as all accessories' fences, ridges, evacuation works PEs. Removal of existing insulation in the attic.

→ Embellishments: Re-equipping of kitchens and bathrooms. Paintings of kitchens, toilets, and bathrooms. Soft flooring in bathrooms.

Pre-retrofit

Post-retrofit

How was it financed?

The total cost amounted to approximately 1.3M€ (design: 10,500€/house, construction works: 121,000 €/house) – which corresponds to 1,525 €/m². Annual maintenance costs are estimated at 1,100€ / house.

The cost of this first EnergieSprong demonstrator was high as it was a first trial in France. The long-term objective is to achieve these refurbishments at standards costs or at least at a cost of about 70,000 €/home for individual houses and 55,000 € per dwelling in multi-apartment buildings, which will be possible as the demand goes higher and the sector gets structured. It took nearly 1,000 homes in 5 years in the Netherlands to reduce costs by 50%.

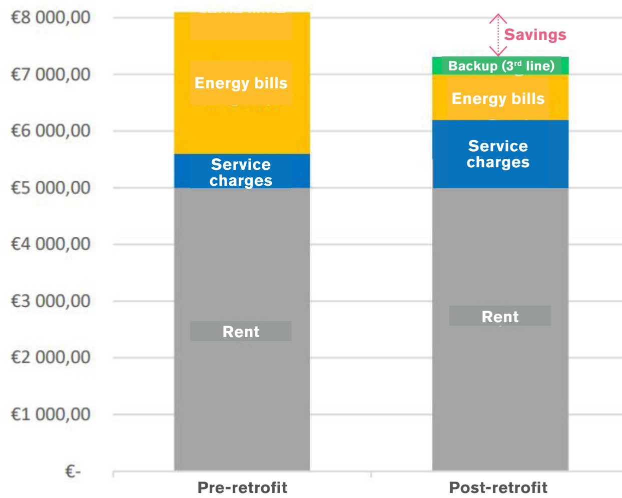
Before the renovation, the global electricity bill for the each of the ten dwellings amounted to 1,500€ per year and each tenant had to pay 400€ in charges. After renovation, the electricity bill stands at 600€ and the charges have been set at 700€. The rent remains fixed.

Interreg NWE (North-West Europe) provided a grant of 51,000€/ house for the construction work. This project also received a co-funding from *ADEME (Agence de l'Environnement et de la Maitrise de l'energie)/ Caisse des Dépôts & Consignations* to perform preliminary feasibility studies.

Annual expenses and savings

Taking as an example house n°46: the tenants attained a total savings, post-retrofit, of more than €500/a. The saving is achieved accounting for an extra fee of €400/a, post-retrofit, collected by the housing provider as a backup for required future maintenance and renovation works.

To follow-up on the monthly expenses, tenants are provided access to an online application and online statements sent by mail. The accountant manager runs annual visits to sign-off the charter of use and keep the tenants better informed.



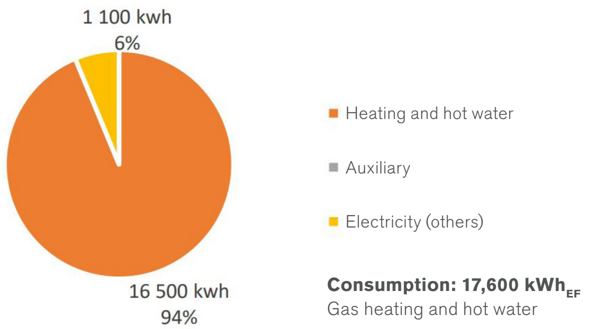
	Pre-retrofit	Post-retrofit	Notes
Energy performance diagnosis (DPE) rating	E (301 kWhep/ m^2.a)	A (70 kWhep/ m^2.a)	DPE is a mandatory survey in France
Energy consumption	Average 25,000 kWhef/house	Average 5,000 kWhef/house	80% saving
Heating and hot water system **controlled mechanical ventilation*	Boiler Gas, single flow VMC* and low insulation	Heat pump boiler, dual flow VMC* and efficient insulation	PV production 1st year: 5.1 MWh

Pre vs post retrofit performance

Monitored performance

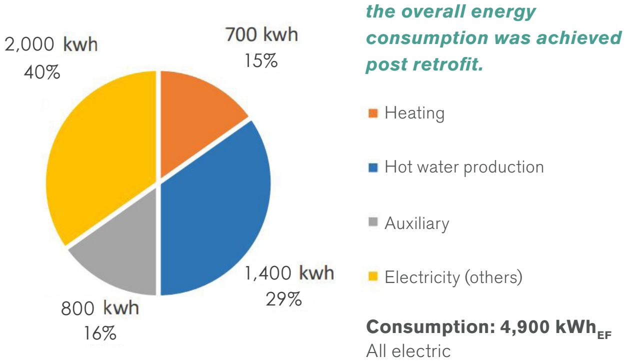
The below diagram illustrates the pre vs post retrofit monitored data for house n°46. The post retrofit data is averaged based on the first year of occupation.

Pre-retrofit



Post-retrofit

72% reduction in the overall energy consumption was achieved post retrofit.



Lessons learnt

Technical

The design phase was crucial, making up 80% of the project. Due to the tight deliverable deadline, everything had to be anticipated, sequenced, planned and programmed in advance. This operating mode required adaptation and modification of working methods, as well as co-construction and cross-functionality of the entire group (technical and tenant management parts).

In addition, the approach depended largely on the landlord who represented the demand side. The terms of cooperation between landlords, industries, project managers, engineers, architects need to be set in the early stage of the project.

Construction time was at least twice as short as usual thanks to the pre-industrialized process; In the long term, it is expected to decrease even further from 6 to 3 weeks.

Environmental

Indoor comfort and a sense of well-being, facilitate behaviour change and the integration of eco-gestures.

Social

The success of the E=0 project depends on reasonable usage behaviours. Vilogia had to define the objectives of the project (zero energy over the year and tenant satisfaction), and ensure the group met the target. Particular importance must be given to supporting tenants and training tenants in new equipment and mastering their energy consumption in a simple way. Moreover, since the tenant is involved in the renovation of his dwelling, it is important to be attentive to his needs.

Recommendations

→ The actors had to be agile, flexible, cooperate and communicate one with others to make processes more fluid and contribute to success.

→ Things must be kept simple with the tenants.

→ It would make a lot of sense to continue to support the start-up of the sector through decreasing subsidies towards pilot projects in each French region. It took nearly 1,000 in 5 years in the Netherlands to reduce costs by 50%.

4

Holistic Retrofit Approach

Developing a retrofit plan

Engage and support community groups to develop Individual houses, blocks and/or neighbourhood retrofit plan(s), including securing funding and managing procurement.

The retrofit plan should be used:

→ to record existing surveyed information about the house, block, or portfolio.
→ to identify and record the most suitable retrofit solutions for the particular house, block or portfolio following documented consultation.
→ to effectively communicate the financial benefits of undertaking different retrofit measures and how to fund the measures to the homeowner/residents.
→ to provide capital and whole life cost information.
→ to state what statutory and legal requirements must be met and how.
→ to effectively describe the best way to manage the phased installation of retrofitt measures (as necessary). This is based on trigger points relating both to the house and its occupants, and opportunities that should be kept open for future staged implementation on neighbourhood or property portfolio programmes, to make decisions regarding which dwellings to start work on first and future phasing.
→ to plan the design, procurement, installation, and commissioning phases of the project.
→ to act as a post-occupancy tool to support a low carbon lifestyle in the home.
→ to act as a tool to manage the maintenance of retrofit measures.

Building renovation passport

Building Renovation Passport could have a positive impact on the rate and depth of energy renovation by:

→ Providing an assessment tool of the home.
→ Developing a whole house renovation plan for the home.
→ Drawing together energy and wider retrofit work.
→ Providing a logbook to track building changes over time.

Some benefits of the Building Renovation Passport:

→ Links to partial retrofits and seeks to go with the grain of how people renovate their homes.
→ A way to provide information to the homeowner about things that can be done to their home – that they might not have found out about otherwise.
→ Protects the potential for retrofit later on down the line.
→ Should help the supply chain by flagging up other measures which could be integrated.
→ Provides better information for the financial sector and could provide a better mechanism for developing financial products than EPCs currently do.
→ Generates better quality data about homes and the potential interventions, impacts and costs.

There are currently a range of passports around, and the Greater London Authority has put together a literature review[1] which seeks to draw together the existing passports. Work is underway to develop a further passport by the Coalition of Energy Efficient Buildings. In the absence of a single, agreed passport, the broader approach[2] of the passports, currently developed in France, Germany and Belgium, can be used to inform the development of a holistic approach to retrofit.

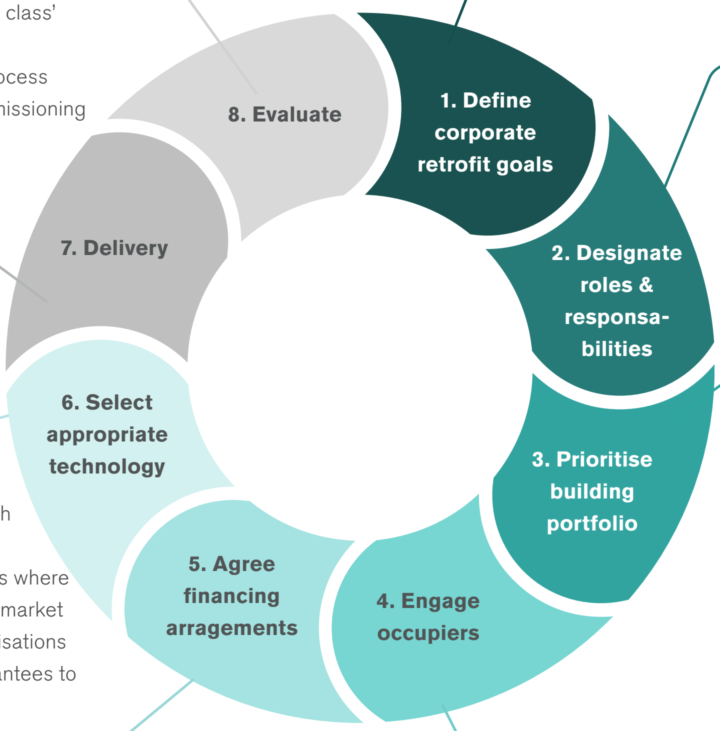
1- Not publicly available, but the work progress can be found in here: https://etude.co.uk/projects/closed-39/

2- M. Fabbri, M. De Groote, and O. Rapf. 2016. 'Building renovation passports. Customised roadmaps towards deep renovation and better homes'. Retrieved from: https://www.bpie.eu/publication/renovation-passports/

Why do you need a retrofit plan?

To manage investment requirements in the home as well as householder expectations.	To inform owners and householders in their engagement with retrofit consultants and contractors.	To plan phased upgrades that align with other works.
To understand the trigger points and when to install particular measures.	To keep a record of installed measures and the achievement of any statutory requirements and warranties.	To achieve target energy and carbon dioxide emissions reduction performance.

Planning low carbon retrofit projects



1. Define corporate retrofit goals
a. Percentage emissions saving
b. Accelerated equipment replacement
c. Number of low carbon retrofit projects over a defined period

2. Designate roles & responsabilities
a. Client instruction
b. Elect board level champion
c. Designate senior management roles to implement targets
d. Establish a key set of approval evaluation criteria
e. Implement an approval process

3. Prioritise building portfolio
a. Undertaking surveys
b. Dwelling typology
c. Occupier type
d. Service charge structure
e. Owner/ occupier relantionships
f. Lease length
g. Carbon saving/ payback potential
h. Building retention strategy

4. Engage occupiers
a. Initial engagement to discuss shared project goals
b. Customer acceptance
c. Agreement of financial evaluation criteria and project limitations
d. Agreement of retrofit options including costs, benefits and impacts
e. Joint discussion to agree payback and commercial options

5. Agree financing arragements
a. Owner funded
b. Occupier funded via service charge
c. Third party options

6. Select appropriate technology
a. Choose technologies which minimise disruption
b. Select proven technologies where data is freely available in the market
c. Where possible use organisations that offer performance guarantees to minimise risk

7. Delivery
a. Identify 'best in class' suppliers
b. Manage the process
c. Focus on commissioning and handover

8. Evaluate
a. Performance monitoring
b. Feeback lessons learnt into internal processes
c. Communicate lessons learnt to educate wider market

Surveys and assessments

Here we look at what an energy surveyor or assessor must do in order to understand the home that is being considered, to provide an accurate assessment and deliver useful advice.

One of the main barriers to action identified by householders is lack of good independent advice, set in the context of their dwellings and their lifestyles. An assessment and the associated advice must reflect "trigger points" such as a planned extension or a redecorating project and show how proposed improvements can be integrated with them. Thus, an assessment is much more than just an exercise in gathering data for input to software.

The aim should be that one visit satisfies all analysis and planning for the job, including the collection of information that sets the context of the calculations and subsequent recommendations. It is good practice to complete the work in a timely but professional fashion with least disruption to the homeowner. The assessor should:

→ show restraint and not second guess the calculations that will follow; it is difficult to engender trust in your advice if subsequent calculations contradict a confident verbal recommendation early in the process.

→ be polite and always remember that he/she is a guest in someone else's home, and a representative of all energy assessors and their profession.

→ observe health and safety rules especially when accessing areas of the house and its surroundings where hazards exist; a risk assessment and method statement should be completed and appropriate insurance cover should be in place.

Data format

Information will usually be recorded in one or more of the following formats:

→ on paper forms, for later input into the assessment.

→ as direct input into software on a portable computer or into a hand-held device for later uploading written notes about lifestyle, programmer and thermostat settings etc.

→ photographs, which can be input directly into some software tools; "a picture paints a thousand words", so a digital camera is an invaluable tool for an energy assessor; video footage with commentary may also be useful.

Data must be collected to support each area of the assessment calculation. The adjacent diagram gives a feel for the work involved. A variety of other surveys or assessments may be used, alongside energy modelling, to contribute to the formulation of appropriate and rounded improvement advice; and those are also illustrated.

Occupancy data

Some analysis methodologies estimate energy-related demands on the basis of other related data, others allow dwelling-specific data to be entered. The crucial point is that for evaluation of fuel cost savings, actual occupancy data are much more accurate than standard occupancy data:

→ The SAP energy rating uses a standard occupancy pattern and heating regime (heating times and temperatures); the demand for hot water is estimated from the floor area, and the use of electricity for fixed lighting is estimated from the floor area and the area and orientation of windows.

→ Other BREDEM-based tools allow for a standard heating regime or one defined from data collected on site; dwelling-specific data on cooking and appliance use may also be entered.

In practice, occupancy patterns vary significantly between dwellings and assessments that are used to support advice should take account of actual occupancy rather than relying on typical or standard occupancy patterns.

Physical characteristics

Built form

- Built form (detached house, terraced house, flat etc)
- Property age, and age of any extensions

Dimensions

- Floor areas
- Storey heights
- Areas of all fabric elements
- identification of heat loss elements

Construction

- Building envelope construction
- Window frames and glazing types, shading, and external door types.

This information is used to calculate U values and the proportion of heat loss attributed to each element.

Ventilation

Types of ventilation, including air bricks, trickle ventilators, extract fans and whole house systems

Lighting and appliances

Information on appliance types and patterns of use (e.g., number of low energy lamps, etc.)

This information is used to make default assumptions about electricity use based on occupancy data require.

Heating and hot water systems

- Main/ secondary heating system
- Boiler or other appliance type
- Heating controls
- Water heating system type and fuel + hot water storage tank
- Solar water heating system

Spatial information

- the positions of services that will affect the location of equipment or fabric alterations
- Condition of underlying structure in case it needs improving
- the availability of space for required building services

Occupancy data

Through interview with the residents determine data such as:

- Internal temperature settings
- heating timings (on, off, schedule)
- number of showers & baths/day
- how “washing up“ is conducted
- number of hot meals cooked.

Contextual information

Physical

It is often important to know what the occupier owns and where the boundaries are; it is possible that the extent of any works may be restricted.

Logistical

The retrofit package must take account of the layout of the building as it may prevent materials being delivered to the house or scaffolding from being erected.

Administrative

Statutory approvals (eg planning permission, approval under the Building Regulations) may be required, especially if the building has Listed status or is in a Conservation Area. As well as covenants preventing certain works, eg Party Wall Agreements.

Other related assessments

Thermography

Thermography allows us to see relative variations in the temperature of the building fabric and is helpful in identifying areas of thermal weakness in the building fabric.

Air permeability testing

Draughtiness is expressed in terms of air permeability (m^3 of air per hour per m^2 of surface area of the building: $m^3/hr/m^2$ @ 50 Pa) or in terms of air changes per hour (the air flow rate in m^3/hour divided by the interior volume of the building).

Others

- Damp surveys
- Asbestos surveys
- Habitation of plants, animals, bacteria or fungus
- Pre-installation surveys for specialist installations to identify the correct equipment, materials & time it will take to do the work.

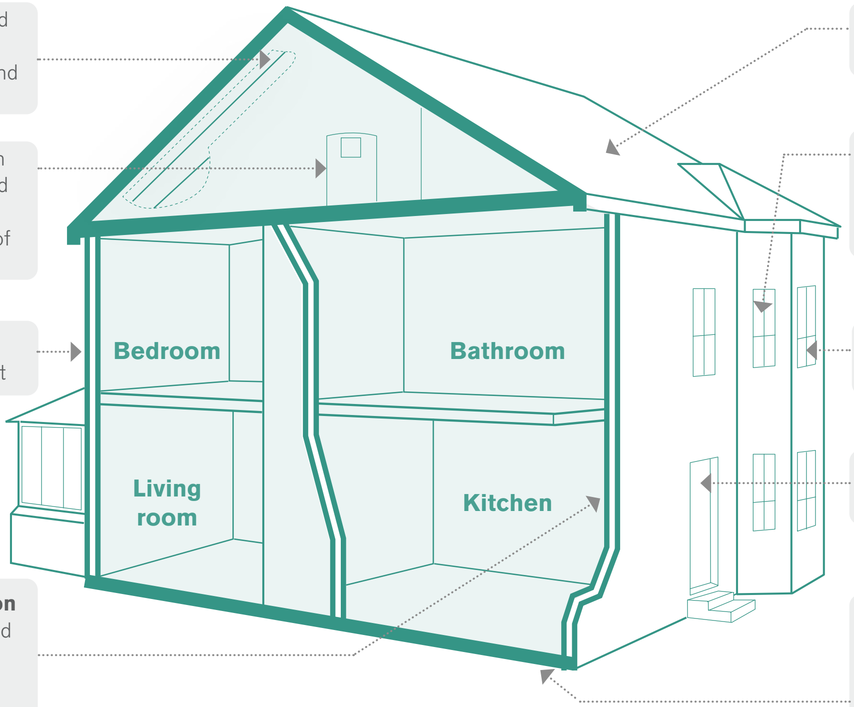
Retrofit solutions

Improving the building fabric

A range of low carbon retrofit options are available, each with a level of impact dictated by housing typology and climate region. Retrofit options are diverse; they have different installation difficulty and cost, as well as varying impacts on comfort.

Low carbon retrofit options include:

- External and Internal Wall Insulation
- Improved/increased roof insulation
- Improved/increased floor insulation
- New or replacement windows
- Improved glazing (up to triple)
- New or replacement external door
- Draught-proofing and air-tightness
- Reduced thermal bridging
- Loft insulation
- Roof/facade finish colour
- External shading
- Improved natural air movement
- Addition or exposure of thermal mass
- Improved natural lighting
- Alterations to the home layout



Re-interpreted diagrams from the 'Building opportunities for business Guides 6 & 7' published by the Institut of Sustainability, September 2011.

**The cost and CO_2 reduction figures are indicative only in today's market, as they are based on the 2010 data and market conditions.*

Improving building services

Low carbon retrofit options include:

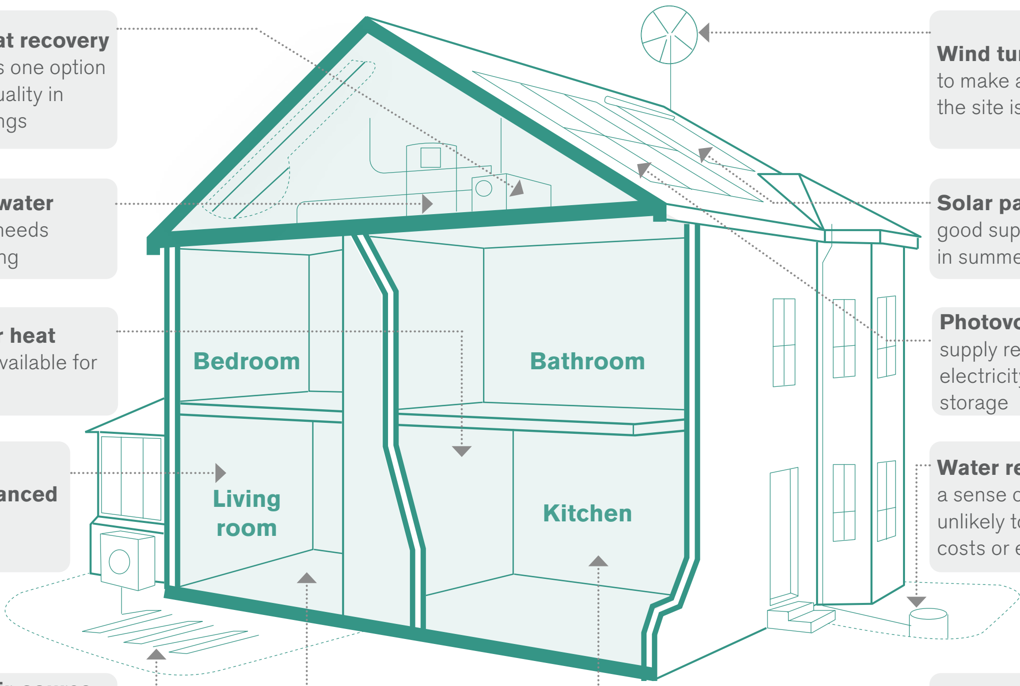
- Heating/cooling system upgrade
- Battery/ thermal storage
- Positive pressure ventilation heating system
- Purge ventilation
- Hot water cylinder insulation
- Primary pipework insulation
- Boiler replacement/ repair
- Biomass boiler
- Ceiling/pedestal fans
- Electric storage heater replacement/ repair
- Warm air heating
- Heating controls
- Flue gas heat recovery
- Intermittent extract ventilation
- Pasive stack ventilation
- Decentralized mechanical extract ventilation
- Centralized mechanical extract ventilation
- Mechanical ventilation with heat recovery
- Radiator panels
- District heating connection and heat meters
- Air-source/ Ground-source heat pump
- Micro combined heat and power
- Solar photovoltaics
- Micro windpower
- Micro hydropower
- Solar water heating
- Energy efficient lighting
- Energy efficient appliances
- Reduced hot water demand (lower flow fittings)
- Advanced metering system

Efficient heat recovery ventilation is one option for good air quality in airtight dwellings

Efficient **hot water production** needs careful planning

Waste water heat recovery is available for showers

Good, user-friendly advanced controls are essential



Wind turbines unlikely to make an impact unless the site is very windy

Solar panels can give a good supply of hot water in summer

Photovoltaic panels supply renewable electricity with battery storage

Water recycling gives a sense of security but is unlikely to reduce energy, costs or emissions

Ground or air-source heat pumps have potential for off-gas-grid properties

Not all modern **gas boilers** are as efficient as one might think

Unless the **householder understands the systems**, the potential benefits can be lost

Over half of the emissions can come from electricity use-**efficient lights and appliances** are essential

Water-saving low-flow appliances reduce energy and carbon emissions as well

Biomass boilers could have potential but need fuel storage

Prefabrication, one-stop-shop approach

An example package

Prefabricated façade with integrated heat pump and PV panels. This package includes:

→ a prefabricated timber façade.
→ a heat pump for centralised heating.
→ photovoltaic panels.

Prefabricated timber framed façade elements are used for the external thermal insulation of walls. The prefabrication enables the industrialisation of the manufacturing process, and reduce the duration of on-site works. The system also integrates windows and HVAC devices. In this refurbishment package, the prefabricated façade is combined with a heat pump that provides space heating and domestic hot water, and with a ventilation with heat recovery. Photovoltaic panels are also installed on the roof.

Business model

In this model the project is carried out by a multi-disciplinary team in a cooperative manner, consisting of partners with complementary competences, such as architects and designers, constructors, energy-efficiency experts, market and financial experts, technology suppliers, strategy and operations planners. Starting from the initial design phase, the team works together, in strict collaboration with the building owner, in order to select the optimal renovation measures to adopt, planning the whole renovation project according to customers' needs.

The cross-fertilisation of gathering different actors together in an early phase of the renovation project permits to define a holistic approach to the renovation intervention. In this way sustainable and energy–efficient retrofitting solutions can be deployed, with an optimal control over the total costs of the renovation project and guaranteed efficiency performances.

A successful example of this business model is Energiesprong. Energiesprong is a whole house refurbishment and new built standard and funding approach. It originated in the Netherlands as a government-funded innovation programme and has set a new standard in this market. It is now being replicated in the UK, France, Germany and Italy.

Recommendations for replication

The key to success for the replicability of this business model is the identification of the market segment to focus on. Building upon the lessons learnt from Energiesprong UK & France case studies, the important elements in order to ensure the success of this business model in the residential sector are:

→ A wide availability of similar single or multi-family buildings, characterized by not overly complex geometries, that are in need of refurbishment.

→ Limited segmentation of the building stock in order to be able to deliver standardized solutions

→ A stable upward trend in real estate market prices that can drive this type of investment.

→ High GDP per capita and low private debt, ensuring the existence of a demand segment capable of dealing with major investments and/or high disposable income in households, or to make it financially sustainable for private individuals to purchase refurbished apartments.

→ Grants and tax incentives that can support this approach in areas with lower incomes.

The adjacent diagram illustrates the design and implementation SWOT analysis for the presented one-stop-shop appraoch (i.e., prefabricated façade with integrated heat pump and PV panels).

Strenghts

1. Precise prefabrication technique off-site and high quality due to a controlledproduction process.
2. Integrated solution, with pre-installed windows and HVAC devices.
3. Fast mounting process with little disturbance of the inhabitants.
4. No scaffolding required.
5. No weather downtime for on-site works.
6. Ecological performance with high CO_2 storing capacity, better LCA (lifecycle carbon assessment) than polystyrene-based ETICS.

Weaknesses

1. Exigent logistics and planning process.
2. Thickness of additional layer.
3. Treatment of interstices between 2 panels.
4. The mounting of prefabricated modules is a new construction process and needs experience to be practised.
5. Upfront cost higher than solutions such as ETICS (External Thermal Insulation Composite System).

Opportunities

1. Integration and extensions of additional building elements, such as windows, balconies/loggias, HVAC devices, plumbing, electricity.
2. Integration of active components (PV & solar thermal).
3. Incentives and subsidies (e.g., bonus for ecological materials).
4. Creates regional added value with local sourcing, production and installation.

Threats

1. Fire regulations in multi-storey buildings > 6 floors.
2. Reduced application for historical buildings.
3. Prefabrication tends to involve the use of new raw materials for bespoke purposes (i.e., high embodied carbon). Project team should prioritise a circular economy approach when specifying materials, otherwise this can be classified as a threat.

Retrofit solutions evaluation

An evaluation process should be used in an iterative way to determine the best retrofit solutions for the house, building or portfolio. All necessary surveys will need to be completed before evaluating solutions.

There are four key evaluation areas that should be considered and integrated into the decision-making process and these should be documented and included in the retrofit plan. The four key evaluation areas are illustrated in the adjacent diagram[1]. The economic impacts of the proposed retrofit solutions have likely to be the key consideration for the owner, but these should be influenced by the owner's preferences or lifestyle.

While evaluating the different building retrofit measures it is worth taking a holistic view considering factors such as payback periods and environmental impact. The latter are summarised in the following pages, 86-87.

Another evaluation consideration is the unintended consequences of single measure retrofit, which can be otherwise minimised with a whole house approach. For instance, insulation and draughtproofing reduce uncontrolled ventilation increasing the risk of overheating. If controlled ventilation is not improved to compensate, Indoor Air Quality will get worse. Another example, some insulations are combustible and electrical equipment is a potential fire hazard, reducing Fire Safety, if not well detailed and considered as part of a robust fire strategy.

1- Re-interpreted from the 'Building opportunities for business Guide 3: planning low carbon retrofit projects' published by the Institut of Sustainability, September 2011.

Undertake all surveys to complete evaluation

Usability impact

When selecting solutions, consideration should be given to:

1. Modelled energy demand for heat and electricity post completion and the predicted savings for the owner or resident. Medium to long-term projected fuel price increases could be usefully presented as scenarios.
2. Modelled carbon dioxide emission reduction post-completion.
3. Modelled impact of potential solutions on the existing fabric. The risk of failure should be evaluated as necessary. This may include:
   - the impact of moisture changes post completion eg interstitial condensation
   - degradation of external fabric from weather exposure caused by increased insulation
   - installation risks that are particular to the house, building or portfolio
   - climate change adaptation.

Performance impact

When selecting solutions, consideration should be given to:

1. Likely positive and negative impacts on internal and external spaces eg boxed-in ductwork that may aff ect minimum clearances, internal wall insulation that strongly influences room geometry.
2. Opportunities to make improvements to the internal layout, particularly where floor or wall insulation is being considered.

Social impact

When selecting solutions, consideration should be given to:

1. Improving thermal comfort for the occupants while managing a reduction in the demand for heat.
2. Improvements that can be made in air quality throughout the house or building with passive and mechanical ventilation.
3. Improvements that can be made to internal finishes eg redecoration.
4. Aesthetic improvements that can be made internally and externally to the house or building. External solutions should take account of the existing streetscape and any local planning requirements.

Economic impact

Typically, the economic analysis of potential retrofi t solutions will need to include an assessment of:

1. Whole-life costs – over solutions predicted product lifecycle:
   - installation cost – the upfront capital cost
   - any likely maintenance costs – planned and reactive
   - any likely management costs (consultant fees, subscriptions or services) required to gain revenue funding.
2. Mortgage lenders and insurance – any fees associated with gaining lender consent (e.g., surveys) or increases in buildings insurance must be considered.
3. Statutory consents – such as gaining planning permission and satisfying Building Control; relevant cost need to be considered.
4. All potential revenue funding streams should be incorporated into the evaluation (e.g., predicted Feed in Tariff or Renewable Heat Incentive) and calculated over the funding term.
5. Reduced energy costs as a result of fabric improvements or the installation of energy generation technologies.

Summary of the payback periods for different retrofitting measures[1]

Measures	Activities	Payback Period (Year)			Average Payback Period (year)	Normalized ECI
		Percentile5	Mean	Percentile95		
Controlling	Install programmable thermostat	0.4	0.6	1.0	0.6	0.835
Mechanical System Upgrade	Tune up HVAC	0.6	0.7	0.8	21.2	0.024
	Install ground source heat exchanger	30.3	35.4	41.6		
	Upgrade evaporative cooler	4.9	6.7	8.6		
Insulation	Insulate Ceilings	9.2	10.2	12.0	12.6	0.040
	Insulate walls	7.9	17.4	33.0		
	Insulate Attic	8.8	11.1	13.5		
Windows & Doors Replacement	Replace doors with insulated core	31.5	74.7	145.6	69.2	0.007
	Replace windows with energy efficient glass	43.0	63.7	97.7		
Fixtures & Appliances Replacement	Replace all lighting with CFLs	0.2	0.3	0.3	6.0	0.084
	Replace refrigerator with an energy star one	14.8	42.9	103.2		
	Replace clothes washer with an energy star one	7.9	14.5	23.5		
	Replace dishwasher with an energy star one	27.9	64.5	133.7		
Renewable Options	Install solar thermal equipment	21.5	32.4	50.1	48.4	0.010
	Install solar electricity equipment	47.6	54.4	62.4		

Summary of the environmental impactfor different retrofitting measures[1]

Measures	Activities	Average Emission Saving per year (lbs/year)			CO_2-Eq Saving (lbs/year)	Normalized ENI
		NO_x	SO_2	CO_2		
Controlling	Install programmable thermostat	0.355	0.155	297.8	471	0.009
Mechanical System Upgrade	Tune up HVAC	1.614	0.489	1572.5	20,842	0.388
	Install ground source heat exchanger	10.150	2.994	9975.0		
	Upgrade evaporative cooler	2.759	0.919	2604.9		
Insulation	Insulate Ceilings	1.194	0.333	1192.8	5,980	0.111
	Insulate walls	1.338	0.075	1640.1		
	Insulate Attic	1.388	0.348	1427.3		
Windows & Doors Replacement	Replace doors with insulated core	0.286	0.015	351.4	2,878	0.054
	Replace windows with energy efficient glass	1.578	0.301	1718.1		
Fixtures & Appliances Replacement	Replace all lighting with CFLs	2.967	1.417	2364.7	4,747	0.088
	Replace refrigerator with an energy star one	0.285	0.136	226.9		
	Replace clothes washer with an energy star one	0.285	0.136	226.9		
	Replace dishwasher with an energy star one	0.138	0.068	107.6		
Renewable Options	Install solar thermal equipment	1.914	0.021	2433.6	18,832	0.350
	Install solar electricity equipment	11.786	5.146	9885.3		

1- A. Jafari, 2017. 'Sustainable impact of building energy retrofit measures'. Journal of Green Building, September 2017. 12(3):69-84. DOI:10.3992/1943-4618.12.3.69.

5

Conclusion & next steps

Financial Mechanisms

Market barriers, specifically split incentives, impede energy efficiency renovations across the building stock. This is particularly apparent in the social rented sector because those who benefit from improvements (the tenants) do not pay for the renovation.

An assessment of the range of solutions to address split incentives should be undertaken to recognise the long-term benefits of energy efficient housing whilst not compromising affordability of the home for the occupants overall.

Austrian housing associations already take into account energy efficiency when setting rent structures for new acquisitions and new build properties. Similarly, in the Netherlands, through a bill approved in March 2011, the rental price evaluation system incorporates energy performance. This is used to determine the rental price for house and apartments in the social housing sector and offers landlords the opportunity to increase the rent if the score on the EPC improves (ensuring that the benefits outweigh the rental price increase), thus incorporating energy in the evaluation criteria. We have seen this also incorporated in Hem's Energiesprong pilot project in France.

It is important to note that under the current UK social housing regulation, an increase in rents or a separate energy efficiency related charge is not permissible. To overcome this, Energiesprong has introduced energy antees with tenants paying a fixed monthly/annual energy service plan charge (i.e., comfort plan) which entitles tenants to a defined annual energy allowance. This results in an additional yet secured cash flow for the housing provider. The approach means that industry takes the responsibility for the long term performance of the refurbishment which allows the provider to offer tenants an energy service plan, giving them an energy allowance for a fixed monthly fee.

Government should however consider introducing the ability for landlords to provide a 'warm rent' tenancy, where slightly more rent is charged for more efficient properties thus reflecting the value, driving demand and raising awareness of improved performance. The extra cost associated with a 'warm rent' service charge is remediated by the tenant through lower energy bills as a result of increased property efficiency. This is similar to the above Energiesprong model, however the energy performance impacts the rental value and can be applied to any home. This addresses the issue of split incentives within the sector and recognises the long-term benefits of energy efficient housing whilst not compromising the affordability of the home for the occupants overall.

Rents can also be used to drive energy efficient behaviour. Holistic rent arrangements which include heating costs could be adopted. These are typically used in Western or Northern countries (e.g. Germany and Sweden) but can be found in student or professional lettings in the UK. A consequence of this approach is that the consumer has little incentive to conserve energy as they are not responsible for paying the bills. Monitoring energy use in these circumstances can help to overcome user-related split incentives. A gross warm rent model with direct feedback can allow landlords and tenants to agree on a set of comfort conditions (e.g. indoor temperatures). If the tenant consumes less than the agreed energy usage, they receive compensation but if they exceed the threshold, they pay the additional energy costs. This could encourage energy efficient behaviour.

Securing a shift from gas to electric heating

Nationwide, we are aiming to decarbonise our current homes in the social housing sector to meet net zero means moving from our current reliance on fossil fuels, such as natural gas, to zero emissions alternatives. In tandem, the aim must also be to reduce fuel bills and drive down fuel poverty. Switching to zero emissions heating at this scale and pace presents three major challenges.

Any programme of change must balance these three challenges, ensuring that social housing remains affordable, in all household costs, for those who most need it.

1. It requires meeting a much larger share of heat demand from renewable electricity, in addition to other demands on the electricity grid such as charging of electric vehicles.
The maturity of the renewable industry in Scotland provides potential opportunities to build on its achievements to date and to help with decarbonisation. Provisional figures indicate that in 2020, the equivalent of 97.4% of Scotland's gross electricity consumption was from renewable sources, falling just short of the 100% by 2020 renewable electricity target.

2. The sheer scale of the infrastructure works required to homes and the challenge of funding it, while again keeping rents affordable, cannot be over-stated.
In practice, taking a Fabric First approach to achieving net zero emissions should be prioritised. This would involve charting a transition from gas and other fossil fuel heating to zero emissions heating while also significantly increasing energy efficiency to reduce energy demand and, at the same time, avoiding increasing the running costs for households and investments in infrastructure works.

3. Electricity is more expensive for end consumers than gas in the current market.
Important to consider in the transition to low carbon heating is the relative levies and charges placed on electricity bills compared to gas. By 2050, gas is considered to be a more carbon-rich source of energy than electricity if the decarbonisation trends in electricity continue. The charges placed on electricity include environmental and social obligations and this results in electricity bills being more expensive than their gas counterparts. Therefore, low carbon heat sources, such as electric heat pumps, may be more expensive than gas which could act to disincentivise low carbon heating and risks the achievement of net-zero. As recommended by the Climate Change Committee (CCC) a review of electricity and fossil fuel bills should be carried out to mitigate this risk. The unit rate for both gas and electricity prices UK wide are measured in kWh (kilowatt hours). The actual rate you will pay can vary based on your region and pricing plan, but the national average[1] for electricity is 14.37p per kWh. The average for gas is significantly less at 3.80p per kWh.

It appears likely that high carbon heating will become more expensive in future. This would mean those in fuel poverty still using fossil fuel heating systems would face increased heating bills, resulting in even deeper levels of fuel poverty.

1- Average UK gas and electricity prices per kWh unit. Extracted from: https://usave.co.uk/energy/average-uk-gas-and-electricity-prices-per-unit/#:~:text=The%20unit%20rate%20for%20both%20gas%20and%20electricity,gas%20is%20significantly%20less%20at%203.80p%20per%20kWh.

Target existing & new-built holistically

A recent research work[1], modelled different Social Housing scenarios in the UK context and identified ways to meet the nation's 2050 carbon targets. The adjacent diagram illustrates the results of the 'further ambition scenario' which considers an extensive retrofit of the existing housing stock along with an optimised scenario for all new build social homes.

The Further Ambition scenario reflects a pathway where emissions reach a level in line with the illustrative net-zero target. As previously proposed, a multifaceted approach will be needed targeting existing and new homes from both a thermal performance and heat perspective.

→ EPC Band C by 2030 for all social homes from a retrofit programme. This is aligned with the government's commitment to bring as many fuel poor households up to Band C by 2030.

→ Increase in new build numbers to 50,000 from 34,500.

→ Improvement in the space heating requirement in new builds in line with the Future Homes Standard at 15 kWh/m_2/year instead of 54 kWh/m_2/year.

→ Oil boilers and solid fuel heating to be phased out by 2026. This is because the UK Government has committed to phasing out 'high carbon fossil fuel heating' throughout the 2020s.

→ Gas boiler usage to fall by 92.5% by 2050. The dominance of gas in heating up to 2050 could present a significant barrier to emission reduction within the EPC B and C Retrofit scenario.

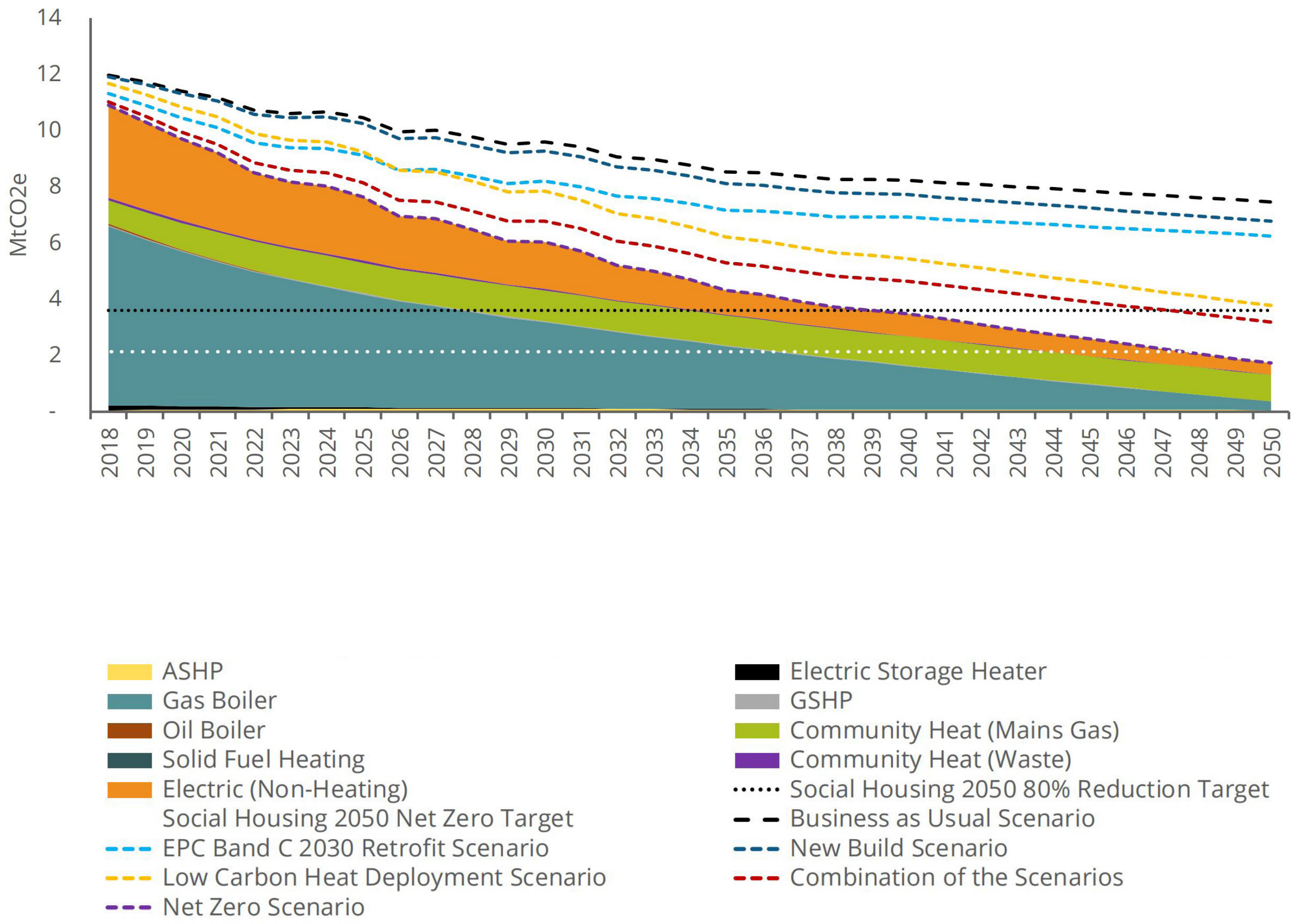
→ No 'inefficient' electric heating by 2050.

The emissions in this scenario fall to 1.72 $MtCO_2e$, which is below the net-zero target of 1.79 $MtCO_2e$. The modelling carried out for this report emphasises the scale of the change which is needed to achieve emission reduction in the social housing sector. This includes the predominant heating fuel needing to shift away from natural gas to low carbon alternatives. Note that ASHP (Air source heat pump), GSHP (Ground source heat pump) are proxies for low carbon heating solutions and community heating is technology agnostic so can incorporate a multitude of low carbon technologies. Whilst it is currently unclear as to which decarbonisation pathway the UK will follow (e.g., electrification, hydrogen, or a combination of the approaches), it is important that the housing stock is prepared for the transition to lower carbon heating solutions.

This analysis[1] suggests that if a retrofit scenario was to be implemented then retrofit programmes will need to be more ambitious and aim for higher thermal efficiency ratings and/or low carbon heat deployment.

1- Sustainable Energy Association, 2019, Social Housing: Leading the way to net zero. Retrieved from: https://www.sustainableenergyassociation.com

Social housing emission projection: Total emissions ($MtCO_2e$) from social housing projection based on 'further ambition scenario' compared to less favoured scenario.



Key takeaways

Recommended works in anticipation for scale-up.
Housing associations should be working on developing stock condition survey: update a great deal of information we have around energy performance of the condition of the unit so that we are better informed strategy by archetype. Housing associations/ developers are highly recommended to collaborate with academia to feed-in the development of a series of tools and help the industry to model retrofit pathways to 2050. A good starting point is the use of a 3D stock model which essentially develops visual and energy performance overview, an interactive tool for looking at the stock in accordance with real energy and EPC & SAP data sets. The industry should be able to model different pathways considering a twofold strategy:

→ One being ready willing and able to take advantage of ad hoc funding pots that come from central/ regional government to deliver whole house retrofit.

→ In in parallel to that, we need to remodel all incremental or elemental retrofit works that we would do across the sectors. Lessons learnt should be gathered, and all research work should influence upcoming works.

Maximise the opportunity to get Government funding when it is released.
Housing associations should be developing financial analysis to have oven ready projects, ready to go when the funding info comes out. When the government comes out with funding proposals is often very short turnaround time from the issuing of the grant timelines to the bid deadline. Housing association should be working now to work out an approach, agree their partners… so as they are ready to go as soon as the grant comes out. They should have a range of projects to suit whatever the shape the grant will come out in, and ultimately develop individual houses, blocks and/or neighbourhood retrofit plan(s), backed up with building passports where possible.

Continue to support the start-up of the sector through decreasing subsidies towards pilot projects.
The cost of early demonstrator projects is anticipated to be high. The cost of delivering low-carbon domestic retrofit will be driven down by the increasing the number of units within the supply chain. For instance, in France, the long-term objective is to achieve Energiesprong refurbishment at standards costs of about 70,000 €/home for individual houses (i.e., ≈45% reduction in cost when compared with the Energiesprong pilot project in Hem, France - see page 68), and 55,000 € per dwelling in multi-apartment buildings, which will be possible as the demand goes higher and the sector gets structured. It took nearly 1,000 deep-whole house Energiesprong retrofit projects, in 5 years, in the Netherlands to reduce costs by 50%.

Metering and monitoring systems is key.
Performance monitoring and analysis enables the industry to feeback lessons learnt into internal processes and educate the wider market. Key considerations include: a) choosing the sensor locations and setting up reliable monitoring is technically challenging; b) cost and privacy concerns are barriers to gaining owner and householder agreement. c) Data communications from monitoring systems is often poor and needs improving. d) Monitoring needs to be automated better and outputs standardised across projects (i.e., proforma reporting).

A fabric first approach!
Improving the building fabric to minimise heat losses and maximise air tightness is sensible because insulation has a relatively low cost, a long-life and should only be required once before 2050 for most properties. Building services, by contrast, have a short life and will almost certainly need to be replaced every 10-15 years. The target is to reduce the overall energy demand as much as possible through a fabric first approach. This will also reduce the burden of electrification on the local and national grid (e.g., smaller heat pumps will be required).

The tenure of the properties plays a major role.

Whereas all eyes are on the social housing sectors given the sheer volume of housing stock they control, the most deprived homes are the once privately owned and more should be done to incentivise deep whole house retrofit in here. Example considerations can include:

a. Legislate the EPC B and C target; wherever practical, cost-effective and affordable by 2035 and starting with social housing by 2030. Energy efficiency is the first step.
b. Set clear deadline on the use of fossil fuel heating systems in social housing with the aim of moving into the private homeowner market later on.
c. Government introducing the ability for landlords to provide a 'warm rent' tenancy, where slightly more rent is charged for more efficient properties thus reflecting the value, driving demand and raising awareness of improved performance.

> "Of the 103,000 dwellings that had a heat pump, half were owner occupied, 23% owned by housing associations, & 16% were owned by local authorities. The proportion of homes with a heat pump in the private rented sector is too small to report."

Source: English Housing Survey Energy report, 2019-20. National statistics, Ministry of housing, communities and local government.

Understanding the local skills and supply chain.

1. Compile local building stock, energy use, and demographic areas.
2. List and group stakeholders that make up the local supply chain (e.g., contractor, SME builders and trade people, suppliers/ manufacturers/ DIY stores/ renewable energy suppliers, education providers, etc.).
3. Circulate a questionnaire and arrange a mapping exercise.
4. Identify gaps in the supply chain and skills.
5. Work with group stakeholders to address those gaps.

Achieving community benefits through retrofit projects.

a. Recruiting local residents for the project this will facilitate the development of resident's skill.
b. Offer work experience, placements, and apprenticeships will help raise employment rates of young people.
c. Partner with charities and not-for-profit organisations to facilitate community initiatives and training opportunities.
d. Including rooftop gardens, trees and benches can improve the wellbeing of residents.
e. Creating community spaces and provide facilities for use by community and voluntary organisations.

Delivery using a trusted supply chain with a performance guarantee to minimise risk and built-up the case for retrofit.

Guaranteed performance is at the heart of the Energiesprong model. One of the innovations that underpins the model is that the contractor signs a performance guarantee, ensuring that the in-use energy use and generation are in line with the approved design. The only way to provide this guarantee is to closely monitor the energy consumption and other metrics after the project is complete. The Energiesprong model Performance Guarantee encompasses the following elements (and more) with corresponding, typical, targets defined for each scheme. These targets apply per property across a scheme.

Performance element	Performance guarantee typical target
Space heating energy demand	<40 kWh/m^2/yr
Hot water allowance	Between 100-140 litres/ day@45°C
Net energy consumption	<1,500 kWh/yr
Tenant energy costs	Less than prior to the retrofit (based on same utility prices)
Internal temperatures	18°C in bedrooms and 21°C in other rooms during heated periods
Electricity use allowance	2,300 kWh/yr

Source: https://www.energiesprong.uk/newspage/energiesprong-performance-in-the-uk-our-top-10-findings-part-1

Conclusion

The residential sector currently accounts for 22% of the UK's emissions. UK's Social housing has been a forerunner in reducing emissions, and on average it is the most energy efficient part of the housing stock. Currently, social housing constitutes 17% of the total housing stock, but only contributes 10% of the emissions from the sector.

Most homes are owned by the volume housebuilders who have shown considerable reluctance to achieve the highest standards. The nation must turn to the social housing sector to set high standards and to take positive action to cut carbon emissions.

Only a combination of deep retrofit of existing social housing, implementing far higher standards of all new builds and encouraging rapid market growth of low carbon heating systems can be successful in achieving the net-zero target. Action is required now if we are to achieve net-zero. Recommended actions are summarised below:

→ Finance is a big barrier to retrofit – teams need to develop and demonstrate an investable pathway to net zero.

→ Political and leadership championing is key to making a net zero project happen. It will help enable funding and support from government bodies.

→ Stakeholders need to work collaboratively to drive economies of scale and should partner up to exchange knowledge and lessons learnt.

→ Get ready to act quickly once funding becomes available – this is a vital starting point for a net zero project.

→ The actors had to be agile, flexible, cooperate and communicate one with others to make processes more fluid and contribute to success. Tenants' involvement is key to a good retrofit project.

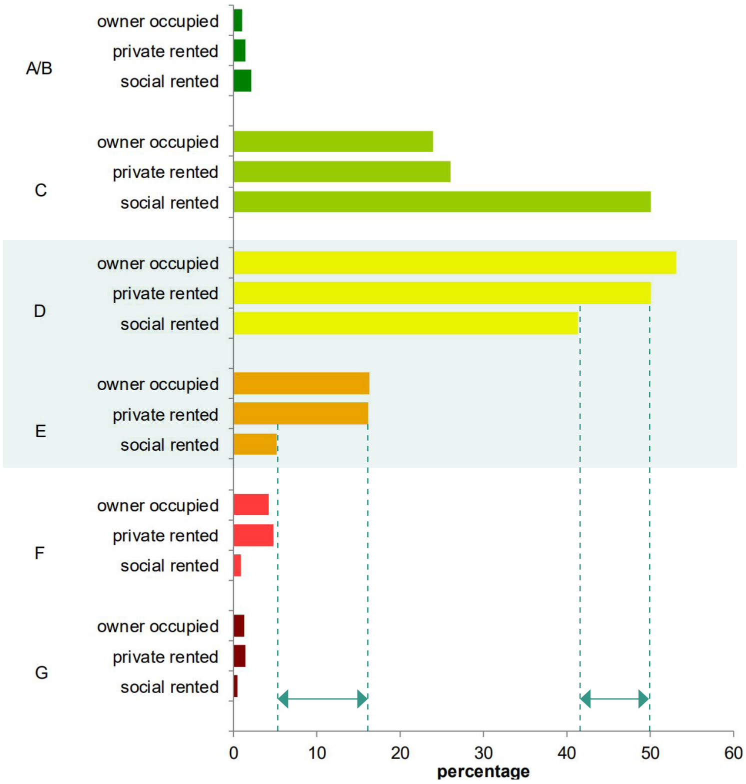
A key challenge as we transition to low carbon domestic retrofit is how to ensure that installers are equipped to support the transition. The transition is likely to involve (re)training and may also require important changes to standards, assessment, and enforcement to ensure all installations are carried out in alignment with a clear framework. Worth noting that the UK Government has committed to a consultation on skills and training in 2022, with Green Skills Bootcamp1 centred around housing retrofit, solar, nuclear energy, and vehicle electrification.

The presented case studies evidence that by combining the planned investment in the maintenance and refurbishment of their stock over 20-30 years with energy cost and other savings over the period, social landlords can make an economic case for investing in deep retrofit to upgrade properties to 2050 standards now. In time, it is likely that a sophisticated UK market will emerge for deep retrofit technologies that will benefit wide sections of the community including landlords and tenants, suppliers and contractors and also the private sector. The cost of delivering low-carbon domestic retrofit will be driven down by the increasing the number of units within the supply chain.

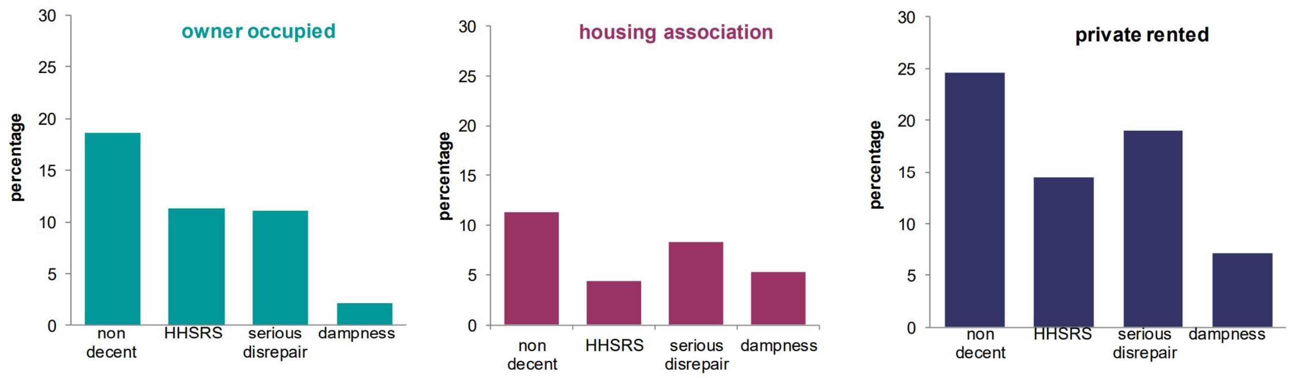
Preventing vulnerable households from living in dangerously cold or damp homes will help tackle fuel poverty, rising energy bills and reduce pressures on health services.

The 2030 Energy efficiency targets (i.e., minimum SAP C) and the 2050 targets set by central government, plus the climate emergencies that have been called by a number of London boroughs, will also increase the interest in retrofit at scale, and deep whole house retrofit approaches. Social housing sector should be the launching market for those approaches, with the aim of moving into the private homeowner market later on. The most deprived homes are the once privately owned (see adjacent diagrams) and more should be done to incentivise deep whole house retrofit in here.

Energy efficiency rating bands, by tenure, 2017[2]



Poor housing conditions, by tenure, 2017[2]



1- https://www.gov.uk/government/consultations/national-skills-fund

2 -Ministry of Housing, Communities and local government, English Housing Survey Home ownership, 2017-18. Published: 17 July 2019. Retreived from: https://www.gov.uk/government/statistics/english-housing-survey-2017-to-2018-home-ownership

Conclusion *(cont'd)*

Energy bills in the UK will leap by 80% this winter, the country's energy regulator Ofgem announced in September 2022, as the Ukraine war continues to drive up prices. The hike means the average household will pay £3,549 (€4,182) each year to heat and power their homes, leading NGOs to warn that millions will be plunged into poverty - unless the government steps in.

The cost-of-living crisis has cast new doubt on the progress towards the UK's Net-Zero ambition. In addition, as the cost of living rises for households across the UK, growing energy prices disproportionately impact those on lower incomes. The measures announced by the new UK's Prime Minister to tackle sky-high energy bills and ease the cost-of-living crisis focused on capping energy prices[1] at £2,500 until 2024 and boosting domestic energy supplies. *The energy price cap is the maximum amount a utility company can charge an average customer in the UK per year for the amount of electricity and gas.* But the package set out no new efforts to help households save energy through increased insulation and other efficiency measures that can permanently cut gas use and bills.

A lack of efforts to insulate millions of homes to keep them warm and cut bills is the "big omission" in the Government's energy package[2].

With the UK Government giving financial support to homeowners to support them with rising energy prices, RICS[3] is calling on the government to extend this support and provide additional financial incentives to homeowners to encourage retrofitting and ultimately helping to tackle the cause of high energy usage.

A suitably retrofitted, low-carbon home can help with the long-term challenges of the cost of living and reducing high levels of energy consumption. Achieving this however is not cheap.

Before any significant investment is made on retrofit measures, RICS[3] urges homeowners and the government to ensure a retrofit assessment is undertaken on the property first – ensuring that no unintended consequences occur such as overheating or increased energy demand.

A recent study[4] highlighted that insulating homes pays back 4x quicker in the UK from October 2022 compared to 1 year ago. This is because gas prices are skyrocketing, and gas is used for heating in ~85% of UK homes.

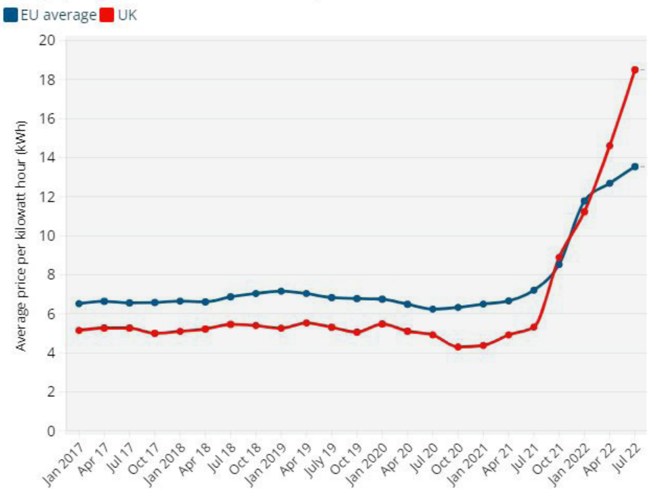
Retrofitting all 26 million existing homes is undoubtedly a colossal challenge in transitioning the built environment to net zero and to overcome the cost-of-living crisis. We need a street-by-street comprehensive retrofit programme targeted at the neighbourhoods where most homes are poorly insulated.

The sheer scale of this task is huge and we should start 'yesterday'!
It is one home to be retrofitted every 35 seconds between 2020 and 2050. If every retrofit takes 4 people 6 months, it's 500,000 simultaneous retrofits needing 2 million people in the industry.

1- Independent, 2022. Retrieved from: https://www.independent.co.uk/news/uk/home-news/what-is-the-energy-price-cap-uk-b2162449.html
2- Yahoo!Finance, 2022. Retrieved from: https://uk.finance.yahoo.com/news/insulation-big-omission-package-bring-down-energy-costs
5- Source: Household Energy Price Index (HEPI) by Energie-Control Austria, MEKH and VaasaETT, © 2022 VaasaETT Ltd.

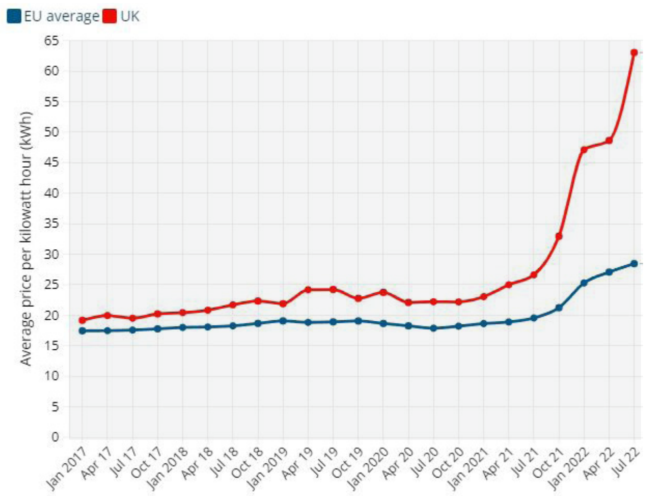
How UK and EU compare on household gas prices[5]

Average price per kilowatt hour (kWh) (PPS adjusted)



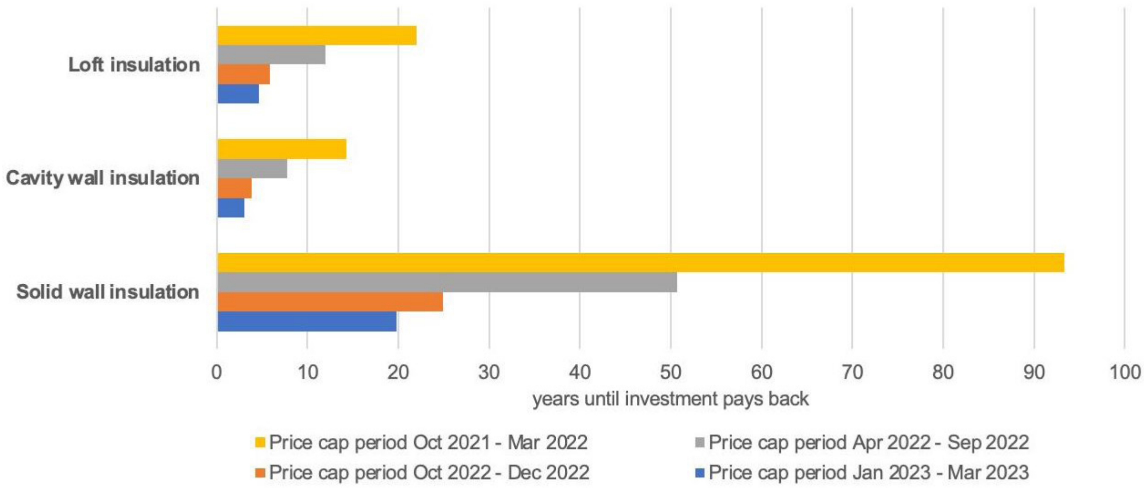
How UK and EU houshold electricity prices compare[5]

Average price per kilowatt hour (kWh) (PPS adjusted)



Payback period for the different insulation measures[4]

See page 37 for the average expected costs to pay to retrofit a typical UK house.



3 - RICS, 2022. 'Cost of living causing consumers to think again about retrofitting', August 2022. Retrieved from: https://www.rics.org/en-in/news-insight/latest-news/press/press-releases/cost-of-living-causing-consumers-to-think-again-about-retrofitting/

4- Jan Rosenow, Director of European Programmes at Regulatory Assistance Project (RAP). September 2022. Based on the following datasets.

- Energy price cap data. Retrieved from: https://t.co/i74OjbRgAq
- Future residential gas price predictions from Auxilione using latest data. Retrieved from: https://t.co/1rDn9nn3NU
- Energy savings data for insulation measures. Retrieved from: https://t.co/yNlxvfo5DQ
- Data on capital costs of insulation measures. Retrieved from: https://t.co/413NTr7kKM

6

Appendix

Circulated questionnaire

2020 CIBSE Ken Dale Travel Bursary – Domestic Retrofit in the European Context Case Study

Thank you for taking the time to complete this questionnaire. I am looking to collate a series of case studies that showcase a good practice with regards to domestic retrofit. Your feedback in this process is invaluable and will require approximately up to 15-20 minutes.

The aim of this questionnaire is to gather targeted feedback to understand what has worked well and what could have been done better. Therefore, identify any learning and recommendations for others to act on and apply in future domestic retrofit projects.

This survey is part of a voluntary research work conducted by Joey Aoun, and the results will be used to inform the Ken Dale Travel Bursary research which will be published in Autumn 2022. Statistics obtained from this survey may be included in the publication of the report on an anonymous basis in hopes to capture industry-wide experience of the projects' stakeholders. All data will be strictly confidential, and your approval will be though any info is to be published.

Section 1: Personal Info

1. Name..
2. Job title..
3. Organisation..
4. Email..
5. What is your current role in the construction industry?
   - Architect
   - Developer
   - Engineer
   - Contractor
   - Other, please specify ....

Section 2: Case Study Background Info

6. Case study name..
7. Project gross internal area (m^2) ....
8. Location (City, Country) ....
9. Scale/ retrofit scope ....
10. Project stage
    - Design stage
    - Under Construction
    - Completed, if yes when? ....
    - Other, please specify ....

11. Number of stories:
    - Low rise (up to 5 stories)
    - Medium rise (6 to 10 stories)
    - High rise (11+ stories)

12. Type of existing structural frame:
    - Concrete
    - Steel
    - Timber
    - Hybrid, please specify.

13. Please could you give us a rough idea the project overall budget (this will help us assess the choice of retrofit routes and options):
    - Up to £50,000
    - £50,000 – £100,000
    - £100,000 – £150,000
    - £150,000 – £200,000
    - £200,000 – £250,000
    - £250,000 – £300,000
    - More than £300,000, please specify..

Section 3: Retrofit Information

14. Have any of these metrics been measured for the case study? If yes, please specify.
    - Predicted operational (regulated and unregulated) energy: ....kWh/m^2/yr
    - In use monitored operational energy data: .... kWh/m^2/yr
    - Renewable energy generation: ....kWh/m^2/yr

15. Which of the following retrofit strategies have been implemented?
    - The whole-house or system approach *considers the interaction between the occupant, building site, climate, and other elements or components of a building).*
    - The "fabric first" approach *prioritises improvement of the thermal properties of the building fabric through the use of high levels of thermal insulation and airtightness.*
    - Passivhaus standard *results in ultra-low-energy buildings that require little energy for space heating or cooling.*
    - "Insulate then generate" approach *first aims to reduce energy demand from passive design strategies (building fabric, thermal mass and airtightness, ventilation, and heat recovery), and then to meet the remaining demand using microgeneration technologies.*
    - Other, please specify ....

Circulated questionnaire *(cont'd)*

16. Please tick which of the following retrofitting options (efficiency measures) you are considering or considered in your project:
    - External shading
    - Battery storage
    - Energy monitoring
    - Alterations to the home layout
    - Primary pipework insulation
    - External Wall Insulation
    - Internal Wall Insulation
    - Improved/increased roof/ loft insulation
    - Improved/increased floor insulation
    - New or replacement windows
    - New or replacement external doors
    - Increased airtightness (talk in permeability and explain ACH)
    - Improved ventilation (including Mechanical Ventilation with Heat Recovery)
    - Hot water system upgrade
    - Air or ground source heat pump
    - Solar water heating
    - District heating connection
    - New central heating system
    - Energy efficient lighting
    - Energy efficient appliances
    - Solar photovoltaics
    - Other, please specify ....

      ....

17. What resources or initiatives did you use or refer to, to help you plan for a successful retrofit? Please select all that apply and specify.
    - Global initiatives (eg. Paris Agreement, UN 2030 Sustainable Development Goals, etc.)

      ....
    - Local initiatives/ regulations/ legislation ....
    - Building benchmarks ....
    - Other, please specify ....

18. Approaches taken to optimise the retrofit process:
    - Benchmarks on targets were used
    - Design tools during design
    - Scope of services included specific Key Performance Indicators (KPIs)
    - Good client engagement
    - Good retrofit was considered from early design stages
    - Other, please specify ....

19. Did you have a plan to achieve net zero carbon (operational and embodied) performance on this project?
    - Yes (for embodied carbon only)
    - Yes (for operational carbon only)
    - Yes (for both)
    - No (Neither)
    - If yes, please briefly describe your overall strategy and goals below..

....

....

20. Did you meet or exceed the requirements of (please tick all that apply)?
    - LETI
    - RIBA
    - Part L
    - Other, please specify ....

21. Did you have a Retrofit coordinator on the project? *If yes, please briefly describe how you did it below*

....

....

Section 4: What went well or could be improved? Learning/ recommendation to take forward

22. At what RIBA design stage were you involved in the project?
    - Stage 0 - Strategic Definition
    - Stage 1 - Preparation & Briefing
    - Stage 2 - Concept Design
    - Stage 3 - Spatial Coordination
    - Stage 4 - Technical Design
    - Stage 5 - Manufacturing & Construction
    - Stage 6 - Handover & Close Out
    - Stage 7 - In-Use

Some items to be considered while answering questions 23, 24 & 25:

- *The brief - suitability, clarity, procurement route, and consistency*
- *Level of project ambition - context, budget, and strategies outline*
- *Construction processes - before, during and after completion*
- *Design - appropriative, change, understanding of occupants needs*
- *Construction - quality, suspension of detail, experience of team*
- *Handover - clarity, timeliness, documentation, use of soft landings*

Circulated questionnaire *(cont'd)*

23. Stages that went particularly well were ...

These good things were enabled by ...

24. Stages that could have been better were ...

In particular I was concerned with ...

25. How to improve future domestic retrofit projects

The following should be considered ...

Section 5: Industry-wide Experience

26. Please rate the following factors to consider when deciding to retrofit a residential property.

	Not a factor	*minor factor*	*considerab le factor*	*major factor*	*critical factor*
The age of the property					
The style of the property					
Whether retrofitting is a viable option					
The financing required					
The time taken to retrofit					
The risk factors involved					
The retrofit processes that are available					
Other, please specify					

27. Please rate the following advantages of retrofitting residential properties in terms of importance

	Not Important	*minor importance*	*Average importance*	*major importance*	*critical importance*
Long-term cost saving on energy bills					
Increase in property value					
A "Greener" household with lower energy usage and lower carbon emissions					
Increased comfort and well-being					
Improvement of buildings appearance					
The preservation of cultural and heritage significance when retrofitting older buildings					
Renewing outdated components of a building					
Other, please specify					

Circulated questionnaire *(cont'd)*

28. Please rate the following Disadvantages of retrofitting residential properties in terms of importance

	Not Important	*minor importance*	*Average importance*	*major importance*	*critical importance*
The cost implication of retrofitting					
The long time return on investment					
The limitation of techniques available depending on the buildings style and age					
The complicated process of retrofitting					
Changes to original cultural and historical buildings					
Unknown risk factors involved					
The lack of available incentive schemes					
Other, please specify					

29. What do you think are the barriers to achieving net zero carbon targets in projects? *(Please place in order of: 1. The biggest barrier to 10. The least barrier).*

- ……………It is too expensive to design
- ……………It is too expensive to construct
- ……………Retrofit is Complicated. The industry is not there yet
- ……………Skills Shortage. There isn't enough knowledge/ expertise
- ……………There aren't enough built precedents/ benchmarks
- ……………Products for the retrofit (eg. Windows/ MVHR/ Heat pumps/ Solar PV, etc)
- ……………Project management
- ……………Lack of occupants and landlord's awareness
- ……………Lack of financial incentives
- ……………Lack of Policies, guidance, and Standards
- ……………Other, please specify ……………………………………………………………………………

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30. What are the most important criteria for you, when formulating a project brief?

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31. What could help you deliver net zero carbon retrofit?

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Section 5: Further Comments!

32. Would you mind if your name will be included in the Acknowledgment section?

- Yes
- No

33. Would you like to share additional comments? If yes, please write below.

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If you have any questions or concerns, please contact the researcher:

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