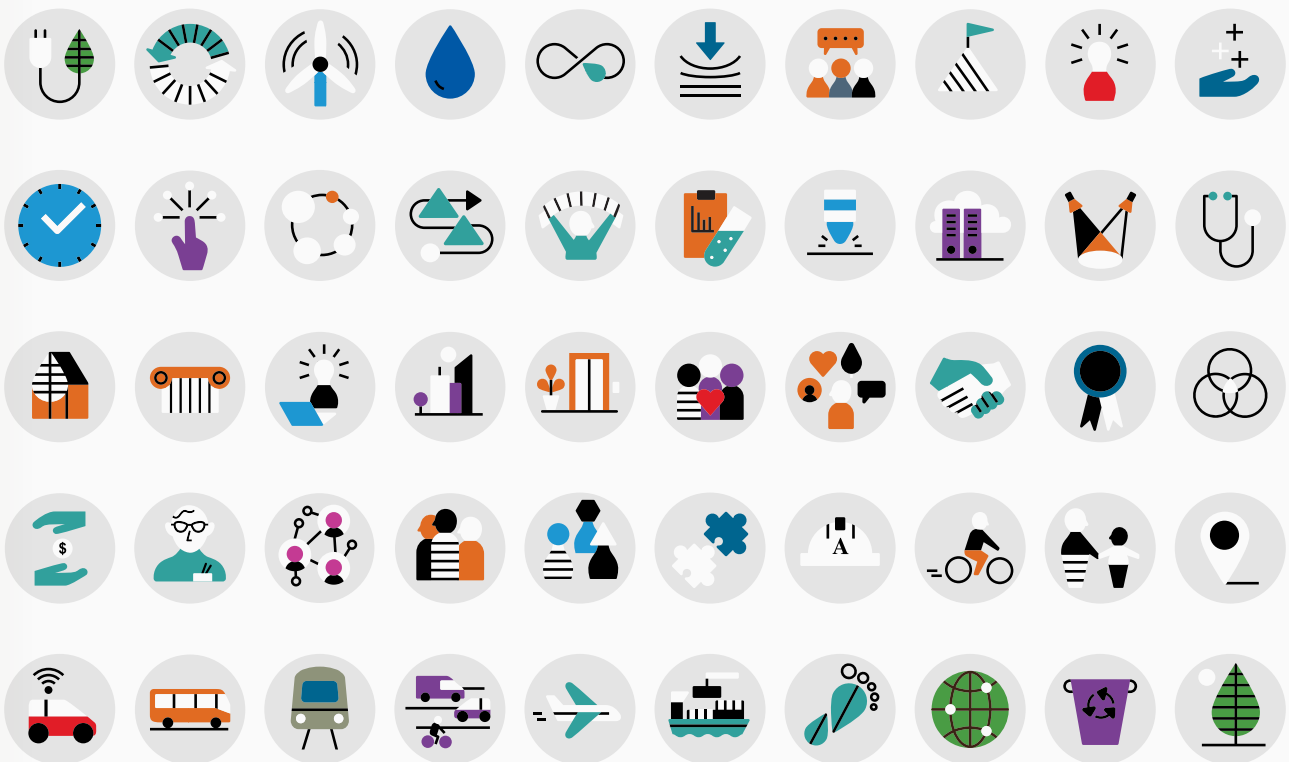


UK Cities Intelligence

April 2024
Retrofit at Scale





Retrofit at Scale

Welcome to the third edition of the Cities Intelligence publication. This time it focuses on one of the most pressing topics on the global agenda... retrofit.

We have a wonderful range of contributors in this edition who cover a broad range of ideas and projects in both the UK and Europe. They each provide reflections on how the built environment can tackle retrofit at scale through different policy levers and approaches. At Arup, we have been providing advice to clients from city leaders and administrations through to developers and funds.

Additionally, we have been undertaking our own research and thought leadership which finds that retrofit is about strong relationships and partnerships between the public and private sector, alongside a systems thinking approach.

Retrofit is not simply about decarbonisation of buildings but also tackles resilience to climate change, energy security, enhanced physical and mental health, better public space and enhanced biodiversity.

Thanks to all those who contributed their time to this collection of stories and happy reading!



Joanna Rowelle
Director, Cities, Planning and Design, UKIMEA

Retrofit adapts our existing buildings and neighbourhoods to be safer, healthier and more sustainable.

Retrofit can improve thermal comfort, improve health, build energy security, minimise carbon emissions and protect against the impacts of climate change.

Arup's UK Retrofit at Scale business confronts the complex system challenge of retrofitting UK building stock at scale to meet our net zero commitments. It also seeks to deliver aggregated benefits to local communities through a place-based approach to transformational change.



Click on page headings to navigate document

Retrofit at Scale

Overview: Future neighbourhoods

The places where we live need to change, to enhance and preserve quality of life, and to meet net zero commitments.

The places where we live are central to our individual and civic health and wellbeing.

But our homes and neighbourhoods need to adapt to policy imperatives, present needs and future risks:

0.5°C

Global and UK average land temperatures have risen by around 1.2°C since the 1850-1900 period and are expected to rise further by at least 0.5°C by 2050, regardless of efforts to cut global greenhouse gases emissions.

(source: [Climate Change Committee](#))

25%

Buildings and infrastructure account for nearly 25 per cent of UK greenhouse gas emissions – and domestic buildings are the largest contributor.

(source: [UKGBC Net Zero Whole Life Roadmap](#))

£900m

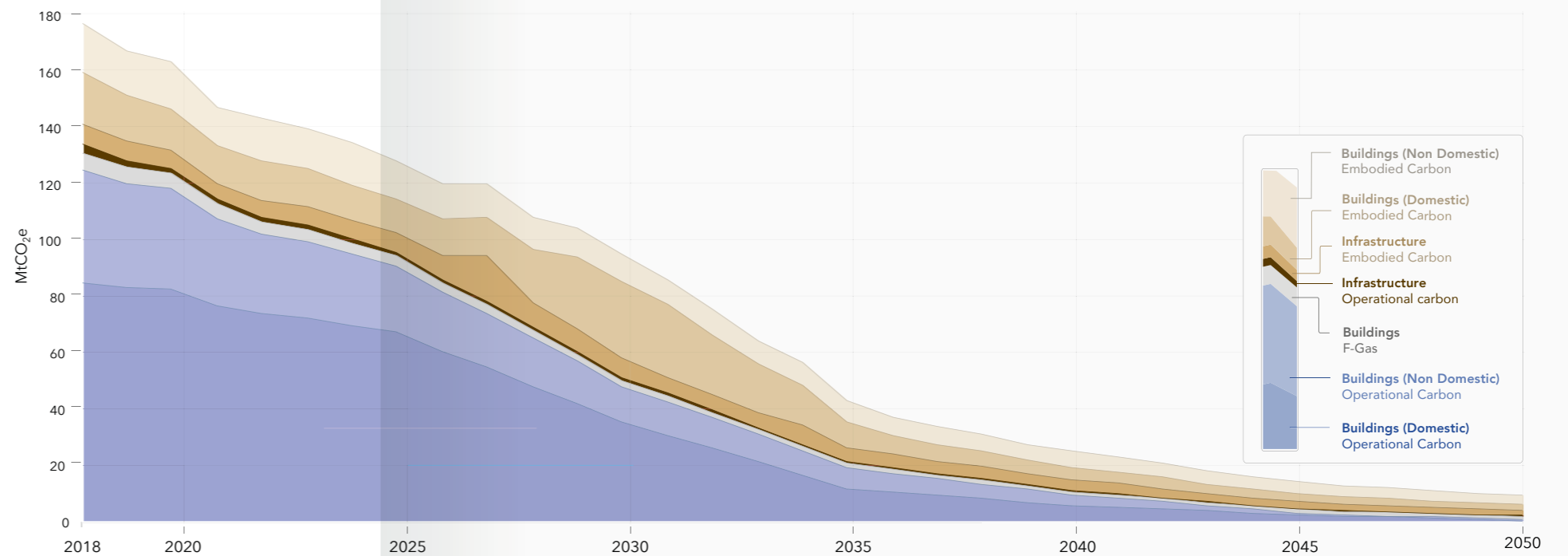
Cold homes and fuel poverty are a major source of ill-health, costing the NHS nearly £900 million each year.

(source: [BRE Group](#))

£2.5m

Climate change will mean more and more homes are vulnerable to overheating and flooding, with 2.5 million people potentially exposed to flood risk by 2080.

(source: [Climate Change Committee](#))



Buildings and infrastructure need to decarbonise at pace over the next decades



Source: [Climate Change Committee](#)
Source: [Arup](#)

[Click to download](#)

Net Zero Whole Life Carbon Roadmap

A Pathway to Net Zero for the UK Built Environment, to which Arup contributed.

Retrofit at Scale is vital to meeting our net zero challenge - to reduce greenhouse gases from heating and powering our homes, without wasteful demolition and rebuilding.

The next ten years need to see a drastic reduction in greenhouse gas emissions.

The latest figures show that emissions fell by 13 per cent between 2018 and 2023, against a target of 19%.

Source: [Whole Life Carbon Roadmap: A Pathway to Net Zero, UKGBC](#)

Meeting multiple objectives at minimal environmental cost.

Retrofit is a major contributor to decarbonising the economy. It can reduce energy consumption, and make our buildings fit for a future of higher temperatures and more extreme weather.

Retrofit upgrades, such as improvements to fire safety, ventilation and overall comfort, can produce improvements in physical and mental health for occupiers that they might not have been able to undertake or fund on their own.

Arup works with stakeholders across every dimension of this issue, from political leaders to local communities, to provide leadership, insight and support for clients wishing to accelerate this vital national priority.

Embodied carbon is a key consideration for retrofit: sometimes materials embodying carbon emissions need to be used now to save operational emissions in the future, balancing energy performance and embodied carbon to minimise the total carbon impact. Arup works with industry leaders to design and optimise use of regenerative materials, which actively support and restore natural resources, and to operate our buildings and communities to minimise carbon impact in the long term.

To facilitate this shift in the way we design and use materials, and to deliver more ambitious retrofit standards, we need new skills across construction and related industries. Arup have a track record in engaging with skills providers to ensure our future workforce is prepared to deliver the scale of retrofit required.

Retrofitting individual buildings is a starting point but scaling up is the only way to achieve wider societal benefits, economies of scale and the pace of change required.



Retrofit at Scale

Overview: Benefits of Retrofit at Scale

Building		Benefits	
1 Heat pumps	3 Roof/loft insulation	<ul style="list-style-type: none"> • More thermal comfort • Fire safety • Lower bills • Lower energy use • Increased property values 	
2 Electric vehicle (EV) charging points	4 PV panels & solar wall/roofpaint		
5 Replacement windows	6 Trees next to windows		
Neighbourhood			Benefits
7 Trees/grass	8 Shared square		<ul style="list-style-type: none"> • Reduced 'urban heat island' effect • Community engagement • Smart low voltage network management • Better public spaces
9 Smart low voltage network management	10 Sustainable urban drainage		
City/local authority		Benefits	
11 Local Authority	12 School	<ul style="list-style-type: none"> • Regeneration and place - Wider wider community engagement - Urban quality • Local economy - Supply chain development and skills - Jobs - Green growth - Community wealth • Reduction in social inequality • Adaption and resilience • Regeneration and urban quality • District heat networks 	
13 Businesses	14 Suppliers		
15 Training hub	16 Interconnected networks		



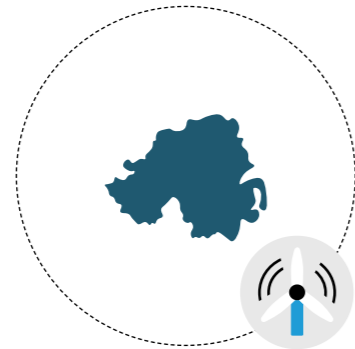
By connecting thinking at building, neighbourhood and city scales, we can improve efficiency and make better places to live.

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Europe

The European Union's Green Deal proposes that Europe will be the world's first climate neutral continent by 2050, and aims to reduce net greenhouse gas emissions by 55% between 1990 and 2030.



Northern Ireland

Net Zero by 2050.
First Local Area Energy Plan due to be complete 2024.



Wales

Net Zero by 2050; interim targets of 63% reduction by 2030 and 89% by 2040.
Local Area Energy Plans now mandatory for all local authorities. See more [here](#).



Scotland

Net Zero by 2045; interim targets of 75% reduction by 2030 and 90% by 2040.
Local Heat and Energy Efficiency Strategies mandatory for all local authorities by 2025. See more [here](#).
Delivering net zero for Scotland's buildings - Heat in Buildings Bill: live consultation closes on 8 March 2024.



England

Net Zero by 2050.
Local Area Energy Plans being trialled in 20 local authorities. See more [here](#).
Social Housing Decarbonisation Fund, Home Upgrade Grant and Energy Company Obligation – grant funding for social housing and fuel poor households.
Heat Network Zoning being rolled out in 2024, consultation finished in February 2024.

Retrofit at Scale

Overview: Policy tools and frameworks



Energy, heating and decarbonisation policy involved all tiers of government - UK, devolved nations and local authorities. Retrofit at Scale can play a holistic role across local authority strategies and plans.

As well as helping to deliver net zero plans, it is integral to energy and heating transitions, to ensuring habitable homes, as well as to other policy priorities such as nature recovery.

As of September 2023, 393 out of 409 UK local authorities have declared a climate emergency, and 298 have adopted a climate action plan.

(source: [CAPE](#))



Climate Action Plans (CAPs)

- Adopted by many councils following declaration of climate emergency
- Includes consideration of transport, biodiversity, energy, waste and adaptation
- No specific template, but in addition to Arup, Local Government Association and Friends of the Earth offer guidance and support.



Local Area Energy Plans (LAEP)

- Set costed and incremental plans for changes to energy system and built environment, including transport and renewables
- Spatially defined and developed with stakeholders
- Guidance issued by Energy Systems Catapult
- Mandatory in Wales and being adopted widely in other UK nations



Decent Homes Government standards on individual buildings

- Specific standards on issues such as damp, mould and thermal comfort for social housing
- Decent Homes currently under review, and set to be extended to private rented homes
- Other standards include building regulations, and the Future Homes and Building Standard, which will apply to all new homes from 2025



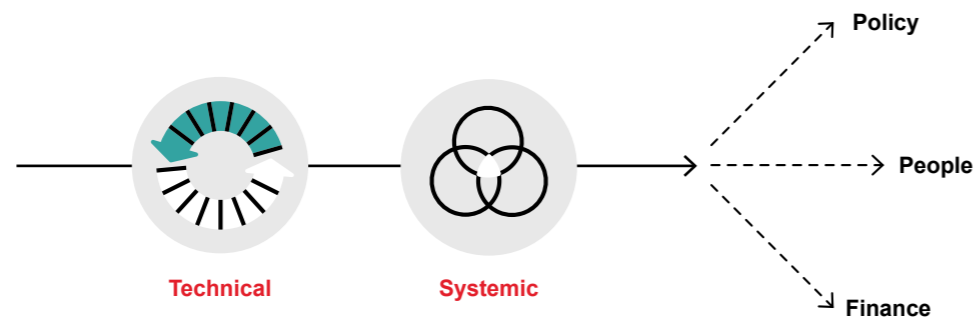
Local Heat and Energy Efficiency Strategies (LHEES)

- Specific focus on heating, including decentralised heat networks and energy efficiency
- Sets out granular details and priority areas for intervention
- Mandatory in Scotland, with government guidance

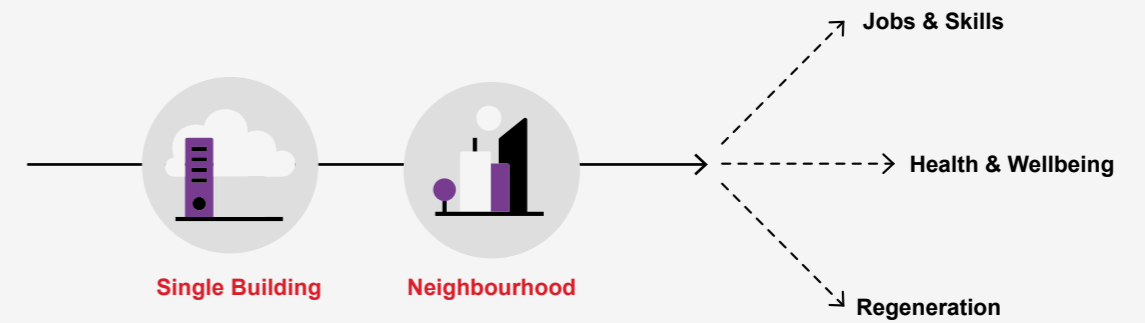
Retrofit at Scale

Overview: Scaling up and delivering Retrofit at Scale

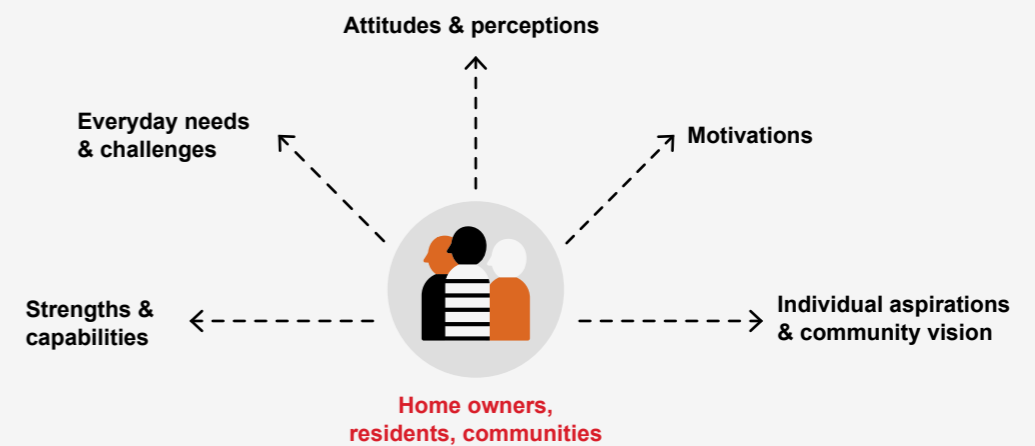
Retrofit at Scale takes a systemic, whole neighbourhood, people-centred approach, which delivers benefits across the board, and moves beyond traditional technically-led approaches.



1 From technical to systemic
Historically, building retrofit was thought as a technical problem. To shift towards a whole system approach, there is a need to improve integration of different disciplines - including finance, planning, service design, public engagement.



2 From single building to neighbourhood
There is also a significant shift from individual buildings towards a whole street or neighbourhood approach. This transition would allow us to address multiple place-based challenges across tenures and typologies, and it is an opportunity to achieve wider benefits, while minimising disruption and taking into account infrastructure changes, allowing the whole system to change in the most efficient way possible.



3 Putting people and community at the heart of the process
The human factor is a significant part of the overall adoption challenge. It requires shifting more focus towards end-users and placing people and community at the heart of the design and innovation process.

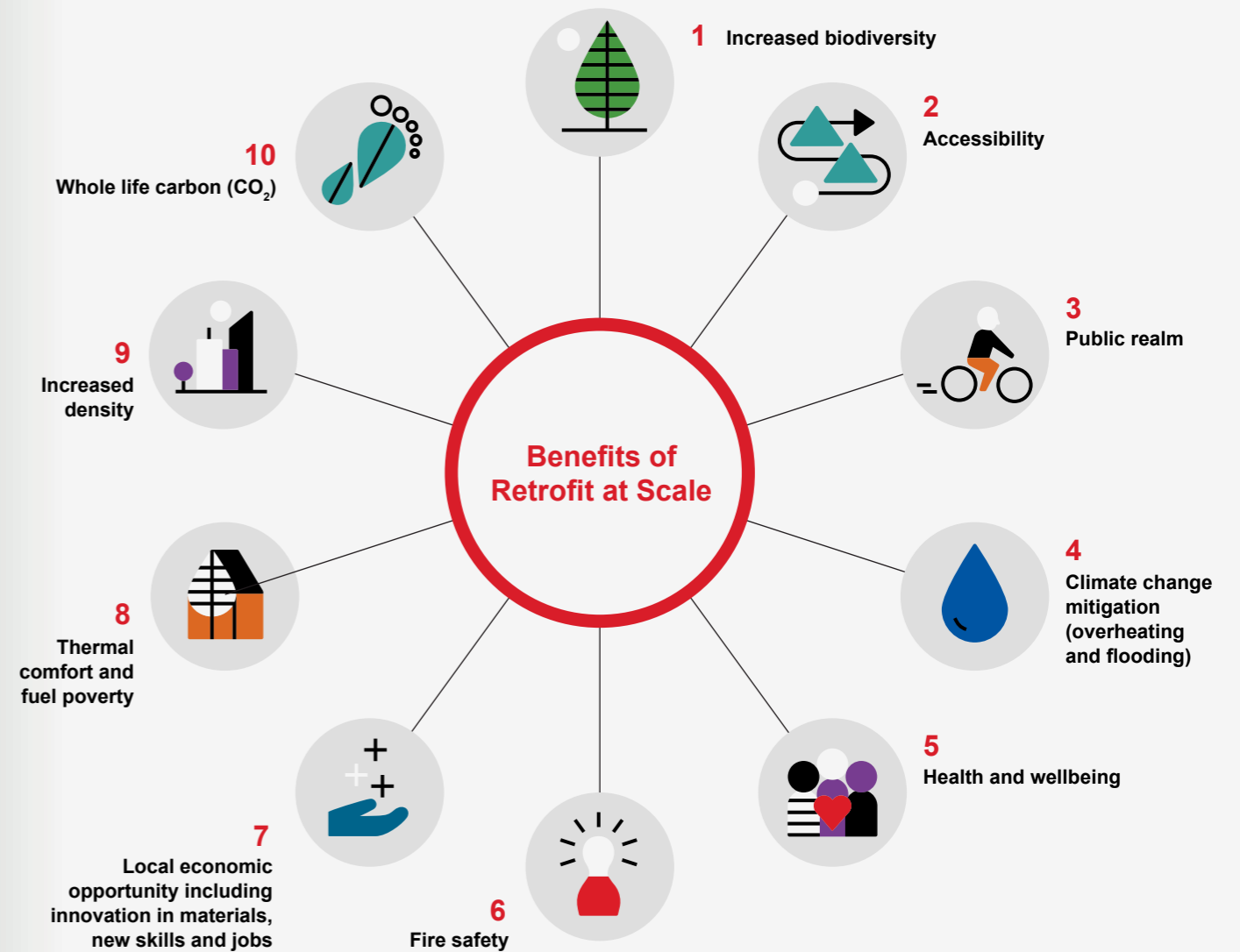
Retrofit at Scale

Overview: Connecting and maximising benefits

Retrofit can start from one point but generate a much broader range of benefits; a holistic review at the planning stage can help identify and test the deliverability of these, minimising costs and disruption, and maximising benefits over the longer term.

While addressing the core retrofit objectives of achieving energy efficiency and meeting net zero targets, retrofitting at scale can support positive outcomes across multiple different systems, such as:

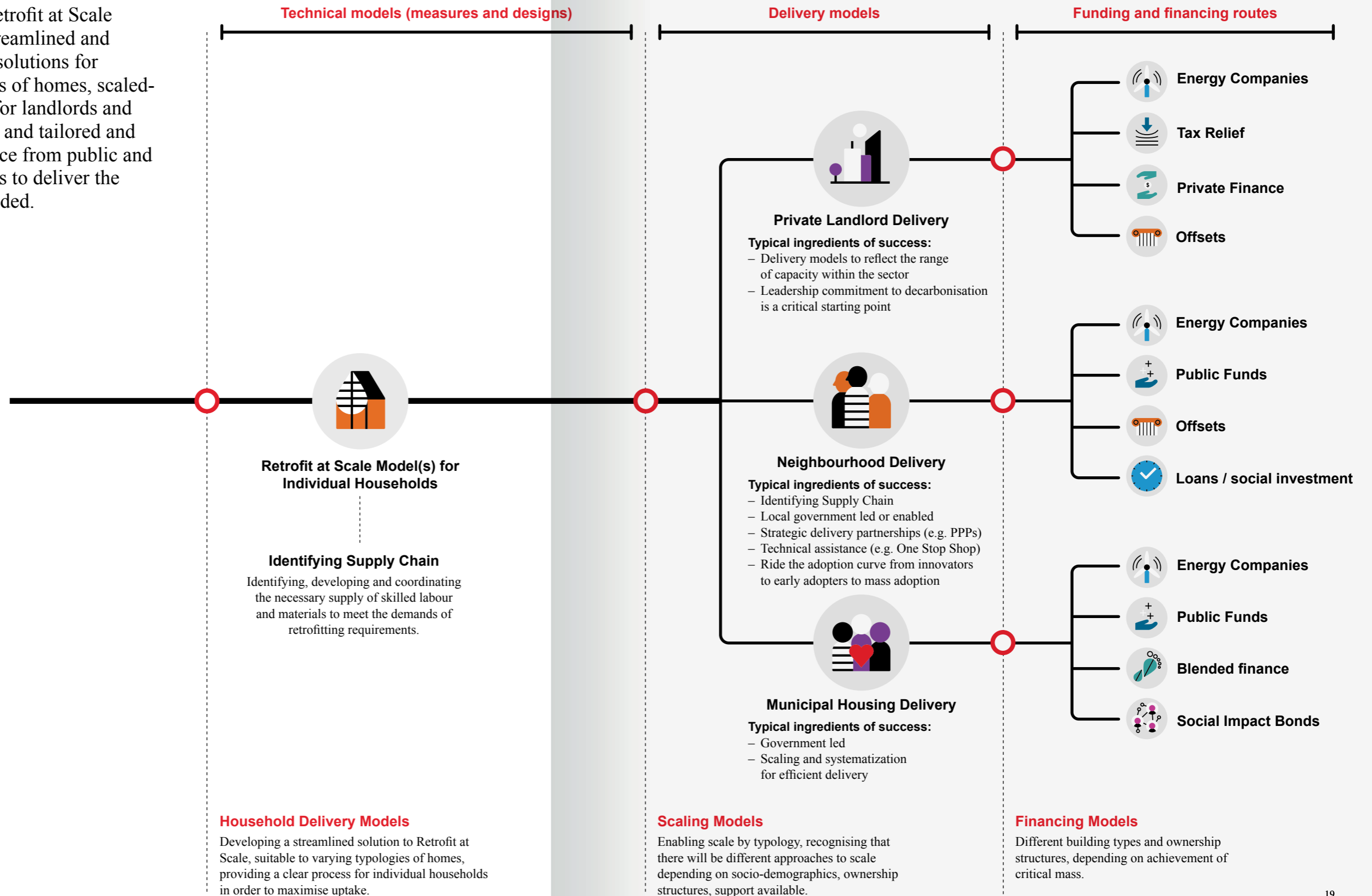
- Schemes to improve water use and reduce flood risk can also create new habitats to support biodiversity and provide opportunities for improving water literacy;
- Making buildings more energy efficient can also improve health through better ventilation and less damp, and can lower household bills for vulnerable people;
- Improvements to public realm to enable walking, cycling and other forms of lower carbon travel can also boost community cohesion and accessibility for all;
- Rolling out programmes of domestic retrofit can create new training and job opportunities for local people.



Retrofit at Scale

Overview: **Delivery and financing**

Delivering Retrofit at Scale can ensure streamlined and standardised solutions for different types of homes, scaled-up solutions for landlords and communities, and tailored and blended finance from public and private sectors to deliver the outcomes needed.

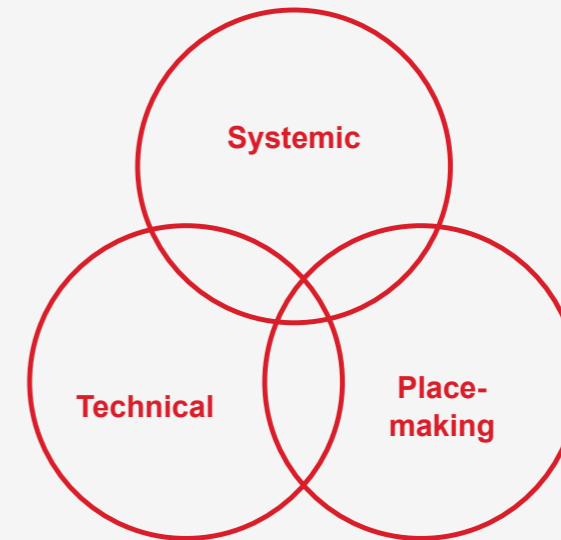


Retrofit at Scale

Overview: Arup's offer



Arup's approach brings together existing established technical expertise and skills, with people-centred skills, systemic thinking, and the ability to convene partners in order to facilitate and support transition.



1

Considering the whole system
An integrated approach that looks at the system as a whole.

2

Deploying a multidisciplinary team
An integration of disciplines; bringing technical solutions together (e.g. economic, planning, engineering, data) and delivery advice to tackle systemic and place-based dimensions.

3

Shifting between micro and macro
Shifting between the scales to draw a complete picture that includes individual, community, regional and national agendas.

4

Designing at neighbourhood scale
Moving away from design for a single building to the neighbourhood/ street or community scale as a whole.

5

Aspiring for wider benefits
Designing for wider social, economic and place-based outcomes.

6

Building on communities' strengths
Developing solutions that build on existing strengths in the community skills, networks and talent.

7

Placing people at the heart of the process
Understanding people's real needs, challenges values and aspirations to create tangible impact and reduce objections.

8

Facilitating transition
Listening, gaining consensus
Guiding partners and stakeholders through the organisational and systemic transformation.

9

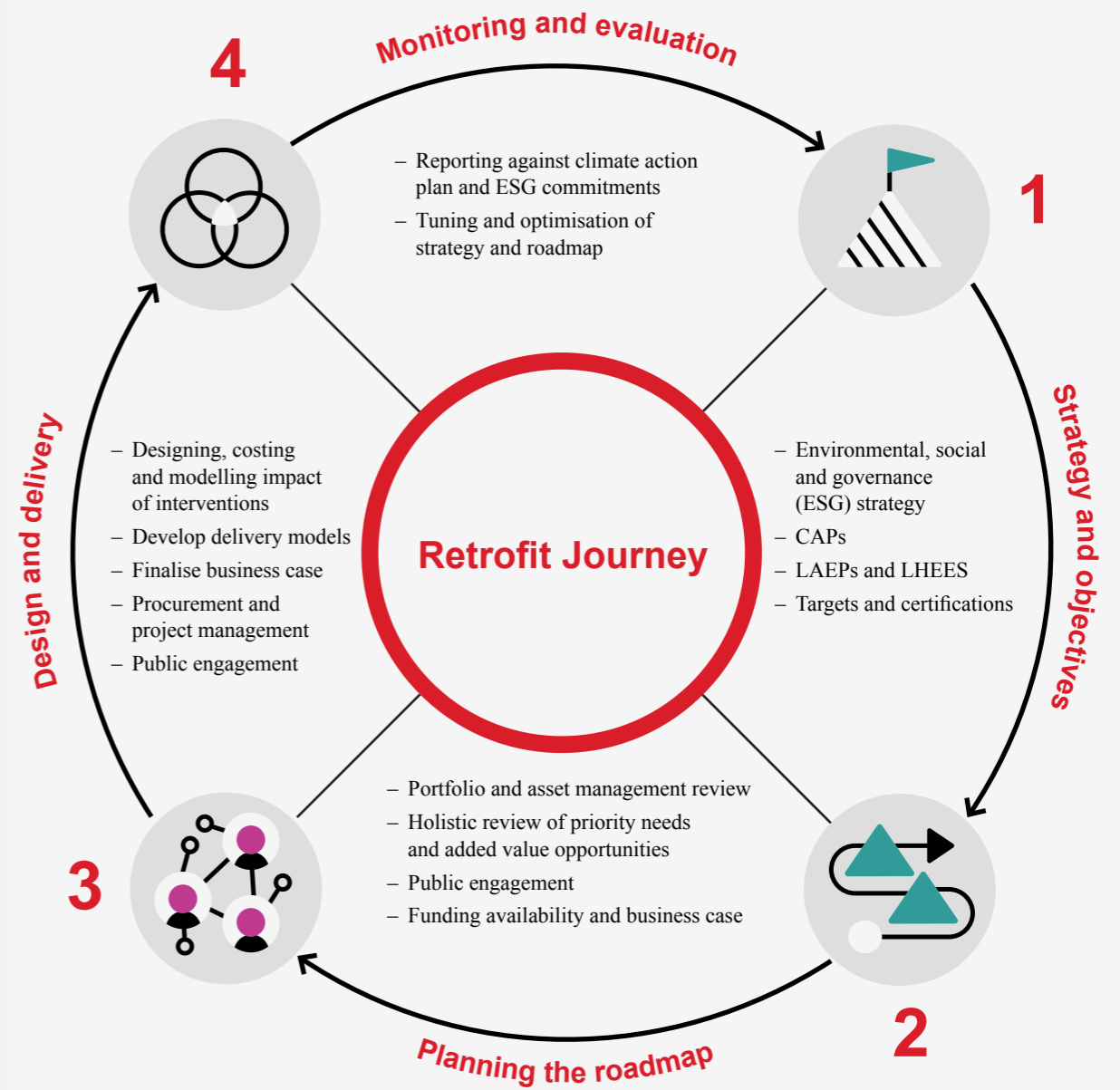
Celebrating engineering excellence
Building on Arup's advanced technological expertise across engineering (including fire and building materials) and digital solutions.

Retrofit at Scale

Overview: The Retrofit at Scale journey



Throughout the delivery process, Arup's expertise is focused on maximising benefits, taking a citizen-focused approach to design and delivery, and using data to optimise prioritisation and efficiency.



Arup have supported our clients from developers to local authorities, in determining how to plan for retrofitting. The following case studies provide an overview of our work. We hear from Perth & Kinross Council about their experience of working with Arup to prepare an integrated heating and energy plan. Other case studies include:

- Financing local authority net zero projects.
- Sharing expertise and tailoring approaches at scale.
- The Crown Estate Sustainability Advisory.
- Leeds low carbon retrofit accelerator one stop shop.
- Retrofit for climate change and urban heat challenges at a city-wide scale.
- Circular concept design for inclusive living district.
- Highlighting retrofit best practice across European cities.



Retrofit at Scale

Case studies: Perth & Kinross Council deliver a combined LHEES and LAEP

Perth and Kinross Council is leading the way in developing their first Local Heat Energy Efficiency Strategy (LHEES) combined with a Local Area Energy Plan (LAEP) for the council area.

Shelley McCann, Strategic Planning and Sustainability Officer, Serge Merone, Climate Change Manager and Grant Key, Principal Officer for Energy and Engineering discuss how they have worked to develop the LHEES and LAEP, together with Stuart Hallett, leader of Arup's Scotland Urban Energy team.



Shelley McCann

Strategic Planning and Sustainability Officer

Perth and Kinross Council



Serge Merone

Climate Change Manager

Perth and Kinross Council



Grant Key

Principal Officer for Energy and Engineering

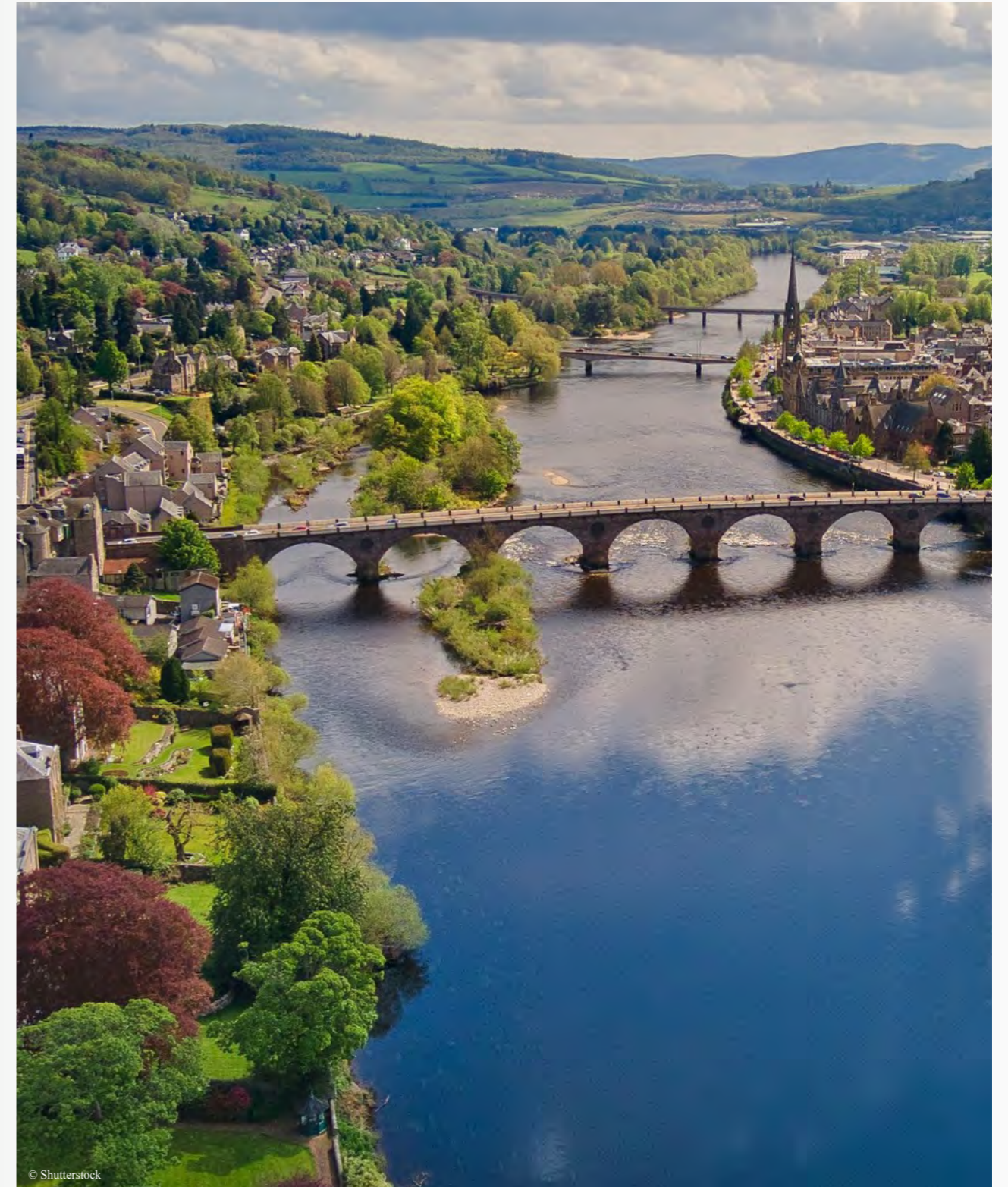
Perth and Kinross Council



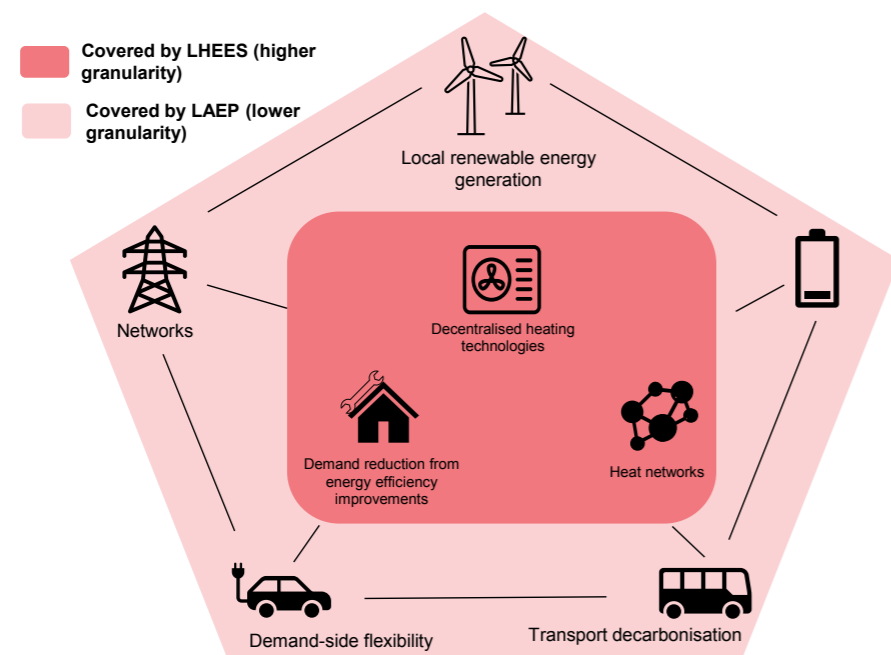
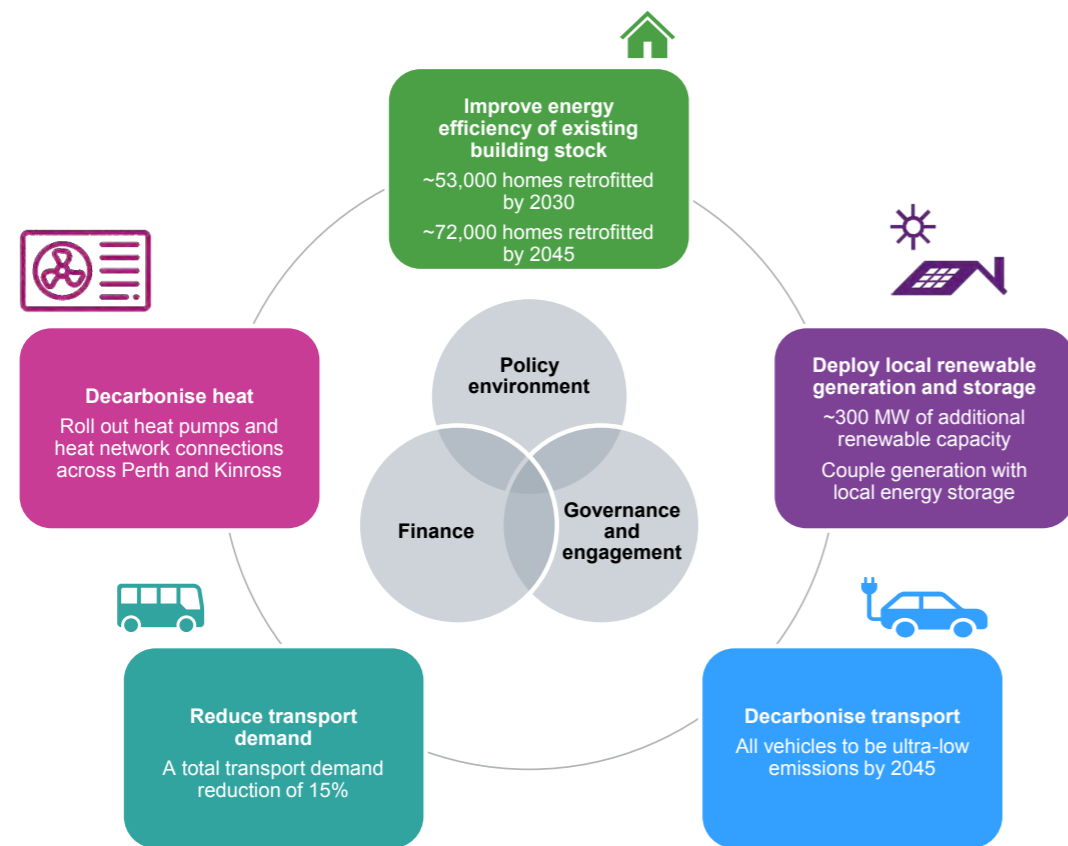
Stuart Hallett

Leader of Arup's Scotland Urban Energy team

Arup



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Q. How did Arup's collaboration with Perth and Kinross Council emerge and develop?

Shelley

We started working with Zero Waste Scotland and a small group of local authorities, using energy and heat map data, and that became formalised into a knowledge sharing group, set up and funded by the Scottish Government. That work heavily shaped the LHEES policy and methodology that you see today. Additional funding was allocated to pilot an LHEES methodology, where we took the work done through the knowledge sharing group into more detail, to focus on how we're going to shape the delivery plans and areas.

Having established this good working relationship, and having a similar vision for whole energy system planning, innovation, and evidence-based policy, we secured Arup as a partner to support us across three inter-related work streams: the LHEES combined with a LAEP, a business case decision-making and development tool, and a detailed decarbonisation plan for the Council's domestic and non-domestic buildings.

Stuart

We began supporting Shelley and her team in the production of one of the very first pilot LHEESs in Scotland, and it's all grown from there. We continue to listen and understand the challenges that the Council face, from the strategic to the detailed, and bring forward thinking and solutions to respond to their needs, including most recently working with Grant, Nicola Lennon and their property teams as we develop the decarbonisation transition planning for the Council's building stock.

Q. What was the rationale for starting with heat and energy efficiency?

Stuart:

There are two main factors: one is that the electricity grid is already rapidly decarbonising at a system level (ie, National Grid), with major investment in offshore wind and other forms of sustainable and renewable generation across the UK. Also, heat is a devolved legislative matter for the Scottish Government, whereas electricity is still a reserved matter. In simple terms, the Scottish Government have far more agency in how they tackle the decarbonisation of heat, than some other aspects of the energy system.

Shelley

We've got just over a third of the population off the gas grid, but we also have a lot of detached older traditional homes in urban and rural areas. It is more difficult to retrofit those, and then there is also less opportunity for heat networks in those more rurally dispersed populations.

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Q. What are some of the solutions that have been used to try and fit into those areas?

Shelley

For us, it is two-pronged: energy efficiency measures within buildings and then looking at heat networks, or heat pumps when there isn't the density to support heat network development.

Serge

What was evident from the data analysis undertaken by Arup was that there's no single solution. Because of the nature of the building stock, you need to develop an approach which is quite flexible, but standardised for specific types of buildings.

Grant

We've got a large diversity of buildings – and our non-domestic estate in particular has a variety of construction types and ages. We are currently reviewing our corporate asset management strategy in conjunction with our decarbonisation

review and this appraisal may determine that some of the buildings we have may not be suitable for retrofit, becoming surplus to requirements. We will then have to look at the potential of consolidating services into fewer buildings that we can refurbish and retrofit.

We know that schools make up about circa 70% of our non-domestic estate and so we will need to do a lot of retrofit work within this sector. The schools are differing construction types, but they've had extensions and alterations throughout the years, so we need to look at tailoring solutions accordingly.

We're starting to work through a limited program of retrofit, shifting to heat pumps and doing targeted building fabric improvements, as well as looking into renewable generation if we can, depending on local electricity grid constraints. One of our key actions is to remove all oil-fired boilers in our non-domestic buildings by 2030.



Q. How have you found public support; has retrofit / heat pumps been a major issue for public engagement?

Serge

When we did the consultation on the LHEES, the public were challenging the viability of heat pumps as a solution because of the off-gas grid situation that we have, which enabled us to start a discussion; using the LHEES to manage expectations and communicate what the challenges and solutions are.

The decarbonisation challenge for individuals can be the money, where to start and where to find contractors. But if there is support available to break down some of these barriers, it's easier for them to become involved. For example, we have worked with social housing tenants to deliver insulation. Some of the apartment blocks were not entirely social housing; but the private owners agreed to be part of the program. If we, as the Council, bring forward the supply chain, it becomes much easier for individual homeowners and landlords to join.

Grant

I think sometimes heat pumps may get unduly negative press. They are a tried and tested technology but the thing that we are finding challenging is getting suppliers to maintain and service them in a non-domestic building; the ongoing cost of servicing can be quite significant due to this supplier shortage. There are numerous suppliers who can install this technology. However it may be that it's less lucrative when it comes to ongoing servicing and maintenance; so there seems to be a shortage of available suppliers who provide this service. There is a large piece of work around the skills shortage in this field to be done.

Q. What are the opportunities for private sector partnerships?

Grant

There are opportunities out there. We're engaging with one private sector organisation that has premises next to our buildings and may be able to provide a joint energy supply solution, for example for a primary school to be supplied with energy from a local business as part of a solar PV array, viewing this as a community benefit.

Serge

The data showed us that the public sector is only a part of the equation. Private landlords have a huge role to play, but they don't always have the money or the will. By developing the LHEES and the LAEP, we're giving the private landlords an indication of our direction of travel.

The other element is for the Council to lead by example. We are exploring a Strategic Energy Partnership. An energy partner would support us in identifying projects and developing business cases, finding the financing and effectively delivering them. That could be also an opportunity for private landowners to become involved, if the Council and the strategic partner are working together and actively showing that the model can work well.

Shelley

I think doing the strategic work on the LHEES and the LAEP has also helped us quantify the investment potential for each of the low carbon portfolios that we have, which is incredibly useful not only to feed into this work with the private sector, but also to feed back to the Scottish Government in terms of the scale of the challenge. I think it'll be interesting when the data for the LHEES is pulled together for all of Scotland, to see how achievable targets are within the current technology available – what's feasible, and how much would that cost?

We're also working quite closely with Scottish and Southern Electricity Networks (SSEN) – who provide electricity to Perth and Kinross – feeding into a platform with a live delivery plan, so we don't end up in a position where we're suggesting a massive transition to electrification of heat and transport where there's no electricity network capacity, but can align with SSEN programmes and avoid the electricity grid constraints that often hinder rollout.



Q. How has the relationship with Arup developed over time?

Shelley

I think that both Arup and PKC are looking pragmatically at the LHEES, within a whole energy system, to push this process forward – and that probably comes from working together in the beginning to develop the process itself and find the best way forward.

Serge

Arup have been able to listen to what our requirements were but also challenge some of our assumptions and our point of view. That's the kind of relationship you want to get the best out of the of the process.

Grant

In my team we are passionate about what we do in relation to energy and engineering. We're interested in fixing things and solving problems, and it's good to engage with Stuart and his team. It's been really refreshing for us to have some open conversations and I think the process has worked really well, to be honest.

We've put a lot of work in at the front end along with Stuart and his team, and we're getting a lot out in return. Arup developing the Power BI dashboard has been fantastic – it's a great tool for us to be able to use and gives a visual representation of what we can do to certain buildings. Now we're moving on to the next stage, looking at a granular level, at surveys and designs and what that actually means for each one of our buildings within the estate, looking across the domestic and non-domestic estate.

Stuart

From our perspective, it's two things: first and foremost, it became very clear to us that we were working with a client that had ambition to keep challenging the way things were done in pursuit of better outcomes and tangible action.

Secondly, we have worked with all the Council teams in a really open and collaborative environment. This environment enables us to have really honest dialogue, where we've been allowed to discuss how we might go about things and to challenge one another's perspectives and logic. This environment fosters a strong sense of unity and trust, and we've felt empowered by Shelley, Grant, Serge and others to bring forward innovation and efficiencies, as appropriate to respond to the challenge at the time.

Ultimately, there has been an alignment of values between our two organisations and this leads to a strong sense of reward and satisfaction in the work we do together.

Retrofit at Scale

Case studies: 3Ci funding and finance models

Financing local authority net zero projects.

Making the investment case is key to the delivery of retrofit, and Arup have supported the Cities Commission for Climate Investment (3Ci) in developing new investment and funding strategies for retrofit projects.

Net Zero Neighbourhoods

The 3Ci Net Zero Programme sought to develop a partnership that could help unlock private sector investment in Net Zero initiatives. Arup were commissioned by Connected Places Catapult, on behalf of 3Ci to act as strategic advisor for the delivery of a Strategic Outline Business Case and Outline Business Case for the programme. We drew upon our multidisciplinary expertise to understand the strategic context and drivers to develop a place-based, system-led delivery model that is supported by blended funding. We investigated the system-wide scale of the challenge, alongside partners Bankers Without Boundaries and Eunomia who developed the financial, commercial and management cases.

The Outline Business Case has acted as the foundations for Phase 3 of the programme, where the core principles of our work, namely the blended finance model and the operational supporting structures, are to be tested through a set of demonstrator projects that seek to provide proof and refinement of concept.

Investible Cities Programme

3Ci also appointed Arup to support the outline and concept development of a National Technical Assistance Facility (NTAF), also referred to as the 'Investible Cities Programme'. The aim of the NTAF is to support local authorities in attracting finance for their net zero projects and programmes.

Arup undertook desk-based research and a knowledge visit to Brussels to learn from European technical assistance facilities. The project began by identifying five priority areas for local authority support from project identification, supply chain management and procurement, scenario modelling, portfolio development and investor engagement.

We then explored what collaborative partners could be identified in each of these areas, and what strategic partnerships might be formed. User personas were developed to explore how different council officers would access support, their motivation and the challenges faced. We also reflected on next steps, and outlined delivery and programme structures 3Ci might want to further explore.



ARUP

You've made a Climate Action Plan... what next?
Guidance for local governments

Have you published your climate action plan? Are you preparing your plan now? This is great progress towards a robust response to climate change. Now is the time to think about **implementation**.

How should we refine our actions ready for implementation?

Research led by Arup in 2021 showed that 80% of people in London, Manchester, Birmingham, Bristol, Cardiff and Glasgow believe Mayors and City Leaders should have a role to play in cutting emissions, based on a survey with 2,400 respondents.

Home > Case Studies > Leeds' bundle of retrofit interventions for multi-tenure neighbourhoods

Case Study

Bringing communities together through energy efficiency

Leeds has successfully delivered 'whole neighbourhood' retrofit programmes in various locations across the city, with a focus on areas in energy poverty. These have been primarily achieved through a mix of different central government grant funds – an approach which doesn't easily scale.

[Click to download](#)

Cities Commission for Climate Investment



Sharing expertise and tailoring approaches at scale.

Wales has a target of reaching net zero by 2050 through an ambitious strategy. The Welsh Government has committed to a policy to develop Local Area Energy Plan (LAEP) for each of the nation's local authority areas by March of 2024, funded nationally but led and developed at the local level.

Following successful delivery of three LAEPs in Wales (Pembrokeshire, Newport, Conwy) as pilots in 2021/22, Arup is now working with the Carbon Trust to deliver a further 13 LAEPs in Wales. The result is a pioneering programme that looks at each area individually, to assess challenges and opportunities at a local level, and to also integrate the LAEPs through both public and private networks, which helps to plan changes to national infrastructure over time.

Our methodology is structured to empower and support each Local Authority as we work with them to deliver their LAEPs, building on our previous work, and working nationally and regionally to share learning and progress.

Plans are also locally tailored to their geography e.g. rural / urban. For example, we worked with Pembrokeshire County Council to develop a LAEP to reflect the council's interest in exploring the potential of hydrogen. We identified seven priority interventions, including network upgrades, transition to heat pumps, and building retrofit for the Council to action immediately, in conjunction with a set of five-year energy proposals. Our work with Conwy focused on the potential for offshore renewables such as a tidal lagoon and offshore wind, while in Newport, we sought to explore industrial innovation using the county's established industrial base.

To help facilitate this large number of unique stakeholders and local scenarios, Arup partnered with The Carbon Trust and Afallen to create a fully integrated collaborative team capable of delivering Welsh-specific plans that are ready to implement – and leaving a legacy of skilled stakeholders who understand energy and the planning process more fully than before.

The LAEPs include all the data and analysis necessary to provide evidence of the possible pathways as well as Arup's recommendations for which elements of the energy system are required in each area with short, medium and long-term action plans.

Read more information [here](#).



Retrofit for climate change and urban heat challenges at a city-wide scale.

As a growing city, London is exposed to rapid heating, with heating rates twice as high globally in urban as in rural areas. As heating leads to more demands for cooling technologies in the summer, energy use will increase, which risks contributing further to climate change. The Greater London Authority (GLA) commissioned Arup to undertake several studies to support the capital with inclusive climate transitions, delivering resilience and equity.

Properties Vulnerable to Heat Impacts

This report maps London’s heat risk across homes, neighbourhoods and essential properties (such as schools, hospitals, care homes, residential buildings) in the wake of climate change, informing the Mayor of London’s plans for resilience and retrofit. The report identified which properties would be most impacted during periods of high temperatures and shows there is a direct correlation between a higher heat risk and areas that have greater socioeconomic vulnerabilities.

Roofs Designed to Cool

This study identified retrofit solutions to minimise the ‘urban heat island’ effect of climate change, while reducing energy use, strengthening communities and reducing inequalities. Arup’s review looked at the potential benefits of retrofitting more reflective materials and installing photovoltaic (PV) cells on roofs across the capital - from homes, to schools, to commercial buildings. The report mapped out areas of greatest need and opportunity for installing these technologies, reviewed case studies, and considered funding, public engagement and delivery. Arup is now working with the GLA to develop pilot projects, which can inform the business case for wider implementation.

In addition to these reports, Arup has supported the Mayor of London’s Climate Resilient Schools programme, which saw the firm lead on bespoke climate adaptation retrofit plans for 60 London schools.



MAYOR OF LONDON

GLA Roofs Designed to Cool

A Review of Reflective and Solar PV Roofs for London

June 2023


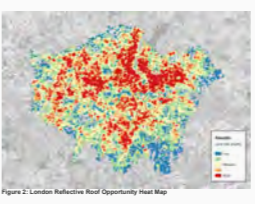



Figure 2: London Reflective Roof Opportunity Heat Map

Using the map, the data has been aggregated to borough level for comparison and for guiding local authorities and decision makers. The London boroughs have been ordered by highest opportunity using the data, with the top ten boroughs shown in Figure 3. For instance, boroughs closer to the centre of London, could be prioritised as they are likely to be at higher risk from heat exposure, and have a higher density of residential properties compared to areas on the outer edge. The risk also highlights neighbourhoods that are at highest risk. This could be helpful at a single building level, whereby this data could be part of a checklist that building owners consider to assess the risk level of their building, and if investing in a cool roof would be beneficial. A Heat Vulnerability Index was developed by Columbia University for New York City that assessed high levels of overheating risk across the city. The study has helped drive the NYC Cool Roofs programme (see Case Study 8: New York Cool Roofs).

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Properties Vulnerable to Heat Impacts in London

Prioritisation for adaptation interventions



ARUP




Figure 9: Heat Risk Map for residential properties aggregated to LSOA

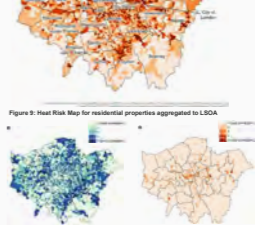


Figure 10: Socioeconomic Vulnerability Map (left) and Property Vulnerability Map (right) for residential properties

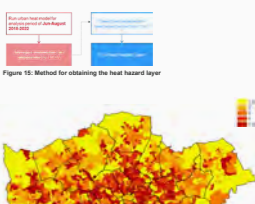


Figure 15: Method for obtaining the heat hazard layer

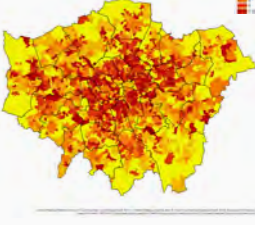


Figure 16: Heat Hazard Map (Averaged temperature predictions June to August 2016-2022) for residential properties

Highlighting retrofit best practice across European cities.

Arup experts are actively working with cities across Europe to accelerate Retrofit at Scale programmes, as part of the Intelligent Cities Challenge (ICC)

In October 2020, the European Commission launched the [Renovation Wave initiative](#) which aims to double the annual energy renovation rate of residential and non-residential buildings by 2030 and foster deep energy renovations. As part of its involvement with the Intelligent Cities Challenge (ICC), Arup prepared the [Renovation Wave in Practice Guide](#) on behalf of the EISMEA and DG Grow.

The Guide is intended to help European cities familiarise themselves with the Renovation Wave and provide guidance on strategies for scaling up retrofit and sustainable construction.

As well as setting out the policy context and making the case for renovation of buildings – to deliver decarbonisation, and enhance affordability, design quality and health – the Guide sets out what city governments can do to accelerate the Renovation Wave. It provides ideas on piloting, accessing finance, supporting innovation, developing partnerships and engaging with communities, drawn from successful case studies from across Europe. These include municipality-led advice services to tackle energy poverty in Barcelona, integrating smart grid solutions in heritage buildings in Limerick, new investment models for retrofitting social housing in Emilia-Romagna, and a community energy pilot in Ghent.

As part of the second phase of the ICC, Arup is working with cities across Germany, Ireland, Italy, Poland and Sweden, supporting them in creating Local Green Deals with the private sector, also focusing on deep retrofit.

EISMEA: European Innovation Council and SMEs Executive Agency
DG Grow: Director General for Internal Market, Industry, Entrepreneurship and SMEs.



INTELLIGENT CITIES CHALLENGE RENOVATION WAVE IN PRACTICE

The European Commission's
100 Intelligent Cities
Challenge

An initiative by **EISMEA** and **DG GROW**

Meet some of our people working together to tackle the Retrofit at Scale challenge; they discuss the opportunities and challenges of delivering retrofit at a large scale.





Retrofit at Scale

Arup people: Becci Taylor and Helene Gosden

Becci Taylor, who heads Arup's Retrofit at Scale business, and Helene Gosden, who has led the Retrofit at Scale task force, talk about multi-disciplinary nature of delivering retrofit at scale, and about the opportunities and challenges involved in achieving the pace that is needed.



Becci Taylor
Director, Retrofit at Scale
Business Leader
Arup



Helene Gosden
Associate Director, Retrofit at
Scale Taskforce Leader
Arup

Q. What were your routes into Arup, and into working on Retrofit at Scale?

Becci

I've been at Arup for 20 years - starting in building services engineering and physics - optimizing the interaction of the built environment and people through building and system design. This has broadened to consider the broader system of value, delivery, finance, and policy alongside. I'm interested in the enormous potential for impact when we consider multiple fronts of decarbonisation, resilience and quality of life.

I'm drawn to complex system challenges, and thrive on bringing people and skills together to solve them. I could see both the urgent need for action to decarbonise our building stock at scale and the number of parts of the system that Arup was working on. To capitalise on this breadth of knowledge we needed dedicated coordination – so Arup's Retrofit at Scale Taskforce was born, connecting across geographies and skills, and with collaborators. This brought together district wide energy planning together with economics and project management, and put deep building technical expertise alongside UX design and data.

Carbon-wise, retrofit achieves two things – firstly, improving the quality and functionality of existing buildings to reduce the need for new construction; and secondly, reducing operational carbon emissions of existing buildings. But that's a limited view as benefits can be widened to take in climate and energy system resilience, health, wellbeing and building safety, and equity.

Helene

I joined Arup over 10 years ago as a structural engineer, and have always led multi-disciplinary projects, the vast majority of which have been retrofit. I moved fully into the design management of complex projects and programmes having completed a master's, in Interdisciplinary Design for the Built Environment at the University of Cambridge, which was supported by Arup.

Arup recognised the need to tackle the carbon footprint of UK housing stock and to consider how we could optimise our contribution to delivering retrofit at scale. Working together with Becci, I established the Retrofit at Scale Taskforce and internal network, which brings together expertise from across the firm and different portfolios.

Achieving the pace and scale of domestic retrofit that is required to meet 2050 targets is a complex challenge that requires us to understand multiple, inter-related levers. From finance to manufacturing capability, and from individual behaviour change to planning and housing policy, coordinated change is required to drive supply and demand simultaneously. Within the Taskforce we are trying to link up experts within the business to tackle these issues together, demonstrating the kind of collaborative leadership needed in this space.

Q. Can you go into more detail on the challenges facing domestic retrofitting?

Becci

I would rebrand 'housing retrofit' as 'home health improvement'. Retrofitting homes, as fast as we can, will be healthier for people and the planet. Living in sub-standard accommodation can have a significant impact on mental and physical health. It reduces people's ability to work and to learn, increases the load on the NHS but is also a brake on productivity. Housing is a core piece of social infrastructure, so as a society, there's a hugely positive cost-benefit ratio in making people's homes comfortable and healthy. We're not valuing this enough at the moment.

From an individual homeowner's perspective, the value proposition for retrofitting your home right now doesn't stack up as we only look at energy savings. Attitudes need to change to see retrofit as home improvement, valuing quality of life 'payback' as you would upgrades like a new bathroom. Environmental performance is just starting to have an impact on house prices, but we need more innovation in the mortgage market with respect to affordability and emissions. For an individual, energy retrofit also seems incredibly overwhelming and disruptive, so we need to make this easier for everyone too – a trusted and scaled up supply chain is key.

For social rented homes, there's a massive funding gap to be bridged in order to achieve trajectories we need, even once we leverage private investment. Private rental is even more complex as benefits are split, so regulation will play more of a part.

Return on investment is challenging based on energy saving alone, but if you include all the indirect financial and non-financial benefits then it does pay back more quickly – but there is not yet an easy way to capture this value. We need a better way to invest in broad outcomes – true neighborhood transition, which is regeneration through decarbonisation, has the potential for this, as do outcome-buying models such as Retrofit Credits which we have been part of developing.

Making our homes fit for purpose is a huge national infrastructure project, delivered locally in every community. This justifies a long-term plan that transcends political cycles – the Sustainable Energy Authority of Ireland is a good example of this – and provides the confidence needed for supply chain, materials and skilled labour planning to support it, alongside alignment with grid electricity and heat infrastructure planning.

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Q. How do we bring communities on board?

Becci

The industry is making progress, but the public still need to be brought on the journey. People should take up retrofit, not because they feel they ought to, but because it's an attractive proposition and they trust the process – maybe because their friends have done it, for example. So there's a general education campaign needed to make the case for improvement-driven retrofit. At a delivery level, well-organised, hyperlocal community engagement will remain critical until we have built truly trusted delivery mechanisms.

It needs to be easier for people with little time or appetite for disruption - that's why we are working on 'one stop shops', where someone can be taken on the full user journey, where they can trust that the result is going to be good quality and will make their life better.

Q. How has the Retrofit at Scale Taskforce's work enhanced Arup's offer to clients?

Helene

The Taskforce brought together people working on complementary themes from right across Arup. Some of the projects we engaged with included [work done by the city economics team](#) to demonstrate the wider benefits of retrofit on social equity, physical and mental health, a [study by our user experience design colleagues](#) into the experience of individuals across different tenures in their retrofit journey, and our [materials team's recent deep dive](#) into the embodied carbon of different external wall insulation systems to enhance our understanding of the embodied carbon impact of retrofit.

We are also working on some fabulous external collaborations including, [supporting the UK Green Building Council](#) with the development of their Domestic Retrofit Calculator – where we have provided benchmark cost data, sponsoring last year's highly successful [Retrofit 23](#) exhibition and series of associated talks at the Building Centre, where we hosted sessions on fire safety and urban heat, and working with the [National Retrofit Hub's](#) newly established Working Group on Delivery Models.

Becci

Beyond our building design, energy systems capability and planning knowledge, we bring skills in the big technical challenges like carbon emissions and climate adaptation, heat decarbonisation, fire safety and materials innovation, alongside social value and health. This knowledge supports our strategic delivery model and business case development with data driven planning to develop programmatic, at-scale approaches.

Pace and scale really matter now – this means a step change in innovation built on strong foundations of best practice and technical expertise. Net zero transition plans need to be actionable, leveraging funding and realising economies of scale. Decarbonisation can be aligned with fire safety, damp and mould remediation, accessibility, and climate adaptation. If the scaffolding is up already, then why not fix other issues at the same time?



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Q. Where will Arup's retrofit at scale journey go next?

Helene

Our retrofit at scale journey continues with wide-ranging commissions, from techno-economic energy infrastructure, modelling at city and region scale, to strategic advisory work on delivery models, and business case development for innovative new funding models.

I'm currently part of the Arup leadership team for the Social Housing Decarbonisation Fund Wave 2 and Home Upgrade Grant Delivery Partner. This is a collaboration with Turner & Townsend and PWC, and is another globally pioneering scheme of which we are hugely proud to be a part. Reporting to Salix Finance, who administer decarbonisation grants on behalf of the government, our role is to enable recipients of these grants to deliver retrofit and realise the benefits for residents and the planet. Local authorities, housing associations and charities are upgrading homes to improve energy efficiency and alleviate fuel poverty, using £1.4bn of funding to upgrade more than 100,000 homes over the next two years. This delivery programme is also intended to gear up the supply chain and create thousands of 'green jobs'.

This commission embodies the principle upon which we established the Retrofit at Scale Taskforce, bringing together colleagues from across Arup including urban energy, climate services, city planning, advisory, technical services and property and science sectors. And

the three-way partnership acknowledges the need for deep collaboration in the industry to deliver meaningful change.

Becci

We are working on some really exciting projects for national government, local and combined authorities, and private clients across the UK, as well as supporting numerous broader initiatives. Our body of work gives us great insight into opportunities, allowing us to make connections across activities that are critical for driving the national transition.

I'm proud of how things have moved on, of being part of transformational change, and of the genuine collaboration across the industry which Arup has been part of. We're starting to look increasingly at global knowledge sharing, connecting increasingly with leading work in Europe (where we prepared an [EU guide on retrofit good practice and case studies](#)) and the US.

The industry has come this far with some amazing people working in this space because they believe in change and want to make it happen. Now we need to supercharge that!

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Retrofit at Scale is not a purely technical process, but one which involved interaction and cooperations between government, suppliers and citizens. Maria Elges and Marta Granda Nistal talk about how focusing on user experience can lead to better outcomes and a smoother transition.

Q. Please introduce yourselves and the project

Marta Granda Nistal

I joined Arup two-and-a-half years ago, and now lead Arup's Digital Studio, focusing on strategic and service design. My background is in building architecture, and business and digital innovation. I guess my main concern as an architect was always really trying to understand the impact of design on people's lives, which led me to a slight shift to digital design and leading this team at Arup has enabled me to connect these strands of my past.

The team focuses on applying the user experience (UX) lens in developing strategic and service design methodologies. I'd say over the last two years, our focus has been more and more on sustainability related issues – on the energy transition, on the water crisis, and on climate change mitigation and adaptation – because these are where there are the big questions about how to introduce a people-based perspective.

So the UX Framework Discovery project was an internally-commissioned initiative to explore how human-centred research and design methodologies can support Arup's Retrofit at Scale taskforce.

Maria Elges

I am a UX designer in Marta's team. My background is in strategic design; I joined Arup in 2021 and worked on projects that connected innovation with community engagement and stewardship, for example on water management and sustainable drainage systems.



Marta Granda Nistal

Director, Digital Studio,
and Strategic and User
Experience Design Leader

Arup



Maria Elges

UX Designer,

Arup

Retrofit at Scale

Arup people: **User Experience design to deliver Retrofit at Scale**

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Q. So what were the drivers for the project?

Marta

Maria, Anastasia Vikhornova and I were super determined to make this happen and managed to secure internal funding, with the support of Becci Taylor and Helene Gosden, who lead the Retrofit at Scale Task Force, and co-funded by the Arup's Excellence Agenda.

I think the rationale was that everyone talks about using a 'people' lens, but very often they mean 'how can we convince people to adopt the solutions we think are good for them?' and it's not really about that, it's about something deeper.

One part is understanding the real barriers to action, through understanding what people really care about, and making it easy for them to take the actions needed, but in a way that they feel they are part of the solution. And the other ambition is really thinking more about the people involved. We all have very different factors that impact our lives. And that will have a huge impact on our response when someone knocks on our door offering a solution.

In the report Maria and Anastasia came up with this really good diagram of the different lenses to look at these human landscapes from – people's income, their trust in authorities, their practical needs, their values. It's the combination of all these factors that is going to determine how you should be engaging and bringing them on board, or how likely they are to follow this or that route.

And I guess the whole point was making our Arup colleagues aware of how they could improve their impact even if a project is very technical, by including the people lens – from the way they talk to clients, to how they scope the work, or how they collaborate with others internally.

Maria

The report tried to broaden the idea of who retrofit 'users' are. The user is not only the person whose house is going to be retrofitted, but also the contractor who will deliver the project, and the local authority who will support it. For Arup, the question is 'how can we provide training and support, with our technical expertise and knowledge on people and systems, for all these users?'

We can come up with technical solutions, but how will these solutions actually be used or affect different people, and how will people implement and deliver them, and what kind of challenges will they face? To do that, we need to address team structure. How should teams be structured for Retrofit at Scale projects, so they not only have a range of technical experts – on materials, on glazing, on renewables, on shared electric mobility – but maybe a behavioural science expert or some communication experts in those teams as well.

Q. How big a barrier is user engagement in delivering Retrofit at Scale?

Marta

I would say this is the elephant in the room. It is very difficult for people to engage with retrofit.

Maria

I have to admit that I wasn't really familiar with 'Retrofit at Scale' as a concept at the beginning of this project. That's partly because coming from Germany, good insulation and double glazing is standard. It's not something we look on as a special feature. In my house there, we had underfloor heating since the nineties and the walls were thick. So I'd never thought about houses being cold, but then you go to some places in England and you see people struggling to keep their houses dry, mould-free and well-ventilated. Working on retrofit can be quite traumatic in that sense, because it just feels so unfair. We have the technological solutions, but why is it so hard?

And when you read that the cost of poor housing to the NHS is £1.5-2 billion a year, and that homes in the UK lose

three times more energy than houses in continental Europe, you get the urgency, and the sense that we need to get this done now, and for Arup to make the most of its role as a convenor, bringing together stakeholders to make it happen.

Marta

Another complexity of this topic is that solutions may change depending on the housing type and geography. Following the Retrofit at Scale Discovery we ran another one called Energy Transition & User Experience Discovery, and we interviewed Arup engineers and Energy leaders who were very much into retrofit, who we could consider to be early adopters. They were describing the struggle to actually do the research and find the solutions that worked for them. These were highly aware, values-driven people, and it was taking them years of research to develop the right options and find someone who could deliver the quality they expected; and they are still encountering problems even now because their neighbours don't want to connect.

Potential end-users of domestic retrofit services mentioned in the research so far:



Private Landlord

Owns the property and rents it out at market value.



Tenant Council housing

Tenant pays rent for the building to local council



Tenant Social housing

Tenant pays rent for the building to housing association



Tenant Private Landlord

Tenant pays rent for the building to private landlord



Private Homeowners Leasehold

Owns the property, but not the land it's on, and only for a limited period of time (often in tower blocks)



Private Homeowners Freehold

Owns the property and the land

Retrofit End-User

People whose property and lives are ultimately affected by the retrofit measures = People who receiving retrofit measures = People who are the customer of retrofit

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Q. How could national policy help?

Maria

I think we need to try to shift the political debate a little bit more. One of our internal interviewees said that he's been to Number 10 to meet government advisors many times, but that policies are short term. When governments change and funds being reallocated, strategies don't last long.

Marta

One approach would be top-down, for example requiring landlords to implement certain measures before they let properties. But I am personally more interested in an incentivised bottom-up approach, where you could incentivize people to come together with others in the area where they live, and to work with them to develop local retrofit plans at community level.

So I would say it's a combination of regulation and incentives, learning from some of the experiments taking place in other countries. I'm most familiar with those in Spain, where in Valencia and Barcelona, they've been running 'energy communities' with residents' groups, local authorities, and utility companies working together. And they are running pilot projects, co-created with local people, testing out where small behaviour changes can have a huge impact if adopted across the group.

Something we've really noticed in talking to communities is that people do care about the place they live, and they are willing to work together to shape it, or play much more of an active role. It would be good to see a policy approach that builds on what communities already have – in terms of tangible assets but also social capital.



Q. What were some of the insights that you gained through the Retrofit at Scale Discovery project?

Marta

I think it was the opportunity for people across Arup to sit around a table together, to create a shared vision, or at least share reflections, about the People-related challenges for Retrofit at Scale, and the impact that they could all have on addressing these.

Maria

Maybe this is a little bit provocative, but if we are criticising the policy framework and system for not being aligned, we need to make sure we are aligned too, bringing all the right disciplines and skills together in a truly multi-disciplinary team. As someone who joined Arup recently, it's nice to see the company reflecting on our own practice.

Marta

Arup has always been a multidisciplinary practice, but this means different things for different types of project. So there is a tried and tested combination of disciplines on a construction project where the engineers, the architects, the masterplanners all know their role because it's been done 100 times before. But when we are talking about innovation and addressing complex challenges, there are often multiple stakeholders and multifaceted issues to address. And that calls for a new combination of disciplines and collaborative processes, which is at the heart of what the Transformation & Design Studio team at Arup is addressing.

Maria

And you don't just need different professional disciplines, but also different skill sets. You need to have people who are system thinkers, conveners and storytellers. So alongside the hard technical skills, we also need those soft skills.

Marta

As this thinking has spread through Arup, we are now starting to see more opportunities to collaborate, and we're also seeing clients seeking user experience skills for Retrofit at Scale and other projects.

Part of it is about asking people to change the way they would traditionally go about scoping or delivering work for their clients. But it's also understanding that clients are now asking for something slightly different, and a mix of skills that include technical expertise, but also creative empathic thinking about user experience.



A system-based approach to Retrofit at Scale can help overcome barriers to implementation.

Becci Taylor, Director of Arup's Retrofit at Scale business reflects on the barriers and opportunities for government agencies and local authorities to take action for building our future communities.



Retrofit at Scale

Policy perspective: **Becci Taylor**

Our homes are vitally important to us - as our physical shelters and emotional refuges. They are also important to our planetary health;

We are behind the planned trajectory required to reach 2030 targets, but there's a bigger picture too. Our homes offer the opportunity for decarbonisation to be aligned with wider social value. Healthy housing is a critical foundation for inclusive change - and we ought to value it as such - it can affect our quality of life, productivity and ability to learn.

We need a shared ambition to scale up that leapfrogs political cycles, with national long-term planning backed by locally-led delivery. We have to send supply chain signals that support steep acceleration, that marshal public and private resources. Ireland is a great example of this: the [Sustainable Energy Authority of Ireland](#) is enshrined in law, with strong cross-party support.

Some of the overarching challenges are:

- There is a lack of knowledge and distrust amongst individual householders. We need a narrative and language that showcases the potential and possibilities of retrofit to landlords, owner-occupiers and tenants, talking about everything from thermal comfort to lower bills, to energy and climate security, to climate resilience and health.

- We need a much more programmatic and holistic approach, bringing together repairs and maintenance, decent homes, façade remediation, building safety, and decarbonisation, where at the moment these projects are funded through different policies, different funding streams, different departments.
- We need more experimental and scaleable approaches to delivery, and better integration between homes and infrastructure - for example embracing peer-to-peer electricity sharing, or community smart grids with microgeneration and storage. This is really about a move from building retrofit to place-based transition.
- Finally, financing and funding remains a big challenge. We need to continue to bring costs down, including through innovation in materials and techniques, and scaling up delivery. We know that there is payback in the longer-term and in taking a broad view of value, but we need to think laterally to realise this. How can we find a way to take into account benefits to health and wellbeing in investment cases, and how can we link finances to properties, rather than to individual owners taking the risk, but not reaping all the rewards.

These are some huge challenges, but the opportunities are equally monumental. Opposite we show some suggestions for taking action.

Key action points for government agencies and local authorities



Enabling measures
'One stop shops' can help individual property owners access the skills and the finance that they need. Arup have supported development of several, including in Leeds and Oxford.



Supply chain
Active intervention to build supply chains and ensure the right training is in place to enable installation of new technologies.



Campaigns
To raise awareness of the importance and impact of retrofit, to build trust in the technology and tailor solutions to local needs.



Strategic planning and delivery approach
Develop long term strategic integrated frameworks such as LAEP and LHEES, working collaboratively with the private sector and energy providers to ensure they are deliverable. Create dashboards, portfolio / asset assessments and digital twins to test delivery scenarios.



Property-owner incentives
Stamp Duty rebates to encourage more renovation, or the reintroduction of minimum energy efficiency standards for rental properties.



Planning
Develop local plan policies to support retrofit at scale, with place-specific supplementary guidance for priority areas. Adapt permitted development rights rules to make retrofit easier for property owners and think how these could apply in conservation areas and listed buildings- which will still feel the impact of climate change.



Financing incentives
For banks to decarbonise their mortgage books, and to reflect energy efficiency in the terms of loans.

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Arup's extensive research and practice have touched on every aspect of retrofit, decarbonisation and energy efficiency. The following pages include links to some of our published work in this area.

Further reading

Overview



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Whole-system energy planning: helping local authorities decarbonise their local areas and achieve net zero



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Decarbonising Scotland's building stock through locally-led planning



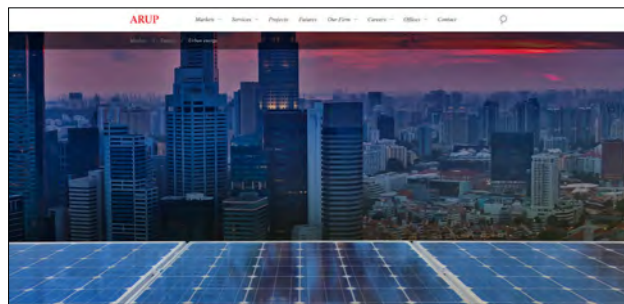
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The race to retrofit UK homes



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The EU Green Deal and building retrofits: making it work for everyone



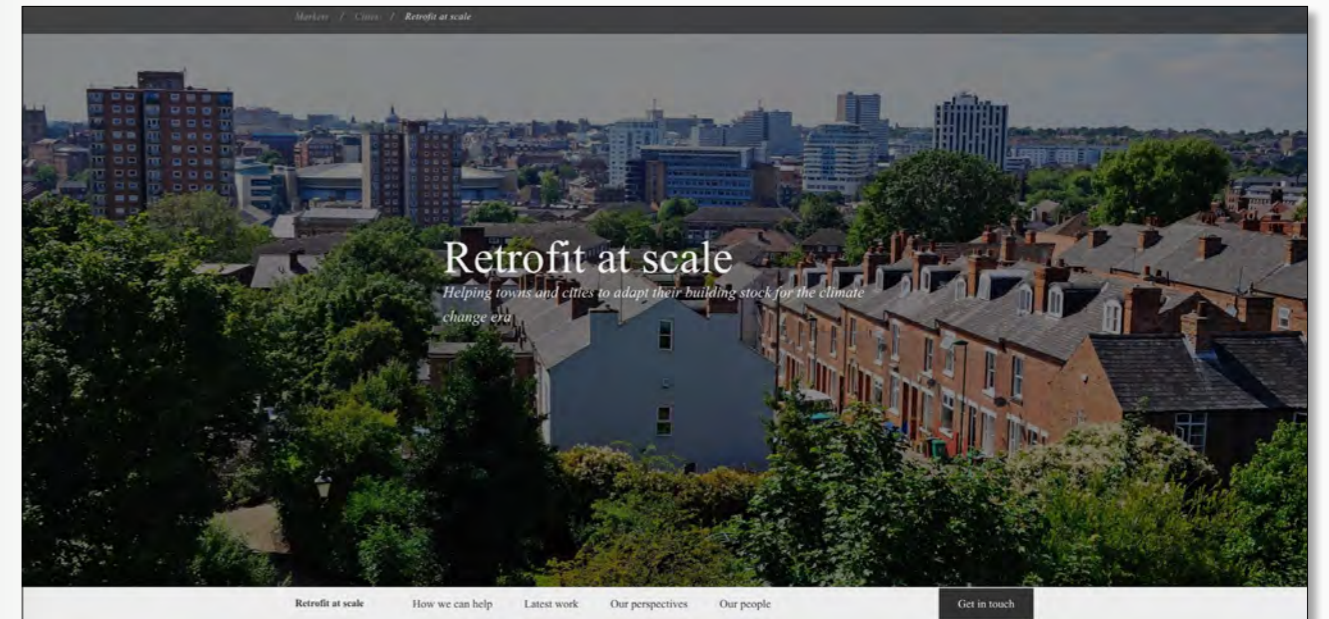
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Urban energy



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How retrofitting homes can also tackle health issues and inequality



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Retrofit at scale: Helping towns and cities to adapt their building stock for the climate change era

Contact the team here:
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Retrofit at Scale
Further reading: **Articles**

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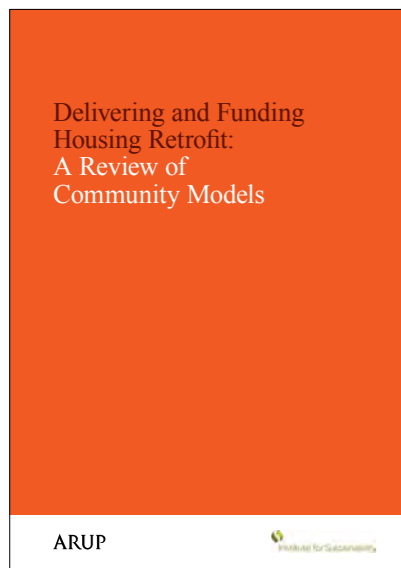
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Green and thriving neighbourhoods



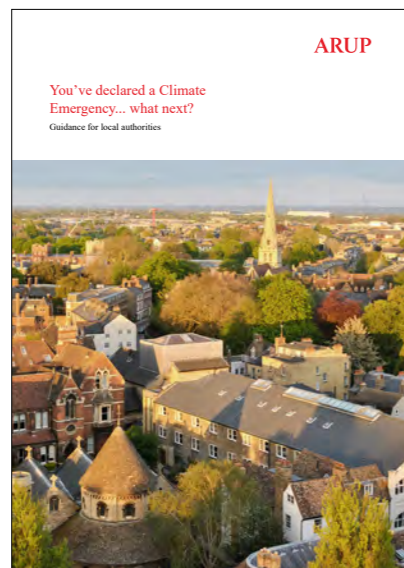
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Addressing overheating risk in existing UK homes



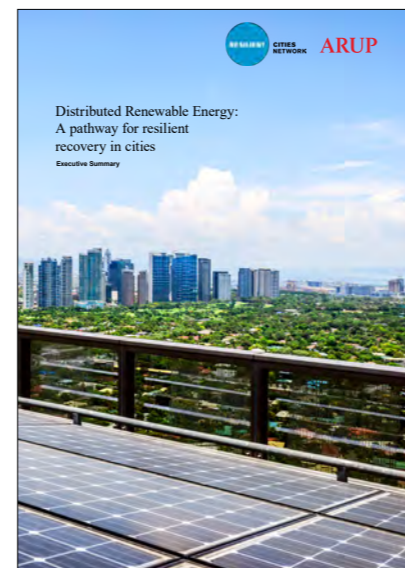
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Delivering and funding housing retrofit



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You've declared a climate emergency...what next? Guidance for local authorities



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Distributed renewable energy: a pathway for resilient recovery in cities



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Transform & Reuse: Low Carbon Futures for Existing Buildings

Retrofit at Scale
Further reading: **Publications**

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