Thought Leadership

Retrofit revolution

Why the world needs one and how we can achieve it

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Executive Summary

Throughout history, improvements in humanity's mastery of building have contributed to rising living standards, helping protect us from the elements (not to mention each other), expand our settlements, and grow our wealth. But, as we outlined in a recent white paper *Rethink, rebuild, reimagine*, today we face a different set of challenges.

Emissions from energy use in existing buildings account for 28% of the global annual total, contributing significantly to climate change, and threatening to disrupt our long-term stability and prosperity. Social challenges posed by high energy costs are resulting in fuel poverty, while poor ventilation in many buildings is causing life-altering health issues like asthma for millions. The old paradigms of mainstream building are no longer up to the task of maintaining and improving living standards in the medium to long term. Retrofitting most of our built environment is therefore one of the most important and pressing measures required to solve this systemic problem. In this report we outline the case for a "retrofit revolution."

Global retrofitting rates need to almost triple

Over 90% of our existing buildings need to be overhauled, equating to an annual retrofit rate of around 3%; currently it languishes at 1%. All countries need to increase retrofitting rates, but action in developed countries, where most of the 2050 building stock is already built, is the most pressing.

This should be one of the easier transition arguments to make. Where some areas of sustainability struggle to gain public support because they demand self-restraint—flying less, eating less meat, throwing less away—retrofitting is an area where environmental needs are aligned with public wants—better thermal comfort, lower energy bills, smarter buildings.

So, what's holding retrofits back?

Retrofitting costs are significant and, in the case of transformative deep retrofits, entail long payback periods of 20–30 years or more. Estimated annual investments of around USD 500bn will be required globally. Accelerating retrofitting rates will require coordinated efforts up and down the value chain to incentivize and cajole building owners into conducting deep retrofits, facilitate the supply chain expansion needed to accommodate those demands, and unlock the financing required to fund the works.

It's not just about emissions

Retrofitting is not just about emissions, but also about reducing the strain on grid infrastructure as we electrify, achieving social aims like reducing fuel poverty, improving health outcomes, and adapting buildings to changing weather patterns.

Shallow retrofitting is worthwhile; deep is better

Where shallow retrofits can result in energy savings of 10–15% in commercial buildings and up to 30% in residential ones, only deep retrofits can achieve transformational energy savings of 40–60% in commercial and 60–90% in residential buildings.

Coordination between stakeholders is critical

Lack of coordination between stakeholders in the retrofit value chain results in fewer, lower quality, more-difficult-to-finance retrofits than need be the case. Grouping individual retrofit projects into single, large propositions, which can then attract institutional finance, forge local retrofit ecosystems, eliminate upfront costs for building owners, achieve co-benefits for the area, and reduce execution times, are a potentially important vector for accelerating retrofitting rates.

A degree of caution is required

A badly thought-out or poorly executed retrofit can be worse than no retrofit at all, resulting in potential overheating, poor air quality, or carbon lock-in. Similarly, a retrofit on a poorly maintained, damp building may fail, expending money and embodied carbon for little return. An emphasis on planning, sequencing, and proper maintenance from the start of the retrofitting process, facilitated by centralized data repositories (e.g., building passports), can help minimize these risks.

Seven essential steps

There are no neat solutions, but the seven steps we have outlined in this report (such as, aligning incentives, improving data quality, unlocking financing, and refocusing regulation) are designed to target individual, and in some cases multiple phases in the retrofit process, and facilitate best practices by relevant stakeholders.

Find more insights in our latest white paper:
"Rethink, rebuild, reimagine—Laying the foundation for better buildings".

www.ubs.com/better-buildings

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1. The case for retrofitting

At a glance

- The existing building stock is mostly energy inefficient, and adversely impacts the health and comfort of inhabitants, leading to costly medical, social, and economic outcomes.
- Retrofitted buildings that are better insulated, better ventilated, and smarter, reduce emissions and the strain on grids as the economy electrifies, while improving health outcomes.
- There is no one-size-fits-all approach, but benefits can accrue from a combination of: minimizing energy use and unwanted heat loss or gain; optimizing ventilation; and maximizing onsite renewable power generation.

1.1. Why the world needs a retrofit revolution

Humanity's mastery of construction—achieving dwellings and non-domestic buildings with sufficient energy, light, heating, cooling, and other facilities to meet human needs—has also helped to sow the seeds of its potential regression. Emissions from ongoing construction and existing buildings account for 37% of the global annual total,[1] contributing significantly to climate change, which threatens to disrupt our long-term stability and prosperity. It is an example of what historian Ian Morris calls "the paradox of social development."[2]

The old paradigms of mainstream building are no longer up to the task of maintaining and improving living standards in the medium to long term. Retrofitting most of our built environment is therefore one of the most important and pressing measures required to solve this systemic problem. Following our White Paper "*Rethink, rebuild, reimagine*,"[3] which laid out the importance of better buildings, here we outline the case for a retrofit revolution and what this entails in practice.

Meeting emissions targets

More than 90%[4] of the world's buildings are out of line with Net Zero emissions targets, i.e., they use more energy and emit more greenhouse gases than is compatible with meeting the Paris climate goals. This is a major global issue—the operational emissions from our use of existing buildings account for 28% of the annual global total.[5] It cuts across all stakeholders, from developed to

[1] UNEP; Global Alliance for Building and Construction (2022), *Global Status Report for Buildings and Construction*, P42.
[2] Morris, I., (2010), *Why the West Rules for Now: The patterns of history and what they reveal about the future*, P329.
[3] UBS, (2023), *Rethink, Rebuild, Reimagine.*
[4] International Energy Agency (2021), *Net Zero by 2050: A Roadmap for the global energy sector*, P141.
[5] UNEP; Global Alliance for Building and Construction (2022), *Global Status Report for Buildings and Construction*, P42.

emerging markets (Interviews 1 and 2), from governments with national emissions targets, to corporates with targets for their own operations and those of their portfolios, to financial institutions with targets for their own buildings and those they finance. In a world that is rapidly warming due to anthropogenic emissions, meeting these targets will require upgrading a large majority of the existing building stock.

Reducing new construction

Deep retrofits can extend the lifetimes of existing buildings, reducing the need for new construction. This is critical from an environmental perspective because new construction typically leads to far higher embodied emissions (those given off in producing and transporting the new building's materials) than retrofitting a similar existing building. On a whole-life carbon basis, the emissions savings of retrofitting versus new construction of similar buildings are estimated by Larry Strain, board member of the Carbon Leadership Forum, at 50–75%.[6]

Managing transition risks for building owners

Making our building stock fit for a Net Zero world is not just an environmental imperative but a financial one, too. Buildings make up over 30% of investable real assets.[7] The scale of retrofitting required to avoid unacceptable environmental damage will affect, directly or indirectly, nearly all professional investment portfolios and most homeowners. Rising regulatory standards like Local Law 97 (LL97) in New York, the Minimum Energy Efficiency Standard (MEES) in the UK, or the General Code for Building Energy Efficiency and Renewable Energy Utilization in China, are increasingly likely to impose penalties on owners of inefficient buildings, impacting the value of these assets.

Meeting social goals and adapting to climate change

Retrofitting is also a major opportunity to improve people's living standards and health outcomes. High energy costs hit the poor hardest, causing "fuel poverty", a term used in the UK to describe the impact on a household spending more than 10% of its income on heating.[8] The recent spike in energy prices concentrated attention on the high energy requirements of inefficient buildings versus their more efficient counterparts. A home retrofitted to the Passivhaus standard can reduce its heating requirement by up to 90% versus a conventional home,[9] reducing residents' exposure to volatile energy prices. "Leaky"—poorly insulated or maladapted buildings—are also bad for our health, an estimated 5.1 million deaths a year globally are associated with excessively hot or cold temperatures, 9.4% of total deaths.[10,11] As the world warms, retrofitting will become increasingly important to adapt to increasing incidences of extreme weather, like heat waves. Poor ventilation also leaves people exposed to various airborne pathogens caused by pollution, mold, and damp. In 2015 it was estimated that, in the US alone, mold and damp were responsible for over 4.6 million of the 22 million cases of asthma, resulting in annual health costs of USD 3.5bn.[12]

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[6] Strain, L., (2017). *Time Value of Carbon, Carbon Leadership Forum*, University of Washington, P6.
[7] McKinsey Global Institute (2021), *The rise and rise of the global balance sheet: How productively are we using our wealth?* Dwellings and non-residential buildings were 31% of global real assets in 2020.
[8] National Energy Action, (2021), What is fuel poverty?
[9] Passivhaus Trust, (2021), *Passivhaus Benefits*, P19.
[10] Brown, P., (2022), *Human Deaths from Hot and Cold Temperatures and Implications for Climate Change*, The Breakthrough Institute.
[11] Zhao, Q. et al., (2021), *Global, regional, and national burden of mortality associated with non-optimal ambient temperatures from 2000 to 2019*, The Lancet.
[12] Cox-Ganser, J. M., (2015), *Indoor dampness and mould health effects – Ongoing questions on microbial exposures and allergic versus nonallergic mechanisms*, National Library of Medicine.

Easing the strain on power grids

Retrofitting to reduce thermal losses is crucial to ease the strain on electricity grids as we electrify the economy. A substantial reduction in overall energy needs reduces peak demand on the grid and in turn the amount of infrastructure upgrades required. It also creates more options for buildings to act as thermal batteries—i.e., at times of high electricity use, a building could be rewarded for not making demands on the system and just using its residual heat, which will last longer if it is better insulated, draft-proofed, and includes materials with higher thermal mass (i.e., that store more heat) like sand infills or concrete slabs. Other forms of demand management or load shifting will also be important to spread the demands on the grid. Installing smart systems can facilitate dynamic time-of-use tariffs, whereby users are rewarded for using electricity at times of low demand, contributing to lower peak load on the grid and lower prices for consumers.[13]

Boosting urban greenery, biodiversity, and flood resilience

Towns and cities typically become less green as they densify, with a 10% increase in urban density associated with a 2.9% reduction in tree cover.[14] This comes at a cost—the benefits of urban greenery are well documented, including boosting biodiversity, improving mental wellbeing,[15] improving climate adaptation by countering urban heat island effects, and reducing flood risks via water run-off absorbance (i.e., sustainable drainage systems).[16] A retrofitting revolution is a chance to path-correct urban areas with, for example, the addition of green roofs. It should, however, be noted that it is not always practical to include greenery in building plans and feasibility will vary widely from building to building.

[13] Freier, J. and von Loessl, V., (2022), *Dynamic electricity tariffs: Designing reasonable pricing schemes for private households*, Energy Economics.
[14] McDonald, R. et al., (2023), *Denser and greener cities: Green interventions to achieve both urban density and nature*, People and Nature.
[15] Bratman G. N. et al., (2019), *Nature and mental health: An ecosystem service perspective*, Science Advances.
[16] McDonald, R. et al., (2023), *Denser and greener cities: Green interventions to achieve both urban density and nature*, People and Nature.

Interview 1: Retrofitting in India—Tarun Garg, Rocky Mountain Institute India (RMI India)

Retrofitting is still at a very nascent stage in India—there is more emphasis on adding to the building stock through new building, because 60% of our 2040 building stock is yet to be built, rather than deep retrofits to decarbonize the existing building stock.

What are the key retrofit priorities in India?
Cooling is more important than heating. Passive measures are more important than active [i.e. measures that do not consume energy]. And shallow retrofits are favored over deep, due to the complexity and cost of the latter.

What are the key retrofit measures for achieving these priorities?
Key measures differ between residential and commercial. 40%-60% of home energy consumption in India is from cooling—10-20% from air-con, which is only in 9% of Indian homes, and 40% from ceiling fans, which are in almost every home—so replacing these with more efficient units where possible is important. Least-cost measures, like switching lights to low energy LEDs and painting roofs white to reflect the sun are more important than building fabric improvements.

In commercial buildings building fabric measures are more important, roof improvements, replacing single-glazed windows is more likely, but there are very few opportunities for changing the building envelope and structure. Replacing appliances, central building chillers, installing automation and energy management systems are key measures in the commercial space.

How are these affected by constraints like credit availability?
Five years ago, credit availability was a huge issue, but I don't think credit availability is the main issue now. There are a lot of credit schemes available—for example, the State Bank of India recently launched a $277m credit line for energy efficient homes in India.

What are the biggest obstacles to retrofitting in India?
We need to create awareness among consumers and building owners of the benefits of the technology; we need to improve confidence that retrofitting is worthwhile; and we need to improve the financial cost-benefit on replacing appliances, because currently people just see the up-front cost. We also need to develop a Measurement & Verification (M&V) protocol to instill confidence for the uptake of retrofitting measures in buildings.

What should key stakeholders like government, finance, and development organizations do to accelerate retrofitting rates?
Government and other stakeholders need more information. M&V frameworks can help to build confidence, education programs can help with awareness. Organizations like RMI can help design and roll out such programs. It's also important for us to message it correctly. If you start talking about energy as 10-15% of operational expense rather than framing it as a climate change issue, that is likely to encourage retrofit take-up more effectively.

The up-front costs of replacing appliances could be addressed via buy-back offers. A tie-up with utilities to roll out such schemes could be useful.

Carbon markets are currently being designed in India—a program could be designed around off-setting ceiling fans in schools and public buildings, with the offset cost being shared with consumers, investors, and other stakeholders to spread the initial cost burden.

Interview 2: Commercial Retrofitting in China—Tom Chueng, Arup

What were the key goals in retrofitting in retrofitting Link Plaza Guangzhou?
Link Plaza Guangzhou is a shopping mall nearby the Machang area, which began operation in 2012. Total GFA is around 140,000m^2. The retrofitting goals are to: update and upgrade design in order to attract more consumer groups; introduce new industry technologies to optimize the original commercial area; increase the commercial leasing area and improve the commercial space ratio; and achieve LEED Platinum, Parksmart Pioneer, WELL and other green building certifications as per the ESG requirements of the company.

What were the main challenges you faced?
Firstly, the project needs to be implemented while the building is operating, because part of the funds for this retrofit comes from the continuous operation of the shopping mall. Secondly, to strengthen the offline experience the retrofit has introduced a new Food & Beverage area of 3,200m^2, which required associated load capacities like power supply to be increased significantly. Thirdly, updating the 12-year-old mall to follow the latest codes, regulations, and new operation requirements.

How did you minimize disruption?
The retrofit is divided into two phases in order to maintain partial operation of the mall while retrofitting another part. Flexible adjustments to reflect changes in the market business environment, to allow the types of shops to benefit the leasing as much as possible.

What lessons did you learn from the project?
Firstly, the biggest difference between a retrofitting project and a new construction project is the estimation of construction costs. The retrofitting project should reserve demolition fees, temporary containment measure fees, special machinery and equipment construction fees, night construction fees, etc. which should be clearly defined in the contract with the contractor when the project is tendering.

Secondly, the operating stops may be affected during retrofit. When an impact is caused, the property management team needs to respond in time and make compensation, so the site investigation and risk assessment before the construction need to be more complicated than that of the new project.

Are there specific issues that need to be taken into consideration when retrofitting in China?
With the rapid development of China, its codes are frequently updated. Assessing the impact of new and old codes and standards on fire installation and how to ensure the fire safety of buildings are essential to the project.

What are the tangible benefits of retrofitting in the corresponding project ?

We have so far seen more than 60 new brands signed to the mall, and the overall rental rate has increased to 95%. After upgrade, more energy-saving designs will have been adopted, such as water-saving appliances, LED energy-saving lamps, frequency conversion air-conditioning equipment, and energy-saving radar induction lamps in the parking etc., which can further reduce the energy consumption of the building operation. Preliminary evaluations suggest the project will have 35% of the energy consumption of regular comparable buildings.

2. Catalyzing a retrofit revolution

At a glance

- Retrofitting is held back by several factors including uncertainty over its rewards, upfront capital intensity, long payback periods, tax treatment, supply chain issues, data inadequacy, and regulatory gaps.
- We outline seven steps which we believe are essential to achieving retrofitting at scale.

2.1. What is holding the retrofit revolution back?

Despite the environmental, social, and economic case for retrofitting, current rates languish at just 1% of the global building stock per year, [17] about a third of the roughly 3% required to keep the 1.5 ⁰C warming target within reach.[18, 19] There are various factors holding back both the demand for retrofits by building owners and the supply and quality of the retrofits themselves.

Financial constraints

- **Uncertainty regarding return on investment:** An estimated investment of USD 500bn per year will be needed globally through 2050 to bring buildings in line with Net Zero priorities.[20] One of the largest obstacles, particularly to deep retrofitting, is insufficient clarity on the rewards for building owners and stakeholders. While there is a growing body of evidence about the existence of a green building premium in some geographies, along with a non-green building discount, there is still significant uncertainty over their size and whether money spent on deep retrofit will have a sufficient return on investment—in price appreciation, rent increase, or penalty avoided terms—to justify the cost of the works or the time the building may have to be vacated and therefore non-revenue generating.[21, 22, 23, 24]
- **Upfront capital intensity:** Retrofitting is typically thought to be one of the lowest-cost emissions abatement options available,[25] but it is also one of the most capital intensive.[26] Such upfront costs pose challenges for all types of building owners but particularly those with the lowest levels of

[17] JLL, (2022), *Retrofitting Buildings to be Future Fit*, P2.
[18] IEA (2023), Net Zero Roadmap: *A Global Pathway to Keep the 1.5 °C Goal in Reach (2023 update)*, P120.
[19] JLL, (2022), *Retrofitting Buildings to be Future Fit*, P2.
[20] Energy Transitions Commission (2023), *Financing the Transition: How to make the money flow for a Net-Zero Economy*, P7.
[21] UBS, (2023), *Rethink, Rebuild, Reimagine*, P14.
[22] Santander, (2022), *Buying into the Green Homes Revolution*, P14.
[23] JLL, (2022), *Return on Sustainability: How the "Value of Green" Conversation is Growing Up*, P5.
[24] LaSalle, (2023), *What is the value of green?* P7-8.
[25] McKinsey & Co., (2009), *Pathways to a Low-Carbon Economy Version 2*, P7.
[26] Ibid, P18.

savings and highest credit risk profiles, like homeowners in poorer areas. A 2022 South African study found that upfront costs and the cost of maintenance were the most frequently mentioned factors regarding whether householders retrofit their home, according to industry participants, cited by 35% of them.[27]

- **Long payback periods:** Payback periods—the time it takes retrofit measures to pay back their cost via reduced energy bills—are not static and vary depending on the cost of materials, appliances, labor, energy, and carbon. But broadly speaking, while shallow retrofit measures can have short payback periods of just a few years, deep retrofit measures, like window replacements, typically have much longer payback periods of 20–30 years,[28] significantly reducing their attractiveness to owner-occupiers and investors, the latter of whom typically assume hold periods of around 10 years (although in practice this is often longer).
- **High cost-to-value ratios:** In areas of lower property values, the ratio of retrofitting cost to the value of a home or commercial building can be significantly higher. This reduces the likelihood of the retrofit increasing the value of the property by enough to cover the cost of the investment. Moreover, this can also have consequences for loan decisions, making the business case for the lender to fund retrofits in those areas less attractive.
- **Less favorable tax treatment than new construction:** Tax incentives are sometimes skewed in favor of new buildings over improving existing ones. For example, in the US, until this year, to take advantage of the tax credit for installing energy efficiency measures, a building had to be 50% more efficient than the minimum ASHRAE standard.[29] But while this was achievable for new construction, for existing buildings it was often out of reach.[30]

Supply constraints

- **Supply chain fragmentation and skills shortages:** An international review of domestic retrofit supply chains found that they are often highly fragmented, with work typically being done by separate contractors. This acts as a drag both on quality, due to the lack of overall coordination and quality control,[31] and on the rate of retrofitting.[32] More industry coordination is part of the solution, but there is additionally a shortage of labor with the needed training to efficiently deliver retrofits.[33]
- **Expertise gaps:** Even among those with training, there may be issues dealing with certain building types, particularly older buildings, as training tends to focus on modern materials and techniques (Interview 3). Especially in developed markets where the average building age is older,[34] this can hinder the number and quality of retrofits carried out.
- **Data inadequacy:** For most buildings, the data available are either limited (energy bills) or arguably questionable. For example, EPCs focus on the modeled cost of heating a building, not on the actual amount of energy required. [35] Switching from a gas boiler to a heat pump, despite improving performance from an emissions perspective, can worsen a building's EPC rating, as electricity is typically more expensive than the equivalent amount of gas. As a result, there is a lack

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[27] Amoah, C. and Smith, J., (2022), *Barriers to the green retrofitting of existing residential buildings*, Green Retrofitting, P9.
[28] Jafari, A., (2017), *Sustainable impact of building energy retrofit measures*, Journal of Green Building, P78.
[29] The American Society of Heating, Refrigerating and Air Conditioning Engineers.
[30] USGBC, (2022), *Improved 179D tax incentive addresses the challenge of existing buildings.*
[31] UK Government, (2021), *International review of domestic retrofit supply chains*, P10.
[32] Brown, D. et al., (2019), *How can intermediaries promote business model innovation: The case of 'Energiesprong' Whole-House Retrofits in the United Kingdom and the Netherlands*, P11.
[33] UK Government, (2021), International review of domestic retrofit supply chains, P34.
[34] Daniell, J.E. et al., (2014), A worldwide seismic code index, country-by-country global building practice factor and socioeconomic vulnerability indices for use in earthquake loss estimation, P7.
[35] Meles, T. H. et al., (2023), How well do building energy performance certificates predict heat loss? Energy Efficiency.

of clarity of the actual performance of individual buildings in terms of energy consumption, comfort, and health outcomes, and thus a lack of clarity on what an optimal retrofit should entail and what it would cost.

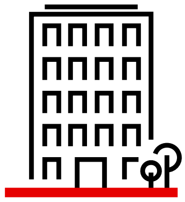
Demand constraints

- **Under-appreciation of non-energy, non-financial benefits:** Social scientists suggest that aesthetics, better health outcomes, and increased comfort levels could be just as, if not more motivating, than lower energy bills or higher property values.[36, 37] However, the level of awareness of such benefits has typically been too low, hindering retrofit demand.[38] Greater understanding (and quantification) is also needed of the health benefits of building retrofits at the macro level to determine what additional public and private resources might be justified to encourage retrofits.
- **Split incentives between tenants and landlords:** Depending on the tenancy agreement, tenants can often enjoy the lower energy bills and improved building experience associated with a retrofit, while the building owners are faced with upfront costs and rents which may not increase sufficiently to reward the investment.[39]
- **Regulatory gaps:** In most cases, regulations are not at the point of mandating retrofitting. But even where building-efficiency regulations are tightening, exemptions intended to avoid imposing excessive expense burdens on building owners mean that regulations are likely to be less impactful than they might first appear. The UK for example has a payback period exemption[40] for its MEES—if the payback period of bringing a non-domestic building in line with rising MEES requirements is greater than 7 years then the building is exempt from the regulation. But given that deep retrofit payback periods are typically 20 years or more (Table 1), there is a potential mismatch between the regulatory driver and the practical reality. Over time, it may be necessary to narrow and eventually phase out such mismatches to achieve Net Zero goals and avoid undermining the effectiveness of the regulation.
- **Inconvenience:** All building works entail some level of disruption, and a deep retrofit involving changes to the building fabric might require the occupants to move out completely while the works take place. The drag this can have on retrofit rates should not be underestimated. In 2012 Affinity Sutton, a large social housing landlord in the UK, offered residents free retrofit packages ranging in value from GBP 6,500 to GBP 25,000. Refusal rates were over 50%, with inconvenience and disruption the most common reasons cited.[41]

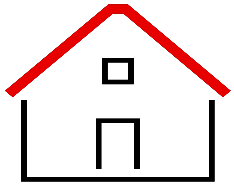
[36] Mogensen, D. and Gram-Hanssen, K., (2023), *Why do people (not) energy renovate their homes? Insights from qualitative interviews with Danish homeowners*, Energy Efficiency.
[37] Pettifor, H. et al., (2015), *The appeal of the green deal: Empirical evidence for the influence of energy efficiency policy on renovating homeowners*, Energy Policy.
[38] Brocklehurst, F. et al., (2021). *Domestic retrofit supply chain initiatives and business innovations: an international review*. Buildings and Cities, P538.
[39] Galvin, R., (2023), *Do housing rental and sales markets incentivize energy-efficient retrofitting of western Germany's post-war apartments? Challenges for property owners, tenants, and policymakers*, Energy Efficiency.
[40] UK Government, (2019), *Guidance on PRS exemptions and Exemptions Register evidence requirements.*
[41] Brown, P., (2014), *Retrofitting social housing: Reflections by tenants on adopting and living with retrofit technology*, Energy Efficiency.

Table 1: The key attributes of archetypical retrofits

The practical goals of retrofitting are: minimizing energy use, minimizing unwanted heat loss or gain, optimizing ventilation; and, where possible, maximizing onsite generation. In practice, however, retrofits will differ depending on depth and building type



Commercial (office)



Residential (single home)

		Commercial (office) Shallow	Commercial (office) Deep	Residential (single home) Shallow	Residential (single home) Deep
What the retrofit may typically entail	Planning	Survey building; determine which appliances should be replaced and systems optimized to increase efficiency	Survey building; plan whole-building retrofit; determine sequencing	Survey building; determine appliances to replaced; whether roof insulation can be installed	Survey building; plan whole-building retrofit; determine sequencing
Implementation	Minimize energy demand	Upgrades to single building elements (e.g. low energy lights);	Likely includes all the shallow retrofit measures	Upgrades to single building elements (e.g. low energy lights);	Insulation of walls (external being more effective than internal), floor and roof
	Minimize unwanted heat loss /gain	Basic remodeling/ replacement	Substructure upgrades (floors and retaining walls)	Roof insulation or passive cooling measures where appropriate	Replacement windows
		Performance optimization (e.g. smart building controls)	Superstructure upgrades (facade, roof elements)	Simple draft proofing	Seal building envelope while upgrading ventilation to avoid damp
	Optimize ventilation	Replacement of old appliances with more efficient options	Central MEP Upgrades	Replacement of old appliances with more efficient options	Upgrade systems e.g. switch out fossil boiler for a heat pump
	Source green energy	Packaged mechanical, electrical and plumbing (MEP) upgrades;	Onsite green energy	Smart systems for minimizing energy use, especially at peak times	Add onsite renewables + energy storage
	Level of disruption	Carried out when building is still operational	Requires building occupants to vacate.	Carried out while occupants remain in place	Likely requires building occupants to vacate
Typical final energy saving		10-15%	40-60%	30%	60-90%
Time		6-12 months	Minimum 1 year (highly variable)	Days or weeks	6-12 weeks if in one project 3-5 years if phased
Typical economic payback*		2-3 years	20+ years	2-3 years	20-30 years
Extends lifetime of building		No	Yes	No	Yes

*Economic payback period is highly dependent on energy and retrofit costs, neither of which are static, so these figures should be considered indicative only.
Note: MEP = Mechanical, electrical, and plumbing upgrades.
Sources: JLL,[42] LETI,[43] UKGBC,[44] Passivhaus Trust,[45] Climate Policy,[46] Energy Efficiency,[47] US Department of Energy,[48] UBS

[42] JLL, (2022), *Retrofitting Buildings to be Future-Fit*, P9.
[43] LETI, (2021), *Climate Emergency Retrofit Guide*, P28.
[44] UKGBC, (2022), *Delivering Net Zero: Key Considerations for Commercial Retrofits.*
[45] Passivhaus Trust, (2021), *Passivhaus Benefits*, P19.
[46] Yu, Z., Geng, Y., He, Q. et al., (2021), *Supportive governance for city-scale low carbon building retrofits: A case study from Shanghai*, Climate Policy.
[47] Bleyl, J.W. et al., (2018*), Office building deep energy retrofit*, Energy Efficiency.
[48] US Department of Energy, (2017), *The Ultimate Retrofit: Zero Energy Homes*, P23.

Interview 3: Historic houses, modern problems—Morwenna Slade, Head of Historic Building Climate Change Adaptation at Historic England

In Europe, 26% of the building stock was built before 1945, using various technologies, techniques, and materials that are no longer in use.[49] What significance does this have for our ability to retrofit these buildings?
Retrofitting is complex regardless of the age of the building, but with older and listed buildings, success lies in the use of compatible materials, understanding the way the building performs, and what makes it culturally significant. While certain aesthetic features may need to be retained, there is also a significant construction and professional skills shortage, which makes the process challenging in terms of design and delivery. The condition of the building is fundamental to the likelihood of sustained improvements in energy performance, and poorly maintained buildings increases the possibility of retrofit failure.

Should we be avoiding retrofitting older buildings?
It's perfectly possible to retrofit an old or listed building. The listing status doesn't change the building physics; all buildings can be improved and often the vast knowledge about listed buildings, materials, historic systems, and services can help identify opportunities for positive change. In the UK, 25% of the domestic building stock is traditional construction (solid wall), but the number of listed buildings is far less. Buildings of all ages should be retrofitted to achieve long-term success and we need to develop the skills, training, and supply chains to deliver this.

How big a problem is retrofit failure?
We have seen significant failures in retrofit both in large programs and individual projects, but there is also a wide range of successful projects that provide the basis of improved approaches to different construction types. We are learning from them. We need an open, honest discussion about failure that does not point fingers at certain groups, but learns, shares, and moves forward to improve our assessment, design, and delivery. Failure can be the result of mistakes in installation due to lack of training or poor maintenance before or after the retrofit.

What are some of the solutions?
We need more training-supported approaches to maintenance (which requires education for those who can pay and grants to those who can't) and better data. The negative "drafty, leaky old buildings" narrative needs to be challenged to demonstrate the positive and sustainable contribution our existing buildings can make. The whole house approach is a fundamental part of how we move forward with any retrofit plan and "building passports" [a log of the work done to enable transparency and information flow required to optimize a phased approach][50] have a central role to play. Ongoing performance-based assessment of retrofits is needed to continue to improve—how long does it last, what maintenance is required, and what is the performance as materials and services reach the end of their lifespan. Developing those datasets is important to understand and improve retrofitting going forward because every retrofit that doesn't last and must be redone is more waste and embodied carbon that has to be made up elsewhere.

[49] Posani, M. et al., (2021), Retrofitting historic walls; Feasibility of thermal insulation and suitability of thermal mortars, Heritage
[50] See Section 3 for a fuller discussion.

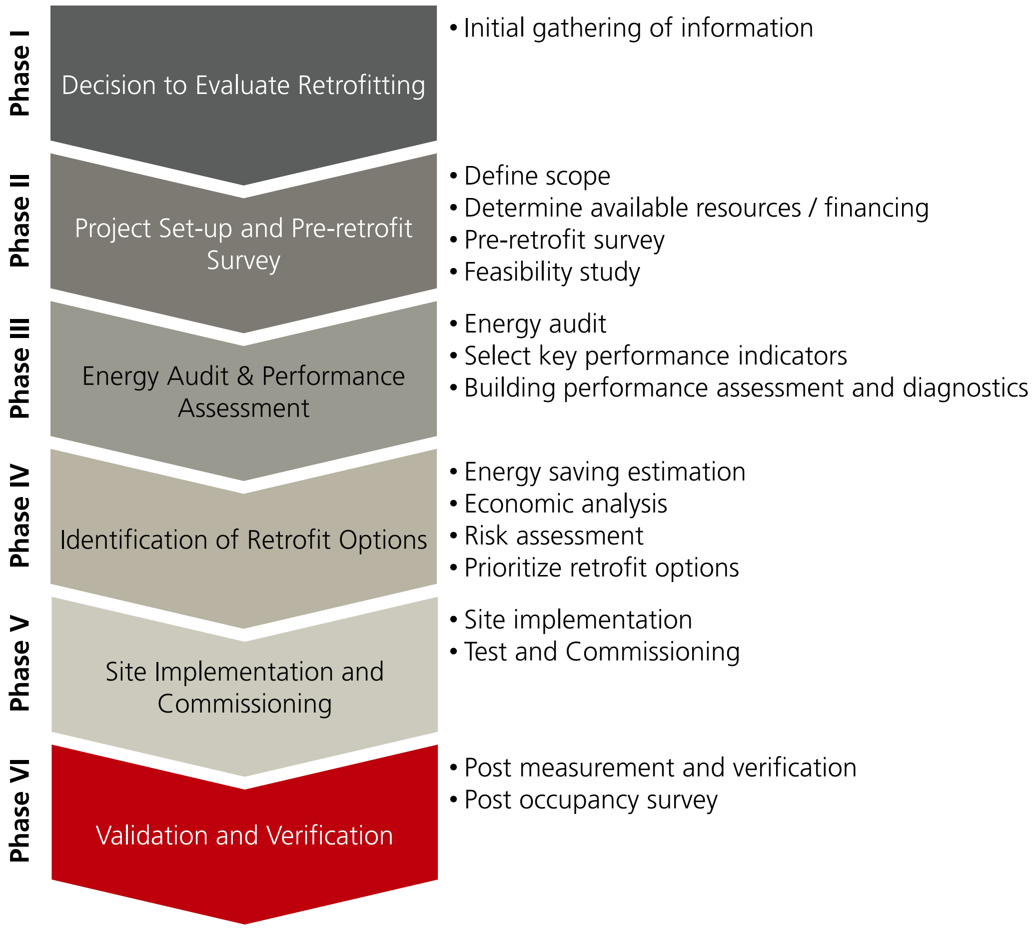
2.2. Seven steps to scale the retrofit revolution

There are many reasons to retrofit, with differing consequences for how we go about it. If reducing emissions were the only goal, we might want to cover the attractive but uninsulated facades of old buildings with external insulation, but this would have social costs—the beauty of our built environment can have a significant impact on people's mental and even physical health.[51] Eroding it would also be likely to undermine public support for broader sustainability goals. Like all issues that cut across environmental, social, governance, and financial lines, there is a balance to be struck, both in terms of how, where, and what we decide to retrofit, and how we go about making it happen and paying for it.

A retrofit is a product of decisions by multiple stakeholders and beneficiaries. There are various phases between a retrofit first being considered and finally being implemented. These can differ in intensity, order, and importance in different settings, and for different building ownership structures, which bring with them varying decision-making processes.

Figure 1 describes the most common phases for an institutional ownership structure, whereas private retrofits mostly have similar but less detailed phases. Each phase offers opportunities for optimization as well as potential stumbling blocks.

Figure 1: Key Phases of Sustainable Building Retrofit Delivery



Sources: Journal of Green Building,[52] UBS

[51] Lavdas, A. A. and Salingaros, N. A., (2022), Architectural beauty: Developing a measurable and objective scale, MDPI.
[52] Luther, M. and Rajagopalan, P., (2014), *Defining and developing an energy retrofitting approach*, Journal of Green Building, P155.

We identify seven steps which we believe are most likely to facilitate a retrofit revolution by facilitating one or several of these phases. We also look at where the benefits of retrofitting accrue, and what that might mean for attempts to scale up retrofitting by grouping projects together to increase efficiencies, lower costs, and unlock finance.

1) **Improve data gathering and transparency:** Ideally, we should understand the history and current performance of every building, residential and commercial. Building history could be detailed in the form of "passports", listing materials, construction methods and improvements that have been done. Current performance could be measured by sensors assessing things like temperature, energy use, air quality, and moisture content. Where such data are produced, they are often spread across different systems in hard to compare formats.[53] Gathering and analyzing these data more efficiently and in an ongoing way could improve building usage, alerting occupants (and owners) if something in the building needs attention (a burst pipe, an upstairs window left open, etc.) or to highlight low-hanging fruit for retrofit.

   Data gathering is a major first step for owners, especially institutional investors looking for efficiencies. It also enables the assembling of large databases, helping governments make more effective retrofit policy and target help and subsidies at the buildings where retrofits are likely to achieve the highest impact. Another advantage is the ability to better track phased retrofits and their impact.

   One reason for poor or missing documentation in building renovations is that they may trigger a tax reassessment. In the shorter term, a tax reassessment amnesty or waiver for building renovations envisioned as part of a proposal to reduce emissions or improve ventilation, etc. could improve information flow. A requirement to monitor and declare undesirable aspects of a building like poor air quality to prospective tenants could also incentivize remedial action.

   Example: Building passports (Section 3).

2) **Improve understanding of retrofitting benefits; reduce upfront costs:** The potential benefits of retrofitting go far beyond energy efficiency.[54] But so far efforts to quantify these at the technical level are hindered by limited data and research. Better technical understanding should also help drive understanding up and down the value chain, e.g., via education programs, helping to stimulate retrofit demand and financing in both the commercial and residential sectors. The US Department of Energy's Weatherization Assistance Program, which directs educational, technical, and financial assistance toward low-income households, to implement energy-efficient home upgrades, is a step in the right direction, albeit modest in scale.[55]

   Many building owners have limited understanding of what their buildings need from a retrofit perspective or how much it will cost. Typically, before embarking on a retrofit in either the residential or commercial space, a pre-retrofit survey should take place, at the expense of the building owner. These kinds of upfront costs incurred in advance of receiving financing are specified as a key barrier to retrofitting in the EU's Renovation Wave stakeholder consultation.[56] Given the right information, these needs, potential benefits, and project costs can be modeled, thereby streamlining the process, reducing upfront costs, and giving asset owners a better

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[54] Baniassadi, A. et al., (2022), *Co-benefits of energy efficiency in residential buildings*, Energy.
[55] Mann, R. and Schuetz, J., (2022), *The US needs better, more accessible home weatherization programs*, Brookings Institute.
[56] European Commission, (2020), *Stakeholder Consultation on the Renovation Wave Initiative*, P8.

understanding of the retrofit potential of their portfolios and where resources can be most efficiently targeted.

Example: UBS planned project (Box 2).

Box 2: UBS real estate decarbonization analytics joint project

UBS is exploring, with a third party, an analytic solution to accelerate decarbonization of the built environment. Using software platforms and services, the solution intends to help real estate developers, investors, and building portfolio owners to proactively screen portfolios for carbon-related risks, as a result of sustainable finance regulations and market demand. It would provide technical and economic assessment of assets at risk and a clear prioritization of carbon mitigation measures to reduce risks of devaluation and identify potential mitigation actions.

The aim is threefold:

- Quick transition assessments for clients with real asset portfolios across different business portfolios, thus reducing investment and decision-making frictions and accelerating the prioritization and allocation of transition finance;
- Improving the understanding of building portfolios, their performance, and retrofit potential; and
- Assisting with the formulation of credible science- and engineering-based transition plans.

The tool would be designed to answer the following questions:

- How can an asset and portfolio achieve 50% emission reduction by 2030 and Net Zero by 2050?
- What technological emission reduction measures are most efficient to implement?
- At what cost, return on investment, timeframe, and what carbon abatement potential?
- Which assets should be prioritized for retrofitting?

3) **Align incentives for building owners:** Governments can encourage retrofitting by offering a "carrot" (green-premium) and "stick" (discount).

   a. **Reward retrofits:** Retrofitted buildings should be more desirable to own than their non-retrofitted counterparts. This means providing certainty to building owners around the green building premium, either via tax credits, allowing higher rent increases to reflect the costs of improvements, or other incentives such as favorable planning exceptions for green upgrades (e.g., allowing extra floors in a prime office location). Such incentives should ideally be part of a broader, long-term retrofitting strategy.

      Example: Singapore offers up to 3% additional gross floor area beyond the typical regulatory restriction for buildings of at least 5,000m^2 that achieve the Green Mark Platinum rating.[57]

   b. **Penalize underperforming buildings:** The flipside of supporting the green building premium with incentives is seeking to reinforce a non-green building discount for underperforming buildings. As with incentives this can be done through the tax code (e.g.,

[57] Singapore Government, (2021), *Built Environment Transformation Gross Floor Area Incentive Scheme.*

carbon taxes) or alternatively via regulation which links buildings' rental or sale viability to their sustainability profile.

Example: The EU will require non-residential EPC G-rated buildings to be renovated to at least an F rating by 2027 and E by 2030. LL97 will, from 2024, require buildings over 25,000 square feet to meet increasingly strict emissions caps, with building owners facing fines for exceeding them.

4) **Refocus regulation:** In energy rating terms, building regulation tends to focus on modeled energy use, as with EPCs in the EU and Energy Star ratings in the US. The problem is that the models tend to diverge significantly from reality. For example, one study found that the average discrepancy between predicted energy and measured energy use of buildings was 34%.[58] Various factors contribute to this, model inaccuracies, "non-typical" occupant behavior, problems with building work, etc. Part of the solution is to shift from model-based ratings to performance-based ones, which look at actual energy use in the form of total energy demand and thermal energy demand intensity (kWh/m^2), as well as factoring in the number of people who use the building and for how long, to benchmark it against others. Another is to use regulation to encourage other desirable but often-neglected building traits like air tightness and optimal ventilation.

   Example: The National Australian Built Environment Rating System (NABERS) is a performance-based rating system that is mandatory for commercial buildings over 1,000m^2. Ratings are based on metered energy and water use, waste, local weather, building fabric, occupancy, and equipment and are renewed every 12 months, giving owners, investors, tenants, and policymakers an up-to-date picture of building performance.[59]

5) **Strengthen the supply chain and coordinate stakeholders:** Streamlining the supply chain is critical for achieving meaningful and sustainable retrofits. Likewise, improving coordination between various stakeholders can be a critical driver of retrofit adoption.

   a. **Strengthen the supply chain:** While it is sometimes tempting to focus on demand-side incentives, without efforts to support and scale up the supply side, bottlenecks will limit the number of retrofits. Support should ideally be targeted at multiple links in the supply chain, while ensuring the highest impact per invested unit of currency. Which supply side measures are most critical will differ from country to country or even region to region. Targeting support upstream, e.g., in the form of loans to ensure availability of adequate retrofit materials, like insulation, and appliances like heat pumps, can be complemented with support downstream, e.g., by subsidizing training for contractors and clean tech installers, supporting retrofit marketing efforts, or linking contractors with "warm" sales leads. Achieving the highest impact for taxpayers' investments requires a careful assessment of the upstream and downstream supply chain.

      Example: Ireland's EUR 8bn National Retrofitting Scheme, launched in 2022, includes a mixture of demand and supply side support including the funding of apprenticeship and skills training to build supply chain capacity.[60]

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[58] McAllister, P. and Nase, I., (2019), *The impact of Minimum Energy Efficiency Standards: some evidence from the London office market*, Energy Policy, P7.
[59] Aegis Property Group, (2023), *What is the NABERS rating?*
[60] Irish Government, (2022), Government launches the National Retrofitting Scheme.

b. **Coordinate stakeholders:** Currently there is not enough coordination between stakeholders in the retrofit value chain. Supply chains are typically fragmented, building owners are mostly disconnected from each other, and potential synergies between private and public goals and benefits (Table 2) are overlooked. Projects, as a result, are atomized, fewer in quantity, more difficult to finance, and more likely to run into execution issues than might otherwise be the case. A potential solution to these issues is "one-stop-shops", a single entity to coordinate various stakeholders, from providers of capital to government entities, to contractors, to the households whose properties will be retrofitted. Coordination of this sort typically starts with bundling retrofit projects together to combine purchasing power, bring down costs, and enable more innovative financing options, like the securitization of energy bill savings to attract institutional financing at scale. The one-stop-shop manages the process, providing a single point of contact to households, as well as information, technical assistance, and post-retrofit quality assurance.

   Example: Energiesprong was developed in the Netherlands and has since expanded to various countries including the US and UK. It works with all relevant stakeholders, from contractors, manufacturers, and households to banks and regulators, combining thousands of retrofits into single deals. Energiesprong seeks to "industrialize" retrofits by using prefabricated, modular retrofit panels,[61] manufactured off-site and installed at pace onsite (typically within 10 days),[62] reducing the cost and inconvenience of a typical deep retrofit. Works are paid for by future energy savings along with government funding and philanthropic contributions, so residents face no upfront costs or increase in bills going forward.

6) **Unlock finance for lower value properties and residential:** Higher value commercial and residential owners might be more responsive to tightening regulatory and reporting requirements, but financial constraints may be insurmountable for many at the lower end of the value spectrum. Remedying this likely requires innovative financing solutions in addition to the more traditional grants, guarantees, concessional loans, or tax credits like Italy's popular but hugely expensive "superbonus" scheme.[63] The Energiesprong approach of monetizing future energy savings is one option. Another, complementary option, which similarly seeks no upfront funds from the homeowner, is to seek to quantify and then monetize the benefits to all stakeholders not just the building owner (Table 2) and seek commensurate contributions from them to the cost of the improvements (Interview 3). Mortgage providers, for example, might contribute to the cost of greening their mortgage portfolios.

   Example: See interview 4.

7) **Target vacant properties:** A surprisingly high percentage of properties lie empty. Just looking at the residential side, OECD data from between 2016 and 2019 suggest vacant dwellings account for over 12% of the total housing stock in Japan, over 10% in the US and Brazil, as well as around 8% in France and Germany. Incentives to retrofit such properties would have the benefit of targeting them at a natural point in their life cycle to do disruptive work to their fabric, while also likely increasing their attractiveness to prospective tenants.

   Example: The UK offers a reduced value-added tax rate for refurbishing properties that have been vacant for more than two years.

[61] The Renewable Energy Hub, (2023), *What Are Energiesprong Homes.*
[62] UK Government, (2021), *International review of domestic retrofit supply chains*, P94.
[63] AFP, (2023), How Italy's generous green homes scheme turned "wicked."

Table 2: Who benefits from retrofitting of the building stock and how

The potential benefits of retrofitting go far beyond energy-efficiency improvements, with health and comfort gains, reduced transition risks, potential green premiums, lower grid infrastructure costs, and economic benefits from local upskilling and job creation all relevant

Stakeholders Benefits	**Occupant**	**Building owner**	**Mortgage lender / debt investor**	**Government**	**Broader economy/society**
Potential increase in building value		Higher exit profit for investor; higher equity for home owner	Lower loan to value ratio reduces loan risk		Economic boost from wealth effects
Better livability	Improved work or living experience	Improved tenant retention; possibly higher rents			Improved wellbeing of population
Improved health outcomes	Better health; lower healthcare costs			Lower healthcare spending, better human capital	Fewer sick days, higher productivity, lower healthcare costs
Lower exposure to regulatory and tax risk		Lower risk of capital loss, asset stranding or tax penalties	Reduce risk from incoming mortgage portfolio standards (MPS)		
Lower emissions	Lower contribution to climate change	Reduce property portfolio emissions	Reduce mortgage portfolio emissions	Nationally Declared Contribution	Lower contribution to climate change
Lower demands on power grid	Lower energy bills			Reduced need for grid upgrades; improved energy security	Lower risks of outages, lower infrastructure costs
Local economic and jobs boost	Regeneration of local area	Regeneration of local area		Improved tax receipts, lower benefit spending	Regeneration of low-growth areas; lower unemployment

Source: UBS

Interview 4: The promise of place-based retrofitting—Rufus Grantham, founder of UK-based social enterprise Living Places, and place-based retrofitting advocate

How would you describe place-based retrofitting?
Place-based retrofitting is the core component of a broader place-based decarbonization and regeneration program focused on nearby properties in a neighborhood. Instead of lots of individual retrofits with the onus on the household, projects are bundled together into a collective, area-based plan, reducing costs, unlocking collective, long-term capital, speeding up the rate of retrofitting and helping to regenerate the local area, delivering other benefits. Matching local demand to local supply is important to create a retrofit ecosystem, and this is one of the advantages over a national plan—giving a strong local retrofit demand signal rather than a diffuse national one.

Why do you believe there is a need for it?
Retrofitting rates need to be ramped up significantly, and national regulations combined with individual-focused finance products are not making sufficient headway. For individuals, the upfront cost is significant and the realized savings too small to make a compelling investment case without a very lengthy payback period—or to put it another way, the mortgage finance costs are likely to be much more than the annual energy savings. In addition, deciding what range of measures to apply is complex and then living through them is disruptive. Place-based retrofitting is about improving and broadening the incentives for households to take part, minimizing the costs and maximizing the potential for institutional and commercial finance, reducing the cost burden on the public sector.

What is the pitch to households?
The pitch to households is that you get a fully-funded deep retrofit to your property with no upfront costs, no increase to your energy bills—in fact a small discount is designed into the finance stack—you get the thermal and health benefits of the retrofit for your own household and the ability to unlock and influence funding of broader benefits to you and your neighborhood.

How does the financing work?
About 50% comes from institutional finance repaid through a collective pay-as-you-save mechanism. The retrofit leads to energy bill savings, part goes to the household, in the form of an energy bill discount to incentivize participation, the rest is sold as an annuity to raise funds for the works. A further 10% comes from other commercial beneficiaries of the program—the grid operator buying deferred network upgrade spend, the water company paying for reduced water volume through installation of sustainable urban drainage, mortgage providers compensating for an improved EPC profile in their mortgage book, etc. The remaining 40% comes from the government, supported by the public goals delivered like better health, lower fuel poverty, local job creation, and of course, emissions reduction.

3. Planning for success

At a glance

- A retrofit revolution needs to be implemented the right way to avoid unintentional negative consequences.
- Badly executed retrofits may suffer performance dips within a few years, result in carbon lock-in, or cause problems like overheating or unhealthy air quality.
- To reduce these risks, each project should consider a whole building plan and "building passports", logging materials used, and details of work done to enable transparency and information flow.
- Post-retrofit performance should be carefully monitored and the building maintained to avoid premature failure.

3.1. Start with a plan

Every applicable building should have a Net Zero plan—a roadmap to net zero emissions—even if budget, time, or other constraints prevent a single step implementation, for several advantages:

- **Helping to ensure optimal operational energy efficiency choices:** A comprehensive plan helps to ensure that retrofit measures taken are the best fit with the budget and, just as importantly, each other. Complementary measures that reinforce each other can contribute to better building performance, e.g., insulation upgrades that reduce the size of the heat pump a house needs,[64] reducing costs, embodied carbon, and the amount of refrigerant necessary (refrigerants typically are potent greenhouse gases).
- **Helping to avoid mistakes in sequencing or installation:** Suboptimal sequencing or installation decisions can undermine a building's energy efficiency, leading to carbon lock-in. For example, installing new windows could disrupt a previously installed wall installation, creating thermal bridges where heat escapes and mold and condensation could occur. This risk could be minimized if that sequencing were reversed and outward-opening windows used.[65]
- **Helping to avoid problems that could undermine the health of occupants:** Installing insulation and eliminating drafts by sealing the building envelope without addressing ventilation could undermine a building's air quality, leading to potential damp and moisture issues, which contribute to adverse health outcomes or result in the building fabric deteriorating more quickly than if the building had not been retrofitted. Alternatively, failing to include adequate ventilation or other cooling measures could lead to overheating, which poses its own dangers.[66]

[64] Lingard, J., (2021), *Residential retrofit in the UK: The optimum retrofit measures necessary for effective heat pump use*, Building Services Engineering Research & Technology, P286.
[65] Green Building Store, (2021), *Installing windows in energy efficient retrofits.*
[66] Fosas, D. et al., (2018), *Mitigation versus adaptation: Does insulating dwelling increase overheating risk?* Building and Environment.

3.2. The importance of introducing "building passports"

With a few exceptions, building passports currently exist mainly as an array of proposals and pilot programs that are yet to be meaningfully implemented. Ideally, they act as a *"data and information hub that supports building owners and their service providers in the use and management of [a] building by facilitating the recording, linking, transfer, and sharing of building data and information among stakeholders across life cycle stages."*[67] In addition they may also contain a long-term roadmap of the building's renovation path to reaching Net Zero.[68]

Why do they matter?

Protagonists knocking through a wall to find a mysterious room they think may be hidden behind is a horror movie trope, but often today the reality is that the only way to see how a building is made, particularly an older building, is to do an "invasive" survey. Very few surveyors would know how a building is constructed or insulated just by looking at it. This leaves owners, contractors, and others running blind much of the time.

As well as keeping a log of a building's construction and materials (including their sourcing and technical specifications), passports are designed to record work that has been done on a building. Currently, if there isn't evidence of work done, the assumption made, for certifications like EPCs, when the building is sold, is that no work has been done. By ensuring that the building information flow is transparent, a passport enables later assessors and contractors to understand what materials have been used, how old they are, how they may interact with subsequent alterations, and what the current state of a building's fabric is. This ensures that the building is properly credited for work done and helps facilitate phased retrofit approaches, allowing building owners to spread costs over a longer period. It also helps future owners, who may be working according to different building standards than those of today, know which materials are still compliant and those that need replacing. This should enable lower levels of replacement and higher reuse of existing materials.

More broadly, passports should help to improve the accuracy of understanding about the wider building ecosystem, of building material and appliance performance, and the performance of retrofits themselves.

Encouraging adoption of passports

Ultimately, regulatory obligations are likely to be most effective in encouraging the adoption of building passports. But in the absence of this, other stakeholders in the building value chain can play important roles. The first step is to engage stakeholders to decide what such a passport should include. The second is creating the data infrastructure—a centralized, digital repository. The third is to combine the various fragmented datasets used by banks, insurers, construction companies, and others onto the shared system. And the fourth is to incentivize use of the system, perhaps by offering favorable rates of insurance to those who use it or integrating it at leverage points when a building survey is being carried out anyway e.g., point of sale or mortgage application processes.[69] Lenders could encourage the use of passports by reflecting the greater level of transparency and (in theory) lower risk of surprises in favorable lending rates.

[67] UN Environment Programme, Global Alliance for Buildings and Construction, (2021), *The Building Passport: A tool for capturing and managing whole life data and information in construction and real estate*, P14.
[68] Green Finance Institute, (2021), *Building Renovation Passports: Creating the pathway to zero carbon homes*, P4.
[69] Green Finance Institute, (2021), *Building Renovation Passports: Creating the pathway to zero carbon homes*, P12.

3.3. Trust, but verify

Understanding the impact of retrofits is critical to the success of any program. Without an understanding of short- and long-term retrofit performance, and the behavioral impact, the worst-case scenario is that as a society we invest large amounts of money and embodied carbon without seeing the impact on energy use, health, or other areas we hope for. For this reason, ongoing monitoring of retrofit performance via smart meters and low-cost sensors is an important part of the retrofit revolution.

Understanding short-term success or failure

Verification of the effectiveness of individual projects is important—a bad retrofit can be worse than no retrofit. A cautionary example of this is the 2013 retrofit of around 390 homes in Preston, UK. Rushed deadlines led to poor installation, resulting in major damp and mold issues in many of the properties.[70] This is an extreme example, but cases of underperformance, which undermine retrofit effectiveness or contribute to problems requiring remedial action at further financial and embodied carbon cost need to be identified to minimize their impact and incentivize best practices.

Understanding retrofit performance over time

It is natural for retrofit performance to degrade over time as materials wear and tear, but poorly implemented retrofits are likely to degrade much faster than they should. Besides helping to evaluate individual retrofit quality, this is also important to create datasets that are needed to assess the impact of retrofitting at the aggregate community or portfolio level. For example, the impact of improved ventilation and building air quality on community health is essential to understanding the full benefits of retrofitting to society, and what level of public resources to devote to it.

Understanding the impact on behavior

Better energy efficiency does not automatically lead to lower energy use. A 2023 study by Peñasco and Anadón found that the energy-saving effects of installing loft and cavity wall insulation in houses in England and Wales tended to "*disappear between two and four years,*" respectively.[71] The authors suggest this was most likely not due to technology decay, e.g., improper installation, but more probably to "*rebound effects*"—i.e., increased energy use due to changes in occupant behavior caused by lower energy costs—and a potential correlation with other construction projects and renovations associated with increases in energy consumption e.g., an extension. The rebound effect may be larger in lower-income households, which are more sensitive to energy costs. There is a strong argument to be made that energy efficiency measures should be combined with other initiatives to encourage lower overall energy use and optimal behavior.

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[70] de Selincourt, K., (2018), *Disastrous Preston retrofit scheme remains unresolved*, Passive House Plus.
[71] Peñasco and Anadón, (2023), *Assessing the effectiveness of energy efficiency measures in the residential sector gas consumption through dynamic treatment effects: Evidence from England and Wales*, Energy Economics.

About the Institute

The UBS Sustainability and Impact Institute was founded in 2021 to contribute to the sustainability debate, with a focus on actionable and timely contributions. The Institute is a collaborative effort with sustainability experts from across UBS's business divisions. We strive to encourage objective and fact-based debate, provide new impulses for action, and identify innovations that will help shape our collective efforts and awareness about sustainability and impact.

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