Retrofitting social housing

A funding roadmap

December 2021

BURO HAPPOLD

The Housing Finance Corporation Limited

Introduction

It has become increasingly clear that decarbonisation represents a significant challenge for the social housing sector. Estimates of the cost of making the UK's social housing stock net zero carbon by 2050 vary from £58bn to £100bn. The cost of not doing so, however, defies analysis. With the energy sector having led the way on decarbonisation thus far, the UK's homes now represent the next major step. Despite social homes being on average more energy efficient than other tenures, 40% are still rated at EPC D or below.

For housing associations already grappling with rising development costs and a large bill for fire safety works, retrofitting existing homes represents another cost without return. The benefit of retrofitting a home, both financial and otherwise, goes directly to the tenant. In the context of a fuel poverty crisis that has been exacerbated by the impact of the Covid-19 pandemic, this is a positive result. But for the financial health of the social housing sector retrofit poses a major problem.

The Government's Social Housing Decarbonisation Fund represents a £3.6bn pot for the worst performing homes, with a 'fabric first' approach targeted at helping associations reach the goal of bringing all stock to EPC C or higher by 2030. Yet this resource not only represents just a fraction of the estimated cost of decarbonisation, but also does not change the underlying financials which make retrofit so challenging.

The question that The Housing Finance Corporation (THFC) and Buro Happold set out to answer is whether there are models which allow retrofit to pay for itself and provide a return over a long period of time. The solution is a combination of grant and guaranteed debt funding, along with the application of energy production and storage technologies.

While there are still obstacles to the realisation of all of this report's suggestions, we believe that it demonstrates that there is a pathway to making retrofit financially viable. If this can be achieved then it will allow housing associations to go green while maintaining the provision of social homes, and improve the sector's financial health.

Contents

1. About THFC and Buro Happold

This report was produced by BuroHappold and The Housing Finance Corporation (THFC).

Buro Happold is an international consultancy of engineers, consultants and advisers, operating in 26 locations worldwide, with over 70 partners and 1,900 employees. Over four decades Buro Happold has built a world-class reputation for developing creative, value-led solutions for an ever challenging world.

The Housing Finance Corporation is a not-for-profit aggregator founded in 1987 to provide housing associations (HAs) with access to capital markets funding. Today THFC has over 160 housing association borrowers across all four regions of the UK, with a loan portfolio of almost £8bn. Created by the sector, for the sector, THFC has a long track record of innovation and reputation for expertise in UK social housing, including the sector's first retrofit oriented loans with the European Investment Bank in 2012.

2. Executive summary

Housing is the next major step on the UK's route to net zero carbon by 2050. Despite generally having a more energy efficient stock than other tenures, housing associations face a big challenge in decarbonisation. The cost of retrofitting existing homes is high, as the retrofit industry remains fledgling, and offers no return on investment. To date grant funding has been very limited, although there a signs of this beginning to change.

This report lays out a roadmap for funding the retrofit of social housing, covering legislation, retrofit options and financing models. It demonstrates that three things are needed for a retrofit project to become financially viable:

- Economies of scale, to reduce per unit capital cost
- Matched grant funding, to reduce the housing association's own cost
- Guaranteed debt funding, to reduce the cost of borrowing to fund initial retrofit investment

With these three components the energy savings achieved by retrofitting a property are able to pay back the capital cost over a period of roughly 30 years. More importantly, this payback is achievable for deep retrofit (to EPC A) as well as fabric first (EPC C). This is crucial, because at present both the legislative environment and prohibitive cost of retrofit are creating a big incentive for housing associations to focus only on fabric first. While being better than nothing, this achieves limited reductions in carbon emissions and does not put the social housing sector on the right course for net zero by 2050.

Housing associations will still need to choose whether to recuperate the energy bill savings of retrofit from the tenant, whether through service charges or rent increases. However, this report shows that over a long period the tenant will still be no worse off, as the energy bill savings are equal to the new charges, not lower than. While not contributing significantly to further decarbonisation, PVs and battery storage will further benefit the tenant and can play a role in mitigating fuel poverty.

The findings of this report suggest that there is a way for the decarbonisation of UK social housing to be achieved in a way that benefits both associations and their tenants. For this to happen however two things are required:

- Grant funding must be made more accessible and inclusive of deep retrofit projects rather than just fabric first
- A Social Housing Retrofit Guarantee programme should be instigated to ensure housing associations can fund the cost of retrofit not covered by grant with the cheapest possible long term debt

These actions will spur the growth of a retrofit sector capable of realising economies of scale, which in turn will reduce costs. Housing associations understand what is expected of them, and are preparing their strategies for decarbonisation, but funding remains a key obstacle. This report aims to address the funding challenge and offer a roadmap to a greener future for social housing in the UK.

3.a. Decarbonising UK housing

Recognition of the climate emergency facing the world is now widespread, with 194 states and the EU having signed the Paris Agreement. The signatories are responsible for over 87% of global emissions. The Paris Agreement addresses greenhouse gas emissions mitigation, financing and adaptation for climate change avoidance, and limiting global warming to well below 2°C. As outlined by a seminal report by the Intergovernmental Panel for Climate Change (IPCC), net zero carbon is required to avoid a 1.5°C temperature rise. Currently, according to the Climate Change Performance Index, very few countries that signed the Paris Agreement are currently fulfilling the requirements to limit global warming to below 2°C.

The UK Government has declared a climate emergency and implemented a legal agreement to decarbonise by 2050. In December 2020 the Climate Change Committee issued their Sixth Carbon Budget report, setting out a pathway for all sectors toward net zero emissions by 2050.

The heating and powering of homes is responsible for 18% of current UK carbon emissions, but until recently much of the focus on emissions has been on the energy sector. With social landlords owning around 17% of UK housing stock, it is clear that housing associations have a major role to play in the goal of reaching net zero emissions by 2050.

Housing association properties perform better than any other tenure. The split of EPC ratings shown here is typical of the associations studied for this report. A majority of HA housing tends to fall near the boundary between EPC D and C.

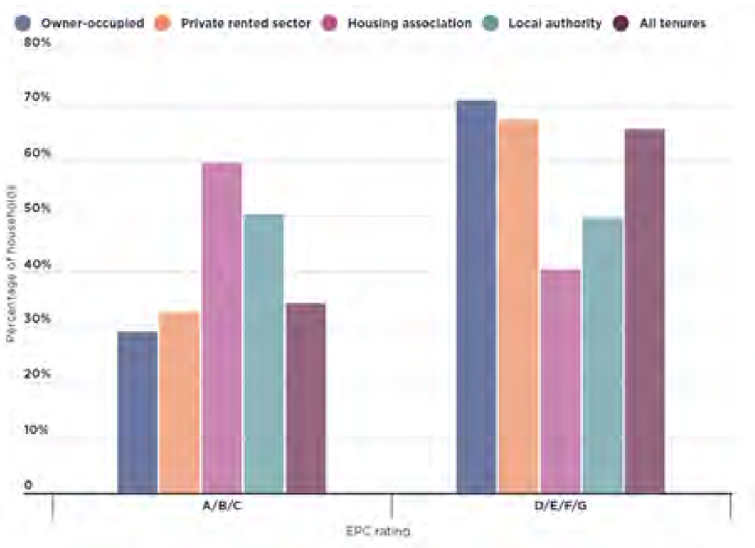


Fig. 3-1. Energy efficiency of UK housing (Savills, 'Decarbonising our social housing', Dec 2020)

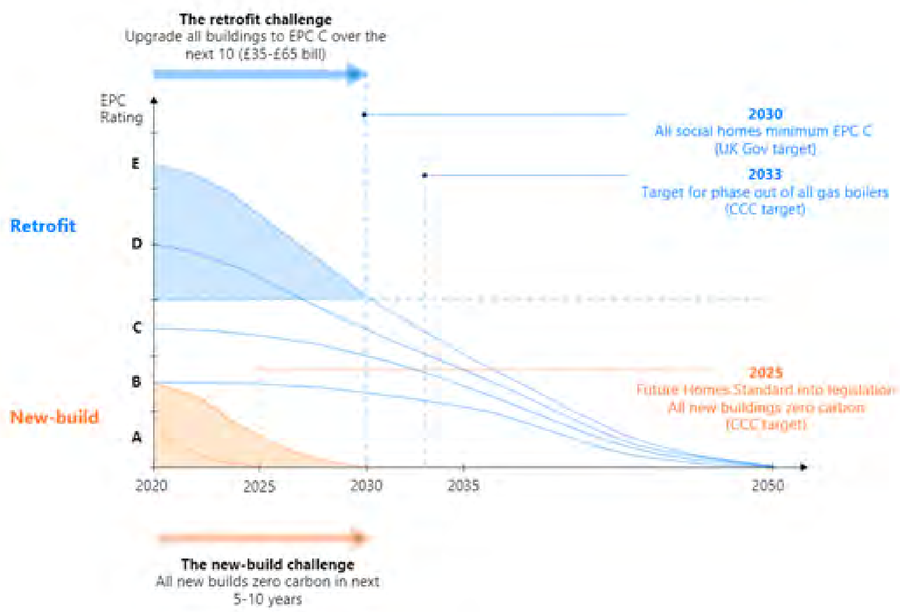


Fig. 3-2. UK housing zero carbon pathway

Fig. 3-2. represents the challenge for the housing sector. For new build an ambitious energy policy is expected to be adopted in the coming years (Future Homes Standard) which would aim to drive standards toward zero carbon within the decade. For retrofit, the Government has set a target for all social homes to be minimum EPC C by 2030, however policy or incentives to drive this change at scale are currently lacking.

3.b. Legislative context

National Planning Policy Framework
Provision of a positive strategy for maximising the potential of energy from renewable and low carbon sources, and at the same time ensure that adverse impacts are addressed in a satisfactory manner.

Identification of areas suitable for renewable and low carbon energy sources and supporting infrastructure, which would help towards securing planning permission for the development.

Identification of opportunities for development to be supplied from decentralised, renewable or low carbon energy systems/sources, as well as from co-locating potential heat customers and suppliers.

Net Zero Target (Recommended by the Committee on Climate Change)
The UK is legally bound to bring all greenhouse gas emissions to net zero by 2050.

National Infrastructure Assessment
At least 50% renewable electricity generation by 2030.

Buildings which require less energy to heat and progress to zero carbon heat. This could be achieved through developing the evidence base on the different options, identifying areas for potential future cost reduction and progressing towards trialling low carbon hydrogen supply and manufacture at scale, including carbon capture and storage.

Building Regulations 2020 Consultation
England – Part L

- A 20% reduction in regulated carbon emissions over the current standard, expected to be delivered predominantly by very high fabric standards.
- A 31% reduction in regulated carbon emissions over the current standard, achieved through a more minor increase to fabric standards, alongside low carbon heating and/or renewables.

Scotland – Section 6

- A consultation document has not yet been produced for 2020 and was expected spring 2020.

Wales – Part L

- A 37% reduction in regulated carbon emissions over the current standard, expected to be delivered predominantly by very high fabric standards and natural ventilation.
- A 56% reduction in regulated carbon emissions over the current standard, achieved through increasing fabric standards, air tightness and mechanical ventilation alongside low carbon heating and/or renewables.

Northern Ireland – Part F

- No documentation released currently, following the publication of the Consultation on Energy Strategy updates to Part F are expected.

Future Homes Standard
The intention is for an average home built to Future Homes Standard (expected 2025) will have 75-80% fewer carbon emissions than one built to Part L 2013.

Clean Growth Strategy
The UK is committed to a 57% reduction in emissions by 2032 and an 80% reduction by 2050.

Fig. 3-3. Future Homes Standard

3.c. Retrofit context

This legislation poses no immediate targets or restrictions around retrofit. Building regulation is focused largely on the quality and performance of new build, while domestic retrofit legislation is fairly relaxed. However, the carbon pathways set out by The Climate Change Committee, amongst others, show that the real challenge ahead is the rapid transformation of the standard of all existing housing stock over the next decade or so.

The Climate Change Committee's Report, *The Sixth Carbon Budget: The UKs Path to Net Zero* (Dec 2020) set out the top priority for the housing sector:

> ***"Deliver on the Government's energy efficiency plans to upgrade all buildings to EPC C over the next 10-15 years"***

The question is how to incentivise property owners to implement such a change. The UK Government has attempted to kickstart the transition with various schemes such as the Green Deal and, most recently, the Green Homes Grant. However, these have not been successful in unlocking retrofit at the scale required, typically due to low take up, complex subscription processes or supply chain bottlenecks. Therefore, further mechanisms are required.

The cost of retrofitting existing UK homes to net zero by 2050 will be signficiant. The Climate Change Committee suggest £55bn, compared with BEIS' published estimate of £35-65bn to reach EPC C. Given that there are currently around 30 million households, this amounts to around £1,833 per home.

Social rented housing in the UK totals around 5 million units, requiring around £9bn of investment to reach net zero. However, recent estimates have put this figure far higher.[1]

3.d. Net zero carbon

The UK Green Building Council (UKGBC) has published 'Net Zero Carbon Buildings: A Framework Definition' document in April 2019 as part of the Advancing Net Zero programme.

The Net Zero Carbon Buildings framework sets out definitions and principles around two approaches to net zero carbon, which are of equal importance:

1. **Net zero carbon** – construction (Embodied Carbon)
   When the amount of carbon emissions associated with a building's product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy.
2. **Net zero operation**
   When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset.

Net zero carbon for both construction and operational energy represents the greatest level of commitment to the framework. A third approach for net zero carbon – whole life – is also proposed at a high level, but further work will be needed to define the scope and requirements for this approach.

Embodied carbon represents the carbon footprint of non-operational processes and materials used during construction and through the building's lifetime, inclusive of supply chain and manufacturer processes.

Whilst the scope of this assessment is limited to in-use energy it is important to recognise embodied carbon as a significant source of emissions related to construction.

[1] See Savills, 'Decarbonising the Housing Association Sector', Nov 2021: https://www.housing.org.uk/globalassets/files/climate-and-sustainability/funding-options-report-final.pdf

Fig. 3-4. highlights the substantial impact embodied carbon has on a new build residential development.

Whilst omitted from the scope of this study, in addition to the adoption of a lean, clean, green approach to building design, the UKGBC framework outlines key considerations to reduce embodied carbon through challenging the construction process as a whole.

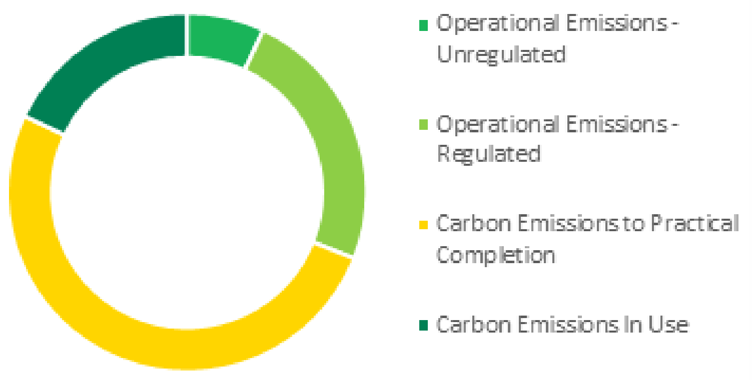


Fig. 3-4. Whole life building carbon emissions

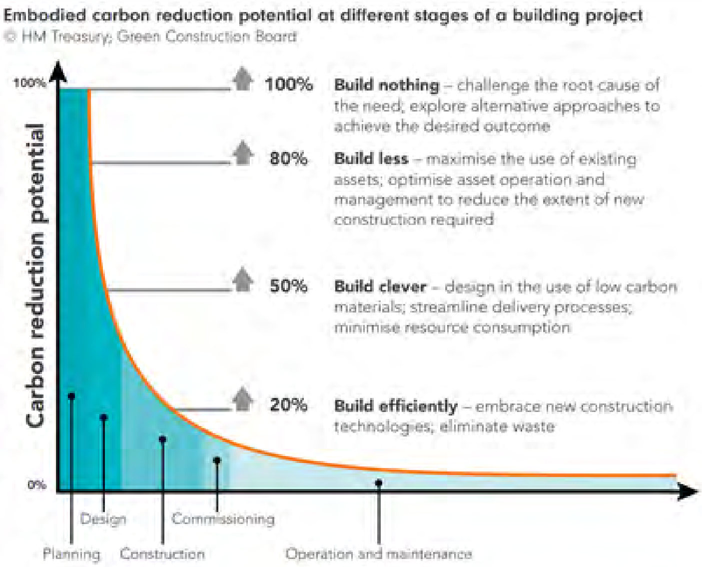


Fig. 3-5. Embodied carbon reduction potential

The principles of carbon reduction in construction are:

- Build nothing
- Build less
- Build clever
- Build efficiently

3.e. Energy performance gap

Post occupancy evaluation and in-use building data indicate a significant difference between design stage building performance and in-use building performance, as they relate to energy consumption. This difference between in-use data and simulated performance is known as the 'Building Performance Gap' or the 'Energy Performance Gap'.

Innovate UK's publication *Building Performance Evaluation Programme: Findings from Domestic Projects* highlights the disparity between modelling and real-life operation due to a number of factors, such as:

- The degree of thermal comfort 'take back' following a retrofit
- Teething problems in the first year resulting in increased CO2 emissions
- On site design changes result in a poorer performing fabric than design stages
- Air tightness problems associated with quick fixes such as plugging gaps with sealant

It is possible to mitigate a number of these factors through some of the processes listed below, however more detailed analysis procedures are required to reduce discrepancies at the design stage:

- Post occupancy performance evaluation and intervention
- Clearer processes to ensure onsite design changes do not affect the building fabric performance (e.g. air tightness)
- Considerations for user behaviour (e.g. occupant training, usability of unfamiliar system, fuel poverty, takeback)

The UKGBC net zero carbon buildings framework also highlights an industry challenge in retrieving data from dwellings due to privacy and GDPR. There are a number of streams identified that may increase the availability of data.

- Location of physical meters (e.g. external and/or communal) for ease of reading (with resident consent in place).
- SMETERS – "Smart Meter Enabled Thermal Efficiency Ratings": a programme that seeks to understand the thermal performance of homes through information retrieved from smart meters.
- Passivhaus – this is a standard that home builders and owners may voluntarily design to, energy monitoring plays a critical role in this standard, as does limiting energy usage.
- Energiesprong – designing to these standards helps to de-risk building performance by setting restrictions on tenants who sign up to an energy plan. This allows for accurate reporting of consumption.

It should be noted, as outlined within the Passivhaus and Zero Carbon publication produced by Passivhaus Trust, that the use of the Passivhaus House Planning Package, being more detailed than SAP, can result in more accurately projected performance. This paired with the fact that Passivhaus certification requires testing for performance leads to a more accurate as-built performance.

4. Barriers to retrofit

The impetus for sustainable new build is gathering, with more ambitious policy to be introduced within the coming years, a maturing renewables market and increasing public pressures.

However, retrofit has proven more challenging, with various interventions and strategies from public and private sectors failing to leverage retrofit at scale. The condition of our existing built environment continues to be the real challenge regards reaching our net zero targets.

The complexities around retrofit are significant, and are set out The Retrofit Playbook, produced by the UK Green Building Council in November 2020.

Barriers to retrofit for housing associations include:

- **Capital cost** – The capital of refurbishment can be significant. HAs often need to prioritise critical maintenance, fire safety measures and the growth of new housing stock before improving the quality of their existing stock.
- **Long payback periods and "who gains?"** – The improvements made to homes often result in modest cost savings relative to the capital injection required. Also, for HAs the benefit of this saving would also ideally be passed on to the tenant to address fuel poverty and wider benefits around wellness and mental health of their tenants. This draws any benefit away from the HA.
- **Lack of economic stimulus** – Lack of subsidy or historic failure of subsidy schemes has resulted in a lack of economic stimulus.
- **Loan securitisation** - The challenges around securitisation of loans against refurbishment is a significant barrier for HAs.
- **Supply chain** – lack of consistent long term retrofit at scale has resulted in a relatively small supply chain and skill set in the UK.
- **Lack of owner knowledge** – Tenants will resist the introduction of new, unfamiliar technologies. This is particularly true of the HA sector.
- **COVID-19** – Renewable & insulation industries have undoubtedly been hindered by COVID-19 and increased uncertainty.

Fig. 4-1. 'Barriers to Retrofit' (Retrofit Playbook, UGBC, Nov 2020)

5. Sustainable bonds

Bond funding has been widespread among housing associations for many years, having been pioneered by The Housing Finance Corporation in 1987. To date capital markets funding constitutes over 40% of the sector's £115bn debt. Bond funding typically offers longer terms and lower interest rates than bank loans, but can be harder to access and require the HA to have a significant funding need (hence the existence of aggregators in the sector, for those HAs who for whatever reason are not able to issue bonds in their own name or who need smaller amounts than would be appropriate for own name issuance).

In recent years the emergence of ESG (Environmental-Social-Governance) as a key investor consideration has driven the growth of Sustainable Bond issuance among HAs. Sustainable Bonds include Social, Green and Sustainability (Social + Green). Typically, these bond 'wrappers' are achieved via the publication of a Framework detailing projects eligible for use of proceeds, the process for the evaluation and selection of projects, the management of proceeds, and subsequent reporting. This Framework will be aligned to the International Capital Markets Association (ICMA) bond principles and assessed by an external Second Party Opinion (SPO) provider. Since Brexit, the UK has been developing its own version of the EU's green taxonomy which is expected to provide further classifications of sustainable activities to fight 'greenwashing' and provide clarity to investors.

Many HAs have chosen to align the reporting metrics in their Sustainable Bond frameworks with the social housing sector's Sustainability Reporting Standard.[2]

Sustainable Bonds are an effective way of funding retrofit projects and can provide mitigations against a number of barriers.

Capital Cost	Sustainable bonds can unlock large amounts of capital for investors who can demonstrate the environmental credentials of their project
Long Payback Periods	Sustainable bonds can offer preferential interest rates compared to commercial loans, thus reducing payback periods
Lack of economic Stimulus	Sustainable bonds can inject capital into the market thus stimulating growth, providing jobs and upskilling industry
Lack of long-term policies/subsidy	The lag of policy behind what is required to achieve our carbon targets is still an issue, as are ineffective short term subsidies. Unlocking the capital markets could stimulate faster change
Lack of supply chain	The supply chain will need to grow, and **long term** predicted growth, increase in demand and stability will stimulate this
Lack of owner knowledge	Sustainable bonds will not upskill building owners, this must come from other source such as government initiatives and energy suppliers
COVID-19	Stimulation of renewable industries suffocated by COVID-19 must be a central part of a green recovery plan

Table 5-1. Benefits of sustainable bonds for retrofit

6.a. Methodology

To ascertain the financial viability of building green housing, be it new build or retrofit, a financial modelling tool has been developed by Buro Happold. The purpose of the modelling was to gain an understanding of:

- The carbon and energy savings associated with various sustainable interventions.
- The business case for green bonds when invested into sustainable housing.
- The sensitivities regarding potential borrowing and funding options.
- The sensitivities regarding who benefits from the savings, be it tenant, landlord or ESCo.

Energy modelling has been carried out to ascertain which interventions are required to reach various energy improvement targets, and the resulting energy and carbon savings. The energy modelling process and assumptions are described in Appendix B.

Table 6-1. sets out the modelled scenarios. The baseline building has been selected as an EPC D rated building, chosen to reflect the immediate challenge faced by a majority of HAs to raise all existing stock to minimum EPC C. The results of the modelling represent the business case for retrofitting beyond EPC C, to the B/A/A* categories.

This approach was applied to a number of different residential building typologies: flats, terraced and semi-detached.

Building design feature	Baseline	Post Improvement Scenarios			
		Min	Mid	Max	Exemplar
	EPC D	EPC C	EPC B	EPC A	EPC A+
Insulation	Uninsulated	Improved insulation	Improved insulation	Passivhaus insulation	Passivhaus insulation
Heating	Gas boiler	Gas boiler	Air source heat pump	Air source heat pump	Air source heat pump
Ventilation	Nat. vent	Nat. vent	Nat. vent	Mech. vent heat recovery	Mech. vent heat recovery
Renewable	-	-	-	-	PV panels

Table 6-1. Modelled scenarios

Results from this modelling were put into a financial model to calculate the capital investment required to achieve the desired environmental performance, cashflow over a fixed term (including operating and maintenance costs) and also different funding mechanisms such as bonds and grants. The model flow chart is shown overleaf.

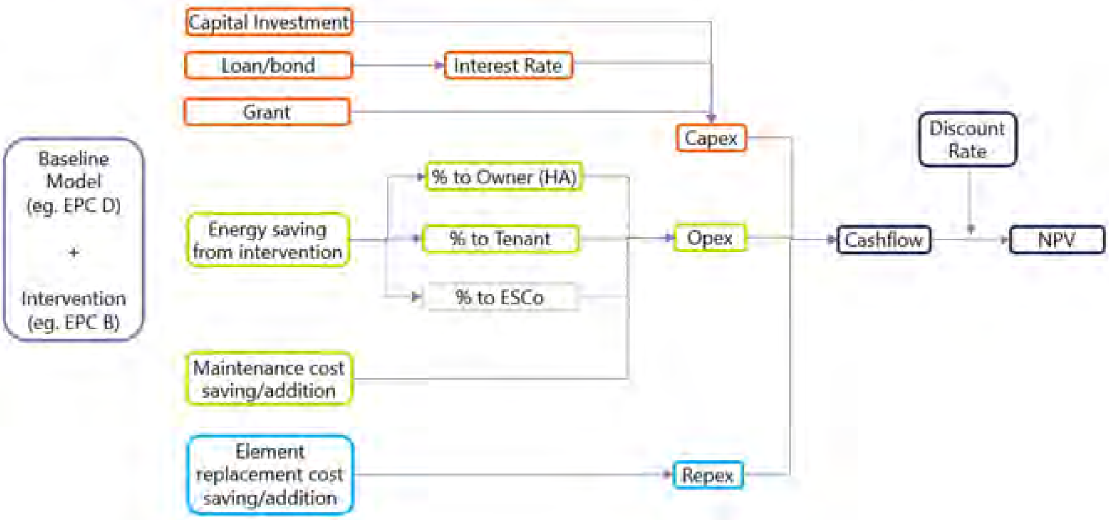


Fig. 6-1. Modelling flow chart

6.b. Key assumptions

For each of the intervention sets shown in Table 4-1., a capital cost has been attributed based from costs reported by the Energy Savings Trust. Figure 4 3 shows the total cost of the suite of interventions required to lift the baseline EPC D dwelling up to each of the associated EPC ratings.

The cost of fuel has been assumed as:

- Gas – 4p/kWh
- Electricity – 13p/kWh

Indexation has been applied to these fuel price figures to project the future change in costs of the fuels. These are based on BEIS figures, and shown in Figure 6 2.

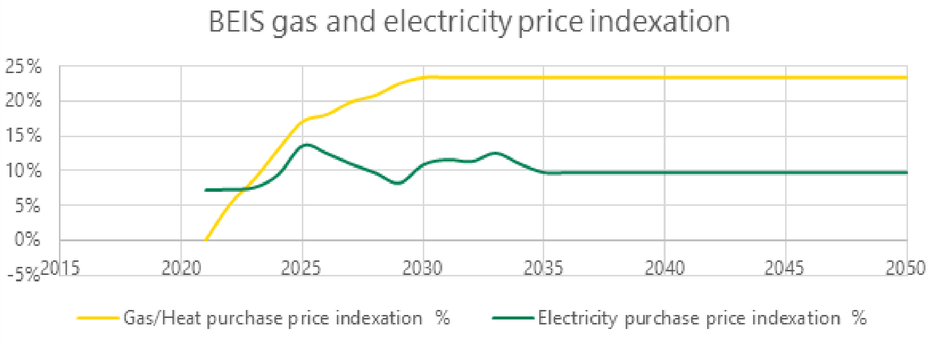


Fig. 6-2. BEIS energy price indexation projections

A thermal comfort take-back factor has also been assumed. This is a factor to account for the fact that the more energy efficient a home is, the higher the energy consumption tends to be. For example, if a house is insulated to a higher specification the occupant will be more willing to turn the heating on for longer. The percentages shown in Table 4-2. have been added to the heat demand figures for the scenarios shown.

On-costs for contractor over-heads, profits etc. have been included in all scenarios as an additional % of capex:

- Preliminaries = 15%
- Overheads and profit = 8%
- Design contingency = 5%

	Baseline	Post Improvement Scenarios			
		Min	Mid	Max	Exemplar
	EPC D	EPC C	EPC B	EPC A	EPC A+
Thermal comfort take-back factor	0%	10%	15%	25%	30%

Fig. 6-3. Thermal take-back factor assumptions

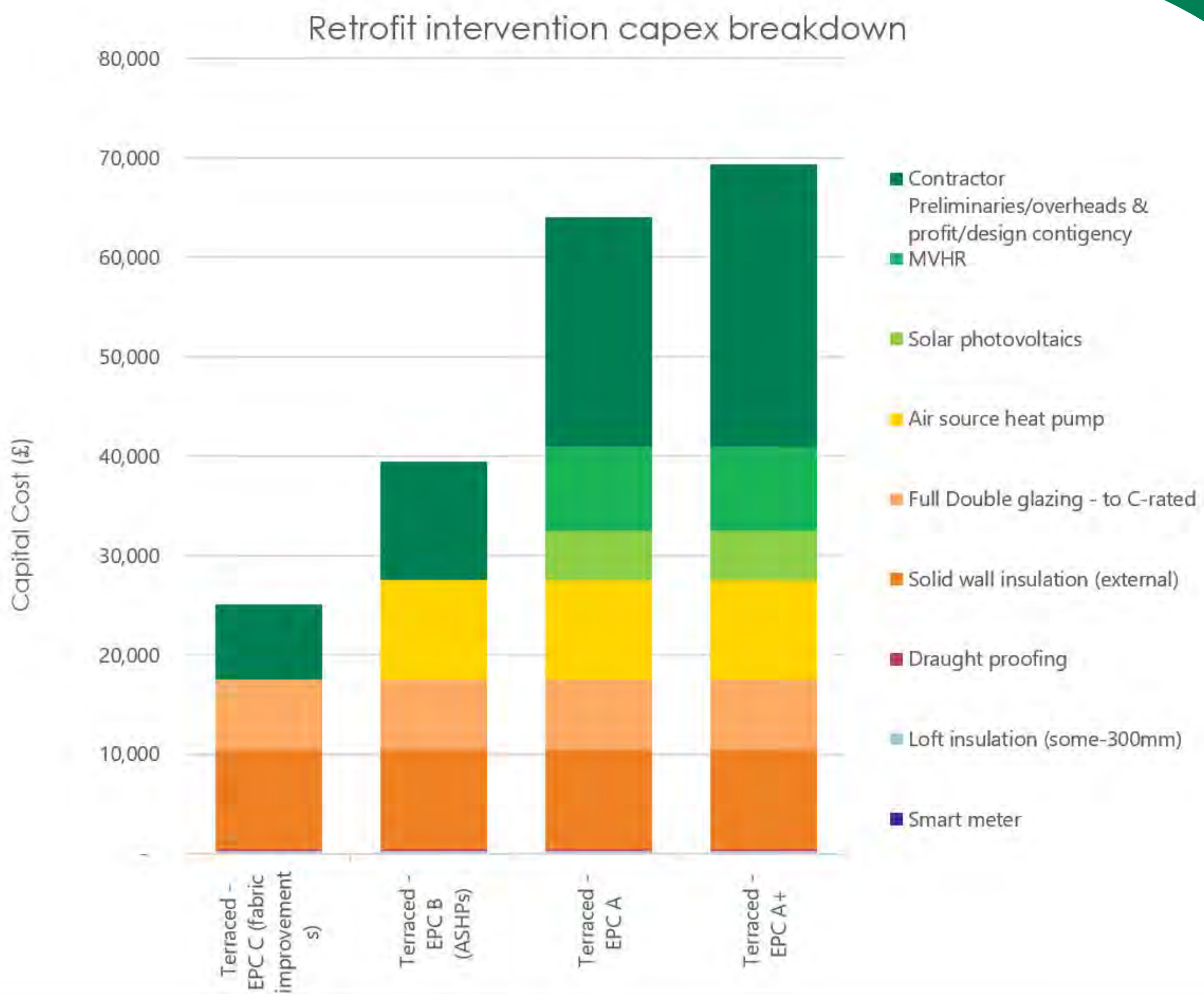


Fig. 6-4. Capex breakdown for terraced house model

6.c. Baseline results

The initial results, based on an EPC D property retrofitted without grant or loan funding, show poor financial performance. Given that these models assume any cost savings through energy efficiency measures are taken by the tenant it is effectively a model demonstrating the financial viability of a homeowner privately investing in energy saving measures and reducing future energy bills.

The capex is considerable, reflecting a lack of savings based on economies of scale, and energy savings are modest with a simple payback not achieved within 40 years. This represents the scale of the issue and the financial challenges behind deep retrofit. Part of the reason for this result is the relatively low cost of the counterfactual fuel of natural gas. The shift from EPC D to C does not require a shift away from natural gas, but as a result the energy savings are modest. To shift up to EPC B involves moving to electric heating. This change will result in more significant energy and carbon savings, and is required to meet future carbon targets, but also involves the use of a more expensive fuel in electricity.

Therefore, without accounting for debt or grant funding, deep retrofit remains prohibitively expensive. However, the steeper gradients of the EPC A and A+ scenarios in Figure 6-6. demonstrate that the step up in energy savings achieved by deeper retrofit does impact the speed of payback.

Fig. 6-7. also shows the effect of the dwelling type on retrofit outcomes. When retrofitting to EPC C (fabric improvements only) flats perform worst, with an IRR over 40 years of -2.7%. Semi-detached properties, however, have a higher initial cashflow.

Scenario	NPV @ 40-years (£)	IRR @ 40-years
Semi-detached - EPC C (fabric improvements)	-18,979	-2.0%
Semi-detached - EPC B (ASHP)	-33,065	-3.4%
Semi-detached - EPC A	-52,484	-3.6%
Semi-detached - EPC A+	-53,723	-2.9%
Terraced - EPC C (fabric improvements)	-15,098	-1.3%
Terraced - EPC B (ASHPs)	-28,823	-2.9%
Terraced - EPC A	-48,374	-3.3%
Terraced - EPC A+	-48,427	-2.5%
Flat - EPC C (fabric improvements)	-17,996	-2.7%
Flat - EPC B (ASHPs)	-31,353	-3.9%
Flat - EPC A	-52,643	-4.5%
Flat - EPC A+	-54,427	-3.8%

Table 6-2. NPV and IRR over 40 years for all scenarios (no subsidy)

The routes to financial viability and incentivising retrofit at scale are investigated in the rest of this report, but some key levers to enable this are:

- Government funding to allow the retrofit market to mature and achieve manufacturing and supply chain efficiencies
- Stronger policy around retrofit, such as point-of-sale legislation that requires all rented or purchased properties or demises to achieve a certain level of environmental performance
- Access to low-cost finance for the housing industry, i.e. sustainable bonds

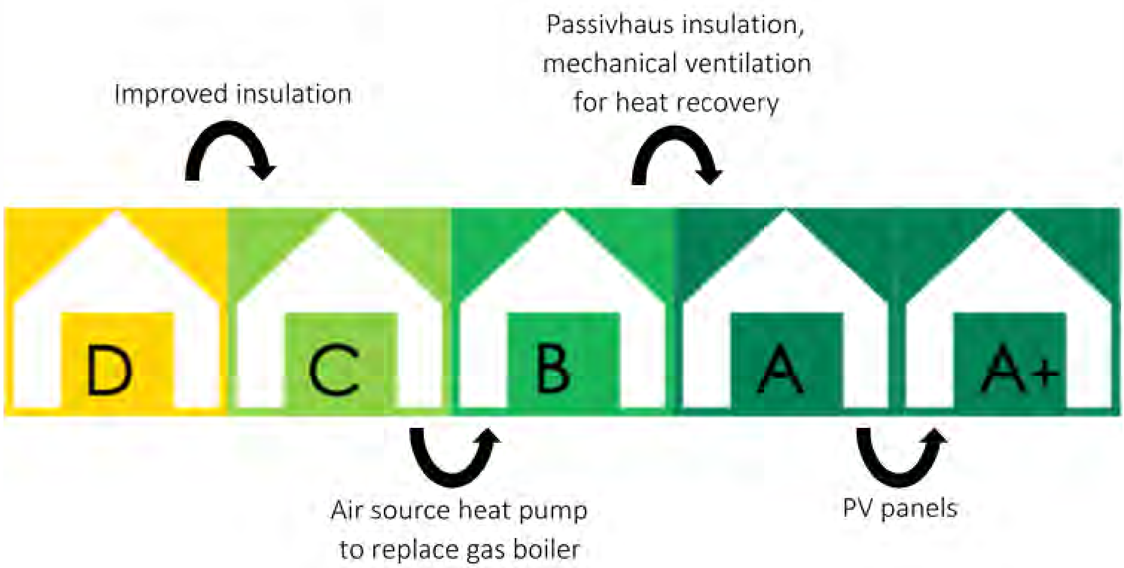


Fig. 6-5. Retrofit changes to terraced house

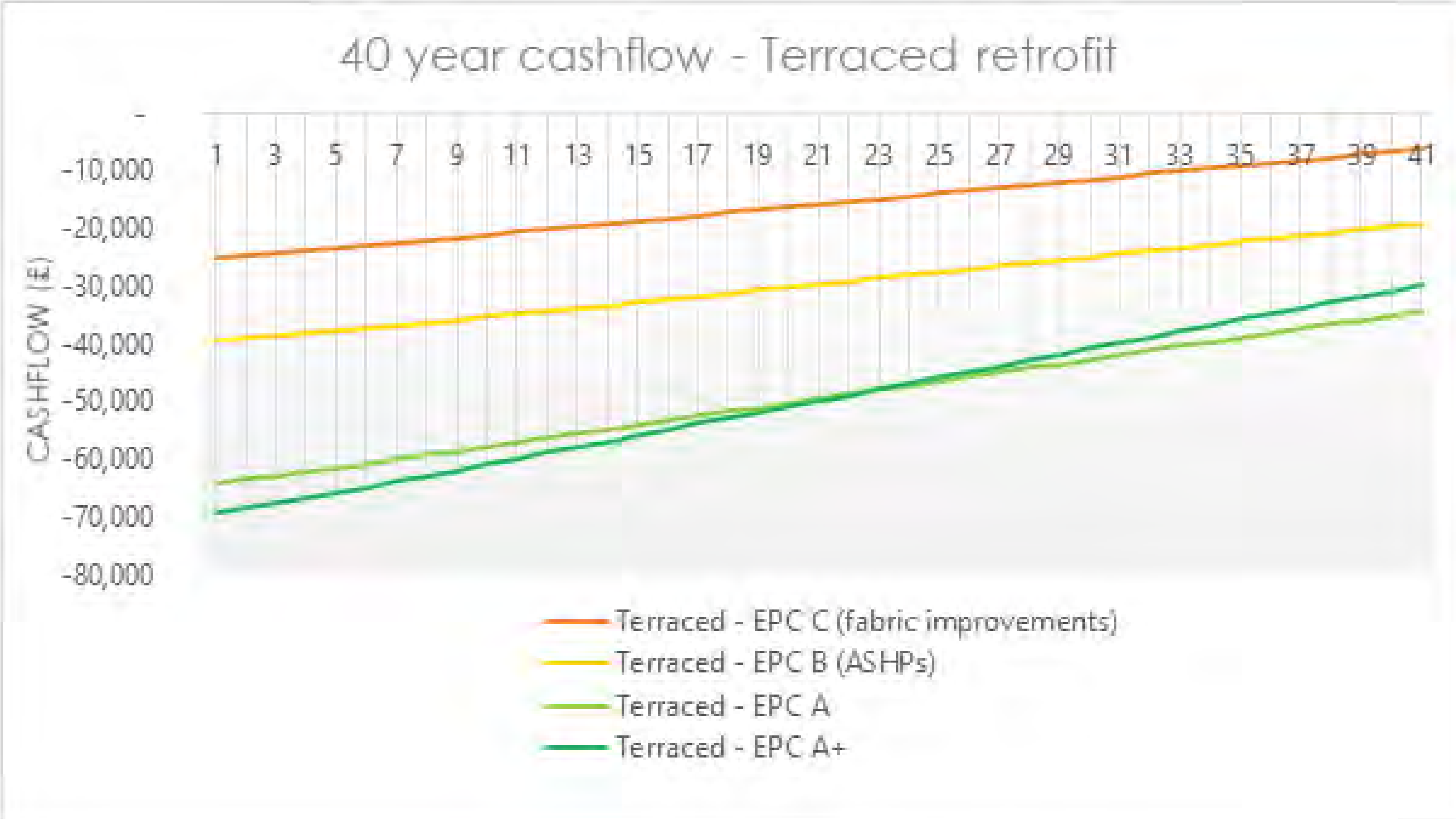


Fig. 6-6. 40 year cashflow for retrofitting a terraced house

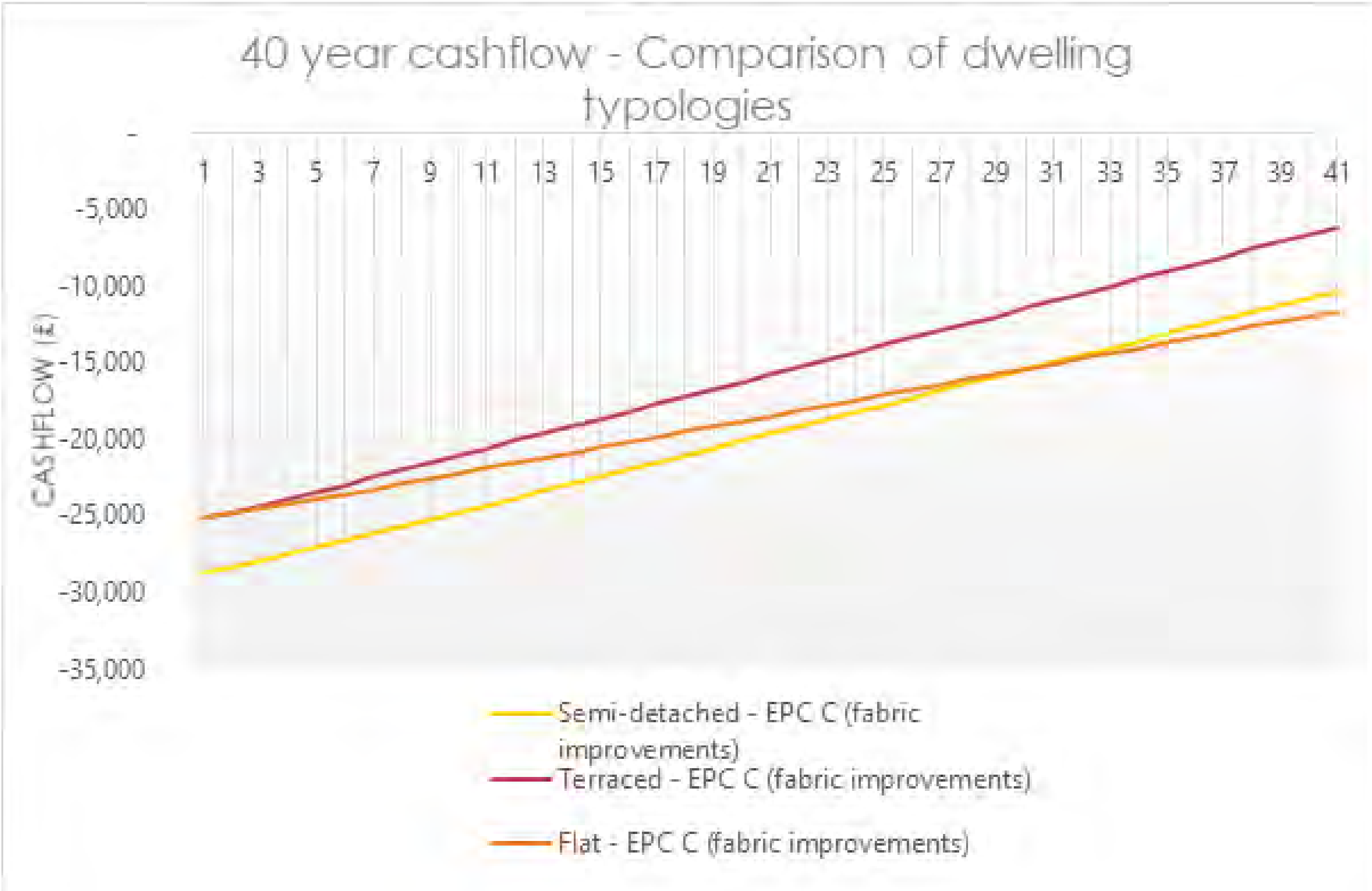


Fig. 6-7. 40 year cashflow comparing retrofit of different dwelling typologies

6.d. Energy storage

Energy storage is likely to play a large role in the future energy mix. On a macro scale, the growing proportion of renewable generation technologies serving the UK grid will result in increasingly unpredictable fluctuations in generation as output becomes more dependent on the degree that the sun is shining and the wind is blowing. To maximise the use of this renewable electricity generation and reduce the cost of infrastructure upgrades, the fluctuating generation needs rebalancing to serve the demand profile, which can be very different. Batteries are a form of storage which enable this rebalancing which have, until recently, have been too expensive to deploy on a large scale. However, the costs of battery technologies are declining in a similar fashion to that of photovoltaics in previous decades.

On a domestic scale, batteries can be used in tandem with PV generation to improve the financial benefits to the tenant. It is important to note, however, that batteries used in this fashion cannot be considered as improving the carbon emissions since the amount of renewable electricity generated will not change, it is simply being stored locally in order to maximise use of that power in the home, and thus minimise the consumption of expensive grid electricity.

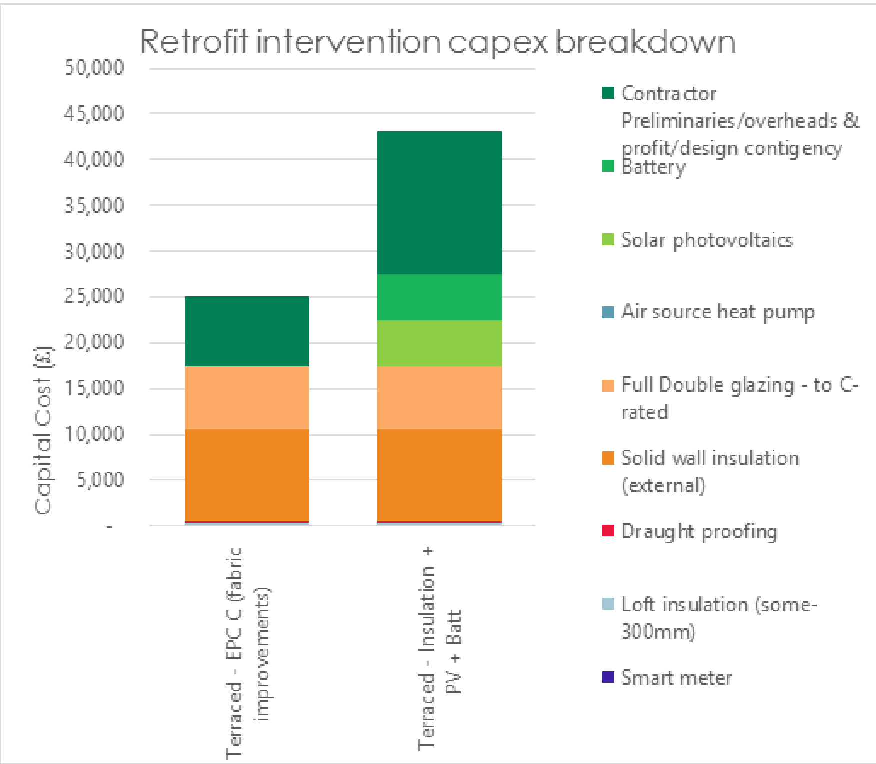
The PV and battery scenario has been tested to compare it with previous modelled options. As the best performing financial model was the terraced house at EPC D retrofitted to EPC C through fabric improvements, this was chosen to test the addition of PV with batteries.

A summary of the model is as follows:

- Typical terraced house
- Install external insulation & double glazing
- Install PV panels with battery storage
- Retain gas boilers

Fig. 6-9. shows the cost of this option in comparison to the fabric only option.

Fig. 6-8. Example PV array and domestic battery unit



The assumptions of the storage model are:

- 10 no. PV panels @ 340W each
- PV covering south facing roof aspect only
- PV provides 2.24MWh/yr electricity, 90% of annual demand
- However, 70% of typical generation exported to grid (without storage) at 5p/kWh
- Inclusion of domestic battery – £5k installed cost, resulting in only 10% electricity import from the grid
- Approximately £340/yr avoided electricity costs
- No revenue from export

Fig. 6-9. Capex of fabric only and PV + battery models on terraced house

Fig. 6-9. shows that the capital cost of such a package of interventions is significant. However, Fig. 6-10. shows how the energy costs to the tenant can decrease dramatically. Figure 6-11 shows the payback is further reduced when implemented a PV and battery package, making it the best performing model that has been analysed.

As shown in Fig. 6-10., the installation of PV with battery storage can realise significant savings, resulting in a faster return despite higher initial capex.

The storage allows the tenant to use energy produced instead of imported energy from the grid, and this is more cost effective than exporting the energy produced by the PV. However, the benefit of the retrofit goes entirely to the tenant. This will help alleviate fuel poverty, but does mean that PVs and battery storage don't represent a means for the recuperation of retrofit costs.

That said, by choosing to install PVs and battery storage for the benefit of tenants, this will mitigate the impact of rent increases on tenants of those HAs who make use of the CPI+1% rise available to them.

Fig. 6-11. Payback of PV and battery package vs. EPC C insulation only

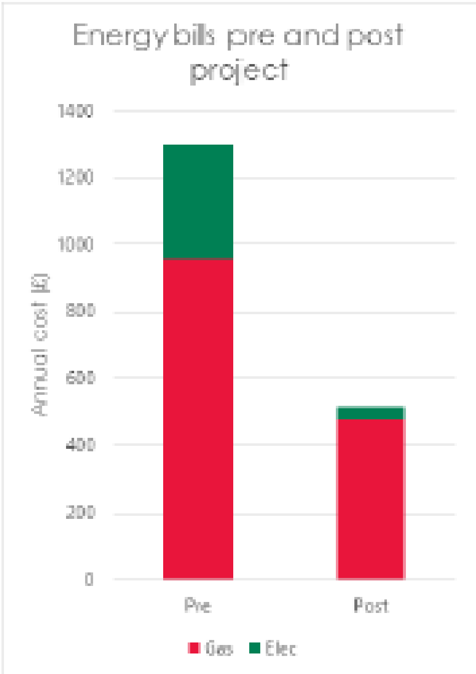


Fig. 6-10. Typical consumer energy bills pre and post insulation/PV/battery retrofit project

6.e. Route to financial viability

It is clear from the results that the cost savings achieved through energy savings alone are modest relative to the capital required, not to mention the fact that these cost savings go to the tenant rather than the HA. To build a roadmap to financial viability there are 3 other functions to consider:

Capital grants

- Energy Company Obligation – Largest energy suppliers obliged to support energy efficiency installations, with a focus on tenants receiving welfare or in social housing units with an EPC rating of D or lower. Deadline for applications to the third iteration is in March 2022, but uptake has been slow due to unclear compliance guidance and funding routes.
- Green Homes Grant – Up to £10,000 government contribution (no more than 2/3rds cost of works) for homeowners and landlords. Efficacy has been limited by complex eligibility criteria, tight deadlines, over-subsription and contractor/supplier bottlenecks. March 2022 deadline.
- Domestic RHI – The RHI pays a tariff for every unit of renewable energy generated for first seven years, covering 5 technologies: air source heat pumps, wood boilers, wood pellet stoves with back boiler, solar water heating. Soon to be replaced by the Clean Heat Grant providing capital grants for heat pump roll out. March 2022 deadline.
- Green Deal – Ran between 2012 and 2015, providing loans to homeowners. Repayments were complex and had high interest rates.

The lessons learned from these schemes support this report's assertion that retrofit should be approach at scale using a combination of grant funding and guaranteed debt funding to allow minimal complicating conditions and requirements.

- Social Housing Decarbonisation Fund – £3.6bn earmarked by BEIS for retrofitting social housing. First wave opened recently to submissions for fabric-first and worst-first (bring up to EPC C) projects which may receive up to 70% grant funding. Intention is to build economies of scale and case studies of best practice; successive £60m waves expected on an annual basis as the Fund gathers momentum. A significant step even though its 'worst-first' is not encouraging of deep retrofit and the overall size of the funding pot is small in comparison to the estimated full cost of decarbonising social housing.

Economies of scale
The retrofit market in the UK is currently not at a maturity to be able to deliver retrofit efficiently at scale. Energiesprong are an example of an ESCo who have realised substantial economies of scale for their operations in Holland. They have several successful case studies and manufacturing capability to deliver retrofit packages efficiently and at relatively low cost. The figure below represents the economies of scale which Energiesprong believe could be achieved. Energiesprong's initial UK retrofit pilot costed around £90k per home. It can be seen from the following table that it has been assumed that these figures could be halved when the economies of scale are realised.

Debt funding
Sustainable bonds allow long-term financing of large-scale retrofit projects to reduce initial capital outlay and increase equity IRR of the business case.

6.f. Impact of grant funding

The testing of the impact of capital grant and economies of scale has assumed a fifty per cent match funding by external/public grant. Figures 6-12. and 6-13 show that the payback period improves to within the 40 year period. Payback is as early as year 28 for a terraced house being taken from EPC D to C.

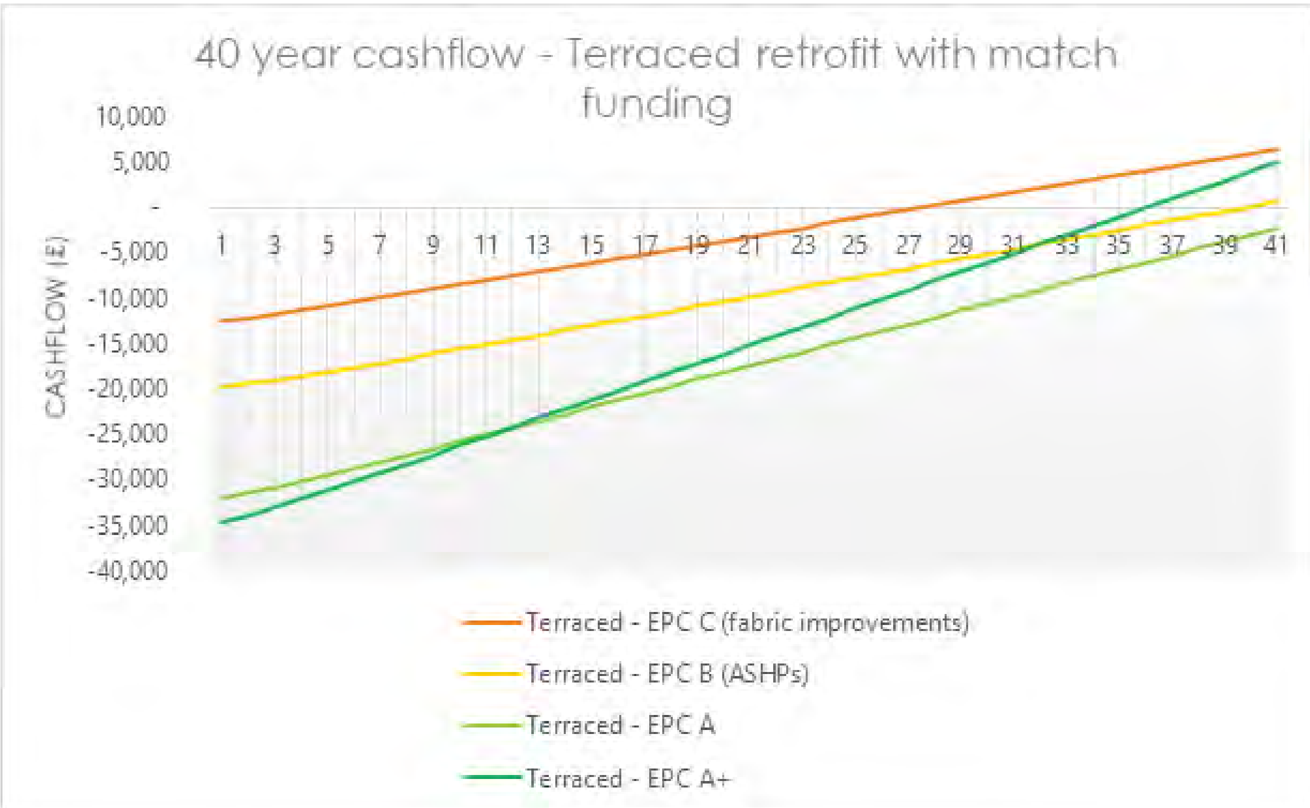


Fig. 6-12.40 year cashflow for retrofitting a terraced house, with match funding

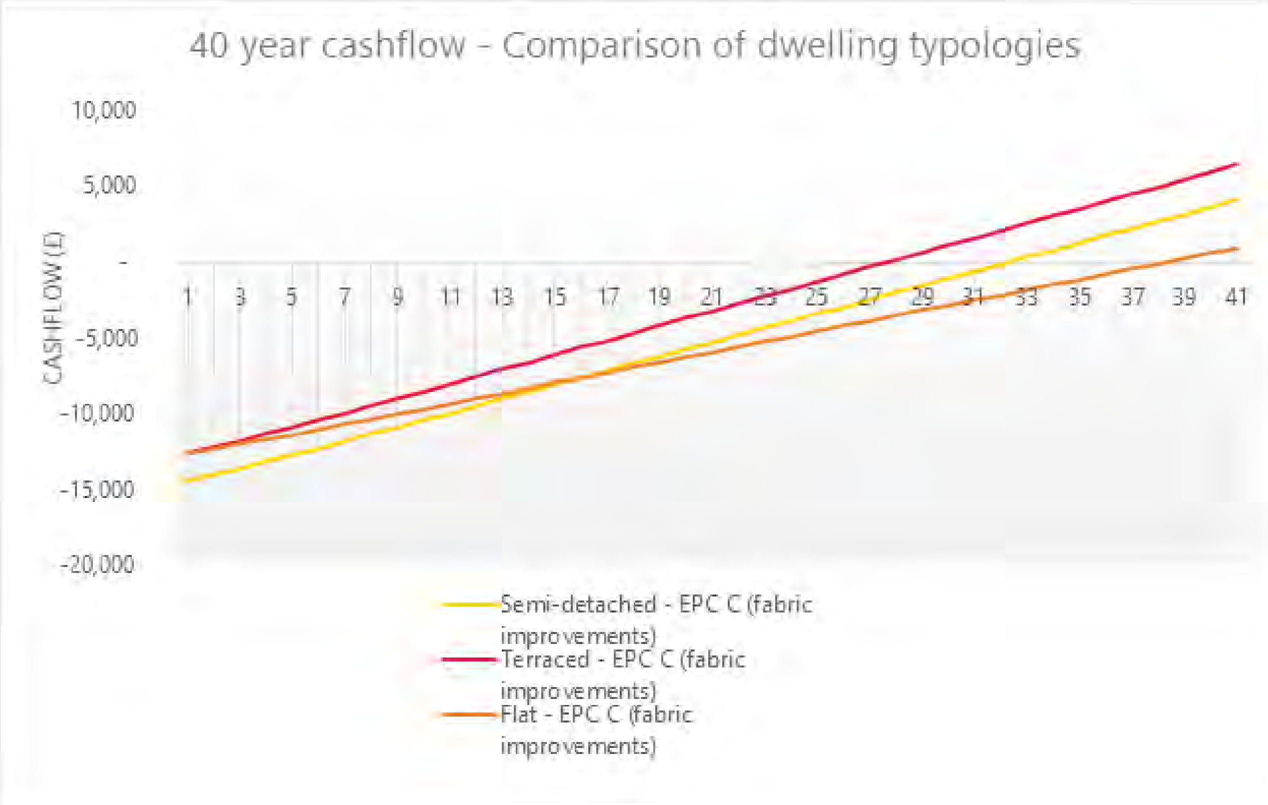


Fig. 6-13. 40 year cashflow for retrofitting different typologies, with match funding

For a terraced house, then, the most financially viable retrofit when match funding is taken into account is either the fabric-first EPC C route or the deepest retrofit to EPC A+ (see Fig. 6-12.). Despite an initial cost nearly three times higher, the A+ only takes 8 more years to payback. In the context of the roadmap to net zero carbon 2050 this shows how grant funding is necessary to make the case for deeper initial retrofit, but also, crucially, that deep retrofit can be financially justified despite the higher cost.

With grant funding, both terraced and semi-detached houses can be retrofitted to EPC C (a fabric first approach similar to that of the Social Housing Decarbonisation Fund) with a cashflow payback within (or just outside of) a typical thirty year business plan of a housing association.

Table 6-4. shows the NPV and IRR for all scenarios. Here, some IRRs can be seen to become positive over the 40 year period, aligning with the fact that the models generally just about manage to payback within the period. Whilst this still does not represent an attractive investment, it represents the demarcation between a loss-making project and one that potentially makes a profit.

Scenario	NPV @ 40-years (£)	IRR @ 40-years
Semi-detached - EPC C (fabric improvements)	-4,606	1.3%
Semi-detached - EPC B (ASHP)	-11,519	-0.6%
Semi-detached - EPC A	-18,493	-0.7%
Semi-detached - EPC A+	-16,900	0.1%
Terraced - EPC C (fabric improvements)	-2,525	2.2%
Terraced - EPC B (ASHPs)	-9,078	0.1%
Terraced - EPC A	-16,347	-0.3%
Terraced - EPC A+	-13,730	0.7%
Flat - EPC C (fabric improvements)	-5,423	0.4%
Flat - EPC B (ASHPs)	-11,607	-1.1%
Flat - EPC A	-20,616	-1.8%
Flat - EPC A+	-19,731	-1.0%

Table 6-3. NPV and IRR over 40 years for all scenarios, with match funding

The sensitivities are shown in fig. 6-14. as applied to the example of a terrace retrofitted to EPC A. Notably, a reduction of capex by 20% yields a 2.3% IRR. The growth of a retrofit industry to achieve economies of scale could therefore have a direct impact on the financial viability of a retrofit project. Match funding can play a vital role in encouraging these economies of scale, with funding being withdrawn gradually as the market adapts and capital costs come down.

This modelling demonstrates that retrofitting to EPC C or A can be achieved without a loss if sufficient grant funding is in place, and economies of scale realised to allow per unit capex to be reduced.

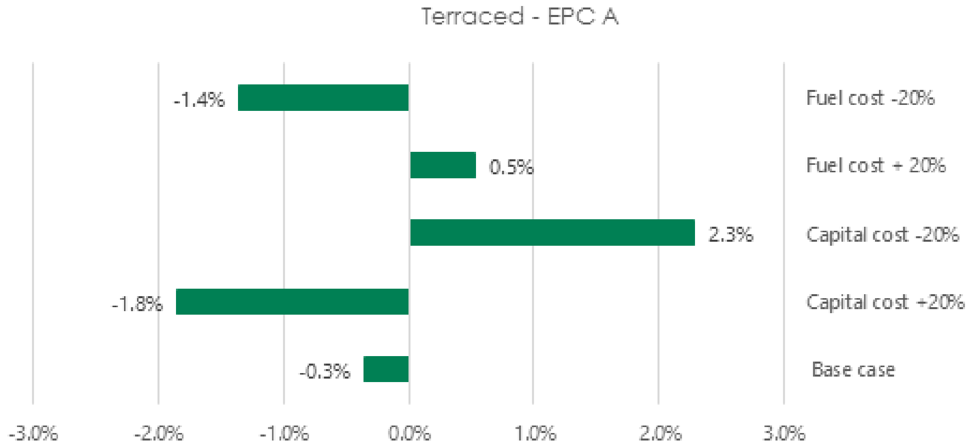


Fig. 6-14. Input sensitivities

6.g. Impact of debt funding

The results presented thus far are simple cashflow models whereby the capital cost for the intervention is assumed to have been paid up front. These models result in the production of the "project IRR". To test the viability of bond funding, the effects of interest rate variations on the business case for borrowing to fund retrofit have been modelled, producing "equity IRR".

We have used the most financially positive models, which are the retrofit of a terraced house from EPC D to EPC C, and the retrofit of a terraced house with insulation, PV and battery storage, without match funding or economies of scale applied. The base project IRR for these were -1.3% and -1.2% respectively. To improve the financial viability of the project the interest rate of the bond would need to be lower than this, which is not possible as the IRRs are already negative. However this test demonstrates that borrowing alone cannot lead to financially viable retrofit.

The tenor of the loan has been set at 40 years and it has been assumed that 70% of the capital is debt funded, with the other 30% paid up front.

It is clear from Fig. 6-15 that, irrespective of the rate of the bond, there is not a financially viable route to retrofit through borrowing alone. A combination of grant funding and borrowing is required to generate a financially viable model.

Combining grant and debt funding

The results presented thus far have tested the financial viability of retrofit scenarios with no funding or borrowing, applying grant funding in isolation, and finally applying borrowing in isolation. The only positive IRRs achieved were a few of the grant funding examples, and even then the IRRs were all below 3% and thus would not be considered attractive propositions, certainly not in the private sector. Therefore, it is clear that a combination of both capital funding and low cost borrowing would be required to generate positive financial scenarios.

Fig. 6-15. Bond interest rate vs. equity IRR

As in the previous chapter, the most financially positive models have been used, which are the retrofit of a terraced house from EPC D to EPC C, and the retrofit of a terraced house with insulation, PV and battery. However, on this occasion match funding has been included in both instances. Thus, base project IRRs for this case are 2.2% and 2.3% respectively. In order to improve the financial viability of the project, the interest rate of the loan or bond would need to be lower than this.

A very low interest rate can lift the equity IRR of a project up to around 5%, as Fig. 6-16. shows.

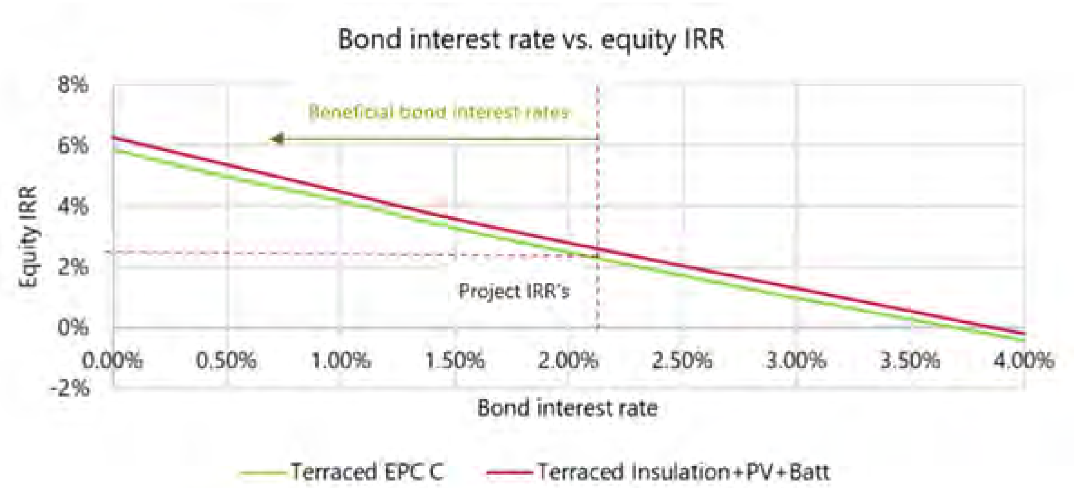


Fig. 6-16. Bond interest rate vs. equity IRR (for retrofitting a terraced house from EPC D to C)

There is demonstrably a huge potential for low interest debt funding to make retrofit projects viable, with a hurdle rate of around 3-6% IRR typical for a public sector type investment.

Examples of very low interest rates have been seen in sustainable bond issuance. In January 2021, Tesco Plc launched a Sustainability-Linked Bond aligned to an agreed Sustainability Performance Target (SPT) of reducing Scope 1 and 2 Greenhouse Gas (GHG) emissions by 60% by 2025 against Tesco's 2015 baseline. The bond has a rate of 0.375% and an 8 year maturity. In September 2021 Stonewater housing association issued a £350m Sustainable Bond at a rate of 1.625% with a 25 year maturity. However, recent issuances of this kind have taken place against the backdrop of historically low Gilt yields since the onset of the Covid-19 pandemic in March 2020. It is unlikely that yields will remain quite so low in the coming years, and therefore it cannot be assumed that future issuance will achieve comparable rates.

While yields are typically lower on short maturities, housing associations tend to issuance on tenors of 30 years or more. This is suitable for retrofit interventions which, as shown, payback over similarly long periods. Modelling has been carried out to assesses the sensitivity of equity IRR to bond term.

Again, the most financially positive models have been used, which are the retrofit of a terraced house from EPC D to EPC C, and the retrofit of a terraced house with insulation, PV and battery, with match funding (or assumed economy of scale capex reduction of 50%). The interest rate of the bond has been fixed at 1%.

Figure 6-17 suggests that longer terms can have a positive impact on the financial attractiveness of bonds as a funding source for retrofit.

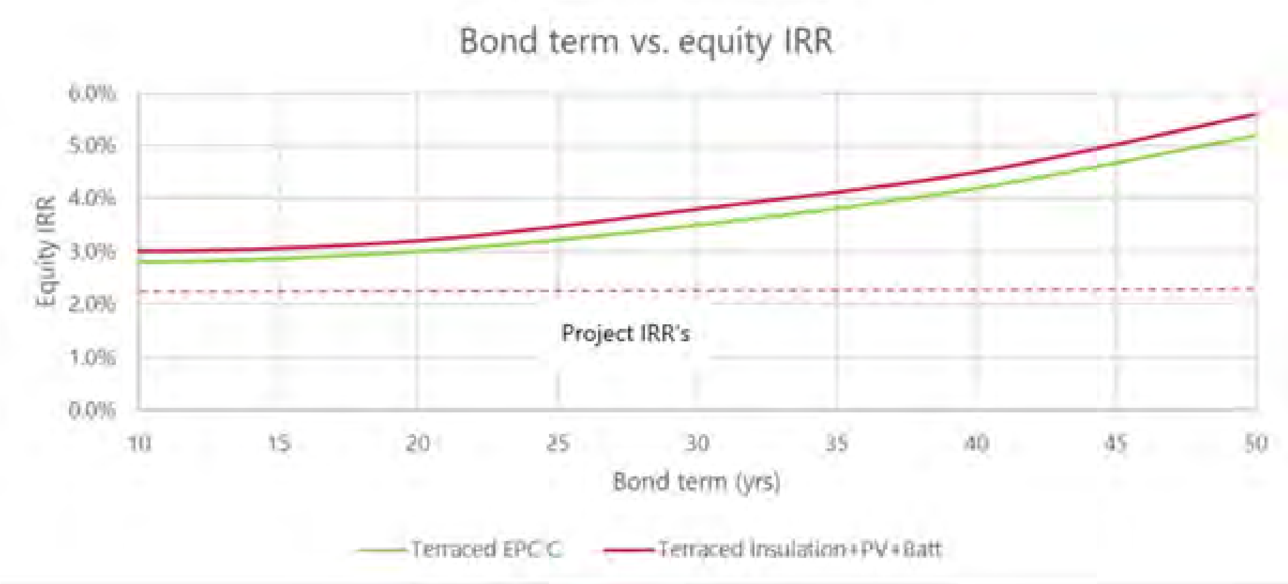


Fig. 6-17. Bond term vs. equity IRR

One method of achieving such a rate (of 1%) for 40 year periods even if changes in the market mean bond rates increase is that of Government Guarantees. Two schemes of this kind exist in the housing sector: Affordable Homes Guarantee Programme 2013-2016, Private Rented Sector Guarantee Programme 2013-2016. The former was run by Affordable Housing Finance Plc, a subsidiary of THFC, and saw £3.2bn issued at record low rates and on-lent to housing associations for the development of new affordable housing. The latter scheme was run by ARA Venn for the development of new private rental sector housing. The bonds issued under these schemes were subject to a Government Guarantee and as a result achieved much lower rates, close to the cost of Government borrowing. A second Affordable Homes Guarantee Programme was announced and awarded to ARA Venn in 2020, however loan proceeds can only be used by housing associations for the development of new housing, not for retrofit. A new guarantee scheme for social housing retrofit would achieve significantly lower interest rates which would allow the realisation of a 4% equity IRR as shown in Figure 6-17.

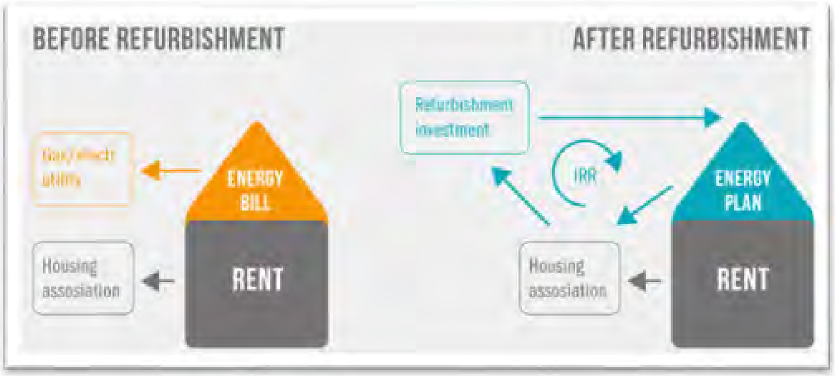
The results of this modelling demonstrate clearly that a combination of grant funding and Government guaranteed debt funding can make large scale retrofit financially viable for housing associations. This applies to both fabric-first EPC C approaches and deeper retrofit. The consequence of this is that deep retrofit need not be a sunken cost for HAs, and this in turn reduces the burden on HAs' cashflows and allows for the provision of social rent homes to be expanded even as HAs tackle decarbonisation.

6.h. ESCO Model and Energiesprong

One way for HAs to build revenue out of retrofit is to pass on the cost to tenants through bills. Dutch not-for-profit Energiesprong are currently refurbishing over 1,000 homes per year in the Netherlands (as well as working in 8 other countries), using an ESCo approach. They retrofit existing affordable/social housing to an extremely high environmental standard, resulting in a large reduction in energy consumption. The tenants then sign up to an "Energy plan" rather than paying for utilities direct to providers, whereby they are paying Energiesprong a fixed annual fee for their energy (as long as they don't exceed a set allowance for electricity usage). This model is shown schematically in Figure 6 18. This cost of energy is determined by Energiesprong such that the tenant takes a significant saving on their energy bills and Energiesprong also take a portion of the saving. The company claims that it is already able to convert homes in the Netherlands at a price that needs no external subsidy.

Energiesprong have trialled this model in the UK, with some terraced housing owned by Nottingham City Homes. The homes were retrofit with high performance insulation, air source heat pumps and PV panels. This cost around £90,000 per home and took around 2 weeks to complete.

However, with manufacturing and supply chain efficiencies in the future, Energiesprong hope to reduce the cost to around £40k per home and reduce the time taken to a few days.



Modelling has been carried to test this approach financially. The model for improving an EPC D to and EPC A+ has been utilised to test this (note that the pre-project Nottingham City Homes terraces were likely worse than this), with a capital expenditure of £40,000. This is the capital cost which Energiesprong hope to achieve for these types of projects. This is a significant assumption, but under today's cost this aspirational future cost could be bridged by subsidy, effectively accelerating the economy of scale savings required. The pilot scheme, for example, was funded via the European Regional Development Fund.

The key question financially is, how much of the energy saving could be offered up to the tenant, whilst still allowing financial viability for the ESCo?

Fig. 6-19. Nottingham City Homes Energiesprong pilot

The graph in Figure 6 20 suggests that, for this particular model, the tenant couldn't be offered more than 20% of the saving. At such figures, the project is not likely to be viable.

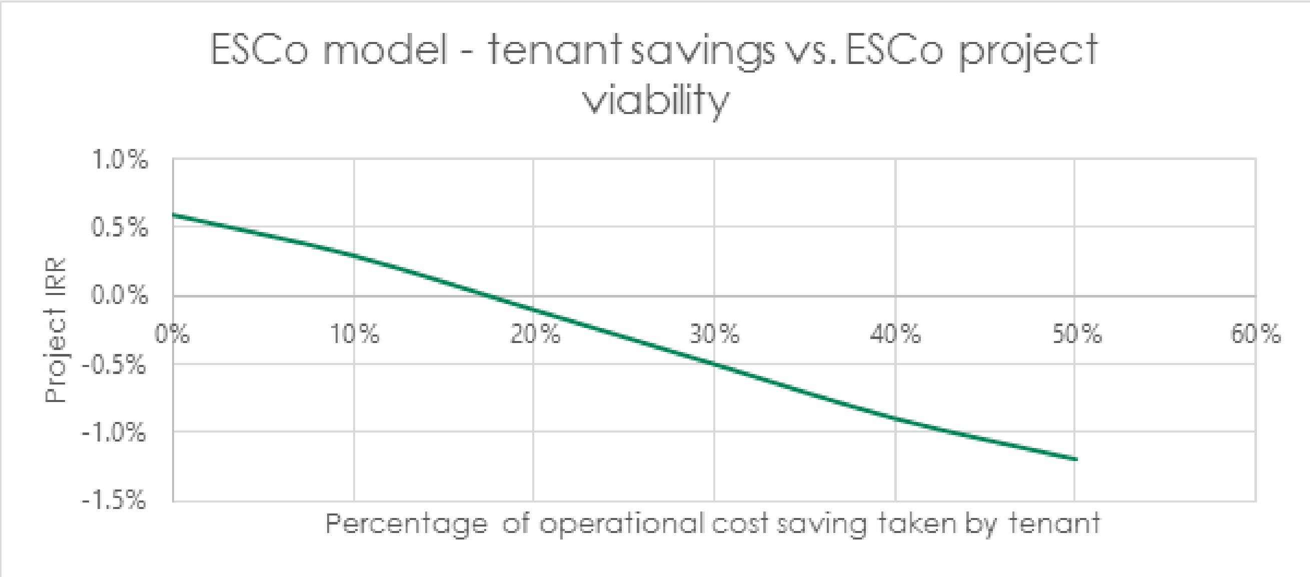


Fig. 6-20. Tenant saving vs. ESCo project IRR

These figures could be improved upon by:

- Low cost loan/bond – if the ESCo were to fund the capital via a long term bond with a low interest rate the equity IRR could be improved. However, the loan interest rate would have to be lower than the project IRR.
- Subsidy – If the capital costs assumed here could be reached without subsidy, there may be the opportunity to obtain subsidy to reduce project costs.
- Assuming a poor performing baseline - The model here assumes an existing property of EPC D, whereas the energy savings a likely to be significantly higher when converted, for example, an EPC F building.

7. UK housing stock

According to the Dwelling Stock Estimates from the Ministry of Housing, Communities & Local Government, in 2020 there were 24.7 million dwellings in England, an increase of 243,770 dwellings (1.00%) on the same point the previous year. 15.7 million dwellings were owner occupied dwellings, 4.8 million private rented dwellings and 4.1 million social and affordable rented dwellings (Private Registered Providers plus Local Authority).

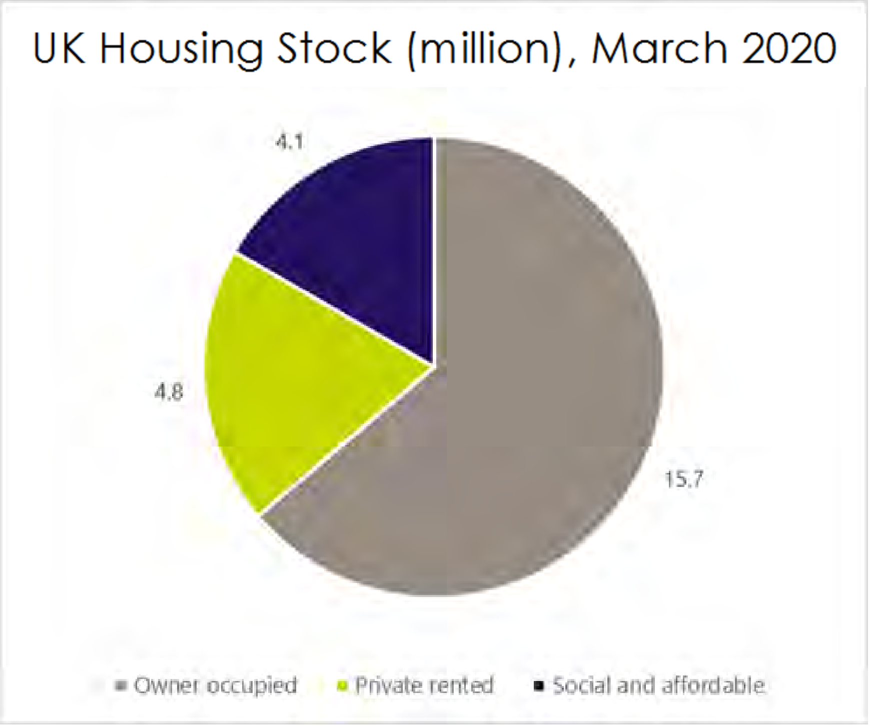


Fig. 7-1. UK housing stock

Fig. 3-1. showed that 45% of social and affordable housing has an EPC rating of D or lower, which relates to total number of around 1.85 million homes. The option with the lowest capital cost to lift homes up to EPC C has been shown here to be around £25k, which would involve upgrading the façade and externally cladding the building. Applying such a method to this many homes comes to **£46 billion**, with half of this requiring match funding from government to allow financially viable projects.

This is in contrast to the CCC 6th carbon budget report which allowed an average of around £5k per home to upgrade stock to EPC C, which would suggest only **£9 billion** would be required.

One thing that is clear is that the scale of investment required is substantial and in order to genuinely accelerate retrofit at scale it will need a combined approach of grant funding and long term borrowing to stimulate the market. In the current environment there is little or no incentive for housing associations, local authorities or homeowners to retrofit their stock to the standards required to achieve our legally binding carbon targets.

8. Performance metrics

The performance of the modelled scenarios described within this report have been largely measured in terms of the EPC rating that could be achieved. However, there can be significant differences between the EPC rating of a building and the actual energy performance of that building. This is known as the "performance gap" and would suggest that the EPC rating is effectively a rather blunt and inaccurate tool regards measuring and reporting of energy performance. The advantage it does have (and the reason why EPC rating has been used within this report) is that is an EPC for a dwelling is legal requirement before it can be sold or rented. For this reason it is used by most HAs regards their performance targets and is a common language through the industry.

The social housing sector's ESG disclosure initiative, the Sustainability Reporting Standard (SRS), also includes provisions for reporting on EPC ratings of stock. In the last year lots of Sustainable bonds and loans have intentionally sought alignment with the SRS, further establishing EPC ratings as a dominant performance metric in the sector.

However, initiatives such as the "Be Seen" requirement (now part of the London Plan) will increasingly require building owners to regularly report on the actual energy use of their building as well as provide more accurate predictions for energy use at design stage. This will lead to much more transparency around energy performance, more energy metering and thus the ability to set actual energy performance targets for buildings.

If energy use could be accurately metered and reported, an energy use intensity (EUI), or a carbon emissions intensity target could be applied. Fig. 8-1. shows an example of an EUI target for small scale housing, taken from the LETI *Climate Emergency Design Guide*.

Fig. 8-2. and Fig. 8-3. show the annual energy consumption and 40 year carbon emissions of the terraced house models. The carbon graph shows significant savings when going from EPC C to B – when gas fired boilers are removed. This shows the importance of a carbon metric, as whilst energy consumption could be reduced by simply reducing demand, significant carbon savings aligned with UK carbon targets can only be achieved when reliance on fossil fuels is removed. This further supports the argument this report makes for deep retrofit, given that the payback for retrofitting an EPC D property to either C or A is broadly similar, but only the latter achieves the necessary drop in carbon emissions at the same time.

Fig. 8-1. Example small scale housing EUI targets (LETI Climate Emergency Design Guide)

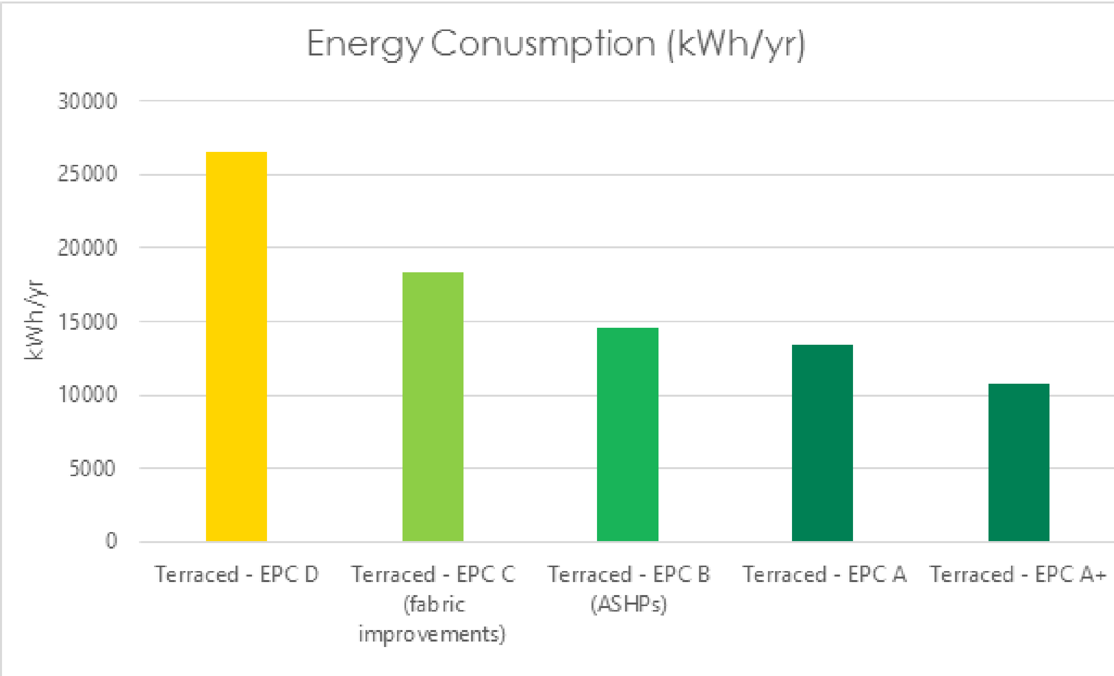


Fig. 8-2. Annual energy consumption for the terraced house models

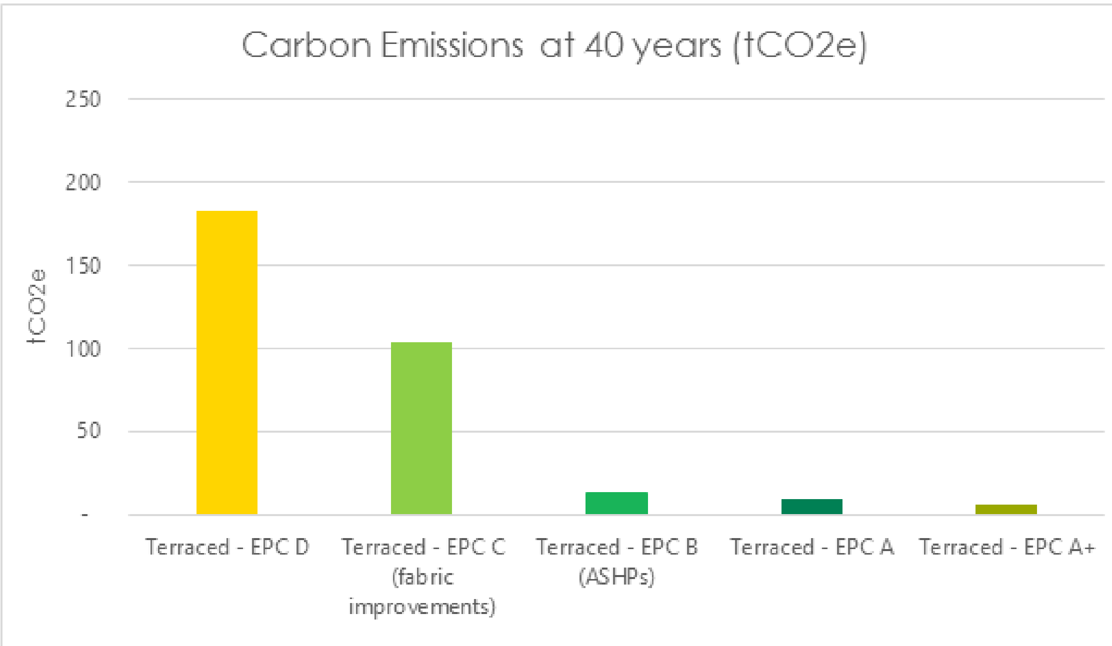


Fig. 8-3. 40 year carbon emissions for the terraced house models

9. Conclusion

Decarbonising UK social housing is now a critical strategic challenge for the sector. Without a roadmap to financial viability of retrofit, existing incentives are likely to push housing associations to focus only on retrofit to the bare minimum of EPC C, and to sell off homes that perform poorly and are hard to retrofit.

However, it is clear from the modelling contained in this report that, with the right policy and funding environment, deep retrofit (to A) can be just as financially viable as shallow retrofit (to C). In addition, housing associations could, with the right funding model, include the installation of PVs and battery storage to reduce tenant energy bills and tackle fuel poverty, while still achieving a positive rate of return on the cost of retrofit.

Yet for now the main obstacles to decarbonising social housing remain:

- No existing capability to retrofit at scale
- No grant funding for deep retrofit
- Difficulty of securing debt funding at low enough rates to realise an acceptable IRR

This report, given its focus on the financing of retrofit, recommends:

- That the UK Government commit further grant funding for retrofit projects that go beyond EPC C to allow housing associations to begin full decarbonisation of existing stock now, which will not only achieve lower emissions sooner, but also avoid duplicating costs by requiring secondary retrofits in the future
- That the UK Government commit to a Social Housing Retrofit Guarantee to allow housing associations to access debt funding at competitive interest rates, which is vital to achieving the financial viability of retrofit.

With these two components in place the economies of scale are likely to become possible as the channelling of more capital into retrofit will support the development of a new sector with the necessary skills and capacity to reduce costs.

It will remain up to individual associations as to whether they choose to recuperate costs from tenants through service charges or rent increases. Because this report shows that there are scenarios where the capex on retrofit can be matched by cashflow savings over a long period, this means that the capex could be recuperated over the same period without a net loss to the tenant.

Even if an association chooses not to recuperate all costs, the implication is that with a combination of rent increases, grant funding, guaranteed debt funding and a small number of disposals, the eyewatering cost of decarbonising the UK's social housing stock can be met.

Despite the obstacles highlighted above, then, the roadmap to funding retrofit is becoming clearer, and on this basis the sector will be able to start focusing on the opportunities and benefits of decarbonisation—for associations, tenants, and their communities—rather than seeing it as an insurmountable challenge.

Appendix

A.1 Methodology

Energy modelling was carried out using The Standard Assessment Procedure (SAP) which is a government- regulated methodology for calculating energy and environmental performance of a domestic property used to produce Energy Performance Certificate (EPC). The outputs from FSAP software were used to calculate energy consumption (regulated and unregulated) and post- processed to determine related carbon performance between 2020-2050.

The scenarios modelled for retrofit include a baseline dwelling and four retrofit packages. Baseline scenario chosen stands for a dwelling from age category F (built in 1980s) representing majority of the existing social housing stock with EPC D to be upgraded to minimum EPC C by 2030. Proposed retrofit packages include interventions required to achieve EPC bands C, B, A and A+.

The new build baseline case represents dwelling of an EPC C and the following scenarios include intervention packages to improve EPC band to B, A and A+.

The energy model assumptions for each of the scenarios are presented in the section A.1.2.

A.1.1 Retrofit – energy modelling assumptions

Assumptions of the energy model for retrofit scenarios are shown in tables below.

Table 0-1 Fabric and technology assumptions for retrofit cases

	Baseline EPC D	Min EPC C	Mid EPC B	Max EPC A	Exemplar A+
U- value- wall (W/m2K)	1	0.17	0.17	0.1	0.1
U- value party wall (W/m2K)	0.5	0.2	0.2	0	0
U- value- roof (W/m2K)	0.68	0.11	0.11	0.1	0.1
U- value- floor (W/m2K)	0.5	0.13	0.13	0.13	0.13
U- value- windows (W/m2K)	4.8 (single)	1.4 (double)	1.4	0.8 (triple)	0.8
G- value- windows (W/m2K)	0.85	0.57	0.57	0.5	0.5
Air Tightness (m3/m2/hr@50Pa)	15	3	3	1	1
Heating	Gas boiler	Gas boiler	ASHP COP 2.7 Communal ASHP COP= 2.5	ASHP COP 2.7 Communal ASHP COP= 2.5	ASHP COP 2.7 Communal ASHP COP= 2.5
Ventilation	NV	NV	MVHR	MVHR	MVHR

Table 0-2 Installed peak power (kWp) of solar PV panels for Passivhaus retrofit cases

	Max EPC A	Exemplar A+
Semi- detached	1 kWp	2.6 kWp
Mid- terrace	0.7 kWp	2.6 kWp
Flat	1 kWp	2.3 kWp

A.1.2 New build – energy modelling assumptions

Assumptions of the energy model for retrofit scenarios are shown in tables below.

Table Error! No text of specified style in document.-3 Fabric and technology assumptions for new build cases

	Baseline EPC C	EPC B	EPC A	EPC A+
U- value- wall (W/m2K)	0.19	0.17	0.1	0.1
U- value party wall (W/m2K)	0.2	0.2	0.2	0.2
U- value- roof (W/m2K)	0.13	0.11	0.1	0.1
U- value- floor (W/m2K)	0.19	0.13	0.13	0.13
U- value- windows (W/m2K)	1.5	1.4	0.8	0.8
G- value- windows (W/m2K)	0.63	0.5	0.5	0.5
Air Tightness (m3/m2/hr@50Pa)	5	3	1	1
Heating	All electric	ASHP COP 2.7 Communal ASGP COP=2.5	ASHP COP 2.7 Communal ASGP COP= 2.5	ASHP COP 2.7 Communal ASGP COP= 2.5
Ventilation	MVHR	MVHR	MVHR	MVHR

Table 0-4. Installed peak power (kWp) of solar PV panels for Passivhaus new build cases

Solar PV panels- installed peak power	Max EPC A	Exemplar A+
Semi- detached	1 kWp	2.6 kWp
Mid- terrace	1kWp	3kWp
Flat	1.3 kWp	2.6 kWp

A.2 Housing typologies

A number of building typologies have been assessed for the purposes of this study:

- Semi- detached House
- Mid- terrace House
- 2 Bed Flat

Floor plans of the dwellings included in the energy model are shown in figures 0-1. to 0-3. below.

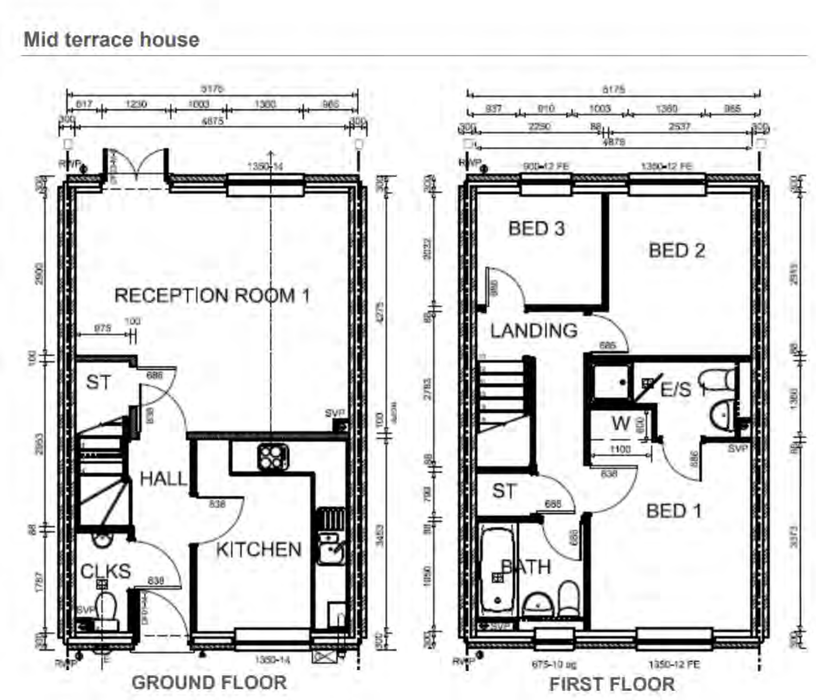


Fig. 0-1. Semi- detached house- floor plan

Fig. 0-2. Mid- terrace house- floor plan

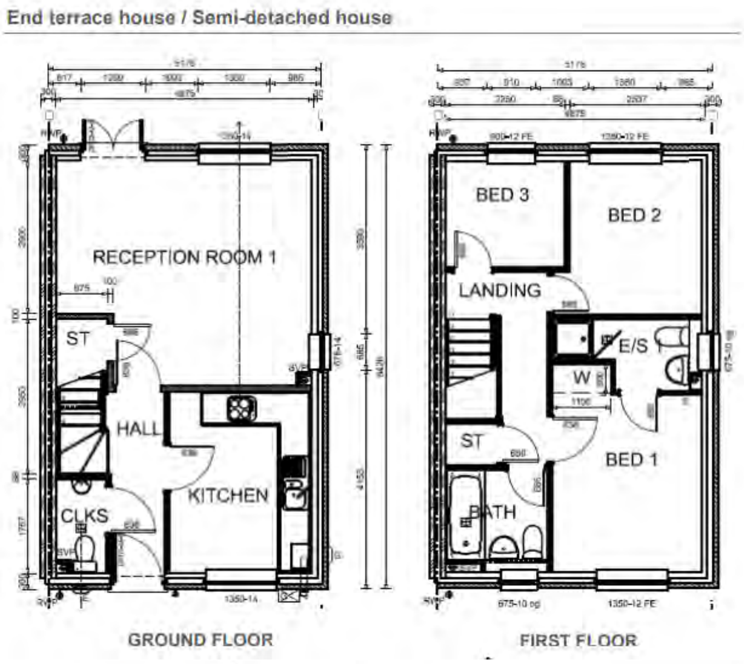


Fig. 0-3. Two bedroom apartment- floor plan

A.3 Sustainable Technologies

A.3.1 Mechanical ventilation with heat recovery (MVHR)

Mechanical ventilation heat recovery units (MVHR) are utilised as an alternative option to opening windows within dwellings to ensure sufficient ventilation rates whilst substantially reducing heat loss within winter months. Typical heat recovery efficiencies range between 73-80% depending on operational conditions and the type of heat exchanger utilised.
As well as benefits during winter operation, MVHR units can be designed to offer 'free cooling' during summer months when ambient conditions are lower than indoor conditions.

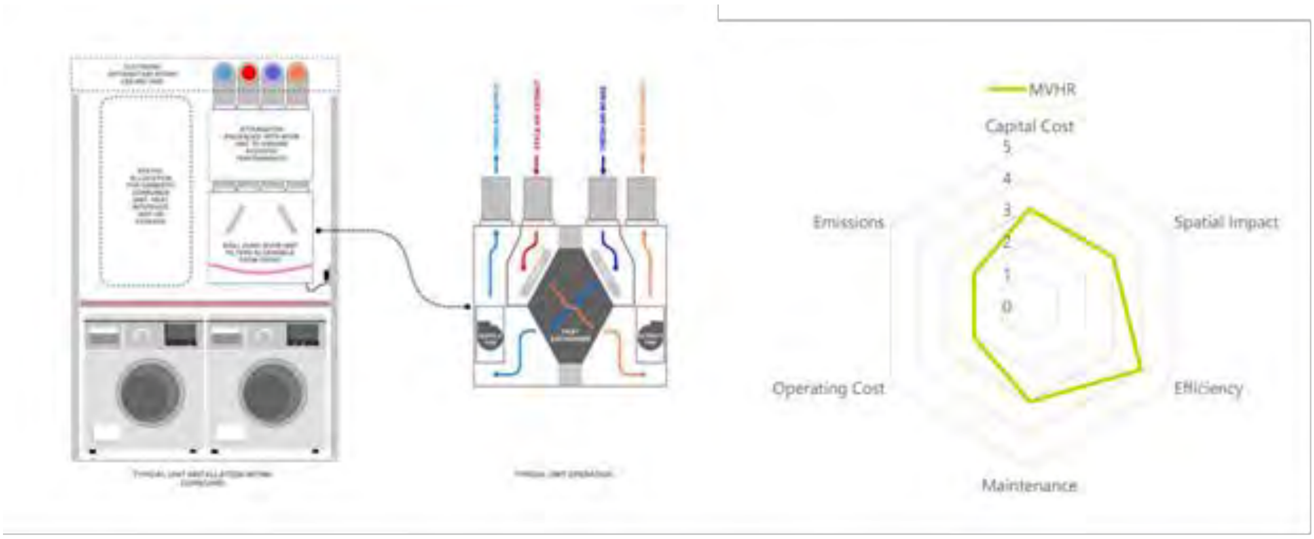


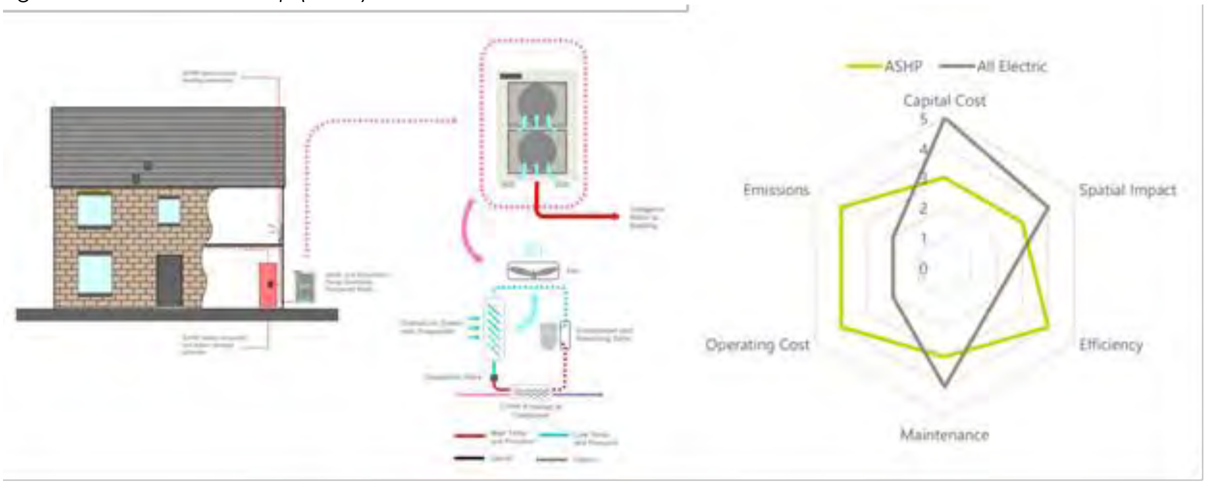
Fig. 0-5. Mechanical Ventilation with heat recovery (MVHR)- overview

Naturally, in comparison to natural ventilation, Mechanical ventilation requires electrical input to operate effectively. In order to minimise the energy usage associated with fan power units with a reasonable Specific Fan Power (SFP) are selected.

A.3.2 Air source heat pump (ASHP)

Air source heat pumps are a technology that have been utilised on a domestic scale in Scandinavia for a number of years. Whilst less popular in the UK at the moment, with a government drive to phase out gas fired installations, the market for domestic ASHPs is set to significantly expand. Air source heat pumps utilise the refrigerant cycle to draw energy from ambient air that is blown over an evaporator. Whilst the refrigerant process does require energy input, the overall system efficiencies can be very high due to the refrigerants used. Air source heat pumps are capable of providing hot water up to ~70C, however efficiency drops as the difference between ambient temperature and water supply temperature increases, this can typically affect seasonable performance as these are the periods in which demand is highest. Air source heat pumps require external installation to ensure free movement of fresh air, however commercial units are designed to have a minimally intrusive footprint.

Fig. 0-6 Air Source Hat Pump (ASHP)- overview



A.3.3 Communal Air source heat pump (ASHP)

The utilisation of Air Source Heat Pumps (ASHP) on a communal or district level involves the installation of a single central ASHP plant that provides low temperature hot water throughout a block of flats or cluster of houses. Typically proposed to reduce the spatial impact and capital cost associated with a large quantity of smaller, local ASHPs, communal systems reduce maintenance requirements for tenants of flats but may result in additional service charges. Commonly, a communal ASHP would couple with a local heat interface unit within each dwelling that is fitted with a plate heat exchanger and heat metering facilities. Local heat interface units would then feed the central heating system and a domestic hot water storage tank, that would typically be topped up through the use of an electric immersion element. Due to the refrigerants and compressors utilised within larger ASHPs there is added efficiency in the production of hot water for heating and consumption when compared to smaller units. However, the extended pipework routing results in an increase in distribution losses.

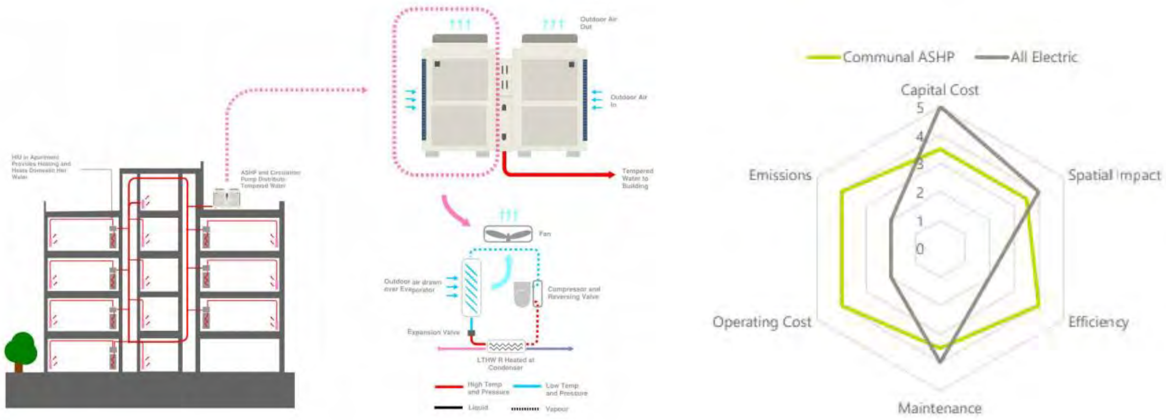


Fig. 0-6. Communal air source heat pump - overview

A.3.4 Solar Photovoltaic (PV)

Solar PV panels are utilised across approximately 1% of UK dwellings as a means of local electricity generation. Electricity is generated through the conversion of solar energy. It is important to note that well considered placement and orientation of PV installations are critical in ensuring optimal output. A 30° tilt on a South facing panel offers the highest rates of production. PV is used more frequently than Solar Thermal, as there is no risk of stagnation and there is potential to sell unused power back to the grid. Worth pointing out that electricity demands for UK dwellings peak during winter in the evening, when solar energy is unavailable- a solution here could potentially involve a battery storage.

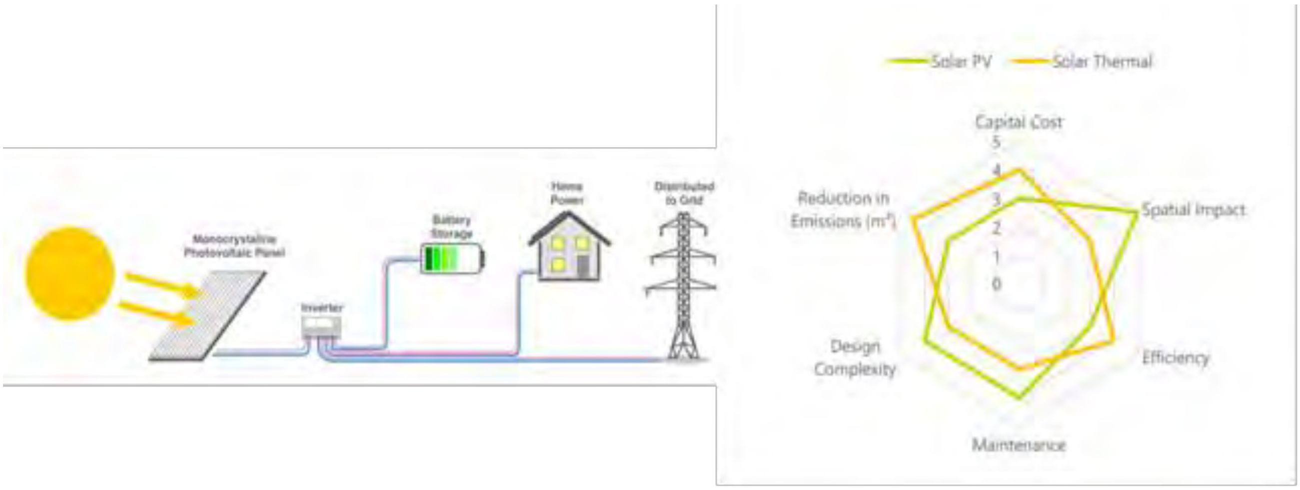


Fig. 0-7. Solar Photovoltaic (PV)- overview