Retrofit factfile

A short summary of facts and publications relevant to domestic retrofit.

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The case for retrofit

Emissions share

The domestic sector has a key role to play in delivering the UK's 2050 targets and ensuring a socially just energy future.

In 2014, the residential sector accounted for 12% of UK greenhouse gas emissions. Despite reductions in overall emissions the share has stayed roughly the same (10% in 1990).

DECC (2015) Final UK greenhouse gas emissions national statistics.

In terms of final energy consumption, the housing sector accounts for 29%, more than either road transport or industry.

DECC (2013) UK Housing Energy Fact File.

Research published by Preston *et al.,* (2013) suggests that household emissions are strongly correlated with household income, with higher income households responsible for a disproportionate share of total domestic sector emissions, a fact that becomes starker if emissions from driving and international flights are included in the analysis. The richest emit twice that of the poorest 10% of households in terms of household energy consumption.

Preston, I *et al.,* (2013) Distribution of carbon emissions in the UK: implications for domestic energy policy. Joseph Rowntree Foundation.

Housing stock

The vast majority of our homes will still be in use by 2050.

As of 2013 there were more than 27 million homes in the UK, compared to just over 23 million in 1990. Around 160,000 new homes are built each year, and far fewer are demolished.

DECC (2013) UK Housing Energy Fact File.

It is estimated that around 80% of the existing housing within Greater Manchester will still be in use by 2050.

New Economy Manchester (2013) Integrated GM Assessment: Environment Evidence Base.

Data from 2013 suggests that as many as:

- 7.6 million homes require solid wall insulation.
- 5.3 million require cavity wall insulation, 3.8 million of which are classed as 'hard to treat'.
- 7.4 million un-insulated lofts, 1.7 million of which are classed as 'hard to treat'.

DECC (2013) Estimates of Home Insulation Levels in Great Britain: July 2013.

In addition, data from 2012 estimates the following technical potential:

- 3 million homes require floor insulation
- 12 million homes require an upgrade to condensing gas boilers
- 2 million homes still have single glazing

DECC (2012) Final Stage Impact Assessment for the Green Deal and Energy Company Obligation. Department for Energy & Climate Change: London.

The case for retrofit

Progress to date

Past programmes have made progress against simple measures such as loft insulation and cavity wall insulation, the 'low hanging fruit'.

A constantly shifting policy environment is failing to deliver the more substantial energy reductions required.

All large energy suppliers have an obligation under the ECO (Energy Company Obligation) legislation to support energy efficiency improvements in both private and social housing.

As of April 2016, approximately 1.8 million measures had been installed. However, these were predominantly:

- Cavity wall insulation (36%)
- Loft insulation (25%)
- Boiler upgrades (22%)
- Solid wall insulation accounted for just 7% with approximately 120,000 installs.

The Green Deal was an initiative designed to support insulation, heating systems and renewable technologies through a 'pay-as-you-save' model, whereby the finance used to cover the cost of the installation is attached to the property, as opposed to the individual. As of April 2016 there were just over 14,000 households with a Green Deal Plan. The Government stopped funding the Green Deal Finance Company, the organisation established to finance Green Deal loans.

DECC (2016) Household Energy Efficiency, Headline Release. Executive Summary.

2001

The Decent Homes Standard is introduced for social housing.

2002

The Energy Efficiency Commitment (EEC) is introduced, covering gas & electricity.

2005

EEC is replaced by a new supplier commitment, the Carbon Emissions Reduction Target (CERT)

2008

The Community Energy Saving Programme (CESP) is introduced, requiring a focus on deprived areas.

2010

The Government announces the phasing out of Warm Front, a scheme that had delivered basic insulation and heating improvements to vulnerable households.

2011

The Energy Company Obligation (ECO) replaces CERT, CESP and Warm Front.

2013

The Green Deal launches. ECO is intended to complement it by subsidising the cost of solid wall insulation.

2014

Changes are made to ECO with targets reduced by over 30%, and resulting in a substantial cut to support for solid wall insulation.

2015

Alongside the scrapping of the zero carbon homes target is the Allowable Solutions Fund which would have contributed to retrofit funding.

The Green Deal Home Improvement Fund is closed.

The government announces it will no longer fund the company that provides Green Deal loans.

2016

In June the government publishes its consultation on changes to ECO for 2017-2018, including a 26% reduction in total funding and a focus on Affordable Warmth and 'low cost insulation' only.

For a more detailed timeline, see the National Energy Action website.

The case for retrofit

Demand, motivations and triggers

There is demand for retrofit in the owner occupier and private rented markets.

'Early adopters' are key.

Comfort is a key motivating factor for households. This challenges widely held assumptions about bill savings and payback.

Many energy efficiency improvements are directly linked and should not be considered in isolation. There are strong links to the general refurbishment and renovation market.

A desire to improve comfort is a repeatedly quoted reason behind much of the work undertaken by householders.

For Carbon Co-op's whole house retrofit programme, householder motivations were (in priority order):

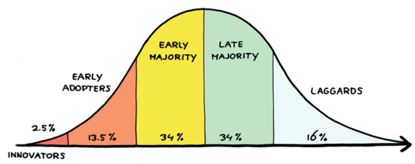
- To reduce carbon emissions
- To improve the comfort of their home
- To save money on their fuel bills

Grimshaw, H and Atkinson, J (2015) A community approach to retrofit and potential implications for the fuel poverty agenda. A report to the Chesshire Lehmann Fund by URBED and Carbon Co-op.

Other motivations (but ranked less highly) were:

- To be part of an innovative project
- To improve the fabric of their home
- To be part of a co-operative project

The innovation curve represents the idea that retrofit could diffuse and become more mainstream after it has been taken up (and tested) first by a small number of innovators and early adopters.



Although the viability of individual insulation measures, heating, ventilation and renewable technologies is relatively well established, the combination of improvements into a whole house package is perhaps less so. At present, the whole house retrofit market lacks clear routes to market, supply chain capacity, up-skilling and lower delivery costs which are all significant barriers.

Wilson *et al.,* (2013) argue that energy efficiency improvements are rarely done alone (only 1 in 10 would consider doing this), whereas including them alongside other 'amenity renovations' is 3 times as common.

Wilson, C., Chryssochoidis, G. and Pettifor, H (2013) Understanding Homeowners' Renovation Decisions: Findings of the VERD project. UKERC: London.

Energy efficiency improvements should not be thought about in isolation, and deep or 'whole house' retrofits have distinct advantages here. Research conducted by the UK Energy Research Council (Parkhill *et al.,* 2013) reinforces that improvements which reduce energy demand are not thought about in isolation, but rather as a key part of a whole range of other household issues.

Parkhill, K.A, Demski, C., Butler, C., Spence, A. and Pidgeon, N (2013) Transforming the UK Energy System: Public Values, Attitudes and Acceptability - Synthesis Report UKERC: London.

Buildings

Typologies

The UK housing stock is diverse, and there is no 'one type fits all' solution.

'The diversity of UK building stock in terms of age, use, materials, build type and quality, thermal mass, location, orientation and occupancy, means that solutions need to be specifically tailored to the building or group of buildings in question' (Stafford *et al.,* 2011)

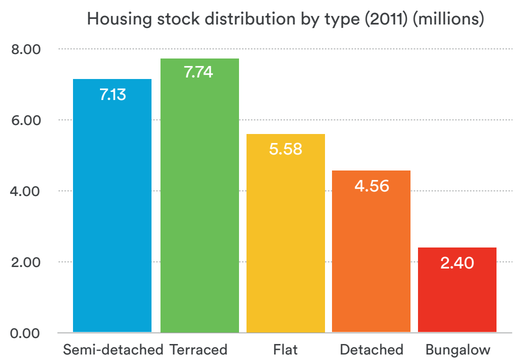
Stafford, A, Gorse, C and Shao, L (2011) The Retrofit Challenge: Delivering Low Carbon Buildings. The Centre for Low Carbon Futures.

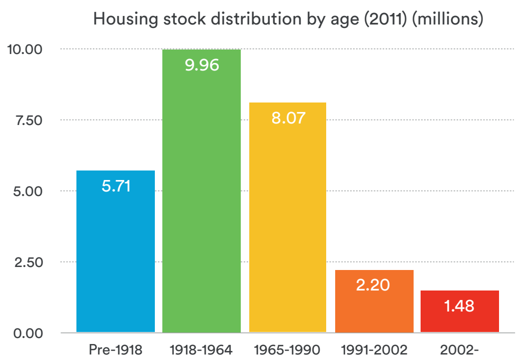
Data from DECC (2013) shows that while semi-detached and terraced houses have always been the most common house types (each representing just under a third of the housing stock from 1970 to 2011), flats and detached houses have become more common. Flats now account for 20% of the housing stock, and detached houses are 17%.

DECC (2013) UK Housing Energy Fact File.

The more compact a building is, the easier it is to make energy efficient. The Heat Loss Form Factor is a ratio of the surface area (thermal envelope) to the treated floor area. The higher the ratio, i.e. the greater the surface area, the more area there is for heat to escape through. If a building has a lot of recesses or protrusions in the thermal envelope, the surface area soon adds up. This means that flats are often relatively cheap and simple to retrofit, whilst complex detached houses are more difficult.

See Elrond Burrell's blog for a more detailed description of the Heat Loss Form Factor.





Buildings

Approaches

Reducing heat loss through the building fabric should be the priority - 'fabric first'.

A whole house retrofit in one go offers the greatest potential for efficiently integrating measures. However, this is not always practical and there is a need to provide guidance for those looking to phase a programme of works or focus on single measures.

Fabric first
'Environmentally and economically, it is often better to reduce overall energy demand before considering energy supply measures.

The ability for the remaining energy demand to be covered by renewables will be limited if efficiency levels are not prioritised, specifically when greater demand for heating occurs over winter, when less renewable energy is generated and storage losses make it difficult to have a sufficient amount available' (Institute for Sustainability, 2012).

Institute for Sustainability (2012) 'Retrofit insights: perspectives for an emerging industry' UCL Energy Institute and Technology Strategy Board.

Shallow vs deep retrofit
'Deep and shallow retrofit are qualitatively different. While shallow retrofit can be achieved by insulation, deep retrofit... typically also requires replacement of existing heating and ventilating systems, and the installation of renewables' (Institute for Sustainability, 2012).

Phased retrofit
'To achieve EU policy goals, it is ideal for a building retrofit to be performed all at once. The reality for many building owners however, is that it is financially and logistically not feasible to complete an entire deep energy retrofit in one step. More common, are partial retrofit steps, completed on a building over time, also known as step-by-step retrofits. In fact, 80-90% of all retrofits undertaken are retrofit measures rather than complete one-time deep energy refurbishments. Specifically for this type of retrofit, an overall and well-thought out plan right from the beginning is therefore crucial to the final energy savings when all retrofit steps are complete… These long-term plans must be tailored to individual buildings and their specific requirements, so as not to jeopardise future steps or to ensure that they are adequate for other steps to be carried out in the future and avoid not being able to further improve, also known as the lock-in effect' (EuroPHit, 2016).

EuroPHit (2016) Implementing deep energy step-by-step retrofits: Increasing the European potential.

Buildings

Building Performance

Understanding what works well, and what doesn't, is key to developing the whole house retrofit industry and increasing confidence amongst householders.

Resources should be made available to support the evaluation of projects.

'Fabric performance generally is a complex web of interactions, including thermal transmission of elements (walls, floors, roofs, windows etc), air tightness, thermal bridging and bypass mechanisms. It is therefore vital to regard refurbishment projects holistically, rather than as a series of disconnected measures, and to understand that the performance of measures in-situ can be affected by many factors, including process issues' (Stafford *et al.,* 2011).

Stafford, A, Gorse, C and Shao, L (2011) The Retrofit Challenge: Delivering Low Carbon Buildings. The Centre for Low Carbon Futures.

Post occupancy performance feedback on Carbon Co-op's Community Green Deal project has been extremely positive. Indications are that levels of post works energy performance are high and comparable to pre-works whole house assessments and modelling. Defects are small and minor for a project of this size and scope. This suggests that URBED's design package was of a high standard and that the contractor implemented it correctly.Post retrofit:

- The average reduction in gas use across the properties monitored is 47%.
- The average estimated space heating demand is 65 kWh/m²/year.
- The average CO_2 emissions reduction (including installed PV) is 62%.
- The average CO_2 emissions rate is 17 kgCO2/m²/year - the 2050 domestic retrofit target for Greater Manchester.

Grimshaw, H and Atkinson, J (2015) A community approach to retrofit and potential implications for the fuel poverty agenda. A report to the Chesshire Lehmann Fund by URBED and Carbon Co-op.

Community Green Deal householders have noted the following post-retrofit:

- Homes are warmer.
- Less damp and that the air feels fresher.
- Homes are less draughty.
- Homes are cooler in summer when it's hot
- Warmer in the mornings suggesting an improvement in minimum internal temperatures (i.e. when the heating is switched off).
- Homes are slower to cool down and faster to warm up.
- Improved occupancy of rooms that weren't frequently used before.

People

Housing and health

The links between poor housing and health are increasingly recognised, mostly recently through guidelines issued by NICE[1] (The National Institute for Health and Care Excellence).

1 The National Institute for Health and Care Excellence (2015) Excess winter deaths and illness and the health risks associated with cold homes.

The Marmot Review highlighted the relationship between excess winter deaths, low thermal efficiency of housing and low indoor temperature. The key health impacts of poor and thermal efficient housing are:

- Excess winter deaths are almost three times higher in the coldest quarter of housing. Excess winter deaths are linked to cardiovascular and respiratory diseases.
- Respiratory problems; children living in cold homes are twice as likely to suffer from these problems. Furthermore, damp and mould are more likely to occur in cold, poorly insulated homes.
- Mental health is negatively impacted by fuel poverty and cold housing for any age group.
- Increased risk of colds and flu, and exacerbation of existing conditions like arthritis.
- Cold housing can also indirectly affect educational attainment, emotional well being and resilience of children, dietary opportunities and choices, dexterity and increases the risk of accidents and falls.

Improving the energy efficiency of the existing stock is highlighted as a long-term, sustainable way of ensuring multiple gains, physical and mental health.

Marmot Review Team (2011) The Health Impacts of Cold Homes and Fuel Poverty. Friends of the Earth and the Marmot Review Team.

Data from the Carbon Co-op retrofits suggests improvements in minimum internal temperatures which could make a huge improvement to the health of vulnerable householders. In one household pre-retrofit temperatures were regularly dropping to 14°c when the heating was off. Post-retrofit, the minimum internal temperature is typically 1°c higher.

Grimshaw, H and Atkinson, J (2015) A community approach to retrofit and potential implications for the fuel poverty agenda. A report to the Chesshire Lehmann Fund by URBED and Carbon Co-op.

People

Fuel poverty

Fuel poverty is a complex issue, caused by any or all of the following factors:

- Inefficient housing
- High energy prices
- Low incomes

Many fuel poor (or vulnerable) households under-heat their homes, making a decision between whether to 'heat or eat'.

Prepayment meters proliferate amongst fuel poor households, locking them in to higher tariffs and effectively disconnecting through choice.

One of the key findings of the Marmot Review is that 'one of the most sustainable ways of tackling fuel poverty and limiting the impact of fuel price increases is to build energy efficient housing and retrofit the existing housing stock to an energy efficiency level that would make it extremely hard for people to fall into fuel poverty.'[1]

1 Marmot Review Team (2011) The Health Impacts of Cold Homes and Fuel Poverty. Friends of the Earth and the Marmot Review Team.

As of 2003 there were approximately 2.44 million (11.8%) households in fuel poverty. In 2011 this was estimated at approximately 2.39 million (10.9%). The fuel poverty gap shows the depth of fuel poverty has increased significantly, with households needing to spend an additional £248 more to reach a modelled 'standard' in 2003, and this increased to £438 in 2011.

DECC (2013) UK Housing Energy Fact File.

Research from Guertler and Preston (2009) estimates that raising all properties in England to a SAP rating of 81 (equivalent to Energy Performance Certificate band B) would lift 83% of households out of fuel poverty.

Guertler, P and Preston, I (2009) Raising the SAP: Tackling fuel poverty by investing in energy efficiency. Consumer Focus.

The Greater Manchester Business Case estimates that for every 2,000 households supported out of fuel poverty, the potential benefits to the NHS alone (due to reduced winter morbidity and mortality) stand at £1m per year.

Greater Manchester Environment Commission. Greater Manchester domestic retrofit programme: red brick to green brick.

England
The target established in the Government's Fuel Poverty Strategy is 'to ensure that as many fuel poor homes as is reasonably practicable achieve a minimum energy efficiency rating of Band C, by 2030'.

DECC (2015) Fuel poverty strategy for England. HM Government.

Scotland
The Scottish Government aims to ensure that by November 2016, so far as is reasonably practicable, people are not living in fuel poverty in Scotland. The Scottish Government is currently working on a new fuel poverty strategy.

Scottish Government's Fuel Poverty Policy

Wales
The Welsh Government published a fuel poverty strategy in 2010. Their target is to eradicate fuel poverty, as far as is practical, in vulnerable households by 2010, in social housing by 2012 and in all households by 2018.

Welsh Assembly Government (2010) Wales Fuel Poverty Strategy.

Northern Ireland
Northern Ireland published a fuel poverty strategy in 2011. It notes that the previous strategy included a target to eradicate fuel poverty by 2016. The current strategy aims to target resources on those vulnerable households most in need of help, but with the eradication of fuel poverty remaining as a core goal.

Department for Communities (2011) Warmer Healthier Homes - a new fuel poverty strategy for Northern Ireland.

People

Fuel bill savings

A widely quoted benefit to retrofit is savings on energy bills.

Although there is evidence of substantial reductions in energy costs, particularly through whole house retrofit, it would be wise not to overstate the benefits, moving away from a fixation on savings and payback periods.

'The installation of a large package of energy-efficiency measures and LZC (low or zero carbon) technologies could enable households to make substantial savings. Overall fuel savings for the UK population associated with a large-scale programme of retrofit are projected to be between £76bn (£70bn in England) and £131bn (£120bn in England) over the lifetime of the measures, depending on the set of assumptions used' (WWF, 2010).

WWF (2010) Retrofitting the UK's homes: opportunities for the economy.

For the Carbon Co-op retrofits, initial analysis of bill data from four of the households suggests reductions in gas use from 56-47%, with annual savings (exclusive of PV generation) ranging from £200-£600. Including income from the Feed in Tariff the average saving is £900, with one householder having bills of £-70 (minus) per year, in effect generating income from their home.

The National Audit Office report into the Green Deal and ECO found that despite consumer research showing that people were interested in benefits other than financial savings, such as a warmer home, early marketing by the government focused almost exclusively on financial benefits.

National Audit Office (2016) Green Deal and Energy Company Obligation.

People

Behaviour change

Any retrofit programme which fails to address wider issues of behaviour is unlikely to reach its full potential.

The ECI 40% House report states that: 'if UK society continues to develop along current trends, no carbon reductions are expected by 2050. Only societies where environmental concern and awareness are much stronger than today will produce significantly reduced carbon emissions.'

Boardman, B, Darby, S, Killip, G, Hinnells, M, Jardine, C N, Palmer, J and Sinden, G (2005) 40% House. Environmental Change Institute.

'A carbon emissions reduction plan directed at existing housing (domestic retrofit), is unlikely to achieve its aims without the positive engagement of the people who live in buildings targeted for improvement.' They (LCEA) suggest that context change (for energy saving measures and behaviours) can be achieved in a number of different ways, but should be focused on three key mechanisms:

- Better information, education and awareness
- Innovative and cost-effective incentives (the "nudge" element)
- Building the capacity of the intermediaries (including community groups) to support and reinforce energy saving decisions (the "think" element)

LCEA Behaviour Change Retrofit Group (2011) The Missing Quarter: Integrating Behaviour Change in Low Carbon Housing Retrofit.

Householders from Carbon Co-op's Community Green Deal programme noted that it has made them more perceptive and questioning of their behaviour. For example, 'do I need hot water for this?'

Grimshaw, H and Atkinson, J (2015) A community approach to retrofit and potential implications for the fuel poverty agenda. A report to the Chesshire Lehmann Fund by URBED and Carbon Co-op.

Take back/rebound effect
'In dwellings where fuel poverty is a factor in restricting energy use, the effect of retrofit interventions may not be to reduce consumption, but instead to allow occupants to increase their levels of comfort. This is the so-called 'take back' effect - i.e. they prefer additional comfort and warmth over money savings' (Maby and Owen, 2015).

Maby, C and Owen, A (2015) Installer Power: The key to unlocking low carbon retrofit in private housing.

The 'rebound effect' occurs where a household reacts to improved energy efficiency by purchasing more energy services (Dimitropoulos and Sorrell 2008). This could be because they have more money to spend (income effect), or that they reallocate resources to energy services now that these give them better value for money (substitution effect). On the other hand, a consumer may build on having made their home more environmentally friendly by taking up other environmentally friendly behaviours (spill over effect).'

Sorrell, S and Dimitropoulos, J (2008) The rebound effect: Microeconomic definitions, limitations and extensions. Ecological Economics, 65 (3). pp. 636-649.

The economy

The market for energy efficiency

The direct market for energy efficiency (e.g. for insulation products/contractors) is substantial but has suffered during the last 5 years of policy changes.

The potential within the wider Repair Maintenance and Improvement (RMI) sector is huge, but poorly engaged with.

The overall market for energy efficiency in the UK was estimated at £8.25bn in 2007 (DECC, 2012).

DECC (2012) Final Stage Impact Assessment for the Green Deal and Energy Company Obligation.

'For every €1 of public funds spent on the KfW Energy-efficient Construction and Refurbishment programme in Germany in 2010, over €15 were invested in construction and retrofit, and more than €4 went back to the public finances in taxes and reduced welfare spending' (KfW, 2011).

KfW (2011) Impact on public budgets of the KfW promotional programmes.

'RMI in total, across all buildings and structures, was an area of economic activity valued at approximately £28 billion (Killip 2012) in 2009 compared with energy efficiency spending, through the energy company obligation Carbon Emissions Reduction Target (CERT) scheme, of £800million in the same year'

Killip, G (2012) Beyond the Green Deal: Market Transformation for low-carbon housing refurbishment in the UK. Retrofit 2012 conference, University of Salford.

'The evidence of pioneers is that there are many good opportunities at the level of room-by-room projects, such as new kitchens, bathrooms, conversions and extensions' (Sustainable Energy Academy 2007).

Sustainable Energy Academy (2007) Old Home Super Home.

Killip (2011) estimates that the untapped market opportunity for room-by-room approaches was some £12.5bn in 2009 (45% of the total spent on domestic RMI).

Killip, G (2011) Implications of an 80% CO_2 emissions reduction target for the UK housing refurbishment industry.

Energy efficiency as a national infrastructure priority

A report headed by the UK Green Building Council (UKGBC) calls on the Government to include energy efficiency within the UK's Infrastructure Plan. This would include an ambitious target of 1 million deep retrofits a year with at least half a million retrofits a year to bring all low income households up to a minimum EPC Band C by 2025.

UKGBC (2015) A housing stock fit for the future: Making home energy efficiency a national infrastructure priority.

In 2014 Labour outlined their plans for energy efficiency suggesting that they would designate it a national infrastructure priority.

Labour (2014) An end to cold homes: One Nation Labour's plans for energy efficiency.

The economy

Whole house retrofit costs

The evidence base for the SHAP 'Beyond Decent Homes' standard suggested a range of between £16,000 to £34,000 per property for a programme delivering 80% CO_2 reductions for at least 1,000 properties.

Whilst this scale of deep whole house retrofit is not taking place as yet, projects completed to date do suggest that there is some room for savings - though the question of how retrofit scales up is crucial.

For the Carbon Co-op programme the following spend and CO2 savings apply:

Household	£ spent (including fees and on costs, ex VAT)	annual carbon savings (kg)
A	£33,295	2,410
B	£41,463	3,093
C	£33,064	2,077
D	£40,105	3,394
E	£55,359	3,466

These are actual figures from construction and post-completion monitoring. These savings should continue for many years, as the majority of the measures were long-lasting, such as wall insulation and windows which should last 30 years or more. Whilst this cost may be justified in environmental terms and because householders gain other benefits, there may be potential for further savings in scaling up the process (Carbon Coop estimates):

Item		Approx. current cost	Potential reduction	Approx future cost	Comment
Assessment		**£1,000**	**50%**	**£500**	Creating web tool, streamlining process.
Contract Works	Net Contract Value:	£30,000	*7%*	£31,674	
	Materials	*£30,000*	*2%*	*£29,400*	Bulk purchase, 'Main Contractor Discount' as projects increase in scale.
	Materials	*£29,400*	*3%*	*£28,518*	Product development - mass production of previously bespoke products, improved manufacturing efficiency.
	Labour	*£28,518*	*2%*	*£27,948*	Construction labour cost reduction through improved build-ability and better contractor understanding.
	Prelims	£4,500 (15%)	20%	£3,354 (12%)	Cost reductions through economies of scale. e.g. 20/30 houses within 10 minutes of each other reduce.
	Sub-Total	**£34,500**	**9%**	**£31, 302**	
Construction Contingency		**£5,175 (15%)**	**32%**	**£3,130 (10%)**	Reduction in contingency through thorough pre-start preparation
Design fees and on-costs		**£4,000**	**5%**	**£3800**	Better information management and work-flow.
Householder engagement		**£1,000**	**30%**	**£700**	Better engagement with householders, as more retrofit show households are created etc.
Misc costs (statutory fees etc)		**£1,500**	**20%**	**£1200**	Some reductions in costs as households aggregate and contracts grow.
Total		**£47,175**	**14%**	**£40,632**	

Note: these costs are for 'retrofit' works only and do not include redecoration or relocation costs. All figures estimated to include VAT.

URBED (2011) Community Green Deal: Developing a model to benefit whole communities. A report for the Sustainable Housing Action Partnership and the Homes and Communities Agency.

The economy

Order of improvements and savings implications

The order in which improvements are made affects the savings potential, and could increase costs. Therefore considering options holistically at the beginning can reap rewards.

Research by Simpson *et al.,* (2015) on the intervention sequence for a 1930s semi-detached house found that whilst a whole house retrofit would reduce cumulative CO2 emissions over 25 years by 54%, the sequences actually implemented by the individual households result in significantly smaller reductions of between 42% and 24%.

'This variation in operational performance due to the intervention sequence means that there is a variable return on the investment for a particular technology and, significantly, that different sequences will yield different cumulative emission reductions. Although different scenarios can achieve the same final annual energy consumption, the cumulative emissions can due to the order and timing of different interventions.'

Simpson, S, Banfill, P, Haines, V, Mallaband, B and Mitchell, V (2015) Energy-led domestic retrofit: impact of the intervention sequence. Building Research and Information.

The economy

Type and quantities of jobs

Tapping into the RMI market could generate opportunities for a wide range of skills and trades.

This includes:

- Roofing activities
- Other building completion and finishing
- Glazing
- Joinery
- Plastering
- Plumbing, heat and air-conditioning
- Electrical
- Construction of new homes

(Maby and Owen, 2015)

'A large proportion of RMI work is delivered by micro enterprises and sole-traders. Working on residential property is the main focus for 42 to 47% of small firms in the construction industry.

It is difficult to separate out firms working on RMI from the broader category of firms working in construction, but the importance of small firms in the sector is clear. Around 330,000 people work in the 120,000 firms who employ 13 people or less in the residential property areas of the construction industry (ONS 2012b, ONS 2013b, ONS 2014b). Of these, over 75,000 are individuals working on their own in terms of running their business, although not necessarily in isolation in terms of delivering projects' (Maby and Owen, 2015).

Maby, C and Owen, A (2015) Installer Power: The key to unlocking low carbon retrofit in private housing.

Office for National Statistics, 2012b. Construction statistics 2012 Table 3.4 reporting on figures to the end of Q3 2011. London, ONS.

Office for National Statistics, 2013b. Construction statistics 2013 Table 3.4 reporting on figures to the end of Q3 2012. London, ONS.

Office for National Statistics, 2014b. Construction statistics 2012 Table 3.4 reporting on figures to the end of Q3 2013. London, ONS.

Job quantities
Over 135,000 people are currently employed in the energy efficiency industry (DECC, 2013).

Department of Energy & Climate Change (2013) Energy Efficiency Strategy: 2013

Some estimate that major investment in energy efficiency could almost double the number of jobs in the sector to 260,000 (Cambridge Econometrics and Consumer Futures, 2012).

Cambridge Econometrics and Consumer Futures (2012) Jobs, growth and warmer homes: evaluating the economic stimulus of investing in energy efficiency measures in fuel poor homes.

Estimates from autumn 2015 suggested that as many as 2,000 jobs directly related to energy efficiency had been lost since the raft of policy changes in summer 2015 (Murray, 2015).

Murray, J (2015) National Insulation Association says 2,000 green jobs lost due to energy efficiency policy 'void'. Business Green.

Role in behavioural change
Recent research has also shown that installers are important in behavioural as well as economic terms. Householders are influenced in what technology they adopt, and how they use it, by the advice they receive from installers, and how they experience the installation process (Owen *et al.* 2012, Owen 2013).

Owen, A., Mitchell, G. and Unsworth, R (2012) Reducing carbon, tackling fuel poverty: adoption and performance of air-source heat pumps in East Yorkshire, UK. Local Environment 1-17.

Owen, A. (2013) Factors that affect the diffusion and impact of domestic 'green technology' and the role of 'place'. (PhD). Leeds, University of Leeds.

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CarbonCo–op