Energy Saving Trust Innovation Programme

Report presented by
Energy for Sustainable
Development Limited
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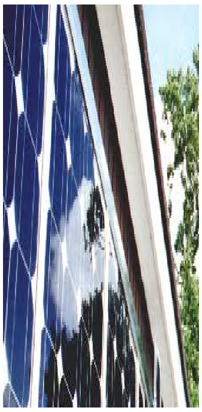
Low Carbon Homes:
towards zero carbon refurbishment
Feasibility study


June 2004

1. PROJECT DETAILS

Project Name	Low Carbon Homes: towards zero carbon refurbishment
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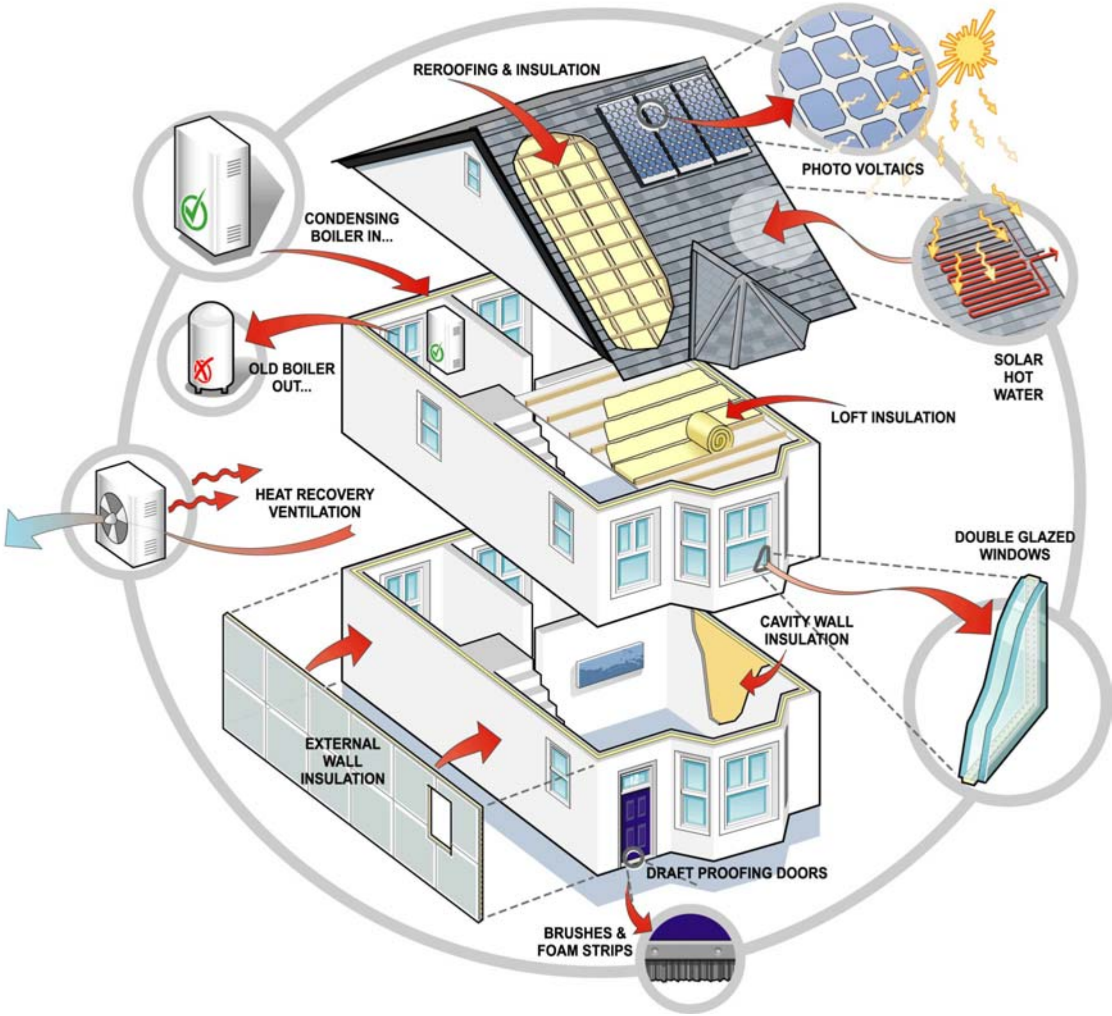
2. PARTNER DETAILS

Partner organisations	What is their role or intended role?
The Rudloe Centre (TRC) – Lead partner	Not-for-profit organisation Overall project management, coordination and reporting
Oxford City Council (OCC)	Local Authority Guidance with housing issues – range of building types, tenant relationships, and refurbishment work in houses
ESD Ltd.	Expertise in building integration of new and renewable energy technologies. Research, preparation of the project plan and final report
INREB Faraday Partnership (BRE)	Expertise in building integration of new renewable energy technologies A DTI Partnership comprising the BRE, De Montfort, Loughborough, Nottingham and Ulster universities.
Loughborough University	University Expertise in renewables in buildings, particularly PV, wind, CHP; understanding of the RE supply chain

3. EXECUTIVE SUMMARY

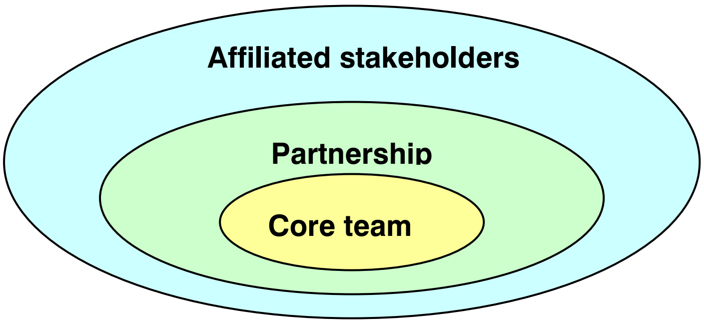
This feasibility study looked at the practical issues of achieving more than 60% CO_2 emission reductions in the existing housing sector by means of an integrated refurbishment approach. The study dealt with three main areas:

1. Availability of technical solutions for carbon emission reductions from residential buildings and their individual and aggregate impact and cost-effectiveness. A range of tried and tested energy efficiency measures and renewable energy technologies were examined against typical domestic energy uses, such as space heating, water heating, cooking, and lighting and appliances. The conclusion is that individually these measures, such as various fabric insulation, high-performance boilers and renewables, cannot achieve the targeted 60% CO_2 cuts. Therefore, several combinations of low-carbon technologies were developed to establish their theoretical impact on carbon emissions and were set against a typical baseline case – a cavity wall semi-detached house. The results show that even a full package of energy efficiency measures needs to be combined with at least one renewable energy technology in order to achieve or exceed 60% CO_2 savings. These findings solicit for a comprehensive approach to energy-driven refurbishment of homes, illustrated in the figure below:



Alongside technical feasibility, the study identified a number of logistical issues relating to the management and occupancy of properties due for refurbishment. Following consultations with social housing landlords, it became clear that tenant attitude and requirements should be carefully considered and taken into account. It is advisable that refurbishment work be planned and carried out in a way that minimises disturbance to the occupants. Decanting should be avoided and refurbishment would preferably be competed quickly through intensive work. The study identified opportunities for improving cost-effectiveness and maximising resources by means of well-planned processes, such as short-term and full-scale installation of measures, either simultaneously or in a tight sequence.

2. Exploring the opportunities for involving a broad group of stakeholders and for establishing an industry partnership. The feasibility work is based on the recognition that a strong private-public coalition is required to promote and mainstream the super low carbon refurbishment of houses in the UK (C60%+). More than 30 private companies and 250 Housing Associations were contacted to gauge the level of interest in the concept. The results show that there is a good potential for establishing a formal partnership that can take the C60%+ concept further to implementation. The scope, diversity and organisation of such a partnership were examined and a model was proposed. Essentially, the low-carbon buildings supply chain needs to be integrated at several levels, allowing for both targeted short-term actions and growing longer-term impacts. The model suggests a core team of 3-5 organisations to lead and co-ordinate a partnership of 20 organisations, representing all segments of the supply chain (technology suppliers, property managers, investors and funders, and consultants). The partnership will maintain contacts with the broader group of affiliated stakeholders and create opportunities for information exchange and project development.



The study also explored the opportunities for financial support to both the partnership and a large scale demonstration project and developed a matrix mapping out potential sources and their level of contribution against perceived project activities. The general conclusion is that the existing funding opportunities can possibly be sufficient to finance such a project, but considerable efforts would be required to secure support. The demonstration scheme itself was defined in terms of size, structure and total value – a total of 100 houses in one or several sites refurbished up to at least C60% level, costing approximately £5 million.

3. Developing of an implementation plan for a large scale C60%+ demonstration project in the social housing sector. The main activities and associated time scales have been proposed for the implementation stages of the project. In order to overcome existing technical, management and financial hurdles without significant delay of the final outcomes, it is necessary to proceed with most tasks simultaneously. Completion of the 100-house demonstration scheme is envisaged for the end of 2006 with significant progress with setting up the scheme achieved by the end of 2005.

The project partners will be applying for EST implementation funding to continue the project.

Contents

4. SCOPE OF THE STUDY

This feasibility study is concerned with the huge existing housing stock in the UK, which will need to be dealt with robustly in order to help meet the Government CO_2 emission targets for the next few decades. There are about 20 million houses in the UK and this work targets the most common types where the largest impact could be achieved - 3-bedroom semi-detached houses (29% of total) and terrace houses (28% of total). Combined, they form more than half of all residential properties in the UK. The study primarily looks at the social housing sector, such as Registered Social Landlords (RSL), which manages approximately 35% of the total stock. Potential replication in the private property sector, comprising 65% of the UK housing stock, has been broadly flagged up and earmarked for further research.

The scope of the study is to look at technical solutions that have the potential to reduce carbon emissions from a property by more than 60%. These include energy efficiency measures, that reduce energy demand and improve energy utilisation, as well as renewable technologies, which can provide an independent source of energy to meet in full or in part the consumption of delivered energy. The study looks at combinations of these technologies in order to establish the theoretical potential for minimising the dependence on mains power.

This work does not discuss behavioural measures for reducing energy consumption in the home or purchasing green electricity from the grid. It is not within the present scope of work to look at high rise buildings.

5. BACKGROUND

In 2003, the Government published its Energy White Paper, which recognised the growing threat of global climate change impacts, and pledged 60% carbon dioxide emission reductions by 2050 in order to minimise adverse consequences. Nevertheless, the current trends show that the discrepancy between targeted and actual emission levels is widening and over time it will become more difficult and expensive to bridge this gap. The required emission reductions from each sector will vary due to their uneven growth and range of available solutions. Thus, the existing housing stock is likely to require emission cuts of more than 60% in order to compensate for other sectors, such as transport.

The current approach to energy-driven house refurbishment is one of piecemeal application of technical measures that by no means have the potential of achieving the 60% emissions target. Moreover, there is only theoretical knowledge of how a more intensified deployment of energy solutions can be carried out and virtually no confirmation of performance of such an approach. Previous demonstration projects involving some monitoring have a relatively narrow scope for significant CO_2 cuts by trialling individual techniques, mainly insulation. The 1973-84 Better Insulated House Programme dealt with cavity wall insulation and resulted in modest energy savings and some increase in indoor temperature. More recent initiatives of some Local Authorities, such as Aberdeen, Bedford, Hull and Leicester City Councils and Kirklees Metropolitan Council, have experimented with various types of insulation and heating/ventilation techniques, which are inherently unable to bring 60%+ CO_2 reductions.

6. PURPOSE OF STUDY

The global objective of the feasibility study is to inform and enable a large demonstration refurbishment project that will test the extent to which carbon savings are possible in practice on an individual house scale with the current spectrum of available technologies. The project will also serve as an example for replication that will address the growing issues of upgrading the existing housing stock to a high energy performance standard.

This work brings extra light to the general theoretical understanding of the technical, economic and social aspects of major refurbishment schemes. By examining the technical solutions and proposing an integrated approach, the study aims to lead to the establishment of a systemised approach to retrofitting of dwellings. By analysing the financial parameters associated with this process, more clarity about the mechanisms for carrying out such capital-intensive works and the potential sources of funding is provided. By looking at the social housing sector, the main logistical issues of working in rented properties have been discussed.

Most of all, this study addresses the existing fragmentation of the sustainable energy sector in the UK and explores the potential for consolidating a broad stakeholder base, which will adopt an organised and intensive long-term approach to converting energy inefficient houses into highly efficient ones. The present work has identified the relevant business groups that need to be involved and suggests a partnership mixture that will be capable of developing and implementing a strategy for a large-scale demonstration scheme.

7. AIMS AND OBJECTIVES FOR THE PARTNERS

The partners to this feasibility study have recognised the complex nature of carrying out a sizeable demonstration pilot in which a large number of stakeholders need to be involved. A three-stage programme has been prepared where each stage represents a key objective in the overall strategy:

Stage 1 – Feasibility study – setting the framework through developing technical solutions, identifying stakeholders and sources of funding for the implementation.

Stage 2 – Stakeholder involvement – assembling a broad group of stakeholders that would commit to further developing the demonstration concept and take it to implementation

Stage 3 – Implementation – Refurbishment of a large group of dwellings beyond 60% carbon reductions by applying integrated energy solutions.

8. ROLE OF PARTNERS

Partner organisations	Role
The Rudloe Centre (TRC)	Overall project management, coordination and reporting; consultation with potential stakeholders
Oxford City Council (OCC)	Guidance with housing issues – building types, tenant relationships, and refurbishment works
ESD	Research, preparation of the project plan and final report
BRE (INREB)	Development of building integration of new renewable energy technologies and optimising combinations of measures
Loughborough University (INREB)	Expertise in renewables in buildings, particularly PV, wind, CHP; understanding of the RE supply chain

9. PROGRAMME OF WORK

Month:	Jan			Feb				Mar				Apr				May				Jun	
Tasks																					
Project Kick Off	■																				
Examine types and number of houses	■	■	■	■	■																
Examine available technical solutions	■	■	■	■	■	■															
Develop integrated packages of measures						■	■	■	■	■											
Explore the implications for householders									■	■	■										
Determine the range of stakeholders										■	■	■	■								
Develop stakeholder partnership concept														■	■	■	■	■			
Develop implementation plan																		■	■	■	
Final feasibility report																					■

Examine available technical solutions - energy efficiency, renewables, establish potential levels of CO_2 savings; gather data on products and prices and clarify installation issues.
Develop integrated packages of measures - identify synergies between technologies and potential for additional CO_2 savings; develop three mini-scenarios involving different number/range of measures to be applied; recommend a best package of integrated measures based on CO_2 savings
Examine number/types of houses needed for a larger demonstration project. Analyse the existing housing stock in terms of type of houses and proportion of total; identify and assess the different house types in terms of applying integrated low-carbon measures; appraise the potential CO_2 savings by house type and recommend optimum mix; analyse the CO_2 impact of a group of refurbished houses; recommend optimum house group size;; appraise the options for refurbishing a larger group (min 20) houses
Explore the implications for householders – establish the practices of carrying out refurbishment works in managed properties; map out and evaluate the processes related to refurbishment and look at the issues of tenant relocation, inconvenience, and approval.
Determine the range of stakeholders that need to be involved - analyse the supply chain: Industry - developers, technology providers, contractors, installers; Property owners/managers - LAs/HAs, landlords, tenants; investors, insurers, community groups, etc. Contact large organisations and discuss concept with them
Develop stakeholder partnership concept - work out structure of partnership; invite particular organisations to participate; carry out consultations with stakeholders to establish their views, commitment, and requirements; look at financial implications, timing, logistics
Develop implementation plan suggest size of demonstration project and participating organisations; work out scope of refurbishment, timing and budget; identify potential sources of funding

10. RESULTS

The feasibility has looked into two main areas:

1. Technical feasibility and hard solutions that relate to combinations of energy-saving or energy–generation measure. This includes carbon reduction effect of a measure, cost, and combination with other measures.
2. Implementation feasibility where the mechanisms for carrying out a full demonstration programme and the range of stakeholders necessary to be involved have been examined

10.1. AVAILABLE TECHNICAL SOLUTIONS

The research work included collecting information on products and materials from manufacturers and suppliers as well as from generic sources, which provide information on performance (longevity and carbon savings) and cost. For the purposes of the study, this has been summarised in the sections below.

Installation issues have also been looked at and summarised as a parameter – 'installation complexity' – this has taken into account several factors:

- Access to part of the house where the measure is to be installed (interior, exterior, roof)
- Number of people required to install the measure (one or more)
- Time required to fully install the measure (half a day, 1 day, more than 1 day)
- Necessity for auxiliary installations (scaffolding, additional storage, digging machines)

The installation complexity scale is defined between 1 (least complex) and 5 (most complex).

10.1.1. Basic improvement measures – fabric

Typical tried and tested energy conservation measures are associated with insulating the building fabric. They are readily available with a life span of about 30 years and include:

- Cavity wall insulation
- Top-up loft insulation
- Full double glazing
- Floor insulation
- Draught stripping and fans

Measure	Cost	Installation complexity	CO_2 savings (tonne/yr)	Lifetime CO_2 saved (tonnes)	£ spent / tonne saved
Cavity wall insulation	£340	2	1.3	39	£9
Top-up loft insulation	£220	2	0.1	3	£74
Full double glazing	£2900	4	0.4	12	£240
Draught stripping + fans	£200	2	0.2	2	£100
Floor insulation	£1500	4	0.3	9	£165
Total fabric package	**£5160**		**2.3**	**65**	**£79**

Applying standard measures to the building fabric can achieve only over half of the targeted level. Therefore, attention should also be given to the house services, including heating, lighting, appliances, etc.

10.1.2. Improvement measures – heating

Typical proven energy efficiency and conservation measures associated with space heating have a life span of about 10-15 years and include:

- Condensing boilers
- Heating controls – thermostatic radiator valves (TRV)
- Heating insulation – hot water cylinder

Measure	Cost	Installation complexity	CO_2 savings (tonne/yr)	Lifetime CO_2 saved (tonnes)	£ spent / tonne saved
TRVs	£200	1	0.1	1	£200
Cylinder insulation	£20	1	0.1	1	£20
Option 1					
Condensing boiler + controls	£1200 (total cost)	3	0.8	8	£150
	£500 (marginal cost)		0.8	8	£63
Total heating package 1	**£1420**		**1.0**	**10**	**£142**
Option 2					
Condensing combi boiler	£1600 (total cost)	3	1.2	12	£134
	£400 (marginal cost)		1.2	12	£34
Total heating package 2	**£1820**		**1.4**	**14**	**£130**

10.1.3. Lights and appliances

Energy efficiency of lights and appliances relates to better performing products. They are readily available with a life span of about 10 years and include:

- Low energy light bulbs
- A-rated appliances

Measure	Cost	Installation complexity	CO_2 savings (tonne/yr)	Lifetime CO_2 saved (tonnes)	£ spent / tonne saved
Lights and appliances	£1360 (total cost)	1	0.5	5	£272
Lights and appliances	£100 (marginal cost)	1	0.5	5	£20

10.1.4. Advanced improvement measures - package

Additional non-standard energy efficiency measures could be applied that are typically capital-intensive. They have been regarded as group alternative to the basic fabric measures and include:

- Cavity wall and external wall insulation
- High performance windows all round
- Insulated doors
- Better controls
- Airtightness measures
- Heat recovery ventilation

Measure	Cost	CO_2 savings (tonne/yr)	Lifetime CO_2 saved (tonnes)	£ spent / tonne saved
Advanced package	£24,000	4.2	94	£255

10.1.5. New and renewable technologies

There is a growing range of technologies that are suitable for deployment in residential buildings either on an individual house basis or for a group of houses (community scheme). Some of them, such as solar thermal and PV, are well established and demonstrate good performance. Others, including biomass heating and GSHP are common in some European countries, but not in the UK. Yet others, namely DCHP and wind, are not well tested and monitored in practice at a small, individual property scale.

- Solar hot water (SHW)
- Photovoltaics (PV)
- Biomass (wood) heating – currently difficult to main due to undeveloped fuel supply chain
- Ground Source Heat Pumps (GSHP)
- Domestic Combined Heat and Power (DCHP)
- Wind – turbines of more than 5kW capacity are unlikely to be installed on individual houses but rather serve a group of several properties (community installation)

Measure	Cost	Installation complexity	CO_2 savings (tonne/yr)	Lifetime CO_2 saved (tonnes)	£ spent / tonne saved
Solar hot water	£2000	4	0.3	3	£670
Photovoltaics	£9000	4	0.7	7	£1285
Biomass heating (wood boiler)	£4000	4	3.9	39	£102
GSHP	£5500	5	2.2	22	£250
DCHP	£3000	4	2.3	23	£130
Wind turbine		5			
400 W	£1500		0.15	1.5	£1000
6 kW	£20,000		5	50	£400
75 kW	£120,000		60	600	£200

A summary of the key components of an integrated package is presented in the table below with rounded figures for costs, since variations by product and suppliers are considerable.

Measure	Cost	Installation complexity	CO_2 savings (tonne/yr)	CO_2 savings (tonne/yr)	£ spent / tonne saved
Basic fabric package	£5000	3	2.3	2.3	£80
Heating and ventilation	£2000	2	1.4	1.4	£130
Lights and appliances	£1400	1	0.5	0.5	£280
Advanced package	£24,000	5	4.2	4.2	£255
Renewables	£2000-£10,000	4-5	varies	varies	£600-£1200

10.2. INTEGRATED PACKAGES OF MEASURES

Synergies between measures are possible in terms of both emission reductions and cost-effectiveness. Regarding energy efficiency, it is important to apply full insulation to the house, including walls, loft/roof, and windows in order to achieve higher air tightness and reduce heat loss. Renewable energy technologies offer a considerable diversity of options, but can rarely be cherry-picked mainly due to site conditions:

- Solar technologies depend on the available roof space and more critically, on its orientation. Where roofs are facing north or well-away from the ideal south orientation solar PV and thermal systems should be ruled out.
- Biomass heaters are usually subject to wood fuel supply and where deliveries are not properly organised or the cost for setting up the supply is too high, this option should be replaced with another renewable technology.
- Ground source heat pumps are suitable for sites where there is sufficient available land for laying horizontal coils, or good ground conditions allowing for the drilling of boreholes.
- Domestic CHP systems work efficiently if there is good match between heat and power baseload or if the system is connected to the grid to export any excess electricity.
- Wind turbines for urban installations have to be carefully selected and designed due to the more turbulent nature of wind in built-up areas and typically face extended planning.

Assuming that site factors allow for all renewable options to be used, additional considerations should be taken into account. Positive synergy could be achieved between thermal and electric technologies, such as a PV system, generating electricity, and a GSHP plant, which will meet the heating demand and run on green PV power. There is little or no benefit combining renewables supplying the same type of energy. It is important to fit high efficiency lights (CFLs) and appliances so that they could be powered by a PV system and thus made carbon neutral.

A number of integrated packages are possible based on the above results. A summary of most combinations is presented in the table below, which gives the approximate cost of the package and resulting carbon savings. The selection of a particular package will depend on the specific requirements for the project.

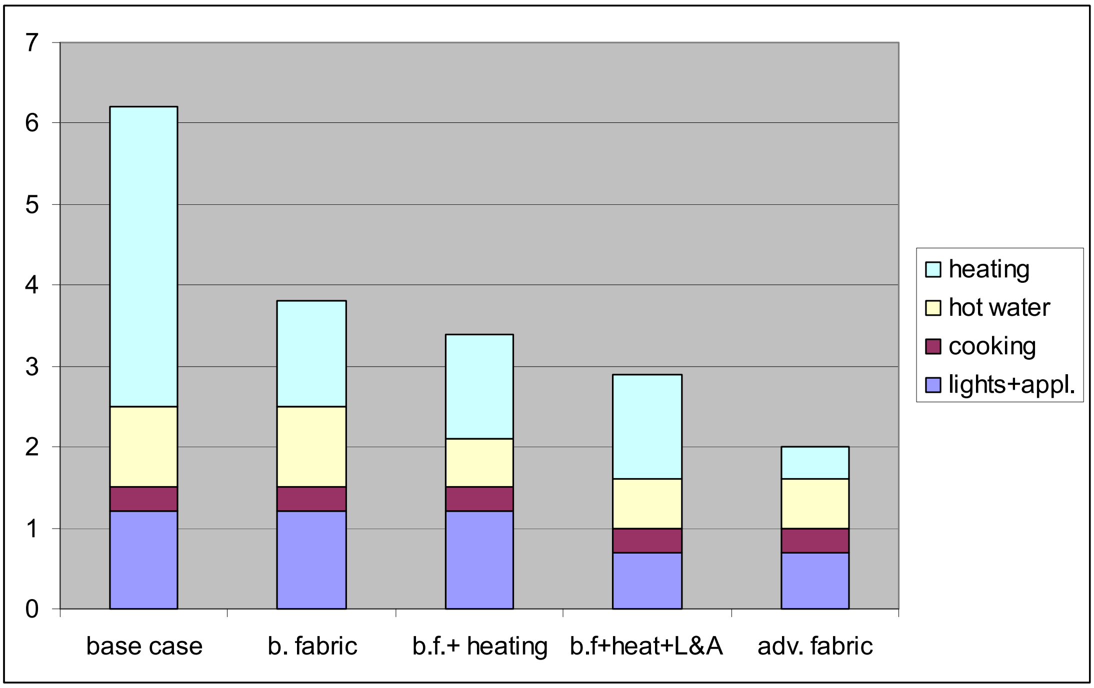
<table>
<tr><th></th><th>Basic fabric package</th><th>Advanced package</th><th>Heating and ventilation</th><th>Lights and appliances</th><th>One renewable technology</th><th>Two renewable technologies</th></tr>
<tr><td>Basic fabric package</td><td>£5000
2.3 tCO_2</td><td></td><td>£7000
3.7 tCO_2</td><td>£6400
2.8 tCO_2</td><td>£7000-
£15,000
2.6-6.2 tCO_2</td><td>£12,000-
£18,000
3.3-8.3 tCO_2</td></tr>
<tr><td>Advanced package</td><td></td><td>£24,000
4.2 tCO_2</td><td>£26000
3.7 tCO_2</td><td>£25.500
4.7 tCO_2</td><td>£26,000-
£34,000
4.5-8.0 tCO_2</td><td>£31,000-
£37,000
5.2-10.2 tCO_2</td></tr>
<tr><td>Heating and ventilation</td><td rowspan="3">£10,500-
£18,500

5.5-8.1
tCO_2</td><td rowspan="3">£27,500-
£37,500

5.9-9.5 tCO_2</td><td></td><td colspan="2">£5,500 - £13,500
2.2-5.8 tCO_2</td><td>£9,000-
£15,000
1.7-5.3 tCO_2</td></tr>
<tr><td>Lights and appliances</td><td></td><td></td><td></td><td>£3,500-
£11,500
0.8-4.4 tCO_2</td></tr>
<tr><td>One renewable technology</td><td></td><td></td><td>£2000-
£10,000
0.3-3.9 tCO_2</td><td>£4000-
£20,000
0.6-7.8 tCO_2</td></tr>
</table>

In order to achieve the targeted high levels of carbon savings, expenditure of £25,000 to £35,000 per house will be required for the capital items and installation alone.

Four packages of measures, excluding renewables, have been compared with the base case of a cavity wall semi-detached house. The graph below shows that only the advanced package achieves more than 60% CO_2 reductions with an associated high cost of £24,000. This means that to exceed 60% carbon savings it is necessary to incorporate renewable technologies as well. In particular, where the advanced package is not technically of financially feasible, the other 'basic' options have to be enhances by a renewables element which will make the package systematic, i.e. suitable for wide replication.



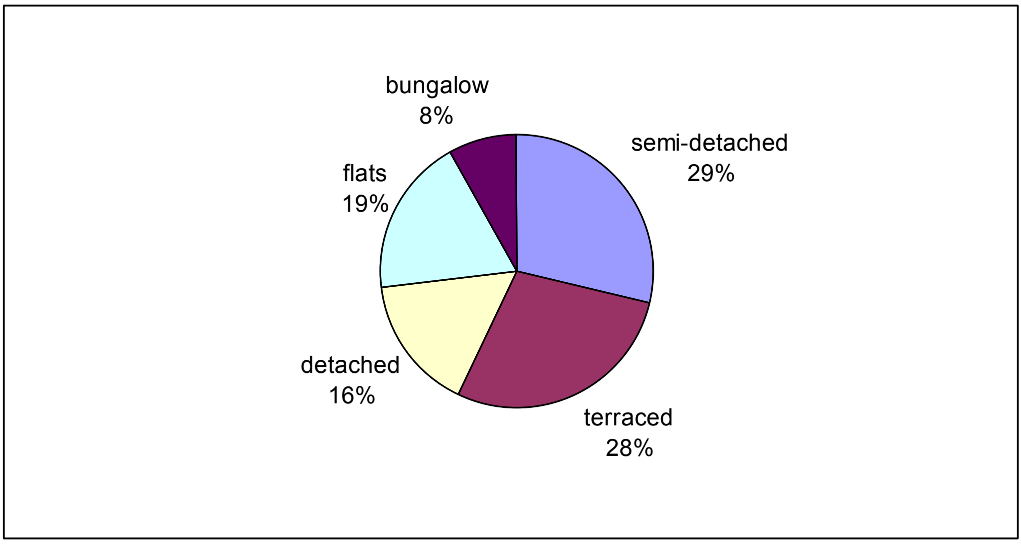
Overall project costs could be reduced through material and labour efficiencies:

- As a rule of thumb, the houses to be selected should be due for a significant refurbishment. Ideally, this will include re-roofing with new rainwater goods and re-pointing.
- While re-roofing a spaced rafter above the existing rafter could be added to give a total of around 300mm of insulation which connects to the external wall insulation. This would reduce the U-value to around 0.1 and be a significant improvement over loft insulation because:
  - it would provide continuity of insulation between roof and wall
  - it would be much easier to achieve high levels of air tightness
  - it would create a warm loft space that can be used for water services so that simple vented services can be installed
  - it would provide a space for a heat recovery ventilation system
  - it would provide a warm area which can be used for storage without compromising loft insulation systems.

- Solar Hot Water and PV systems could be integrated into the new roof system, saving roofing material, and putting up scaffolding for this particular work. With a warm roof space it would be possible to install an advanced heat recovery ventilation system. This would recover at least 85% of the heat from the exhaust air.

10.3. HOUSING TYPES IN THE UK AND POTENTIAL FOR A LARGER DEMONSTRATION PROJECT

Breakdown of the existing housing stock in the UK is characterised by the by type of property (Figure 1). The predominant type is the semi-detached house (29%), followed by the terraced house (28%), which combined constitute more than half of the total stock. Therefore, in order to have a significant environmental impact, focussing on these two house types should be a priority.



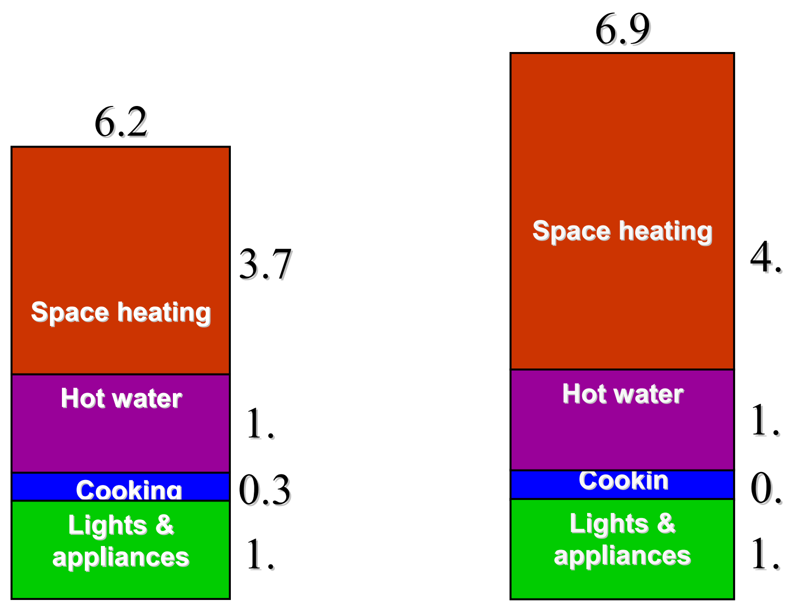
The typical UK semi-detached house has the following characteristics:

- 3 bedrooms
- Approximately 90 m^2
- Built around 1935
- Masonry construction
- Some loft insulation (50-100 mm)
- Some double glazing
- Standard efficiency boiler
- Some hot water tank insulation
- Heating thermostat

U-values

Walls	1.5
Windows	3.7-4.0
Roof	0.4
Floor	0.8

The carbon emissions of a property vary by the wall type mainly due to differences in the space heating requirements with two predominant cases - cavity walls and solid walls.



	Cavity walls	Solid walls
Annual emissions	**6.2 tCO_2/yr**	**6.9 tCO_2/yr**

The Government Energy White Paper sets a target of 60% carbon emission reductions which in the case of the typical UK house means a drop from **6.2 tCO_2 to 2.5 tCO_2** for a cavity wall construction and from **6.9 tCO_2 to 2.8 tCO_2** in the case of solid walls. This requires respectively 3.7 tCO_2 and 4.1 tCO_2 savings on the annual emission levels.

Consequently, it is marginally easier to achieve the 60% target in a cavity wall house than in a solid wall one. Since the main difference is in the heating demand, measures for space heating demand minimisations should be more advanced for solid wall properties.

The cumulative impact on emissions of the technical solutions presented in the previous section is only theoretical as there are no case studies in the UK where the C60 or better standard has been applied and monitored. Therefore, there is a distinct need for field trials that would provide insights into the organisation and implementation of C60%+ schemes and their actual performance. To this end, detailed monitoring of the refurbished properties before and after the upgrade should be carried out to confirm the effectiveness of deployed technologies and to inform future improvement of the method. Moreover, the size of any demonstration project should be of technical and statistical significance through a large number of properties in order to produce outcomes which will indicate the strong and weak aspects of the C60%+ concept.

The demonstration scheme should try to address the following issues:

- Consistency in the housing type (within a site) – the individual site(s) selected should be of the same, or at least have large groups of the same, building type, such as semi-detached or terrace houses, in order to fully develop the cost-effectiveness model and to be able to compare and analyse the outcomes.
- Consistency of occupation – properties will have the same occupancy pattern (occupied, void, decanting)

- Large scale – impact through size could be achieved in several directions:
    - lower capital and installation costs through sales in bulk and uninterrupted work;
    - market stimulation and economic incentives for the suppliers;
    - a serious impetus to setting a C60%+ trend in house refurbishment
    - significant absolute carbon emissions saving from the entire scheme that will contribute to the overall UK target and will complement marketing efforts;
- Realistic time scale – the selected properties should be due for refurbishment within the next two years, which will allow time for setting up the project(s) but without extensive delays.
- Financial and implementation viability – the total scheme value should reflect the potentially available funding and be comparable to existing public and private programmes of similar remit and social landlords' practices.

Following consultations with a number of Housing Associations, who described their typical refurbishment practices with regard to resource availability, timing and property portfolios, and analysis of costs against outputs, the study came up with an optimal demonstration project size of 100 houses. Most of the desirable criteria listed above will be met as follows:

- It will be possible for several Housing Associations to participate by putting forward smaller but sizeable projects that add up to 100 units. Up to 5 groups of 20 to 30 properties will ensure greater geographical spread and house type diversity, while maintaining economies of scale.
- Housing Associations have rolling refurbishment programmes that are typically limited to no more than 100 properties at a time.
- Suppliers have expressed interest in being associated with the scheme and in offering bulk product discounts for volumes of this size. The same applies to procurement where processes can be rationalised, thus, bringing costs down.
- Emission savings will be significant – in the case if cavity wall semi-detached houses, 370 tCO_2 per year, or more than 100 tC/yr, will be achieved.
- The project value will be up to £5 million, including capital costs, monitoring, project management and dissemination, which will have considerable positive impact on the sustainable energy for housing market, without being unrealistic.

10.4. IMPLICATIONS FOR HOUSEHOLDERS

Local authorities and Housing Associations have extensive experience with refurbishment work. The main issue encountered is with the physical assess and intrusion to the property while carrying out work with respect to its current occupancy pattern. The social landlords' preferred approach is to work with empty properties, which is possible either by decanting tenants or by selecting voids. This allows for major works to be done in shorter time and with a good potential for better cost-effectiveness. The other possibility is to carry out works around tenants, where typically only minor improvements and alterations are acceptable, but there are cases showing larger-scale interventions during occupancy.

Consequently, when dealing with major refurbishment, social landlords often have to decant tenants to temporary accommodation and the following arguments apply:

- major works in a group of empty properties can achieve significant economies of scale
- working in an empty property is easier and therefore cheaper than working in an occupied property
- sequencing of works is easier and more efficient
- access to the property and services is simpler

- later/early hour and weekend working is possible
- there are fewer security issues
- Health and Safety issues are easier to resolve (e.g. asbestos removal)
- Large scale and more disruptive works can be completed more speedily
- the trades are used to working in “building site” conditions rather than “home” conditions
- not all trades people are used to dealing with the needs of occupiers who can be seen as difficult, demanding, unreasonable, etc.
- more trades can work simultaneously in an empty property
- there is no need to leave facilities working at end of each day, services can be disconnected when required.

Additionally, wherever possible working on pairs of semi-detached houses or rows of terraces, or houses in close proximity is preferred due to noise issues, and efficiency gains from sequential deployment of trades. Costs of specialist trades (eg. external wall insulation, supply and fit of replacement glazing etc.) reduce substantially on larger volumes. Decanting to mobile homes located in the same area as the refurbished homes is a strategy that has been used with some success. Costs of the temporary accommodation must be considered.

However, having to decant occupants is seen as a major headache for social landlords, and works of a scale requiring decant of occupants are not undertaken lightly. Undertaking opportunistic upgrades to properties when they become vacant is an approach that is often used, but does not have many of the cost/scale advantages listed above for works done under the same contract in adjacent or nearly properties. On the plus side, there may be reduced loss of rent. In many cases, for major works void properties are chosen to avoid conflicts and lengthy consultation procedures. Where possible, this should be used as a rule of thumb when selecting and initiating refurbishment projects as part of the Low Carbon Homes scheme.

Specific tenants issues also need to be considered when planning major refurbishment, as perceived by social landlords, experienced in dealing with social housing tenants, as follows:

- elderly and disabled people can have special health needs and may not wish to decant for major refurbishment, indeed they may not wish to have any works carried out in their home due to the perceived disruption
- younger occupants are usually more flexible about works to their homes
- every occupant will have a different set of concerns about the planned works
- a tenant who has just decorated/had new carpets fitted may be less willing to accept works which will undo this investment than someone who has some need for redecoration
- there needs to be obvious betterment for the occupants as a result of the refurbishment
- the resulting benefits to the tenants needs to be “sold” to get cooperation for refurbishment
- appropriate compensation packages may be required to achieve the most expedient solution
- tenants need to be consulted and have active involvement in the process from the outset – owning the decision will help with implementation
- if decanting is not used then Health and Safety of tenants, supervision of works, access, cleaning up, reconnection of services etc. are all major issues that need to be managed daily.
- If there is no decanting, loss of rent for the social landlord are reduced

10.5. STAKEHOLDER INVOLVEMENT

In order to assess the viability of implementing a large demonstration project as outlined in the previous sections, an extensive stakeholder consultation was carried out. The range of stakeholder groups is given in the table below and several organisations from each group were approached, using the partners' existing contacts database and through further research and networking. The leading companies in each sector were approached with the view of establishing the scope for their involvement at a UK national scale and of maximising the project benefits and impact through economies of scale, training and employment, and change in attitude.

Stakeholder group	Number contacted	Number interested in being involved
Housing Associations	**250**	**40**
Technology suppliers (of which:)	**34**	**21**
Insulation materials companies	8	4
High performance window companies	4	2
Condensing boiler companies	3	2
Solar technology companies	10	4
Ground Source Heat Pump companies	2	2
Domestic Combined Heat and Power companies	3	3
Wind turbine companies	2	2
Domestic appliances companies	2	2
Testing and Monitoring companies	**2**	**2**
Property developers	**3**	**0**
Power supply utilities	**6**	**3**
Consultants	**2**	**2**
Funding agencies (public and private)	**4**	**2**

The research into the supply side, as well as demand for integrated energy solutions shows that there is a very strong existing industry base with a number of established companies even in the novel technology streams. Coupled with their strong interest in the C60%+ concept for housing, there are favourable conditions for setting up a long-term partnership that will bring the project to fruition. There is significant additional value in bringing organisations and individuals with profound experience in refurbishment projects and products.

A key question, on which contacted organisations were asked to provide feedback, is the range of perceived beneficial outcomes of the demonstration scheme for the organisation itself and for the industry in general. The responses received will form the basis for establishing the industry partnership and could be summarised as follows:

- Good PR for all organisations involved, both from the public and private sectors. For suppliers the project would be additional promotion that will reinforce their strong market position or for some smaller ones it could mean being put back on the business map. The project would be a testimony of quality of their products and market leadership.

- The project is an excellent opportunity for learning by doing. The results will confirm the viability of C60%+ schemes and the range of technological solutions applied. Lessons will be learnt on how to best deploy them in the existing housing context.

- High energy performance of managed properties will result in lower bills for the occupiers and improved comfort and health conditions. Consequently, 'customer' satisfaction will be greater with reduced tenant turnover and less complaints. Housing Association will enjoy improved occupancy patterns, reduced void of the dwellings and greater income.

- There are significant job-creation opportunities through an increased need for quality installers and servicing. This should be particularly appealing to Regional Development Agencies (RDAs). There are also opportunities to develop and carry out skills training in terms of the *design* of refurbishments that go beyond the norm. This can be extended to skills training in terms of the *installation* of insulation, air tightness measures, renewable technologies (solar PV, SHW, DCHP), etc.
- For suppliers, the project and its impact on demand for better energy performing homes mean an increase in commercial sales and greater turnover. As a result, the cost of products and installations is likely to fall, ultimately benefiting the consumer.
- Confirmation of what levels of CO_2 reductions are possible *in practice*. This is equally relevant to suppliers, property managers and consultants, who will better understand the value of applying integrated packages of measures and their overall cost-effectiveness. Housing Associations will be able to set targets for their properties with more confidence, while suppliers will be better informed of how to improve their products.
- Setting up local exemplars which can be a focus of activity in the local area. Replication is often subject to proper marketing of a successful case study, which is more effective if located closer to the target market/audience. Through a network of smaller demonstration projects across the UK, there will be a good potential for a nation-wide replication.
- Through monitoring the individual projects, the performance of the new and renewable technologies in the context of very energy efficient fabric and systems will be established.
- A range of environmental issues beyond energy, related to an *EcoHomes* 'very good' standard, can be addressed, such as water consumption and grey water use, waste and recycling, pollution, health and well-being.
- The servicing of such technology-loaded properties will be addressed and ideas for a one-stop shop could be developed.

Several potential projects have been identified, however, detailed planning and design is required before they could go ahead.

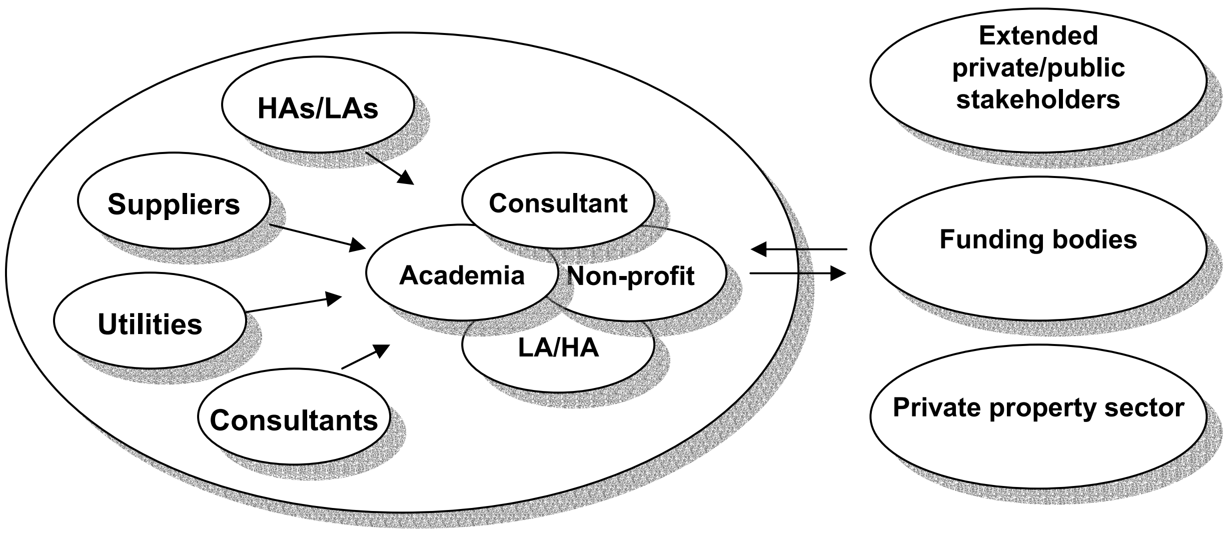
10.6. STAKEHOLDER PARTNERSHIP CONCEPT

The envisaged partnership should include a broad spectrum of organisations, however certain considerations should be taken into account:

- Focus on the private sector since it is in a position to deliver integrated technical solutions.
- Manageable size – two organisations per sector will provide good representation in the core partnership. A maximum of 20 key core partners will give sufficient weight and credibility to the initiative, while keeping it possible to manage effective communication.

- Core partners – a group of 2-4 organisations with different business backgrounds should maintain internal (partnership) communication as well as liaise with the larger industry stakeholding.
- Stakeholder support – a broad group of non-partner organisations need to be involved on a certain level in order to have a wide industry support and to increase the opportunities for co-operation, implementation of the project, and long-term market impact. At least 20-50 such entities should be on the partnership distribution list.

A possible partnership structure is presented in the graph below:



10.7. OUTLINE IMPLEMENTATION PLAN

There are 3 main challenges to the future of the project:

1) attracting and retaining partners covering the entire supply chain
2) identifying suitable projects where the C60%+ can be achieved
3) financing a large demonstration scheme

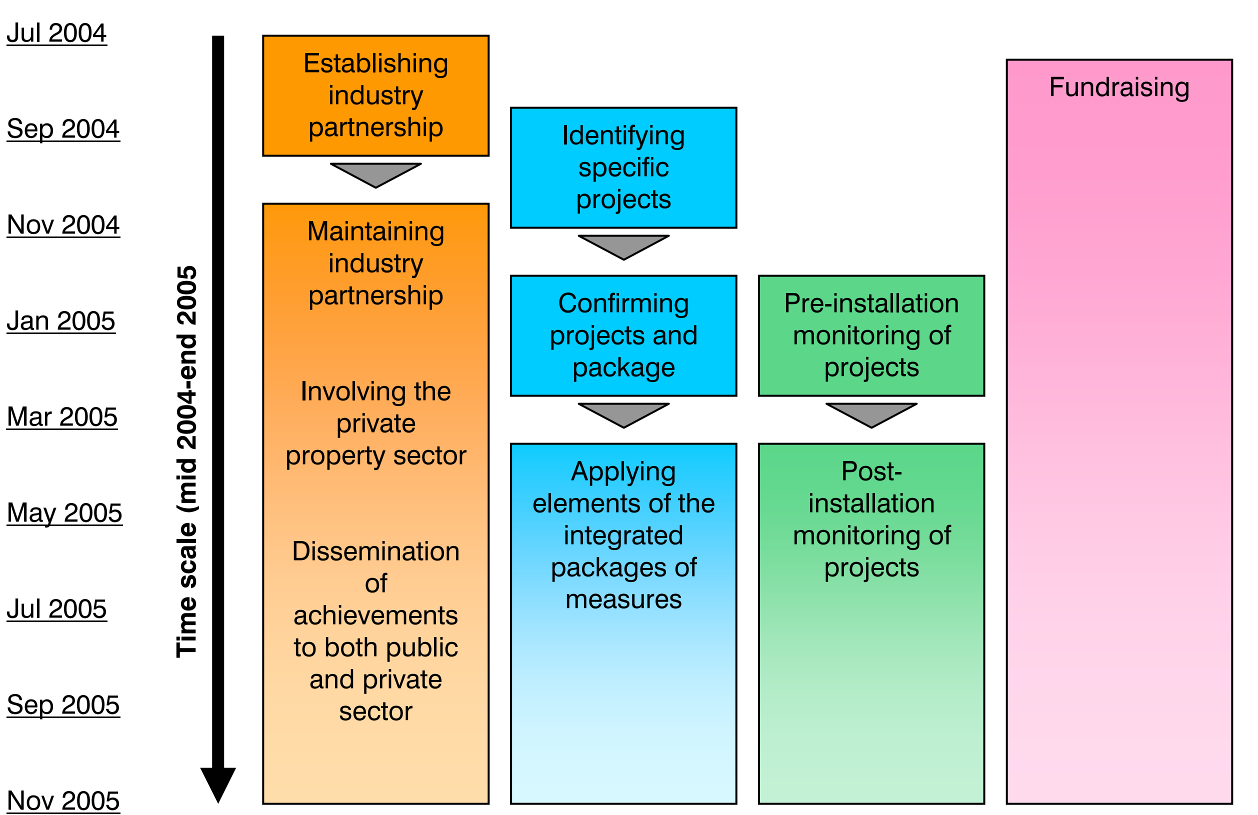
The initial response from and dialogue with a good number of organisations relevant to the initiative show that timing is appropriate for bringing together the existing, but so far fragmented, technologies for improving the domestic energy performance. As a first step towards implementation, it is important to formally invite stakeholders to join an industry partnership and to agree on a strategy and action plan. Through an industry consolidation individual company efforts will be channelled in the same direction, including information and resources flow. Better opportunities for fundraising will also be created. A key priority would be to maintain the partnership due to the long-term operational life of the project, as well as the overall goal of having an impact on the whole residential building stock.

Several potential demonstration schemes emerged as a result of the feasibility study, but the scope for 60%+ CO_2 savings and available funding still need to be confirmed. Although in principle Housing Associations expressed enthusiasm to exceed the statutory requirements for energy performance, timing and limited resources are issues that need further attention and analysis. Where specific projects could be confirmed, detailed specification and costing of the measures appropriate to the site context would be carried out. One possible route, informed by feedback from Housing Associations, is to phase in the installation by applying a limited number of measures at a time. In this way, the spending burden will be relaxed over an extended period of time, while securing the required additional funding.

In order to develop a method that could be replicated across the UK, it is important to monitor the house performance before and after installation and identify positive outcomes and areas fro improvement. Since the proposed demonstration is by far unique for the UK, its implementation will be a learning-by-doing process which needs to allow for sufficient flexibility along the way.

The total value of the project is likely to reach £ 5,000,000, which is unlikely to come from a single source. Therefore, fundraising will be a dynamic process that will continue almost to the end of the project.

Implementation plan



10.7.1. Funding

The feasibility has looked at potential sources of funding relevant to the project scope. Funding mechanisms are critical for the success of the scheme as the total spending for retrofitting 100 dwellings is likely to be in the area of £5,000,000 towards the capital, monitoring and management costs. Ideally, a single source would be identifies to fully fund the scheme; however this is rather unlikely and drawing contributions from multiple investors/donors will be required. The following matrix has been developed matching project elements with potential sources. The funding patch-work demonstrates a large diversity of sources. Certain effort will be required to approach them and secure sufficient funding. The range of sources and extent of funding will be further detailed in the following stages of the project.

Element / **Source**	Building fabric measures	RE technology	Heating + ventil.	Monitoring	Project mngmnt	Dissemi-nation
Property manager (HA, LA, private, etc.)	At least 50%	At least 50%	At least 50%		Some	
Technology/product suppliers	Some via discounts (10-15%?)	Some via discounts (10-15%?)	Some via discounts (10-15%?)			
Energy Efficiency Commitment EEC*	Varying subsidies	As innovation	Varying subsidies	Possible		
Public agencies (EST, Housing Corp, CT, etc.)**	Some	Some	Some	Yes	Some core funding; innovation progr.	Yes
Government grants (Clear Skies, MPVDP)***	Up to 50% for innovation	50% for most RE	Up to 50% for innovation			Up to 50% for innovate.
Government departments (DTI, DEFRA) ^				Possible if in priority area	Possible if in priority area	Possible if in area of priority
Generation Homes partnership				Some	Yes	Yes
Research councils (EPSRC, etc.) ^ ^				Yes; to cover most costs	Some	Some
Regional development agencies (RDA) ^ ^ ^					Some if priority +job creation	Some if priority +job creation
Charities				Possible	Possible	Possible
European Commission * ^		Possible if large scale + priority		Possible	Possible	Possible

* All major UK energy supply companies are required to achieve significant energy savings in the residential sector under EEC. They offer 10% to 100% subsidies for cost-effective measures.
** The Energy Saving Trust, the Housing Corporation and the Carbon Trust offer grants for various carbon saving projects, typically involving some innovations. Grants are up to £250,000
*** Government grants mainly for renewables are up to £300,000 for PV and £100,000 for other technologies. Innovative energy efficiency projects can also attract government funding
^ The Department for Trade and Industry and the Department for Environment, Food and Rural Affairs encourage mainstreaming of innovative energy technologies and projects.
^ ^ The research councils invest large funds into R&D for new technologies and methods
^ ^ ^ The Regional Development Agencies focus on stimulation the local economy and businesses
* ^ The European Commission typically funds large building-related multinational programmes

11. KEY ISSUES AND LESSONS LEARNT

Size of demonstration project

The envisaged demonstration will comprise at least 100 housing units. Ideally, this will be a single project, fully planned from the start and actively manage throughout. Extensive stakeholder involvement and full funding from the outset are other looked-for characteristics.

Assessment of the current housing situation in the UK and extensive consultation with various relevant stakeholders show that it is unlikely for such project to be practicable within the above definition. In order to achieve the overall scale and volume of proposed refurbishment, several smaller schemes may need to be set up that are more easily identifiable and manageable. Between 4 and 6 groups of 20 to 30 houses is a realistic option, where additional benefits could be realised, i.e. geographical spread covering different parts of the UK, working with several house types, and wider dissemination of the results. Flexibility should be maintained in order to enable all parties to deliver to the overall objectives and to meet their individual targets.

Integrated package of measures

The feasibility looks at packages of energy-conservation measures as discussed in the previous sections. More detailed designing is required before moving to implementation as their extent will largely depend on the specific situation of the selected properties. Key factors that will determine the elements in a package include type of house fabric, positioning and orientation, measures already in place, occupancy pattern, and available funding and its sources.

Timing of installation work

Timing relates to three main factors: (i) available funding for the whole project, (ii) need for all proposed measures to be installed at the same time, and (iii) flexibility to carry out work considering current occupancy of the houses.

As a result, it may be necessary to phase in the full installation of the package over a longer period of time to allow for extra flexibility. Fund-raising is also likely to be facilitated in terms of breaking the total budget into smaller parts.

Private sector involvement

It is felt that involving the private property sector is necessary to secure the long-term take up of the C60%+ concept, as well as for implementing early pilots, which will bring additional experience for all parties. There is clear merit in such an approach as the majority of housing is privately owned and has to be tacked at a certain point in time. The discernible challenge here is the inherent fragmentation of the stock and the possible routes for involving individual home owners into a group project.

12. RECOMMENDATIONS FOR IMPLEMENTATION

The feasibility study is the first part of a larger three-stage project, where Stage 2 is focused on establishing and maintaining a close relationship with the stakeholders as identified earlier in this report and Stage 3 is dedicated to carrying out a large demonstration project.

Thus, Stage 2 is regarded as an implementation project dealing with the organisational aspect of the scheme and trialling individual technical measures as a build-up to the full demonstration scheme. It is recommended that a core partnership be established comprising 10-15 organisations covering the full spectrum of stakeholders. Additionally, a broader affiliation to the partnership of another 15-20 organisations should be maintained in order to carry out wider dissemination of the objectives, programme, and on-going results. Formal involvement in the form of membership should be required to ensure objectives are pursued consistently and thoroughly.

Dissemination should be a key activity involving organisations and individuals with considerable experience with refurbishment projects. It should be anticipated that a number of RSLs and private individuals will buy into the concept and put forward demonstration projects, which will achieve material carbon savings. Dissemination will also assist the on-going fund-raising activity by means of approaching and informing prospective investors/donors, both public and private.

Stage 2 will also need to be dedicated to detailed integrated system development tailored for specific projects. This will entail engineering design and costing of the package elements and assessment of the site conditions. Negotiations with suppliers should aim at preferential prices of equipment and installation.

13. CONCLUSIONS

This study has found out that in theory it is technically feasible to achieve significant carbon dioxide emissions reductions in existing residential buildings through refurbishment. The reductions can meet and exceed the 60% mark my means of applying a combination of measures – energy efficiency and conservation, and renewable energy generation. A range of packages have been identified, whose application will depend on the specific site conditions, namely building fabric, measures already in place, and occupancy patterns.

The proposed approach is discernibly capital-intensive and will require high levels of commitment of the property owner or manager and considerable level of external funding in the form of grants and subsidies. The average cost per property will be in the area of £25,000 to £35,000. Detailed system development and specification should be carried out for any identified candidate project to determine the exact cost.

Despite the high cost, many organisations have expressed interest in participating in the scheme, including Housing Associations, who will have to take most of the financial burden. A number of technology suppliers and companies investing in sustainable energy are also willing to contribute to the scheme once trial sites have been confirmed and subject to aligning the project objectives with their corporate ones. It is expected that the detailed planning and negotiations will take between 6 and 12 months for full-scale refurbishment. Less time will be required to install individual technologies in a phased-in approach to a complete demonstration scheme.

In this respect, developing an implementation plan has focussed on the parameters of the refurbishment scheme with the recognition that it is important to establish and maintain a strong industry partnership as a necessary step towards confirming specific projects in order for the latter to be viable. The feasibility study has identified a broad spectrum of funding sources and routes which need to be explored more thoroughly. By targeting and involving a combination of potential investors it could be possible to finance a scheme of 100 properties and to further stimulate industry to adopt a unified approach to the existing housing stock. Dissemination of the results, professional training, and education are some of the envisaged tasks for the emerging industry partnership.

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