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# FLASH

## Connecting built environment SMEs in London with sustainable opportunities

**London Project Hindsight Review Meetings**

**Part 1: Interim Findings**

Technology Strategy Board
Driving Innovation

UCL ENERGY INSTITUTE

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**Part 1: Interim Findings**

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Authors:
Rokia Raslan
Robert Lowe
Lai Fong Chiu
Hector Altamirano

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# Table of contents


1 Executive summary ........ 4
2 Introduction and overview ........ 6
2.1 Report structure ........ 6
2.2 Background: Retrofit for the Future ........ 7
2.3 The Facilitation Learning and Sharing (FLASH) programme ........ 7
2.4 Research programme ........ 7
2.5 Hindsight review/ “wash-up” meetings ........ 8
2.6 Report aims and objectives ........ 8
3 Overview of findings ........ 10
3.1 Overview of London projects ........ 10
3.1.1 Project descriptions ........ 10
3.1.2 Approaches to retrofit ........ 11
3.2 Perceived resident/tenant experience ........ 12
3.2.1 Tenant engagement and communication ........ 13
3.2.2 Tenant disruption ........ 13
3.2.3 Handover Procedures ........ 14
3.2.4 Sequencing of construction works ........ 15
3.2.5 Communication with neighbours ........ 15
3.3 Lessons Learned ........ 17
3.3.1 The Importance of project review feedback ........ 17
3.3.2 The use of new materials and technologies ........ 18
3.3.3 Contracting practices ........ 18
3.3.4 Supply chain development ........ 19
3.3.5 Cost-Effectiveness of retrofit ........ 20
3.4 Opportunities for future improvement ........ 21
3.4.1 Space and water heating systems ........ 21
3.4.2 Ventilation and Air-tightness strategies ........ 23
3.4.3 Renewable generation strategies and resource recycling ........ 23
3.4.4 Insulation solutions and thermal bridging ........ 24
3.4.5 Other areas ........ 25
3.5 Novel solutions and business opportunities ........ 26
3.6 Planning and building control ........ 28

# 1 Executive summary

The Facilitation Learning and Sharing (FLASH) programme is an initiative part-funded by the European Regional Development Fund (ERDF) and supported by the Technology Strategy Board through its 'Retrofit for the Future' (R4TF) programme. This document aims to capture the key messages from the hindsight review/"wash-up" meetings held for a number of Retrofit for the Future case study projects located within the London area. These provisional findings were based on the discussions undertaken by the project consortia members and integrated with background knowledge from the UCL research team, relevant literature and input from other strands of the research project, which were available at the time of writing.

These hindsight review/"wash-up" meetings aimed to provide an opportunity for participants in each R4TF project to identify the important lessons learned during the project up to the point of completion and occupation. The main participants in each of the projects (i.e. project consortia partners) were invited to discuss the project using a pre-prepared agenda as a guide for discussion. The key aspects examined included the resident/tenant experience, the lessons learned in terms of the overall design challenges and viability of different technical solutions, the assessment of opportunities for future improvement for building technologies and construction materials, the identification of novel solutions and business development opportunities and the role, impact, challenges faced and suggested solutions relating to building control and planning requirements as part of the retrofit process.

Through the work undertaken for this report, hindsight review/"wash-up" meetings emerge as a valuable tool for re-examining projects after they are completed. These reviews provide a forum for the multi-skilled teams to refine and identify solutions and crystallise ideas to inform future projects they are involved with, and will be particularly relevant in the case of future roll out of mass retrofit. As a result of these meetings, a number of key issues and obstacles for Small and Medium-sized Enterprises (SMEs) in delivering domestic retrofit on time and on budget were identified by the project consortia partners. These include such issues as:

***The importance of developing a high level retrofit strategy*** encompassing all aspects of the work to be done including fabric and energy system strategies designed to deliver the overall energy objective, engagement with the supply chain, the management of the retrofit process, engagement and involvement of dwelling occupants, and the interactions between these different aspects.

***The importance of the early engagement of the tenant and neighbours*** from the perspective of project consortia. This requires the establishment of a co-ordinated strategy for liaison and maintaining open and consistent lines of communication through meetings and other approaches. These can aid in avoiding miscommunication and can play a key role in the minimisation of disruption, the management of expectations and the resolution of any arising issues or conflicts.

***Effective handover procedures*** involving meetings, information sessions, walk-throughs, occupant guides and other forms of communication are a key part of an effective communication strategy that ensures that tenants are appropriately informed about the purpose, operation and maintenance of all relevant systems and components. Note that deciding **what** is to be expected of occupants in these respects is a key part of the **high level retrofit strategy**. In some cases there was a divergence of opinion concerning the effectiveness of specific handover approaches, this will be further investigated in subsequent analysis.

***Supply chain considerations*** such as ensuring appropriate product specification, the simplification of delivery logistics and setting out contingency measures such as the use of alternative sources in the case of supplier failure, and the provision of appropriate documentation for the occupant should all be included as part of the retrofit planning phase. Evidence emerged from the "wash-up" meetings of supply chain weaknesses, which are likely to impede large scale retrofit in the UK.  These weaknesses need to be addressed either through the expansion of the UK manufacturing base and/or by strengthening distribution and support systems.

***The on-site training for trades*** through methods such as on-site workshops and alternative training material e.g. DVD/video should be employed to ensure that design information is correctly understood.  It is also essential to adequately communicate the project aims to on-site operatives (functional and performance objectives) and why they are important to the overall aims of the project. This is especially relevant when there is a “learning curve” resulting from working with new technologies and materials.

***The establishment of early liaison with planning and building control*** is an important factor in ensuring the safe handover of a project, since it reduces the occurrence of ineffective design practices and can potentially ensure that the guidance provided is both design-effective and cost-effective. However, issues such as the inconsistent interpretation of requirements and the revision of inconsistent and disproportionate permitted development rights need to be addressed at the national level.

# 2 Introduction and overview

The Retrofit for the Future (RftF) programme led to the funding of an overall 87 projects, 26 of which were based within the defined London catchment area, and therefore of primary interest to the FLASH programme. As of October 2011 an estimated 16 out of the 26 London-based projects had been completed.

As one of the academic delivery partners for the project, the work programme undertaken by University College London Energy Institute included the facilitation and analysis of data from project hindsight review/“wash-up” meetings (Task 2). As a result, hindsight review/”wash-up” meetings were held for eight of the completed London-based projects. These meetings aimed to provide an opportunity for participants in each RftF project to discuss and identify the lessons learned during the project up to the point of completion and occupation.

This report provides an overview of the interim findings of the hindsight review/”wash-up” meetings. These findings are based on the discussions undertaken by the project consortia members integrated with background knowledge of the UCL research team, relevant literature and input from other strands of the research project, which were available at the time of writing.

It should be recognised that key messages contained in this report are based in the main on just one of several perspectives – that of the retrofit teams as captured in the hindsight reviews. The final stage of the project will bring together findings from all three strands - hindsight reviews, physical monitoring and an in-depth post-occupancy evaluation exercise undertaken with the tenants of each of the investigated properties - to produce a comprehensive project report, covering:

- Project overview, aims and design challenges
- The retrofit solutions and various strategies and measures employed
- Opportunities for improvement in the retrofit process
- Project costs, budgets and cost-control measures
- Analysis of feedback from the post-occupancy evaluation exercise
- Analysis of available physical monitoring data and comparison of as-designed and as-built retrofit performance targets.

## 2.1 Report structure

This report discusses the key interim findings of the 8 hindsight review meetings that were facilitated by UCL. The main aspects discussed are:

- ***Perceived resident and tenant experience:*** This provides an overview of issues concerning the tenant communication, handover procedures, sequencing of construction and issues with neighbours as perceived by members of the project consortia.
- ***Lessons learned:*** This provides a summary of the overall design challenges, strategic approaches, what worked well or less well, and why.
- ***Opportunities for future improvement:*** This provides an assessment of specific technologies used on different projects (e.g. heating and hot water systems, ventilation and airtightness, renewables etc.) and possible routes to improve implementation on future projects.
- ***Novel solutions and business opportunities:*** This highlights innovative design and construction solutions that were developed for a number of Retrofit for the Future case studies. A number of opportunities for business
- developments are also presented.

- ***Planning and Building Control:*** This highlights the specific aspects relating to the role and impact of building control bodies such as Building Control Officers and planning requirements on the retrofit process in general and with regard to a number of specific projects. The challenges faced and suggested solutions are also discussed.

## 2.2 Background: Retrofit for the Future (RftF)

R4TF was a multi-phase competition launched by the Technology Strategy Board to fully fund whole dwelling retrofit projects that aim to investigate ways by which to enable the retrofitting of UK social housing stock in order to meet future targets in reduction of $CO_2$ emissions and energy use. Although the competition was open to all companies, applications that enabled small companies to participate within the supply chain were particularly encouraged[1]. In total, over 200 competitive bids were received and judged on innovation, potential for impact and projected build cost[2]. An overall 87 projects were consequently funded to undertake deep retrofits of a wide variety of properties across the social housing stock.

## 2.3 The Facilitation Learning and Sharing (FLASH) programme

The FLASH programme is part-funded by the European Regional Development Fund (ERDF) and is supported by the Technology Strategy Board through its RftF programme. The programme aims to provide London-based SMEs with access to the most recent and credible research on sustainable development and retrofit. The ultimate goal is to help SMEs to expand into low carbon businesses and take advantage of the commercial opportunities created through the transition to a low carbon economy.

The FLASH programme has, together with its academic partners,undertaken a wide range of research and analysis activities focusing on the 26 London-based RftF projects - eight of which were examined as part of the UCL research programme. These projects provide examples of best practice in sustainable development and retrofit and are considered to be one of the key elements of the FLASH programme delivery.

Through collaborating with existing networks within the industry, the FLASH programme will ultimately share the findings coming out of this work to aid SMEs in taking advantage of the commercial potential of these markets through a range of support measures[3].

## 2.4 Research programme

As one of the academic delivery partners for the project, the work programme undertaken by University College London Energy Institute consists of five main research tasks:

**Task 1:** Analysis of physical monitoring data from London-based projects
**Task 2:** Facilitation and analysis of data from project hindsight review/“wash-up” meetings
**Task 3:** Undertaking post-occupancy survey questionnaire and interviews
**Task 4:** Analysis of Meter Point Administration Number (MPAN) data
**Task 5:** Integration of findings
**Task 6:** Dissemination of research findings

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[1] TSB website: http://www.innovateuk.org/competitions/retrofit-for-the-future.ashx
[2] RIBA website: http://www.architecture.com
[3] Institute for Sustainability website: http://www.instituteforsustainability.co.uk/flash.html

## 2.5 Hindsight review/ "wash-up" meetings

A number of hindsight review/ "wash-up" meetings were held for a range of completed London-based projects. These meetings aimed to provide an opportunity for participants in each RftF project to discuss the extent to which each project met (or exceeded) its objectives and to identify the important lessons learned during the project up to the point of completion and occupation[4].

The main participants at each of these meetings typically included the property owner (either the housing association or local authority) and the project designer or architect. In addition, other members of the design team such as the quantity surveyor, the energy/environmental consultant, the main contractor and representatives of the key sub-contractors were also included.

The meeting format involved the use of a pre-prepared agenda listing all aspects associated with the project as a guide for discussion. The typical items covered within this agenda are described in Box 1. As part of the scope of research work for the FLASH programme, the UCL Energy Institute was actively engaged in offering support in the following areas:

- Undertaking the role of meeting facilitator
- Developing a meeting agenda or "facilitation plan" that specifically considered the context of each project
- The production of a headline report for attendees.

**Box 1: Meeting agenda topics**

1. **Pre-retrofit property and design intent**: context and aims of the project
2. **Design challenges and solutions** : what was expected to be delivered?
3. **Programme:** did it run to time, if not why?
4. **Construction reality**: how/ why was the design changed to adapt to circumstances?
5. **Practical challenges of a major retrofit**: access, interaction of trades, occupants, etc.
6. **Construction success stories:** what went well and why?
7. **Construction problems:** what was difficult, why and how was it overcome?
8. **System interactions**: any issues or success stories in making technologies work together
9. **Lessons learned**: in commissioning or equipment and controls
10. **Handover and training** : how was this handled and how was it received by the tenant/occupant?
11. **Costs:** actual vs. budget, detail available for reporting and scope for reducing costs.
12. **What should be repeated:** reduced scope scheme for replication
13. **What should be avoided**: technologies and processes

## 2.6 Report aims and objectives

The main aim of this report focuses on the delivery of requirements of Task 2, which involves the synthesis of the findings from the project hindsight review/"wash-up" meetings to identify key factors to help SMEs deliver domestic retrofit on time and on budget. The specific objectives underlying this aim can be summarised as follows:

[4] Bordass et al. (2006) A guide to feedback and post-occupancy evaluation, The Usable Buildings Trust.

- To bring together information from the analysis of hindsight review/“wash-up” meetings that were organised for a number of completed projects located in the London area
- To contribute to an understanding of the roles of key actors within the project consortia involved in the retrofit process and their relationship with other responsible parties
- To contribute to an understanding of the important lessons learned during the project up to the point of completion and occupation
- To acquire feedback and contribute to an understanding of the required practical and legislative improvements for future retrofit projects
- To contribute to an understanding of future business opportunities and areas of potential innovation in the field of retrofit.

# 3 Overview of findings

The following overview highlights the key themes and issues that have arisen for the eight London-based projects reviewed by UCL Energy Institute. In interpreting these findings, it is important to consider the boundaries of the investigation which are determined by both the context and characteristics of the projects discussed and by the nature of the hindsight review meetings themselves. These can be summarised as:

- The projects discussed (with the exception of Case E and Case G) were mainly single property retrofits, which were implemented with the tenant in-situ. This therefore restricts the wider exploration of decanting and void property retrofit.
- The projects were all owned by social housing providers, therefore only one tenure type was included (social landlords). Findings therefore generally relate to the specific circumstances of this sector
- Although a number of tenant types are included (families, older tenants, etc.), specific information concerning tenants was not always available and/or disclosed by project consortia partners on certain projects
- Tenants were in the main selected to maximise the likelihood that the projects would be successful.

## 3.1 Overview of London projects

The RftF programme led to the funding of an overall 87 project, 26 of which were based within the London catchment area and therefore of primary interest to the FLASH programme. As of October 2011 an estimated 16 out of the 26 London-based projects had been completed. Of these, eight projects were selected as case study candidates for the hindsight review. The selection process and criteria are outlined in detail in the overall case study report.

### 3.1.1 Project descriptions

The London-based RftF projects encompass a range of house types, building ages as well as locations. The details of the specific properties selected as case studies are outlined in the overall case study report.

**In general, the following house types are represented:**

| Case | House type | Project Type | Building age/era | Location |
|---|---|---|---|---|
| **A** | Mid terrace | Single Property | Post 1990 | East London |
| **B** | Short terrace | Multiple Properties (4 Houses) | 1970s | North London |
| **C** | Terraced/Semi-detached | Single Property | Victorian | East London |
| **D** | Mid terrace | Single Property | 1960s | East London |
| **E** | Mid terrace | Single Property | Victorian | South East London |
| **F** | Semi-detached | Single Property | 1960s | West London |
| **G** | End terrace | Single Property | Edwardian | North East (Greater) London |
| **H** | Semi-detached | Single Property | N/A | West London |

**Table 1: Project house type**

In the following sections, some relevant observations or quotations concerning specific case study projects are included in the text to illustrate particular issues. To enable the cross-referencing of this content to the cases discussed in Part 2 of this report, a referencing system is employed where each of the projects is denoted by the use of the letter code listed above (e.g. Case E).

### 3.1.2 Approaches to retrofit

Most of the consortia involved tenants in discussions to develop their retrofit strategies. These discussions were perceived to have helped determine:

- How the property would be used (both spatially and in terms of energy use).
- How the retrofitting process could be used to add asset value and amenity, as well as reduce energy use.

All but one of the consortia explicitly identified their high level strategy with one of the following approaches. It should be noted that in reality, these approaches are not mutually exclusive. Significant overlaps exist between some of them.

**i. The whole-house approach**

A whole-house approach (also known as whole-house systems approach) regards the building as an energy system with interdependent parts. The approach was used on one of the eight projects (Case A) and considers the interaction between the tenant, building site, climate, and other elements or components of a building. In this approach the features and performance of any one component are strongly affected by the rest. Overall energy performance emerges from the system as a whole.

**ii. The fabric first approach**

The "fabric first" approach was used on three of the eight case study projects discussed here (Cases B, C and G). This approach:

1. Prioritises improvement of the thermal properties of the building fabric through the use of high thermal insulation and airtightness
2. A range of measures are then employed to increase the efficiency of various systems (e.g. heating/hot water, lighting and electrical appliances). System re-sizing may be desirable as a consequence of reduced energy demand, but oversizing such as that of heat distribution systems can significantly improve overall performance
3. Finally, renewables are installed to meet the remainder of the $CO_2$/energy reduction.

**iii. Passivhaus Strategies**

The Passivhaus standard for energy efficiency for buildings was used in two of the eight case study projects (Cases D and H). The application of this German-developed standard, which can be considered as a high specification fabric first approach with an enhanced Quality Assurance element, reduces the ecological footprint of a building and results in ultra-low energy buildings that require little energy for space heating or cooling. The Passivhaus standard for central Europe requires that the building fulfils the following requirements:

- The building must be designed to have an annual heating demand, as calculated with the Passivhaus Planning Package, of no more than 15 kWh/m² per year for heating and/or cooling energy or to be designed with a peak heat load of 10W/m²
- Total primary energy (source energy for electricity, etc.) consumption (primary energy for heating, hot water and electricity) must not be more than 120 kWh/m² per year
- The air permeability of the building must not exceed 0.6 air changes per hour at 50 Pa[5].

**iv. Insulate then generate philosophy**

This philosophy was developed by one of the competition participants and used for Case study F. This philosophy, which is very similar to the fabric first approach, first aims to reduce energy demand from passive

[5] Note that while the units used here differ from those normally used in the UK, this makes little practical difference, particularly at such low permeabilities.

design strategies (building fabric, thermal mass and air tightness, ventilation/heat recovery), then meet the remaining demand through the use of microgeneration technologies.

## 3.2 Perceived resident/tenant experience

**The key findings and recommendations from this section are:**

- General design lessons can be learnt by engaging with specific tenants which can help to ensure that key sub-systems are operable by a wider range of occupants.
- In the case of in-situ tenants, disruption not only affects tenants but also impacts the implementation of works, with tenants themselves contributing to disruptive through-traffic during works.
- Specific tenant types present the most difficult challenge when retrofitting. These include larger families or properties with a larger number of occupants and tenants who are at home for extended periods of the day (e.g. working from home or unemployed and older tenants). In these cases, in-situ works may more adversely affect the daily routine and mobility of these tenants within the property than the option of decanting.
- It is important to ensure that consistent information is conveyed to the tenant throughout the retrofit process. A variety of handover strategies such as tenant meetings, information sessions and walk-throughs can be used to achieve this.
- It is recommended that a strategy for liaising with residents and neighbours is established and employed as early as possible. This helps avoid such issues as miscommunication and the subsequent mismanagement of tenant expectations and also allows for the planning of works to accommodate tenant needs/requirements and helps mitigate their concerns throughout the period. Aspects that should be discussed include:
    - The acceptable level and type of disruption for each tenant.
    - Alternate options to in-situ retrofit such as decanting and storage facilities for possessions.
- Effective handover procedures must also be put in place for future “follow-on” tenancies to ensure that any new tenants who were not part of the retrofit process are properly informed.
- Whenever possible, works should be scheduled around the tenant’s daily routine.
- Disruption or decant allowances must be budgeted for to compensate tenants who might lose the use of house facilities or are decanted for a period of time during retrofit works.
- Risks associated with tenants in neighbouring properties include disruption to neighbours (e.g. noise), conflicts concerning the use of shared outdoor spaces or pathways, limitations to accessibility during the retrofit process and issues with party walls.
- Effective communication practices with neighbours include face-to-face individual or community scale meetings, information notices and letters and should be employed to address the aforementioned issues.

The majority of the case study projects discussed in this report were implemented with the resident in-situ throughout most or all of the retrofit process. This therefore provided an opportunity to investigate the resident-side impact on retrofit including the management of tenant expectations and the protection of both tenants’ belongings and the construction team’s work productivity. In general, a diverse range of tenant types (e.g. elderly retirees, families with young children and families with adult children living at home) occupied the selected properties. It is clear that there is a need to assess the following, both at the level of the individual dwelling and in the context of a mass retrofit programme:

- The availability and development of technical solutions supporting both in situ and decanting approaches
- Costs and other impacts of in-situ retrofit (including disruption to occupants both during and after the retrofit, impacts on energy performance), as a function of tenant type, dwelling type, and chosen retrofit strategy and technologies (e.g. internal versus external insulation options)

- The options for decanting (how? Where? How far? How long? Cost implications etc) if the in-situ option cannot be implemented throughout the process
- Impact on work programmes and the sequencing of works.

While a diverse range of tenant types were included, most projects were selected for the Retrofit for the Future works based on tenant willingness to be involved in a retrofit of this type. As a result, this limits our ability to generalise from the R4tF retrofits and the project consortia's ability to use this opportunity to explore the roll-out of mass retrofit for tenants who are less willing to participate.

**The important aspects concerning resident experience (as perceived by the project consortia), key issues highlighted and recommended actions can be summarised as:**

### 3.2.1 Tenant engagement and communication

The role of occupant lifestyle, behaviour, commitment to the project, and educational level are all issues that need to be considered during retrofit design and execution. In all cases, it is important to ensure that tenants are well informed of the works throughout the process, and that they are provided with the information and understanding they need to enable them to live in and operate their home afterwards. Consistency of information is important to secure and maintain trust and manage tenant expectations.

**Key issues**

- Inadequate engagement with tenants can lead to designers making decisions that might render key sub-systems inoperable by some categories of occupants (e.g. the elderly or disabled may find certain window types such as double-glazed tilt windows difficult to reach and difficult to operate).
- Potential problems that can occur as a result of inconsistent information include:
    - Tenant dissatisfaction with the retrofit process. This may result in a lack of co-operation from tenants that may lead to delays in the work schedule and additional financial costs.
    - Tenant dissatisfaction with installed features. This may result in the consequent removal or changing of installed features. In addition to the financial costs incurred, this will also have implications regarding the integrity of the retrofit (achieving targets, etc.). The extent of dissatisfaction is affected by contextual factors such as the size of the dwelling (e.g. the use of Mechanical Ventilation with Heat Recovery (MVHR) in smaller dwellings in Cases A and C).

**Recommended actions**

- It is essential that the development and application of a tenant communication and liaison strategy be encouraged, through this general design lessons can be learnt by engaging with specific tenants.
- To avoid communication-related problems it is recommended that the tenant communication and liaison strategy be established and employed as early as possible in the process.
- In the likely case of several stakeholders being involved in the project, it is essential that a proper strategy be put in place to guarantee good coordination between them in communicating with the tenants.
- Issues of language and literacy should be considered when formulating the tenant communication strategy and alternatives to written communication should be explored (e.g. the use of audio/video, DVDs).
- Websites may provide a useful supplement to paper-based communities for some categories of tenants.

### 3.2.2 Tenant disruption

Disruption is an important aspect that affects both the planning and implementation of retrofit works, especially in the case of the in-situ tenants. Disruption may occur in the form of visual and noise disruption, health and safety issues, limitations in space usage, reduction of privacy, reduction in accessibility and potential damage to property contents.  The extent of disruption will of course be affected by the retrofit strategy employed (e.g. external versus internal insulation options).

**Key issues**

- Retrofit with tenants in-situ, impacts both on tenants and on the implementation of works with tenants themselves contributing to disruptive through-traffic.
- Properties with larger families or with a larger number of occupants and those with tenants who are at home for larger portions of the day (e.g. those who are working from home or unemployed and older tenants), present the most difficult challenge to retrofit.

**Recommended actions**

- The acceptable level and type of disruption should be adequately communicated and discussed with tenants. This will allow for the planning of works in a way that accommodates tenant needs/requirements and mitigates their concerns throughout the period.
- Alternate options such as decanting and storage facilities for possessions should be discussed with tenants and where possible, advice and help in setting these up is provided.
- Whenever possible works should be scheduled around the tenant (‘s) routine, e.g. noisy works could be carried out while tenants are out of the house.
- Disruption and/or decant allowances should be budgeted to compensate tenants who might lose the use of certain facilities (e.g. kitchen) or who are decanted for a period of time during retrofit works.

### 3.2.3 Handover procedures

Handovers are a key aspect in ensuring that tenants are well-versed in the operation of installed systems and are fully aware of how to maintain and deal with new building materials and other new features throughout their tenancy. It should be noted that project teams operated divergent strategies for involving occupants during the handover. While some wanted to hide complexity and not let occupants touch it, others wanted to involve occupants by, for example, encouraging them to change filters.  This was particularly clear in the case of MVHR systems.

**Key issues**

- Newly installed elements often employ new, unfamiliar or sophisticated technologies (e.g. new metering systems, light sensors) that will require a degree of tenant interaction to operate them.
- Retrofitting a property will result in a change to its internal environment. Tenants may need to be educated as to how to adjust to these changes.
- Various risks are associated with “follow-on” tenancies (future tenants who were not part of the retrofit process), these include the lack of information provided and unsuitability of installed technologies to their requirements.
- There are hints in the POE data that where occupants don't understand technical systems, they don’t operate them successfully.

**Recommended actions**

- Tenants must be made aware of the changes and provide information on how to properly use new systems.
- It is recommended that technical parties responsible for systems maintenance should be included in the handover process.
- A variety of effective handover strategies such as tenant meetings, information sessions and walk-throughs can be used. These should be selected to suit tenant circumstances and preferences. For example, an elderly tenant may not feel comfortable with allowing a large number of people into their

home for a handover meeting, in this case a walk-through with a tenant liaison officer may be more appropriate.

- An alternative method is the use of illustrated "user guide" information sheets mounted on walls or the inside of accessible (utility) cupboards. These outline the main features of the retrofit (applied fabric measures and installed features), set out simplified instructions for the operation of various installations such as boilers, thermostats and solar tanks and advise tenants which manuals to refer to for further information.
- The opportunity for the use of other innovative methods such as instructional audio/video, DVDs and websites should be explored, particularly where technical literacy may be a problem.
- Effective procedures must also be put in place to support future "follow-on" tenancies to ensure that any new tenants who were not part of the retrofit process are properly informed about the nature of the house and how to operate the various technologies installed.
- Such procedures will almost certainly be the responsibility of the landlord. It is therefore important to help to ensure that the landlord has and can retain a sufficient understanding of the retrofit to be able to handover to future occupants.

### 3.2.4 Sequencing of construction works

The sequencing of construction works is an integral factor in ensuring that works are properly implemented and can also be a key tool in mitigating tenant disruption. As the majority of these projects involved one property, it should be noted that the full impact of construction sequencing was not fully explored.

**Key issues**

- In many tenant in-situ retrofit cases, work programmes are implemented in a sequence designed to appeal to the tenant and accommodate their specific needs. However, this may not necessarily be the optimum logistical approach to construction that should be used.
- Complexities of dealing with occupants and supply chains make sequencing of work on one-off projects difficult and potentially inefficient.
- Inadequate consideration of sequencing can lead to works being carried out at inopportune times, for example the replacement of windows during the winter.

**Recommended actions**

- The planning of sequencing should be coupled, where possible, with larger mass-scale retrofit projects to fully realise its benefits.
- The interaction between design decisions, product choices, supply chains and sequencing should be carefully considered. For example, sequencing should take account of seasonal weather issues (e.g. possibility of rain, frost) and their impact on external wet trades and replacement of windows.
- Delivery teams need to consider the interaction between design decisions, product choices, supply chains and sequencing when developing and implementing retrofit strategies (Cases A, B and E).

### 3.2.5 Communication with neighbours

A retrofit project cannot be treated as a sequence of tasks implemented in an isolated property. Occupants of neighbouring properties and their relationship with tenants of the retrofit property play an important role in the design and implementation of works.

**Key issues**

- The early engagement of neighbours is a key aspect in the implementation of future mass-retrofit strategies to ensure effective co-ordination and implementation of works.

- Risks associated with tenants of neighbouring properties include disruption to neighbours (e.g. noise, dust, fumes etc.), conflicts concerning the use of shared outdoor spaces or pathways for storage of building materials, limitations to accessibility during the retrofit process and issues with party walls.
- Risks associated with undocumented extensions to neighbouring dwellings should be assessed. In such circumstances (Case H) neighbours may be less co-operative.

**Recommended actions**

- Effective communication practices such as face-to-face individual or community scale meetings, information notices and letters should be employed to address potential risks listed above.
- Any pre-existing issues (e.g. existing conflicts) with the neighbours should be addressed and if possible, a formal agreement defining responsibilities and access rights during retrofit should be put in before works begin.
- Effective communication with tenants in neighbouring properties throughout the retrofit process also offers an opportunity to relay information and can potentially encourage them to undertake similar works. But for this to work, the retrofit itself needs to be seen to be a success (Case B).

### 3.3 Lessons learned

**The key findings and recommended actions from this section are:**

- Hindsight review/"wash-up" meetings are a valuable tool in building a "knowledge-based" business. They provide the opportunity to re-examine projects after they are completed and should be used to provide a forum for multi-skilled teams to identify and refine solutions and crystallise ideas to inform future projects.
- The use of innovative and new technologies/materials should be balanced with the inclusion of technologies and materials that are well-known and familiar to the contactor to minimise risk and avoid over-complication of the works. It is also important to factor in the "learning curve" for the team in the overall planning of the works.
- The use of a single sub-contractor appears to offer significant advantages for retrofit. When this option is not available, there may be an advantage in small teams of people drawn from clusters of businesses who can develop trust and shared experience of retrofit over a number of projects.
- There is often a tension between the desire to source products and materials locally, and the difficulty of sourcing at the right price and right performance without going overseas.
- A strategy of local sourcing of materials and the use of local tradesmen as part of a "local knowledge, local interest, local communities" approach is attractive, but may not provide the whole solution to dwelling retrofit. Decisions as to whether to source locally or from further afield need to be taken pragmatically.
- Working closely with supply chain/manufacturing representatives throughout the retrofit programme will help to ensure that any arising issues or design problems are more effectively resolved. Effective engagement with the supply chain, particularly with large UK-based or overseas suppliers is likely to be easier when working at mass-scale.
- It is important to consider any economies of scale that can be achieved with volume increases. Project scheduling and logistics should be planned to allow for the largest (bulk) orders to be made. Co-ordination and aggregation of one-off projects, where feasible, may allow for increased economies of scale. Co-ordination with other contractors on nearby projects could be considered.
- Good co-ordination between contactors/operative and the design team should be achieved through open communication channels and frequent up-dating through such means as site meetings/workshops. Tools such as Building Information Modelling (BIM) should be used to aid this.

This area of discussion looks at the design challenges and assesses what worked well or less well, provide an understanding of why this occurred and possible routes to improve future projects. The main lessons learned are highlighted as follows:

#### 3.3.1 The importance of project review feedback

Through the work undertaken for this report, hindsight review/"wash-up" meetings were identified as a valuable tool for re-examining projects after they are completed. These reviews provide a forum for the multi-skilled teams to refine and identify solutions and crystallise ideas to inform future projects they are involved with, and will be particularly relevant in the case of future roll out of mass retrofit and in building "knowledge-based" businesses. Some important aspects to consider when setting up a hindsight review meeting are[6]:

- It is recommended that hindsight review/"wash-up" meetings are set up and take place as soon as possible after handover (typically within the first year). This is to ensure that team members are still available and memories are still fresh.
- It is important to note that at the organisational level, the usefulness of hindsight activities in general and hindsight review meetings in particular, are contingent on the existence of an effective internal feedback ("knowledge management") system within the organisation itself.

[6] Bordass et al. (2006) A guide to feedback and post-occupancy evaluation, The Usable Buildings Trust.

### 3.3.2 The use of new materials and technologies

Many of the design proposals discussed combined both existing technologies and new innovative solutions in an attempt to form a comprehensive retrofit strategy. While these projects provided the opportunity to investigate the "buildability" of various new retrofit solutions and how new technologies operate in real world situations, they also allowed construction companies involved to scope out potential workmanship issues. Examples of new technologies used, the key issues experienced in their installation or use, and some recommended actions include:

**Key issues**

- For one project (Case E), the installation of MVHR was assessed in the early stages of the proposal. It was however deemed by the design team to be a non cost-effective and non-replicable solution due to the associated design constraints e.g. in smaller properties where space is at a premium. High quality MVHR installations need room for generously sized ducts and heat exchangers, for sound attenuation and to facilitate maintenance. In smaller properties there is a risk of energy and acoustic performance being compromised.
- Nanogel (Spacetherm) insulation products are a relatively new and expensive product. The material is also hard cut on-site due to the amount of dust produced (Case C).

**Recommended actions**

- While the use of new building materials and systems may offer significant advantages, cost-effectiveness, applicability, replicability and workforce familiarity of various technologies must all be taken into account.
- When new technologies and materials are used on projects, it is important to factor in the "learning curve" for the contractor in the overall planning of the works.
- For hard to use or expensive materials such as Nanogel (Spacetherm), use should be restricted to where space is at a premium.
- On-site cutting of Nanogel (Spacetherm) should be minimised through ensuring that pre-cut panels dimensions are based on precise on-site measurements.

### 3.3.3 Contracting practices

The use of a well-informed single (multi-trade) sub-contractor on the majority of the building work and a well co-ordinated design team was considered to be one of the most important factors in the success of a project.

**Key issues**

- Difficulties currently exist in commissioning a single sub-contractor for all building works. This is due to the specialisation of existing sub-contractors and the lack of qualified, multi-skilled sub-contractors.
- External sub-contracting practices and long sub-contracting chains tend to be less effective than an in-house team, and should therefore – where possible – be avoided or minimised.

**Recommended actions**

- The procurement of a single sub-contractor model is considered to offer significant advantages for future mass retrofit. This particular model resolves the gaps between design and installation, enables clear communication and accountability on-site and can also be a capacity building model for the industry.
- It is recommended that at least in the short to medium term, future retrofit projects be carried out with small teams of people with strong working relationships and who are capable of supporting mutual learning.

- Project consortia are also encouraged to prioritise local sourcing of materials and the use of local tradesmen where possible as this can be considered part of a “local knowledge, local interest, local communities” approach. Many consortia deemed this an important element of sustainable approach to retrofit, and especially relevant given the current economic environment. However, sourcing products and materials locally may conflict with other goals including the need to source at the right price and right performance.
- Good co-ordination between contactors/operative and the design team should be established through open communication channels and frequent up-dating through means such as site meetings.
- The use of Building Information Model (BIM) technology can be used to aid in maintaining the continuity of information throughout the project lifecycle. Stored information can be used to re-examine the viability of solutions in the long-term.
- Project teams need to be vigilant for emergent problems and conflicts between technical systems and be prepared to develop innovative solutions to overcome these (e.g. Case A).

### 3.3.4 Supply chain development

The supply chain for a construction project includes the network of organisations involved in both the manufacturing and supply (transport logistics and delivery) of building materials and components. On retrofit projects, in particular ones where the tenant remains in-situ, the supply chain is a critical aspect in the delivery of often short programme schedules.

**Key issues**

- There is a tension between the desire to source products and materials locally, and the difficulty of sourcing at the right price and right performance without going overseas.
- While reliance on foreign-based supply chains may be necessary to access the latest technologies and materials, and also mature products in categories not commonly used in the UK, this leaves project implementation at an increased risk from issues such as transport problems and currency exchange rises.
- In addition, there may be increased difficulty in maintaining relationships with overseas suppliers and manufacturers.
- Various issues and weaknesses such as lack of competitiveness, poor collaborative integration and inflexibility have been identified with the current UK supply chain. These affect industry’s ability to deliver required products and materials and must therefore be adequately addressed.

**Recommended actions**

- As noted earlier, a strategy of local sourcing of materials and the use of local tradesmen as part of a “local knowledge, local interest, local communities” approach is attractive, but may not provide the whole solution to dwelling retrofit. Decisions as to whether to source locally or from further afield need to be taken pragmatically. For mass-scale retrofit in particular, it is recommended that the supply chain/manufacturing representatives are included in the process of designing the retrofit programme. This can ensure that any arising issues or design problems are more effectively resolved and that solutions can be replicated on a wider scale (an example of roof light design issues and involvement of the manufacturer in addressing these in finding an adequate solution was presented).
- A small number of specialist UK-based wholesalers can already provide crucial information on products and systems for retrofit, but their capacity is unlikely to be sufficient to support mass retrofit.
- A long-term strategy for supply chain development should focus on the expansion of UK-based supply and distribution chains to support mass retrofit, as well as on manufacturing.

- In cases where products and systems are sourced from overseas, the local availability of connecting products may be a problem. Past examples have included brackets to facilitate the installation of high-performance windows.

### 3.3.5 Cost-effectiveness of retrofit

Given the specific circumstances of the projects discussed, the establishment of an economic case for retrofit is currently a challenge. The installation of any retrofit measure requires a balance between cost and performance benefit. A cost-benefit analysis (assessing the extra benefit achieved in thermal performance versus the disruption/cost) is therefore a key element in assessing the viability of measures. Cost-effectiveness and certainty is also impacted by a number of factors which may not be directly related to the construction process itself (e.g. price changes).

**Key issues**

- Economic viability can be hard to realise on single project retrofits. The wider policy context is likely to have a profound impact on this in the near future, through mechanisms such as Green Deal.
- Project budgets can be at risk from unexpected but unavoidable works that are not recognised until part way through a retrofit e.g. discovering that wiring is defective and needs to be replaced.
- Cost certainty is also affected by extraneous circumstances such as unexpected rises in VAT, price changes and currency exchange rate fluctuations.

**Recommended actions**

- For single project retrofits, it is important to consider any economies of scale that can be achieved with volume increases and it is therefore essential that project scheduling and logistics are planned to allow for the largest (bulk) orders to be made.
- It is also recommended that any opportunity to integrate projects, where feasible, be taken to allow for increased economies of scale. For example co-ordination with other contractors on nearby projects could be considered.
- However, mass retrofit (either on a company or national scale) is considered to be the key in achieving cost-certainty and making measures more cost-effective. R4TF contractors estimated that a cost reduction of 25-30% could be achieved through economies of scale.
- Approaches such as value engineering or “efficiency driving” may help to keep projects within budgetary constraints.
- The early engagement of manufacturers is a key element in achieving cost-certainty and cost-effectiveness.
- Adequate budgetary contingency should be included to fully cover any unexpected costs incurred throughout the project.
- For future retrofit projects, technology costs (which are often the main contributor to the high cost of retrofitting properties) are expected to decrease as demand volumes and competitiveness increases. This should be considered in budgeting for future works.

## 3.4 Opportunities for future improvement

**The key findings and recommended actions from this section are:**

- As part of a more sustainable approach to retrofit, it is recommended that the use of original system components be encouraged in retrofit where possible. This decision must be based on a thorough assessment of the condition of the original systems and risks involved in using them (e.g. effect on overall performance of system).
- To avoid issues regarding "systems not talking together" designers need to consider system interactions during the design process. Contracting single organisations for integrated system provision (e.g. heat distribution, heating system, and controls) is likely to minimise problems in this area.
- The employment of an "on-site Mechanical and Electrical (M&E) co-ordinator" with a combined expertise in both heating and ventilation systems can improve system installation and help resolve installation issues.
- It is important that early engagement with utility companies in the retrofit process be established to ensure that any works they are involved in (installation or moving of meters) be completed on time.
- Temporary systems used during interim change over periods should be adequately planned to ensure that they do not interfere or adversely impact the retrofit process. In addition, tenants must be made fully aware of their temporary nature and their potential short term impact on energy bills.
- Choice of ventilation system is complex. In airtight dwellings (permeability less than $3m^3/m^2/h$), MVHR can significantly reduce energy consumption and improve indoor air quality. But high quality MVHR installations need room for generously sized ducts and heat exchangers, and for sound attenuation. In smaller properties there is a risk of energy and acoustic performance being compromised. At intermediate levels of airtightness, simpler strategies such as continuous mechanical extract ventilation (MEV) or positive input ventilation (PIV) may deliver lower $CO_2$ emissions. A full assessment of the viability of these technologies (in terms of expected post-retrofit airtightness of the building fabric, availability of space requirements) should be undertaken to determine their suitability for individual retrofits.
- PIV can deliver lower energy use than MEV by recovering heat from attic spaces. But careful attention to insulation and airtightness in retrofits should mean that there is minimal heat available.
- Both MVHR and PIV support the filtration of air supply. But PIV may offer poorer control of internal sources of air pollution than MVHR or MEV. Passive stack ventilation has the advantage of requiring no electricity to operate it, but may not provide such close control of air flows, and may require fan assistance in summer.
- The effective use of renewable systems such as solar thermal in parallel with more conventional systems such as gas heating, requires a whole systems design approach and careful consideration of control strategies.
- External wall Insulation can be used as a "generic" solution for insulating hard to treat properties. It is important to develop solutions to address detailing, eaves extensions and window replacement as part of this process.
- Communication of the aims and strategy adopted by the project (e.g. required functional or performance targets and the reasons for them) to all installers and specialist trades can help to improve quality of work.

Based on the discussions undertaken for the hindsight review meetings, suggestions for the improvement of each of the following areas were highlighted.

### 3.4.1 Space and water heating systems

**i. Adequate assessment of the re-usability of system components**

It is recommended that the use of original system components be encouraged in retrofit where possible (Case E). This requires that:

- The condition of original systems is sufficiently assessed and deemed acceptable for re-use
- No significant risks to newly installed components can be identified from using a combination of new and old elements
- There is no significant reduction to both the performance of the newly installed kit and the system as a whole
- It is essential that future sizing requirements be considered in assessing the suitability of this approach and ensuring that later alterations are not required.

For one of the case study projects (Case B) where the original radiators were to be reused in conjunction with the new systems, the radiators were considered to be over-sized for the (much reduced) demand and were therefore removed. On reflection, this may have been unnecessary. Oversizing of heat distribution systems should allow heating systems to operate at lower temperatures and therefore more efficiently – particularly where heat is supplied by heat pumps or solar systems.

**ii. A systems approach to system installation**

In many of the project cases discussed issues regarding "systems not talking together" were reported (e.g. Case B and Case F). It is therefore recommended that when planning a retrofit project:

- A single organisation for integrated system provision (e.g. heat distribution, heating system, and controls) is used
- Adoption of a whole system approach in the design phase and careful consideration of system interactions.

**iii. Improving system installation and resolving installation issues**

- The presence of an M&E services consultant on board throughout projects was considered to be essential. It is suggested that this include the employment of an "on-site M&E co-ordinator" with a combined expertise in both heating and ventilation systems.
- The M&E designer should be informed at the point of installation of any snags in the operation of the systems installed. This is to enable these issues to be resolved as quickly as possible.

**iv. Planning interim systems**

- Temporary systems may be needed for periods during retrofit, e.g. to bridge between the original heating system and a replacement. These should be adequately planned to ensure that they do not interfere or adversely impact on tenants or the retrofit process.
- Tenants must be made fully aware of the temporary nature of these systems and their likely impact on energy bills in the short term (e.g. where the interim system uses on-peak electricity).
- Increased energy bills associated with the installation of temporary systems can impose constraints on the tenants (especially in low income housing), a compensation allowance should be therefore be included in the project contingency budget.

**v. Co-ordination with utility companies**

- The involvement and performance of utility companies can be important to the success of retrofit projects. Poor or late engagement with utilities can lead to extensive delays in work programmes (Case B).

**vi. Space requirements**

- The installation of the large mechanical systems should involve careful planning for the space requirements needed and selection of systems that can be more easily accommodated within the limited available space.
- In the case of many retrofit schemes, useful storage space has been compromised to accommodate these systems. Tenants must therefore be adequately informed, their consent sought and alternative arrangements made where required.

### 3.4.2 Ventilation and air-tightness strategies

- Choice of ventilation system is complex and a number of competing systems are available. The main ones are MVHR, MEV, PIV, and passive stack ventilation (PSV).
- In airtight dwellings (permeability less than about $3m^3/m^2/h$), MVHR can significantly reduce energy consumption and improve indoor air quality. But high quality MVHR installations need room for generously sized ducts and heat exchangers, for sound attenuation and to allow for maintenance. In smaller properties there is a risk of energy and acoustic performance being compromised. They are also relatively expensive to install, unless used in conjunction with air heating as an alternative to a wet central heating system.
- At intermediate levels of airtightness, simpler strategies such as continuous mechanical extract MEV or PIV may deliver lower $CO_2$ emissions at reduced capital cost. PIV in principle delivers lower energy use than MEV by recovering heat from attic spaces. But careful attention to insulation and airtightness in retrofits should mean that there is minimal heat available.
- Both MVHR and PIV support the filtration of air supply. But PIV may offer poorer control of internal sources of air pollution than MVHR or MEV, unless used in conjunction with local extract fans.
- Passive stack ventilation has the advantage of requiring no electricity to operate it, and of being silent. But it may not provide such close control of air flows, and may require fan assistance in summer. It may also be less effective in controlling external noise than the other systems.
- A full assessment of the viability of these technologies (in terms of expected post-retrofit airtightness of the building fabric, availability of space requirements) should be undertaken to determine their suitability for individual retrofits.

### 3.4.3 Renewable generation strategies and resource recycling

Renewable energy systems can be essential to achieving more challenging energy and $CO_2$ targets in retrofit projects. Renewable systems should be selected and sized in conjunction with fabric and system measures and with careful consideration of relative costs. Renewable energy systems considered to be most suitable for domestic retrofit include:

#### i. Solar thermal systems

- Solar hot water systems were installed in all eight of the case study projects. In principle, solar thermal systems have been found to be an especially successful strategy for domestic retrofit properties due to their effectiveness in meeting the hot water demand. However, in practice system performance can be compromised by poor installation practices and poor control strategies.

#### ii. Photovoltaic (PV) systems

- PV systems were installed in six out of the eight of the case study projects. While solar thermal installations are prioritised, PV systems are often installed alongside them when enough roof space is available.
- While PV systems appear to be more expensive than solar thermal installations, they present a simpler control problem and do not suffer from diminishing returns to scale when installed on single houses.

- It is important to note that PV panel types which can be installed in the plane of the roof can provide an effective solution in the case of stringent planning laws, since they are deemed more acceptable by planning officers (Case C).

**iii. Water harvesting and recovery systems**

- The operation of waste water heat recovery systems may be affected by the existing low water pressure level (Case A). These issues must be resolved before the installation of such systems to ensure efficient operation.
- Combined rain and grey water harvesting systems are often used around Europe; as a result a large labour force with the required skills to install them exists. These skills still have to be developed in the local UK market to meet projected increased demand for the installation of such systems.
- For one of the case study projects (Case F) such a system was initially proposed. This was changed to a rainwater harvesting system due to the cost implication and grading of the site, which added complications with installing an underground tank, cost associated with the excavation works, and labour. This water is used for toilets and washing machines.

### 3.4.4 Insulation solutions and thermal bridging

- External wall insulation is regarded to be a successful "generic" solution to insulating hard to treat properties, and is also considered to be a less disruptive and more viable option (than internal insulation) when undertaking the retrofit of blocks of houses since it minimises thermal bridging (e.g. Cases B andD).
- External wall insulation is also considered to be cost-effective and can in certain circumstances improve the appearance of the properties.
- It should be noted that external wall insulation interacts with poorly constructed extensions, eliminating some thermal bridges while creating others. Handling such issues demands a clearly thought-through retrofit strategy, sufficient funding within the project budget and careful engagement with tenants.
- While internal insulation is a more difficult option to install, especially in limited spaces, it is an option that must be used in particular situations where properties are located in conservation areas, in the case of strict planning restrictions and if tenants do not wish to alter the external appearance of their property (e.g. Cases A and E).

Issues that require further consideration in the case of both types of insulation include:

- For internal insulation, insulation companies must provide more specification for a major number of details.
- For external insulation the following details must be adequately planned for:
    - Eaves: In the case of external insulation, eaves must be brought out to be in line with the extended facade. To achieve this, bespoke solutions developed on-site were used. For future retrofits "clip on" eave extension solutions could be used to enable this to take place more easily (Case B).
    - Windows: Positioning of windows needs to be considered to maintain facade appearance and light levels within the internal space. It is important that high quality and sufficiently informative detailing is provided to ensure that the window-wall-insulation interfaces are correctly handled (Case A).
    - Planning constraints: In the case of stringent planning constraints, more acceptable external insulation solutions should be developed to allow increased applicability. These should ideally aim to decrease the thickness of current external insulation materials and more closely replicate existing finishes.

### 3.4.5 Other areas

**i. Lifecycle assessment**

The requirements of the TSB competition dictated that certain elements be replaced (e.g. boilers) even though these had not come to the end of their physical lives.

- A possible approach for future retrofit methods would be to implement a lifecycle approach rather than retrofitting in one go.
- The expected life span of a property, the level of intervention desired, trigger points and payback period of installations and technologies should be considered in planning this process.
- The use of the whole house approach also allows for better future planning through the consideration of trigger points and co-ordination of works accordingly.

**ii. On-site interpretation of information**

- Architects felt that on-site workers had not fully understood the detailed drawings provided and that the time spent producing the drawings was not adequately reflected in the implementation.
- A tendency for the workers to revert to habitual ways of carrying out work instead of working to design information (drawings and specifications) was also reported.
- It is suggested that on-site "tool-box" workshops and alternative training material such as videos could be used to extend the information provided to on-site operatives and ensure that it is correctly understood.
- It is also essential to communicate to operatives the aims of the project (e.g. required functional or performance targets) and how implementing the works as specified is essential in achieving this.

**iii. Embodied energy**

- Although it is encouraged that materials with low embodied energy are used where practical, embodied energy was not thoroughly assessed for all installations on case study projects.
- The true carbon cost of discarding appliances and materials to be replaced should be included in assessment of the retrofit. Studies have found that extension of product life can reduce resource consumption for some systems, but the success of such a strategy requires the careful consideration of impacts on embodied and operation energy[7].
- It is unclear whether such a strategy could be implemented on mass-scale.

**iv. Detailed survey**

- It is suggested that a detailed survey be carried out prior to the retrofit works (e.g. by the architect) with the aim of identifying latent defects that could adversely affect the retrofit if discovered part way through.

[7] Truttmann,N and Rechberger, H (2006) *Contribution to resource conservation by reuse of electrical and electronic household appliances. Resources*, Conservation and Recycling Vol. 48 (3), Pp 249-262

## 3.5 Novel solutions and business opportunities

**The key findings and recommendations from this section are:**

- The future mass uptake of retrofit will encourage the development of both novel processes and products to fulfil current and future demand in the UK market. It is recommended that SMEs in particular take advantage of this opportunity and gain the adequate expertise, accreditation and experience to meet this need.
- It is suggested that SMEs develop a focused "single-builder" culture, with "retrofit-dedicated" contractor teams.
- Novel solutions and processes applied for retrofit projects include:
- Development of whole house energy measures plans which apply a lifecycle approach to implementing retrofit.
- Innovative solutions to deal with chimneys, insulation of loft spaces.
- It is recommended that business development opportunities in the following areas be encouraged:
- Increasing the manufacturing base of energy efficient appliances and electrical goods (e.g. solar doorbells, wireless light controllers, roomstat and controlled radiator valves) in the local UK market.
- The organisation of decanting tenants, either throughout part of or the entire retrofit process.
- Product development activities areas where the use of currently available technologies and materials does adequately fulfil market requirements (e.g. non-disruptive solid floor insulation solutions).

**i. Whole house energy measures plan**

- A lifecycle whole house energy measures plan was developed by the architects of one of the case study projects for implementing retrofit over a 25-30 year programme that unfolds over time (Case C).
- This approach could be widely used to incorporate measures as and when most cost-effective with identified trigger points for intervention.
- This could potentially allow all properties to be retrofitted (over a long period of time) without having to decant any resident.
- Discussion of issues concerning the maintainability, upgradability and accessibility of retrofit over the lifecycle of a project was not recorded during the hindsight review/"wash-up" meetings, but is clearly an issue that must be considered for future retrofits.

**ii. Decanting residents and the provision of retrofit-related tenant services**

- The organisation of decanting tenants, either throughout part of or the entire retrofit process, provides a potential business opportunity for the various organisations operating in the field.
- Similarly, opportunities exist in the organisation and provision of storage and possibly insuring tenant possessions for retrofit works. This can build on existing services in this field to increase the focus on the particular requirements of that market (e.g. temporary facilities for increasing local storage capabilities in the case of mass retrofit in a particular area).

**iii. Solid floor insulation**

- Solid floors are often not insulated due to the disruption involved. While various products currently exist on the market, all involve the complete removal of the floor covering.
- Product development in this area is therefore required to develop a new material for solid floor insulation. This issue potentially affects a large number of properties.

- A defective floor makes insulation considerably easier, using straightforward approaches and materials. Retrofit teams should be alive to such opportunities.

**iv. Energy efficient appliances**

- Energy saving A++ appliances are currently very difficult to locate and source in the UK. In addition, other energy efficient small electrical kit such as “solar” door bells which are available in other countries are not available locally and must be imported. This highlights that there is a market for developing and manufacturing products such as wireless light controllers, roomstat and controlled radiator valves locally.

**v. Construction practice and organisation**

- It was highlighted that current procurement practices by contractors lead to fragmentation in installation.
- It is suggested that this model be replaced by a more focused “single-builder” culture, where “retrofit-dedicated” contractor teams could be set up.
- This in particular highlights the opportunity for SMEs to be properly accredited and certified to meet this need.

**vi. Strategies for chimneys**

- In existing properties chimneys are one of the main areas for heat loss and an opportunity for innovative solutions to address this issue.
- An innovative and highly replicable solution used in one of the projects (Case F) involved inserting a thermal break plate to create a thermal break between the chimney on the top and the house at the bottom. This solution maintained the existing chimney as a ventilated space to reduce mould growth and preserved its structural integrity.

**vii. Rigid board for loft insulation**

- For one of the case study projects (Case G) a high airtightness level was required. The roof insulation strategy employed a rigid board (instead of a membrane) on the floor of the loft space to provide insulation and an instant working platform for installing other equipment (PVs, etc.). This was the first time this approach has been used and was viewed as one that could be widely applicable in the UK.
- When using this approach, the space under the board and between the joists needs to be filled to prevent convective bypassing of insulation.

## 3.6 Planning and building control

**The key findings from this section are:**

- Many retrofit projects will be located within conservation areas and will therefore be subject to more stringent planning guidelines that limit changes to the building's appearance.
- Inconsistency between BCOs (Building Control Officers) was reported. This highlights the need for BCOs to have good technical competence and knowledge in this area. In addition, uniformity of approach based on technical competence and knowledge should be established and the provision of a national guidance to aid this must be prioritised.
- The involvement of Building Control Bodies (BCBs) is an essential factor in ensuring the safe handover of a project, since it reduces the occurrence of ineffective design practices. It is therefore recommended that appropriate engagement is established early on in retrofit project to facilitate easier and more productive interaction between stakeholders.
- Permitted development rights are currently inconsistent and disproportionate. A national strategy that aims to develop these to allow for the inclusion of more retrofit measures must be put in place to address the requirements of future mass-scale retrofit.

The extent of involvement of building control bodies is typically influenced both by the project type and by the design team. Traditionally, health and safety aspects were considered to be the most important areas covered by the regulations. Energy legislation in general and Part L in particular, had previously been considered less important in terms of priority. It is expected that BCBs will need to up-skill as the importance of energy efficiency in the built environment increases and mass retrofit is rolled out.

For the case studies discussed in this report, some of the main findings include:

**Impact**

- Many retrofit projects will be located within conservation areas and will therefore be subject to more stringent planning guidelines that limit changes to the building's appearance. This will be a key influencing factor in determining both fabric retrofit methods used (windows, insulation) as well as technologies installed (solar PV on roofs).
- The involvement of BCBs is an essential factor in ensuring the safe handover of a project, since it reduces the occurrence of ineffective design practices.
- In addition, effective communication can potentially ensure that the guidance provided is both design-effective and cost-effective.

**Challenges**

- Inconsistency between BCOs was reported by project teams on two of the eight case study projects. Such inconsistency unsettles design teams.
- It was noted that BCOs appeared less interested in achieving energy efficiency (and applying related legislation) than they were in addressing other factors such as means of escape and stair riser dimensions.
- Planning requirements were also deemed confusing and inconsistent in their application. This will be an especially relevant issue in the case of mass retrofit where construction works may be carried out on a number of clustered properties located within the boundaries of different boroughs.

**Recommended actions**

- It is important that appropriate engagement is established early on in retrofit projects.
- Meetings held early on in the design process are preferred since they facilitated easier and more productive interaction between stakeholders.

- Interaction with BCBs can be undertaken in both formal and informal settings through methods such as scheduled meetings and inviting BCBs to attend design meetings to less interaction-intensive methods such as letters or telephone calls.
- BCOs are often knowledgeable and experienced individuals. If approached appropriately they can be a resource, rather than an obstacle to retrofit.
- Permitted development rights (which are currently inconsistent and disproportionate) need to evolve to be appropriate for the imminent flood of retrofit activity.