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Briefing Paper

Sustainable refurbishment – how to better understand, measure and reduce the embodied impacts

BRE Centre for Sustainable Products

Summary

Around 10% of UK emissions are associated with the manufacture and transport of construction materials, and the construction process; and refurbishment projects make up a significant percentage of activities in the built environment. The UK is committed to reducing carbon emissions by 80% by 2050; savings linked to refurbishment will have an important part to play in meeting this target. This paper, funded by the BRE Trust, discusses how to reduce the environmental impacts of refurbishment with a focus on the embodied impacts of construction materials. It describes tools and other forms of support available, particularly from BRE, that can be used for assessing the environmental impact of refurbishment projects and products and provides some examples in the form of case studies.

BRE Trust

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This Briefing Paper has been produced by the Building Research Establishment (BRE) on behalf of the BRE Trust.

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Contents

1 The environmental impacts of UK Construction

The following figures for UK environmental impacts, gathered by the UK Green Building Council in Key Statistics reports[1,2], provide the context for the challenges that the UK construction industry is facing.

Carbon dioxide (CO_2) emissions

- The construction and maintenance of buildings and other structures is responsible for around half of UK carbon dioxide emissions[1].
- Around 10% of UK emissions are associated with the manufacture and transport of construction materials, and the construction process[1].

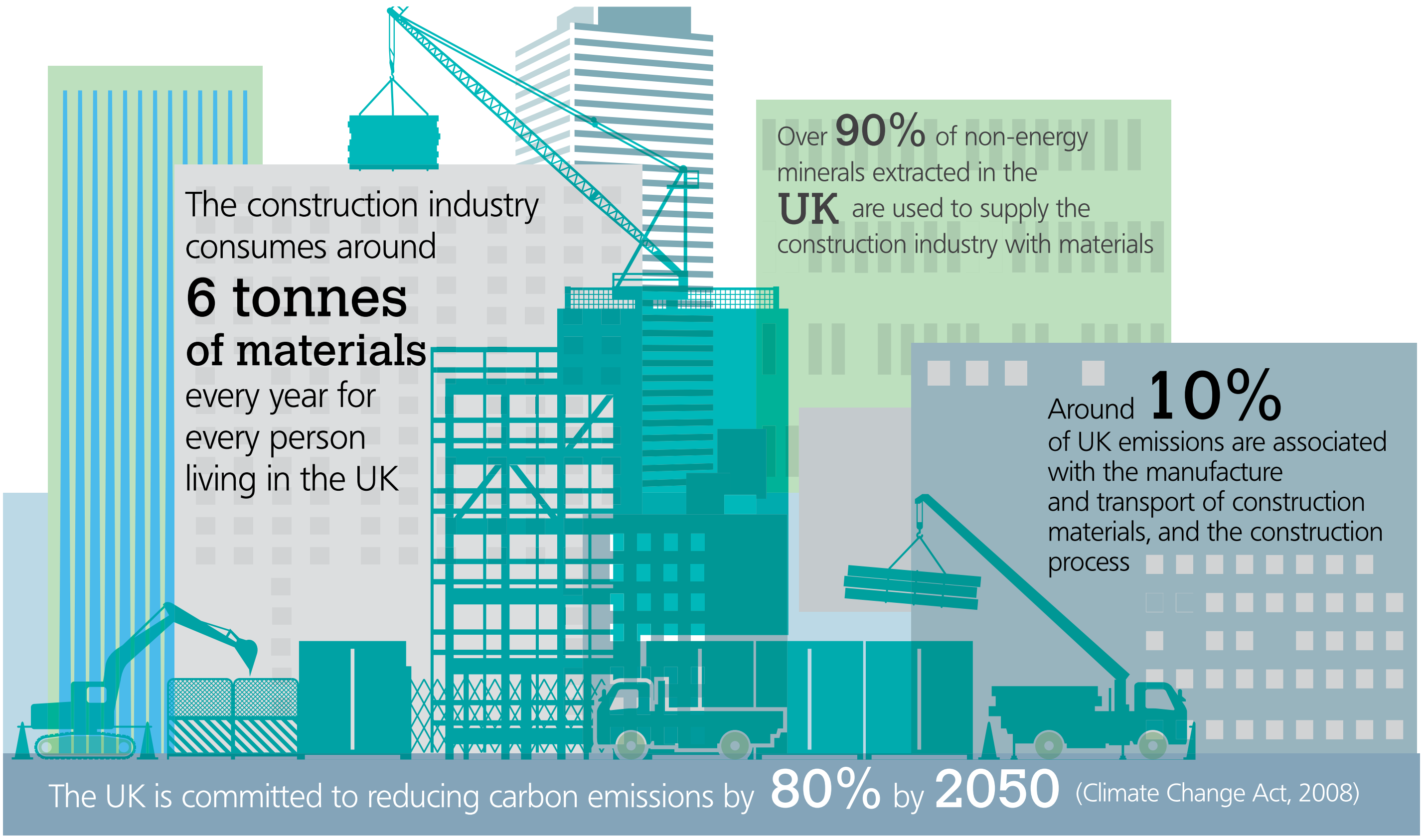
Materials

- Over 90% of non-energy minerals extracted in the UK are used to supply the construction industry with materials[2].
- The construction industry consumes around 6 tonnes of materials every year for every person living in the UK[2].

Regulations

- The UK is committed to reducing carbon emissions by 80% by 2050 (Climate Change Act, 2008) and has increasingly stringent targets for the thermal performance of new buildings[1].
- The requirement for new housing to be zero carbon, planned for implementation in 2016, means that any carbon dioxide emissions caused by the generation of electricity used during the normal operation of a building must be balanced by savings elsewhere (e.g. over the course of a year, energy taken from the grid when demand is high is to be balanced by energy returned to the grid when demand is lower); this means that onsite generation of renewable energy is generally necessary[1].
- The UK Government has set targets of BREEAM ratings to be achieved in the development of new or significantly refurbished public buildings. (See the BREEAM website for details of the ratings to be achieved by different types of public buildings).

1. http://www.ukgbc.org/resources/additional/key-statistics-construction-industry-and-carbon-emissions, accessed on 22 April 2015
2 http://www.ukgbc.org/resources/additional/key-statistics-materials-and-recycling, accessed on 22 April 2015



1.1 Planning for a reduction in environmental impacts

A defining feature of a sustainable building is that it reduces environmental impacts significantly. This can include measures to reduce energy consumption and carbon dioxide emissions; minimise the use of resources such as water; reduce the release of pollutants; maximise the use of reclaimed and recycled materials; and promote sustainable travel choices such as public transport and cycling.

It is at the project appraisal stage that such environmental matters are best incorporated into a construction project. This allows a building's environmental performance to become an objective that can be balanced against other project's objectives. Unfortunately this happens very rarely and it seems common practice is to address environmental impact at the design and later stages when some of the opportunities to make a difference are reduced to some extent.

1.2 Environmental impacts – embodied versus operational

Until recently the embodied carbon impact of buildings have been less well studied, owing to the difficulty in analysing it and also to its perceived lack of importance in comparison with the carbon dioxide emissions (operational impacts) over a building's lifetime.

The operational impact of a building corresponds to the impact of heating, cooling, lighting and ventilating it.

The embodied impact of a building corresponds to the impact of the manufacture and transport of construction materials, as well as the construction process itself.

The split between embodied and operational CO_2 emissions in new dwellings was estimated to be 20% to 80% respectively in several studies dating from 2008 (Empty Homes, 2008). Owing to the evolution of building regulations, operational emissions are predicted to drop radically in the next few years. The balance between these two kinds of impacts will therefore change. As buildings become increasingly more energy efficient, embodied CO_2 emissions will become increasingly significant in terms of the percentage they contribute to the overall CO_2 impact of new buildings. Furthermore, energy efficiency usually implies a larger amount of materials used (e.g. thicker insulation, triple glazing), which also increases the embodied impact of buildings in absolute terms. These factors point to the need for a holistic approach to reducing both kinds of impact, in part by making informed trade-offs between the two when taking design decisions.

The changing balance between embodied and operational CO_2 will cause the construction market to place greater emphasis on the materials used within buildings and on the reduction of their impacts. Resource efficiency will become a more important consideration and the option of refurbishment will increasingly be considered alongside the option of demolition and rebuild.

2 The challenge of refurbishment

In the non-domestic construction sector in Europe new build represents annually less than 1.5% of the building stock. Refurbishment, therefore, presents a significant opportunity for reductions in environmental impacts. In the UK domestic market 87% of the existing stock (2008) is predicted to still be standing in 2050, according to a research report of the University of Oxford's Environmental Change Institute[3].

Refurbishment can be defined as fundamental remodelling or adaptation of existing elements of the building envelope and renewal of key building services. On completion of the works, such remodelling and renewal will materially impact on the performance of the building

In this definition:

A. The building envelope includes the walls (including glazing), roofs (including rooflights) and floors.

B. The building services elements include lighting (artificial and daylighting), heating, mechanical ventilation/cooling plant and ductwork, water/drainage systems.

To be classified as a major refurbishment both A and B must be within the scope of the refurbishment. Where only individual elements of the building envelope element (e.g. windows or doors), or individual services elements (e.g. a boiler, heating system or lighting installation) are being replaced, remodelled or upgraded, then the project should be classed as a minor refurbishment (BREEAM Retail, 2008).

Using a retail unit as an example, refurbishment can come in several different forms through the life cycle of a building, as indicated in Figure 1.

The environmental impact of maintaining and cleaning the interior of a retail environment is proportionally small compared to the overall impact of the building.

Two areas are responsible for an increase in embodied CO_2 during retail refurbishment:

Disposal – the removal of existing materials and the subsequent impacts of disposal by sending to landfill, incineration, recycling or reuse.

Construction – the addition of new materials, which have had to be manufactured, transported and installed on site.

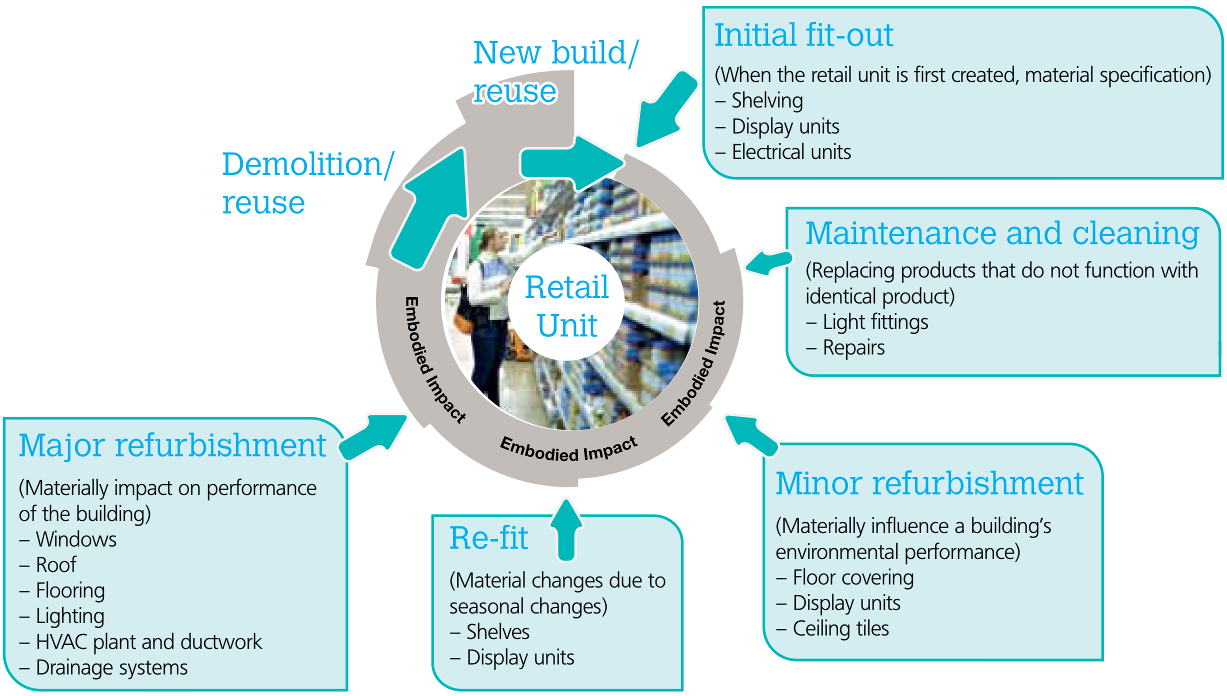


Figure 1: Retail refurbishment – BRE Trust 2012 Refurbishment

3 Home truths: a low-carbon strategy to reduce UK housing emissions by 80% by 2050, Brenda Boardman, 2007 http://www.foe.co.uk/sites/default/files/downloads/home_truths.pdf, accessed on 22 April 2015

2.1 The case for refurbishment

Old buildings can use large amounts of energy and provide less than ideal living and working conditions for their occupants. They may be difficult to heat, have poor lighting, poor ventilation, solar penetration and glare and poor control of heating and cooling. One option is demolition; however, the alternative of refurbishment may be considered more sustainable in terms of including saving in the embodied impact of materials, waste disposal and even architectural value.

Examples of the challenge of meeting environmental targets in the context of retaining the UK's traditional urban landscape were addressed in the 2006 BRE Trust publication "Sustainable refurbishment of Victorian Housing, guidance, assessment methods and case studies" (see box below – FB14).

FB 14, Sustainable refurbishment of Victorian Housing, guidance, assessment methods and case studies, Tim Yates, BRE, 2006

'This project has its origin in the discussions that ensued after the publication of the ***40% House report*** by Oxford Environmental Change Institute in 2005.

The report again put into public debate the potential conflict between the need to meet environmental targets, particularly carbon dioxide emissions, whilst retaining our traditional urban landscape and so re-using the resources – materials and energy – that had gone into their construction. The situation is made more complex by the need to take into account the wishes of the communities that live in the traditional housing found in many urban and rural areas and to achieve this within a market driven economic system.

From these background considerations the idea of the development of a methodology for the assessment of the different interventions was put to the BRE Trust who agreed to fund the 12 month project from which this report is the output. The method used for the comparison of different options is based on EcoHomes, a rating method for new, converted or renovated homes, which covers both houses and apartments, which has been developed by BRE and proved over many years.

This report is aimed towards those involved in deciding on the viability of regeneration and refurbishment projects in pre-1919 housing. It provides guidance on assessing different options for interventions and defines limits which need to be considered in examining the viability of these options – in terms of conservation, environment, economics and social needs. It illustrates some of the different approaches that have been tried through case studies in Nelson, London and Nottingham.

The merits of refurbishment over new build were considered in the 2008 BRE Trust publication "New build and refurbishment in the sustainable communities" (FB16).

FB 16, Knock it down or do it up? New build and refurbishment in the sustainable communities plan, F Plimmer, G Pottinger, S Harris, M Waters and Y Pocock, College of Estate Management, 2008

'Key findings

- The research points to refurbishment as the more sustainable option, but developers and their advisers currently see more drawbacks than incentives to housing refurbishment over demolition and new build.
- Refurbishment projects tend to be smaller, and can be cost-effective where the original stock is in good condition and is capable of relatively quick, simple conversion.
- Refurbishment can also be cost-effective on more major projects that attract VAT zero rating or tax relief.
- Significant savings in embodied energy and improvements in energy performance through refurbishment are not highly rated by developers and their advisers as a driver for retaining existing housing.
- Refurbishment is viewed as more risky and costly than new-build housing, particularly where the existing stock is in poor condition.
- Standard refurbishment solutions are needed that meet sustainability objectives, but are perceived to be unattainable because every project is unique.
- Specialists in new-build housing weight its advantages more strongly than those who have experience of refurbishment projects. The new-build specialists are also more inclined to the view that saving energy is more important than, and less compatible with, building conservation.
- The prior experience and specialisation of prospective developers and their advisers could sway decisions about redevelopment versus refurbishment on specific sites, particularly in the absence of well-developed appraisal techniques for comparing relative costs and sustainability criteria.
- The benefits of refurbishment in terms of heritage conservation, community retention and high values for well-restored buildings are recognised, but refurbishment cannot necessarily overcome community problems associated with social issues, poor design and lack of infrastructure.
- Most developers and advisers believe that eco-friendly and energy-efficient features are not currently a strong influence on homebuyer choices. Relying on a change in consumer attitudes to drive sustainable construction practices is currently unrealistic, and government intervention to promote refurbishment is needed in the form of regulation, grants and tax incentives.'

2.2 Opportunities to reduce environmental impacts within refurbishment

The opportunity to address the environmental impacts within refurbishment can be considered under four categories: materials, waste, water and energy.

a) Materials

The materials used can be considered at each stage of a refurbishment project, the stages being: survey, design, and construction.

Early stage consideration of environmental issues can also provide opportunities for reducing costs, in addition to minimising the embodied carbon and water of a project.

WRAP (Waste & Resources Action Plan) identifies key considerations for materials as follows:

- Specify materials with a higher recycled content
- Specify materials with lower embodied carbon
- Specify materials with lower embodied water
- Are there opportunities to consider durability / intended lifespan?
- Specify materials that can be sourced locally
- Consider specifying materials / equipment with minimal maintenance requirements

b) Waste

UK statistics on waste for 2010 to 2012 published by the Department for Environment, Food & Rural Affairs (DEFRA) in 2015 identify that in 2012 the UK generated 200.0 million tonnes of total waste. Half of this (50%) was generated by construction. Almost half of the 186.2 million tonnes of total waste that entered final treatment in the UK was recovered. The proportion that went to landfill was 26.1%.

The initial stages of a construction project represent the best opportunity to limit waste. A building survey can be done at the beginning in order to implement waste minimisation throughout the project cycle, by identifying opportunities to retain, re-use and recycle existing features.

Consideration should be given to the following regarding waste:

- Will there be sufficient room on site for skips?
- How many segregated waste streams are feasible on site?
- Are there opportunities to re-use / retain features of the existing building?
- Can any excavation materials be reused?
- Are there opportunities to maintain a favourable cut / fill balance on site?

c) Water

The reduction of water in-use is an important goal which can have economic as well as environmental benefits. The real cost of water and sewerage services have increased by 40% since 2002.

A range of simple water efficient fittings provide favourable rates-of-return, with payback often less than one year. The installation of advanced options such as rainwater harvesting or greywater recycling can also offer a commercial payback where the building form and occupation are appropriate. All these solutions should be considered within a refurbishment project.

The following three steps regarding savings in operational water use should be considered:

- Investigate opportunities to install rainwater harvesting
- Review the potential for a 'Green Roof'
- Specify and install water-efficient fixtures and fittings

d) Energy

Undertaking a refurbishment constitutes an ideal opportunity to improve the 'energy in-use' performance of a property. The implementation of energy-efficient solutions has to be done while considering the other aspects of refurbishment work, especially use of materials (products and material used in making these).

Possible improvements include the installation of energy-efficient light fittings, improving the thermal insulation or HVAC plant updates.

The following issues should be considered:

- Are there opportunities to specify energy-efficient heating and cooling systems?
- Are there opportunities to specify LED and / or T5 lighting as opposed to standard T12 lighting?
- Is there potential to specify passive infrared (PIR) and photocell sensors to the light fittings?
- Are there opportunities to improve / increase the insulation of the building?

3 Tools and methodologies to support sustainable refurbishment

There are a number of tools and standards that can be used to provide information and help in delivering a sustainable refurbishment project. The tools and standards available come in different forms, e.g.: assessment methods, databases, modelling tools and evaluations; and are applicable to different stages of the refurbishment process. Some are relevant to the procurement and design of products used, and others to the construction of a building as a whole.

This document will consider the following;

– Whole building certification schemes.
– Modelling / tools / information.

3.1 Whole building certification schemes

In recent decades schemes have been developed throughout the world to assess the performance of buildings in terms of their environmental and social impact. Many of these schemes are voluntary, but publicising an organisation's sustainability credentials is becoming increasingly important as public knowledge and understanding of sustainability and environmental issues grow. Both voluntary and mandatory schemes are increasingly used worldwide.

Some of the major schemes are:

– BREEAM (Building Research Establishment Environmental Assessment Methodology): UK, International and Refurbishment versions – UK and worldwide
– LEED (Leadership in Energy and Environmental Design) – predominantly used in North America, plus other use worldwide
– Green Star – Australia, New Zealand and South Africa
– HQE (Haute Qualité Environnementale) – France, Brazil, Canada
– Ska Rating – non-domestic fit out – developed by RICS

Most of these schemes offer versions or criteria that relate to the function of the buildings, such as housing, offices, education, health, commercial, industrial, and courts and prisons. Each version includes a number of topics or categories in which points can be awarded to reflect the environmental impact of the design.

These schemes primarily address new construction. However, specific schemes for fit-out and refurbishment have now also been developed. The two that will be described in more detail are BREEAM (Non domestic refurbishment and fit-out) and Ska. Both BREEAM Refurbishment and Ska aim to assess interior fit out, deliver interiors with lower environmental impacts, and improve practice – but their methodologies differ.

a) BREEAM

Originally launched in 1990, BREEAM is an assessment and certification method for whole buildings. There are specific versions of BREEAM for different types of buildings.

BREEAM®

Figure 2: BREEAM logo

BREEAM demonstrates best practice in sustainable refurbishment and fit-out.

BRE Global has recently launched a new standalone scheme for the assessment of non-domestic building refurbishment entitled 'BREEAM Non Domestic Refurbishment 2014'. This new version of BREEAM provides a dedicated scheme for non-domestic refurbishment and fit-out, an addition to the existing schemes BREEAM New Construction and BREEAM In-Use, which focusses on operational impact. Projects registered before the 16th February 2015 can still be assessed under BREEAM New Construction 2011 for major refurbishment or BREEAM 2008 for fit-out and refurbishment, predecessors of the new scheme.

BREEAM Non-Domestic Refurbishment and Fit-out 2014

The BREEAM Refurbishment and Fit-out 2014 scheme introduces a new four part modular approach, providing a range of certification options:

Part One
Fabric and Structure

Part Two
Core Services (e.g. centralised M&E plant)

Part Three
Local Services

Part Four
Interior Design

Refurbishment and fit-out projects can be assessed against one or all of the four parts, or any combination, depending on which are relevant to a particular project. It allows more flexibility in the assessments which can be fit for purpose to meet the need of a project. The assessment can therefore be carried out against the relevant parts.

The scheme also introduces assessment criteria that have been adapted for refurbishments and fit-outs. These reflect the split between responsibilities of tenant and landlord and the limitations or opportunities for improving existing buildings. Defined performance benchmarks reward improvements in cases of poor performing buildings, while also giving recognition for buildings achieving high performances. These improvements especially focus on the Energy and Materials categories. For instance, the calculation for reduction of carbon emissions of the building is made in assessing the initial as well as the final energy performance of the building. The score is then calculated through a 'translator' which is based on the percentage of improvement achieved through the refurbishment.

Using BREEAM, buildings can be assessed at both design and post-construction stages; however, certificates are only awarded at post-construction stage. The assessment is carried out by a trained assessor who records information against a set of criteria, which are arranged under various categories including Energy, Water, Materials, Waste and Ecology. The categories are weighted to reflect their relative importance. Each category is underpinned by a number of sub-categories for which a number of credits are available. The more credits the building can accumulate, the higher the overall mark. BREEAM awards marks from: Pass, Good, Very Good, Excellent and Outstanding (http://www.bream.org).

b) SKA Rating

Ska Rating began in 2005 when Skansen, in collaboration with RICS (the Royal Institution of Chartered Surveyors) and AECOM (Architecture, Engineering, Consulting, Operations and Maintenance), began researching how the environmental impact of fit-outs could be measured.

SKArating

Figure 3: Ska logo

Launched in November 2009, Ska is a certification method for fit-outs within non-domestic buildings. Ska is designed to be used by occupiers, but can also provide useful information for those in the supply chain, landlords and property developers. Two versions exist, one for retail and one for offices.

Using the online Ska tool, occupiers can carry out an informal self-assessment of the environmental performance of their fit-out. A quality-assured assessment and certificate can also be awarded by a RICS-accredited Ska assessor, who will assess the building in three stages: design/planning, handover and post-occupancy. The certificate is presented at the handover stage. The post-occupancy stage is carried out 12 months after the design or handover assessment has been completed.

The project is assessed against 99 good practice measures which are ranked in order of their importance for sustainability. The measures fall into the following categories: energy and CO_2, materials, other, pollution, transport, waste, water and wellbeing.

Certificates are presented according to overall performance and the meeting of mandatory measures at Gold, Silver and Bronze level.

3.2 Modelling/tools/information

a) Green Guide

The first edition of The Green Guide published in 1996 aimed to provide a simple 'green guide' to the environmental impacts of building materials which would be easy to use and reliably based on consistent numerical data.

The Green Guide, currently in its fourth edition, now contains more than 1500 specifications used in various types of building. It examines the relative environmental impacts of the construction materials commonly used in six different generic types of building:

- Commercial , such as offices
- Educational
- Healthcare
- Retail
- Domestic
- Industrial

The Green Guide is arranged on an elemental basis so that designers and specifiers can compare and select from comparable systems or materials as they compile their specification. The elements covered are:

- External walls
- Internal walls and partitions
- Roofs
- Ground floors
- Upper floors
- Windows
- Insulation
- Landscaping
- Floor finishes

The Guide provides a catalogue that covers most common building materials; it is extensive but not a complete list of everything available.

The Guide presents an overall rating for the material specification, from A+, the current best practice, lowest environmental impact, to E, the highest environmental impact. These environmental rankings are based on Life Cycle Assessments (LCA), using BRE's Environmental Profiles Methodology 2008. Figure 4 from the Green Guide (online version) shows an example of ratings for upper floor element constructions in a domestic building type

Green Guide 2008 ratings

Building type >	Domestic
Category >	Upper Floor Construction
Element type >	Upper Floor Construction

	Element number	Summary rating
Chipboard decking on galvanised steel joists	807280080	A
Chipboard decking on metal web joists	807280005	A+
Chipboard decking on timber battens on grouted beam and dense solid block flooring	807280033	B
Chipboard decking on timber battens, grouted beam and aircrete block flooring	807280002	A
Chipboard decking on timber battens, grouted beam and medium dense solid block flooring	807280043	B
Chipboard decking on timber battens, grouted hollow precast prestressed concrete planks	807280048	C
Chipboard decking on timber battens, grouted hollow precast reinforced slab flooring	807280047	E
Chipboard decking on timber I joists	807280024	A+
Chipboard decking on timber joists	807280081	A+
OSB-2 decking on galvanised steel joists	807280040	A+
OSB-2 decking on timber battens, grouted beam and aircrete block flooring	807280032	A
OSB-2 decking on timber battens, grouted beam and dense solid block flooring	807280034	B
OSB-2 decking on timber battens, grouted beam and medium dense solid block flooring	807280001	A
OSB-2 decking on timber battens, grouted hollow precast prestressed concrete planks	807280050	B
OSB-2 decking on timber battens, grouted hollow precast reinforced slab flooring	807280049	D
OSB-2 decking on timber I joists	807280044	A+
OSB-2 decking on timber joists	807280041	A+

Figure 4: Example of Green Guide ratings

By evaluating the performance of materials and building systems against selected environmental impact parameters, which have also been ranked on an A+ to E basis, it is possible for the specifier to select specifications on the basis of personal or organisational preferences or priorities, or take decisions based on the performance of a material against a particular environmental impact.

b) IMPACT

The Integrated Material Profile and Costing Tool (IMPACT) is a whole building assessment protocol and database that is integrated into BIM (Building Information Modelling). It allows construction professionals to measure the embodied environmental impact and life cycle cost performance of buildings. IMPACT can be incorporated into CAD tools,

IMPACT takes quantity information from the BIM and multiplies this by environmental impact and/or cost 'rates' to produce an overall impact and cost for the whole (or a selected part) of the design. The results generated by IMPACT allow the user to:

- analyse the design to optimise cost and environmental impacts.
- compare whole-building results to a suitable benchmark to assess performance, which can be linked to building assessment schemes.

The overall aim of IMPACT is to integrate LCA, LCC (Life Cycle Costing) and BIM. IMPACT currently uses BRE's 2008 Environmental Profiles Methodology but by the end of 2015 should utilise EN15804 EPD data. See www.impactwba.com.

c) LIST

The Low Impact Shopfitting Tool (LIST) – see Figure 6 – is a web-based tool designed to be used to calculate the environmental impact of shopfitting. It helps retailers to design and specify shopfitting display equipment that has a reduced impact on the environment. It does this by evaluating the impact of each stage of the product life cycle: manufacture, packaging, transport, use, maintenance and end-of-life. LIST uses BRE's 2008 Environmental Profiles Methodology to produce its results. The methodology has been adapted to fit the specific requirements of shopfitting display areas.

The tool enables retailers to estimate the overall sustainability credentials of their shopfitting display materials at the design stage in order to select the unit with the lowest environmental impact.

Design decisions are often made without considering thoroughly the environmental impact and there is then little opportunity to reduce it at installation and operational stages. LIST highlights the importance of considering the environmental impacts of manufacture at the design stage. It provides a tool to enable the quick comparison of different solutions. Various parameters, such as materials used, can easily be changed.

LIST has been conceived as an easy-to-use tool and its use does not require expertise in LCA. The tool is owned by BRE and licences are sold to companies that design and manufacture display equipment. They can then input data such as dimensions, material, finishes, transport and packaging into the tool to produce an overall score.

Figure 5: IP1/11 on LIST, cover page
http://www.brebookshop.com/details.jsp?id=326651

LIST provides a consistent approach in the environmental assessment of shopfitting display equipment and other "moveable" items. The tool allows the user to:

- demonstrate the environmental credentials of a design
- compare two or more designs
- understand how components contribute to the overall impact at each stage of the life cycle
- improve the environmental performance of a design

LIST was developed to assess shopfitting display equipment, but can be used for other products. The tool can provide an estimate of the environmental impacts of products and designs – a simplified LCA approach and thus help the user to understand and reduce the environmental impact of their designs. LIST reports the results in $kgCO_2eq$[4] and Ecopoints per design against the different life stages of equipment or components:

- Raw materials
- Packaging
- Transport
- End of life

It also gives the details of all the environmental impacts assessed through the BRE Environmental Profiles Methodology. The user is then free to prioritise a specific impact.

4 Equivalent carbon dioxide – measures for describing how much global warming a given type and amount of greenhouse gas may cause, using the functionally equivalent amount or concentration of carbon dioxide (CO_2) as the reference.

LIST provides a baseline rating of the initial sustainability impact and can then provide continual improvement evidence for designers, equipment suppliers, brand companies and retailers. Designers and engineers can use this database-driven tool to score all equipment measured and can easily compare design variations or different approaches. The fact-based score then becomes an additional decision-making metric. LIST also provides guidance on recycled content and the proportion of the material that can be recycled at end of life.

The various results obtainable from the datasets can be used to make decisions on current or future products. Designers can also focus on specific priorities and objectives. LIST gives a detailed analysis of the different impacts and of the split between the different stages of the life cycle. LIST then highlights the improvement potential of each stage and the areas that need to be improved if the environmental impact is to be reduced.

The results shown in Figure 6 demonstrate the complex relationships of broad environmental impacts. LIST translates scientific data into a user-friendly interface with results that can aid discussions on appropriate elements being used in refurbishment projects. However, the difference between two products is not always obvious. Individual projects can have different objectives, e.g. reducing embodied carbon might be the highest priority on one project, and achieving zero waste might be the target on another project.

A difference of design between two products can, for example, decrease the $kgCO_2eq$ but increase the overall environmental impacts when considered as a whole. In such a situation the solution is not straightforward.

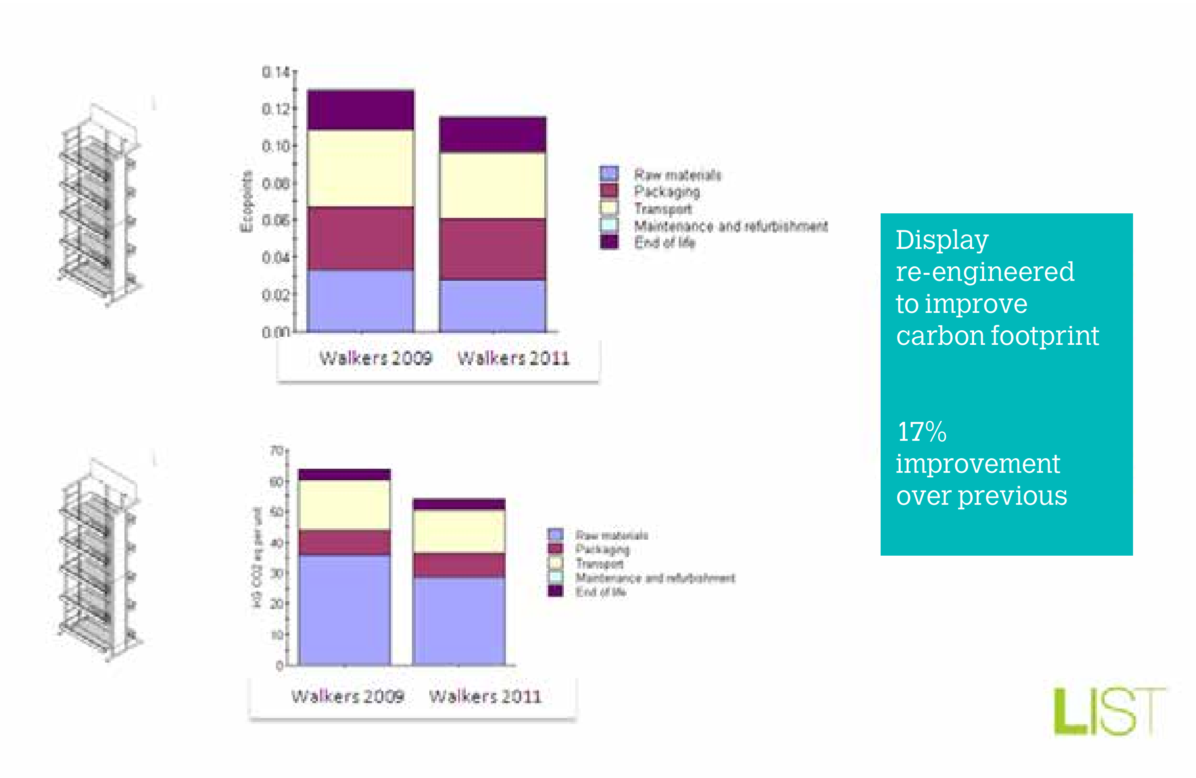


Figure 6: Comparison of two displays from a LIST assessment

4 Summary and conclusions

While refurbishment often appears to be a more sustainable solution than demolition and rebuild, especially in terms of resource efficiency, it is recognised that it is not always the more sustainable and economic option. A refurbishment project can sometimes be more complicated, and so more expensive.

Given, however, that the UK is committed to reducing carbon emissions by 80% by 2050 and due purely to the number of existing building that will still be present in 2050 and the current rate of new build – it is clear that if these targets are to be met refurbishment should be targeted. Considering embodied impacts in particular, it is also clear that there are significant opportunities to create appropriate solutions for refurbishment projects.

There is a significant amount of support from BRE available to those attempting to deliver sustainable refurbishment.

At the highest level building environmental assessment rating schemes are developing bespoke versions that deal specifically with refurbishment e.g. BREEAM Non domestic refurbishment and fit out (2014).

BRE has produced a number of tools that can also assist in minimising embodied environmental impacts:

- Building level – IMPACT
- Specification level – Green Guide to specification, LIST.

Progress is on-going in relation to the refurbishment process, and three case studies have been reproduced below to highlight some of these developments:

1 Morelands Rooftop

2 2014 Solar Decathlon Competition

3 Huckletree

Case Study
Morelands Rooftop

About the building

The building was assessed against BREEAM 2008 Offices and achieved BREEAM outstanding at the post-construction stage with the new build floor achieving 89.8% and the refurbished floor achieving 91.7%.

Morelands sits at the junction of Old Street and Goswell in London's Clerkenwell area. The Morelands complex comprises a cluster of warehouse buildings built, over three decades, around a U-shaped courtyard. Constructed between 1905 and 1940, the building provides around 86,000 sq ft of office and retail/restaurant space.

The latest works for the client, Derwent London, are a major overhaul of the entire complex; creating a new entrance, refurbishing the 4th floor 850m^2 office floorplate and providing improved level access throughout, while significantly enhancing the building energy performance. The final element of this phase was a new 860m^2 rooftop penthouse office floorplate.

Green strategy

Because Derwent understands that a high quality working environment would attract good tenants, the client opted in favour of BREEAM certification, along with sophisticated, modern spaces and improved amenities.

Morelands was the first BREEAM Outstanding office building for both AHMM and Derwent London. A benefit of the long standing relationship between AHMM and Derwent is that 'lessons learnt' from previous schemes regarding the durability of materials can be applied. The project design provides generous volumes that maximise natural light and ventilation and minimise materials and energy. Comprised of a new 5th floor with a full refurbishment of the existing 4th floor; merging four blocks (A-D) to create open plan office space totalling 18,400 sq ft. The result is an aspirational workspace, which retains and extends the old structural frame. Among the works are a light well cut out of the roof to bring light into the centre of the plan above a circulation stair, open-plan project studios over two floors, a large refectory and open-air rooftop amenity.

Morelands was designed to be a 'laboratory', with environmental monitoring equipment throughout the building and all occupants can witness how the spaces react (or not) to the external conditions. Live feedback is an inherent part of the continued education of the users and this was designed to allow the architect to design better and smarter buildings in the future. The simple and low-tech solutions do not cost a lot, but they do work.

Major environmental features

The building scored particularly well in the Transport, Energy and Pollution sections in part due to maximising its beneficial location in Central London, set back from a main road. Key environmental features are:

- **Natural cross ventilation and stack effect**
  A "Passive first" approach to design and servicing has been applied. The offices are naturally ventilated, with low level perimeter windows assisted by high level windows to light wells, to assist in stack effect purge. Low-e coatings were applied to the glass to reduce solar gain, in addition to which, vertical external blinds linked to wind and UV sensors were installed to control light penetration.
- **Good levels of thermal insulation**
  Avoiding demolition and disposal of the original structure to construct a replacement resulted in CO_2 savings, which contribute to the inherent sustainability of the development. Along with the new 5th floor above, the 4th floor façade was enclosed within a skin of insulation and render achieving a Green Guide rating of A. The render unified the appearance externally and significantly improved the thermal performance of the building, resulting in an improvement to the existing 4th floor of 1.54 W/m^{2}K – exceeding the requirements of Part L. Airtightness was reviewed throughout construction, as the existing building had evident weak spots at concrete floor to ceiling junctions etc. Final tests of 5.66m^3/hr/m^{2}at 50Pa meet 'Good Practice' guidelines.
- **Very efficient lighting**
  Lighting is triggered by PIRs, reflecting the office's occupancy and saving energy.
  The new 5th floor has significant height (3.7m floor to ceiling) meaning better daylight penetration and less artificial lighting. In addition, new lights on occupant-controlled triggers were installed to common parts and courtyards further reducing the electrical load on the building.
- **Renewable technologies**
  PV panels feed into common parts, reducing electricity bills whilst solar thermal panels supply hot water to 4th & 5th floor showers.
- **Water saving fittings**
  Toilets, taps and showers are water-efficient. All in all, 4th & 5th floor saves the equivalent of 78,049 WC flushes per year.
- **Biodiversity**
  A large area of brown roof has been added, providing a new opportunity for biodiversity on the complex. Swift and swallow boxes have been integrated into the fabric of the building.
- **Transport**
  Those who cycle now enjoy greatly improved facilities, an important employee incentive, including 45 new secure cycle spaces, showers and changing facilities with an additional two showers and drying rooms to 4th & 5th floors respectively. Two Barclays London cycle-hire sites are situated nearby and the building is extremely well located for public transport connections. There is no car parking on site and a green travel plan has been developed by the client, Derwent London.

Lessons learned and future plans

Full size mock-ups for the most important elements of the building were produced early to avoid costly and wasteful changes later on. This proved a very successful opportunity to engage the client and we will continue to recommend this on future projects.

As a consequence of occupying the offices ourselves, we have access to a level of data about the scheme scarcely available to architects post completion. Having recorded temperature data in our previous office for several years, we have installed an array of thermal, humidity and CO_2 detectors throughout the new office. The results from these studies, as well as those reviewing energy and water use, will be fed back to FM team, management and architects to ensure that our own operations are continually refined and improved. We will also be able to apply lessons learned to future projects.

Since moving from 2nd floor to 4th & 5th floors our operating costs have reduced significantly, including a 69% saving in electricity. Additionally, we are currently reporting a 31% efficiency in gas usage, however we appreciate that this will fluctuate with heating demands during the winter months and will require future assessment to fully understand annual economies.

The completed building has been evaluated for quantitative performance metrics as well as qualitative occupant satisfaction. The study comprised of:

– A CIBSE TM22 style energy audit was carried out and compared to design stage compliance calculations
– A Building User Survey (www.busmethodology.org) was used to assess occupant satisfaction in a longitudinal comparison to a similar survey carried out in the same organisations previous offices.
– Temperature, relative humidity and CO_2 monitored data from the occupied spaces as well as within the new building fabric provide contextual information for the energy consumption and occupant comfort.

Whilst energy consumption is higher than compliance calculations, the energy end-use analysis shows that this is due to occupant equipment loads not included in regulated energy figures. Per person energy consumption is lower than in our previous office.

Space heating loads are much lower than design stage predictions.

Despite internal temperatures frequently higher than the 'comfort envelope' the building occupants are largely satisfied with the space and the conditions. This influences how we design the services for other buildings.

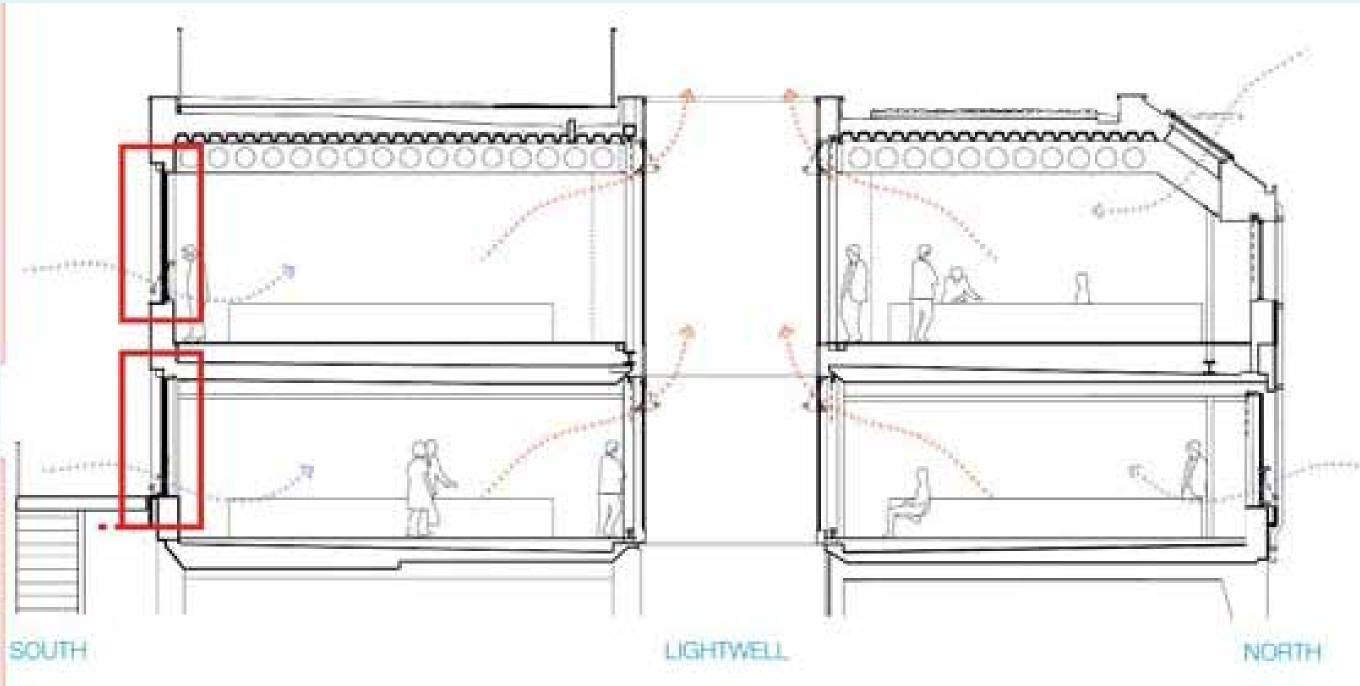
Engaging the thermal mass through night cooling can reduce temperatures by 3-4°C at the start of the working day.

Occupant behaviour in an adaptive building is key to comfort conditions. The relationship between CO_2 and temperature is a crucial one and in this building, occupants only engage with the windows when the temperatures are already high. We are actively looking at ways of instigating ventilation earlier in the day to prevent high CO_2 and temperatures.

Occupant satisfaction means that perceived productivity has increased by nearly 10%.

Lessons from this study are applied to run the studied building more efficiently as well as to design decisions on current projects.

General view of Morelands



Natural cross ventilation schematic

Case Study
Philéas – Solar Decathlon Competition 2014

Philéas is the name of the project carried out by the French team Atlantic Challenge for the international student competition Solar Decathlon Europe 2014 that took place in Versailles, France in July 2014 (http://solarphileas.com).

Philéas was conceived within the context of a vast programme of urban refurbishment on the banks of the Loire in Nantes, within walking distance of the city centre. The programme aimed to take advantage of what already exists, in maintaining the historical identity of the built environment. Within this former industrial area, the building Cap 44 was chosen by the team.

The following issues had to be tackled:

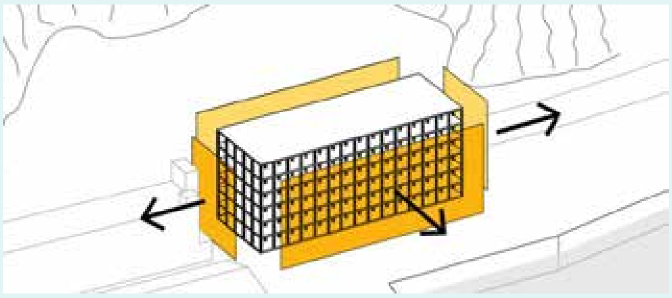
- How to retrofit heritage buildings with efficient and economic solutions and make them accessible to everyone
- How to reduce urban sprawl
- How to avoid in fill
- How to limit the environmental impacts of materials used within the refurbishment
- How to benefit from the existing features

The aim of the project was to give new life to the Cap 44 building, maintaining its identity and optimising resource efficiency within the refurbishment. This building, dating from 1895, has experienced several uses: initially a flourmill, it was then occupied by the Loire Océan Agriculture Coopérative, before being turned into offices in 1974. Through Project Philéas, a fourth life was devised for the building, which was derelict at the time.

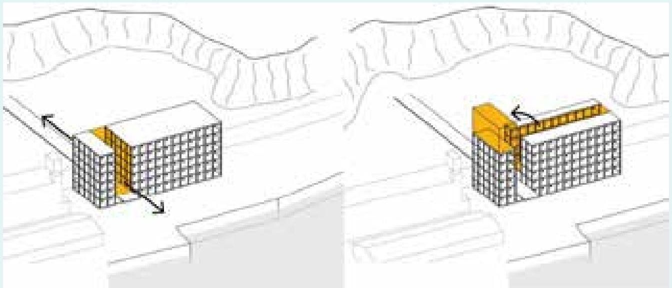
The outdated thermal envelope, containing asbestos, would be removed to expose the concrete structure, a post-beam framework system designed by François Hennebique.

In order to solve the problem of poor penetration of daylight into the structure, two gaps would be cut through the building. As well as bringing daylight into the building, they would also enable the creation of shared spaces, aiming to stimulate social exchange.

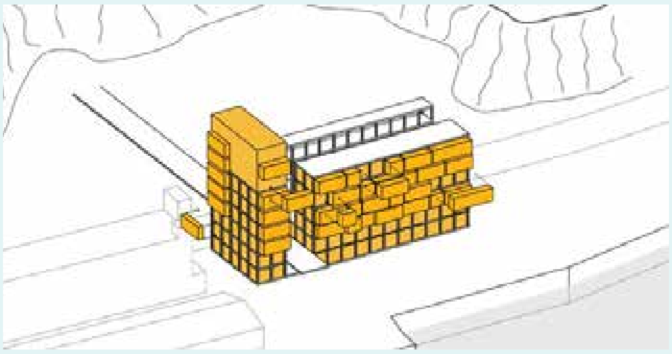
Prefabricated 3D wood modules would then be plugged into the structure: these are designed to optimise the use of the existing concrete framework, for structural as well as for thermal reasons. The concrete also supports loggias on the southern side of the building that play a bioclimatic regulation role. The thermal mass of the concrete is also used to ensure a comfortable temperature in winter and summer. The 3D modules are also a solution that anticipates future retrofitting in that they are easy to disassemble and replace.



The original envelope



Creation of gaps or 'breaches' through the building



Prefabricated 3D modules plugged into the structure

Simulation of a view from the Loire of the refurbished building

A greenhouse structure would be built on top of the flat roof. This would grow crops for the use of occupants of Cap 44, in order to reduce the environmental impacts linked to transport.

The project was devised to minimise the environmental impacts of the building in use, especially through using Life Cycle Assessment at the very beginning of the design stage. The impacts of the materials used as well as the scalability have been taken into account. The findings are envisaged to support improvement in practice of new build or refurbishment when specifying and selecting products.

The project also aimed to limit the impacts of its inhabitants, in creating a convenient place that includes mixed uses: housing, offices, a nursery, a library, a restaurant, and food for retail directly supplied by the crops in the greenhouse. A transport plan was also developed.

Philéas was rewarded with the Second Prize in the competition, after the building of a full-scale prototype of a housing unit in Versailles, in July 2014.

Case Study
Huckletree

Author: Elina Grigoriou, Grigoriou Interiors

grigoriou interiors
design wellbeing sustainability

The brief to Grigoriou Interiors (GI) was to design a pioneering shared membership-based workspace, creating a concept and style that could be rolled out to further sites. The vision was to create an inviting and functional space, enabling Huckletree's Members to interact in a familiar and active way, move around easily and make the best use of areas specifically designated for quiet, focused work, collaboration or socialising.

From a very early stage Grigoriou Interiors' input was instrumental in introducing the sustainable principles and practice that form the core of brand 'Huckletree' today. The design brief was to create a workplace suitable for dynamic, entrepreneurial, friendly and internationally minded professionals. GI developed a design concept with a style verging on minimalism but with warmth, a predominant use of light colours, reclaimed wood and foliage, with wall graphics to communicate Huckletree's ethos and etiquette. GI created a workspace that enhances user wellbeing and productivity, and enjoyment while working, without compromising on style.

Feasibility studies were carried out on two previous sites before settling on the Charterhouse premises in Clerkenwell, London. Budget constraints encouraged lots of creative thinking and solutions! A Ska Rating assessment of the project was also a requirement and the project succeeded in achieving a Silver rating.

Despite project limitations, the space is designed to not just meet current workplace standards but to move ideas forward: to meet a need before it is required, to establish a desire before it has been thought of. The GI design team used their creative skills, technical knowledge and holistic sustainable thinking, and together with the resourceful network of suppliers and specialist consultants, came up with interesting solutions that met the design brief and the budget.

Huckletree Clerkenwell has three floors, a feature which the design embraced so that each floor creates a different type of working environment:

– **1st Floor:** to meet people, socialise, relax and create
– **2nd Floor:** for group work, to collaborate, discuss and exchange ideas
– **3rd Floor:** an independent working area for concentration and analytical work.

GI integrated the services of environmental psychologist experts SpaceWorks Consulting, and developed the concept to meet the human needs of refuge and prospect, as well as key features that enhance interaction, such as a large kitchen table. The graphics on the walls, designed by illustrator Elliott Quince, communicate the Huckletree etiquette and guide Members to get the maximum benefit out of their workplace while considering the environment and their co-workers. All joinery and reclaimed materials were supplied by Dresd and their efforts to reclaim materials from film sets were in line with the project's aims.

Environmental performance features include:

Energy: A/C system on the Energy Technology List (ETL), natural ventilation, LED lights throughout, maximising daylight use.

Water: Spray taps and sensor-operated filtered water units using mains water, water-efficient toilet cisterns.

Wellbeing: Occupant control of temperature, fresh air and lighting. Zero-VOC paints, adhesives and finishes. Plants visible throughout.

Waste and re-use: All timber, glass partition or door elements were from reclaimed sources or re-used from the existing space. All waste materials not re-used on the project were sent for reuse through 'Freecycle' or for recycling.

Materials: All new materials were Cradle to Cradle or Ecolabel certified, or made with 100% post-consumer material.

Following occupation, SpaceWorks Consulting were commissioned to conduct an occupant survey, which revealed that 8 out of 10 occupants thought their productivity was higher in this space than elsewhere. Members seem to be really pleased with the space, stating: "It has its own personality…it's not overly corporate", "super cool" and "love it, it's awesome". Huckletree Clerkenwell reached its membership capacity only two months after opening!

Huckletree's workspaces

Elliott Quince's graphic illustrations

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