fundamental series 10

The Continuing Professional Development Programme, produced in association with energy INSTITUTE

Current thinking on...

Sustainable refurbishment

by Kevin Boniface, Low Carbon Buildings Manager (Residential) Sustain

The European Union has set a target of reducing carbon dioxide emissions by 20 per cent and securing 20 per cent of energy by renewable means by the same timeframe. The previous UK Government made a commitment in the 2008 Climate Change Act to go further than this and reduce carbon dioxide emissions by 80 per cent relative to 1990 levels by 2050.

Of the UK's total annual carbon dioxide emissions, around half is attributable to buildings, and of that, energy use in domestic buildings is responsible for more than a quarter. There has been lots of effort over the last decade particularly to reduce this, chiefly by improving thermal performance, but thanks largely to the proliferation of electrical appliances and increasing numbers of individual households, emissions are still on the rise.

Over 80 per cent of the homes we will be occupying in 2050 exist today. This equates to around 24m properties. An often missed, but sobering fact is that for the last 50 years the average replacement rate of existing dwellings (with much more efficient new build) has been less than 1 per cent. It is clear that at this rate of regeneration, we cannot rely on new build dwellings to provide us with the solution to a low-carbon existence in our homes.

Two-pronged attack

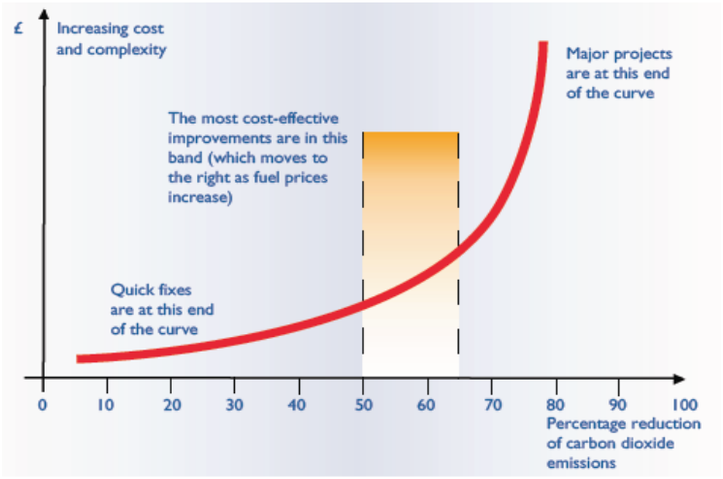
National policy essentially adopts a two-pronged attack to address this fact and reduce emissions. There is an important role for new build in setting the example and developing new technologies and knowledge which can cross-fertilise into the retrofit arena. To achieve this, the Government has a target to improve Building Regulations so that all new build housing is 'zero carbon' by 2016.

While this is to be encouraged, it will be difficult to persuade developers to absorb the costs of doing so in a depressed housing market. Improving the energy efficiency of the homes we live in today, from solid-wall Victorian terraces to 1970s high rise blocks, will be where the battle will be lost or won.

The Building Regulations Part L1B require minimum standards to be complied with during the refurbishment or extension/ modification of existing properties but these fall way short of the improvements needed to get our existing dwellings to a 80 per cent reduction. For sustainable refurbishment the 'best practice' and advanced practice' standards as covered in technical guidance by the Energy Saving Trust (www.est.org.uk) and also outlined in "An introduction to low carbon domestic refurbishment" by the Construction Products Association (http://www.constructionproducts.org.uk/sustainability/buildings/domestic-refurbishment/a-guide-to-low-carbon-domestic-refurbishment/) should be the first port of call for anyone looking for further guidance in upgrading domestic properties to reduce their impact on the environment.

Figure 1 shows how the cost of reducing carbon dioxide emissions in a refurbishment projects increases exponentially with the percentage by which emissions are to be reduced. The capital outlay required increases significantly as we approach an 80 per cent reduction. It is possible to see that a more cost-effective approach might be to achieve a 50-60 per cent reduction, which would require a significantly reduced outlay.

Fig.1 How the cost and complexity of refurbishment varies with emissions reduction



(Source: An Introduction to Low Carbon Domestic Refurbishment, 2010, Construction Products Association)

Financial incentives throughout the housing sector will clearly pay an important part, and the Government is planning on using a combination of obligations on the energy suppliers (the Energy Company Obligation) plus a market-based scheme (Green Deal) to help drive substantial improvements in energy efficiency.

Move to incentive schemes

The Government's long-term aim for increasing the integration of renewable technologies is to move towards incentive schemes that pay a nominal tariff according to the electricity or heat delivered. The Feed-in-Tariff (FiT) for microgeneration of electricity is already in operation and has been very successful, with the equivalent scheme for renewable heat to be known as the Renewable Heat Incentive (RHI).

Phase 1 of the RHI has been in operation for non-domestic buildings and communal heating (schemes which serve dwellings) since November 2011. Uptake of the scheme has been slow and of the 200 or so accredited installations to date, the vast majority (93 per cent) comprises biomass boilers. Solar thermal and ground source heat pumps make up most of the remainder.

For individual dwellings the intention was to introduce Phase 2 of the RHI alongside the Green Deal, but a further consultation is likely before

For details on how to obtain your **Energy Institute CPD Certificate**, see entry form and details **on page 32**

it is known exactly how this will work (and what the final tariffs will be). There is likely to be a raft of eligibility constraints including the need to achieve a minimum level of energy performance. This will be achieved through declaration of an Energy Performance Certificate (EPC) so a holistic approach to energy reduction will need to be adopted to qualify.

No single measures

To put us on the right path to a 80 per cent reduction in emissions, financial incentives will need to move away from the previous approach of installing single measures (such as filling cavity walls, topping up roof insulation, replacing single glazing and boilers) towards a whole-house approach where multiple measures are installed in parallel. This has many advantages but (at present) is the most costly way to significantly reduce CO2 emissions.

Making this step change will require a carrot and stick approach to achieve roll-out of the scale required. In addition, ever increasing fuel prices will help to focus minds on reducing energy consumption, but this is still only part of the story. Individual properties typically receive some kind of major refurbishment every 20-30 years and even this may be limited to just replacing windows or a putting in a new boiler. There are however lots of other trigger points (where opportunities for improving energy efficiency become available, driven by other improvements) which will need to be taken up by all of us much more frequently than every 30 years. The benefits to households will be reduced energy bills and improved comfort. As fuel prices continue to rise, there will also be increased desirability and ability to sell or rent (for homeowners or landlords).

The solution will depend on many factors such as type and age of the property, wall, roof and floor construction, type of heating and distribution system, controls, lighting, ventilation, electrical appliances and perhaps most importantly of all, the occupier's attitude to energy reduction.

The table above shows how some typical home improvements could provide the opportunity to improve energy efficiency. For example when replacing windows, external or internal wall insulation could be applied, the ventilation strategy revised or infiltration heat loss reduced by improving air tightness levels. If a kitchen needs replacement, any of the above plus additional measures such as upgraded floor insulation, heating controls, lighting and more efficient appliances could all potentially be integrated to reduce the demand for heat and power.

Fig.2 How typical home improvements could provide the chance to improve energy efficiency

Measures to consider	Opportunity: Moving in or out	Extending	Loft conversion	Adding a conservatory	New kitchen	New bathroom	Re-roofing	Re-plastering	Replacing windows	Re-wiring	Re-flooring	New heating	Replacement boiler	Replacement hot water cylinder	Re-rendering
Wall insulation	■	■	■	■	■	■	■	■	■	■	■	■	■	□	■
Roof insulation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Floor insulation	■	■	□	■	■	■	□	□	□	■	■	■	■	□	□
Heating controls	■	■	■	■	■	■	□	■	□	■	□	■	■	■	□
Cylinder/pipe insulation	■	■	■	■	■	■	■	□	□	■	■	■	■	■	□
Airtightness improvements	■	■	■	■	■	■	■	■	■	■	■	■	■	□	■
Efficient ventilation	■	■	■	■	■	■	■	■	■	■	■	■	■	□	■
Windows	■	■	■	■	■	■	■	■	■	□	□	■	■	■	■
Low energy lighting	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Energy efficient appliances	■	■	□	■	■	■	□	■	□	■	■	□	□	□	□

Key
Good opportunity ■ Possible opportunity ■

(Source: Sustainable Refurbishment, CE309, Energy Saving Trust, 2010)

It is always prudent to consider any appropriate energy efficiency measures prior to the replacement of existing heating systems or the integration of alternative energy generation sources. In many cases this can lead to smaller systems being installed as the fabric and ventilation heat losses are reduced by the different thermal elements having lower U-values (a measure of the rate of heat transfer) and better levels of airtightness.

Cavity wall insulation is one of the most basic and cost-effective insulation upgrades to employ; filling a 50mm cavity in traditional construction would typically lower the U-value from 0.7 W/m2K to around 0.4 W/m2K – a 40 per cent reduction in heat loss through the total external wall area. However, many properties have already had this carried out and so to go further would mean the installation of additional insulation externally, or if the compromise on living space is palatable, internally.

When checking feasibility of external wall insulation, exterior details or architectural features may make it more difficult (in other words more costly) to implement and planners may object to the idea for aesthetic reasons. There are however a plethora of different systems and finishes commercially available, and it is possible to find a cladding product that will fit with the existing appearance, for example brick slips with insulation underneath can be used to provide a decorative brick wall finish.

Both external and internal wall insulation upgrades can be noisy and disruptive both in preparing the wall and fixing the insulation system. For external wall, full scaffolding will also be required. With internal wall, the property occupants will need to vacate the property while works are ongoing and with external insulation there could still be short term disruption while services are removed and then refitted afterwards (e.g. satellite dishes). Ideally, any window replacements would be carried out at the same time to allow correct detailing around windows and positioning of the frames.

Additional loft/roof insulation is probably the most cost effective insulation improvement, is easy to fit and can save a significant amount of heating bills. If the current insulation level in the roof is already 250mm or higher than there is little benefit in increasing this further – the money would be better spent elsewhere (e.g. improving airtightness).

Windows and doors

Windows and external doors are a major source of heat loss from any dwelling as the rate of heat transfer through them will almost always be significantly higher than cavity filled walls (standard modern double glazing is comparable in performance to uninsulated solid brick walls).

Windows and doors generally have a 25-30 year lifetime, however waiting for this full period to expire before wholesale replacement could mean

additional energy and cost savings are not realised.

A window energy rating (WER) scheme now exists in the UK and under the 2010 Building Regulations (Part L1B for existing dwellings) a window with a WER of C or better (corresponding to a U-value of 1.6 or better) should be installed during replacement. U-values below 0.8 W/m2K would constitute the best commercially available windows and doors currently. Budget permitting, as with all the energy efficiency measures that are in-situ for many years, it is strongly recommended to select the best performance possible.

As long as they are installed properly, with good attention to detail, high performance glazing and doors can provide substantial savings in heating costs as well as improved thermal comfort. Since we as dwelling occupants tend to turn up the heating thermostat when we feel cold draughts, it is as important to get the detailing and draughtproofing right around the window frame as it is to specify low U-value high performing glazing.

Air leakage is the uncontrolled movement of air. In dwellings this could be into and out of the building through cracks and gaps, service penetrations, windows and external doors, letter boxes, extract fans and wall vents, loft hatches and many other different air leakage paths. This infiltration of external air is usually far more than what is actually required for ventilation (to provide decent air quality) and for a typical house is around 1 ACH (air change per hour). Because it is uncontrolled, air infiltration occurs all the time even when the property is unoccupied with the consequence that the heating system needs to work harder to replace lost heat.

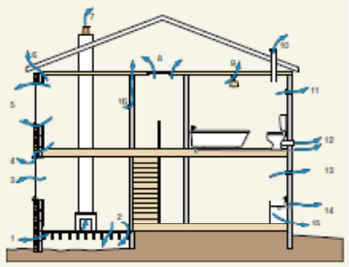
Draughtproofing is a relatively simple measure that can be carried out at any time around loft hatches, doors, windows and letter boxes. Service penetrations can be sealed when plumbing work is being carried out. Air pressure testing and remedial work following tracing of all air leakage paths is best carried out as part of major refurbishment or extension work.

Fig 3 indicates some of the common air leakage paths where uncontrolled air infiltration can result in significant heat loss.

The correct philosophy with regards to minimising infiltration and ventilation heat losses is 'build tight and ventilate right'. Any existing extract fans need to be operating properly and trickle ventilators on windows correctly sized and clear of obstruction. Wherever extract fans are to be replaced or a new one added (e.g. into a new extension) then single room heat recovery ventilators can be specified instead, recovering 60-80 per cent of the waste heat and returning it to the same room rather than rejecting it to ambient.

More major refurbishment work can give the opportunity for air infiltration to be addressed throughout the approach through an air pressure test. This will permit all other air leakage paths to be identified and addressed, although it must be remembered that consideration needs to be given to ensuring sufficient ventilation (perhaps through a whole house mechanical ventilation system with heat recovery) as the airtightness is improved.

Fig.3 Common air leakage paths



Most common air leakage paths

1 Underfloor ventilator grilles.
2 Gaps in and around suspended timber floors.
3 Leaky windows or doors.
4 Pathways through floor/ceiling voids into cavity walls and then to the outside.
5 Gaps around windows.
6 Gaps at the ceiling-to-wall joint at the eaves.
7 Open chimneys.
8 Gaps around loft hatches.
9 Service penetrations through ceilings.
10 Vents penetrating the ceiling/roof.
11 Bathroom wall vent or extract fan.
12 Gaps around bathroom waste pipes.
13 Kitchen wall vent or extractor fan.
14 Gaps around kitchen waste pipes.
15 Gaps around floor-to-wall joints (particularly with timber frame).
16 Gaps in and around electrical fittings in hollow walls.

(Source: Energy Efficient Ventilation in dwellings, GPG268, Energy Saving Trust, 2006)

Changing lamps to low energy versions is a very cost-effective investment and easily implemented, major refurbishment provides the opportunity to review low energy lighting, increase the levels of natural daylight wherever possible, and potentially upgrade the lighting to LEDs to provide further energy and running cost savings. Whenever a significant electrical consumer such as a washing machine, fridge freezer or dishwasher is being replaced or bought, A, A+ or A++ rated appliances should be sourced. Solar photovoltaics could be installed on roofs that are between south-east to south-west facing to offset the annual electricity consumption although to provide the full benefit, use of appliances needs to be shifted to day-time use. The feed-in-tariff can be used to pay off the system cost as quickly as possible, or help to finance other energy reduction measures.

Existing central heating systems should as a minimum have a room thermostat, central programmer or timeswitch and thermostatic radiator valves (not in the room where the thermostat is installed) fitted to achieve a reasonable level of heating control. The overall efficiency of the system will still be mainly determined by the boiler however and if this is 15-20 years old, upgrading to an 'A' rated model with more sophisticated time and temperature control can provide further significant savings.

This will mean a condensing boiler which can yield seasonal efficiencies over 90 per cent but in order to provide the maximum benefit it is important to ensure the new boiler is sized accurately to meet the heat demand of the property. Improvements in thermal performance through some of the measures mentioned in this article will significantly reduce heat losses and it is likely therefore that a boiler with reduced heat output could still be sufficient to meet peak heating and DHW demand. The hot water system should be upgraded at the same time as the main heating system, and if a hot water tank is installed and also around 15-20 years old, a twin coil cylinder (has two heat exchanger coils, one for the boiler at the top, and one for the solar system at the bottom) should be installed. This will have better levels of insulation to reduce standing heat losses and also permit the installation of solar hot water heating either during refurbishment or at some point in the future.

If a major refurbishment is planned then the opportunity could exist to investigate alternative low carbon heating options such as solar water heating for generating a proportion of the hot water demand, air-source or ground-source heat pumps for providing low temperature space heating or biomass heating if space and accessibility for fuel storage is available.

There are many different measures and technologies which can be integrated into dwellings to substantially reduce energy use, fuel bills and carbon dioxide emissions. Indeed if we are to (at a significant scale) move along the road towards an 80 per cent reduction in emissions, wholesale adoption of all these measures will be required. Which measures are appropriate, how they are integrated to gain maximum benefit, how to finance this work and how to ensure the works complement each other should all be assessed as part of an overall carbon improvement plan for each property.

Further reading and references

- *"An Introduction to Low Carbon Domestic Refurbishment"; Construction Products Association, 2010*
- *"Sustainable Refurbishment, towards an 80 per cent reduction in CO2 emissions, water efficiency, waste reduction and climate change adaption" CE309, Energy Saving Trust, 2010*
- *"Here comes the sun: a field trial of solar water heating systems"; Energy Saving Trust, September 2011*
- *"Trigger points: a convenient truth promoting energy efficiency in the home" Energy Saving Trust*
- *"New tricks with old bricks" The Empty Homes Agency.*
- *"Improving airtightness in dwellings"; Energy Saving Trust, CE137*
- *"Energy efficient ventilation in housing"; Energy Saving Trust, CE124*
- *Central heating system specification (CHeSS); Energy Saving Trust, CE51, 2008*

Sustainable refurbishment

PROMOTING ENERGY EFFICIENCY www.eibi.co.uk

ENERGY IN BUILDINGS & INDUSTRY

How to obtain CPD accreditation



Energy in Buildings and Industry and the Energy Institute are delighted to have teamed up to bring you this Continuing Professional Development initiative.

This is the sixth module in the tenth series and focuses on sustainable refurbishment. It is accompanied by a set of multiple-choice questions. To qualify for a CPD certificate readers must submit at least eight of the ten sets of questions from this series of modules to ***Energy in Buildings and Industry*** for the Energy Institute to mark. Anyone achieving at least eight out of ten correct answers on eight separate articles qualifies for an Energy Institute CPD certificate. This can be obtained, on successful completion of the course and notification by the Energy Institute, for a fee of £15 (for members) or £25 (for non-members).

The articles, written by a qualified member of the Energy Institute, will appeal to those new to energy management and those with more experience of the subject.

The forthcoming modules in the tenth series will focus on: LEDs, combined heat and power, training for energy management, and compressed air. The first five modules examined small-scale wind power, water management, fuel cells, solar thermal power and smart metering systems.

All previous modules from this series as well as the 90 modules from the first nine series are available free of charge on CD. Send your request to **mark.thrower@btinternet.com**

MARK THROWER, MANAGING EDITOR

PLEASE COMPLETE YOUR DETAILS BELOW IN BLOCK CAPITALS

Name..... (Mr. Mrs, Ms).....

Business.....

Business Addres.....

.....

.....

.....

Post Code .....

email address.....

Tel No. .....

Completed answers should be mailed to:

The Education Department, Energy in Buildings & Industry, P. O. Box 825, GUILDFORD, GU4 8WQ

SERIES 10 MODULE 6: QUESTIONS

Sustainable refurbishment

Please mark your answers on the sheet below by placing a cross in the box next to the correct answer. Only mark one box for each question. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet in ink, return it to the address below. Photocopies are acceptable.

1. At what rate do we replace our most inefficient existing dwellings, each year, on average?

☐ 5 per cent ☐ 10 per cent ☐ 1 per cent ☐ Less than 1 per cent

2. Which of the following is probably not an ideal trigger point for upgrading floor insulation?

☐ Building a conservatory ☐ Refurbishing a kitchen
☐ Converting a loft space ☐ Putting in a new heating system

3. The legislation relating to the energy efficient performance of existing dwellings is which of the following?

☐ Part L1B ☐ Part L2A ☐ Part M ☐ Part P

4. If a dwelling needs re-rendering and you are already planning to upgrade the wall insulation which of the following should also be considered at the same time?

☐ Floor insulation ☐ Hot water cylinder insulation
☐ Replacing windows ☐ Updating heating controls

5. Which financial incentive is intended by the UK government to promote the uptake of renewable heating systems in non-social housing properties?

☐ The feed-in-tariff ☐ The non-domestic renewable heat incentive
☐ The domestic RHI ☐ The low carbon buildings programme

6. What is the minimum requirement in the Building Regulations Part L1B in terms of energy rating when replacing windows in houses?

☐ WER 'D' ☐ WER 'A' ☐ WER 'B ☐ WER 'A, B or C'

7. Which ventilation measure should be implemented when replacing individual extract fans?

☐ Single room heat recovery extract fans
☐ Whole house mechanical ventilation with heat recovery
☐ Positive input ventilation
☐ Passive stack ventilation

8. What approach is the best to adopt when planning to significantly cut running costs of a typical three bed semi-detached house

☐ If the boiler is at end of its life, replace with an A rated appliance then look at insulation improvements
☐ Develop (or commission a expert consultant to help develop) a carbon improvement plan for the property or property archetype looking at energy reduction first and then alternative energy generation
☐ Install solar photovoltaics on the roof and air source heat pump connected to the existing wet system
☐ Refurbish the property room-by-room as needed and only consider reducing carbon emissions after the main renovations have been completed

9. When considering alternative heating options which of the following is unlikely to be a factor?

☐ Currently a combi gas condensing boiler is installed
☐ The homeowner wants to pull up the suspended ground floor and insulate
☐ The house already has LED lighting installed throughout
☐ The current owner has had the windows replaced, draughtstripped throughout and installed a heat recovery system but the boiler is 20 years old

10. A useful strategy to adopt when reducing heat losses due to air infiltration is:

☐ Ventilate tight and build it right
☐ Eliminate all avenues for heat loss due to air infiltration and only consider ventilation once that has been done
☐ Assume the homeowner/tenant will not need to use their heating system
☐ Build tight and ventilate right