

# SUSTAINABLE REFURBISHMENT OF NON-TRADITIONAL HOUSING AND PRE-1920's SOLID WALL HOUSING

Colin King and Caroline Weeks

Non-traditional housing (eg BISF, No Fines, Laing Easiform, Cornish) and pre-1920's solid wall houses are among the most difficult properties to bring up to modern energy performance standards. However, this Information Paper demonstrates that there is scope for improving SAP ratings and reducing carbon dioxide emissions during refurbishment of these houses. Example measures have been modelled on a typical as-built property to demonstrate the carbon savings that can be achieved through adopting a 'whole house' approach. In addition, wider sustainability issues have been identified that can be addressed relatively easily and effectively while other refurbishment measures are taking place, such as the renewal of windows, kitchens, bathrooms, electrics, etc.

This guidance is not restricted to social housing — it can be applied to housing across all tenures. The same method of refurbishment can be used for both non-traditional housing and pre-1920's solid wall housing.

This *Information Paper* highlights the findings of recent work carried out by BRE Wales for the Welsh Assembly Government and the Countryside Council for Wales on the most sustainable way to refurbish pre-1920's solid wall housing in Wales, and also previous work undertaken in South Wales and other regions of England on non-traditional housing (including No Fines, BISF, Cornish, and Airey build types). Although this study is targeted towards the specific requirement to meet a Standard Assessment Procedure (SAP)<sup>[1]</sup> rating of 65 set out in the requirements of the Welsh Housing Quality Standard (WHQS)<sup>[2]</sup>, its findings, outcomes and recommendations are as applicable and relevant for pre-1920's housing anywhere in the UK. The WHQS sets the minimum standards that



Figure 1: Woolaway houses, Caerphilly: (a) before and (b) after refurbishment

all dwellings in Wales should meet (similar to England's Decent Homes Standard<sup>[3]</sup>). All social landlords are required to bring their housing stock in line with this standard by 2012. The property types and measures included in this *Information Paper*, although undertaken on social housing, are widespread in the private and rented sectors and the recommendations and measures are just as relevant to those sectors.

It should also be remembered that an Energy Performance Certificate (EPC) is now required when any property is either sold, or rented. Further, improving the energy efficiency of a property helps make it more desirable and affordable<sup>[4]</sup>.

Although for social housing the WHQS and Decent Homes Standard goes some way to contributing to a reduction in energy demand and hence reduced carbon emissions from existing dwellings, housing refurbishments could be further optimised to bring about higher carbon reductions, while addressing several wider sustainability issues. The standard suggested in this *Information Paper* therefore represents best practice that could be adopted on any solid wall dwelling anywhere in the UK. It follows a 'whole house' approach in which all factors that can contribute to reduced energy demand and thus reduced carbon emissions are examined. This *Information Paper* will therefore be of interest to anyone who is refurbishing solid wall dwellings, either privately or for social housing, including clients, designers, owner occupiers, landlords and specifiers.

## BACKGROUND

The domestic sector contributes approximately 27% to the total CO<sub>2</sub> emissions of the UK<sup>[5]</sup>. The majority of emissions are a result of energy use for space heating so there is a significant drive by the UK Government to improve the energy performance of buildings to meet the UK's obligations under the Kyoto Protocol. Building Regulations have been tightened, with further increases anticipated in coming years, to reduce the energy demand of new buildings. However, it has been calculated that 70% of the 2050 housing stock has already been built<sup>[6]</sup> and these existing buildings are not regulated in the same way, making this a much more significant and difficult matter to address.

The 2006 revision of the Approved Document L1 of the Building Regulations (England & Wales)<sup>[7]</sup> requires any 'renovation works' to existing buildings to be brought in line with current standards. If more than 25% of a building element (eg a wall, roof or floor) will be affected the entire element will be required to comply with current Building Regulations. This will bring about improvements to the existing building stock where works are being carried out anyway. However, tighter targets will need to be imposed on the existing housing stock to yield significant benefits to carbon reduction.

Solid walled homes are deemed harder and more costly to bring up to modern energy performance standards compared with more recent cavity wall dwellings. Solid wall houses are seen as the greatest consumers of energy and greatest emitters of CO<sub>2</sub>, and consequently, if appropriately addressed, have the greatest potential to improve the carbon footprint of the housing stock. Hence, this study focuses on methods to improve the sustainability of solid wall or non-traditional system-built homes.

## INTERNAL OR EXTERNAL IMPROVEMENTS?

Detailed guidance on choosing between internal or external insulation is given in the Energy Saving Trust's publication *Practical refurbishment of solid-walled houses*<sup>[8]</sup>. This *Information Paper* describes installation methodologies. The fundamental issues to be considered for each application are given in Table 1.

External insulation offers the technically most effective enhancement to the thermal performance of a building, minimising the risk of condensation and thermal bridging, but it should be noted that constraints on changing the external appearance of a property may not for a variety of reasons be a viable option (eg planning, client wish to improve the aesthetic appearance, technical issues, etc.).

## ASSUMED MINIMUM ASPIRATIONS OF THE REFURBISHMENT

The WHQS sets out a series of key parameters that any refurbished dwelling in Wales should meet. It is reasonable to expect any refurbishment to meet such criteria regardless of its geographical location within the UK, hence it has been used in this instance to inform the absolute minimum aspirations for any refurbishment strategy. According to the WHQS, all dwellings are required to:

- be safe and secure (ie secure windows and doors, improving boundary protection),
- be adequately heated, fuel efficient and well insulated,
- meet a minimum SAP rating of 65 (SAP 2005<sup>[1]</sup>; see next section)
- have up-to-date kitchens and bathrooms.

## STANDARD ASSESSMENT PROCEDURE

The UK Government's Standard Assessment Procedure (SAP) is the methodology used for calculating the energy performance of dwellings. The SAP rating is based on the energy costs associated with space heating, water heating, ventilation and lighting, less cost savings from energy-generation technologies. A SAP rating of 100 represents zero operational energy cost for heating, hot water and lighting to the household. The rating is often used as a means of assessing comparative performance of dwellings. A modern new-build house will typically have a SAP rating of approximately 80.

**Table 1: Advantages and disadvantages of installing internal or external wall insulation**

|                                 | <b>External wall insulation</b>                                                                                                                                                                         | <b>Internal wall insulation</b>                                                                                                                                                                |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Internal effects                | Higher surface temperatures of walls (assuming similar heating regime)                                                                                                                                  | As with re-plastering or drylining, services need to be refitted and skirting and architraves replaced. Surface may be less robust than a solid surface. Loss of floor area and room size      |
| External effects                | Can improve rainscreen protection and appearance. The aesthetic appearance may not always be easily matched to the original in all cases and there may be some increased fragility to the exterior skin | None                                                                                                                                                                                           |
| Disruption to residents         | Limited to scaffolding, exterior noise and nuisance                                                                                                                                                     | Requires displacement while work is carried out                                                                                                                                                |
| Thermal mass and responsiveness | Effect of building as a thermal store is improved by reducing swings in temperature, for instance from solar gain                                                                                       | Increases the responsiveness of the heating system. Likely to reduce the effective thermal capacity of the wall                                                                                |
| Thermal bridging                | Can more easily deal with thermal bridges                                                                                                                                                               |                                                                                                                                                                                                |
| Asset value                     | Can be significantly enhanced                                                                                                                                                                           | Unlikely to make much difference                                                                                                                                                               |
| Detailing                       | Important to ensure that fixings are secure and that holes in the outer surface are made good to stop rain penetration                                                                                  | Important to ensure that all wall surfaces and junctions are sealed to prevent warm air condensing behind the insulation layer. Damp problems should be resolved before installation commences |
| Maintenance issues              | Holes through the wall should be minimised and made good. Panels or exterior render should be reviewed regularly                                                                                        | Holes through the wall should be minimised and made good                                                                                                                                       |
| Other benefits                  | Extends the life of an older property. Systems are available from approved installers with warranties                                                                                                   | Can be applied to part of a dwelling                                                                                                                                                           |

SAP ratings for properties older than 1919, and the most common non-traditional build forms are typically between 20 and 40. It has been demonstrated that it is possible to achieve SAP ratings of 80 to 100<sup>[9]</sup> during refurbishment using the SAP 2001 version, although ratings of between 70 and 85 seem more realistic for hard-to-treat homes based on the current SAP scale (SAP 2005<sup>[11]</sup>). It is anticipated that such an increase will lead to reductions in CO<sub>2</sub> emissions of approximately 1–2 tonnes per year<sup>[10]</sup>.

Requiring a minimum SAP rating of 65 is a crude method of ensuring that at least reasonable measures are taken to improve the thermal performance of the building. However, the higher the SAP rating that can be achieved, the further carbon reductions that can be realised, as well as providing improved comfort and affordability to residents. Requiring properties to be safe and secure typically means that new windows and doors will be fitted. The installation of modern windows will further help to conserve energy, thereby contributing to reduced carbon emissions.

The key parameters listed above can be used as a stepping stone to influence the wider sustainability impacts of the refurbishment in terms of:

- life-cycle impacts of materials used (including future waste impacts)
- water use
- potential to add low or zero carbon (LZC)/renewable technologies
- mitigating fuel poverty.

When considering overall sustainability, in addition to the importance of improved energy performance, it is necessary to consider the overall environmental and life-cycle impacts of materials used as well as potential issues that may affect us in the future (ie fuel, materials or water shortages). Consideration should therefore be given to material selection when refurbishing properties, as well as the water usage of sanitary fittings, the potential for using renewable technologies and the impact all these parameters have on the risk of falling into fuel poverty.

## THE BASELINE/AS-BUILT HOUSE

For the purposes of this study, a 'typical' house was assumed as a basis for modelling various refurbishment measures. This was a 3-bedroom terraced property with:

- a floor area of 89 m<sup>2</sup>
- solid wall and pitched roof construction
- built around 1900–1920
- minimal insulation in the roof space
- uninsulated ground floors and
- a pre-1998 heating system with a mains gas fuel supply.

The assumed U-values of each element are given in Table 2, taken from SAP 2005<sup>[1]</sup> v9.80 Tables 6, 9, 11 and 12. It has also been assumed that no significant measures have been undertaken to improve the thermal performance of the dwelling since the property was constructed\* and SAP's default airtightness value of 15 m<sup>3</sup>/m<sup>2</sup>h at 50 Pa has been used. The performance of any non-traditional terraced property does not fundamentally alter from this baseline.

## REDUCING ENERGY DEMAND THROUGH REFURBISHMENT

### The Building Regulations scenario

It is assumed that once the decision is made to improve a building element (ie the roof, walls or floor) the 2006 AD L1B of the Building Regulations would impose minimum performance standards that should be met (ie maximum U-values that should be achieved). For the purposes of this example, the Building Regulation maximum values have been assumed as a minimum performance upgrade. The U-values imposed by the Building Regulations are compared with the assumed as-built values in Table 2. Although these minimum requirements may be met, overall compliance with

the Building Regulations may still not be awarded. The absolute Building Regulations requirements would need to be considered on a case-by-case basis, depending on the extent of the work to be carried out on a property. The U-values assumed here merely provide a baseline requirement.

In addition to these measures, it is assumed that the heating system would first be optimised, with the boiler being replaced for a solar-hot-water-compatible A+ rated (90%+ efficient) condensing gas boiler. It is also assumed that the airtightness of the property will have been improved from the SAP default assumption of 15 m<sup>3</sup>/m<sup>2</sup>h to 10 m<sup>3</sup>/m<sup>2</sup>h at the air infiltration measurement, q50, while the walls are being refurbished and insulated.

Table 3 shows the impact on the SAP rating and the cumulative CO<sub>2</sub> savings of each of the improvement measures compared with the as-built property. These have been included in the order in which they are likely to be prioritised for a dwelling. It is assumed that the first action will be to upgrade the heating system as this is likely to provide the single biggest CO<sub>2</sub> and cost saving of all potential measures. New windows and doors are then likely to be installed to meet the security aspects that are required, closely followed by insulating the roof, as this is likely to be a relatively cheap and easy measure. Improving the wall and floor insulation are likely to be much more disruptive and costly measures, although they each bring about significant emissions reductions. It can be seen that overall the SAP rating can be improved from 43 to 77, with a corresponding CO<sub>2</sub> emissions saving of 4.44 tonnes per year.

An example specification to meet the Building Regulation target U-values and a SAP rating of 77 is shown in Table 4. It should be noted that the table is only indicative of how to meet the elemental targets within the 2006 Building Regulations and many other options for material selection could be used to attain the same performance requirements. The Energy Saving Trust guidance<sup>[8]</sup> gives examples of alternative specifications and insulation thicknesses to achieve equivalent overall performance levels.

\* If any improvement measures have already been carried out over the life of the property (eg installation of loft insulation) the actual thermal performance of the elements may be improved over those assumed here. Each house should therefore be considered on a case-by-case basis.

**Table 2: Comparison of elemental U-values for a typical as-built mid-terraced 1920's solid wall property with the current minimum area weighted Building Regulations requirements and Energy Saving Trust Best Practice guidance**

| Element | U-values (W/m <sup>2</sup> k)                     |                                                                                         |                                                                                |
|---------|---------------------------------------------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
|         | As-built mid-terraced 1920's solid wall property* | Minimum area weighted average for Building Regulations AD L1B <sup>[7]</sup> compliance | Best practice values, in line with Energy Saving Trust guidance <sup>[8]</sup> |
| Roof    | 2.30                                              | 0.25                                                                                    | 0.16                                                                           |
| Wall    | 2.10                                              | 0.35                                                                                    | 0.30                                                                           |
| Floor   | 1.20                                              | 0.25                                                                                    | 0.20                                                                           |
| Windows | 4.80                                              | 2.20                                                                                    | 1.50                                                                           |
| Doors   | 3.50                                              | 2.20                                                                                    | 1.50                                                                           |

\* U-values are taken from SAP 2005<sup>[1]</sup> v9.80.

**Table 3: Incremental SAP and CO<sub>2</sub> emissions improvements of each of the Building Regulations scenario refurbishment measures for solid wall housing**

|                                                                                                                                     | SAP rating | Annual CO <sub>2</sub> emissions (tonnes) | Incremental CO <sub>2</sub> savings (tonnes) |
|-------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------------------------|----------------------------------------------|
| As-built specification...                                                                                                           | 43         | 6.71                                      | —                                            |
| plus A+ rated boiler                                                                                                                | 57         | 4.81                                      | 1.90                                         |
| plus new windows and doors (U value of 2.2 W/m <sup>2</sup> K)                                                                      | 59         | 4.58                                      | 0.23                                         |
| plus roof insulation (U value of 0.25 W/m <sup>2</sup> K)                                                                           | 67         | 3.62                                      | 0.96                                         |
| plus wall insulation (U value of 0.35 W/m <sup>2</sup> K) and airtightness improved from 15 to 10 m <sup>3</sup> /m <sup>2</sup> /h | 74         | 2.76                                      | 0.86                                         |
| plus floor insulation (U value of 0.25 W/m <sup>2</sup> K)                                                                          | 77         | 2.27                                      | 0.49                                         |
| <b>Total change</b>                                                                                                                 | <b>+34</b> |                                           | <b>– 4.44 tonnes</b>                         |

### The Best Practice scenario

The Building Regulations provide a minimum standard that should be achieved if any significant works are to be carried out on a dwelling. However, given the considerable effort that goes into improving any of the construction elements (roof, walls, floors, windows), it makes sense to aim for the highest performance standards possible and practical. Energy Saving Trust guidance<sup>[8]</sup> sets best practice U-value targets for elements and these have been included in Table 2 for comparison with the Building Regulations requirements and the typical as-built performance of solid wall terraced housing.

Again, it is assumed that the boiler will have been replaced by a solar-hot-water-compatible A+ rated (90%+ efficient) condensing gas boiler and in this scenario the airtightness of the property will have been improved from the SAP default assumption of 15 m<sup>3</sup>/m<sup>2</sup>/h to 5 m<sup>3</sup>/m<sup>2</sup>/h at q50 as a result of the refurbishment of the external walls. Thermal bridging should be carefully considered when attempting to achieve such advanced U-values in practice and appropriate detailing employed

(Box 1). Attention to detail at joints, junctions, reveals, and window heads is imperative if the bridging factor and air permeability of the properties is to be improved (Figure 2). Unless undertaking a refurbishment to the standard of a Passive Haus<sup>[11]</sup> it is unrealistic to expect a significant improvement to the air infiltration rate in an older property such as those in this study, but careful detailing and quality control in the construction process can greatly improve this. Figure 3 shows an example of good detailing at cill level before sealing and finishing.

Table 5 shows the impact on the SAP rating and the cumulative CO<sub>2</sub> savings of each of the best practice improvement measures, compared with the as-built property. These have again been included in the order in which they are likely to be prioritised for a dwelling. It can be seen that overall the SAP rating can be improved from 43 to 80, with a corresponding CO<sub>2</sub> emissions saving of 4.71 tonnes per year.

An example specification to meet the Best Practice U-values and a SAP rating of 80 is shown in Table 5. It should again be noted that the table is only indicative

**Table 4: Example of the measures needed for an as-built solid wall house to meet the Building Regulations and Best Practice scenarios**

| Element      | Measure                                         | Specification example                                       |                                                                 |
|--------------|-------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------|
|              |                                                 | 2006 AD L1B Building Regulations scenario                   | Best Practice scenario                                          |
| Roof         | Insulation                                      | 200 mm mineral wool quilt at ceiling level                  | 250 mm cellulose at ceiling level                               |
| Walls        | External or internal insulation                 | 100 mm mineral wool directly applied                        | 120 mm mineral wool directly applied                            |
| Floor        | Insulation                                      | 80 mm extruded polystyrene (XPS)                            | 100 mm extruded polystyrene (XPS)                               |
| Windows      | Double-glazed windows                           | Argon filled ≤ 2.2 W/m <sup>2</sup> K                       | High performance, low e double glazing ≤ 1.5 W/m <sup>2</sup> K |
| Doors        | New doors                                       | Solid with argon filled glazing ≤ 2.2 W/m <sup>2</sup> K    | High performance ≤ 1.5 W/m <sup>2</sup> K                       |
| Airtightness | Draft proofing, back boxes, parging coats, etc. | Maximum air leakage of 10 m <sup>3</sup> /m <sup>2</sup> /h | Maximum air leakage of 5 m <sup>3</sup> /m <sup>2</sup> /h      |



Figure 2: External insulation detailing: (a) insulated reveal frame seal, (b) typical board fixing pattern, (c) typical corner bead mastic before pebbledash finish is applied

Photos (a) and (c) courtesy of Wetherby Building Systems

#### Box 1: Thermal bridging

The importance of thermal bridging should not be underestimated. Significant heat losses can occur at the junctions between construction elements and around openings; approximately 30% of the total heat loss through a building's fabric can be through such bridging. The effects of bridging are specifically included in SAP 2005<sup>[1]</sup> and better detailing and improved airtightness can reduce the annual CO<sub>2</sub> emissions of a dwelling by up to 10%. In particular, bridging should be addressed with care when retrofitting insulation to avoid the risk of internal or interstitial condensation. More information can be found in BRE's publication *Thermal insulation: avoiding risks*<sup>[12]</sup> and in the Energy Saving Trust publication *Enhanced construction details: introduction and use*<sup>[13]</sup> on how to ensure that detailing is carried out to minimise thermal bridging and optimise thermal performance.



Figure 3: An example of good detailing at cill level before sealing and finishing

**Table 5: Incremental SAP and CO<sub>2</sub> emissions improvements of each of the Best Practice scenario refurbishment measures for solid wall housing**

|                                                                                                                                           | SAP rating | Annual CO <sub>2</sub> emissions (tonnes) | Incremental CO <sub>2</sub> savings (tonnes) |
|-------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------------------------|----------------------------------------------|
| As-built specification...                                                                                                                 | 43         | 6.71                                      | —                                            |
| <i>plus</i> A+ rated boiler                                                                                                               | 57         | 4.81                                      | 1.90                                         |
| <i>plus</i> new windows and doors (U value of 1.5 W/m <sup>2</sup> K)                                                                     | 60         | 4.49                                      | 0.32                                         |
| <i>plus</i> roof insulation (U value of 0.16 W/m <sup>2</sup> K)                                                                          | 68         | 3.48                                      | 1.01                                         |
| <i>plus</i> wall insulation (U value of 0.30 W/m <sup>2</sup> K) and airtightness improved from 15 to 5 m <sup>3</sup> /m <sup>2</sup> /h | 76         | 2.52                                      | 0.96                                         |
| <i>plus</i> floor insulation (U value of 0.20 W/m <sup>2</sup> K)                                                                         | 80         | 2.00                                      | 0.52                                         |
| <b>Total change</b>                                                                                                                       | <b>+37</b> | <b>– 4.71 tonnes</b>                      |                                              |

of how to meet the elemental target values; many other options for material selection could be used to attain the same performance requirements. The Energy Saving Trust publication *Energy efficient refurbishment of existing housing*<sup>[14]</sup> is a useful source of information, for example for vacuum insulated panels (VIPs) which may be considered for either external insulation or internal insulation, where appropriate.

## IMPLICATIONS FOR FUEL POVERTY

The refurbishment measures detailed in the Building Regulations and Best Practice scenarios serve to reduce energy demand in the home, hence resulting in reduced carbon emissions associated with heating and hot water provision. This will also lead to a reduction in fuel bills which will help reduce the risk of households falling into fuel poverty. A household is defined as being in fuel poverty if they are required to spend more than 10% of their disposable income on maintaining a satisfactory heating regime<sup>[15]</sup>. Houses with poor energy performance will have higher heating bills so families that would otherwise cope relatively well in a more energy-efficient home could find themselves in fuel poverty.

The refurbishment scenarios detailed here are estimated to bring about cost savings in annual fuel bills of 57% for the Building Regulations scenario and 61% for the Best Practice scenario, which would clearly be of significant benefit to households. Since this is the result of an actual reduction in energy demand, it will provide longer term security than switching energy provider or indeed switching to a different fuel source since the majority of these will still be at the mercy of price fluctuations linked to the cost of primary fuels.

The use of renewable energy sources, such as wind or solar power to produce electricity, would effectively provide free energy after the up-front investment has been made, thus protecting against future energy price trends. However, typically, more benefit will be realised through fabric improvements than could be achieved through displacing primary energy use with renewable technologies alone. Most benefit is of course achieved by implementing both measures.

## ALTERNATIVE ENERGY

Once appropriate improvements have been made to the building fabric, consideration may be given to the use of low- or zero-carbon (LZC) technologies to reduce primary fuel demand and/or carbon emissions still further. Guidance on the selection of renewable energy systems for domestic applications is provided in the Energy Saving Trust guidance *New and renewable energy technologies for existing housing*<sup>[16]</sup>. Contribution to the cost of such systems may be sought via the Low Carbon Buildings Programme (LCBP), where up to 50% of the costs can be recovered by qualifying social housing organisations\*. A separate scheme with varying rates of grant under the LCBP exists for private home owners<sup>†</sup>.

The scenarios in this report have assumed that the properties in question are being supplied by the mains gas network, hence one of the most beneficial upgrades during refurbishment is the installation of a highly efficient condensing gas boiler (with compatibility for the addition of solar hot water to future-proof the system to some

\* [www.lowcarbonbuildings.org.uk/home/](http://www.lowcarbonbuildings.org.uk/home/)

† [www.lowcarbonbuildings.org.uk/how/householders/](http://www.lowcarbonbuildings.org.uk/how/householders/)

extent). This is a relatively low-cost measure for dwellings already supplied by gas. However, where properties are not supplied by mains gas, alternative measures will be required. In these instances, the fuel being used in place of gas will inevitably be more carbon-intensive, unless biomass is already used. For example, electricity used as a primary fuel emits over 2.5 times more CO<sub>2</sub> than gas per kWh of delivered energy. Therefore, once the thermal fabric performance has been addressed, properties off the gas network should be encouraged to switch to less carbon-intensive heating and hot water systems. Examples that may be considered are outlined below, though appropriate feasibility studies should be carried out on a case-by-case basis to ensure the most appropriate option is identified for a specific property and its residents.

### Biomass

Biomass room heaters, fuelled by small deliveries of bagged wood pellets, can be used in place of open coal or wood fires. They can be controlled electronically using a room thermostat or timer to improve efficiency and can also be integrated with a boiler and room radiators (and/or a solar hot water system) as a means of providing low-carbon space heating and hot water throughout the year.

Fully automated biomass boilers may be suitable for serving central heating systems. However, they typically need to be sited outside the dwelling due to the space required and the need for adjacent biomass storage. Where multiple properties are located close to one another, a single, larger scale biomass boiler to supply multiple properties becomes well worth considering (effectively, a small district heating scheme). The cost savings of such systems are likely to be significant but access, storage and maintenance issues will need to be considered.

### Air source heat pumps

Although heat pumps still rely on electricity and hence are not strictly a renewable technology, they produce two to three times more energy than they consume. Therefore, they can bring about significant reductions in energy used and emissions generated by a property. If the electricity used was provided by a renewable source such as wind power or photovoltaics (PV), the energy delivered could be considered renewable. Such heat pumps may not be capable of completely serving a household's heating and hot water demand due, for example, to the delivery

systems installed in a property. However, they can at least be used to pre-heat hot water or act as a supplementary heating system in conjunction with a biomass room pellet heater, for example, in the main living area. It is often assumed that there will not be enough space for ground source heat pumps, though these could similarly be considered.

### Solar thermal panels

Although solar hot water systems may be beneficial in any property, their contribution is likely to have a greater impact on carbon emissions in properties that use a fuel other than gas (ie more carbon-intensive fuels) as their means of water heating (although gas used to provide a dwelling's hot water can result in CO<sub>2</sub> emissions of over 600 kg per year). As a general rule, a correctly scaled solar hot water system should be capable of providing 50–60% of the annual hot water demand of a home in the UK, offsetting between 300 kg and 800 kg of CO<sub>2</sub> per year (depending on the fuel source displaced).

Used in combination with the Best Practice refurbishment scenario detailed on page 5, a 4 m<sup>2</sup> evacuated tube solar hot water collector would only increase the SAP rating from 80 to 81 in the example property. This reinforces the fact that it is generally preferable and more advantageous to optimise the building fabric before resorting to renewable energy options.

### Photovoltaic panels and wind power

Photovoltaics (PV) and wind power provide electricity in a completely renewable way and will essentially provide power for 'free' after the up-front cost of installation. However, PV is relatively expensive and it would generally not be affordable to install sufficient capacity into a refurbished dwelling to serve the heating and hot water demand unless significant measures to reduce this demand up-front have first been made.

Wind turbines are again relatively expensive and issues of wind speed and turbulence close to the ground and buildings often prevent per-dwelling micro-wind systems from being viable<sup>[17]</sup>. Where larger, more powerful turbines can be suitably sited and serve multiple dwellings, wind power typically becomes a more feasible solution to the provision of energy. Again, optimising the thermal performance of dwellings will allow the energy provided by such means to go further.

## WIDER SUSTAINABILITY CONSIDERATIONS

Energy aside, there are other factors that could and should be considered if the extent of the refurbishment works allows. These are discussed in the following sections.

### *Emissions other than carbon dioxide*

When installing new boiler systems, as well as seeking high efficiency ratings, consideration should be given to the level of pollutants other than CO<sub>2</sub> that are emitted. For instance, dry NO<sub>x</sub> emission rates of below 40 mg/kWh should be targeted.

### *Daylighting*

Any extensions to be added or any remodelling of openings during window replacement should optimise natural daylighting, ideally providing a daylight factor of  $\geq 2\%$  in kitchens and  $\geq 1.5\%$  in other rooms. Many people prefer naturally daylit rooms to artificial lighting and reducing the need for artificial light will obviously bring about a corresponding reduction in energy demand and hence lower CO<sub>2</sub> emissions.

### *Life-cycle assessment of material specifications*

All construction elements and products used should be selected with consideration of their life-cycle performance, including their likely maintenance requirements and their fate at end of life. Materials and products that can be easily recovered and reused or recycled should be selected in preference to those that cannot, to reduce the future waste burden of the building. *The Green Guide to Specification*<sup>[18]</sup> is a useful reference source to compare the life-cycle impact of construction elements and products. Elements are ranked on a scale from A+ to E, with A+ being the lowest life-cycle impact and E the highest. Selection of specifications with A or A+ *Green Guide* ratings should help to limit the life-cycle impact of the refurbishment. Ratings exist for walls, floors, roofs, windows, boundary protection, insulation and others.

### *Responsible sourcing of materials*

Materials and products (including kitchens when they are being replaced) should be responsibly sourced to ensure sustainability through the supply chain. For instance, several certification schemes exist for timber products that demonstrate that the wood used comes from sustainably managed sources. Since such established sourcing schemes do not currently exist for non-timber products, other means of demonstrating sustainable sourcing include the BRE Environmental and Sustainability Standard BES 6001<sup>[19]</sup> to assess the responsible sourcing of construction products, or where manufacturers have a certified Environmental Management System (EMS) in place.

### *Provision of space for household recycling storage*

Where possible, consider introducing dedicated space internally and/or externally for recycling bins and segregation of waste streams. This should obviously fall in line with any pre-existing or anticipated local authority collection schemes, which may differ from area to area.

### *Energy-efficient lighting*

Where light fittings are being renewed or added, (including external security lighting), dedicated energy-efficient light fittings should be installed to minimise energy demand. These should only accommodate low-energy bulbs to ensure that they cannot be replaced in time with non-energy-efficient types. Changing to 100% energy-efficient lighting could further improve the example CO<sub>2</sub> saving scenarios in this study by ~235 kg per year which is equivalent to 3–4 SAP points. Although standard energy-efficient bulbs could create similar savings, this could only be guaranteed to be an improvement long term through the use of dedicated fittings.

### *Energy-efficient white goods*

If white goods, such as refrigerators, freezers, washing machines, dishwashers, etc. are being replaced during kitchen upgrades, the most energy-efficient products should be sought, as indicated by the EU Energy rating. The EU Energy rating scheme ranks the efficiency of products from A to G (or from A++ for refrigerators and freezers), where A represents the best-performing and G the worst-performing products on the market, from an energy efficiency point of view. The Energy Efficiency Recommended logo from the Energy Saving Trust can also be used to identify the most energy-efficient products on the market as it is only awarded to the best-performing products of each type.

### *Reduced potable water use*

When kitchens and bathrooms are replaced, consideration should be given to the water usage of any new items being installed. Water treatment processes and pumps for transporting water around the national water network require considerable amounts of energy and hence water use carries an associated carbon impact, even in areas where water is rarely scarce.

Replacement of sanitary fittings in a bathroom and/or taps in kitchens should be used as an opportunity to drive down water use through the selection of appropriate fittings. For example, shower units should be selected with a flow rate of  $\leq 12$  litres per minute, 6/4 litre dual flush toilets or lower should be used and taps for hand basins should be aerated or fitted with flow regulators to reduce flow to a rate of around 1.5 litres per minute. In kitchens, sink taps should again be aerated or fitted with flow regulators to reduce flow to a rate of around 4 litres per minute. Lower flow rates than this are likely to be deemed unsatisfactory for kitchen use and would probably be replaced by residents.

Depending on the extent of the works, greywater recycling or rainwater harvesting may be considered to displace a proportion of mains water, particularly for toilet flushing. With appropriate treatment, rainwater may also be used in some washing machines.

For anyone wishing to take this option forward, the principles and methodology set out in the *Code for Sustainable Homes: Water efficiency calculator for new dwellings*<sup>[20]</sup> can easily be adopted for any refurbishment package, although designed specifically for new build many of the recommendations and principles are as relevant for older buildings.

## CONCLUSIONS AND RECOMMENDATIONS

There is significant scope to improve the sustainability of non-traditional housing and pre-1920's solid wall housing in the UK. Carbon emission savings of up to 4.71 tonnes per year per dwelling can be realised by adopting best practice measures and a whole house approach to refurbishment. Corresponding reductions in fuel bills will be of additional benefit to households and will minimise the risk of fuel poverty. Where refurbishment of solid wall properties is being considered, it is recommended that as many measures as possible are carried out to the Best Practice standards detailed in this *Information Paper* so as to optimise carbon reductions.

Such refurbishment can be used as an opportunity to address wider sustainability issues, such as daylighting, material life-cycles and sourcing, energy efficiency of lighting and household appliances and water use within the home. Many of these additional factors can be achieved at little or no additional cost when upgrades are being carried out and sustainable specifications are considered up-front.

## REFERENCES

- [1] BRE. SAP 2005, revision 3. The Government's Standard Assessment Procedure for energy rating of dwellings. Available at [www.bre.co.uk/sap2005](http://www.bre.co.uk/sap2005)
- [2] Welsh Assembly Government. Living in Wales 2004: Welsh Housing Quality Standard. Cardiff, Welsh Assembly Government, 2006
- [3] Department for Communities and Local Government (CLG). Decent Homes Standard. For information visit [www.communities.gov.uk/housing/decenthomes/whatis/](http://www.communities.gov.uk/housing/decenthomes/whatis/)
- [4] Butterworth M. Home owners failing green targets to pay more Council Tax. Personal finance section. The Telegraph, 24 August 2009
- [5] Defra. Environment in your pocket 2008. Available as a pdf from [www.defra.gov.uk](http://www.defra.gov.uk). Search for EYIP 2008
- [6] Broadman B et al. 40% house. Environmental Change Institute, Oxford University, February 2005. For information visit [www.40percent.org.uk/](http://www.40percent.org.uk/)
- [7] Department for Communities and Local Government (CLG). The Building Regulations 2000. Approved Document L 1B Conservation of fuel and power in existing dwellings, 2006. Available from [www.planningportal.gov.uk](http://www.planningportal.gov.uk) and [www.thenbs.com/buildingregs](http://www.thenbs.com/buildingregs)
- [8] Energy Saving Trust. Practical refurbishment of solid-walled houses. CE184. 2006. Available as pdf from [www.est.org.uk/housingbuildings/publications](http://www.est.org.uk/housingbuildings/publications)
- [9] Energy Saving Trust. Energy-efficient refurbishment of existing housing. GPG155. 2001 edition. Available as pdf from [www.est.org.uk/housingbuildings/publications](http://www.est.org.uk/housingbuildings/publications). *Note this publication has been revised as CE83, 2007 edition, see ref. [13]*
- [10] Yates T. Sustainable refurbishment of Victorian housing: guidance, assessment method and case studies. FB 14. Bracknell, IHS BRE Press, 2006
- [11] Passiv Haus. Continental standard for new build and refurbishment. For information visit [www.passivhaus.org.uk](http://www.passivhaus.org.uk)
- [12] BRE. Thermal insulation: avoiding risks. Report BR 262. 2002 edition
- [13] Energy Saving Trust. Enhanced Construction Details: introduction and use. CE297. 2008 edition. Available as pdf from [www.est.org.uk/housingbuildings/publications](http://www.est.org.uk/housingbuildings/publications)
- [14] Energy Saving Trust. Energy-efficient refurbishment of existing housing. CE83. 2007 edition. Available as pdf from [www.est.org.uk/housingbuildings/publications](http://www.est.org.uk/housingbuildings/publications)
- [15] Defra and BERR. The UK Fuel Poverty Strategy: 6th Annual Progress Report 2008. Available from [www.defra.gov.uk](http://www.defra.gov.uk) and [www.berr.gov.uk](http://www.berr.gov.uk)
- [16] Energy Saving Trust. New and renewable energy technologies for existing housing. CE102. 2005. Available as pdf from [www.est.org.uk/housingbuildings/publications](http://www.est.org.uk/housingbuildings/publications)
- [17] Phillips R, Blackmore P, Anderson J et al. Micro-wind turbines in urban environments: an assessment. FB 17. Bracknell, IHS BRE Press, 2007
- [18] Anderson J, Shiers D & Steele K. The Green Guide to Specification. 4th edition. BRE Report BR 501. Bracknell, IHS BRE Press, 2009
- [19] BRE Global. BRE Environmental & Sustainability (BES) Standard 6001: Issue 2.0, 15 June 2009. Framework Standard for the Responsible Sourcing of Construction Products. Available as a pdf from [www.greenbooklive.com](http://www.greenbooklive.com)
- [20] Department for Communities and Local Government (CLG). The water efficiency calculator for new dwellings: the Government's national calculation methodology for assessing water efficiency in new dwellings in support of: The Code for Sustainable Homes, May 2009 and subsequent versions, The Building Regulations 2000 (as amended), The Building (Approved Inspector, etc) Regulations 2000 (as amended). [www.planningportal.gov.uk/uploads/br/water\\_efficiency\\_calculator.pdf](http://www.planningportal.gov.uk/uploads/br/water_efficiency_calculator.pdf)

## FURTHER READING FROM BRE

Available from IHS BRE Press, Tel: 01344 328038,  
Email: [brepress@ihs.com](mailto:brepress@ihs.com), [www.brebookshop.com](http://www.brebookshop.com)

- Anderson B. Conventions for U-value calculations. Report BR 443. 2006 edition
- BRE. Part L explained: the BRE guide. Report BR 489. 2006
- BRE. Installing thermal insulation: Good site practice. Good Building Guide 68 (2 Parts). 2006
- BRE. Non-traditional housing CD. A collection of BRE publications. AP 149. 2002
- Cartwright P, Moulinier E, Saran T, Novakavic O & Fletcher K. SmartLIFE — Lessons learned. Report BR 500. 2008
- Doran S. Masonry walls and beam-and-block floors: U-values and building regulations. Special Digest 4. 2007 edition
- Harrison H. Plasterboard. Good Building Guide 70. Part 1: Types and their applications, Part 2: Fixing and finishing non-separating walls and floors, Part 3: Fixing and finishing separating and compartmenting walls and floors. 2007
- Harrison H, Mullin S, Reeves B & Stevens A. Non-traditional houses: identifying non-traditional houses in the UK 1918–75. Report BR 469. 2004
- Hodgson G. An introduction to PassivHaus: a guide for UK application. Information Paper IP 12/08. 2008
- Jaggs M & Scivyer C. Achieving airtightness. Good Building Guide 67. Part 1: General principles. Part 2: Practical guidance on techniques: floors, walls and roofs. Part 3: Practical guidance on techniques: windows and doors, sealing methods and materials. 2006
- Lauchlan C, Griggs J & Escameia M. Drainage design for buildings with reduced water use. Information Paper IP 1/04. 2004
- Stirling C. Insulating solid masonry walls. Good Building Guide 50. 2002

## ACKNOWLEDGEMENTS

The initial research work for this report was funded by the Countryside Council for Wales and the Welsh Assembly Government whose support and funding is acknowledged.

The author also gratefully acknowledges the support of the BRE Trust in the preparation of this *Information Paper*.

bretrust

## BRE Connect Online

Unlock the wealth of knowledge and expertise of BRE



- Full-text access to over 1,500 weekly updated BRE titles with an easy and powerful searching interface
- View the abstracts of 26,000 documents from over 500 other construction publishers
- Up to 30% off IHS BRE Press titles in hard copy
- Discounts of 20% on British Standards
- Access to Specify-it (Silver); a searchable database of more than 90,000 construction product catalogues from 9,000 suppliers and over 30,000 CAD drawings from over 80 manufacturers
- Personalised browse facility and alerts

Call us today on 01344 328038 to find out more

breconnect  
online

bre

**BRE** is the UK's leading centre of expertise on the built environment, construction, energy use in buildings, fire prevention and control, and risk management. BRE is a part of the BRE Group, a world leading research, consultancy, training, testing and certification organisation, delivering sustainability and innovation across the built environment and beyond. The BRE Group is wholly owned by the BRE Trust, a registered charity aiming to advance knowledge, innovation and communication in all matters concerning the built environment for the benefit of all. All BRE Group profits are passed to the BRE Trust to promote its charitable objectives.

BRE is committed to providing impartial and authoritative information on all aspects of the built environment. We make every effort to ensure the accuracy and quality of information and guidance when it is published. However, we can take no responsibility for the subsequent use of this information, nor for any errors or omissions it may contain.

BRE, Garston, Watford WD25 9XX

Tel: 01923 664000, Email: [enquiries@bre.co.uk](mailto:enquiries@bre.co.uk), [www.bre.co.uk](http://www.bre.co.uk)

**Information Papers** summarise recent BRE research findings, and give advice on how to apply this information in practice.

Digests, Information Papers, Good Building Guides and Good Repair Guides are available on subscription in hard copy and online through BRE Connect. For more details call 01344 328038.

**BRE publications** are available from [www.brebookshop.com](http://www.brebookshop.com), or IHS BRE Press, Willoughby Road, Bracknell RG12 8FB  
Tel: 01344 328038, Fax: 01344 328005, Email: [brepress@ihs.com](mailto:brepress@ihs.com)

Requests to copy any part of this publication should be made to: IHS BRE Press, Garston, Watford WD25 9XX  
Tel: 01923 664761  
Email: [brepress@ihs.com](mailto:brepress@ihs.com)  
[www.brebookshop.com](http://www.brebookshop.com)

IP 3/10

© BRE 2010

January 2010

ISBN 978-1-84806-119-4