Building services and the code for sustainable homes.

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Building Services and the Code for Sustainable Homes

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Abstract

This paper investigates the design of space heating and ventilation to meet Code for Sustainable Homes (CSH) (CLG, 2008) targets for detached housing. The design of building services plant is radically affected by the requirements of the CSH. "Super insulated" u values and much "tighter" construction lead to fabric losses and uncontrolled ventilation rates that are considerably lower than those achieved by Building Regulation Approved Document L1A (ODPM, 2006). Before considering renewable technologies such as photovoltaics, designers should fully explore the potential of envelope and plant to achieve minimum CO2 emissions. Even with the most stringent envelope build quality it is not possible to meet CSH Level 3 without either triple glazing, solar thermal or mechanical ventilation with heat recovery. The CSH will require designers, builders and plant manufacturers to reconsider traditional envelope, heating and ventilation solutions.

Introduction

The UK government is proposing an increase in the annual construction of homes from 214 000 (2005/06) to over 300 000 by 2016 (RAB 2007). "25% of UK carbon emissions derive from consumption of energy in the home and by 2050 approximately one third of the housing stock will have been built since 2006. So new homes have a vital role to play in helping to meet the United Kingdom's target of 60% reduction in carbon emissions by 2050." (HRMC, 2007)

The government has targeted these new dwellings for emissions reductions in three stages based on the ADL1A (2006) benchmark, in effect, Level 0. The Code for Sustainable Homes (CLG, 2008) identifies six "levels" of carbon dioxide reduction and a three stage programme which would require Level 3 (-25%) by 2010, Level 4 (-44%) from 2013 and zero net emissions Level 6 from 2016. Various bodies have proposed new standards of envelope construction, ventilation and renewable technologies to achieve zero emission dwellings. As of April 2008, social housing needs to meet Level 3. We are therefore considering mass-build low and zero emissions dwellings, an entirely new approach to housing in this country. The aim of the paper is to establish whether these new standards of building are achievable in a mass build context, whether Code 3 can be achieved using improvements in the envelope alone and what implications low emission envelopes have on space heating and ventilation systems.

The paper is structured in the following manner: A review of current guidance for low emission dwellings is carried out. A 3 bedroom detached masonry build house of 96 m2 floor area is modelled using National Home Energy Rating Standard Assessment Procedure Assessor software (NHER SAP) based on the current SAP procedure (BRE, 2008). The results are analysed for currently achievable best practice construction techniques. A discussion then proceeds based on the SAP data and available building services technologies highlighting a number of important issues which will have to be addressed if the eventual Government aim of zero emissions dwellings is to be achieved.

Literature search

In order to facilitate the development of Level 6 dwellings, with renewables off-setting the carbon emissions, the Renewables Advisory Board (RAB, 2007) have proposed new envelope heat losses to be achieved by lower u values, reduced linear (non-repeating) thermal bridging, reduced air permeability, mechanical ventilation with heat recovery, increased solar gains from window orientation and 100% low energy lighting, see Table 1. Similar values have been proposed by the Energy Savings Trust Advanced Practice Guidelines (EST, 2006), the Sustainable Building Association's Gold Standard (AECB, 2007) and the Passive House Institute.

Table 1 Comparison of ADL1A and RAB design standards

U values (W/m2K)	ADL1a	RAB
Doors	2	0.8
Windows	2	0.8
Ground Floor	0.25	0.15
Walls	0.35	0.15
Roof	0.25	0.15
Thermal Bridge y (W/m2K)	0.08	0.04
VENTILATION		
Infiltration	10	1
Mechanical heat recovery	Optional	Yes

GLAZING ORIENTATION	NA	20% North, 80% South
Fixed low energy lighting	30%	100%

It is important to establish realistic heat loss calculations for the envelope based on current best practice rather than assuming that lower thermal bridges and exemplar standards for infiltration can and will be consistently achieved in the mass build market. By creating an envelope using 150 to 300 mm of insulation and triple glazed window units, the element u values are currently achievable in traditional construction. Double glazing is, however, the industry standard and by specifying quality low e double glazing with argon fill, window u values may be reduced to 1.6 W/m2K. To achieve window u values of 0.8 W/m2K, low e gas-filled triple glazing is required.

There is currently no limit to thermal bridge heat loss set by ADLIA (ODPM 2006). SAP assumes a default value of 0.15 W/m2K where no specific detailing is given. Accredited Construction Details (CLG, 2007) have been established in order to address the issue of both thermal bridging and air infiltration. These details set average thermal bridge y values for typical construction details at 0.08 W/m2K. There is no reason why designers should not improve on this value to achieve 0.04 W/m2K or, thermal bridge free details.

Infiltration is uncontrolled ventilation or draught caused by air leaks around openings and by micro-leaks through the structure. ADL1A sets maximum air permeability at 10 m3/m2h@50Pa. Building an air tight envelope appears to be difficult to achieve in practice. Research carried out by BSRIA between July 2005 and July 2006 (Housebuilder, 2006) shows that only 5.4% of traditional new build houses achieve air permeability rates of less than 5 m3/m2h. The Energy Savings Trust's guide, Energy efficiency and the Code for Sustainable Homes for Levels 5 & 6, (EST, 2008) appears to recognise this by setting 3 m3/m2h as the standard to be achieved. It seems reasonable therefore to set new maximum targets at 3 m3/m2h while industry gains sufficient knowledge of how to achieve this consistently.

Achieving these low infiltration requirements also demands close attention to adequate ventilation. Trickle ventilation is uncontrollable and extract fans generally do not provide heat reclaim. Both RAB and EST specify mechanical ventilation with heat recovery (MVHR) for maximum energy efficiency and to ensure sufficient air changes for internal air quality

Glazing size and orientation is an architectural and site specific function and its design will depend on too many factors to proscribe anything other than an 80/20% South/North mix. Winter solar heat gains during high atmospheric pressure conditions (clear skies) will reduce the annual heating requirements in kWh but not necessarily the maximum demand in kW at design conditions where skies may well be overcast.

It would therefore appear that current best practice standards of envelope construction should be able to meet opaque u values of 0.15 W/m2K, thermal bridges of 0.08 W/m2K and air permeability of 3 m3/m2h@50 Pa.

In order for houses to meet the "true Zero Carbon Dwelling" target for CSH (CSH, 2008), the house must comply with a Heat Loss Parameter (HLP) of ≤0.8 W/m2K. The HLP is the heat loss from the envelope per degree temperature difference based on the total floor area. The aim is to reduce envelope losses to a minimum using advanced practice construction techniques rather than off-setting these emissions with renewables.

Methodology

In order to investigate these proposed construction standards a model detached house has been developed. The Renwables Advisory Board (RAB, 2007) state that 57% of all dwellings are houses and that the average house floor area is 69 m2. Although the number of flats and maisonettes is increasing annually, 2007 data from the National House Building Council (NHBC, 2008) for South East England show the total starts for new detached houses, bungalows, semis and terraced houses amount to 46%, flats and maisonettes 54%. CLG statistics (CLG, 2008), based on NHBC data for the South East 2006/07, show that 2 and 3 bedroom make up 70% of these new houses. A non-exhaustive search of new build detached houses produces a range of floor areas from around 110 m2 for a four bedroom, 70-96 m2 for three bedroom, down to 58 m2 for a two bedroom coach house. A traditional build two storey detached house has been modelled based on a large 3 bedroom house size of 96 m2 floor area. The physical dimensions are shown in Table 2 below.

Table 2. Three bedroom house dimensions

Ground floor	Total Floor Area	Walls	Openings (18% of floor area)
48 m2	96 m2	143 m2	17 m2

It has been assumed that opaque envelope u values of 0.15 W/m2K can be achieved by additional insulation in walls, floor and roof. Current practice is to specify double glazing. Accredited Construction Details are specified in order to achieve thermal bridge values of 0.8 W/m2K and air permeability of 3 m3/m2h. House ventilation is most commonly achieved with trickle ventilation and extract fans. SAP analysis was initially carried out using the criteria given in Table 3 below as a default design.

Table 3. Default thermal criteria

Ground Floor (Solid)	220 mm insulation	0.15 W/m2 K
Walls (Cavity masonry)	150 mm insulation	0.15 W/m2K
Roof	300 mm insulation	0.15 W/m2K
Openings	Double glaze	1.6 W/m2K
Thermal bridge y values	Accredited Construction Details	0.08 W/m2K
Air permeability	Current best practice[i]	3m3/m2h @ 50 Pa
Ventilation	Trickle vent & 3 extract fans	Low energy fans
Gas Boiler, Programmer, room thermostat, TRVs	Condensing, auto-ignition, 1998 or later	91% efficiency

Results

The default thermal criteria produce the following output: It can be seen that it is not possible to meet Level 3 using double glazing or an improved thermal bridge value of 0.04 W/m2K, see Table 4.

Table 4 Double Glaze (u = 1.6 W/m2K)

Thermal Bridge	Code Level	CO2 % savings over ADL1A
0.08	2	18.72
0.04	2	23.58

In order to meet Level 3 by envelope specification alone, it is necessary to change the windows/doors to meet a triple glazing specification, such as a low e argon fill, with u values of 0.8 W/m2K, see Table 5.

Table 5. Triple Glaze (u = 0.8 W/m2K)

Thermal Bridge	Code Level	CO2 % savings over ADL1A
0.08	3	25.05
0.04	3	29.67

Thus Level 3 may be achieved without renewables but at the expense of quality triple glazing.

Using a boiler and cylinder would allow for multiple appliances to draw hot water at the same time and offers a solar hot water or solar thermal solution. Returning to the double glazing option, a typical domestic solar thermal design of 200 litre cylinder with 100 litres dedicated solar thermal and 4 m2 of flat plate panels achieves CSH Level 3, see Table 6.

Table 6 Double Glaze with Solar Thermal

Thermal Bridge	Code Level	CO2 % savings over ADL1A
0.08	3	38.79

Level 3 is thus achievable using double glazing and Accredited Construction Details where a domestic solar thermal system is specified.

CSH Level 3 may also be achieved with double glazing, y values of 0.08 W/m2K and 3 m3/m2h by installing mechanical ventilation with heat recovery (MVHR) but only by using typical manufacturers' efficiency ratings of 90% and specific fan power 0.46 W/l/s taken from SAP Appendix Q (BRE, 2006), see Table 7. Default MVHR, with its efficiency of 66% and specific fan power of 2.0 Watts/l/s, actually produces more CO2 emissions than the trickle vent and extract fan option.

Table 7 MVHR

MVHR @ 3m3/m2h	Thermal Bridge	Code Level	CO2 % savings over ADL1A
Double glaze	0.08	3	25.85
Double glaze	0.04	3	30.07
Triple glaze	0.08	3	31.34
Triple glaze	0.04	3	35.32

MVHR achieves further emissions reductions where air permeability meets Passive House standards of <1 air change per hour. Modelling the house at 1 m3/m2h @50 Pa, provides the following results, see Table 8.

Table 8 Air Permeability 1m3/m2h@50Pa

MVHR @ 1m3/m2h	Thermal Bridge	Code Level	CO2 % savings over ADL1A
Double glaze	0.08	3	28.87
Double glaze	0.04	3	32.97
Triple glaze	0.08	3	34.25
Triple glaze	0.04	3	37.95

In order for houses to meet the "true Zero Carbon Dwelling" target for CSH (2007), the house must comply with a Heat Loss Parameter (HLP) of ≤0.8 W/m2K. To achieve a HLP of 0.8 W/m2K, the envelope must meet RAB (RAB, 2007) requirements for triple glazing, thermal bridges, air permeability and MVHR, see Table 9.

Table 9 Meeting HLP 0.8 W/m2K

Gas boiler, trickle vent and extract, 3m3/m2h@50Pa	Thermal bridge	HLP
Double glaze	0.08	1.13
Double glaze	0.04	1.03
Triple glaze	0.08	1.13
Triple glaze	0.04	1.03
Gas boiler, MVHR, 3m3/m2h@50Pa		
Double glaze	0.08	1.06
Double glaze	0.04	0.96
Triple glaze	0.08	0.93
Triple glaze	0.04	0.83
Gas boiler, MVHR, 1m3/m2h@50Pa		
Triple glaze	0.08	0.86
Triple glaze	0.04	0.76

The Government programme of mass house building is unlikely to rely on biomass boilers. Occupants have become reliant on automatic boilers connected to mains supplied fuel requiring no storage, filling or emptying. It therefore appears more likely that natural gas and electricity will be the main sources of heating. Electricity allows designers to use heat pumps at efficiencies of 200 to 300%. Combined Service Units (CSU) combine a heat pump (air to air space heating) with MVHR and a hot water cylinder (air to water) into a single unit for ease of installation and integrated control. The SAP output for a typical CSU model is shown below in Table 10.

Table 10 Typical Combined Service Unit (CSU)

Heat Pump, MVHR, 3m3/m2h@50Pa	Thermal bridge	CSH Level	CO2 % saved	HLP
Triple glaze	0.08	4	52.51	0.93
Triple glaze	0.04	4	54.97	0.83
Heat Pump, MVHR, 1m3/m2h@50Pa				
Triple glaze	0.08	4	54.27	0.86
Triple glaze	0.04	4	56.65	0.76

There is therefore the option to design with heat pumps and MVHR to RAB build standards to achieve a HLP of ≤0.8 W/m2K and CSH Level 4.

For developers aiming at achieving the minimum standard of Level 3, the results may be summarised as follows:

- A gas condensing boiler (91% efficient), opaque u values of 0.15 W/m2K and double glazing, combined with thermal bridges meeting y = 0.08 W/m2K and air permeability of 3 m3/m2@50Pa can only achieve CSH Level 2. Improvements in thermal bridges to meet 0.04 W/m2K will still only achieve CSH Level 2.
- Changing envelope opening u values to quality triple glaze standards will achieve CSH Level 3 without renewables.
- Solar thermal with 4m2 of panel and a 200 litre cylinder will enable CSH Level 3 to be met using quality double glazing.
- MVHR using typical Appendix Q efficiency values only will also achieve Level 3 with double glazing.
- MVHR with triple glazing and air permeability of 1m3/m2@50Pa will still only achieve Level 3.

For developers aiming at achieving a Level 6 HLP of 0.8 W/m2K using a gas condensing boiler, the results may be summarised as follows:

- A gas condensing boiler (91% efficient), opaque u values of 0.15 W/m2K and triple glazing, combined with thermal bridges meeting y = 0.04 W/m2K and air permeability of 1 m3/m2@50Pa. This is the RAB standard.

Discussion

Various assumptions have been made with regard to thermal bridges, air permeability, MVHR efficiency, boiler efficiency and plant maintenance.

Thermal bridge losses are important. The thermal bridge y value is added to the element u values for the effective fabric u value. Where for example wall u values are reduced to 0.15 W/m2K, a y value of 0.08 W/m2K produces an effective u value for that element of 0.23 W/m2K, a 50% increase. There is no demand in ADL1A to meet even Accredited Construction Details. To guarantee a reduction by half may require the introduction of some form of Robust Detail system for thermal bridges. The European low energy standard promoted by the Passive House Institute (PHI) demands what is effectively thermal bridge-free construction with a maximum ψ "psi" value of 0.01 W/mK. The PHI report, Passive House Solutions (PEP, 2006), states that whilst thermal bridge values vary across Europe: "In several countries information and education are needed to overcome limited skills and know-how with respect to thermal bridge-free construction. This could be done in the form of standard details and training material for contractors and inspectors." It notes that the UK shows: "Lack of solutions and guidance." It seems appropriate then to demand that all new build dwellings minimally meet Accredited Construction Details but that lower values of 0.04 W/m2K are both necessary and achievable.

Air Permeability

Achieving low air permeability demands close attention to both envelope design and services penetrations as well as providing adequate ventilation. The Energy Savings Trust report, Achieving air tightness in new dwellings (EST 2007), identifies the main features for achieving low permeability. Based on the recently completed testing, the EST found air permeability to be between 2 and 4.7 m3/m2h@50Pa for 700 new masonry homes, whilst SIP and timber frame low energy demonstration homes achieved 2.89 and 2.52 m3/m2h@50Pa respectively. It would appear that we have some way to go before being able to consistently achieve RAB standards of air permeability at 1 m3/m2h@50Pa.

RAB specify air permeability of only 1 m3/m2h@50Pa with mechanical ventilation with heat recovery (MVHR) for maximum energy efficiency and to ensure sufficient air changes for internal air quality. Tighter construction effectively produces sealed buildings which will need a minimum of 0.3 ac/h and approximately 30 m3/h of fresh air per occupant to comply with Approved Document F (ODPM, 2006). Whilst trickle ventilation and extract fans may maintain internal air quality for air permeability of 3m3/m2h, meeting RAB air permeability rates of 1m3/m2h will demand a step change in building tightness and the installation of whole house mechanical ventilation to ensure the removal of smells and moisture.

MVHR

The installation of MVHR is a step change in building design when compared with trickle ventilation and extract fans. MVHR is a new technology in this country, unfamiliar to most heating and ventilating specifiers. An Austrian study (Greml, 2004) identifies that occupants are generally satisfied with MVHR and that the technology is robust. The Austrian market is mature compared with this country, however, the majority of owner-occupied low energy houses appear to have had client involvement in the design and hence 'ownership' of the system. The nearest equivalent in the report to a mass market scenario appears to be the multi-occupant building where: "occupants did not consciously decide in favour of such a system; furthermore, cost pressure sometimes made contractors install systems that do not work well. In this context, users also complain about inadequate information about function and proper handling of the system."

"Problems frequently addressed by occupants of single-family homes (SFH) and multi-family homes (MFH) include: noise emissions (41 % SFH), dry air (49 % MFH), and limited controllability of the ventilation system (48 % of all users). It is encouraging that users' satisfaction clearly increases with more recent installations."

Noise is a function of duct air velocity and is related to fan power, duct size and type, filter maintenance, etc. Designers will need to consider the size implications of duct distribution using 100 and 150 mm ducts. Ducts in cold spaces need to be insulated, adding to the diameter. Dry air is caused by using air as the heating medium. High air temperature is a function of design heat loss and fan flow rate. Fan size may dictate that high temperatures are necessary to achieve the design space heating requirements at maximum fan flow rate. Other issues identified include: "Airflow in dwellings, i.e. air change in individual rooms is not optimal with some systems. In many cases, adaptation of air volume performance is not adequate. Calculated air volumes are insufficient, especially in areas like bedroom, kitchen, and bathroom. In many cases, the possible impact of ventilation systems on fireplaces has not been taken into account. Integration of the range hood into the ventilation system and ducting exhaust air directly to the outside may cause problems. Sizing of vents is frequently insufficient or these are located in the wrong place or are lacking at all."

"On balance, the study has shown that while the requisite components for high-quality ventilation systems are available, planning concepts for and realization of the installation still have a considerable potential for improvement. Substantial cost savings could be achieved through better coordination of the various contractors involved."

For heating specifiers working on ducted systems, apart from manufacturers' data, there is little design advice available in comparison to the profusion of wet central heating design guides.

We must assume that MVHR manufacturers' operating data apply to real buildings with typical maintenance regimes. SAP default MVHR produces more CO2 than trickle ventilation and extract fans. Only when manufacturers' data for high efficiency units are applied does MVHR produce CO2 savings. However, MVHR efficiency assumes adequate maintenance. If filters are not maintained the air flow will reduce. For the flow rate to remain the same, the fan power must increase (turn up the fan setting). If for any reason filters are removed, perhaps to improve the flow rate, the heat exchanger efficiency will drop due to a build up of dirt between the plates. Many manufacturers show the unit located in the roof space. Maintenance will only be achieved by accessing this space which may have up to 300mm of insulation, removing unit covers, extracting and replacing filters. There is a distinct possibility that mean life cycle efficiencies for a mass build MVHR population will be closer to default than excellent.

Boiler Efficiency

A boiler is selected based on design space heat load and hot water requirements. The space heating load may be calculated from the HLP by multiplying the HLP by the floor area and design temperature difference. The various design options have produced HLPs which range from around 1.13 W/m2K at Level 3, down to 0.76 W/m2K at Level 6. For a heating design temperature difference of 21K typical of southern England, the maximum space heating load is 2.3 kW. For a 25K temperature, difference typical of Central or Northern England, the load is 2.7

kW. Where HLPs are reduced to 0.8 W/m2K these temperature differences provide heat loads of 1.6 and 1.9 kW respectively. This space heating load only occurs during sustained zero and sub-zero outdoor temperatures. For most of the heating season the heating load will be substantially less than this. "The House Builders Federation claim that 47% of projected growth in England between 2001 and 2021 is likely to be in London and the South East, with three quarters of the total in these two regions plus the East and South West (HBF 2003). Hence the highest growth in household numbers is expected in the warmest regions of the country." (Boardman, 2005)[ii]

Most gas boilers are modulate their output to match the load. Gas boiler efficiencies are tested at 100% and 30% of the mean modulating range and the results published as Seasonal Efficiency Domestic Boilers UK (SEDBUK). It is these SEDBUK ratings which are used for SAP ratings. A non-exhaustive internet and Journal search for micro-boilers produced only one boiler where at 1.5 kW load falls within this test range. More typical small boilers operate below the 30% mean for the entire heating season. The Carbon Trust report on field trials of micro combined heat and power units, which also looked at gas boilers, (Carbon Trust, 2007) comments thus:
"A heating device should ideally be sized so that its rated heat output is able to satisfactorily meet end user comfort requirements on the coldest winter days. Anything larger than this is unnecessary and is likely to detract from optimum efficiency. In general, smaller systems will have longer operating times and achieve better overall efficiencies."

Combination boilers enjoy about 70% of the boiler market (DTI, 2005). The author has been unable to identify any "combis" currently available with very low space heating output, the lowest being an output to space heating of 6.7 kW. For a 2 kW load, this is only 16% of the mean.

Personal correspondence with a boiler efficiency testing company indicates that when operating at very low loads, the seasonal efficiency is: "substantially less than the SEDBUK rating." A realistic boiler seasonal efficiency needs to be identified when assessing SAP CO2 emissions.

Combined Service Units

Combining MVHR with an air to air or air heat pump provides heating to the supply air for a warm air heating system. Designed in Continental Europe for the Passive House market, these units are also available with built-in cylinder thus providing a 'Compact Service Unit' (CSU).

The heat pump output is generally around 1.5 kW, the unit relying on electrical resistance heating to support the heat pump when necessary. They are a compact design solution where the heating, ventilation, hot water and control system are provided from a single unit by a single supplier. This has obvious advantages for installation, maintenance and servicing where established manufacturers are concerned. This type of system has been identified for use in both the Barrett 'Green House' and the 'Eco TECH house' at the BRE Innovation Park.

CSUs provide a single unit solution utilising heat pumps to provide both heating and hot water. It is necessary to establish whether the electrical resistance back up is needed in practice (especially at low outside temperatures and for 60^{o}C hot water) so that a realistic emissions comparison with natural gas boiler plant may be made. The thermal response of a dwelling to a hot water cylinder control regime needs to be modelled for hot water usage, building thermal mass, night set-back temperature and occupant comfort. It would then be possible to identify whether hot water demand needs to be added to space heating and therefore whether resistance heater backup is likely.

CSUs with micro gas boilers would be an appropriate alternative to the heat pump were they currently available. There few manufacturers of CSUs and there is a lack of appropriate technical knowledge required to specify, install, commission, service and maintain these units.

Mass house building and maintenance

As of April 2016, all housing is to meet CSH Level 6 which, as we have seen, requires "new technologies" such as heat pumps, MVHR and CSUs along with renewable electricity. There are currently approximately 10 000 dwellings built to Passive House standards in Europe. What is envisaged is an entirely different size of low energy housing market. Where these dwellings are private houses maintenance is the responsibility of the occupier. An analysis of 75 single-family detached Passive Houses, based on Greml[iii] (2004), provides floor areas with a mode of 150 m2. This indicates a wealthy client group with an active interest in procuring low energy housing and the financial means to maintain it. In this country, mass build 3 bedroom houses are about half that size, may be "Affordable Homes" and their heating and ventilation systems are being designed without the input of the buyer. We need to explore occupant expectation and response to technically complex services systems before we can assume operating efficiencies and CO2 savings.

Conclusion

The aim of the paper is to establish whether these new standards of building are achievable in a mass build context, whether Code 3 can be achieved using improvements in the envelope alone and what implications low emission envelopes have on space heating and ventilation systems.

Code Level 3 is the current requirement for publicly financed housing and will be required for all housing by 2010. For Level 3 to be met using the envelope only, condensing gas boilers and current ventilation practice of trickle vents and extract fans, much higher standards of construction will be required than is current practice. These standards will require opaque u values of 0.15 W/m2K, triple glazing of 0.8 W/m2K and an air permeability of 3 m3/m2h at 50 Pa. Double glazing of 0.16 W/m2K may be used but some form of renewables is required to off-set emissions. Solar thermal offers a reliable, tried and tested technology to achieve this.

Meeting zero carbon emissions requirements with a heat loss parameter of 0.8 W/m2K will demand triple glazing, the envelope air permeability to be upgraded to 1 m3/m2h at 50 Pa and the installation of MVHR using Appendix Q best practice units. Whilst this quality of build has been achieved in the niche “eco-homes” market, there is currently no experience of achieving it for the mass build housing market in this country.

MVHR is set to replace trickle ventilation and extract fans as the route to house ventilation. There is little guidance available on MVHR design and little experience in ducted ventilation within the house building industry for the 18 000 plus contractors and developers [registered with the NHBC]. Occupants have no experience of MVHR, will not be consulted on its use and will receive minimal instructions for its operation and maintenance. Longitudinal studies are needed to ascertain whether mass market occupants maintain filters (and thus fan and heat exchanger efficiencies) and if they actually prefer sealed dwellings. MVHR is perfectly suited to continental weather conditions with long periods of sub-zero temperatures. Within a maritime context, it seems appropriate to consider the spatial requirements, design, install and maintenance cost of MVHR and ductwork, its embedded energy and CO2 potential savings. Where MVHR is specified, noise, inadequate air flow, room distribution and control have been identified as the main design problems.

Gas boiler manufacturers need to consider the requirements of low and zero emission housing. Appliances need to remain fully efficient at very low loads in comparison with current house heat losses. Boilers need to be marketed which are capable of modulating from perhaps 1 kW to 2 kW to deal with seasonal space heating loads. Information needs to be made available on boiler efficiency when operating below 30% of the badged rating capacity since for much of the heating season, outputs from current boilers may be as little as 5 to 20%. It would appear that actual efficiencies for currently available boilers will be substantially less than the SEDBUK rating when installed in low emission homes, therefore the CO2 emissions will be higher than those modelled.

Combined Service Units offer a compact solution for low and zero emission housing. CSUs consist of a single unit utilising a heat pump to provide heating, ventilation with heat recovery and hot water with an integrated control system. Currently there are few units available in this country and little or no experience of installation, commissioning, servicing and maintenance. Again it is not difficult to perceive the challenge of occupant education in their operation, control and maintenance.

The construction industry needs to consider investment in training in order to ensure the success of mass build low energy housing and developers must take on the responsibility of educating house buyers with simple yet comprehensive operation and maintenance instructions.

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