DEFINING A FABRIC ENERGY EFFICIENCY STANDARD

FOR ZERO CARBON HOMES

Task Group Recommendations
November 2009

FACILITATING THE MAINSTREAM DELIVERY OF LOW AND ZERO CARBON HOMES

Zero Carbon Hub

Further copies of this report are available as a PDF download from **www.zerocarbonhub.org**

London Office
62-68 Rosebery Avenue
London EC1R 4RR

Milton Keynes Office
NHBC House, Davy Avenue
Milton Keynes MK5 8FP

T 0845 888 7620
F 0871 813 0569
info@zerocarbonhub.org
www.zerocarbonhub.org

Acknowledgements

The Zero Carbon Hub is very grateful to the following organisations for their involvement and contributions in developing these recommendations.

Association for Environment Conscious Building (AECB)
Aecom
Anser Project Managers
Barratt Developments PLC
British Electrotechnical and Allied Manufacturers' Association (BEAMA)
Building Research Establishment (BRE)
Building Regulations Advisory Committee (BRAC)
Construction Products Association (CPA)
Countryside Properties PLC
Crest Nicholson PLC
Davis Langdon
Energy Saving Trust (EST)
Fairview New Homes Ltd.
Federation of Environmental Trade Associations (FETA)
Federation of Master Builders (FMB)
Fulcrum Consulting
Good Homes Alliance (GHA)
Heating and Hotwater Industry Council (HHIC)
Heatrae Sadia
Home Builders Federation (HBF)
Homes and Communities Agency (HCA)
Hot Water Association (HWA)
House Builders Association (HBA)
Ian Andrews Associates
Inbuilt
Leeds Metropolitan University
Lighting Industry Federation (LIF)
London Borough of Barnet (Building Control)
Haringey Council (Planning)
National House-Building Council (NHBC)
Richard Partington Architects
Robust Details Limited (RDL)
Royal Institute of British Architects (RIBA)
Space Air
University College London (UCL)
Vent Axia
WWF

Observers

Department for Communities and Local Government
Department of Energy and Climate Change
Scottish Government
Welsh Assembly

Contents

List of figures

Executive summary

The context

In December 2008 Government consulted on the definition of zero carbon homes[b] to provide industry with a clearer concept of what this would mean from 2016 onwards. The definition is based around a hierarchical approach to achieving 'zero carbon' (Figure i):

1. Ensuring an energy efficient approach to building design
2. Reducing CO_2 emissions on-site via low and zero carbon technologies and connected heat networks
3. Mitigating the remaining carbon emissions with a selection of Allowable Solutions

In order to provide further clarity and confidence for industry, the Housing Minister announced in July 2009 that the Carbon Compliance level would be set at a 70% reduction in regulated CO_2 emissions[c]. In addition, a specialist Task Group was set up to advise on the definition of 'minimum energy efficiency for zero carbon dwellings' so that an announcement on the standard could be made before the end of 2009.

Embedding a high level of energy efficiency within the 2016 zero carbon homes policy is an important step. Minimising energy demand will ensure that dwellings utilise Low and Zero Carbon (LZC) energy sources in the most efficient way. This supports the Government's parallel agendas of carbon reduction, long term energy security and reducing fuel poverty.

Focusing efforts on the comparatively long-lived building fabric helps to 'future proof' the homes. Increased fabric energy efficiency means homes will be less likely to require difficult and expensive refurbishment upgrades at a later date.

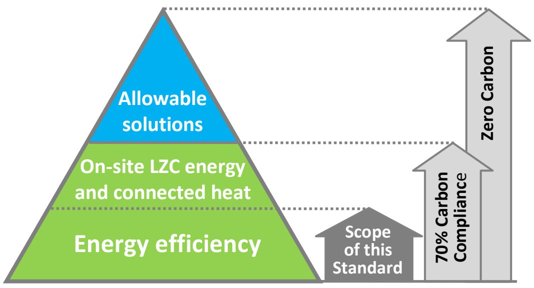


Figure i: Zero carbon hierarchy

The Task Group was asked to:

'Examine the energy efficiency metrics and standards which will realise our ambition of the highest practical energy efficiency level realisable in all dwelling types' [a]

[a] Ministerial Statement by the Rt Hon John Healey MP, EcoTowns and zero carbon homes, 16th July 2009

[b] CLG, Definition of Zero Carbon Homes and Non-domestic Buildings: Consultation, 17th December 2008. The consultation document applied to England and Wales only.

[c] According to the assumptions contained within the Zero Carbon consultation document.

The Task Group's recommendations

The Task Group's investigations and discussions provided answers to four key questions:

- **What is the metric?**

  The preferred metric is **kWh/m²/yr** covering space heating and space cooling energy demand (modelled utilising a notional dwelling assuming natural ventilation and excluding any internal gains from the domestic hot water system)

- **Should all dwelling types be treated the same?**

  The Task Group felt that as far as possible all dwelling types should be able to be built to a similar construction specification. As a consequence there are **two levels:** blocks of flats and mid terrace houses have one level; semi detached, end of terrace and detached houses have another level

- **What are the recommended levels?**

  Apartment blocks and **mid terrace houses** have a maximum energy demand of **39 kWh/m²/yr**[d]

  Semi detached, end of terrace and **detached houses** have a maximum energy demand of **46 kWh/m²/yr**[e]

  What this means in terms of build specification is illustrated in Figure ii.

- **When will it be implemented?**

  The Task Group is recommending full implementation in 2016, with an interim step in 2013

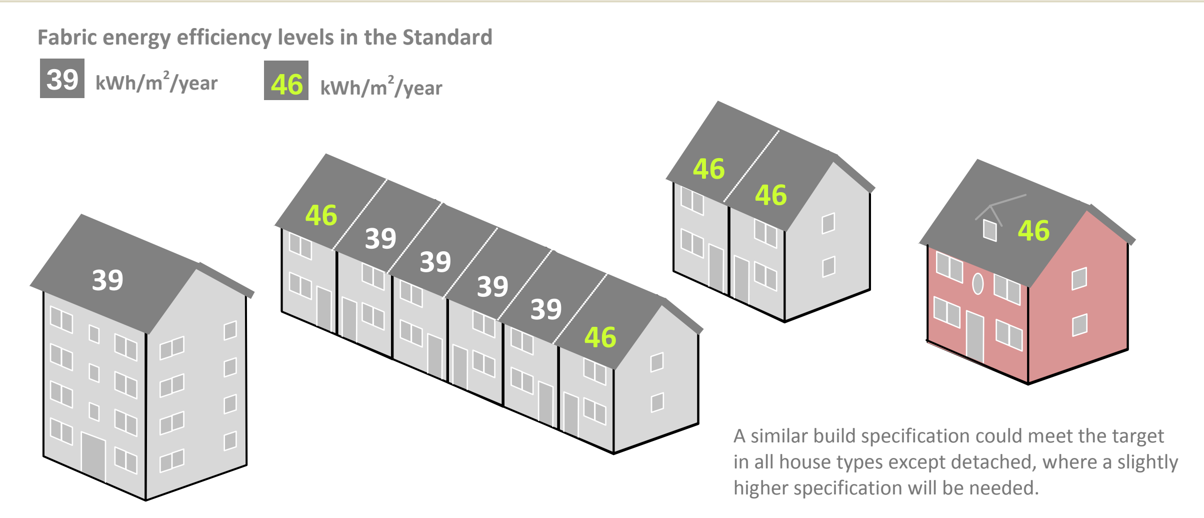


Figure ii: Target energy demand levels for the main dwelling types

The UK is leading internationally by having both a minimum fabric energy efficiency and carbon reduction policy approach with implementation in 2016. By recommending a challenging level for the Fabric Energy Efficiency Standard using a performance-based metric, the Task Group aims to: allow for flexibility in design; encourage innovations in both products and processes; and enable the delivery of a consistently high level of dwelling performance.

[d] Based on cSAP modelling. This may require re-basing when the final version of SAP2009 is available.

[e] As above

Further details of recommendations

The scope of 'energy efficiency'

The Task Group wanted to be sure that the scope of 'energy efficiency' was complementary to that of Carbon Compliance and Allowable Solutions, and the reach of other legislative drivers.

A number of options were considered:-

- Dwelling level energy demand only
- Dwelling level energy demand plus building services appliance efficiency
- Dwelling level energy demand, building services appliance efficiency plus energy conversion and distribution efficiencies

The Task Group concluded that the minimum energy efficiency standard should focus on limiting the energy demands of heating and cooling the dwelling and cover passive measures only. The aspects that are included and how this approach complements other parts of the zero carbon hierarchy is illustrated in Figure iii below.

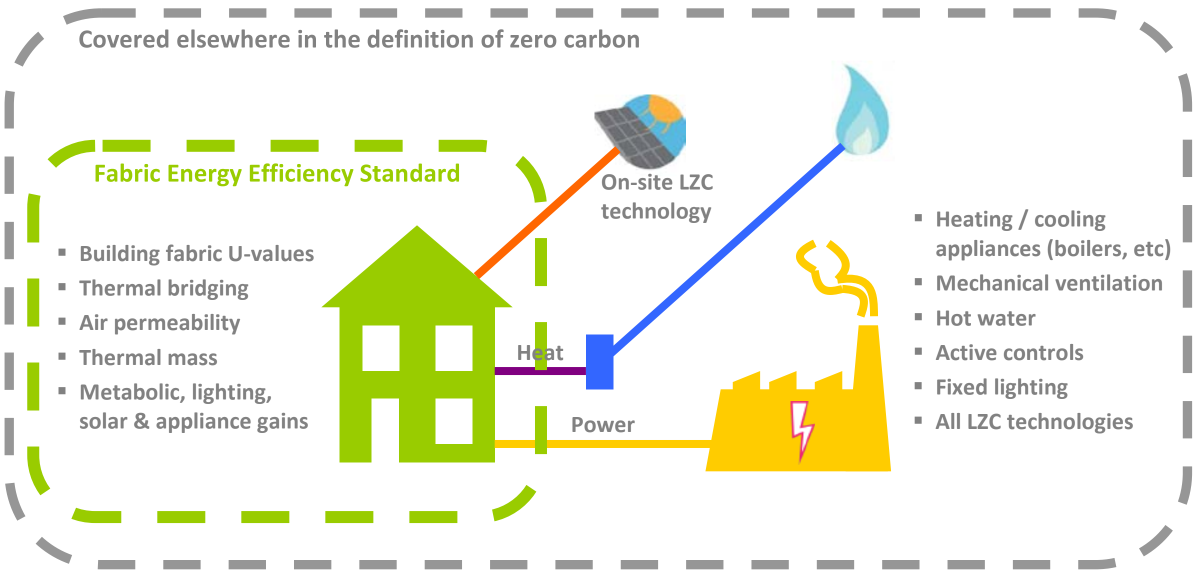


Figure iii: Task Group definition of the scope of the Fabric Energy Efficiency Standard

Metric

The Task Group's recommendation is to use a performance metric of $kWh/m^2/yr$. This is supported by consultation responses as shown in Figure iv.

Although complementary to the overall zero carbon metric of $kg/CO_2/yr$ the metric of $kWh/m^2/yr$ was deemed to be more appropriate for energy demand and is independent of fuel type.

This approach has the additional benefits of:-

- Allowing design flexibility
- Taking into account building form
- Promoting innovation
- Delivering a specific level of dwelling performance
- Being a known 'currency' for energy efficiency internationally

To support industry, design guidance would be created to provide examples of a range of dwellings with a broad combination of solutions that meet the standard.

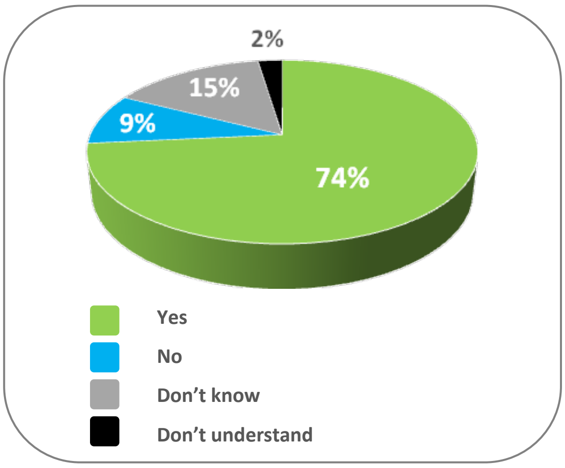


Figure iv: Metric - should this be $kWh/m^2/yr$? Views from the industry consultation events

Levels

How many levels?

Two performance levels are recommended by the Task Group: one for apartment blocks and mid terrace houses; one for end terrace, semi-detached and detached houses.

By recommending two levels related to dwelling type, the Task Group aimed to set the minimum Fabric Energy Efficiency Standard in a manner that was equally challenging for most construction types.

This is because certain dwelling types, such as mid floor apartments, which have less exposed fabric relative to the floor area, are able to achieve a particular $kWh/m^2/yr$ space heating and cooling demand with a less challenging construction specification than other dwelling types. A detached house, for example, has a much higher exposed fabric:floor area ratio so is inherently less energy efficient.

Setting a single level across all dwellings types would result in either detached homes being required to achieve extreme specifications or for little additional effort above current specifications being required by apartments.

On balance the Task Group concluded that it was appropriate to require a realistic but somewhat more challenging construction specification for detached homes. They also wanted to ensure that the construction specifications for mid terraces and end of terraces would be similar.

What are the levels?

The Task Group recommended that the minimum Fabric Energy Efficiency Standard should be set at:

- **39 kWh/m²/yr** for apartment blocks and mid terrace houses
- **46 kWh/m²/yr** for semi detached, end of terrace and detached houses

This sets a challenging but realistic increase in dwelling performance.

Government was considering challenging standards such as PassivHaus and Energy Saving Trust Advanced Practice Energy Efficiency Standard in its December 2008 Zero Carbon consultation. On balance and taking into account a range of important decision criteria the Task Group decided that the above levels would be more appropriate.

Figure v illustrates the two levels and how they relate to current practice and other specifications considered including PassivHaus when modelled in cSAP.

The introduction of a minimum Fabric Energy Efficiency Standard will encourage innovation and development within the UK supply chain. The overall Carbon Compliance requirement will lead to house builders exceeding the minimum performance where it makes sense to do so.

Figure vi shows consultation responses to the level of ambition of the proposed standard and demonstrates broad support.

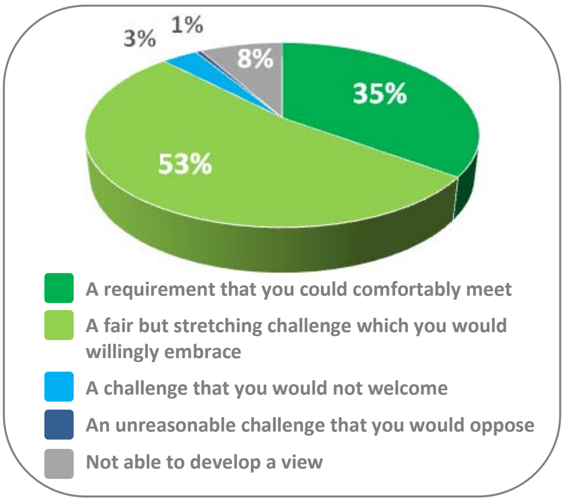


Figure vi: What is your view about the suggested energy efficiency target set by the Task Group? Views from the industry consultation events

Those involved in the consultation process will recognise that the energy demand levels adopted have increased. This does not represent a change in ambition but is due to the removal of hot water gains from the calculation (and therefore the minimum level) due to potentially unintended consequences associated with hot water system choice. Further details can be found in the main report.

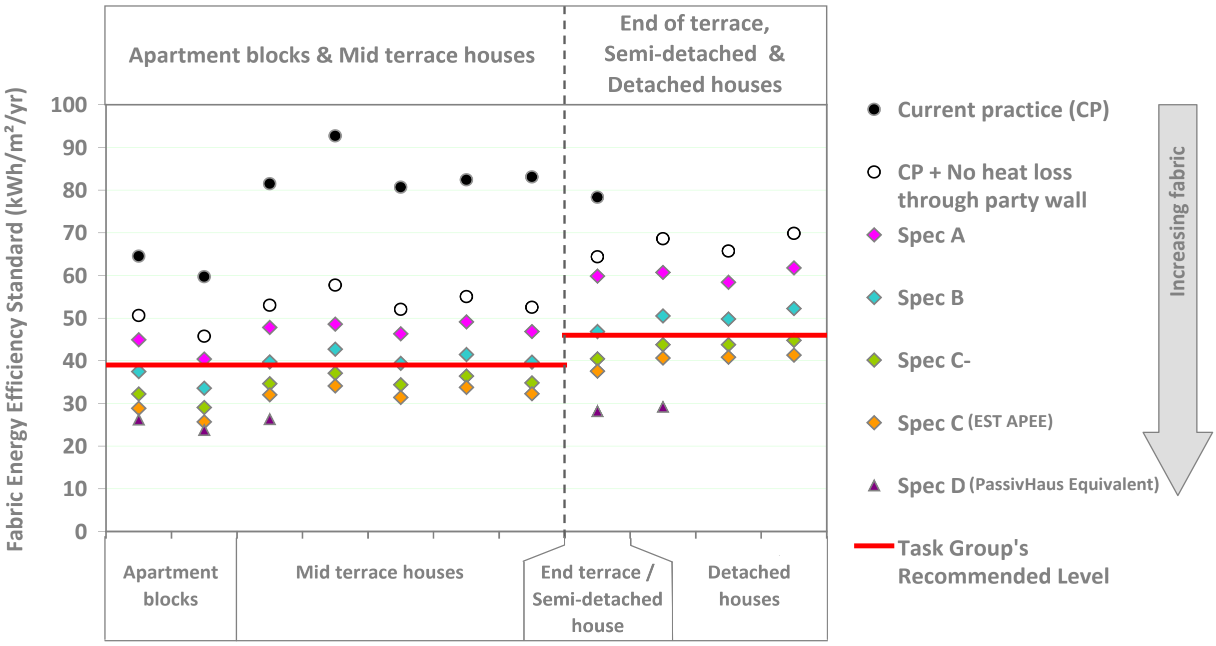


Figure v: Recommended level of the Standard shown with the range of specifications modelled

What this means in practice

Buildability

The Task Group concluded that the construction specifications required to achieve the minimum Fabric Energy Efficiency Standard are achievable with a sufficiently wide selection of products and techniques.

Figure vii illustrates the type of fabric specifications required to achieve the Fabric Energy Efficiency Standard. However, as it is a performance standard, there is flexibility in the individual element specifications used to comply.

	Dwelling type			
	4-storey apt. block	Mid terrace	End terrace / Semi	Detached
Target Fabric Energy Efficiency Standard (kWh/m²/yr)[f]	39	39	46	46
Wall U-value (W/m²K)	0.18	0.18	0.18	0.18
Floor U-value (W/m²K)	0.18	0.18	0.18	0.14
Roof U-value (W/m²K)	0.13	0.13	0.13	0.11
Window U-value (W/m²K)	1.4	1.4	1.4	1.3
Air permeability (m³/m²/hr @ 50Pa)	3	3	3	3
Thermal bridging y-value (W/m²K)	0.05	0.05	0.05	0.04

Figure vii: Examples of construction specifications that meet the Fabric Energy Efficiency Standard

Design Performance

The Task Group discussed the question of 'design' versus 'actual' performance as it was recognised that there is currently a gap between the two. It was concluded that only a design standard could be set at this time but further work was urgently required to understand and narrow this gap.

Health and wellbeing

The Task Group considered householder health and wellbeing within energy efficient dwellings to be of utmost importance.

In particular it was concluded that there is currently insufficient research available to fully understand the relationship between indoor air quality and associated ventilation strategies in homes with low air permeability. The level selected allows for various air permeability and ventilation combinations and the Task Group strongly recommends further research in this area.

[f] Based on cSAP modelling. This may require re-basing when the final version of SAP2009 is available.

Cost

Financial analysis has understandably been an important factor in the decision making process. The following charts illustrate both the capital costs and whole life costs[g] relating to the range of construction specifications that were defined by the Task Group to explore both technical and financial issues.

The two charts below (Fig viii and Fig ix) illustrate 70% carbon compliance using Solar Hot Water (SHW) & Photovoltaic (PV) panels in combination with various fabric improvements. Only Spec C and above would be more costly than current practice.

The Task Group's work indicates a 3-9% increase in capital cost to the build fabric across dwelling types modelled. However, this is incorporated within the cost of achieving overall Carbon Compliance as shown in Figure viii.

Fig ix shows the upfront capital costs, together with the replacement costs and operational savings over 60 years[h].

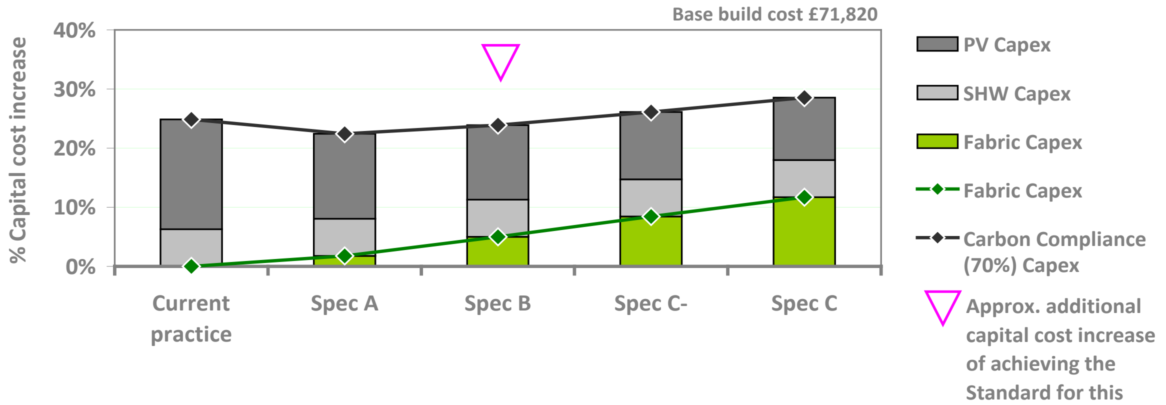


Figure viii: Semi-detached house: % capital cost uplift to achieve 70% Carbon Compliance

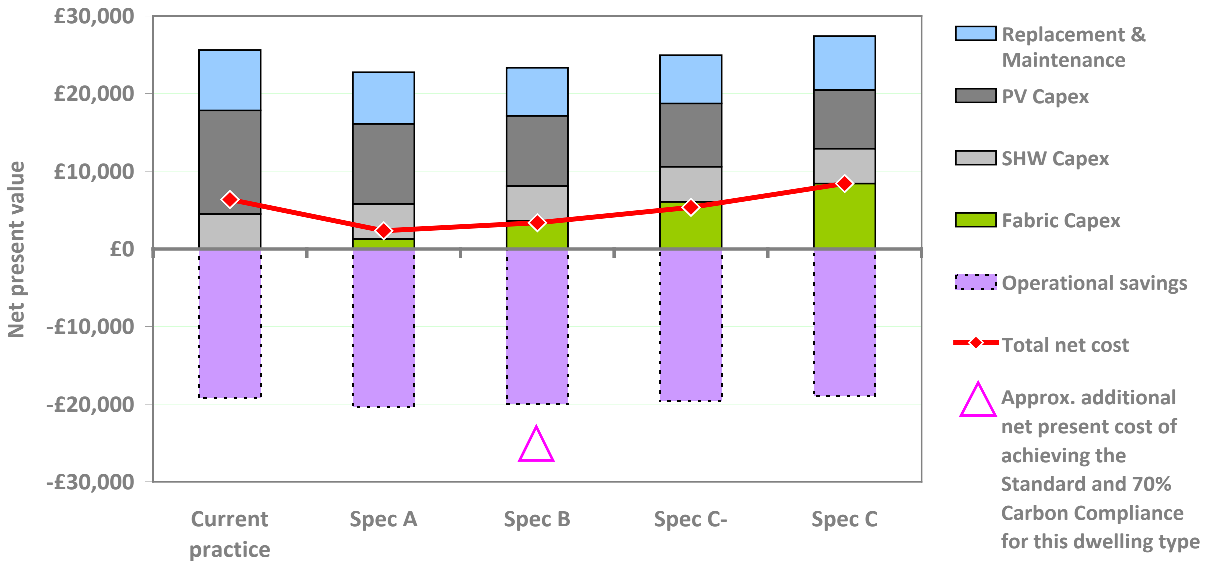


Figure ix: Semi-detached house: Whole life costings over 60 year period

---

[g] These costs are for second quarter 2009 and do not include any adjustment for learning curves, inflation or economies of scale in 2016.

[h] Net present extra over costs. Energy inflation = Retail Price Index (RPI) + 2.5%, 5% discount rate

Implementation

Early announcement of the final details of the Standard is required to enable industry to fully engage with the proposals, develop appropriate solutions, and commit to delivering energy efficient fabric on a mass scale. The proposed timescales are:

- Full implementation in 2016
- Interim step in 2013
- Formally consulted on within the forthcoming Code for Sustainable Homes consultation
- A very strong policy commitment announced at the earliest possible opportunity

The recommended timescales are confirmed by consultation responses as shown in Figures x and xi.

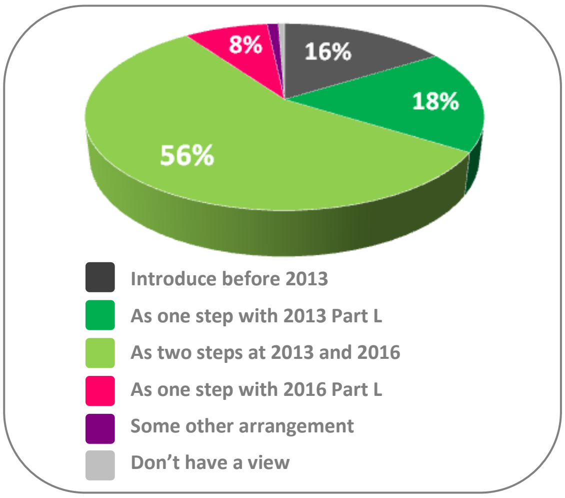


Figure x: When to introduce the Standard? Views from the industry consultation events

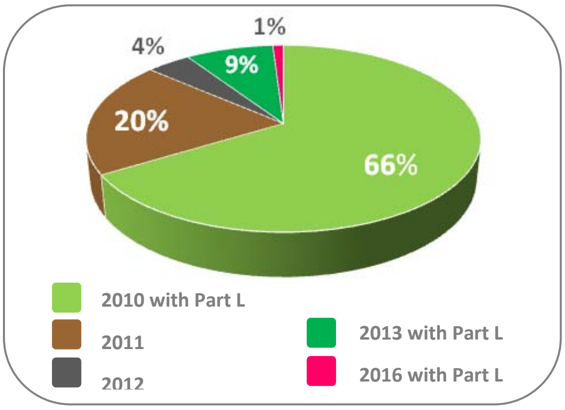


Figure xi: How soon should the final decision on the Standard be announced? Views from the industry consultation events

Contribution to emission reduction

Relationship: Past

Figure xii shows the energy demand of homes built to different building standards[i] and how these relate to the recommended Fabric Energy Efficiency Standard. This shows the significant reduction in space heating demand and the increasing relative importance of unregulated electricity and hot water demand.

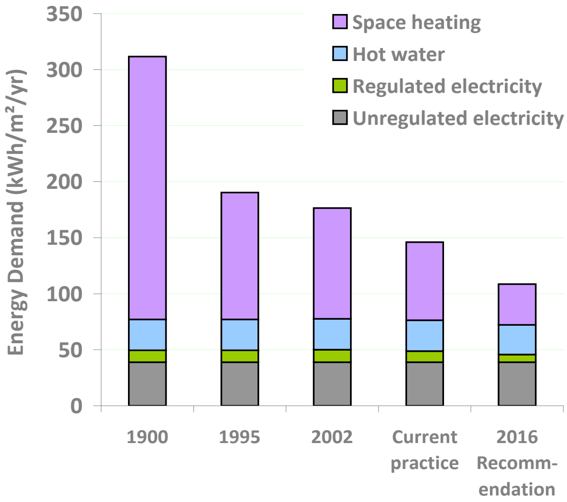


Figure xii: Energy demand of a semi-detached home built to different building standards, assuming a contemporary occupant

Relationship: Present

The proposed Fabric Energy Efficiency Standard equates to around a 20-25% reduction in carbon dioxide emissions[j] compared to current Part L 2006 compliance, assuming gas fuelled heating.

Relationship: Future

How the Fabric Energy Efficiency Standard relates to achievement of the minimum 70% Carbon Compliance standard is important. The choice of fuel and dwelling type play a significant role in overall carbon performance. However, assuming a gas fuelled heating system, the minimum Fabric Energy Efficiency Standard would produce around a 25-30% reduction in regulated emissions[k].

---

[i] As modelled in cSAP 2009

[j] As modelled in SAP 2005 and according to Building Regulations Part L 2006 methodology

[k] According to the assumptions contained within the Zero Carbon consultation document

The process followed by the Task Group

Intense work was conducted by the Task Group over a three month period in order to provide recommendations in advance of the forthcoming Code for Sustainable Homes consultation and to enable further details of the Zero Carbon Homes policy to be announced before year end.

A series of Work Groups[i] were established to provide the Task Group members with detailed information and assessments relevant to their deliberations. The approach followed the basic structure outlined below:

- Initial data and information gathering
- Extensive energy and financial modelling, architectural and buildability analysis and assessment of the wider policy implications / benefits
- A review of the findings followed by a series of consultation events and an online survey

The combined consultation approach allowed around 400 industry stakeholders (over 180 attended the events and over 200 responded online) to feedback their opinions to the Task Group prior to the final decision workshops which took place in early November 2009.

Task Group Considerations

In order to ensure that the wider policy objectives and implications of setting the minimum level for the Fabric Energy Efficiency Standard were addressed, an assessment matrix was developed. This included nine areas for consideration:

- Building practices
- Future proofed construction
- Buildability at mainstream delivery scale
- Health and well being
- Desirable homes
- Upfront build costs
- Long term maintenance and energy costs
- Energy security
- Broader environmental concerns

This matrix provided a structure for the Task Group's initial review of the data generated by the Work Groups. Key areas of interest included:

- **Technical implications**

  A range of construction specifications were modelled in the latest consultation version of SAP 2009 (cSAP).

  This, in conjunction with architectural, structural and buildability reviews, allowed the Task Group to understand the practical implications of delivering the various levels of performance at a mainstream delivery scale from 2016 onwards.

- **Financial implications**

  Each of the construction specifications were modelled to understand the capital cost of the energy efficiency measures, how this might fit within a wider approach to achieve 70% minimum Carbon Compliance, and also whole life costings.

- **Wider policy implications**

  Broader policy implications were also considered, such as: supply chain development, skills and training requirements, consumer acceptance, fuel resource efficiency and health and wellbeing for the eventual occupants of these homes.

---

[i] The three Work Groups were: Form & Fabric, Services and Lighting. Membership lists and the detailed information developed by these groups can be found in the Appendices

Supplementary work required

Defining the Energy Efficiency Standard is a critical step in engaging industry in the widest sense and setting the trajectory for delivery. To support this process a range of supplementary actions are also required; again working with established industry groups.

The table below summarises these actions and broadly identifies: Government responsibilities, areas where considerable additional research is required and tasks where the Zero Carbon Hub may provide a coordinating role. Many of the new activities will need to be scoped and budgets / funding sources agreed.

	Zero Carbon Hub	Government	Research
Integration into Code for Sustainable Homes consultation		CfSH	
Health / Air permeability / Ventilation	Task Group*	Part F	Required*
Overheating	Task Group*	Part L	Required*
SAP 2009 modelling tool development / rebasing	Task Group*	SAP / Part L	
Additional dwelling modelling		Required*	
Design Guidance	Task Group* / industry		
Daylight requirements		Required*	
Land take costs	Task group*		
Certification, Verification & Audit	Task Group*	Part L	Required*
Actual dwelling performance	Facilitation*	TSB / other	Required*

* New or substantially increased activities

Figure xiii: Overview of supplementary work required

Introduction

When the Code for Sustainable Homes was first announced in 2006, it contained the first definition of ‘zero carbon’ homes, asking for all CO_2 emissions from use of the home to be mitigated on-site or by directly connected infrastructure.

In July 2007 the Government made a policy commitment to require all new build dwellings to achieve zero carbon from 2016 onwards. Following this a great deal of collective industry thought was put into understanding the implications of that announcement, and in 2008 the UK-Green Building Council set up a task group to consolidate this effort. The main finding of the group was that requiring all CO_2 emissions to be mitigated on-site would be physically unachievable by the vast majority of new developments and proposed an alternative definition structure[13].

During late 2008, Government consulted on the definition of zero carbon homes[14] to provide industry with a clearer concept of what this would be for 2016. The definition is based around a hierarchical approach to achieving ‘zero carbon’ (Figure 1):

1. Ensuring an energy efficient approach to building design
2. Reducing CO_2 emissions on-site via low and zero carbon technologies and connected heat networks
3. Mitigating the remaining carbon emissions with a selection of Allowable Solutions

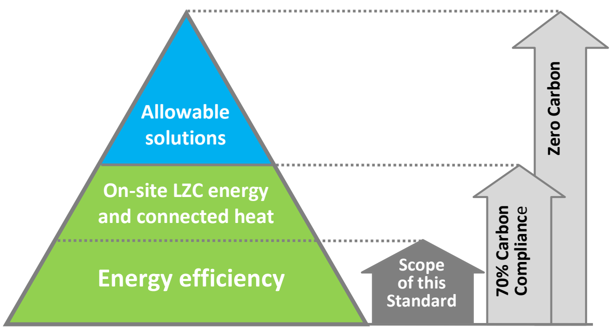


Figure 1: Zero carbon policy relationships

---

[13] www.ukgbc.org

[14] CLG, Definition of Zero Carbon Homes and Non-Domestic Buildings: Consultation, (December 2008)

In order to provide further clarity and confidence for industry, the Housing Minister announced in July 2009 that the Carbon Compliance level would be set at a 70% reduction in regulated CO_2 emissions[15]. In addition, a specialist Task Group was set up to advise on the definition of 'minimum energy efficiency for zero carbon dwellings' so that an announcement on the standard could be made before the end of 2009.

The Zero Carbon Hub was requested by the Department of Communities and Local Government (CLG) to convene a specialist industry task group as proposed by the Housing Minister. A diverse selection of industry stakeholders were gathered, ranging from large scale housing developers and product manufacturers to smaller niche house builders and national sustainability groups. The aim of the Task Group was to fully investigate the spectrum of issues surrounding the proposed definition of a national Energy Efficiency Standard for zero carbon homes and provide recommendations to the Minister.

Embedding a high level of energy efficiency within the 2016 zero carbon homes policy is an important step. Minimising energy demand will ensure that dwellings utilise Low and Zero Carbon (LZC) energy sources in the most efficient way. This supports the Government's parallel agendas of carbon reduction, long term energy security and reducing fuel poverty.

Focusing efforts on the comparatively long-lived building fabric helps to 'future proof' the homes. Increased fabric energy efficiency means homes will be less likely to require difficult and expensive refurbishment upgrades at a later date.

The Housing Minister's challenge was posed in the following way:

'To examine the energy efficiency metrics and standards which will realise our ambition of the highest practical energy efficiency level realisable in all dwelling types'

[15] According to the assumptions contained within the Zero Carbon consultation document.

The Task Group has therefore focused on the three key areas highlighted by this question:

- An appropriate metric with which to describe such a standard
- Set at an appropriately ambitious level
- Achievable in all dwelling types at mainstream delivery scales

The following sections of this report first describe the process that the Task Group undertook to ensure robust and balanced conclusions and proposals were drawn. Greater detail is then provided regarding the technical and financial modelling that was undertaken to understand the implications of different energy efficiency standards. Discussion then turns to the selection of a preferred metric for this standard and how different approaches can influence the wider implications for industry.

Finally the Task Group's preferred Fabric Energy Efficiency Standard for zero carbon homes is proposed in conjunction with a series of recommendations including the date of introduction and identifying areas that needing further research.

A variety of consultation activities were undertaken to gather feedback from wider industry stakeholders on the Task Group's work[16]. Key findings of this work have been included within highlighted boxes to aid the reader's understanding of the issues being discussed.

[16] These included three events with live voting, opinion boards, comment cards and an online survey. Further details can be found in Appendix F

Task Group process

As a result of the request from CLG, the Zero Carbon Hub began work by bringing together a core Task Group consisting of representatives from a wide selection of industry stakeholders. Initial discussions helped to clarify a process that would facilitate investigations, consultation and analysis of the necessary issues.

An overview of the process is illustrated left (Figure 2).

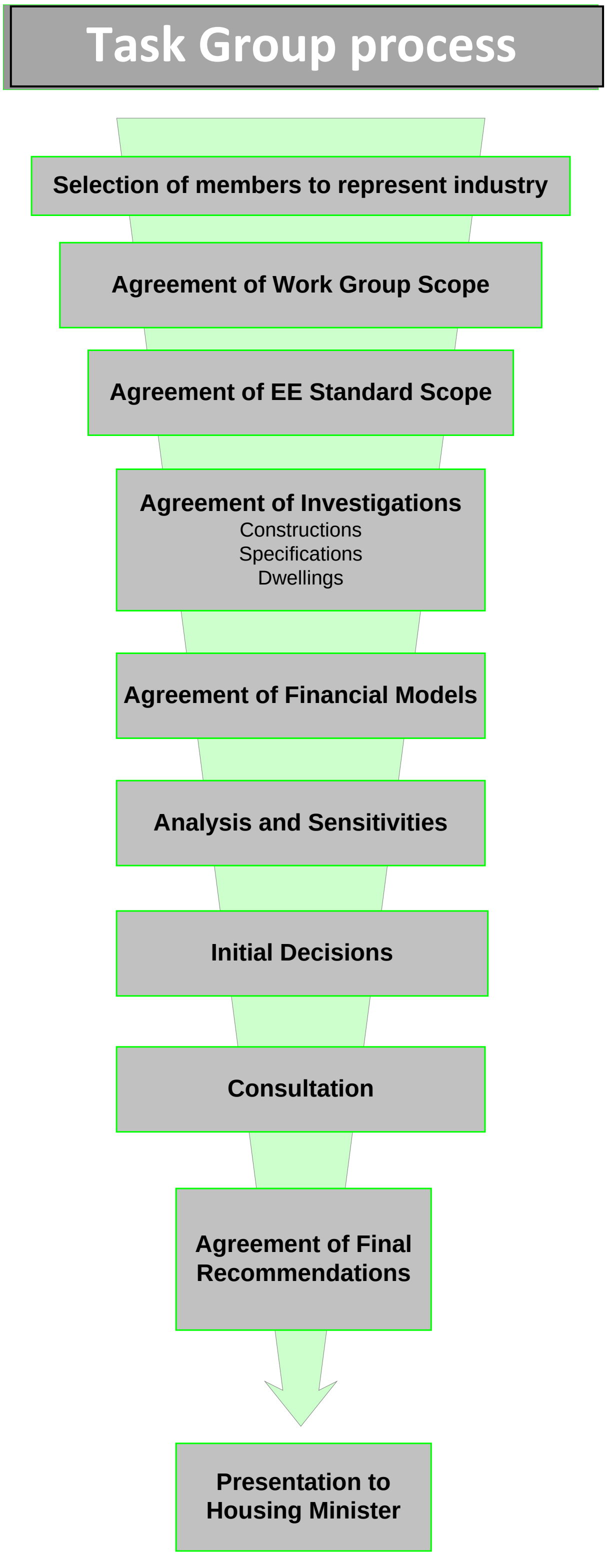


Figure 2: Task Group process

Creation of the Work Groups

A series of Work Groups[17] were established to provide the Task Group members with detailed information and assessments relevant to their deliberations. Each of the Groups convened separate meetings to discuss key issues, with the Technical Manager of each Work Group reporting back at Task Group meetings.

The groups established were:-

Work Group 1 – Form and Fabric

- Containing housing developers, builders, construction product manufacturers, architects, energy consultants and academic researchers
- Considering materials, construction skills, build quality, supply chain management, aesthetic impacts, built form and site layout in the context of 2016
- Delivering build specifications for energy and financial modelling

Work Group 2 – Services

- Containing heating, hot water and ventilation manufacturers plus energy consultants and academic researchers
- Considering space heating, water heating and storage and ventilation systems currently available and how they might change within the context of a 2016 zero

[17] The detailed information developed by these groups and their members can be found in the Appendices

carbon home, plus installation skills and commissioning quality

- o Delivering clarity on policy drivers and Energy Using Products Directive (EuP) Lots plus a 'forward look' paper

Work Group 3 – Lighting

- o Containing housing developers, lighting designers and energy consultants
- o Considering product innovation by 2016, the link between daylight factors and artificial lighting plus related European policies driving energy efficiency
- o Delivered recommendations for daylight factors and future lighting technologies paper

The outputs from these groups helped the main Task Group understand the wider implications of increasing the energy efficiency standard across technical, delivery and financial areas, and also aided definition of the scope of the Standard. Figure 3 illustrates the relationship between the various groups and key members responsible for the work produced

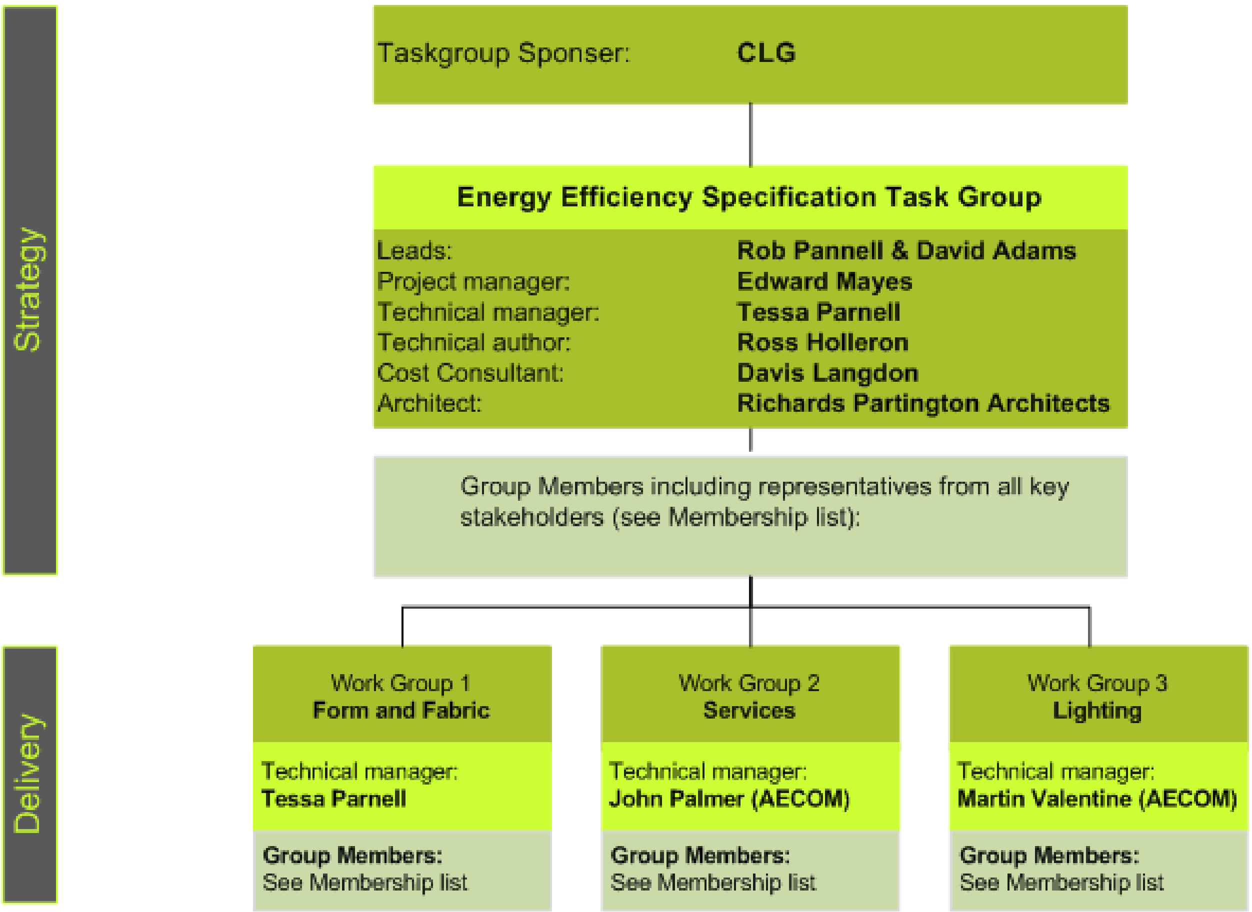


Figure 3 Task Group structure

Policy level considerations

In order to encourage a balanced and structured analysis the Task Group developed an assessment matrix. The aim being to ensure the group took into account all aspects pertinent to setting a minimum energy efficiency standard and were fully aware of the wider implications such a policy decision might create and, wherever possible, highlight increased risks of unintended consequences.

The diagram below (Figure 4) illustrates the nine criteria considered and shows the matrix prior to its usage to assess the four initial construction specifications that were developed by Work Group 1 – Form and Fabric. These are detailed further in the following Technical section of this report.

Increasing level of ambition

	Spec ?	Spec ?	Spec ?	Spec ?
Building practices				
Future proofed construction				
Buildability at mass scale				
Complexity of ensuring house-holder health and wellbeing				
Desirable homes for householders on a mass scale				
Upfront build cost				
Longer term maintenance and householder energy costs				
Energy security				
Broader environmental concerns				

Low Medium High concern of negative consequences

Figure 4: Task Group assessment matrix

The Task Group's assessment criteria aimed to consider a range of broad questions whilst reviewing the technical construction specifications and financial analysis such as:-

- **Building practices** – Is the construction specification technically achievable? Will it have the necessary structural abilities? Are the materials required to achieve the standard likely to be available at competitive prices in 2016 at appropriate volume? Will the standard unduly impact on house builders methods of construction and processes? Will the construction workforce require extensive retraining and skills development?

- **Future proofed** – Will the construction specification reduce the need for future performance upgrades? Is there a greater risk of summertime overheating? Will the design restrict future occupants from modifying the layout of the home?

- **Building at mass scale** – Does the specification require overly complicated construction processes? What are the implications for site management and build process? Will the supply chain be able to deliver circa 200,000 units p.a. to this standard?

- **Health and wellbeing** – What ventilation regimes will be required to meet the designed permeability necessary for good indoor air quality? Does designing to low air permeabilities unreasonably limit the range of solutions available for builders? Does the specification create any specific ventilation problems for single aspect dwellings?

- **Desirable** – Will the specification require fundamentally different dwelling designs than are currently being built? Will these homes be desirable to mainstream house buyers?

- **Upfront costs** – Is the investment in energy efficiency measures cost effective in achieving the policy aims? How does the specification affect the overall cost to achieve the minimum 70% Carbon Compliance across the dwelling types modelled?

- **Maintenance and energy costs** – How would the specification affect the LZC technologies likely to be installed to achieve Carbon Compliance level? How will energy efficiency measures affect future maintenance costs for the occupier? What are the component 'end of life' replacement cost implications?

- **Energy security** – What are the wider national infrastructure and energy demand implications of the specifications? Do some specifications provide enhanced individual energy security / protection from fuel poverty?

- **Broader environmental** – Will the embodied energy, and carbon, of the construction materials required increase significantly? Does the specification require the use of materials that have significant negative environmental impacts?

Please note that these questions were not specific to any particular industry sector and are purely shown to illustrate the broad extent of the Task Groups deliberations

Further details of how this was used to guide the Task Group's proposal is provided in the 'Task Group wider analysis' section of this report

Technical considerations

To define a minimum energy efficiency standard clearly requires a significant degree of technical analysis. The Task Group considered it important to base their conclusions upon the specialist knowledge of the Work Groups and the recommendations their investigations generated.

A guiding strategy was developed by the Task Group for the three Working Groups to follow. A schematic diagram (Figure 5) was developed to help the Work Groups understand strategically how their knowledge and research would contribute to the overall task.

The Work Groups explored a variety of issues surrounding the setting of a minimum Energy Efficiency Standard. The scope of the CLG remit allowed them to investigate not only the technical and financial issues, but also the metric or ‘language’ in which this would be communicated.

For example, some members within the groups may have favoured a range of elemental backstops, whereas others may have preferred a headline figure in terms of kWh. This variety of options meant the groups had to consider the context within which their specific expertise, products and systems might influence the standard.

.

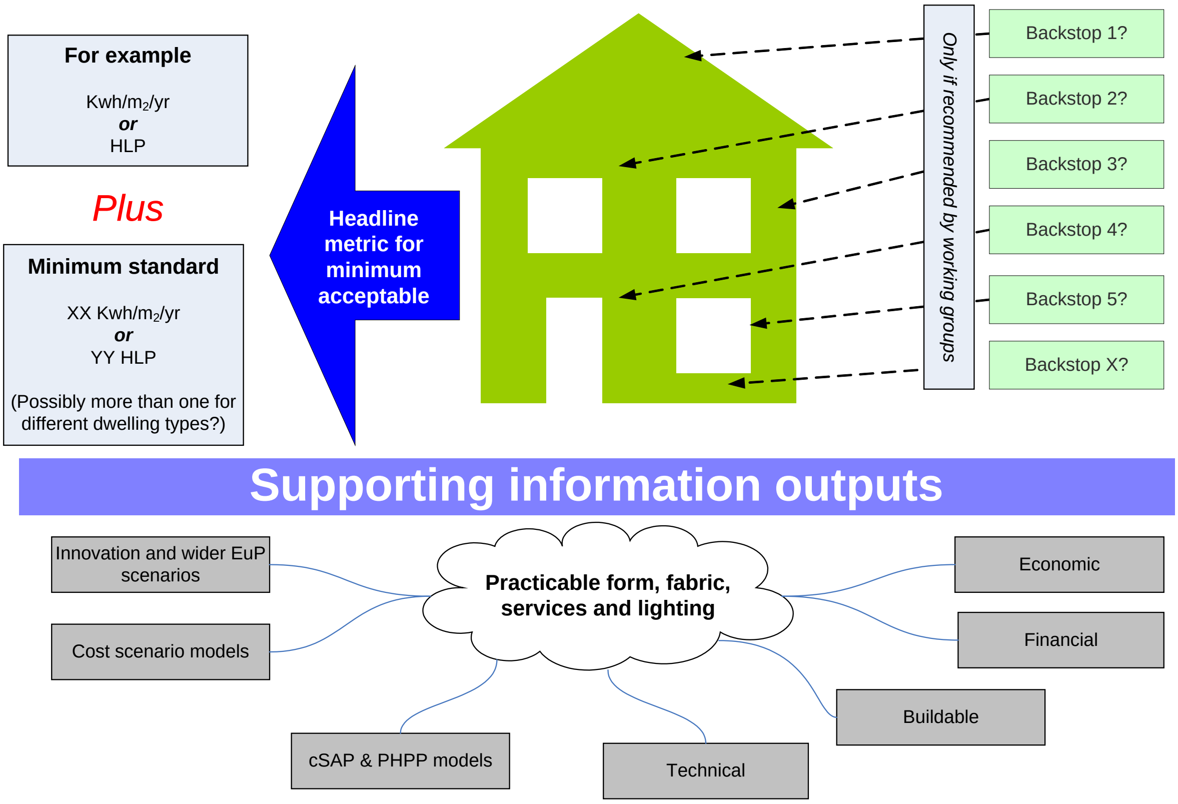


Figure 5: Task Group scope of activity

Defining the scope of energy efficiency

At the start of its work, the Task Group set out to define the scope of the standard. The group wanted to be sure that the scope made sense in terms of the relationship with Carbon Compliance and Allowable Solutions, and the reach of other legislative drivers.

The Task Group first decided that the Energy Efficiency Standard should be a 'design' standard, not an 'as-built' standard. This decision was made on the basis that there is not currently enough data on which to set an as-built standard, and suitable test methods have not yet been developed. Furthermore this aspect of the policy is being considered by another Zero Carbon Hub Task Group[18] as well as being considered through regulatory compliance and verification groups.

The Task Group considered there were three general scopes available for consideration as illustrated in the diagrams which follow.

Scope 1 (Figure 6) includes everything within the dwelling itself that can reduce energy demand such as the fabric performance, air permeability, thermal bridging plus the benefits of solar gain and internal gains[19].

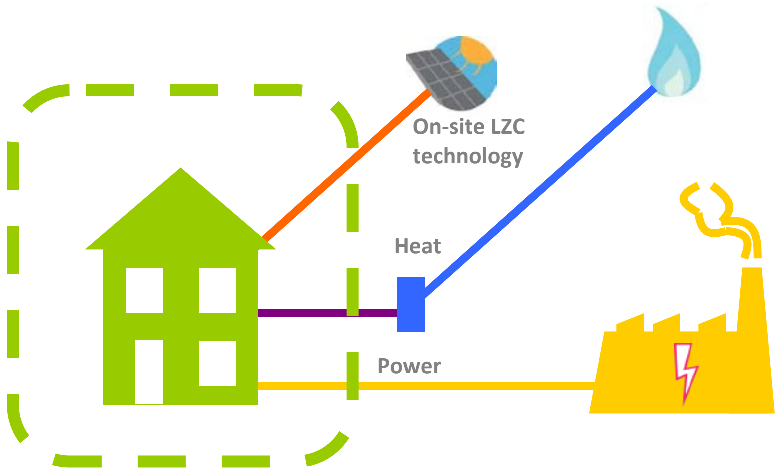
It does not include the efficiency of building service appliances such as heat pumps or boilers, ventilation fans, lighting, solar thermal panels or photovoltaics. Also it does not include the conversion and distribution efficiencies of national infrastructure such as the electricity grid.

---

[18] Carbon Compliance Tool Policy Assumptions Task Group

[19] This does not include gains from the domestic hot water storage or distribution system as is discussed further in the 'Defining the Fabric Energy Efficiency Standard' section of this report

Scope 1 – Dwelling energy demand only



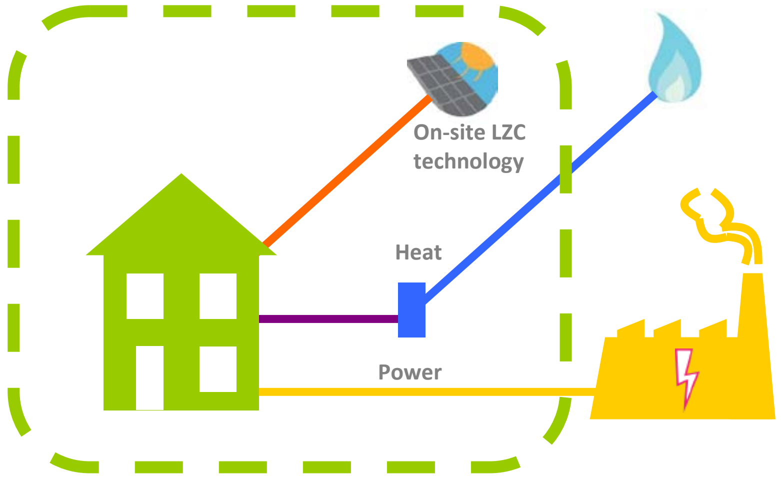
Pros	Cons
Easily interpreted approach that is easy to communicate	Requires other policies to cover wider issues
Targets longest surviving parts of the building	Does not include building service appliance or grid efficiencies. Therefore reliant on Carbon Compliance in this respect
Areas are all within the builder's control	Potentially requires technologies such as whole house ventilation heat recovery to be 'split' in their treatment (i.e. heat recovery within the scope, fan energy consumption outside of scope)
Not influenced by energy supply technology choice	

Figure 6: Scope 1 Dwelling energy demand only

Scope 2 (Figure 7) includes the demand reduction areas within Scope 1 but also includes building service appliance efficiencies (including boilers, heat pumps and LZC technologies), ventilation fans and lighting.

However it still does not include the conversion and distribution efficiencies of national infrastructure such as the electricity grid.

Scope 2 – Dwelling energy demand and appliance efficiency, excluding energy conversion and distribution efficiencies

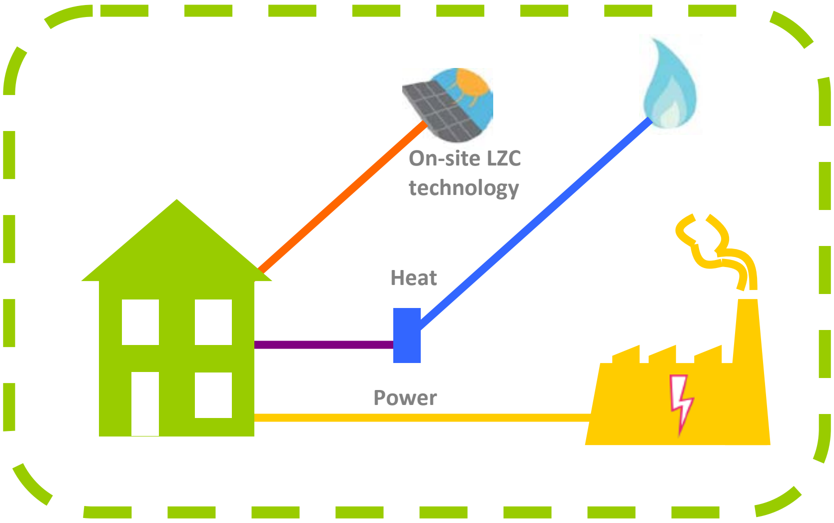


Pros	Cons
Reflects the current Part L Building regulations scope of control	Building service appliances are likely to see rapid innovation and therefore the standard may need revising frequently
Includes building service appliance and lighting efficiencies	Electricity is treated as 100% efficient as the efficiencies of power stations and transmission losses are ignored unlike other energy sources
Unambiguously includes both passive and active parts of ventilation heat recovery	Could allow high efficiency building service appliances to counter balance basic poor fabric performance with legacy implications

Figure 7: Scope 2 Dwelling energy demand and appliance efficiency of energy conversion

Scope 3 (Figure 8) includes the demand reduction and appliance efficiencies of Scope 1 and 2 plus the conversion and distribution efficiencies of national infrastructure such as the electricity grid.

Scope 3 – Dwelling energy demand and appliance efficiency, plus energy conversion and distribution efficiencies



Pros	Cons
Ensure energy efficiency from generation to consumption	Large proportion of the efficiency performance is outside of the builder's control and will change over time.
Reflects the overall carbon agenda scope	Innovation in building service appliance and generation efficiency will mean the standard may need revising more frequently
Takes into account the whole 'end to end' energy efficiency for all fuel types	May require multiple standards to deal with variety of energy sources such as gas, coal, biomass, waste heat due to differing primary energy contents

Figure 8: Scope 3 Dwelling energy demand, efficiency of energy conversion and energy distribution

Task Group definition of the energy efficiency scope

On balance the Task Group concluded that the minimum Energy Efficiency Standard will focus on limiting the energy demands of heating and cooling the dwelling and be limited to passive measures only. The implications of this decision, the exact areas that are included, and how this approach complements Carbon Compliance are illustrated in Figure 9.

By limiting the scope of the standard to passive measures designers and builders will be encouraged to create energy efficient dwellings using the elements most likely to remain in place for the duration of the home.

This approach does raise the issue of how ventilation and heat recovery should be considered. As these systems typically combine a passive aspect (heat recovery block) and an active aspect (fans to drive air flow). It is important to ensure the standard takes into account some, but not all, of the heat gains falling within this scope. Further details are provided later in the 'Defining the Fabric Energy Efficiency Standard' section of this report.

Figure 10 shows the response to this proposal at the consultation events.

Task Group definition of the energy efficiency standard scope

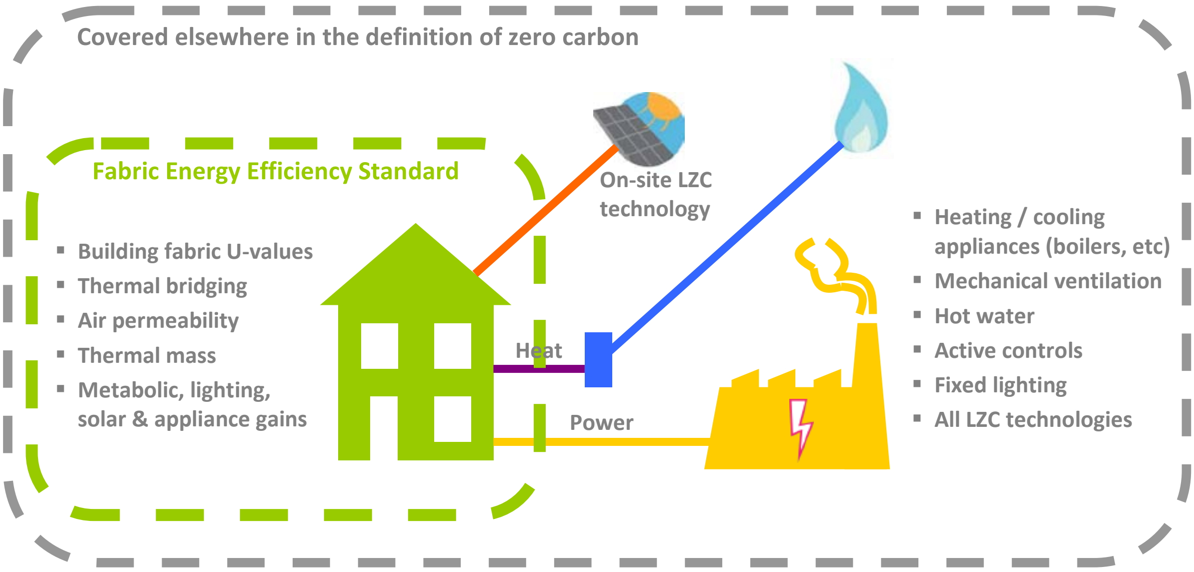


Figure 9: Task Group definition of the energy efficiency standard scope

Ventilation systems

Whole house ventilation and heat recovery can reduce the energy demand for heating quite dramatically. The Task Group decided that the standard should not be seen to imply the requirement for the inclusion of ventilation and heat recovery in all dwellings. This was in order to maximise the variety of design solutions available to achieve the standard.

The consequence of this decision is that the benefit of heat recovery would not be taken into account when checking compliance with the Fabric Energy Efficiency Standard. However any carbon benefit or penalty from the use of ventilation heat recovery would be taken account of within the overall Carbon Compliance standard.

Carbon Compliance issues

In a similar fashion the areas that fall outside of the standard's scope will be controlled primarily via Carbon Compliance regulations and wider European policy drivers such as the Energy Using Products Directive.

The scope for the Fabric Energy Efficiency Standard reinforces the Government's policy premise that long lasting energy efficiency should be the first step in any strategy to achieve Carbon Compliance and zero carbon, irrespective of the carbon content of the fuel used.

Hot water demand

It should be noted that the Task Group initially intended to include the energy demand relating to hot water within the scope. However following consideration of the energy modelling and selection of the preferred metric it was decided to exclude hot water demand from the scope. Hot water demand is primarily driven by the flow rates and volume of hot-water using appliances in the home such as taps, showers and baths. Part G (Water Efficiency) and the Energy Using Products Directive were considered to be of greater significance in reducing hot water demand.

In addition the replacement timescales for these elements is very short compared to the building envelope of the home.

It is important to note that hot water demand is taken into account within the Carbon Compliance standard.

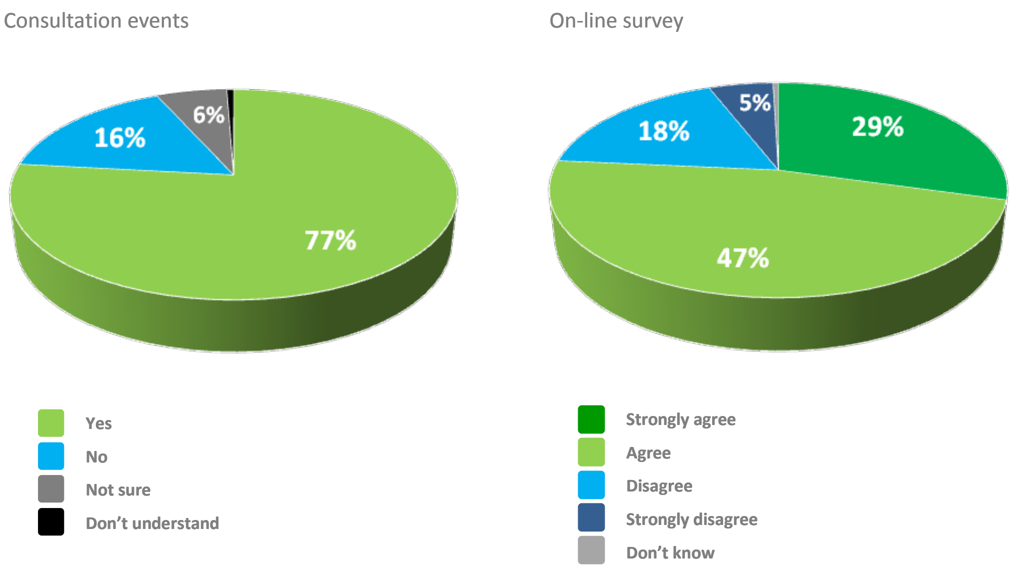


Figure 10: Consultation on scope of standard

Consultation feedback

- Live voting at the three consultation events and via the online survey posed specific questions about the emphasis on fabric and passive measures in the standard
- As illustrated in the charts above when asked:-
  - 77% of people at the events agreed that the standard should focus on fabric and passive measures
  - 76% of online voters either agreed or strongly agreed that the standard should focus on fabric and passive measures

Technical investigations

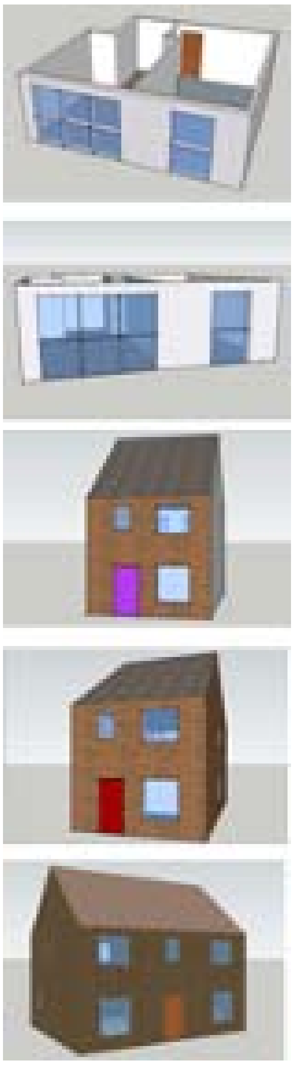


Figure 11: Core dwelling types for energy, buildability and financial modelling

The Task Group was determined to ensure the proposals ultimately developed were based on a clear appreciation of the technical and practical consequences the performance level demanded in 2016. In order to generate this information Work Group 1 – Form and Fabric were tasked with developing a range of design specifications based upon known UK and European energy efficiency standards to avoid unnecessary duplication of research.

Definition of dwelling types

A selection of dwelling types were chosen based upon the recorded mix registered with the NHBC during 2007 to ensure a representative range 'as built' by mainstream builders. Housing Developer members of the Task Group and Work Groups then kindly provided a selection of plans and elevations for dwellings of these types. The following core dwelling types were then used as the basis for all energy, design/buildability and financial investigations:

Small apartment (43m²)
Large apartment (66m²)
Mid terrace house (76m²)
Semi detached/ end terrace house (76m²)
Detached house (118m²)

In addition a number of 'sensitivity' dwellings were selected to help the Task Group identify any potential unintended consequences of a particular specification for outlying types. For example, to establish if it became technically impractical to achieve a certain performance level with either a 3-story town house or a large detached bungalow.

This additional selection of dwellings was modelled under a more limited number of energy scenarios:

Small mid terrace house
Life time homes compliant mid terrace house
3-storey mid terrace house + integral garage
2.5-storey mid terrace house (room-in-roof)
Large detached house
Bungalow

Definition of performance scenarios

A selection of design specifications were developed based upon four well known energy efficiency standards. These were AECB Silver Standard, EST Best Practice Energy Efficiency Standard, EST Advanced Practice Energy Efficiency Standard and Passivhaus.

Discussions following the first phase of modelling resulted in the number of standards being expanding to eight in order to understand the implications of excluding mechanical ventilation heat recovery from the calculations and the related significance of air permeability below 5 $m^3/h/m^2$@50Pa.

The following chart (Figure 12) provides details of the key performance criteria assumed for each during the modelling using cSAP 2009.

Current practice

Modified AECB Silver Standard

EST BPEE Standard = between Spec A & Spec B

EST APEE Standard

Passivhaus Equivalent

		Construction Specifications								
		Baseline	Spec A (NV)	Spec B (NV)	Spec B (MVHR)	Spec C- (NV)	Spec C- (MVHR)	Spec C (NV)	Spec C (MVHR)	Spec D (MVHR)
U-Value (W/m²K)	**Wall**	0.28	0.25	0.18	0.18	0.15	0.15	0.15	0.15	0.1 - 0.15
	Floor	0.2	0.2	0.18	0.18	0.15	0.15	0.15	0.15	0.1 - 0.15
	Roof	0.16	0.15	0.13	0.13	0.11	0.11	0.11	0.11	0.1
	Windows	1.8 (double)	1.5 (double)	1.4 (double)	1.4 (double)	1.2 (double)	1.2 (double)	0.8 (triple)	0.8 (triple)	0.8 - 1.0 (triple)
	Doors	1.6	1.4	1.2	1.2	1	1	1	1	0.8
	Air permeability(m³/hr/m²)	7	5	3	3	3	3	3	1	0.41 - 0.5
	Thermal bridging (W/m²K)	0.08	0.06	0.05	0.05	0.04	0.04	0.04	0.04	0.04
	Ventilation	Natural (extract fans)	Natural (extract fans)	Natural (extract fans)	MVHR	Natural (extract fans)	MVHR	Natural (extract fans)	MVHR	MVHR

Figure 12: Construction specifications for energy, buildability and financial modelling

It should be noted that in order to achieve the Passivhaus performance criteria[20] the core dwellings were first modelled to Spec C (MVHR) within cSAP and then transferred to Passivhaus Planning Package for fine tuning.

Whilst this results in a range of elemental specifications across the various house types it is important to note that the financial investigations have assumed that Spec D does not have a traditional wet central heating distribution system. This is a key feature of Passivhaus design as the very low heating demand can be provided by the Mechanical Ventilation Heat Recovery (MVHR) system, therefore realising a reduction in capital cost for the building services.

The Task Group acknowledged that trying to achieve Passivhaus performance using typical current designs does not take advantage of the role passive solar gains and optimised orientation can play. The resulting low range of U-values may be an indication of this limitation however the Task Group felt it important to understand the potential challenges without assuming that both planners and consumers will accept such fundamental design requirements all zero carbon homes.

Construction elements and frame types analysed

Work Group 01 (Form and Fabric) worked in conjunction with architects in order to appreciate the buildability and design implications of the fabric specifications proposed. A series of wall, floor, roof, window and door solutions were designed based upon the following principles:

- Walls for houses and the 4 storey apartments would be designed in both cavity masonry and timber frame
- Walls for the 8 storey apartments would be designed in concrete frame with block infill
- These reflect the mainstream construction types and provide a reliable basis for financial modelling
- It is recognised that other construction systems such as Insulated Concrete Formwork (ICF), Structural Insulated Panels (SIPs) and single skin block with External Wall Insulation (EWI) and many other systems also have the ability to achieve these specifications. Innovative build systems such as these may well provide additional solutions but the Task Group felt it unwise to presume this within the core assessments. Ultimately the market will gravitate to the most appropriate solutions. If these are lower cost than traditional solutions modelled this represents an additional benefit.

The following diagrams (Figure 13) provide an initial indication of the progressively different fabric characteristics of the four general specifications (Spec A, B, C and D). A structural engineer was consulted during their development to ensure issues such as cavity wall stability and load bearing strengths were not compromised.[21]

.

[20] In simple terms achieving a space heating demand of 15 kWh/m^2/yr or less. Plus a heat load of 10 W/m^2 or less so that space heating can be distributed by the ventilation system More information can be found at www.passiv.de

[21] Further details can be found in Appendix A

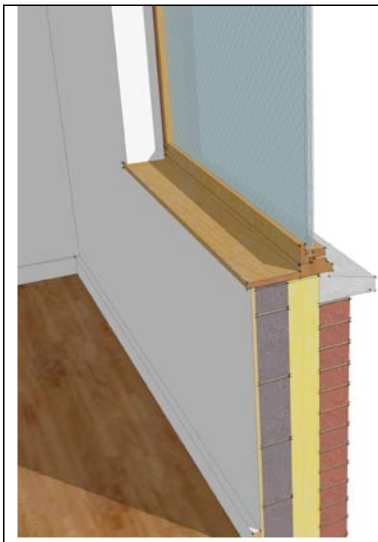
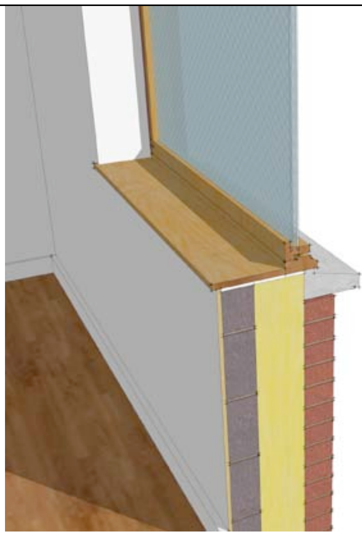
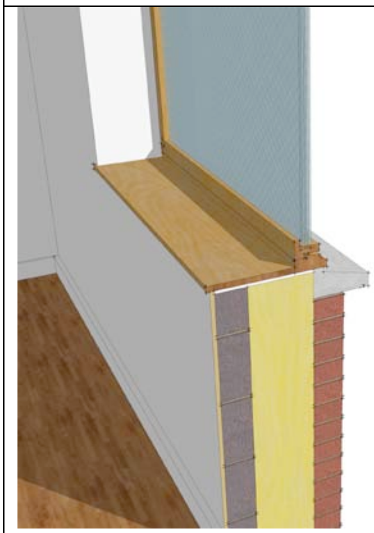
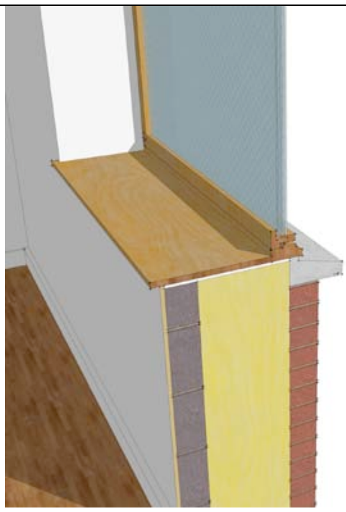
	
Spec A – Circa AECB Silver Standard 100mm Glass wool Total wall 320mm U-value = 0.25 W/m^2K	**Spec B – Circa EST Best Practice plus** 160mm Glass wool Total wall 385mm U-value = 0.18 W/m^2K
	
Spec C – Circa EST Advanced Practice 210mm Glass wool Total wall 425mm U-value = 0.15 W/m^2K	**Spec D – Circa Passivhaus levels** 300mm Glass wool Total wall 515mm Indicative U-value = 0.11 W/m^2K

Figure 13: Indicative masonry wall construction sections for Spec A – D

Even from this simple illustration it is clear that requiring increased levels of minimum energy efficiency has a real and direct impact on how dwellings will be designed and constructed. The following more detailed diagrams provide indicative cross sections for walls, floors and roofs that could achieve the performance range indicated by the four specifications (A – D).

It should be understood that these are not the only ways, or even the Task Group's preferred ways, to achieve such performance. These are merely examples to aid the reader in understanding the physical implications. All examples are based on mainstream masonry and timber frame construction.

Masonry Walls (Glass wool insulation)

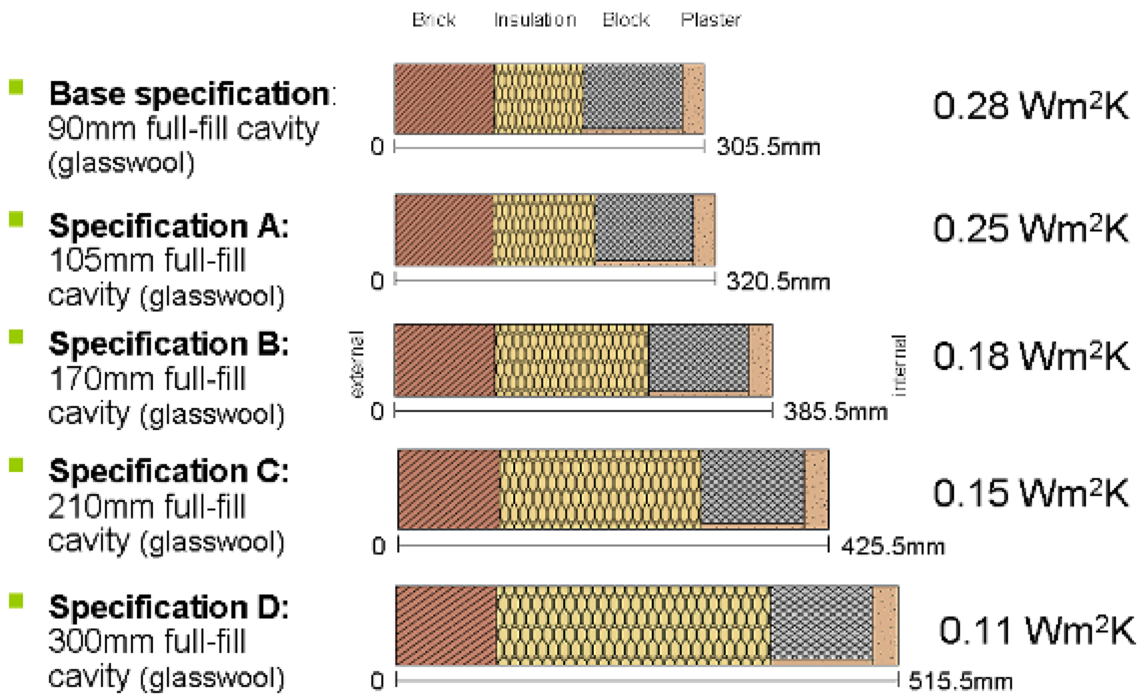


Figure 14: Full fill cavity masonry wall construction sections

Masonry Walls (PU Foam insulation)

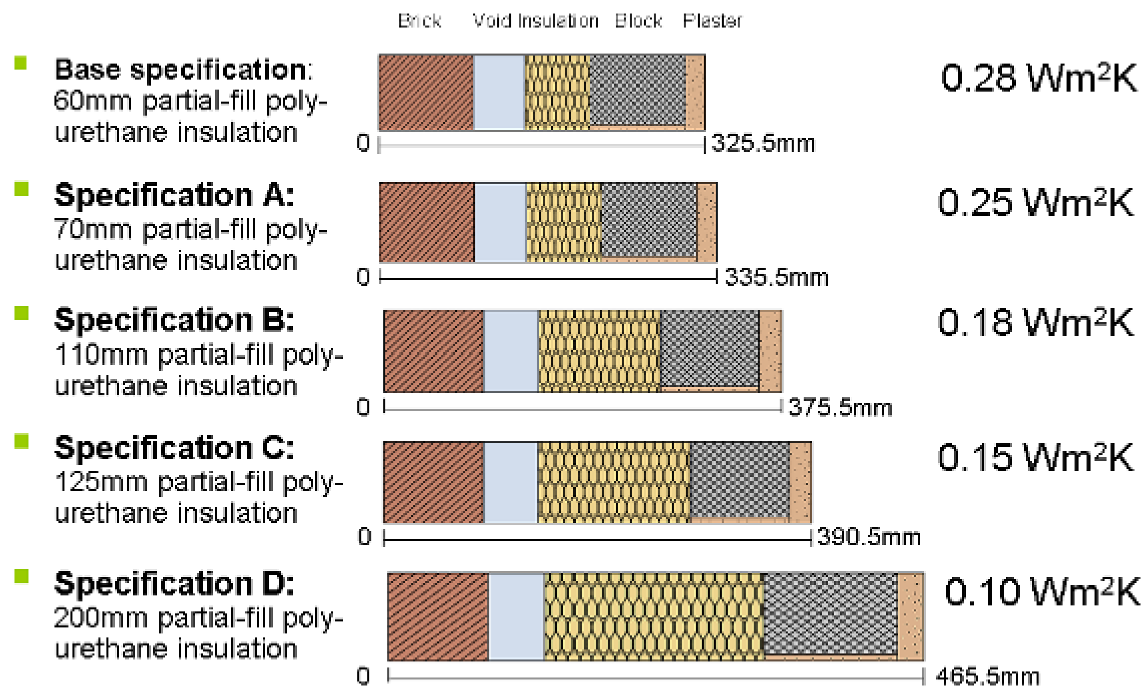


Figure 15: Partial fill cavity masonry wall construction sections

Timber Frame Walls

- **Base specification:** 140mm insulation between studs (mineral wool)
- **Specification A:** 140mm insulation between studs (glass wool)
- **Specification B:** 140mm insulation (glasswool) between + 50mm outside of frame
- **Specification C:** 140mm insulation (glasswool) between plus 90mm outside of frame
- **Specification D :** 140mm insulation (glasswool) between plus 200mm outside of frame

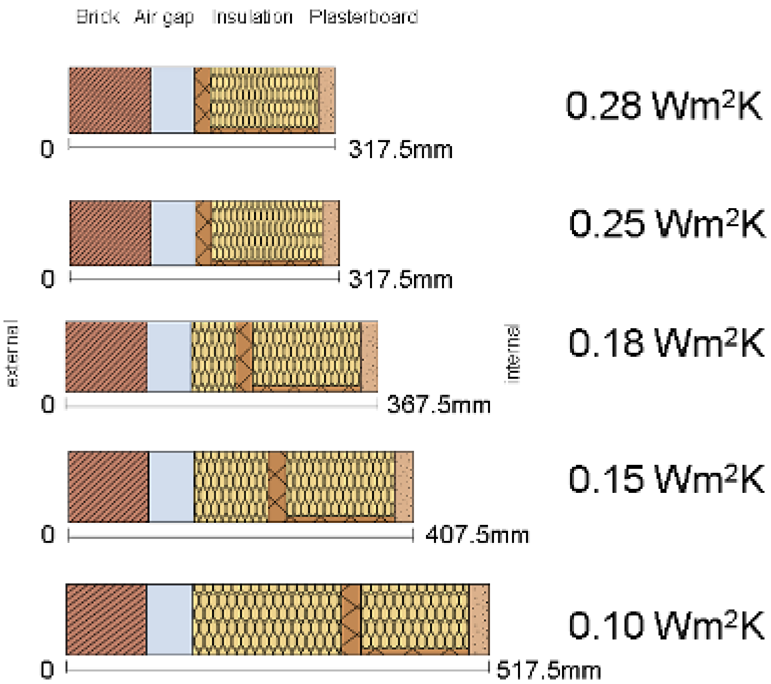


Figure 16: Timber frame wall construction sections

Floors – Beam and block suspended floor with internal screed

- **Base specification:** 218mm insulated concrete beam system + 10mm rigid insulation, screed
- **Specification A:** 218mm insulated concrete beam system + 10mm rigid insulation, screed
- **Specification B:** 218mm insulated concrete beam system + 15mm rigid insulation, screed
- **Specification C:** 218mm insulated concrete beam system + 40mm rigid insulation, screed
- **Specification D :** 218mm insulated concrete beam system + 110mm rigid insulation, screed

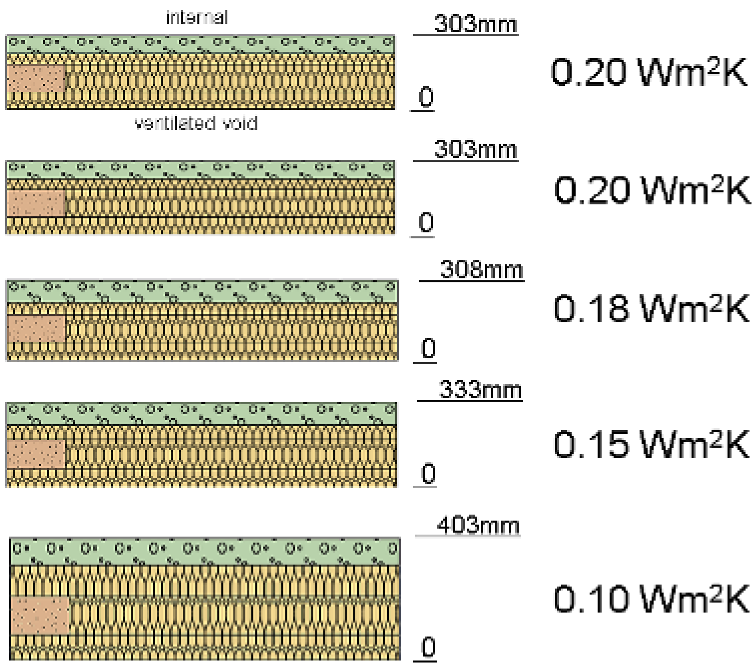


Figure 17: Suspended beam and block floor construction sections

Roofing – Insulation between and above joists in ceiling void

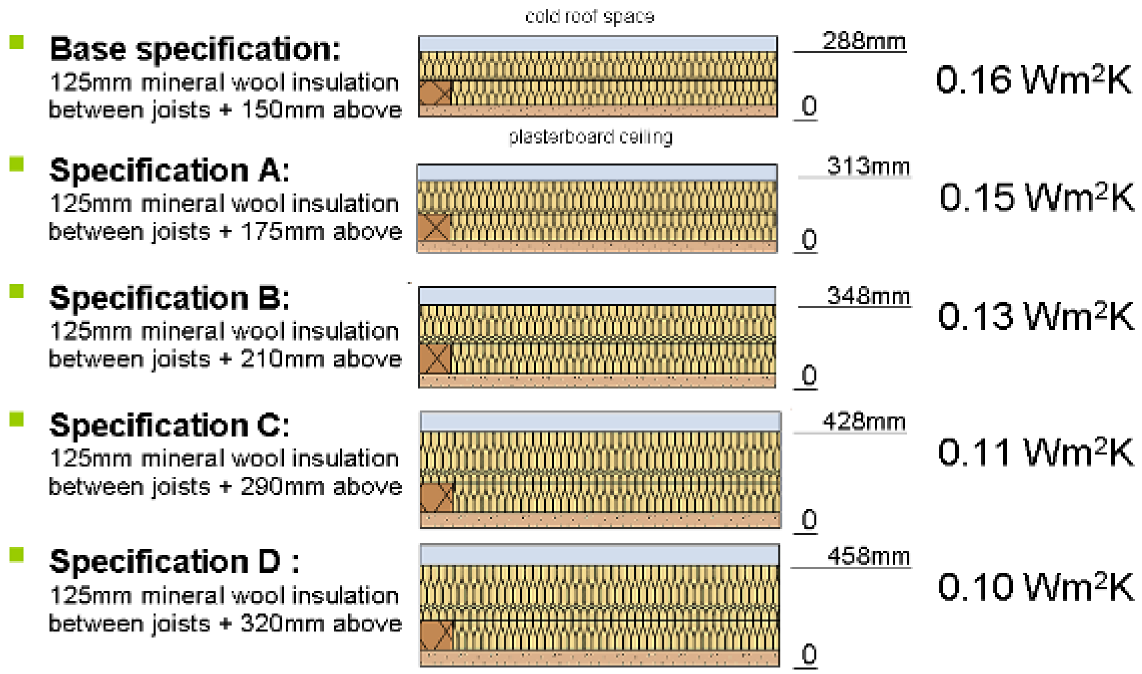


Figure 18: Ceiling level insulated ceiling construction sections

It is important to note that these construction cross sections only illustrate a small proportion of the products available to industry. The thermal conductivities used for the various materials are deliberately typical of mainstream products.

This is a conscious decision to avoid developing a standard with an inherent assumption that materials currently at prototype stage will become mass market by 2016. The Task Group took the view that should these materials proceed into mainstream use then this represents an additional benefit.

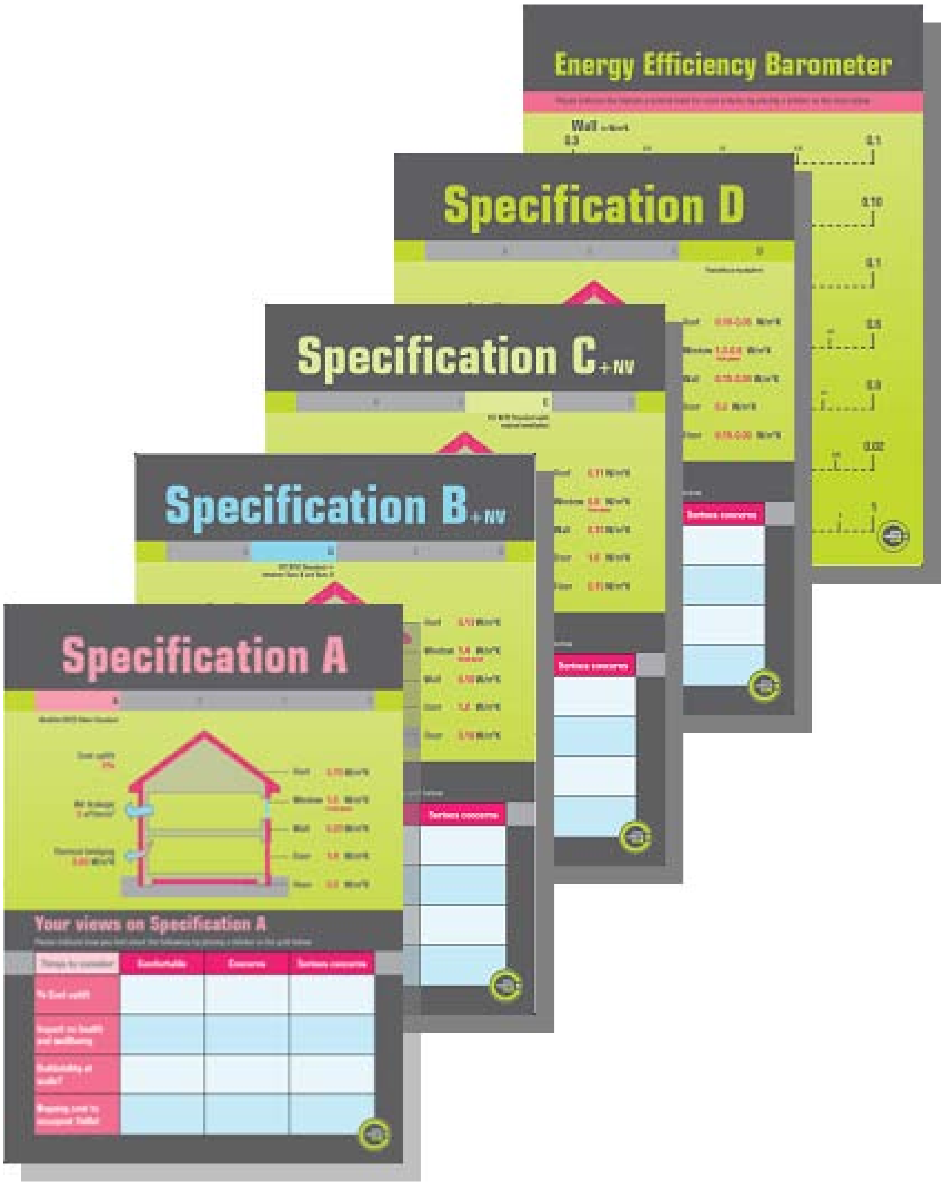


Figure 19: Event construction opinion boards

Consultation feedback

- A combination of live voting and opinion boards were used at the three consultation events to gather views on the construction specifications modelled
- When ask to rate the specifications (A – D) in terms of buildability at mass scale in 2016 on the boards:
    - o 100% of people comfortable with Spec A
    - o 78% of people comfortable with Spec B
    - o 38% of people comfortable with Spec C – but 18% of people had serious concerns
    - o 47% of people had serious concerns with Spec D
- This indicates that most people were comfortable at Spec B but that at Spec

Initial modelling results

With the general range of construction specifications agreed by the Task Group, a series of cSAP models were created to help the group understand the energy demand implications of each increase in specification. This section provides a summary of the initial results for all of the specifications across the core dwelling types and a selection of the sensitivity dwelling types, such as bungalows and 2.5 storey mid-terraces.

The following graphs (Figures 20 and 21) illustrate the two extremes of results from a Current Practice 2006 specification (black line)[22] to Specification D (Passivhaus - purple line). It is clear from the distance between these two that energy efficiency is considerably increased when designing to the Passivhaus standard.

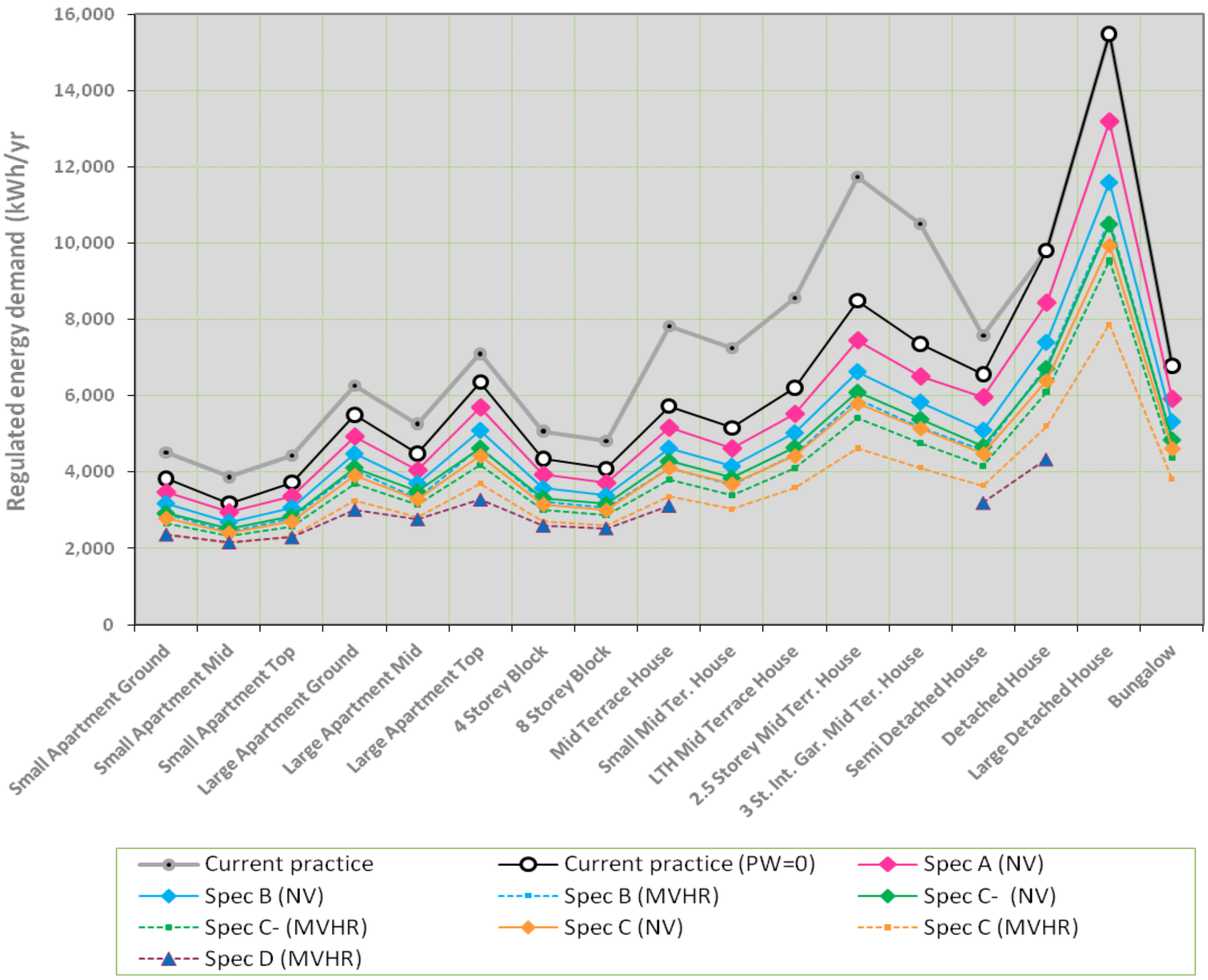


Figure 20: Initial energy modelling results – kWh/yr

[22] There are two Current Practice lines. The one noted PW=0 assumes zero heat loss through party walls whilst the other assumes some heat loss as has been highlighted in the recent Part L consultation. Hence the top line has a different shape for the terrace and semi detached dwellings than all other specifications.

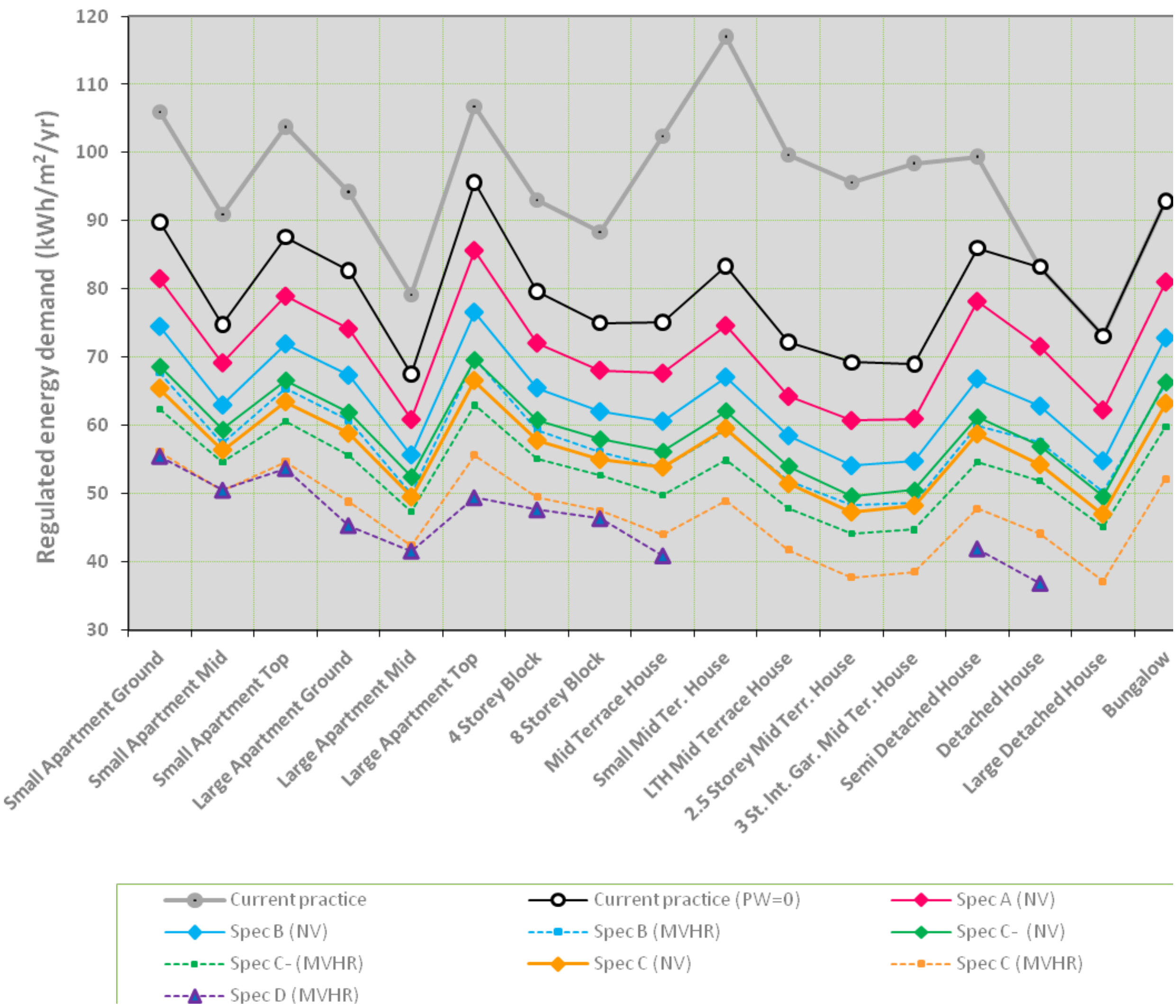
When initially reviewing these results there were, in general, two views expressed. One being that the Passivhaus range of performance (Spec D) represented the 'level' of ambition required and that the resulting construction specifications were indeed buildable. The opposing view was that a construction specification closer to A or B was a pragmatic, buildable level suitable for a minimum standard.

It is interesting to consider the results of the consultation when viewing these graphs. The majority of people who expressed an opinion via the boards were happier in buildability terms around Specification B. Whilst 47% of people had serious concerns about the buildability of Specification D (Passivhaus) at mass scale in 2016.

It can also be seen that when shown in terms of total kWh per annum, the regulated energy demand varies considerably from small apartments to the larger detached houses. Whilst this is not a surprise due to their relative external heat loss fabric areas it does begin to illustrate that some metrics are less suitable if one is trying to define a single or limited number of standards for all dwelling types.

Figure 21 presents the same energy efficiency performance across the range of dwelling types. However in this case by using a floor-area related metric ($kWh/m^2/yr$) the upper and lower figures between a small apartment and a large detached house are drawn closer together. We will explore the Task Group's recommendations for a metric within the 'Metric Investigations' section of this report.

Figure 21: Initial energy modelling results – $kWh/m^2/yr$



The final graph in this section (Figure 22) provides an insight into exactly which areas of energy demand within the regulated energy calculations are responsible for the greatest proportion[23]. It can be seen that as the fabric specification is improved to Specification B and above domestic hot water (DHW) demand becomes increasingly significant, particularly in apartments and mid terrace houses.

It is also possible to identify the reduction in space heating demand with the inclusion of an efficient Mechanical Ventilation Heat Recovery (MVHR) system. In all of the cases modelled the MVHR scenario results in a lower overall energy demand, even with the additional demand required to drive the fans within the system.

This analysis helped the Task Group to quantify, in energy demand terms, its decision to exclude whole house ventilation with heat recovery from the Fabric Energy Efficiency Standard. Whilst this does mean all of the specifications assuming natural ventilation result in slightly higher energy demand it was felt the greater flexibility provided for designers and house builders by not assuming a standard that must include such an approach to ventilation was considered important.

It should be remembered that whilst ventilation heat recovery is not included within the Fabric Energy Efficiency Standard it is rewarded in the accompanying Carbon Compliance calculation. Therefore the benefits of such a system will be rewarded within the overall Zero Carbon standard.

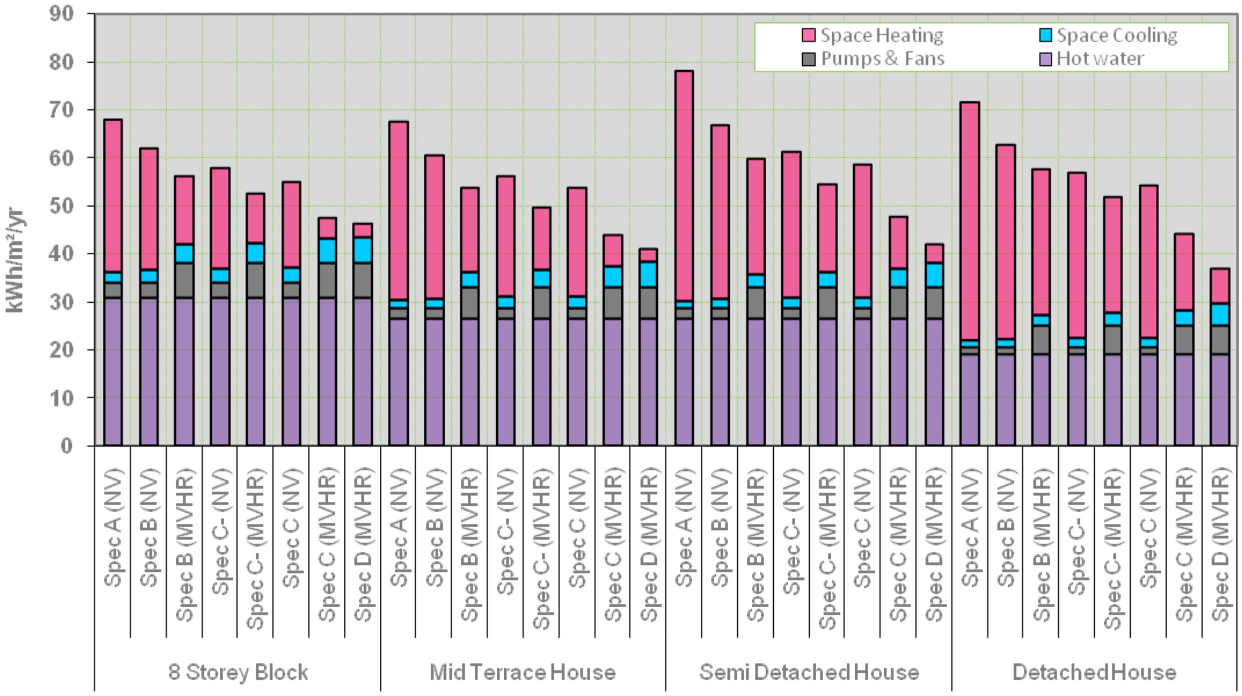


Figure 22: Initial energy modelling results – Energy demand breakdown

23 Please note due to the Task group's decision regarding the Fabric Energy Efficiency Standard Scope these figures do not include lighting demand

Financial investigations

The Task Group has worked with a leading Cost Consultant to explore the financial implications of the various construction specifications being modelled across the core dwelling types. This has included not only the additional capital costs associated with the increased energy efficiency, but also the crucially important relationship this has to achieving the minimum 70% Carbon Compliance standard. Scenarios have also been explored to try and provide an indication of how the relationships between whole life costs might help inform the wider policy decision on what is considered to be an acceptable increase in capital costs.

Capital cost assumptions

Upgrades priced on an elemental basis (e.g. extra wall insulation, window triple gazing, etc)

All costs are extra over costs from the baseline specification

Data sources:

Davis Langdon data for simple fabric elements (e.g. insulation)

Market supplier's quotations for windows and mechanical ventilation

Air-tightness and thermal bridging were based on costs by DL plus Fabric and Form working group

Remaining are Davis Langdon 2009 Q2 prices

All costs include supply and labour and any direct implications of upgrades

Costs are based on prices for a medium size developer (average between small and large) and for a small development (less than 25 units).

Main assumptions:

1) All costs Include preliminaries and overheads/profits

2) Exclude external works, drainage and services

3) Exclude VAT, professional fees etc

4) Assume a basic and minimal specification of finish

5) Assume there are no abnormals

6) Cost of land has been excluded

Costs for technologies (PV & Solar Thermal)

1) Include installation, testing & commissioning, attendances and overheads/profits

2) Exclude VAT and building services distribution

3) No allowance included for grants

4) Exclude feed-in tariffs

Capital cost of Carbon Compliance

The UK is leading internationally by having both a minimum fabric energy efficiency and carbon reduction policy with implementation in 2016. It is clearly important to have an understanding of how the minimum energy efficiency level interacts with the minimum Carbon Compliance level (70% improvement as defined in the 'Definition of Zero Carbon' consultation)[24], especially as improved energy efficiency helps achievement of Carbon Compliance.

If the minimum energy efficiency level is set too high there is a danger that industry will be required to increase investment to an unnecessary extent into achieving a fabric performance beyond an optimum point when weighed against the full range of policy objectives.

In contrast, if the minimum energy efficiency level is set too low this may result in industry to diverting finances towards Low and Zero Carbon (LZC) technologies. This would increase the risk of their being insufficient investment in the longer lasting core fabric efficiency which are likely to have the most prolonged influence on energy demand through the dwelling's useful lifespan.

There are clearly a myriad of LZC technology combinations that a house builder or developer may choose to achieve 70% Carbon Compliance. This will be influenced by development size, location, construction team skills, supply chain capacities and the availability of potential Allowable Solutions. In order to simplify the illustration the Task Group decided to model the core dwelling types using the following assumptions.

The fabric energy efficiency for each of the eight specifications (A – D with and without MVHR) would be used as a base, with:-

- A gas condensing boiler for space and water heating
- To this would first be added solar thermal panels to provide a proportion of the hot water demand
- Finally the required area of photovoltaic panels would be included to achieve 70% Carbon Compliance

Due to the complexity and variety of issues involved the figures should be viewed with the following cautions in mind:-

- The energy modelling assumptions defining 70% Carbon Compliance are based on the Task Group's understanding of current CLG policy guidance. Refinements to this in the future have the potential to influence the results
- The costs assumed for solar thermal and photovoltaics are based on standard industry figures and do not include any grants or possible future 'feed-in tariffs'
- A different combination of technologies will result in different cost levels

The charts that follow illustrate the total additional costs relating to the increase in energy efficiency, addition of solar hot water (SHW) and finally photovoltaics (PV) for the detached, semi detached and small ground floor apartment.

Following discussions it was decided that all cost modelling would be expressed in today's terms as these would be most understandable to the wider industry. Therefore all costs are based upon second quarter 2009 prices rather than any future date and do not include learning curves or economies of scale.

---

[24] Compared to Part L 2006 this assumes a Fuel Factor of 1.0 for all Target Emissions Ratings, carbon intensity of electricity of 0.43 kg/CO_2/kWh (import and export), and the benefit of 100% low energy lighting. Further details can be found in Appendix A

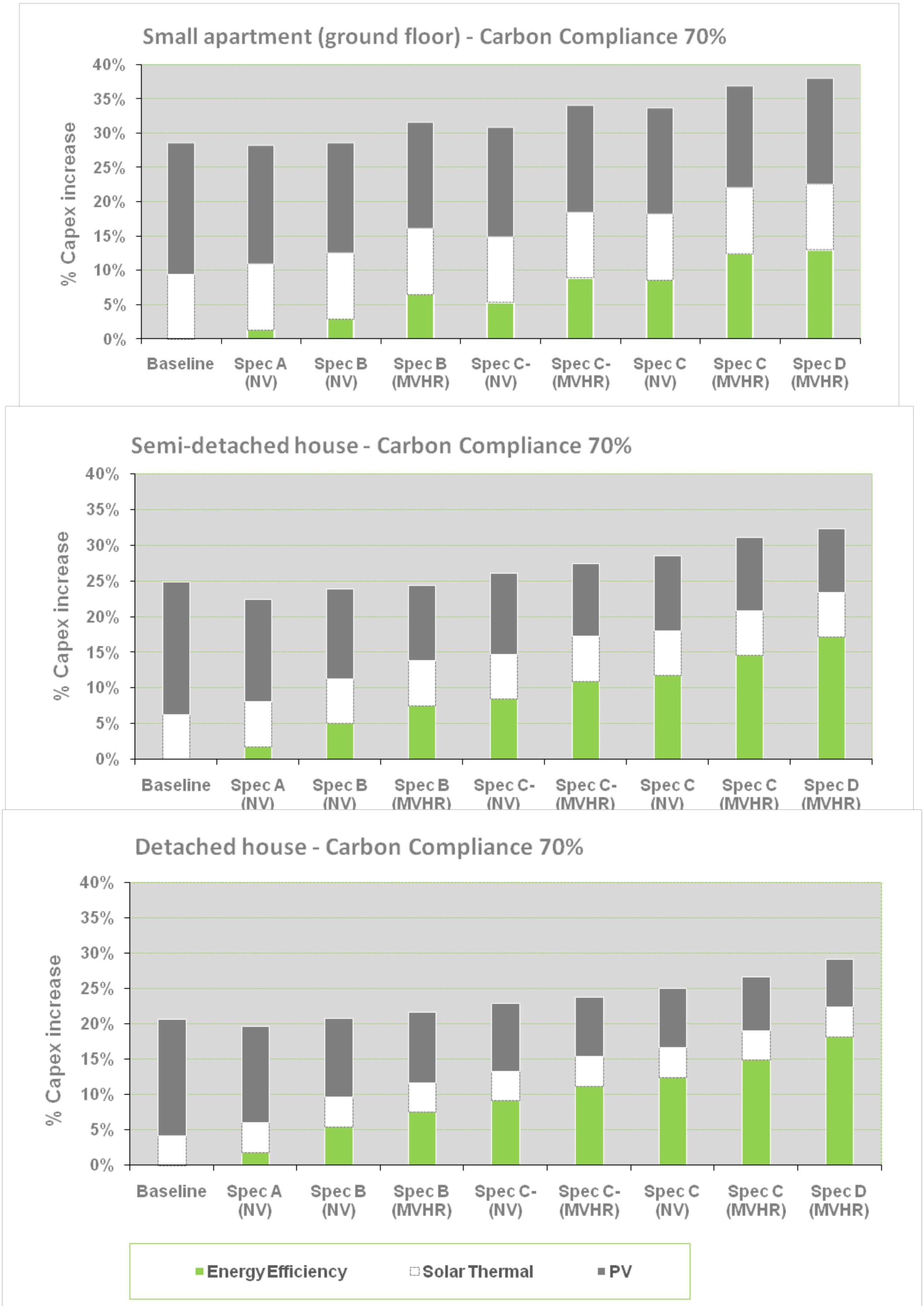


Figure 23: 70% Carbon Compliance capital costs (Second Quarter 2009)

A number of observations can be drawn from these Carbon Compliance capital cost charts:

- **Detached house** – The Current practice baseline specification plus SHW & PV is of equivalent cost to Spec B (NV) (~20% uplift). As the energy efficiency specification increases to Spec C (NV) the total increase in cost rises despite the reduced requirement for PV (~25% uplift)

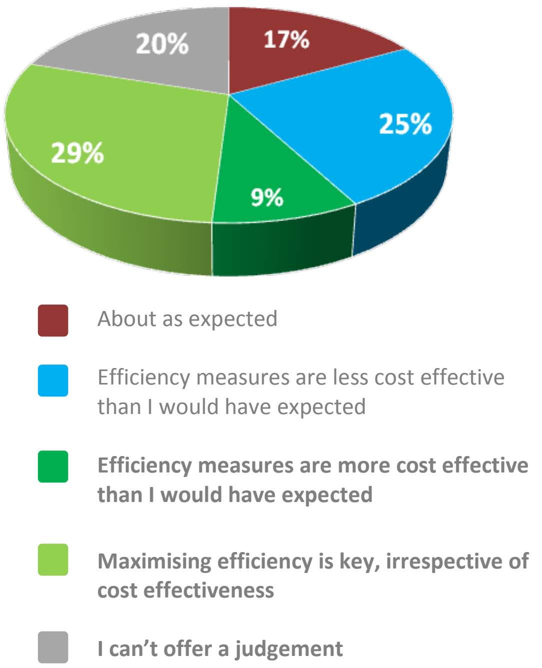


Figure 24: Consultation feedback on 70% Carbon Compliance capital costs

- **Small apartment** – The Current practice baseline specification plus SHW & PV is of equivalent cost to Spec B (NV) (~28% uplift). As the energy efficiency specification again increases to Spec C (NV) the total increase in cost rises despite the reduced requirement for PV (~34% uplift)
- **Semi detached house** – In this case the Current practice baseline specification plus SHW & PV is of equivalent cost to a higher Spec C- (NV) (~26% uplift).

Consultation feedback

- Live voting at the three consultation events posed specific questions about the relationship between energy efficiency and Carbon Compliance costs
- As illustrated in the charts above when asked:-
  - 17% found the costs as they expected
  - 25% thought the energy efficiency measures would be more cost effective
  - Almost 30% felt that maximising energy efficiency was key irrespective of cost

Capital cost of Energy Efficiency

This section provides the predicted increase in capital cost for three of the core dwelling types; detached house, semi detached house and a small ground floor apartment. They assume a small development of 25 units being built by a medium scale developer.

The charts which follow provide an insight into not only the increased cost resulting from the improved energy efficiency specifications but also the associated reduction in total regulated energy demand.[25]

Please note that Specification D (Passivhaus) includes the expected cost reduction resulting from the exclusion of a traditional wet central heating system as all heat can be distributed via the mechanical ventilation system[26].A number of observations can be drawn from these energy efficiency charts:

- The cost relating to the increased energy efficiency specifications rise in a linear fashion. This is because they are all achieving different levels of performance as opposed to the Carbon Compliance scenarios when each was achieving a 70% reduction but via different routes
- There is a slight fluctuation in the costs, most noticeably in the small apartment. This is due to the inclusion, or not, of a MVHR system in the specification assumptions.
- It should be noted that the small decrease in capital cost if MVHR is not used is always accompanied by a small increase in energy demand due to the lack of heat recovery. (It should be reiterated that whole house ventilation with heat recovery is not included within the Fabric Energy Efficiency Standard but was included within the financial analysis to provide the Task Group with additional information)
- In the apartment chart the energy demand flattens from Spec C – (NV). This is due to the previously mentioned dominance of domestic hot water demand (DHW) in this dwelling type. As the modelled specifications do not include measures to reduce this DHW demand the increases in fabric insulation begin to have less and less impact on the overall demand.

[25] Please note the energy demand relates to all regulated energy except that from lighting

[26] Further details of the assumptions used can be found in Appendix D

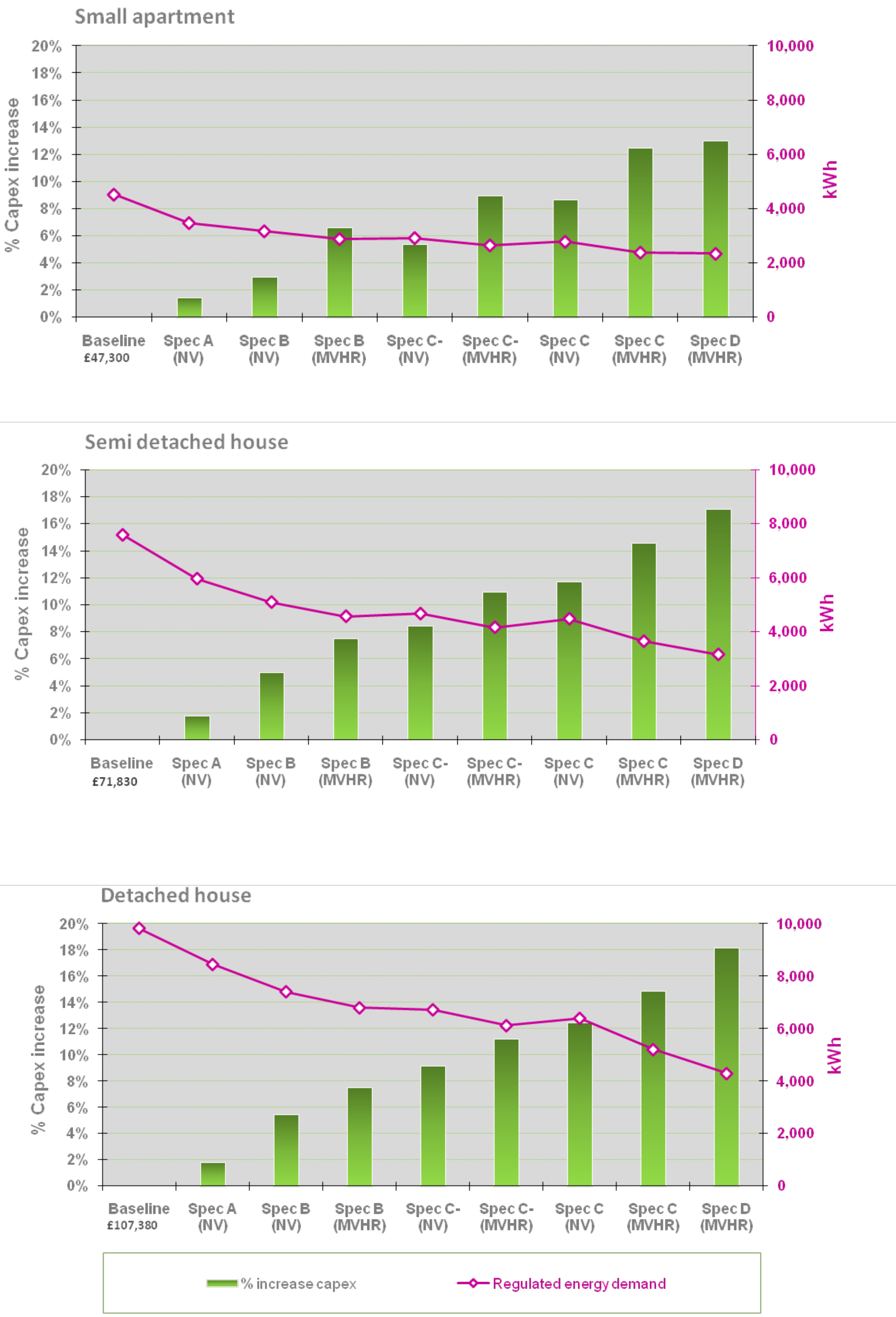


Figure 25: Additional capital cost compared to baseline for energy efficiency measures only (Second Quarter 2009)

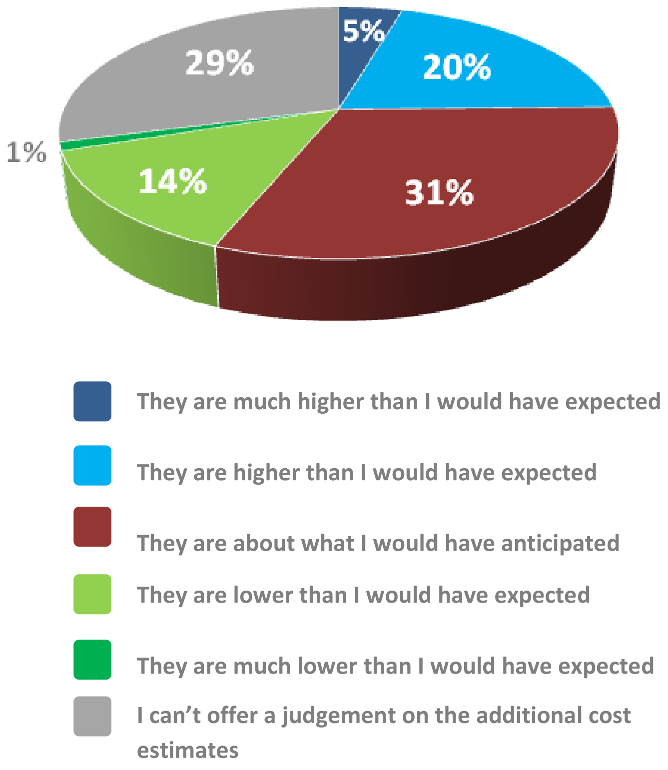


Figure 26: Consultation feedback on the energy efficiency related capital costs

Consultation feedback

- Live voting at the three consultation events posed specific questions about the capital costs related to energy efficiency
- As illustrated in the charts above when asked:-
  - 20% found the costs higher than expected
  - 30% thought they were as expected
  - Almost 30% felt that they could not offer a judgement on the additional costs

Whole life cost modelling exercise

The Task Group has been mindful of the wider implications a Fabric Energy Efficiency Standard might have if introduced at a national level in 2016. One area of particular interest has been the whole life cost implications of fabric specification increases when compared to LZC technologies such as SHW and PV.

This section provides an indication, based upon the semi detached house type, of how the various specifications modelled to achieve the minimum 70% Carbon Compliance standard differ over an assumed 60 year lifespan.

In financial modelling over such a long term the influence of both discount rate and energy cost inflation can be significant. The Task Group has therefore modelled two financial scenarios:-

- 5% discount rate and energy cost inflation at Retail Price Index (RPI) + 0%
- 5% discount rate and energy cost inflation at Retail Price Index (RPI) + 2.5%

A number of observations can be drawn from these lifecycle cost charts:

- Whilst only one dwelling type scenario of many, the semi detached charts shown for a 5% discount rate indicate that over the 60 year period specification up to Spec C-(NV) has approximately the same whole life cost as less energy efficient current practice baseline specification (circa £5,500 compared to circa £7,000)
- However the chart above clearly illustrates how sensitive the analysis is to the assumed future energy cost inflation assumptions. Increasing the inflation rate from the base RPI to RPI + 2.5% has the effect of reducing the Net Present over cost of Spec C (NV) from circa £17,000 down to circa £9,000
- Further analysis will be required for the purposes of any Impact Assessment by Government in due course, taking into account the energy prices, discount rates and other analytical approaches used in Government economic analysis.

Whole life costs assumptions

The scope includes the extra over components affected in each spec (i.e. baseline house is not modelled)

- Affected fabric elements are lighting, windows and MVHR (where applicable)
- Analysis carried out for 60 year period
- Whole life scope includes strip-out, maintenance and replacement for building components (lighting, windows and MVHR) and maintenance/replacement for PV and solar thermal. Replacement of PV and solar thermal carried out every 25 years.
- All costs and savings are discounted into present values using either a 5% discount rate (detailed on graphs)
- Energy savings for Energy Efficiency measures are based on cSAP energy outputs and current gas/electricity price factors.
- Energy savings for SHW and PV are based on modified SAP2005 energy outputs (as per Zero Carbon consultation document assumptions) and current gas/electricity price factors
- The energy savings are factored through an RPI (2.5%) and RPI+2.5% (5%) energy price inflation

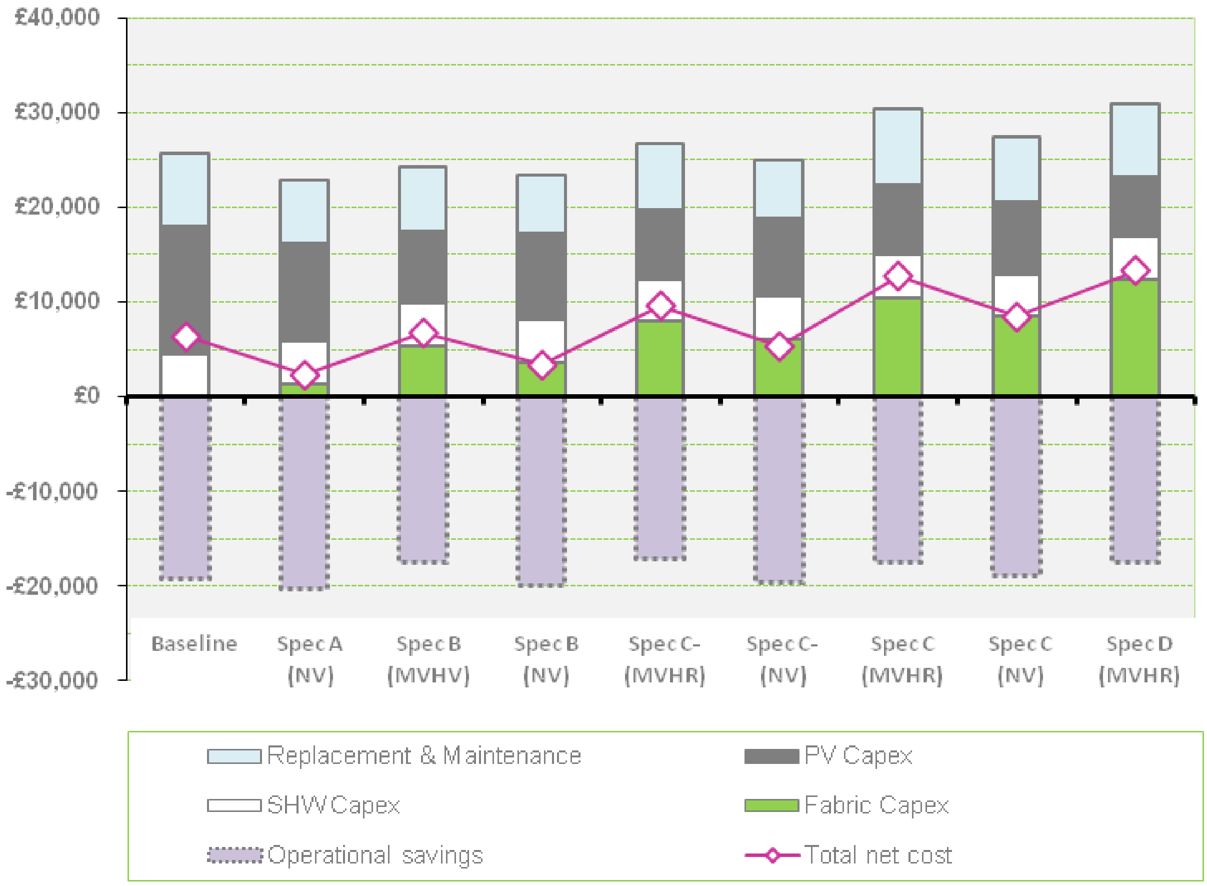


Figure 27: Whole life costs for 70% Carbon Compliance semi detached house over 60 years

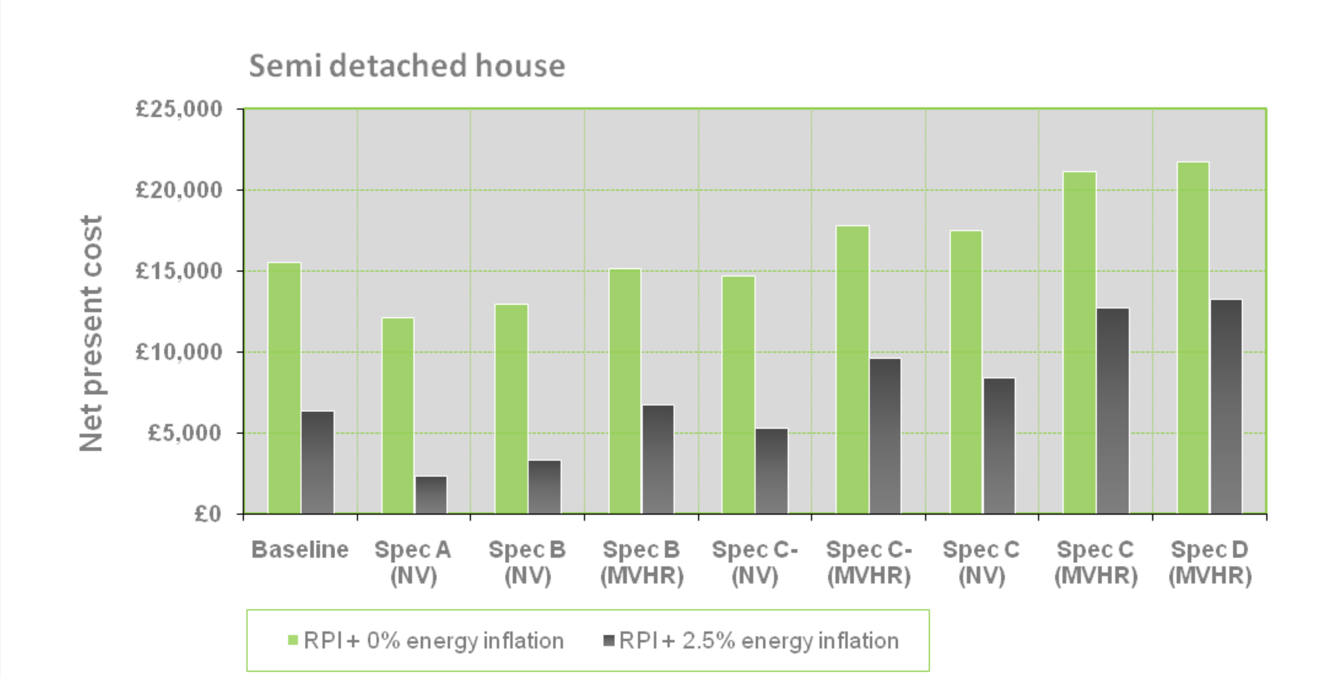


Figure 28: Summary whole life costs for 70% Carbon Compliance semi detached house over 60 years with differing energy inflation rates

Metric investigations

There are a number of different metrics that the Fabric Energy Efficiency Standard could be expressed in. The criteria used to determine the chosen metric included:

1. **Stability across house types for a given specification**
2. **Range of energy demand areas it could contain**
3. **The ease with which it could be understood by industry**
4. **Relevance to other legislation (e.g. Europe).**

In terms of the range of issues covered, for some of the metrics there is a certain amount of flexibility in setting this, whereas for others the issues encompassed are fixed. For example, Heat Loss Parameter (HLP) has become a common term following its inclusion within the Code for Sustainable Homes, but is fixed in its definition, rewarding improvements in fabric, detailing and ventilation whilst not accounting for the role of passive solar gain and cooling demand.

In simplistic terms there are two types of metric that can be considered and these are:

1. **Prescriptive elemental standard**
2. **Performance standard**

Prescriptive elemental standards

Prescriptive elemental standards means specific performance requirements are defined for a selection of 'elements' considered of particular importance to achieving energy efficient design. What this would mean in practice is that effectively a single, worst acceptable, design specification is created for all dwelling types irrespective of their particular built form or orientation.

The most significant consequence of this approach is that whilst the building specification can be simply communicated, the resulting range of energy efficiency performance for the variety of dwelling types can be significant. The following graph (Figure 29) illustrates this effect based upon a standard assuming Spec C - with Nat Vent across a range of house types.

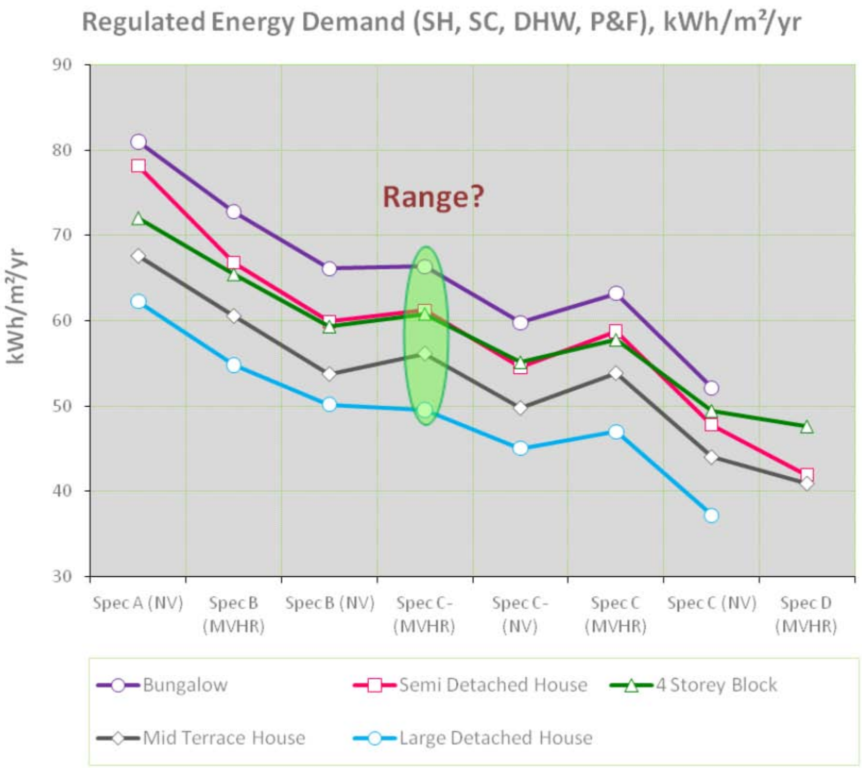


Figure 29: Illustration of prescriptive metric

Pros	Cons
Consistent build specifications across different house types	Difficult to limit the extent of thermal bridging, glazing orientation etc in actual dwelling design
Encourages standardisation	Standardisation could stifle innovation
Recognised and understood by housing and Building Control sector	Does not encourage more efficient forms such as less complex staggers and excess heat loss areas in large detached dwellings
Unaffected by changes to SAP	Predetermines the relative carbon cost effectiveness of each element
	Non tradable across elements limiting design flexibility
	Results in a wide range of energy demand performance across house types

Performance standard

Performance standard means that an overall energy efficiency performance is defined rather than a selection of elemental specifications. For example this could be defined in terms of a Heat Loss Parameter (as used in the current Code for Sustainable Homes), KWh/yr or a maximum kWh/m^2/yr

The most significant consequence of this type of standard is that a variety of elemental specifications can be combined to achieve the required performance. Therefore whilst the headline performance standard may be simple enough to express in a single number, the variety of actual design solutions can vary significantly. The following graph (Figure 30) illustrates this effect based upon a standard assuming 60 kWh/m^2/yr.

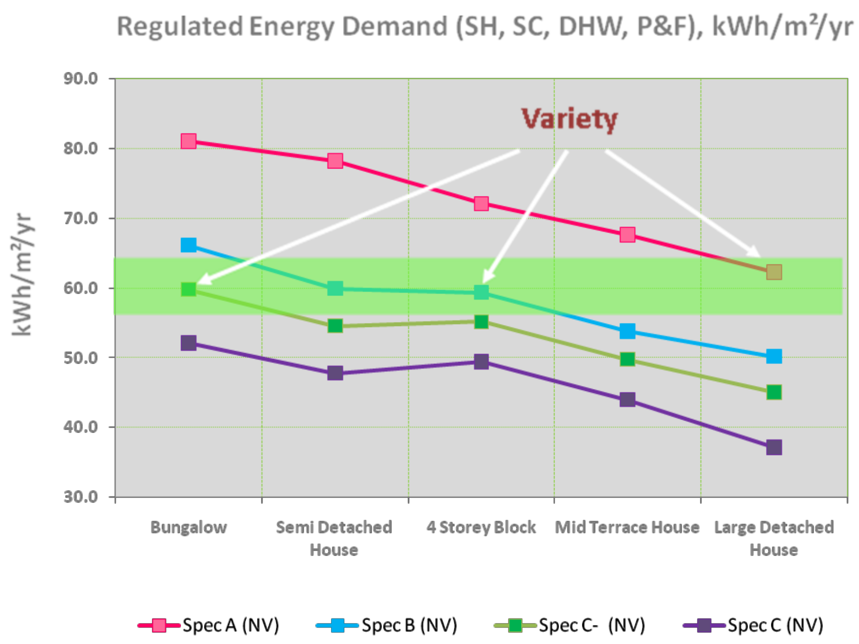


Figure 30: Illustration of the implications of a Performance metric

Pros	Cons
Allows trading of elemental performance giving design flexibility	Potentially more difficult for product and materials supply chain to understand
Promotes innovation	Level would need updating whenever SAP changed, to maintain the same ambition
Takes account of built form	
Sets objective as energy performance rather than being a collection of elemental specifications	

Preferred metric – Performance with design guidance

The Task Group favoured a Performance metric supported by design guidance. The reasoning for this can be summarised as:-

- It is flexible for designers and builders so skills and supply chain strengths can be exploited
- It takes into account building form
- It encourages innovation via the ability to achieve the standard with a variety of solutions
- It has the ability to deliver a specific level of dwelling performance, as opposed to a range as explained earlier for the prescriptive approach
- When combined with industry-developed design guidance, greater knowledge of the most cost effective options between wall, floor, roof and glazing specifications will be generated
- If a suitable 'currency' is selected it can reward both passive design and efficient built forms
- If normalised by floor area it can create a more stable metric between dwelling types

Whilst there are a variety of 'currencies' that fall into the definition of a Performance Standard the Task Group's discussions focussed on four main options:-

Kg/CO_2/m^2/yr

- Whilst this may at first seem to provide useful continuity with the associated Carbon Compliance standard it does not ensure an efficient fabric specification
- This is because the fuel type selected will have a significant impact in the CO_2 emissions and may for example result in a relatively poor fabric being used with, say, biomass.

Heat Loss Parameter

- Already known in the England (and Wales) via the Code for Sustainable Homes but not used in other countries
- Includes heat losses via fabric and ventilation but does not include passive solar gains or internal gains

kWh per year

- An internationally understood figure that can include heating, cooling and gains
- Difficult to use across a range of dwelling sizes due to large fluctuations in total demand values

kWh per m^2 floor area per year

- An internationally understood figure that can include space heating / cooling demand and internal gains
- Suitable for use across a range of dwelling sizes due to the floor area normalising total demand values thus reducing fluctuations

The preferred unit

The Task Group's preferred unit for the Performance based metric is **kWh/m^2/yr** due to its ability to cover the positives and negatives of space heating and cooling demand relating to fabric, thermal detailing, air permeability, ventilation, passive gains, internal gains and within one internationally understood figure.

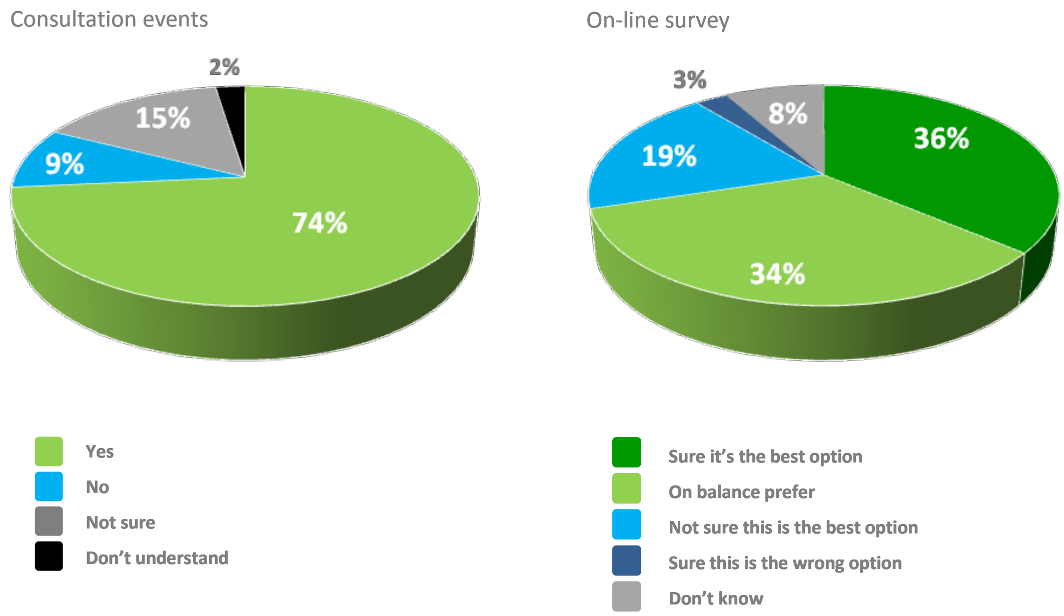


Figure 31: Consultation feedback on the preferred metric

Consultation feedback

- The selection of kWh/ m^2/yr as the metric was questioned via live voting at the three consultation events and the online questionnaire
- As illustrated in the charts above when asked:-
  - 74% of the people attending the events agreed with the choice
  - This matches well with the combined online vote of 70% in favour
  - A comparatively small number of people were convinced that this was the wrong choice of metric

Task Group wider analysis

Following the generation of both energy and financial modelling data for the various specifications applied to the dwelling types the Task Group convened for decision making workshops. The aims of these intense periods of debate were to:-

- Gain agreement on the relative significance of the nine assessment criteria[27]
- Discuss the technical achievability of the specifications being investigated
- Discuss the resulting energy efficiency performances achieved by each specification
- Discuss the capital costs for both energy efficiency and 70% carbon Compliance scenarios
- Discuss the lifecycle costs for 70% carbon Compliance scenarios
- Gain agreement on the preferred metric for the standard
- Gain agreement on the range of levels considered suitable for presentation at the consultation events

[27] Further details of the discussions and diagrams showing key issues can be found in Appendix E

Importance of the assessment criteria

The perceived risks for each of the specifications in relation to the assessment criterion were discussed by the Task Group. It should be noted that Specifications C and D were assumed to include whole house ventilation at this point in the debate to fully appreciate the implications of a potential standard that inherently presumed its presence in a dwelling design. The matrix below (Figure 32) illustrates the results.

From this exercise the Task Group concluded that the following areas should be considered as not crucial to the setting of the standard. This was not because they are not important, but because they were not sensitive to the actual specifications modelled.[28]

- Future proofed construction
- Energy security
- Broader environmental concerns

Figure 32: Task group Assessment Matrix completed

[28] Further details of the discussion process can be found in Appendix E

The discussions and resulting matrix revealed that the following criteria did merit particular consideration when assessing the specifications and any resulting standard.

- **Building practices**
  - o Availability of materials and products with the required performance requirements
- **Buildability at mass scale**
  - o Implications on supply chain capacity and construction quality management
- **Capital costs**
  - o Especially the relationship with achieving the minimum Carbon Compliance standard
- **Occupant health and well being**
  - o In particular the relationship between reduced air permeability at design stage and the fluctuation of actual performance on site in trying to achieve the design target.

There was anecdotal evidence raised within the Task Group suggesting that house builders are 'accidentally' achieving air permeability results of say 3 m3/h/m2@50Pa when aiming for a design target of 5 m3/h/m2@50Pa for example.

Some within the Task Group also referred to NHBC research[29] highlighting concerns regarding the lack of current understanding, by some sectors in the industry, of the relationship between air permeability, ventilation systems, indoor air quality and highly energy efficiency homes

Consequently the increasing requirement for purposely designed whole house ventilation systems (both passive and mechanical) and their ability to control humidity levels and maintain acceptable long term indoor air quality was an area of considerable discussion.

[29] NHBC Foundation 2009 Indoor air quality in highly energy efficient homes – a review

Defining the Fabric Energy Efficiency Standard

This section draws together the Task Group's decisions relating to the following five questions:-

- Should there be a single or multiple level(s)?
- What should the level or levels actually be?
- What exact aspects of energy demand should be contained within the metric expressing the level (s)?
- When should the standard be introduced?
- When should a definitive policy statement be made?
- How would compliance be demonstrated?

Single level or multiple levels?

One of the benefits made possible by selecting kWh/m^2/yr as the metric for the Fabric Energy Efficiency Standard is the ability to easily set a variety of standards dependent on dwelling type.

As previously described certain dwelling types, such as mid floor apartments, which have less heat loss area compared to floor area, are able to achieve a particular kWh/m^2/yr space heating and cooling demand with a less challenging construction specification than other dwelling types, such as detached houses, with a higher exposed fabric: floor area ratio.

However as with each of the decisions faced by the Task Group there are both positives and negatives to defining more than one level.

Some within the Task Group considered the move to a metric including an allowance for floor area (kWh/m^2/yr) already sufficiently takes into account the perennial issue that larger, less compact dwelling forms will by their very nature use more energy than smaller, more compact forms. Therefore they felt that should be no further concession such as a less challenging minimum level for semi-detached and detached houses, for example.

Others felt that the challenge inherent in a single level that is ambitious in line with government aspirations for all dwelling types created a higher risk of unintended consequences for larger detached dwellings.

These range from the more immediately identifiable construction challenges, to the more far reaching possibility of a future reduction in the supply of larger dwellings suitable for families due to significantly increased capital construction costs.

Figure 33 presents a selection of the issues relating to the setting of multiple levels, relating to dwelling type.

Pros	Cons
Acknowledges detached dwellings are less energy efficient	Accepts less energy efficient dwelling forms
Helps normalise the increase in capital costs	Reduces the incentive for larger detached dwellings to be built with higher construction specifications compared to more inherently energy efficient dwelling types (e.g. mid terrace)
Reduces risk of larger detached dwellings being technically and/or financially unviable for developers due to the need for an exceedingly high construction specification	Signals an acceptance that owners of detached homes, who might be better able to afford larger energy bills, are able to consume more

Figure 33: Pros and cons of setting a multiple level

The Task Group decided to propose the concept of three levels during the consultation activities to gauge industry opinion. These were based upon the following groupings:-

- Blocks of apartments (averaged as per current Part L conventions) and mid terrace houses
- Semi detached and end of terrace houses
- Detached houses

Following the feedback received (as detailed on the following page) and after further deliberations, the Task Group has decided on two Fabric Energy Efficiency Standard levels:-

- Blocks of apartments (averaged as per current Part L conventions) and mid terrace houses
- Semi detached, end of terrace and detached houses

By recommending two levels related to dwelling type, the Task Group aimed to set the minimum Fabric Energy Efficiency Standard in a manner that was equally challenging for most construction types.

On balance the Task Group concluded that it was appropriate to require a realistic but somewhat more challenging construction specification for detached homes. They also wanted to ensure that the construction specifications for mid terraces and end of terraces would be similar.

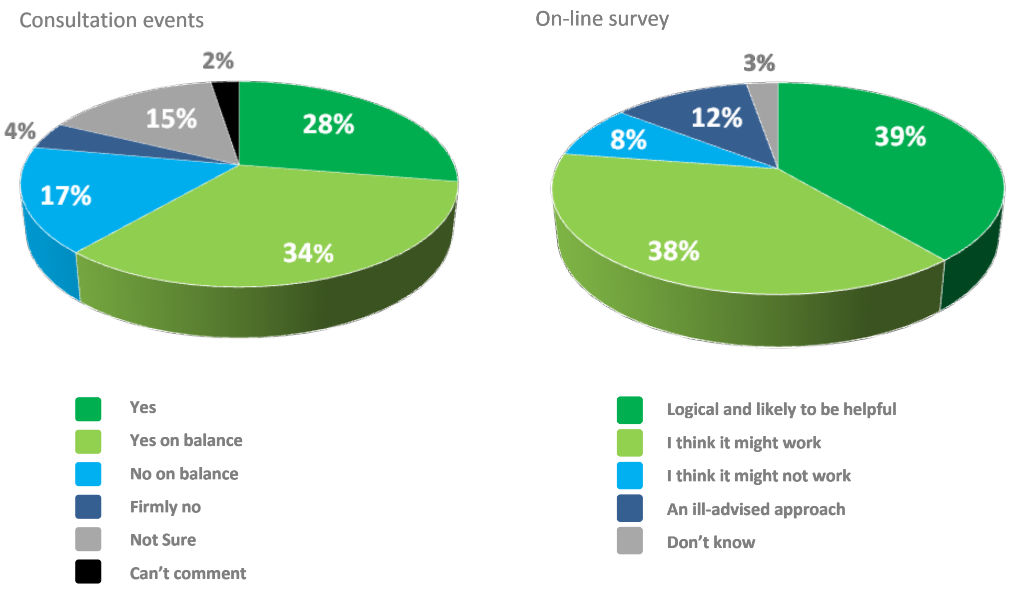


Figure 34: Consultation feedback on a variable level

Consultation feedback

- The principle of multiple levels based on dwelling type was questioned via live voting at the three consultation events and the online questionnaire
- As illustrated in the charts above when asked:-
    - 62% of the event attendees supported the idea
    - 77% of the online voters also supported the idea
    - However a number of people had concerns (20% event, 20% online)

Refining the metric scope

As a result of the initial modelling activities the Task Group felt it important to understand a selection of possible sensitivities within the assumptions used. The following section presents the areas of most interest and explains the significance of each aspect.

Thermal mass parameter

The Task Group has recommended that the Fabric Energy Efficiency Standard includes both space heating and space cooling demand to ensure designers and house builders are aware of the need to ensure both reduced heat loss during cold periods and reduced overheating risk during the summer months.

A key parameter within SAP 2009 that can influence cooling is known as the Thermal Mass Parameter (TMP). This is established by defining the materials used to construct the dwelling, in particular the internal elements and their finishes. Whilst thermal mass needs to be linked to a solar shading strategy and night time ventilation to be affective, modification of the TMP within cSAP provides a useful sensitivity check for its influence on the overall energy demand.

The following graph (Figure 35) illustrates that whilst changing the TMP does have a noticeable effect it is typically limited to +/- 2 kwh/m^2/yr. Therefore the Task Group is satisfied that the modelled assumption of a medium TMP does not unnecessarily limit the design solutions available to achieve the standard.

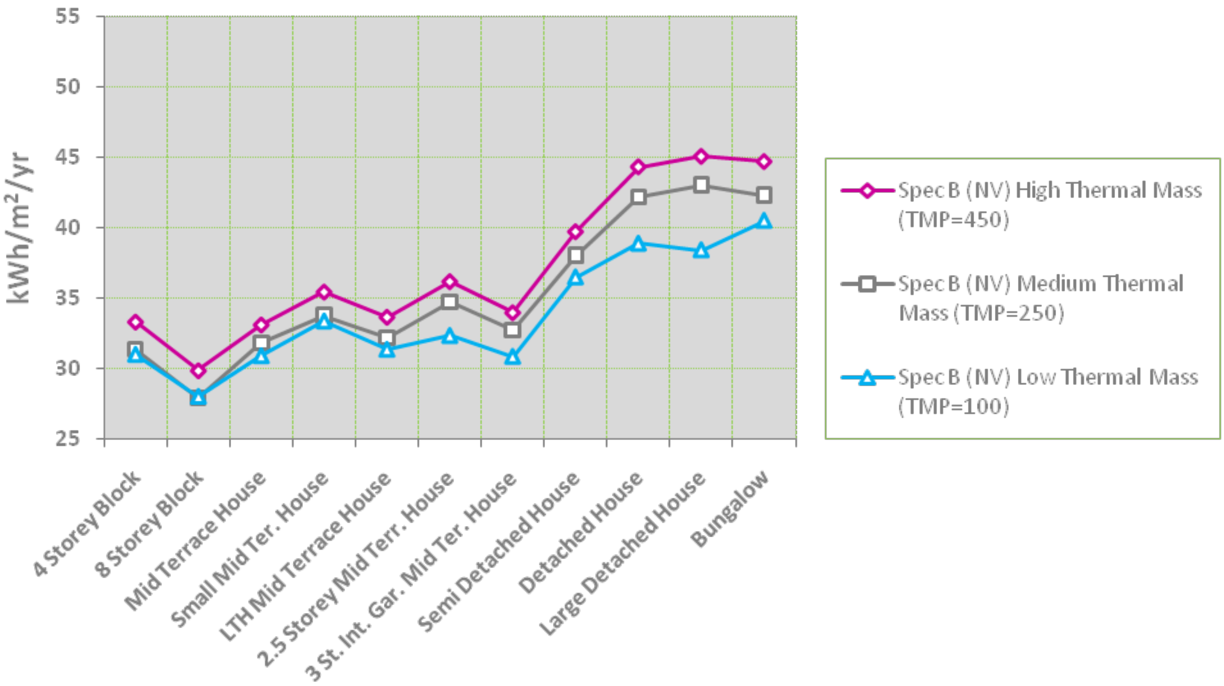


Figure 35: Thermal mass sensitivity analysis

Orientation

In a similar manner to thermal mass the orientation of a dwelling can in principle have a significant affect on its heating and cooling demand. The Task Group was therefore interested to understand the influence the assumed orientation used for the specification modelling would have on the overall performance.

The following graph (Figure 36) illustrates the affect of rotating the various house types between North, East and South within the cSAP model.

The results indicate that, as with the thermal mass, an impact can be identified but this is typically limited to +/- 2 kwh/m^2/yr. It is therefore acceptable to conclude that the Task Group's work is not based on an assumed orientation that would mean the Fabric Energy Efficiency Standard was unachievable on anything but the most advantageous site orientations.

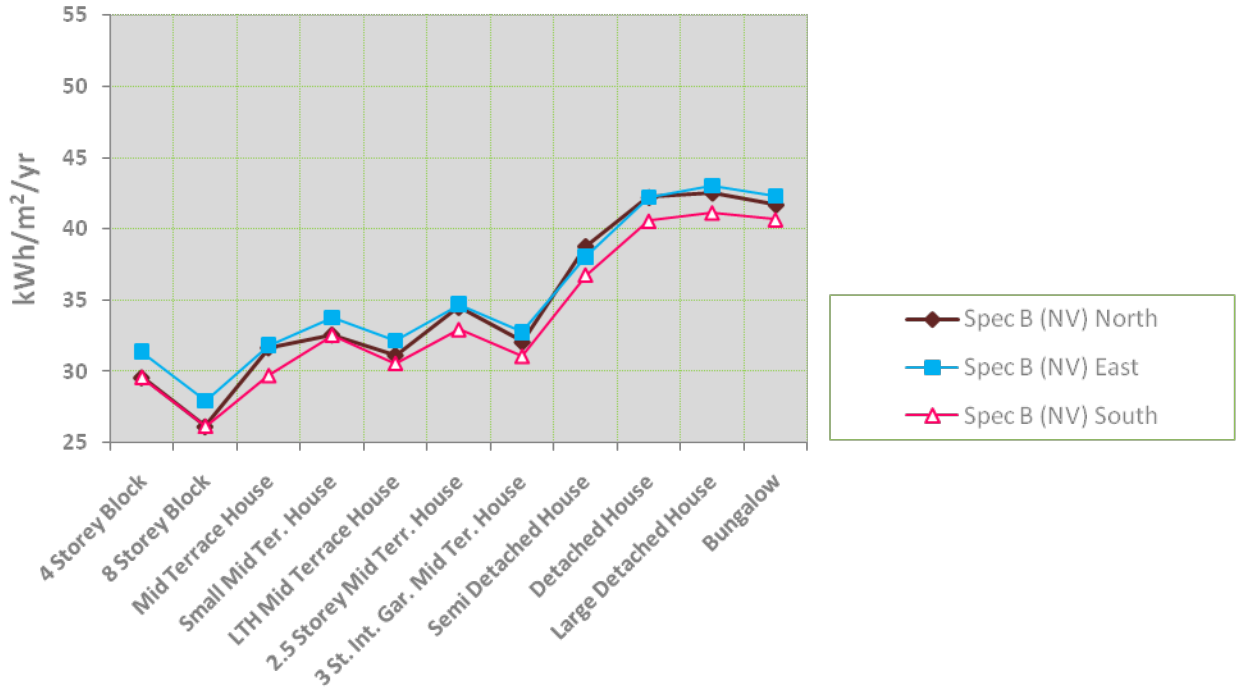


Figure 36: Orientation sensitivity analysis

Air permeability

The decision to define the Fabric Energy Efficiency Standard without the inclusion of whole house ventilation with heat recovery raised the question of what effect air permeability levels would have on the various natural ventilation specifications.

It is important to note that by recommending a performance standard, in kWh/m^2/yr, the Task Group does not need to define a specific air permeability target or 'back stop'. The modelling included within this report has solely been used to inform the definition of the levels and is in no way intended to inform exact designs aiming to achieve the standard.

With this in mind the following graph (Figure 37) illustrates that within a natural ventilation scenario the specifications are not acutely sensitive to a change from 3 m^3/h/m^2@50Pa to 5 m^3/h/m^2@50Pa. The effect is similar in magnitude to that previously discussed for changes to thermal mass and orientation.

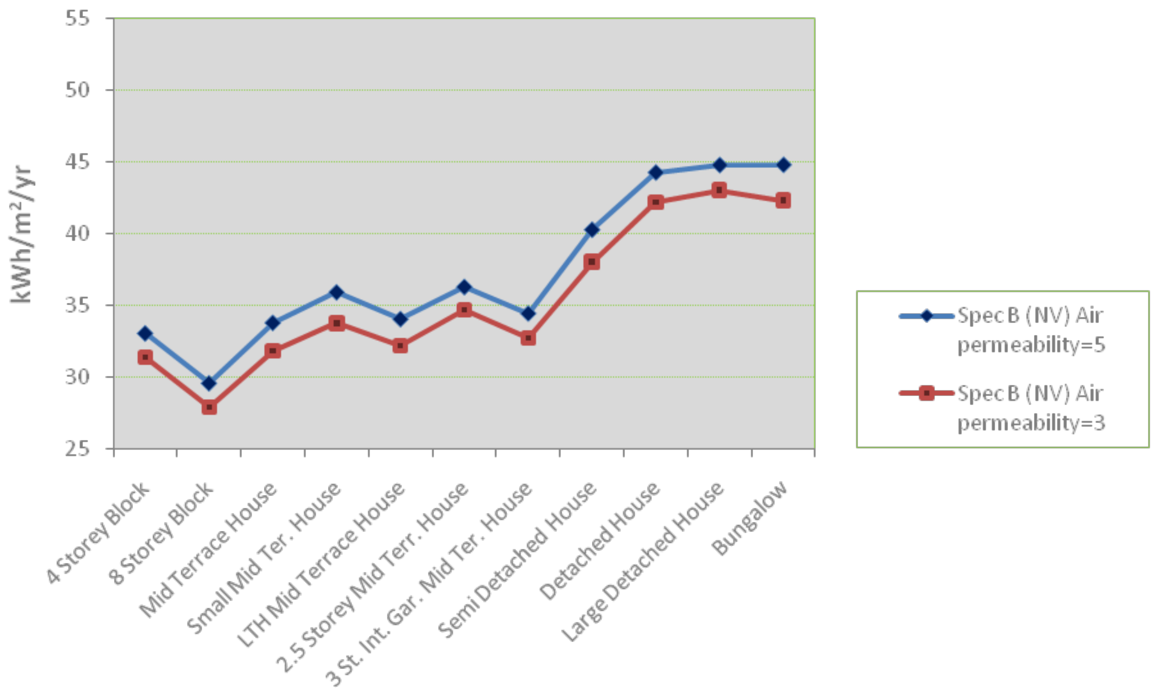


Figure 37: Air permeability sensitivity analysis

Internal gains due to hot water storage and distribution

In more energy efficient dwellings the internal gains provided by passive solar, lights, appliances and the occupants themselves can play a significant role in fulfilling the space heating demand.

The Task Group was concerned that the inclusion of gains from any domestic hot water storage and distribution system present may have the potential to produce some unintended consequences.

The following graph (Figure 38) illustrates the effect of removing the assumption of these gains from the cSAP model. To aid understanding, this is as if the dwelling design had been changed from one with an individual hot water storage cylinder to one with instantaneous electric hot water heaters at the point of use.

It is immediately clear from the graph that this assumption can have a significant effect on the dwellings space heating demand when modelled to demonstrate the Fabric Energy Efficiency Standard. The impact can be identified as around 7 kwh/m^2/yr.

One potential unintended consequence of including gains of this type is that dwellings serviced by a communal boiler, which have no individual storage cylinder, would be required to have a higher fabric specification to achieve the minimum level.

The Task Group considered this an unacceptable sensitivity and has therefore concluded that the Fabric Energy Efficiency Standard should be exclusive of gains from domestic hot water storage and distribution systems.

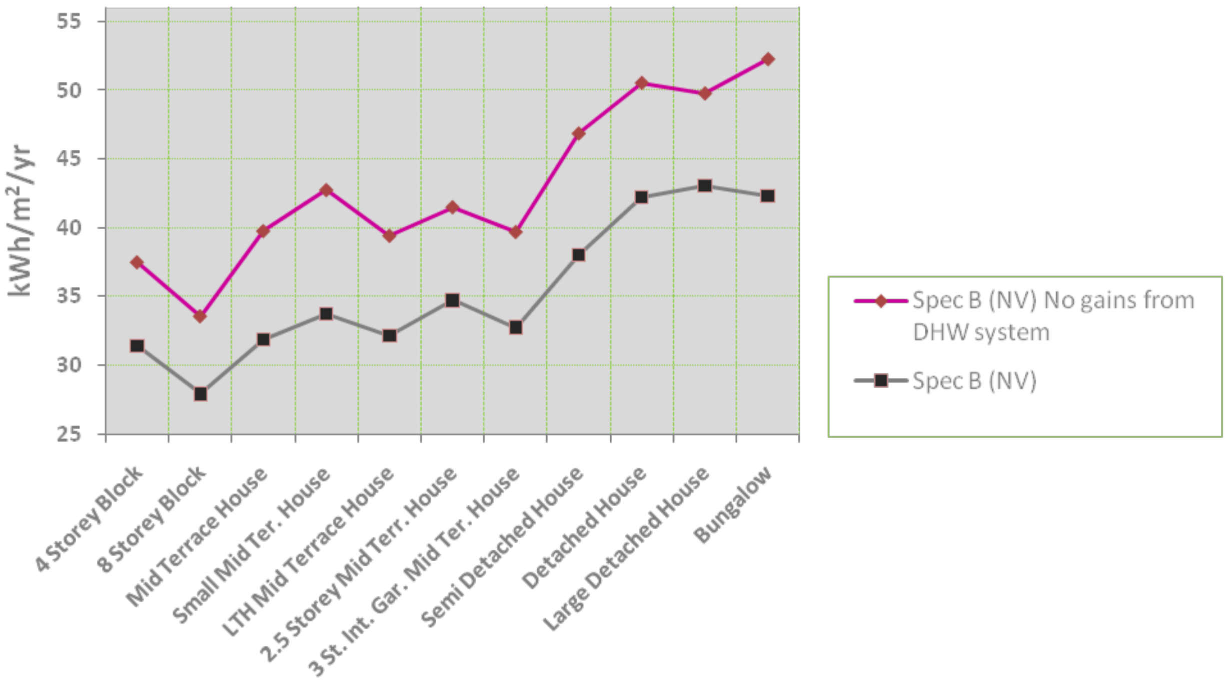


Figure 38: Hot water (DHW) system related internal gains sensitivity analysis

Standard levels

As a result of the energy and financial modelling, technical and buildability analysis, and consulting on an initial range the Task Group recommends the following:-

- **39 kWh/m²/yr for space heating and cooling demand in apartments (averaged as per current Part L conventions) and mid terrace houses**
- **46 kWh/m²/yr for space heating and cooling demand in end of terrace, semi detached and detached houses**

The following graph (Figure 39) places these two levels (red line) in context of current practice and the Passivhaus standard. It can be seen that to achieve the standard, apartments, mid terraces and semi detached houses will typically have to be designed to Spec B or similar, with detached houses having to be designed to approximately Spec C-. This is illustrated more clearly on the following page (Figures 40 & 41).

Those involved in the consultation process will recognise that the energy demand levels adopted have increased. This does not represent a change in ambition but is due to the removal of hot water gains from the calculation (and therefore the minimum level). This is due to potentially unintended consequences associated with hot water system choice as explained further in the previous section.

Figure 39: Task Group recommended Fabric Energy Efficiency Standard

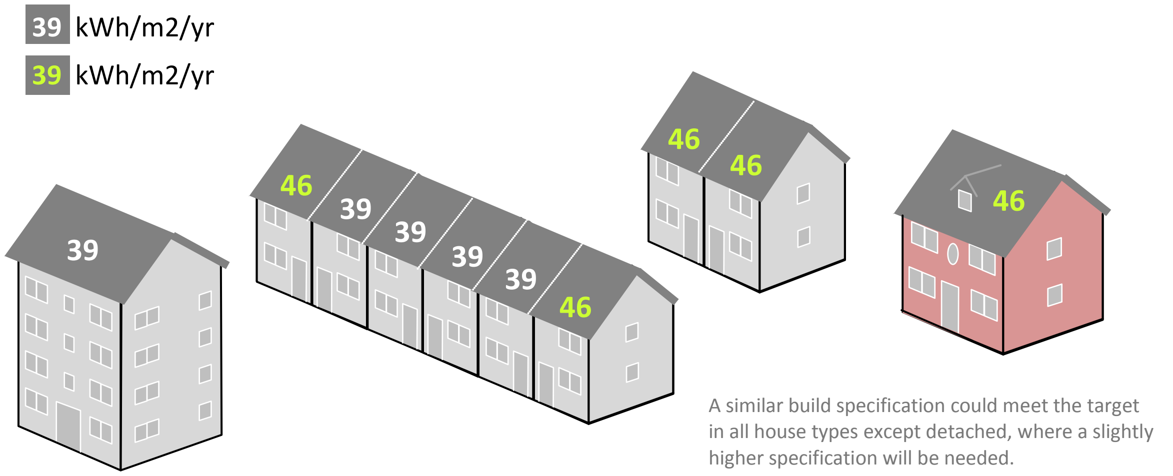


Figure 40: Example of the relationship between build specification and standard level

	Dwelling type			
	4-storey apt. block	Mid terrace	End terrace / Semi	Detached
Target Fabric Energy Efficiency Standard ($kWh/m^2/yr$)[30]	39	39	46	46
Wall U-value (W/m^2K)	0.18	0.18	0.18	0.18
Floor U-value (W/m^2K)	0.18	0.18	0.18	0.14
Roof U-value (W/m^2K)	0.13	0.13	0.13	0.11
Window U-value (W/m^2K)	1.4	1.4	1.4	1.3
Air permeability ($m^3/m^2/hr$ @ 50Pa)	3	3	3	3
Thermal bridging y-value (W/m^2K)	0.05	0.05	0.05	0.04

Figure 41: Example fabric specifications to achieve the Fabric Energy Efficiency Standard for different dwelling types

Government was considering challenging standards such as PassivHaus and Energy Saving Trust Advanced Practice Energy Efficiency Standard in its December 2008 Zero Carbon consultation. On balance and taking into account a range of important decision criteria the Task Group decided that the above levels (Figure 40) would be more appropriate.

It is important to note that as the Fabric Energy Efficiency Standard is expressed as a 'performance metric' ($kWh/m^2/yr$), rather than a set of elemental backstops, the example fabric specifications (Figure 41) can be fine tuned by designers and house builders to take advantage of their particular site, supply chain and construction skills.

The Task Group's recommendation for the development of design guidance means that a variety of potential solutions to the standard will be available to industry.

[30] Based on cSAP modelling. This may require re-basing when the final version of SAP2009 is available.

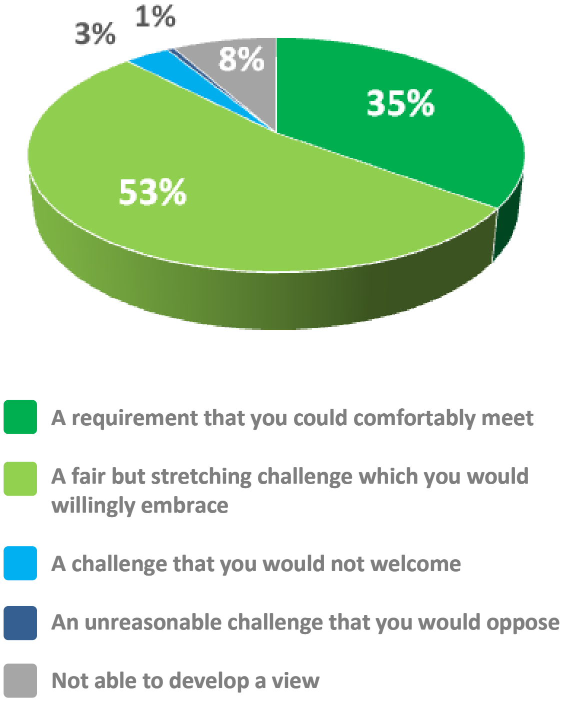


Figure 42: Consultation feedback on the degree of challenge represented by the suggested performance requirements

Consultation feedback

- The level of challenge proposed was questioned via live voting at the three consultation events (albeit with the DHW gains included in the figures shown)
- As illustrated in the chart above when asked:-
    - 88% of people considered it a fair or comfortably achievable level range
    - 3% of people considered it a challenge they would not welcome

Demonstrating compliance

The following diagram (Figure 43) illustrates the basic principle that is proposed for demonstrating compliance with the Fabric Energy Efficiency Standard. It can be seen that all calculations required are already within SAP and therefore can be automatically generated as outputs.

The main area to note is the use of a notional dwelling which assumes natural ventilation and no internal gains from DHW as defined previously in the scope of the standard.

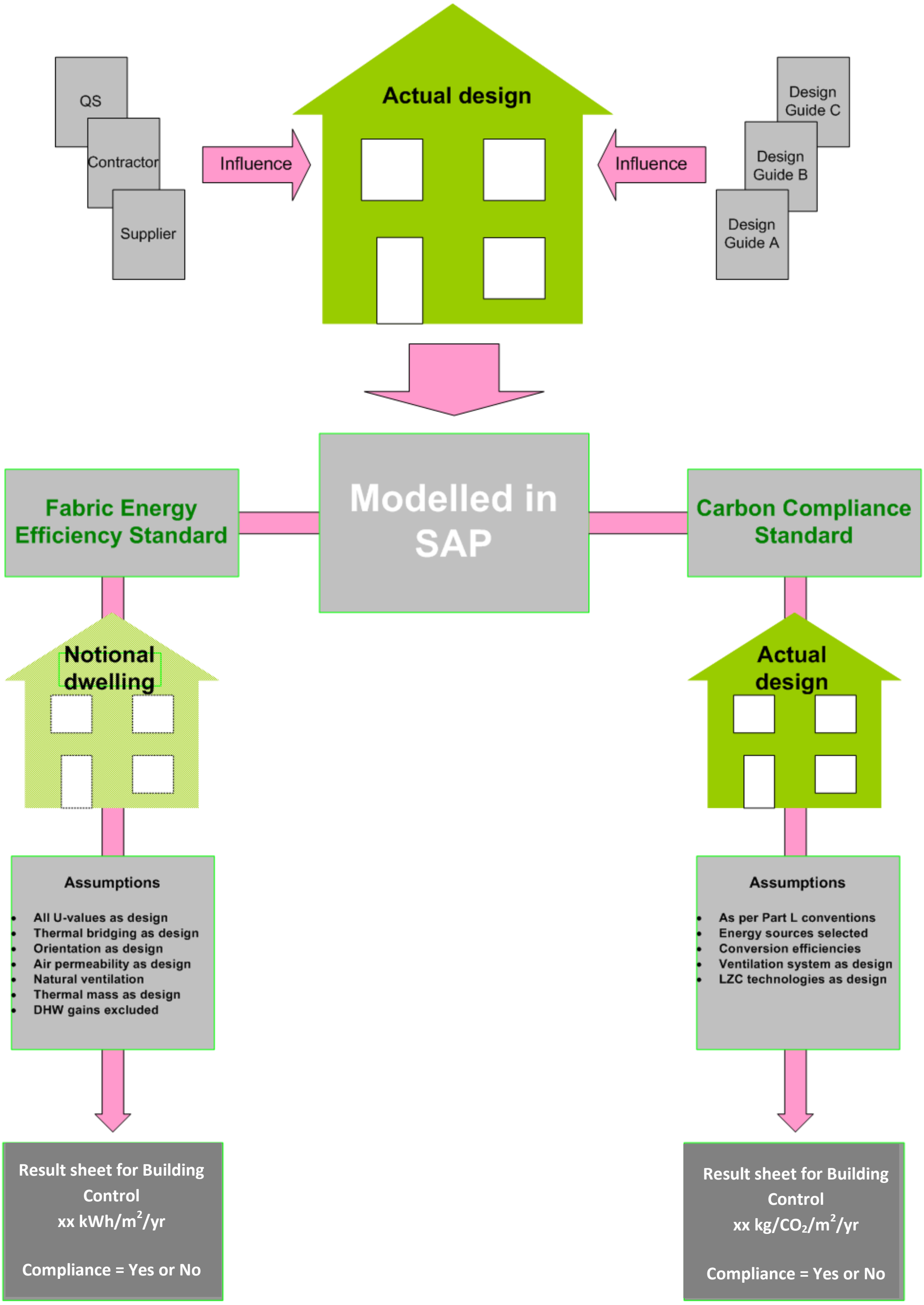


Figure 43: Demonstrating compliance with the Standard

Introduction timeframe for the Fabric Energy Efficiency Standard

The Task Group were requested by CLG to provide not only recommendations as to what the Fabric Energy Efficiency Standard for zero carbon homes should be, but also the timeframe within which this would be introduced towards the 2016 policy date.

A selection of scenarios was consulted upon including:-

- Introduced before 2013
- One step at 2013
- Two steps first at 2013 then 2016
- One step at 2016

The recommendation from both the Task Group and through the consultation process is for a two step introduction, with the Standard implemented in 2016 but with an interim step at 2013. Within the timescales available for this initial project the Task Group has concluded that the exact details of what the '2013 step' might include requires further research.

The discussions have centred around either:-

- A interim performance target which is less onerous than the 2016 level, or,
- An increased testing and monitoring programme from 2013 focusing on key aspects including air permeability, thermal bridging and installation quality to accelerate industry learning prior to 2016

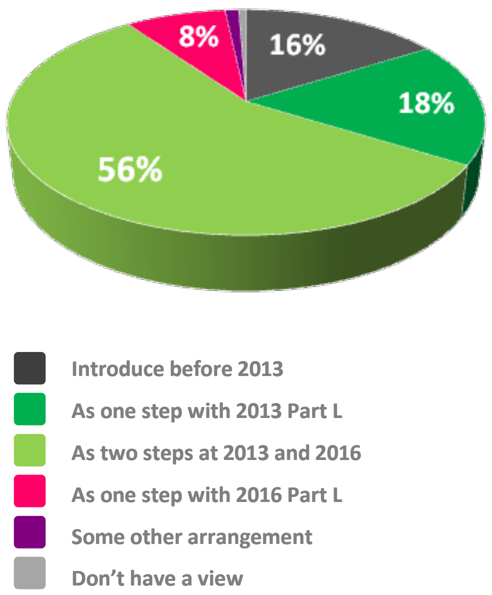


Figure 44: Consultation feedback on the timeframe for introduction of the Standard

Consultation feedback

- The timetable for introduction was questioned via live voting at the three consultation events
- As illustrated in the charts above when asked:-
  - 56% preferred the two step 2013 / 2016 approach

Policy definition announcement date

In a similar manner to the exact policy introduction the Task Group considered it important to understand exactly when the Fabric Energy Efficiency Standard levels should be formally defined. A selection of possible timescales was consulted upon:-

- 2010 with Part L
- 2011
- 2012
- 2013 with Part L
- 2014
- 2015
- 2016

The recommendation is for an announcement at the earliest possible opportunity to provide industry with the maximum amount of certainty on their journey to 2016 and beyond. It is recognised that this is a challenging timescale for Government and that further consideration is required to ensure the necessary policy assessments take place.

To date the discussions have centred around either:

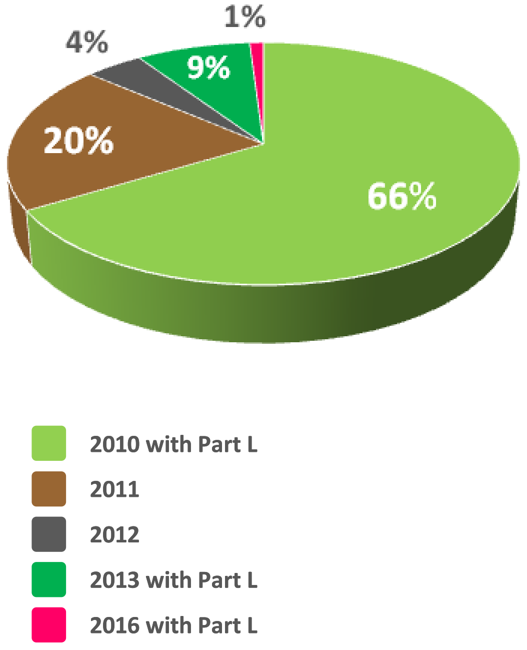


Figure 45: Consultation feedback on the date for announcement of the policy decision

Consultation feedback

- The policy announcement date was questioned via live voting at the three consultation events and the online questionnaire
- As illustrated in the chart above when asked:-
    - 64% preferred an announcement in 2010 with Part L
    - 10% preferred an announcement in 2013 with Part L
    - Only 1% preferred an announcement in 2016

Requirements for future work

During the Task Group's work it has become apparent that a number of areas closely related to the Fabric Energy Efficiency Standard require, or will in the near future require, further research and investigation. This section provides a brief summary of the key areas. Some of these issues will need resolving prior to the formal introduction of the Fabric Energy Efficiency Standard.

	Zero Carbon Hub	Government	Research
Integration into Code for Sustainable Homes consultation		CfSH	
Health / Air permeability / Ventilation	Task Group*	Part F	Required*
Overheating	Task Group*	Part L	Required*
SAP 2009 modelling tool development / rebasing	Task Group*	SAP / Part L	
Additional dwelling modelling		Required*	
Design Guidance	Task Group* / industry		
Daylight requirements		Required*	
Land take costs	Task group*		
Certification, Verification & Audit	Task Group*	Part L	Required*
Actual dwelling performance	Facilitation*	TSB / other	Required*

Figure 46: Overview of supplementary work required

Energy modelling

All of the energy modelling has, by necessity of the timescales, been conducted using cSAP. Whilst this is the most current version of SAP it is by definition open to modification due to its consultation status. Any changes within the calculation assumptions will have an affect on the performance levels that a particular construction specification achieves. Therefore:-

- The level figures of 39 and 46 $kWh/m^2/yr$ recommended in this report will need to be reassessed if there are any changes to SAP now or in the future
- Sensitivity analysis within this project has raised questions around the assumptions used to calculate cooling demand within cSAP which requires further analysis
- A wider selection of dwelling types and combinations need to be modelled to further ensure that the levels defined will not result in any unintended consequences for more unusual layouts

Financial modelling

The complex interaction between energy efficiency and Carbon Compliance strategies needs further consideration including:-

- Costing of a wider selection of LZC technologies (beyond SHW and PV) for 70% Carbon Compliance
- The potential impact of future feed-in tariffs on the predicted Lifecycle costs for 70% Carbon Compliance
- The significance of increased wall thicknesses on plotting factors and therefore, potential, loss of revenue from the reduced number of units within typical developments

Links to Part L implementation

As Part L 2010 is still subject to change following its consultation process it is not possible to fully investigate the implications of this on the proposed Fabric Energy Efficiency Standard. Therefore:-

- The link between the final Part L 2010 approach and the role of the Fabric Energy Efficiency Standard in achieving 70% Carbon Compliance needs investigation
- A more detailed understanding and recommendations for the exact manner of the proposed two stage introduction of the Fabric Energy Efficiency Standard needs to be developed
- The exact manner in which dwelling types are defined (e.g. semi detached, mid terrace) needs to be clarified and included within future revisions of Part L
- There maybe a case for including a minimum daylight factor within future versions of Part L to encourage better design, reduce artificial lighting demand improve indoor environments

Links to the Energy Performance of Building Directive (EPBD) recast

Due to the timeframe within which this research has been conducted the Task Group has not been able to consider the potential implications of the current discussions surrounding the EPDB recast. Therefore:

- The implications of the EPBD recast when announced need to be investigated further

Scope and contents of design guidance

An important supporting aspect of the Task Group's recommendation for a Performance Metric is the concept of supporting design guidance. Therefore:

- An industry work group should be created to agree the scope, contents and communication style for such guidance
- The issue of designing to achieve a balance between heat loss through glazing and maximising usage of natural daylight is of particular interest
  - Recommendations generated in Work Group 3 – Lighting include the requirement for a minimum daylight factor for various rooms in order to reduce demand for artificial lighting
  - Without this link there is a concern that designs maybe developed that reduced glazed areas in order to minimise heat loss at the expense of natural light

Health and well being

Discussions within the Task Group have highlighted several issues with health and well being when setting this minimum energy efficiency standard. As highlighted by the previously mentioned NHBC Foundation research there is currently a lack of detailed understanding across industry in this area. [31]Therefore:

- The link between reduced air permeability and suitable ventilation systems requires increased levels of monitoring and technical research

Compliance and verification processes

The Fabric Energy Efficiency Standard is by definition a 'design standard'. However the Task Group is acutely aware of the important role compliance and verification plays in closing 'the gap' between designed performance and that achieved in reality. Therefore the following investigations should be considered:

- Certification and verification of products, systems and designs?
- Increased frequency of post construction testing to accelerate industry learning towards 2016
- A review of the building regulations compliance and verification requirements

[31] NHBC Foundation *2009 Indoor air quality in highly energy efficient homes – a review*

Appendices

The following sections provide links to greater detail regarding the Work Group's activities including the underlying technical and financial assumptions used within their investigations.

Appendix A – Work Group 1 – Fabric and form

Further information regarding the energy modelling, design details and construction discussions can be downloaded from the Zero Carbon Hub website via the link below:-

www.zerocarbonhub.org

Appendix B – Work Group 2 – Services

Further information regarding the role of building services in future zero carbon homes and discussions regarding how the key elements of such systems may develop between now and 2016 can be downloaded from the Zero Carbon Hub website via the link below:-

www.zerocarbonhub.org

Appendix C – Work Group 3 – Lighting

Further information regarding the role of natural daylight design and artificial lighting in future zero carbon homes plus discussions regarding how light source types may develop between now and 2016 can be downloaded from the Zero Carbon Hub website via the link below:-

www.zerocarbonhub.org

Appendix D – Cost analysis

Further information regarding the methodology and key assumptions used for the Energy Efficiency and Carbon Compliance related capital and life cycle costing exercises can be downloaded from the Zero Carbon Hub website via the link below:-

www.zerocarbonhub.org

Appendix E – Task Group Assessment Matrix

Further information regarding the discussions and development of the Assessment Matrix can be downloaded from the Zero Carbon Hub website via the link below:-

www.zerocarbonhub.org

Appendix F – Consultation activities

Further information regarding the three consultation events and online survey, including copies of the presentations and questions asked can be downloaded from the Zero Carbon Hub website via the link below:-

www.zerocarbonhub.org

Appendix G – Task Group members

Further information regarding the organisations and individuals represented on both the Task Group and three Working Groups can be downloaded from the Zero Carbon Hub website via the link below:-

www.zerocarbonhub.org

The following page provides an overview of the members involved in the research and delivery of this project

Energy Efficiency Specification Task Group

Members List

Number: Date: **November 2009**

Revision: **17** Issue: **Final**

Task G:	Core group	**XXX**	Substitute when necessary
WG1:	Form & Fabric	**XXX**	**Copy information only**
WG2:	Services		
WG3:	Lighting		

Category	Organisation	Name	Task G	WG1	WG2	WG3
Lead	Zero Carbon Hub	David Adams	√	√	√	√
		Rob Pannell	√	√	√	√
Technical author	Zero Carbon Hub	Ross Holleron	√	√	√	√
Project manager	Zero Carbon Hub	Edward Mayes	√	√	√	√
Technical manager	Zero Carbon Hub	Tessa Parnell	√	√	√	√
(Tech Manager role where shaded – Member role where not shaded)	Aecom	John Palmer	√	-	√	-
	Aecom	Martin Valentine	√	-	-	√
Cost consultant	Davis Langdon	Jobran Hammoud	√	-	-	-
	Zero Carbon Hub	Ian Butterss	-	√	-	-
Architect	Richards Partington Architects	Alex Dutton / Richard Partington	√	-	-	-
Large housebuilders	HBF (& BRAC)	Dave Mitchell	√	√	√	√
	Barratt	Terry Ritchie / Derric Heyden / Jacquelyn Fox	√	-	-	-
	Crest Nicholson	Gordon Andrews (Elizabeth Ness)	√	-	-	-
	Crest Nicholson	Paul Greenland	-	√	-	-

Category	Organisation	Name	Task G	WG1	WG2	WG3
Medium house builders	HBA	Roger Humber	√	√	√	√
	Fairview	Kirk Archibald	√	√	-	-
	Countryside Properties	Andrew Day	-	-	-	√
Small house builders	FMB	Peter O'Connell	√	-	-	-
	Good Homes Alliance	Neil May	√	-	-	-
Construction products	CPA (& BRAC)	John Tebbit	√	√	√	√
Industry Bodies	Lighting Industry Federation	Nic Mallinson	-	-	-	√
	Heatrae Sadia Heating	Alan Clarke	-	-	√	-
	Hot Water Association	Martyn Griffiths	-	-	√	-
	BEAMA	Kelly Butler	-	-	√	-
	Ian Andrews Associates (Aereco)	Ian Andrews	-	-	√	-
	Heating & Hotwater Ind.	Chris Yates	-	-	√	-
	FETA / Space Air	Cedric Sloan / Neil Afram	-	-	√	-
	Vent Axia	Lee Nurse	-	-	√	-
Consultants	Aecom	Steve Irving (David Ross)	√	-	-	-
	Aecom	David Ross	-	-	√	-
	Inbuilt	Nick Jones	-	-	-	√
Academics	UCL	Bob Lowe (Tadj Oreszczyn)	√	√	-	-
	Leeds Metropolitan	Malcolm Bell	√	√	-	-
	UCL	Peter Raynham	-	-	-	√
Standards / BC / Consumer	NHBC	Mike Priaulx	√	-	-	-
	Robust Details	David Baker	√	√	-	-
	EST	Mat Colmer	√	-	-	-

Category	Organisation	Name	Task G	WG1	WG2	WG3
Scale Up	HCA	Emyr Poole	√	-	-	-
	LGA - Planning (Haringey)	Sule Nisancioglu	√	-	-	-
	LGA - Building control (Barnet)	Richard Morcom	√	-	-	-
	RIBA (& BRAC)	Lynne Sullivan	√	√	-	-
	BRE	Alan Yates (CSH) (Lee Smith)	√	-	-	-
	BRE	Mich Swainson	-	-	√	-
	WWF	Zoe Leader (Simon McWhirter)	√	-	-	-
	AECB / Carbonlite	Liz Reason	√	-	-	-

Observers	CLG	Mark Davis	√	-	-	-
		Paul Decort	√	-	-	-
		David Craine (economist)	√	-	-	-
		Jeannette Henderson	-	-	-	-
		Mary Edmead (Copy info only)	-	-	-	-
	DECC	Hunter Danskin	√	-	-	-
		Alan Christie	√	-	-	-
		Neil Witney (copy info only)	-	-	-	-
	Scotland Government	Steven Scott	√	-	-	-
	Welsh Assembly	Francois Samuel	√	-	-	-

Zero Carbon Hub

The Zero Carbon Hub was established in the summer of 2008 to support the delivery of zero carbon homes from 2016. It is (we are) a public/private partnership drawing support from both government and the industry and reports directly to the 2016 Taskforce.

Zero Carbon Hub has developed five workstreams to provide a focus for industry engagement with key issues and challenges:

- Energy Efficiency
- Energy Supply
- Examples and Scale Up
- Skills and Training
- Consumer Engagement

To find out more about these workstreams, please visit **www.zerocarbonhub.org**.

If you would like to contribute to the work of the Zero Carbon Hub, please contact **info@zerocarbonhub.org**.

LONDON OFFICE
62-68 Rosebery Avenue
London EC1R 4RR

MILTON KEYNES OFFICE
NHBC House, Davy Avenue
Milton Keynes MK5 8FP

T 0845 888 7620
F 0871 813 0569
info@zerocarbonhub.org
www.zerocarbonhub.org