Communities and Local Government

Zero Carbon Homes

Impact assessment (December 2009)

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Zero Carbon Homes

Impact assessment

December 2009
Department for Communities and Local Government

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Impact assessment

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Department /Agency: **Communities and Local Government**	**Title:** **Updated Impact Assessment on Zero Carbon Homes: Fabric Energy Efficiency Standard proposal**	
Stage: Consultation	**Version:** 2.0	**Date:** 16 December 2009
Related Publications: Zero Carbon Hub Taskforce report on energy efficiency standard; Definition of Zero Carbon Homes Impact Assessment (July 2009 and December 2008); Consultation on the Code for Sustainable Homes (December 2009)		

Available to view or download at:
www.communities.gov.uk/planningandbuilding/theenvironment/zerocarbonhomes/

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What is the problem under consideration? Why is government intervention necessary?

The housing stock represents 27 per cent of UK emissions and new additions have a long lifespan so it is important to take the opportunity to reduce their environmental and carbon dioxide impact when they are first built.

The market will not deliver carbon savings from new buildings alone in the timescale needed, due to financial barriers and market imperfections (such as lack of information), so the Government proposes regulating a zero carbon homes standard to achieve this. This updated impact assessment supports announcement of further details of the definition of zero carbon homes, i.e. the fabric energy efficiency standard to be required for zero carbon homes.

What are the policy objectives and the intended effects?

To set a clear, ambitious and realistic trajectory for substantially reducing carbon emissions from energy use in new homes.

The objectives are to have zero net emissions of carbon dioxide from all energy use in new homes from 2016. This comes from improved energy efficiency of buildings, a low or zero carbon energy supply and other measures equivalent to the remaining emissions. Other effects include increasing the supply of renewables, effecting a transformation in the market and bringing forward low and zero carbon technologies.

What policy options have been considered? Please justify any preferred option.

1. Do nothing.
   Reference case: 25 per cent reduction on 2006 Part L Building Regulations from 2010 and 44 per cent reduction from 2013.
2. 70 per cent reduction on Part L 2006 in 2016 with the energy efficiency requirement proposed by the Zero Carbon Hub Taskforce and allowable solutions for dealing with the remaining emissions.
3. As option 2 (70 per cent carbon compliance) with more demanding Advanced Practice energy efficiency (APEE) and allowable solutions to deal with the remaining emissions.

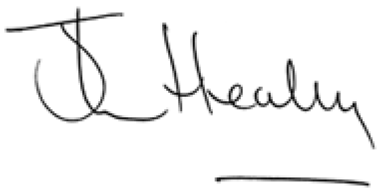
When will the policy be reviewed to establish the actual costs and benefits and the achievement of the desired effects?

This is the third consultation on aspects of the zero carbon homes definition. The impact assessment will be further updated as further aspects of the policy are announced.

Ministerial sign-off For consultation stage Impact Assessments:

I have read the impact assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible minister:



Date: 16 December 2009

Summary: Analysis & Evidence

Policy Option: Reference case	Description: A 25 per cent reduction on 2006 Part L in 2010 and 44 per cent in 2013; these are the two interim steps before applying the zero carbon homes standard from 2016

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'	
One-off (Transition)	**Yrs**	£0.5bn upfront capital cost plus £0.3bn maintenance costs to reach 25 per cent improvement in 2010. A further £5.5bn capital costs to reach 44 per cent improvement in 2013, plus £3.0bn maintenance costs. These steps both assume an energy efficiency standard broadly similar to Best Practice Energy Efficiency (BPEE). Construction costs are borne by house builders and land owners, and ongoing servicing and maintenance costs are borne by house holders or Energy Service Companies. (ESCOs).	
£5m one-off cost to industry of 2013 Building Regulations change	56		
Average Annual Cost (excluding one-off)			
£0.4bn		**Total Cost** (PV)	**£9.3bn**

Other **key non-monetised costs** by 'main affected groups'.
Costs reflect capital spend of housebuilding (from 2008 to 2025) and servicing and maintenance costs for the lifetimes of the technologies.

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'	
One-off	**Yrs**	£4.6bn financial benefits via fuel bills plus £0.5bn carbon benefits in traded sector and £2.1bn carbon benefits in non-traded sector. Avoided cost of renewables monetised at £0.9bn for reduced energy usage and £2.0bn for renewable energy generated. Average household fuel bill savings of up to £110 per year. The avoided cost of renewables and retail value of fuel bill savings are not included in the Total Benefit or NPV below.	
£0	56		
Average Annual Benefit (excluding one-off)			
£0.3bn		**Total Benefit** (PV)	**£7.1bn**

Other **key non-monetised benefits** by 'main affected groups'.
Diversifying energy mix and helping Government's targets for decarbonising energy supply; action to meet CO_2 targets – the reference case saves a total of 13 $MtCO_2$ in the traded sector and 49$MtCO_2$ in the non-traded sector, totalling 62 $MtCO_2$ by 2065 (from homes built by 2025); reducing dependence on fossil fuels; lower fuel prices for consumers; fewer EU Emissions Trading Scheme (ETS) allowances required by UK generators.

Key Assumptions/Sensitivities/Risks Central electricity price assumptions from interdepartmentally-agreed guidance (with sensitivity on high and low prices); housebuilding projections following Government's targets; modelling done by consultants - see methodology annex to impact assessment and Zero Carbon Hub Taskforce report on fabric energy efficiency standard. Annual costs and benefits occur over 56 years (from 2008 to end of policy impacts in 2065). Net benefit range below reflects sensitivity on energy prices and carbon values.

Price Base Year 2009	**Time Period Years** 56	**Net Benefit Range** (NPV) **£0.2bn to £–5.6bn**	**NET BENEFIT** (NPV Best estimate) **£–2.2bn**

What is the geographic coverage of the policy/option?			England	
On what date will the policy be implemented?			2010–2013	
Which organisation(s) will enforce the policy?			Building control bodies	
What is the total annual cost of enforcement for these organisations?			£	
Does enforcement comply with Hampton principles?			Yes	
Will implementation go beyond minimum EU requirements?			N/A	
What is the value of the proposed offsetting measure per year?			£	
What is the value of changes in greenhouse gas emissions?			£3.8bn	
Will the proposal have a significant impact on competition?			No	
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?	No	No	N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices)		(Increase – Decrease)
Increase of £8.1m from 2013 onwards	Decrease of £	**Net Impact £8.1m**

Key:	**Annual costs and benefits: Constant Prices**	**(Net) Present Value**

Summary: Analysis & Evidence

Policy Option: 2	Description: Require Energy Efficiency standard as proposed by Zero Carbon Hub Taskforce from 2016 as part of 70 per cent carbon compliance, and allowable solutions to abate residual emissions to reach zero carbon

COSTS			
ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups' All costs and benefits are additional to the baseline of 25 per cent reduction on Part L 2006 standards from 2010 and 44 per cent from 2013 (i.e. the reference case), so represent the marginal impact of the policy. Additional construction costs caused by the policy fall mainly on the housebuilder or landowner. Total cost comprised of cost of onsite capital costs (£5.8bn), onsite servicing and maintenance costs (£4.6bn) and allowable solutions net cost (£2.1bn).	
One-off (Transition)	**Yrs**		
£5m one-off cost to industry of 2016 Building Regulations change	49		
Average Annual Cost (excluding one-off)			
£0.5bn		**Total Cost** (PV)	**£12.5bn**
Other **key non-monetised costs** by 'main affected groups'. Costs reflect capital spend of housebuilding (from 2008 to 2025) and servicing and maintenance costs for the lifetimes of the technologies. Indirect impact on economy of reduction of value of land caused by higher build costs; cost to society of need for 'back up' power station generation due to intermittency and unpredictability of some renewables. Additional CO_2 required due to use in Ground Source Heat Pumps: 6.9 $MtCO_2$			

<table>
<tr><td rowspan="6">BENEFITS</td><td colspan="2">ANNUAL BENEFITS</td><td colspan="2" rowspan="4">Description and scale of key monetised benefits by ‘main affected groups’
£3.2bn financial benefits via fuel bills plus £1.6bn carbon benefits in traded sector and £2.7bn carbon benefits in non-traded sector. Avoided cost of renewables monetised at £0.2bn for reduced energy demand and £7.8bn for renewable energy generated. Additional household fuel bill savings of up to £180 compared to reference case. The avoided cost of renewables is not included in the Total Benefit or NPV below. The NPV range represents the sensitivity analysis on this option.</td></tr>
<tr><td>One-off</td><td>Yrs</td></tr>
<tr><td>£0</td><td>49</td></tr>
<tr><td colspan="2">Average Annual Benefit
(excluding one-off)</td></tr>
<tr><td>£0.3bn</td><td></td><td>Total Benefit (PV)</td><td>£7.4bn</td></tr>
<tr><td colspan="4">Other key non-monetised benefits by ‘main affected groups’.
Diversifying energy mix and helping Government meet targets on decarbonising energy supply and CO_2 reduction targets. Option 2 saves a total of 41 $MtCO_2$ onsite and a further 85 $MtCO_2$ through allowable solutions over policy lifetime on top of reference case savings. Other benefits: reducing dependence on fossil fuels; business and employment opportunities of developing and deploying low carbon solutions; lower fuel prices for consumers.</td></tr>
</table>

Key Assumptions/Sensitivities/Risks Energy prices and carbon values from interdepartmentally-agreed guidance (with sensitivity on high and low fuel prices); housebuilding projections following Government's targets (~1.7 million of new homes built from 2016 are zero carbon). Annual costs and benefits occur over 49 years (from 2016 to 2065). The net benefit range below reflects sensitivity for energy prices, carbon values, and allowable solutions.

Price Base Year	Time Period Years	Net Benefit Range (NPV)	NET BENEFIT (NPV Best estimate)
2009	49	**£–2.8bn to £–8.7bn**	**£–5.1bn**

What is the geographic coverage of the policy/option?			England	
On what date will the policy be implemented?			2016	
Which organisation(s) will enforce the policy?				
What is the total annual cost of enforcement for these organisations?			£	
Does enforcement comply with Hampton principles?			Yes	
Will implementation go beyond minimum EU requirements?			N/A	
What is the value of the proposed offsetting measure per year?			£	
What is the value of changes in greenhouse gas emissions?			£4.2bn	
Will the proposal have a significant impact on competition?			No	
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?	No	No	N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices)		(Increase – Decrease)
Increase of £11.6m occurring from 2016 onwards	Decrease of £	**Net Impact £11.6m**

Key:	**Annual costs and benefits: Constant Prices**	**(Net) Present Value**

Summary: Analysis & Evidence

Policy Option: 3	Description: Require Advanced Practice Energy Efficiency standard from 2016 as part of 70 per cent carbon compliance, and allowable solutions to abate residual emissions to reach zero carbon

COSTS	**ANNUAL COSTS**		Description and scale of **key monetised costs** by 'main affected groups' All costs and benefits are additional to the baseline of 25 per cent reduction on Part L 2006 standards from 2010 and 44 per cent from 2013 (i.e. the reference case), so represent the marginal impact of the policy. Additional construction costs caused by the policy fall mainly on the housebuilder or landowner. Total cost comprised of cost of onsite capital costs (£9.3bn), onsite servicing and maintenance costs (£4.6bn) and allowable solutions net cost (£2.1bn).
	One-off (Transition)	**Yrs**	
	£5m one-off cost to industry of 2016 Building Regulations change	49	
	Average Annual Cost (excluding one-off)		
	£0.7bn		**Total Cost** (PV) **£16.0bn**
	Other **key non-monetised costs** by 'main affected groups'. Indirect costs to economy of reduction in value of land caused by higher build costs; cost to society of need for 'back up' power station generation due to intermittency and unpredictability of some renewables.		
BENEFITS	**ANNUAL BENEFITS**		Description and scale of **key monetised benefits** by 'main affected groups' £3.2bn financial benefits via fuel bills plus £1.3bn carbon benefits in traded sector and £3.6bn carbon benefits in non-traded sector. Avoided cost of renewables monetised at £0.8bn for reduced energy demand and £7.4bn for renewable energy generation. Additional household fuel bill savings compared to reference case are up to £180 per year. The avoided cost of renewables is not included in the Total Benefit or NPV below. The NPV range represents the sensitivity analysis on this option.
	One-off	**Yrs**	
	£0	49	
	Average Annual Benefit (excluding one-off)		
	£0.3bn		**Total Benefit** (PV) **£8.1bn**
	Other **key non-monetised benefits** by 'main affected groups'. Diversifying energy mix and helping Government meet targets on decarbonising energy supply and CO_2 reduction targets; reducing dependence on fossil fuels; business and employment opportunities of developing and deploying low carbon solutions; lower prices for consumers.		

Key Assumptions/Sensitivities/Risks Energy prices and carbon values from interdepartmentally-agreed guidance (with sensitivity on high and low fuel prices); housebuilding projections following Government's targets (~1.7 million of new homes built from 2016 are zero carbon). Annual costs and benefits occur over 49 years (from 2016 to 2065). The net benefit range below reflects sensitivity around energy prices, carbon values and allowable solutions.

Price Base Year 2009	**Time Period Years** 49	**Net Benefit Range** (NPV) **£–5.5bn to £–11.9bn**	**NET BENEFIT** (NPV Best estimate) **£–8.0bn**

What is the geographic coverage of the policy/option?			England	
On what date will the policy be implemented?			2016	
Which organisation(s) will enforce the policy?				
What is the total annual cost of enforcement for these organisations?			£	
Does enforcement comply with Hampton principles?			Yes	
Will implementation go beyond minimum EU requirements?			N/A	
What is the value of the proposed offsetting measure per year?			£ unknown	
What is the value of changes in greenhouse gas emissions?			£4.9bn	
Will the proposal have a significant impact on competition?			No	
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?	No	No	N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices)		(Increase – Decrease)
Increase of £11.6m occurring from 2016 onwards	Decrease of £	**Net Impact £11.6m**

Key:	**Annual costs and benefits: Constant Prices**	**(Net) Present Value**

Evidence Base (for summary sheets)

Introduction to update of the impact assessment

1. This document presents an update of (and should be read alongside) the impact assessment on the Definition of Zero Carbon Homes published 16 July 2009[1], following a statement by John Healey on 24 November 2009[2] committing Government to consult on the energy efficiency standard proposed by a specialist task group by the Zero Carbon Hub[3]. The costs and benefits of the proposed standard are appraised, along with the standard that was appraised in previous impact assessments, and the carbon compliance costs updated accordingly. There is no update to the policy delivery or costing of allowable solutions and the analysis is the same as for the July 2009 impact assessment. Further analysis of allowable solutions will follow at a later date as the policy is further developed.

2. This impact assessment uses a similar approach to the July 2009 impact assessment except that it takes into account the latest guidance on grid decarbonisation assumptions and biomass prices for valuing the energy savings and costs. The model has changed and more detail can be found on this in the methodology and key assumptions section. Table 10 provides the figures on the previous basis for consistency with previous impact assessments and the non-domestic zero carbon work[4]. It shows that using the previous electricity carbon factors and biomass prices improves the NPV by about £1.8bn.

3. There are further details in this impact assessment of the dwelling-level costs and benefits, addressing responses to the consultation that said this would be helpful. It also serves to inform policy work on the regulatory burdens faced by house builders. The distribution analysis section looks at the availability of renewable energy financial incentives to developers and home owners. It is possible that developers could reduce their costs by setting up a mechanism to recoup these financial incentives.

4. The cost and benefit calculations – and the assumptions underlying them – are uncertain in an impact assessment looking ahead to a policy commencing in 2016. These will continue to change in future as evidence on technology costs, innovation rates and benefits valuation changes. They will also be influenced by behavioural aspects, i.e. how people actually use their homes, which also affect costs and benefits. As such, readers should bear in mind that these figures should be seen

[1] http://www.communities.gov.uk/publications/planningandbuilding/impactzerocarbon

[2] http://www.communities.gov.uk/news/corporate/1391989

[3] http://www.zerocarbonhub.org/news00005.php

[4] The zero carbon non-domestic buildings consultation, launched on 24 November 2009, has modelling underpinned by a model which was set up before the change in methodology of carbon emissions factors. More detail can be found here: http://www.communities.gov.uk/publications/planningandbuilding/newnondomesticconsult

as best available estimates at the present time[5]. The cost estimates will need to be updated from time to time as understanding of the policy and technologies develops. It is considered that greater transparency in cost estimates can play a useful role in helping industry to adapt to the policy. CLG will therefore work with industry, via the Zero Carbon Hub, to ensure that the industry understands the key assumptions underpinning the costs of delivering to the policy.

5. The written ministerial statement in July 2009 indicated the Government's thinking on the energy efficiency, carbon compliance and allowable solutions aspects of the definition of zero carbon, and confirmed that the carbon compliance level would be 70 per cent. This impact assessment therefore focuses on recommendations on energy efficiency by the Energy Efficiency Task Group in November 2009[6], and keeps the 70 per cent carbon compliance level and allowable solutions analysis as conducted in the July 2009 impact assessment. The impact assessment will be further updated from time to time as the policy develops.

Background

6. In December 2006, the Department for Communities and Local Government (the Department) issued a consultation document *Building a Greener Future: Towards Zero Carbon Development*[7]. That document consulted on proposals to progressively tighten Part L of the Building Regulations so that, from 2016, new homes would emit zero net carbon. Following the consultation, the Department issued its policy statement *Building a Greener Future: policy statement*[8] confirming Government's policy decision in July 2007. The policy statement was supported by a final regulatory impact assessment[9].

7. The July 2007 policy statement confirmed Government's intention that new homes should be zero carbon from 2016, with progressive reductions in the emissions currently regulated by the Building Regulations of 25 per cent and 44 per cent (relative to current 2006 Part L1a regulations) in 2010 and 2013 respectively. The details of the 2010 changes were issued for consultation on 18 June 2009[10].

[5] In order to avoid an unrealistic degree of precision in the presentation of costs and benefits, all present value (PV) figures have been rounded to one decimal place. Un-rounded figures are shown in the annex tables.

[6] http://www.zerocarbonhub.org/downloads/ZCH-Defining-A-Fabric-Energy-Efficiency-Standard-Task-Group-Recommendations.pdf

[7] http://www.communities.gov.uk/archived/publications/planningandbuilding/buildinggreener

[8] http://www.communities.gov.uk/publications/planningandbuilding/building-a-greener

[9] http://www.communities.gov.uk/publications/planningandbuilding/final-regulatory

[10] http://www.communities.gov.uk/publications/planningandbuilding/partlf2010consultation

8. *Building a Greener Future* recognised that there may be circumstances or sites where it would be difficult for developers to achieve zero carbon using the definition proposed in the July 2007 policy statement[11] and undertook to consult again on how to reach zero carbon in such circumstances. In December 2008, the Government consulted upon a proposed approach which would apply in all situations, based on a hierarchy of energy efficiency standards, carbon compliance standards, and allowable solutions for dealing with the remaining emissions[12]. A summary of responses was published in July 2009[13].

9. In July 2009, John Healey, the Minister for Housing and Planning, issued a Written Ministerial Statement[14], accompanied by an updated impact assessment[15], in which he set out that the definition of zero carbon homes would follow the overall approach proposed in the December 2008 consultation and, among other things:

   - announced the formation of a specialist task group to advise on the energy efficiency metric and standard that should apply to all zero carbon homes from 2016 and meet Government's ambition of the highest practical energy efficiency level realisable in all dwelling types
   - confirmed that the carbon compliance level would be 70 per cent of regulated emissions, based on the assumptions laid out in the consultation document
   - confirmed that on-site renewables would be eligible for Clean Energy Cash Back (also known as feed-in-tariffs) and Renewable Heat Incentives
   - indicated those measures which had commanded broad support as allowable solutions and announced that Government would undertake further work to consider practical arrangements for putting the allowable solutions in place and to set a guideline maximum price industry would be expected to bear in implementing allowable solutions

10. The specialist task group (under the co-ordination of the Zero Carbon Hub) published its recommendations in November 2009[16]. On 24 November 2009, John Healey issued a further Written Ministerial Statement[17] in which, among other things, he confirmed that the standard recommended by the task group would be used within the definition of zero carbon homes and that Government would use the forthcoming consultation on updating the Code for Sustainable Homes to check that there are no unintended consequences from this standard and to seek views on the energy efficiency standard to be adopted in 2013.

[11] UK Green Building Council report (May 2008) The Definition of Zero Carbon research concluded that "anywhere from 10% to 80% of new homes may not be able to meet the original definition of zero carbon"

[12] http://www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinition

[13] http://www.communities.gov.uk/planningandbuilding/theenvironment/zerocarbonhomes/

[14] http://www.communities.gov.uk/statements/corporate/ecozerohomes

[15] http://www.communities.gov.uk/publications/planningandbuilding/impactzerocarbon

[16] http://www.zerocarbonhub.org/bui-standard01.php

[17] http://www.communities.gov.uk/news/corporate/1391989

11. This impact assessment has been therefore prepared to accompany the consultation on the Code for Sustainable Homes[18] and, in particular, the section of that consultation relating to the energy efficiency standard proposed to underpin the definition of zero carbon homes.

What is the problem and why is Government intervention necessary?

12. The impact assessment published in July 2009 set out the market failures which justify the need for Government to regulate on the carbon emissions from new homes[19]. Government considers that those arguments, which are not repeated here, remain unchanged and support the policy that has been announced for all new homes to be required, as a matter of regulation, to be built to a zero carbon standard from 2016 (as set out in paragraph 9). The problem considered by this impact assessment relates to the energy efficiency standard that should be required of zero carbon homes.

13. In order to meet the carbon compliance requirement, it is likely that developers will typically build to energy efficiency standards higher than those prevailing today as well as installing low and zero carbon (LZC) energy technologies. The existence of an ambitious carbon compliance requirement means that Government should not need to rely on an energy efficiency standard alone in order to drive higher levels of energy efficiency. However, even with 70 per cent carbon compliance, it cannot be taken completely for granted that developers will always choose high levels of energy efficiency. There may be situations where the on-site renewable potential and the incentives available for exploiting those renewables make using LZC technologies alone the cheapest way for the developer to satisfy the carbon compliance requirement – in locations, for example, where space and air quality are not significant constraints to biomass LZC technologies.

14. Government considers that, owing to market failures, it would be preferable to set a minimum energy efficiency standard than to leave it entirely to the developer to decide the preferred combination of energy efficiency and LZC measures. The reasons are set out below.

15. Whole life cost. In general, energy efficiency measures are assumed to entail lower life-cycle costs than LZC technologies (fuel, maintenance, replacement). Because those cost differentials may not be fully reflected in the market price of the home[20], the developer might, in the absence of a minimum energy standard, choose a carbon compliance strategy which minimises the capital cost but does not minimise whole life costs.

[18] http://www.communities.gov.uk/planningandbuilding/theenvironment/codesustainable1

[19] See paragraphs 11 to 23 of the July 2009 impact assessment.

[20] This is an example of a market failure based on split incentives and asymmetry of information.

16. Robustness. Energy efficiency measures are less dependent than LZC technologies upon the behaviour of occupants in order to realise carbon savings. For example, occupants cannot easily 'turn off' or fail to maintain the insulation in an exterior wall, and (unless the wall is inadvertently damaged) will not need to service or replace that insulation in order to maintain its effectiveness. That is not equally true of LZC technologies. So, requiring developers to meet at least a part of the on-site carbon reductions through energy efficient fabric should yield more robust carbon savings than a policy which allows complete flexibility.

17. Future-proofing and uncertainty. Homes are long-lived assets, and the cost of retrofitting the fabric of new homes at a later date is likely to be high. At the same time, the long-term costs of carbon and energy are uncertain. It may therefore be appropriate to seek an energy efficiency standard which will continue to be considered appropriate at a later date, once the implications of long-term carbon reductions and energy security are better understood. At the same time, future-proofing also means building to a standard which we will not regret in terms of climate change adaptation (in particular overheating).

18. Embodied Carbon. The value of net carbon savings included in this impact assessment does not take account of embodied carbon. In other words, the quoted carbon savings relate to the reduction in emissions from the **operation** of energy efficiency and micro-generation related installations, and not their manufacture, distribution or assembly. It is very difficult to net out such embodied carbon because it requires second guessing the nature and origin of manufacture for such energy products and for products and processes which they are replacing, many years ahead. Because such carbon is excluded it is possible that the carbon savings quoted are over-estimated. The approach in this impact assessment with respect to embodied carbon will be kept in line with agreed cross-departmental guidance.

19. Energy security. In general, reducing energy demand by a given amount should be more conducive to our energy security goals than meeting that energy demand with on-site LZC technologies. LZC technologies may be intermittent (not generating energy when it is most needed in the home) or require scarce resources (e.g. biomass). Hence, all other things being equal, demand reduction should contribute to our energy security goals to a greater extent than providing equivalent on-site energy.

What are the policy objectives and the intended effects?

20. It is for the above reasons that Government has announced that there should be an energy efficiency standard which delivers an agreed part of the carbon compliance target. Requiring such a standard, set at an appropriate level, would mean that developers would not meet the carbon compliance level through LZC technologies alone (perhaps incentivised by Feed-In-Tariffs (Clean Energy Cash Backs) and Renewable Heat Incentive) but would build homes which have an inherently low demand for energy to provide space heating and cooling. The intended effects of such an approach are therefore:

- reduced fuel bills for occupants
- more robust long-term carbon reductions
- homes that are less likely to require major retrofitting in the future
- greater contribution of the policy to energy security goals

21. It would be possible to set the energy efficiency standard underpinning the zero carbon definition at a very high level indeed. The December 2008 consultation on the definition of zero carbon homes set out Government's ambition for a high standard and illustrated this by referring to PassivHaus and the Energy Saving Trust's Advanced Practice standard. Many responses argued that those standards were too demanding for the temperate climate in England and inappropriate as a minimum regulatory standard applicable to all dwellings.

22. Recognising those concerns, the July 2009 statement expressed the Government's ambition in terms of the *"highest practical energy efficiency level realisable in all dwelling types."* Implicit within this phrase are a number of criteria which have informed the work of the task group:

    - technical achievability. If the standard cannot be achieved, in theory and in practice, on a sufficient proportion of housing developments in order to realise our housing ambitions then it would not be practical
    - affordable and cost-effective. Similarly, economic and financial considerations also need to be part of a practical standard. However, those criteria need to be considered in the context of the technological progress, cost levels and economic conditions that might be expected in 2016, rather than solely those prevailing today
    - innovation. The standard should not be so tightly drawn as to stifle innovative approaches to improving energy efficiency
    - workable regulatory framework. If there were no way of confirming that the developer has designed and/or built to the prescribed standard, then it would not be a practical standard
    - broader environmental considerations – the need to avoid a standard which has strongly undesirable environmental implications (e.g. in terms of selection of materials)
    - desirable and healthy homes. It would not be acceptable to require a standard which presents known and insurmountable risks to the comfort and health of occupants, e.g. because of poor indoor air quality and/or overheating

What policy options have been considered?

23. In advising on the energy efficiency standard that should apply, the specialist task group needed to undertake two types of task. First, it considered, in light of the carbon compliance proposals, what should be within and beyond the scope of the energy efficiency standard and the metric that should be used to measure it. In parallel, the task group analysed a range of energy efficiency specifications, so as to decide upon the level of ambition that was consistent with the Government's objectives. To help the latter analysis, the task group devised a variety of specifications representing different levels of ambition, ranging from current practice through to EST's Advanced Practice (i.e. the standard considered in CLG's July 2009 and December 2008 impact assessments) and PassivHaus.

Table 1: Construction specifications of the energy efficiency levels looked at by the Taskforce

		Construction Specifications								
		Current practice	Modified AECB Silver Standard	EST BPEE Standard = between Spec A & Spec B					EST APEE Standard	Passivhaus Equivalent
		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

Source: Zero Carbon Hub.

24. In November 2009, the task group published a report setting out its analysis, reasoning and recommendations[21]. The key recommendations were that:

- the energy efficiency standard should be based on the delivered energy demand for space heating and cooling within the home
- it should take into account the fabric and passive design features only, without regard to the services providing space heating, mechanical ventilation, heat recovery and cooling and without including internal gains from hot water in the energy efficiency calculation
- the standard should be expressed in kilowatt-hours of energy demand per square metre per year (kWh/m²/year)
- a different level of kWh/m²/year should apply to different dwelling types to reflect the physics of different built forms
- the standard applicable to detached homes should be based upon a slightly more challenging specification than other dwelling types
- based on the 2009 consultation version of the Standard Assessment Procedure (SAP), the energy standard applicable from 2016 should be 39 kWh/m²/year for apartments and mid-terrace houses; and 46 kWh/m²/year for end-terrace, semi-detached and detached houses. This standard is more demanding than current practice but less demanding than the Advanced Practice standard on which the July 2009 impact assessment was based
- the performance standard should be re-based, as necessary, to take account of any further revisions made to SAP so as to hold the level of ambition constant in terms of the building specifications required to achieve the standard

25. The reasoning behind the task group's recommendations is summarised in Part B of the consultation document and further explained in the task group's report.

Options taken forward

26. Government's view is that the recommendations of the task group meet its ambition of the highest practical energy efficiency level. In particular:

- the standard, expressed as a performance-based metric measuring the performance of the fabric and passive measures in terms of delivered energy, complements the carbon compliance requirement well
- the differentiation by dwelling type should allow the energy efficiency potential of all dwelling types to be realised in an equitable and cost-effective manner
- the levels proposed set a suitably ambitious trajectory for realising our goals for the zero carbon homes of the future

[21] http://www.zerocarbonhub.org/bui-standard01.php

27. This impact assessment is therefore based on the following options:

- option 1 – do nothing, i.e. continuing with current (2006 Part L) Building Regulations
- reference case. This is as per the July 2009 impact assessment reference case and assumes the pre-2016 regulatory trajectory shown in *Building a Greener Future*, i.e. to continue the 2006 Part L Building Regulations to 2010; to require a 25 per cent improvement in regulated carbon emissions from 2010[22]; and a 44 per cent improvement from 2013. However, unlike the *Building a Greener Future* trajectory, no further improvements are assumed for 2016 or beyond. The reference case is modelled assuming a level of fabric energy efficiency based upon Specification A in Table 1 i.e. broadly similar to EST's Best Practice that was assumed for the reference case in the July 2009 impact assessment. All costs and benefits of the reference case are shown relative to Option 1
- option 2 – the zero carbon homes policy as announced in July 2009 (i.e. 70 per cent carbon compliance and remaining emissions dealt with via allowable solutions) but based on the energy efficiency standard recommended by the task group
- option 3 – the zero carbon homes policy as announced in July 2009 (i.e. 70 per cent carbon compliance and allowable solutions) but retaining the more demanding Advanced Practice energy efficiency standard (equivalent to specification C in Table 1) which was assumed in the July 2009 impact assessment

28. Although the task group's recommendations relate to the energy efficiency standard to be included in the definition of zero carbon (i.e. from 2016), they also considered whether any requirements should be introduced from 2013 in order to help prepare industry for 2016. They recommended that there should be such an interim requirement, which could take the form of a slightly lower energy efficiency standard and/or requiring particular measures (such as mandatory air pressure testing) which would improve industry's understanding of how to build energy efficient homes.

29. As well as consulting on the task group's recommended standard for 2016, CLG is also consulting on the general principle of the requirements that should be introduced in 2013 (the detail of the 2013 requirements will be consulted on as part of the normal process of Part L consultations in advance of 2013). In the absence of detailed recommendations for 2013, we have assumed, for purposes of this impact assessment, that the 2013 requirements will be similar to specification A in Table 1. This is assumed to apply from 2013 in each of the Reference Case and (until 2016) Options 2 and 3.

[22] Government is currently consulting on the amendments to be made in 2010 – see http://www.communities.gov.uk/publications/planningandbuilding/partlf2010consultation

30. Since the purpose of this impact assessment is to update the previous impact assessment to take account of the energy efficiency proposals, no changes have been made to the policy assumptions regarding carbon compliance and allowable solutions that were announced in July 2009 and presented (as Option 3) in the July 2009 impact assessment. The key features of carbon compliance and allowable solutions, as set out in the July impact assessment, are repeated in Annex 5 of this impact assessment.

31. Although the carbon compliance requirements remain unchanged from the July 2009 Written Ministerial Statement, the energy efficiency standard does have implications for the way that carbon compliance is modelled. In particular, an energy efficiency standard that is less demanding than the Advanced Practice standard previously modelled implies that, unless the developer chooses to go beyond the minimum energy efficiency standard (which is of course a possibility open to him), there will potentially be greater use of on-site LZC technologies (and/or directly connected heat) in order to meet the carbon compliance requirement. So, updating the energy efficiency standard also implies re-modelling the way that carbon compliance will be achieved.

32. No such changes are implied for allowable solutions, however. It remains open to the developer to go beyond the minimum energy efficiency standard and carbon compliance requirement in order to reduce reliance on other allowable solutions. However, for modelling purposes, the approach to allowable solutions is independent of energy efficiency and carbon compliance. Therefore we have simply retained the assumption from the July 2009 impact assessment that allowable solutions will be delivered at an average cost of £75 per tonne of carbon dioxide. This is based on half the allowable solutions being renewable electricity at £100/tCO_2 and half renewable heat at £50/tCO_2. However, a range of £50 and £200 per tonne of carbon dioxide has been included in the sensitivity analysis in Table 10 to reflect the uncertainty around these assumptions.

Analysis of options – methodology and key assumptions

33. Previous results as shown in the July 2009 impact assessment come from a dynamic cost and benefit model originally produced by Cyril Sweett, Faber Maunsell and Europe Economics. Further modelling work, using elemental cost models, was also undertaken by both Davis Langdon, and Fulcrum Consulting on behalf of the Zero Carbon Hub's specialist task group in order to determine the proposed energy efficiency metric and standard, and the implications for carbon compliance costs.

34. The dynamic nature of the model developed for the earlier impact assessments allows for a sophisticated approach to modelling such factors as industry learning curves (i.e. the process by which costs should fall over time as technologies are increasingly deployed) and lifetime cost optimisation. However, the downside of such a sophisticated approach is that it can be more difficult to understand the calculations at the individual dwelling level, and a number of respondents to the consultation were concerned by the lack of transparency.

35. Therefore the present impact assessment uses a simpler and more transparent model, constructed by the Department, in order to produce costs on a 'per dwelling' basis, which underpins the headline aggregate figures seen on the cover sheets. The technology cost assumptions underpinning the model are drawn from work undertaken by the energy efficiency task group (including costing work undertaken by Davis Langdon[23]) and by the Zero Carbon Hub (which has been undertaking separate work on the costs of compliance for purposes of its wider work to support the delivery of zero carbon homes). In addition, the model uses assumptions which apply to all Government analysis of energy and climate change policy, for example energy price scenarios and carbon values. The Zero Carbon Hub is programming more detailed work to model future financial scenarios related to delivering the 70 per cent compliance level. This will focus on the current financial models used in the sector and on developing a better understanding of impacts on whole life costs.

36. For the energy efficiency portion of capital costs, the Department's model takes the average of Davis Langdon's and the Zero Carbon Hub's own estimates. The costs of achieving the carbon compliance standard, over and above the measures required in order to achieve the energy efficiency standard, are taken from the Hub's estimates[24]. This approach – drawing on multiple sources – gives us a more robust assessment of likely costs of the proposal. An approximation of technology learning rates was then applied to the costs of each technology, to reflect that these costs are likely to fall over time. Details of these learning rate factors are in annex Table A10.

37. Broadly speaking, the modelling assumptions provided by each of the sources fell into one of two categories, either (a) an elemental cost approach whereby individual components or measures were costed and summed (Davis Langdon and the earlier work of Cyril Sweett), or (b) an average of cost data from a variety of housebuilders, suppliers, and consultancy sources (Zero Carbon Hub). All followed similar sets of assumptions on baseline specifications and the feasible potential of technologies, and all included ongoing operation and maintenance costs.

[23] available on http://www.zerocarbonhub.org/bui-standard01.php

[24] Davis Langdon also provided an estimate of meeting 70 per cent carbon compliance. However, this was based on a very restricted range of technologies and it was considered important to look at the wider range of technologies modelled by the Hub.

38. The differences in costs between the Hub's own modelling of carbon compliance, and the Davis Langdon modelling on energy efficiency levels, is partly explained by additional costs accounted for in Davis Langdon's work (such as extra for preliminaries and contingency).

39. By constructing an average of the Hub's and Davis Langdon's modelling approaches in order to reach certain levels of energy efficiency and carbon compliance, CLG has come up with a best estimate of build costs for each of the four major dwelling types identified. It was not possible to include Cyril Sweett's cost estimates in the average because their model was set up to look at the APEE and BPEE energy efficiency levels only, whereas the Hub and Davis Langdon costs are based on the Taskforce's proposed energy efficiency standard.

40. The per dwelling costs and benefits produced by the models (with learning rates applied), have been put into the Department's model, which is consistent with the Government's housebuilding targets of 240,000 net additions per annum by 2016 as set out in the 2007 Housing green paper[25], in order to produce the overall costs of the policy.

41. The fundamental assumptions on the number and type of dwellings built to each build standard in each year has not changed. Assumptions on energy prices, carbon valuation, discounting and the baseline regulated and unregulated emissions have not changed.

42. However, due to the change in modelling approach, and as update to government appraisal guidance, a number of inputs and assumptions have changed. These – and the effect they have on the costs and benefits – are detailed below:

- baseline dwelling specifications. In previous modelling, a much smaller gross floor area for detached houses, and a larger floor area for flats was assumed. This means the current analysis shows an overall increase in costs, all things being equal, because the build mix assumptions (which are 25 per cent detached houses, as before) give more weight to this additional cost for detached homes than to the lower cost for smaller flats. See annex Table A3 for baseline dwelling specifications
- the new modelling is less sophisticated than the previous Cyril Sweett modelling in that there are only four dwelling types modelled and aggregated into the whole stock, rather than the previous approach which had the four dwelling types being modelled for each of four development scenarios (urban infill, market town etc). This means more broad-brush assumptions on uptake, and no optimisation by development type

[25] http://www.communities.gov.uk/publications/housing/homesforfuture
As per previous impact assessments, the numbers of new dwellings assumed to be built from 2016 is 219,000 rather than 240,000, to take account of around 21,000 coming from conversions rather than new dwellings

- the previous Cyril Sweett modelling results were based on a purely lowest-cost optimisation, whereas the new modelling uses a 'middle of the road' cost estimate, i.e. not necessarily the cheapest if it would imply an unreasonable reliance on a particular technology. For example, the four dwelling types modelled deliberately incorporated a range of renewable technologies between them, rather than the cheapest available to the model
- the Cyril Sweett modelling resulted in a significant amount of large wind, PV and community biomass, and less (or none) of other renewables. In the Hub's modelling, we have selected uptake of micro wind, PV, ground source heat pumps and biomass community heat and power (and no large wind, which is significantly cheaper than micro wind). This inflates the costs
- the Cyril Sweett model optimised on the cheapest carbon abatement options for each dwelling and development mix to get from the energy efficiency requirements to carbon compliance; the Hub model selected a renewable heat and a renewable electricity measure for each dwelling type (unless the renewable heat technology alone would suffice, for example in the case of biomass community heat and power)
- the Cyril Sweett modelling had learning rates modelled by year, depending on the cumulative uptake, for both local and global learning. The current modelling has an approximation of these learning rates applied to the reference case (2013) standard and the 2016 build standards. Details are given in annex Table A10
- the biomass price – of biomass as a fuel input – is higher in the latest modelling, to be consistent with DECC assumptions[26] which are higher than 2.4p/kWh as assumed in the Cyril Sweett model. Full fuel cost assumptions are spelled out in annex Table A8 and a comparison with the previous methodology is shown in Table 10
- operation and maintenance costs are now shown explicitly, based on costs from DECC's Renewables Advisory Board (RAB) report[27]
- administrative costs are now modelled separately (see Annex Table A13 for the assumptions) and appear in the cover sheets administrative burdens and one-off transitional costs
- the baseline energy use (kWh) assumptions are the same, but due to modelling carbon compliance in both SAP 2006 – which is what the Department announced the level of effort would be comparable to (subject to some adjustments listed in Annex E of the December 2008 consultation document) – and the proposed SAP 2009, an average of energy savings (in kWh) was taken from the two Hub models. This is in line with the approach to averaging the capital cost of reaching the energy efficiency standards from the two Hub models, since the SAP 2009 (Davis Langdon) Hub model has higher energy

[26] An average of the cost of wood chips, at 2.3p/kWh, and wood pellets, at 5p/kWh, were modelled. These are used in DECC modelling and are detailed in Annex Table A4

[27] http://www.renewables-advisory-board.org.uk/vBulletin/showthread.php?t=208

savings at higher cost, whereas the SAP 2006 (Hub's own estimates) model has lower energy savings at lower cost. This makes direct comparison with the Cyril Sweett energy savings less simple

- the carbon factor for grid electricity was previously modelled at a flat marginal rate of 0.43 $kgCO_2$/kWh, whereas the current modelling has a declining marginal rate – according to the latest DECC guidance – which starts at 0.43$kgCO_2$/kWh but falls over time. This makes carbon saved in the traded sector fall over time, which lowers the financial value of those carbon savings, worsening the Net Present Value. Sensitivity showing the previous carbon factor is provided in Table 10

43. The combination of measures used to achieve a specific carbon reduction against the baseline represents a 'middle-of-the-road' approach to costs. It is not supposed to be in any way indicative of what a certain dwelling type should look like, nor should it restrict the technologies used on any particular type. This has been done for each dwelling type as identified in previous modelling. More detail on alternative technology combinations and costs to reach the carbon compliance level for each of the dwelling types is provided in Annex 4.

44. The modelling looks at a range of technologies under assumptions at a given moment in time. It does not claim to predict the technologies that will actually come forward in the future. For example, it is possible that the selection of technologies will be influenced by the progressive decarbonisation of the grid and the way that is reflected in the Standard Assessment Procedure.

45. There are four generic dwelling types: detached house; semi-detached; mid-terrace and a flat. The model analyses the costs and benefits for each year of 2008 to 2025 based upon:

- housing projections consistent with the Government's housebuilding targets
- build mix and housing development projections
- dwelling types and their baseline energy use and carbon emissions (see Table 2 below)
- proportion of new build adhering to each Building Regulations standard each year[28]
- policy standards for percentage improvement in regulated and unregulated carbon emissions for each year 2008-2025 (homes built after 2025 have been excluded from the analysis, although benefits of innovation, as well as the ongoing costs and benefits of the policy, would be expected to continue after this point)

[28] In this way, we can account for the fact that publicly-funded housing is being built to higher energy efficiency levels than standards currently mandate

- build costs, based on four dwelling types
- carbon saving options for each dwelling type, consisting of energy efficiency measures and renewable energy technologies
- financial value of energy and carbon savings (following DECC guidance) by using energy price projections (see annex Table A7) and carbon values (see annex Table A9)[29]
- carbon intensity of grid electricity, assumed to be at a declining marginal rate (published by DECC) starting at 0.43kgCO_2/kWh[30]
- domestic energy prices, using DECC guidance[31]
- valuation of the avoided cost of renewables has been included (see below) and
- all figures are presented in 2009 prices[32]

Table 2: Baseline CO_2 per dwelling (tCO_2 per annum), assuming build to 2006 Part L standards

	Detached	Semi/end-terrace	Mid-terrace	Flat
Regulated	2.08	1.60	1.46	1.33
Unregulated	1.46	1.16	1.12	0.94
Total	**3.54**	**2.77**	**2.58**	**2.27**

46. As uncertainty surrounds some elements of the input data, sensitivity analysis is performed in the costs and benefits section for key variables such as energy prices, carbon values, house building numbers, the availability of biomass, and the cost of allowable solutions.

47. As set out in the December 2008 guidance on appraising greenhouse gas policies, the avoided cost of renewables are valued is to reflect that any policy reducing energy demand or increasing renewable energy generation contributes towards meeting the renewable energy target[33]. The marginal cost of delivering renewable energy to meet the UK renewable energy target has been estimated to be £118/MWh in 2020 over and above the displaced energy and carbon costs. The target level of renewable energy delivery in 2020 is 15 per cent of final energy consumption. Reducing final energy consumption by 1 MWh in 2020 will reduce the quantity of renewable energy required by 0.15 MWh. As such, in this modelling, the avoided costs of renewables

29 DECC carbon valuation paper (July 2009) http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/valuation/valuation.aspx

30 Prior Impact Assessments have used a flat marginal rate of 0.43kgCO_2/kWh; however, this has been updated to reflect new guidance on option appraisal released by DECC.

31 http://www.decc.gov.uk/en/content/cms/statistics/projections/projections.aspx

32 The exception is that the £50/tCO_2 and £100/tCO_2 modelled costs of allowable solutions are still described in the text and modelled at these 2008 levels

33 http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/greengas-policyevaluation.pdf
Note that this guidance is due to be updated in early 2010 so the avoided cost of renewables figures should be seen as illustrative.

from reduced energy demand is £18/MWh in 2020 and changes in the level of renewable energy delivered are valued using the marginal cost of delivering it from other sources: £118/MWh.

48. To increase transparency, the financial costs are broken down into upfront capital costs (the 'build' costs) and ongoing servicing/maintenance costs. In previous impact assessments these were merged. Also, an indication of cost uplift per dwelling is given.

49. The analysis allows for various technologies to be adopted. These include:

- energy efficiency measures[34]
- solar water heating
- solar photovoltaics
- individual biomass boiler (small and large)
- ground source heat pump (GSHP)
- air source heat pump
- biomass or gas combined heat and power
- small/large scale wind turbines

50. The following technologies were selected as inputs for the Department's model, purely to get an illustrative estimate of costs and benefits arising from the policy:

Table 3: Technologies by dwelling type

	Detached	Semi/end-terrace	Mid-terrace	Flat
Primary electricity technology:	Wind	PV	Biomass combined heat and power	Biomass combined heat and power
Annual production (kWh)[35]	1561	1230	1114	684
Primary heat technology:	GSHP	Solar Thermal	As above	As above
Annual production (kWh)	6910	1467	4953	3042

51. Some of these technologies will have a corresponding ongoing cost with regard to

[34] The two options in this impact assessment look at (1) the energy efficiency levels proposed by the Taskforce, which for modelling purposes was set at Table 1's Spec B for flats, semi's/end terraces and mid-terraces, and Spec C- for detached; and (2) all dwelling types achieving EST Advanced Practice (APEE) which closely corresponds to Table 1's Spec C with MVHR. To model the 2010 and 2013 intermediate steps to zero carbon, we assumed Spec A from Table 1in the model. Details of these can be found in the full report here: http://www.zerocarbonhub.org/downloads/ZCH-Defining-A-Fabric-Energy-Efficiency-Standard-Task-Group-Recommendations.pdf

[35] Annual energy production, in kWh, for a single dwelling once all homes are being built to a Zero Carbon Home standard in order to reach 70% carbon compliance (Option 2). These capacities reduce slightly under Option 3 due to the more demanding Advanced Practice Energy Efficiency requirement assumptions used in Option 3

e.g. additional electricity consumption in the case of a ground source heat pump. These feed into the ongoing cost analysis. The assumptions regarding the fuel requirement have been taken from those modelled by the Zero Carbon Hub and costed using DECC's energy price assumptions (see annex Tables A7 and A8). Additional 'one-off' costs have also been considered to reflect maintenance and servicing of these technologies. The assumptions on ongoing servicing and maintenance are set out in annex Table A12.

52. In our approach neither capital costs nor ongoing costs have been optimised in the modelling (in the sense that the lowest cost technology will not necessarily be selected). However, it is assumed that developers will only build to minimum requirement in order to reach the new standard. In this sense, the estimates from this modelling are conservative and it might be expected that economies could be achieved in reducing the costs if a more integrated approach were taken. (For an estimate of the savings, see Cyril Sweett's September 2008 report and the July 2009 impact assessment.)

53. The July 2009 Written Ministerial Statement confirmed that on-site renewable technologies installed to meet carbon compliance requirements would be eligible for feed-in tariffs and renewable heat incentives. The availability of such incentives allows for the possibilities that (1) zero carbon homes will realise a greater sales price premium, compared to other homes, than would otherwise have been the case and/or (2) developers will themselves be able to realise (through financial structuring mechanisms based on an assignment of some or all of the revenues from the buyer of the home) a proportion of the benefit of these incentives. No account is taken of such incentives in the cost-benefit analysis but they are considered in the distributional analysis section[36].

Costs and benefits of options considered

54. Due to the significant changes in modelling since the July impact assessment (see paragraph 42), the following costs and benefits should be viewed as separate from those presented in July. Therefore, the costs presented in Option 2 and Option 3 should be viewed relative to each other and be indicative of the cost difference in the task group's proposed energy efficiency standard, and Advanced Practice Energy Efficiency as modelled in previous impact assessments.

[36] For the illustrative purposes of distributional analysis, it has been assumed that FITs for PV microgeneration would be 31 pence/kWh generated. As of yet, figures for RHI have not been announced but will be included in future analysis.

Option 1: do nothing

55. Continuing with current (2006 Part L) Building Regulations would still entail costs. Local authorities can set their own requirements for developers to meet energy and carbon standards of the Code for Sustainable Homes, where reasonable to do so[37]. This could cause extra costs for developers particularly if, in the absence of a strong national framework, local authorities seek to fill the void by setting local building standards via planning.

56. There would also be an opportunity cost (reflected as benefits under the other options) of foregone carbon and fuel bills savings, higher total energy demand (requiring more EU allowances and additional generation capacity) and it would be harder to meet the legally-binding climate change targets.

Reference case: 25 per cent reduction in regulated emissions from 2010 and 44 per cent reduction from 2013, modelled with an energy efficiency standard based on specification A

57. 2013 Part L standard was modelled using the Energy Efficiency Task Group's 'Spec A'. A small range of renewable energy technologies was selected in order to meet the 44 per cent reduction – see Annex Table A4 on 'Technologies selected and capital costs for Part L 2013 Standard Homes'. It is assumed that no renewable energy technologies are required in order to meet the 2010 standard, given that the 'Spec A' already achieves this.

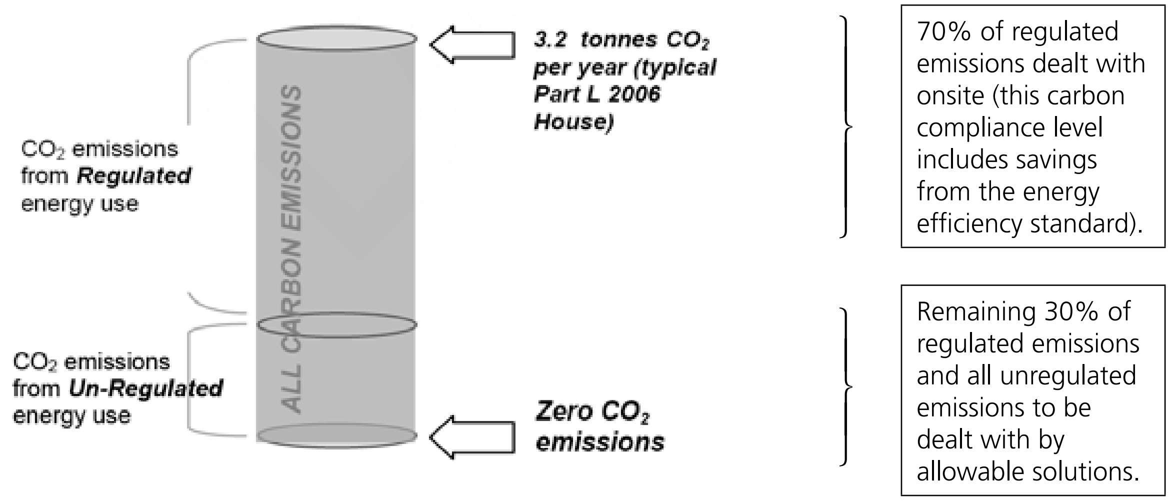
Table 4: Cost and benefits of the reference case

	Present Value (PV) capital cost (£bn)	PV on-going costs (£bn)	PV financial benefits (£bn)	Financial NPV (£bn)	PV traded carbon benefits (£bn)	PV non-traded carbon benefits (£bn)	Total NPV (£bn)	Total NPV – including avoided cost of re-newables (£bn)
2010 Part L standards	0.5	0.3	0.9	0.1	0.1	0.4	0.5	Not quantified
2013 Part L standards	5.5	3.0	3.7	-4.8	0.4	1.7	–2.7	Not quantified
Total	**6.0**	**3.3**	**4.6**	**-4.7**	**0.5**	**2.1**	**–2.2**	**0.7**

37 CLG (December 2007) *Climate Change Planning Policy Statement* http://www.communities.gov.uk/publications/planningandbuilding/ppsclimatechange

Option 2 – energy efficiency standard as recommended by the Energy Efficiency Task Group as part of 70 per cent reduction on regulated emissions from 2016 (carbon compliance), plus allowable solutions to deal with residual emissions

Diagram 1: Representation of what 70 per cent carbon compliance level means



Source: Zero Carbon Hub[38]

58. The 2016 step to Zero Carbon Homes was modelled using the energy Efficiency Task Group's recommendation i.e. detached homes to meet specification 'C-' (based on natural ventilation), and all other dwellings to meet specification 'B' (based on natural ventilation).

59. Technologies were selected as per Table 3, shown again in Table 5 below – for full details on the assumptions behind these technologies, see Annex Table A11.

[38] Zero Carbon Hub (2009) Defining Zero Carbon Homes: Have Your Say http://www.zerocarbonhub.org/cons000001.php

Table 5: selected technologies by dwelling type and annual energy production, with additional reductions in energy demand due to energy efficiency measures (task group proposal): onsite measures only (i.e. excluding costs and benefits of allowable solutions) for Option 2

	Detached	Semi	Mid	Flat
Primary electricity technology:	**Wind**	**PV**	**Biomass combined heat & power**	**Biomass combined heat & power**
Annual production (kWh)[39]	1,562	1,230	1,114	684
Primary heat technology:	**GSHP**	**Solar thermal**	**Biomass combined heat & power**	**Biomass combined heat & power**
Annual production (kWh)	6,910	1467	4,953	3042
Electricity required (kWh)[40]	2,395	0	0	0
Biomass required (kWh)[41]	0	0	7,429	4,562
Annual reduction in electricity demand due to energy efficiency measures (kWh)[42]	314	240	246	142
Annual reduction in heat demand due to energy efficiency measures (kWh)	3,603	2,862	3,635	1,359
Upfront capital cost per dwelling (£)	**Detached**	**Semi**	**Mid-terrace**	**Flat**
Total	**14,111**	**9,502**	**5,684**	**5,094**
Energy Efficiency	5,371	2,041	1,492	887
Carbon Compliance	8,740	7,461	4,191	4,207

39 Annual energy production of selected technology for a single dwelling once all homes are being built to a Zero Carbon Home standard from 2016, in order to reach 70 per cent carbon compliance.

40 The additional annual electricity demand that would be required to operate the selected heat technology for a single dwelling to realise heat generation required to reach 70 per cent carbon compliance from 2016.

41 Additional annual biomass demand per dwelling in order to realise heat and power generation required to reach 70 per cent carbon compliance from 2016 (applies only to biomass technologies).

42 Annual reductions in energy demands for a single dwelling as a result of installed energy efficiency measures that are realised for each year of the lifetime of the measure.

Table 6: Cost and benefits of Option 2 including onsite measures and allowable solutions (net of reference case)

	PV capital cost (£bn)	PV ongoing costs (£bn)	PV financial benefits (£bn)	Financial NPV (£bn)	PV traded carbon benefits (£bn)	PV non-traded carbon benefits (£bn)	Total NPV (£bn)	Total NPV – including avoided cost of re-newables (£bn)
2016 ZC: onsite measures	5.8	4.6	3.2	–7.3	0.3	1.3	–5.7	2.3
2016 ZC: allowable solutions[43]	2.1	n/a	n/a	–2.1	1.3	1.4	0.5	Not quantified
Total	**7.9**	**4.6**	**3.2**	**–9.4**	**1.6**	**2.7**	**–5.1**	**2.9**

60. The homes built to this 70 per cent carbon compliance standard not only reduce their energy demand (e.g. through better insulation), but also generate renewable electricity and heat. Both of these make meeting the Government's 2020 renewable energy target easier, and as such, are given a monetary value for both the energy demand they reduce, and the renewable energy they generate (the 'avoided cost of renewables').

61. This option leads, over and above the reference case, to:

- £3.2bn of fuel bill benefits, equivalent of between £120 and £440 per household per year over and above the reference case savings[44]
- Feed-in-Tariff revenues of around £500 per annum for the lifetime of the onsite renewable electricity technology[45]
- A fall of 36.3 million tonnes CO_2 in the traded sector over the lifetime of the policy, valued at £1.4bn[46] where at least 2.9MtCO_2[47] of this is done onsite and the remainder by allowable solutions[48]
- a fall in 65.1 million tonnes CO_2 in the non-traded sector over the lifetime of the policy, valued at £2.7bn, of which at least 31.7MtCO_2 is done onsite and the remainder by allowable solutions

43 The cost modelled for allowable solutions is a net cost, which means costs minus benefits. It appears here in the costs column.

44 The fuel bill saving depends on the type and amount of technology deployed, as well as the building type. All dwellings had fuel bill savings due to the energy efficiency component alone of £70 to £180, where detached houses have higher savings but also a higher baseline fuel bill

45 Feed-In-Tariff (FIT) policy to be confirmed – these are illustrative figures based on 31p/kWh for domestic PV or wind. For modelling purposes, no degression was taken into account.

46 The policy results in £1.6bn value of saved traded carbon, however £0.2bn is subtracted from this to account for extra electricity used in heat pumps

47 The policy results in a saving of 9.8MtCO_2 in the traded sector but due to the increase in electricity use because of heat pumps, the saving quoted above is 2.9MtCO_2.

48 Assuming, as before, that half of renewable solutions are in the traded sector and half in the non-traded

- 383 GWh increase in electricity demand (annual) in 2020 (21 TWh increase in electricity demand over the policy lifetime)
- 526 GWh reduced gas demand (annual) in 2020 (57 TWh reduction in gas demand over the policy lifetime)
  - these reductions in energy demand have a present value of £0.2bn, valued using the avoided cost of renewables
- 533 GWh renewable electricity generated onsite (annually) in 2020 (29 TWh generated over the policy lifetime)
- 2,083 GWh renewable heat generated onsite (annually) in 2020 (114 TWh generated over the policy lifetime)
- the present value of this renewable energy generation is £7.8bn

62. **Including these 'avoided cost of renewables' and carbon in cost-benefit analysis gives a final social net benefit of onsite and allowable solutions of £2.9bn**, i.e. the benefits outweigh the costs. It should be noted that the quantified energy generation (and corresponding avoided cost of renewables) is only calculated for onsite carbon compliance renewable energy generation, even though it would also apply to generation which is part of the allowable solutions. This should be reflected in future analysis.

Table 7: Per dwelling costs of cost to reach 70 per cent carbon compliance (incorporating proposed energy efficiency standard), onsite costs of Option 2 only i.e. no allowable solutions (£)

	PV capital cost (£)	PV ongoing costs (£)	PV financial benefits (£)	Financial NPV (£)	PV traded carbon benefits (£)	PV non-traded carbon benefits (£)	***Total NPV (£)***
Detached	14,111	5,660	6,893	–12,878	396	2,195	***–10,287***
Semi/End-terrace	9,502	3,244	4,528	–8,218	450	1,119	***–6,650***
Mid-terrace	5,684	9,013	5,555	–9,141	291	1,901	***–6,949***
Flat	5,094	6,978	2,912	–9,159	175	896	***–8,088***

63. Capital costs reflect the upfront build cost per dwelling in order to reach a particular standard for energy efficiency (task group proposal) and carbon compliance costs from 2016. Cost-effectiveness figures are in annex Table A17.

64. Ongoing costs reflect the servicing and maintenance of energy efficiency measures installed in the home. This additionally includes fuel requirements for selected technologies e.g. biomass for combined heat and power, and electricity required to run a Ground Source Heat Pump (GSHP). Full details can be found in annex Table A12.

65. Administrative costs are not included in the per dwelling costs as they are covered separately. Calculations behind the administrative burdens are set out in annex Table A13. Admin costs reflect the additional burdens that developers face as a direct consequence of policy and include time spent with familiarisation, compliance with policy (e.g. inspections), and providing certification that a home has achieved the standards required.

66. Carbon benefits are derived from energy efficiency savings (due to decreased energy demand within the home), in addition to heat and electricity generation from renewable sources installed as part of the new standard from 2016.

67. Zero carbon dwellings built to these standards might expect revenue from Feed-in-Tariffs (based on a flat rate of 31p/kWh) of:

Table 8: FITs revenues

	Present Value of FITs revenue over lifetime (£)	Annual FITs payment (£2009)
Detached	6,637	484
Semi/End-terrace	6,878	381
Mid-terrace[49]	4,736	346
Flat	2,909	212

68. Allowable solutions per dwelling are modelled as:

Table 9: Allowable solutions and total upfront costs per dwelling per year

	Tonnes of CO_2 saved per dwelling per year	Upfront cost of 30 years of allowable solutions (present value) (£)	Total upfront cost of building a zero carbon home (both onsite and allowable solutions) (£)
Detached	2.1	2,909	17,020
Semi	1.6	2,290	11,792
Mid-terrace	1.6	2,157	7,841
Flat	1.3	1,869	6,963

Sensitivity analysis

69. The table below shows how the costs and benefits change when certain assumptions are changed individually. These are to emphasise there is uncertainty around key variables.

49 FITs revenues for mid-terrace and flats are based on shared biomass CHP, as such these figures should be seen as illustrative estimates only

70. Using the previous appraisal methodology with a flat electricity carbon factor and 2.4 pence/kWh biomass price improves the onsite-only NPV of option 2 from –£7.8bn to –£6.4bn and the total NPV (including allowable solutions costs and benefits) from –£7.3bn to –£5.5bn.

71. If biomass is unavailable, capital costs rise. However, in the 'with biomass' modelling, we have not assumed all buildings use biomass anyway which would understate their cost compared to a model like the Cyril Sweett one used in July 2009 which selects the most cost-effective option.

72. Table 10 also presents sensitivity analysis around the cost per tonne of carbon dioxide for allowable solutions. A range of £50- £200 per tonne of carbon dioxide has been included to reflect the uncertainty around the cost. Further work to develop more precise and robust cost assumptions for allowable solutions will be carried out as the policy continues to develop with respect to delivery. This is consistent with the Impact Assessments for Zero Carbon Non-Domestic Buildings and the Code for Sustainable Homes.

Table 10: Sensitivity analysis around Option 2 (onsite and allowable solutions costs shown both separately and combined) from 2016

	PV capital cost (£m)	PV financial benefits (£m)	Financial NPV (includes ongoing costs) (£m)	Carbon compliance NPV (includes carbon) (£m)	Net cost of allowable solutions only (£)	Total NPV (includes carbon and allowable solutions) (£m)
No sensitivity: Reference case costs and benefits only (from 2016)	6,048	4,580	–4,739	–2,184		
No sensitivity: Option 2 costs/benefits (for comparison)	11,828	7,749	–11,990	–7,836	2,122	–7,330
Energy and carbon prices low	11,828	4,016	–15,018	–12,889	2,122	–13,688
Energy and carbon prices high	11,828	9,696	–10,538	–4,377	2,122	–2,582
Biomass unavailable	12,340	7,345	–10,508	–6,613	2,122	–6,107
Allowable solutions costs low (£50/tCO_2)				–7,836	1,415	–6,623
Allowable solutions costs high (£200/tCO_2)				–7,836	5,659	10,867
Low house-building (150,000 pa)	7,745	5,068	–7,278	–4,576	1,250	–4,278
High house-building (350,000 pa)	17,184	11,026	–17,748	–11,819	3,188	–11,059
Flat 0.43kgCO_2/kWh marginal emissions factor for electricity and 2.4p/kWh biomass price	11,828	7,749	–10,944	–6,352	2,585	–5,489

Option 3 – Advanced Practice energy efficiency standard as part of 70 per cent reduction on regulated emissions from 2016 (carbon compliance), plus allowable solutions to deal with residual emissions

73. This option is more expensive as the marginal cost of going further on the energy efficiency standard is higher than the marginal cost of using more renewable energy technologies to reach the carbon compliance level. As such, Option 2 offers a saving relative to Option 3.

Table 11: selected technologies by dwelling type and annual capacities, with additional reductions in energy demand due to energy efficiency measures (Advanced Practice)

	Detached	Semi	Mid	Flat
Primary electricity technology:	**Wind**	**PV**		
Annual capacity (kWh)	1,562	1,230	1,114	684
Primary heat technology:	**GSHP**	**Solar thermal**	**Biomass community heating**	**Biomass community heating**
Annual capacity (kWh)	6,910	1,467	4,953	3,042
Electricity required (kWh)	2,395	0	0	0
Biomass required (kWh)	0	0	7,429	4,562
Annual reduction in electricity demand due to energy efficiency measures (kWh)	–209	–102	–97	–36
Annual reduction in heat demand due to energy efficiency measures (kWh)	5,902	4,861	5,459	2,164
Upfront capital cost per dwelling (£)	**Detached**	**Semi**	**Mid-terrace**	**Flat**
Total	**16,541**	**11,670**	**9,605**	**9,300**
Energy Efficiency	9,112	5,984	4,325	3,722
Carbon Compliance	7,429	5,685	5,280	5,578

Table 12: Cost and Benefits of option 3 including onsite measures and Allowable Solutions (Net of Reference Case)

	PV capital cost (£bn)	PV ongoing costs (£bn)	PV financial benefits (£bn)	Financial NPV (£bn)	PV traded carbon benefits (£bn)	PV non-traded carbon benefits (£bn)	Total NPV (£bn)
2016 ZC: onsite measures	9.3	4.6	3.2	–10.7	0.0	2.2	**–8.5**
2016 ZC: allowable solutions[50]	2.1	n/a	n/a	–2.1	1.3	1.4	**0.5**
Total	**11.4**	**4.6**	**3.2**	**–12.8**	**1.3**	**3.6**	**–8.0**

[50] The costs and benefits of allowable solutions are the same in Options 2 and 3

Table 13: Per dwelling costs (£) of Advanced Practice energy efficiency standard and additional cost to reach 70 per cent carbon compliance (onsite costs only i.e. no allowable solutions)							
	PV capital cost (£)	**PV ongoing costs (£)**	**PV financial benefits (£)**	**Financial NPV (£)**	**PV traded carbon benefits (£)**	**PV non-traded carbon benefits (£)**	**Total NPV (£)**
Detached	16,541	5,660	6,821	–15,380	139	2,911	**–12,330**
Semi/End-terrace	11,670	3,244	4,327	–10,587	197	1,741	**–8,649**
Mid-terrace	9,605	9,014	5,911	–12,708	156	2,469	**–10,083**
Flat	9,300	6,963	3,009	–13,254	104	1,144	**–12,006**

74. Zero carbon dwellings build to these standards might expect revenue from Feed-in-Tariffs (based on a flat rate of 31p/kWh) of:

Table 14: FITs revenues		
	Present Value of FITs revenue over lifetime (£)	**Annual FITs payment (£2009)**
Detached	5,410	395
Semi/End-terrace	4,601	255
Mid-terrace	4,737	346
Flat	2,896	211

Sectors and groups affected by the policy

House builders and landowners

75. As discussed in the previous impact assessments (and reflected in the capital costs presented in this impact assessment), zero carbon policies will place additional costs on builders. These costs include:

- the need for new designs and being sensitive to site conditions
- purchase of materials and equipment either of a higher specification than otherwise required or that otherwise would not be required at all
- increased costs in building and installation
- increased project management
- cost of dealing with residual net emissions via allowable solutions and
- increased compliance costs to ensure high performing homes are built as designed

76. Government considers that by setting the policy a number of years in advance of its introduction, the increased costs can be reduced and mitigated. In particular:

- industry can work to come up with new designs and influence supply chains so that the costs of preparing for and meeting the new requirements are minimised
- setting a clear national framework should reduce the costs that could potentially otherwise be caused by proliferation of local standards. This should facilitate industry to focus its research and development in bringing forward innovation and exploit economies of scale and
- costs of the policy can potentially be passed back to landowners in the form of reduced land prices (see below)

77. The recommendations of the task group have taken account of the capital costs of the energy efficiency standard. The standard they have proposed has a lower up-front capital cost than the Advanced Practice standard analysed in previous impact assessments. It is possible that, through clever design and learning, the cost of very high levels of energy efficiency can be progressively reduced[51]. Indeed, pursuing energy efficiency levels higher than the minimum standard will be an option open to builders as part of their strategy for meeting the carbon compliance requirement.

78. The additional costs associated with zero carbon homes will largely be passed back to landowners in reduced land value uplift (the difference between the value of their land with and without planning permission for housing development). This risks eroding the value of land for housing and potentially reduces the amount of land that will come forward for housing, especially in areas of lower house prices, higher existing/alternative use values and remediation costs. In practice however the scale of any such impact will depend on a variety of factors such as:

- the scale of the starting land values and uplift – sites and areas with high starting land values will be able to absorb more of the increase in costs without an impact on land being brought forward
- the possible increase in land values that may be expected, all things being equal, as a result of increased house building targets due to greater demand for land
- the impact of other claims on land value uplift (whether through Building Regulations, e.g. water efficiency or other policies such as S106 or community infrastructure levy (CIL)) that may be passed back to land-owners and reflected in land values. The Pre-Budget Report 2009[52] committed Government to scale back section 106 requirements as part of CIL implementation

[51] Research has a role in helping identify the potential for cost savings. In November 2009, the Government announced £3.2m of funding from the Technology Strategy Board to support a research project which will design, build and monitor homes built with 44 per cent lower carbon emissions than a home built to current building regulations without the use of renewable energy supply, ie carbon reductions achieved through fabric-related energy efficiency measures alone. http://www.communities.gov.uk/news/corporate/1391989

[52] http://www.hm-treasury.gov.uk/prebud_pbr09_index.htm

- any reduction in negotiable costs and planning obligations. The Government stated in its August 2008 policy document on CIL, that alongside the introduction of CIL, it is considering whether there is a case to restrict the use of planning obligations in the future
- the substitution of development which can support higher costs
- housing market conditions: house prices ultimately drive the value of the land on which the housing will be built, reflecting the fact that the demand for land is 'derived demand'
- the extent to which home builders are able to pass back (to landowners) or pass forward (to house buyers) the net increase in costs of meeting zero carbon standards
- the availability to home builders of incentives for installation of renewable electricity or heat in the form of Feed In Tariffs and Renewable Heat Incentive, either directly or (via an uplift in the sale price of the home) from home buyers. The availability of such incentives has not been modelled at a macro-economic level in the impact assessment but an illustration is provided in Box 1 below
- any change in landowner expectations (as to land values)

Box 1: Realising value from zero carbon homes

Table 9 above suggests an increased construction cost of £7,000 to £19,000 in today's costs for a zero carbon home (with the proposed energy efficiency standard and allowable solutions). The capital cost does not take into account learning effects and innovation which could bring the cost down over the coming decade. It is possible that housebuilders will realise a higher sales price, or other value, for a zero carbon home. For example:

- a zero carbon home should achieve energy bill savings in the region of £120 to £240 per year compared to homes built today
- a zero carbon home would typically generate approximately 1,500kWh of renewable electricity per year. This would be eligible for Feed-In-Tariffs in the range of perhaps 31p/kWh (refer to the FIT consultation document on DECC's website for details). This implies annual revenue of up to £480 per annum and
- a zero carbon home would be eligible for Renewable Heat Incentive (RHI) payments. As of yet, this is unquantified.

With the introduction of Energy Performance Certificates (EPCs), it is to be expected that energy bills will become a more important factor in determining property values. There is some international evidence of this and research is underway in the UK. The amount that homebuyers will be willing to pay for a home with a revenue stream such as FITs or RHI is not yet certain. However, the consultation on FITs holds open the prospect that FITs could be contractually assigned to the party installing the technology. Such an arrangement could potentially be used by housebuilders to recoup expenditure incurred on onsite renewables.

79. Some of the net costs of meeting the zero carbon homes standard may be reflected in a reduction in the price of land sold for housing development. This is not modelled as a separate cost in our analysis of costs and benefits as it simply represents a transfer from one economic agent to another, rather than an additional cost or benefit. To include it separately would be to double-count the increased costs of construction that are already included in the analysis.

80. However, it is possible that less land – or different land – would be brought forward for development with the policy in place. For example, some sites might be less suitable for onsite low and zero carbon (LZC) energy supply, and this would impact on the value received by sellers of such land. Additionally, the possibility of less land being brought forward for housing would mean foregone learning and experience benefits from building zero carbon homes and fewer knowledge spill-overs.

81. Recognising the need to preserve the viability of housing development, the July 2009 Written Ministerial Statement made clear the priority that Government places on the zero carbon homes policy relative to other regulatory claims on land values.

Supply chain

82. The need to install new energy saving measures and renewable energy technologies creates opportunities for suppliers and installers of energy efficiency products and micro-generation technologies to expand their sales and to develop new products and services aimed at new zero carbon homes. This may in turn require manufacturers to invest in research and development and in new or expanded production facilities.

83. The announcement of the carbon compliance level and the energy efficiency standard should give the supply chain an important insight into the features that can be expected in a zero carbon home. This should in turn give supply chains confidence to invest in production facilities for the necessary materials and equipment.

84. For a further discussion of the impact of the zero carbon homes policy on the UK and international market for micro-generation technologies, see two recent reports by Element Energy[53]. They suggest that the zero carbon homes policy would not only meet the Government's objective of accelerating the uptake of existing technology, but that it could also meet its objective of developing new technology. The new build market will drive significant economies of scale in manufacturing, which should be reflected in lower costs for onsite renewable technology and stimulate an increase in uptake in existing homes.

[53] *The Role of Onsite Energy Generation in Delivering Zero Carbon Homes: A study* – Element Energy (2007) http://www.renewables-advisory-board.org.uk/vBulletin/showthread.php?p=123#post123 and *The growth potential for Microgeneration in England, Wales and Scotland* – Element Energy (June 2008) http://www.berr.gov.uk/whatwedo/energy/sources/sustainable/microgeneration/research/page38208.html

Home buyers

85. As noted above, buyers of new zero carbon homes may bear some proportion of the cost of meeting the zero carbon standard in the form of a premium to the market price of a new home. However since the price of new homes is determined mainly by the market for existing homes, any such premium should depend on the willingness and ability of consumers to pay extra for zero carbon homes rather than a straightforward cost pass-through from house builders.

86. Research suggests that there is not a lack of desire for low or zero carbon homes, but rather a reluctance to pay a higher price[54]. It is possible that growing consumer awareness of energy costs and environmental issues, and the introduction of FITs and renewable heat incentives, will mean that consumers will be prepared to pay a premium for zero carbon homes.

87. In the longer term, the introduction of energy performance certificates may address some of the information barriers that prevent the energy efficiency of homes being fully reflected in house prices, and greater familiarity with zero carbon homes should enable the housing market to price in the attributes on which consumers might place a value, in particular:

- lower energy bills as a result of energy efficiency and use of on-site LZC technologies (see Box 1)
- receipt of revenues from on-site renewable energy in the form of FITs and RHI
- costs associated with servicing and eventually replacing microgeneration technologies installed on the home[55]
- costs of running renewable energy system such as biomass heating and
- non-monetary benefits and costs, e.g. enhanced thermal comfort[56] (although conversely there could be some negative connotations, which will need to be addressed, in relation to summer temperature and ventilation), consumer preferences for environmentally sustainable housing, aesthetic considerations and the 'hassle' factor of operating and servicing microgeneration technologies

Energy companies and consumers

88. In the absence of the policy, 240,000 new homes per year would add to the total demand for energy in the economy. All things being equal, such increases would be met primarily from large scale centrally generated sources (i.e. grid electricity and natural gas). Hence the policy may save the energy sector from needing to invest in

[54] http://www.spongenet.org/index.php?page=news&news_id=101 .

[55] Note that these are included in the 'capital and ongoing costs' modelling analysis, however replacement costs are not included. After the useful estimated lifetime has expired, the ongoing servicing and maintenance costs no longer accrue. Likewise, any financial and carbon benefits stop after this point.

[56] A reduction in assumed benefits to reflect comfort-taking has not been factored into the analysis. In practice, we anticipate that this should be less significant for new homes than for existing homes (which are less energy efficient and, in many cases, harder to keep warm).

additional large scale electricity generating plant and upstream gas infrastructure as well as purchasing larger amounts of fossil fuel resources to meet this demand. Additional energy demand also means that even more renewables are needed to meet EU targets. In a competitive market, such costs would be passed on to energy consumers at large.

89. So, by conserving energy and providing renewable energy supply, there is an avoided cost of renewables and energy infrastructure for the energy sectors.

90. The reduction in fossil fuels used for electricity generation should mean that electricity generators should be able to buy fewer EU ETS permits than would otherwise be the case, or to sell more surplus permits. This should offset some of the reduction in revenues (from lower demand) compared to the do-nothing case and make it easier to meet renewable energy targets.

Local authorities

91. It is unclear at this stage what the financial impact would be on local authorities (LAs). These depend on the regulatory role taken on by LAs in relation to the policy and, perhaps, on extra capital costs of any new homes built by LAs to the extent not funded through Government grant programmes. If there are additional net funding requirements for LAs a result of these issues, then Government will provide the necessary additional funding, in accordance with the new burdens doctrine. This will be analysed further as the approach to ensuring compliance and enforcement is taken forward.

Risks

92. **Industry preparedness**. There is a risk that the house building industry and its supply chain will not have sufficiently adapted its designs, products and production capability, or made the necessary investment in developing skills, to meet the zero carbon standard in 2016. To minimise this risk, we have signalled the policy almost a decade in advance of the policy coming into effect so as to give industry as much time as possible to adapt. An industry-led zero carbon delivery body has been formed to identify and address these issues over the period to 2016[57]. The need for industry to follow a trajectory to the zero carbon homes standard, via the interim changes in 2010 and 2013, also reduces the risk that industry takes no steps to prepare.

93. **Learning rates**. The analysis in this impact assessment assumed that costs will decline over time as energy efficiency and LZC technologies are deployed. The analysis conducted by Cyril Sweett in support of the *Building a Greener Future* policy included sensitivity cases varying capital costs and learning rates. This showed a range of some £6bn in the net present value of costs between the high and low case. Whilst this is significant, it should not fundamentally affect the ability of the industry

57 Zero Carbon Hub http://www.zerocarbonhub.org/pressrelease.html

to comply with the policy. The policy will need to be structured in a way that is viable from 2016, at a stage when the impacts of the learning effects will have had relatively little time to work their way into the industry cost structure.

94. **Economics of housing development**. It is important that the costs of zero carbon do not undermine the economic viability of housing development. There are a number of factors which influence land viability, both on the cost side and on the price side (housing market). Please refer to paragraphs 75 to 81 for more detail on the impact on house builders and housing supply.

95. **Consumer acceptance**. There is a risk that consumers might be reluctant to buy zero carbon homes if they are uncomfortable with some of the features described earlier. Similarly, there is a risk that they might not use the installed technologies correctly, with the result that energy and carbon savings are not fully realised. To minimise these risks, as part of its work programme the Zero Carbon Hub is planning to address consumer issues, so that consumers are receptive to the features of zero carbon homes and understand how to operate them.

96. Prioritisation of energy efficiency measures within the zero carbon hierarchy and inclusion of technologies which are not all mounted on the individual home should minimise the risks associated with home occupants allowing microgeneration technologies to fall into disuse. The energy efficiency task group recommended a standard which does not take into account the energy consumed and recovered from mechanical ventilation with heat recovery (MVHR) technology. This means that builders are not implicitly obliged to adopt MVHR and can choose (or not) to pursue it as part of their carbon compliance approach, depending on their own perception of consumer acceptance of MVHR.

97. **Compliance and enforcement**. There is a risk that builders will not comply with the regulations and that they will not be enforced effectively by the relevant regulators, with the result that energy and carbon savings will be lower than predicted. Again, this risk will be reduced by giving industry and regulators sufficient time to become accustomed to the regulations, and by ensuring that there is straightforward guidance on how to comply. Government is taking steps to improve compliance as outlined in its *Future of Building Control* consultation.

98. **Technology risks**. There is a risk that new technologies do not operate as well as predicted. There is also the risk that the policy could inadvertently encourage builders to adopt particular technology solutions which, in the longer term, are sub-optimal. The zero carbon policy does not rely on development of brand new technologies, and our analysis has explored the implications of a particular technology (biomass) not being available. So rather than rely on currently unavailable technologies, the policy will encourage the deployment, and perhaps ongoing improvement, of technologies which are already available but not yet widely adopted in this country.

This will be complemented by the introduction of other policies aimed at stimulating such technologies, for example FIT and Renewable Heat Incentives (RHI). The policy is designed to accommodate a range of energy technologies at a variety of scales, and should, therefore, be relatively robust if any particular technology proves to be less effective than assumed in the analysis.

99. **Unintended health consequences**. There is a risk that buildings with high levels of air-tightness could, if not correctly ventilated, have adverse health impacts in terms of moisture and air quality. That is why Part F (Ventilation) of the Building Regulations is reviewed in parallel with Part L, so as to ensure that energy efficiency is not pursued at the expense of occupants' health. The energy efficiency task group has recommended that further research be undertaken on the ventilation and air quality implications of highly energy efficient homes. Government will work with the Zero Carbon Hub and relevant industry and research bodies to ensure that these research needs are met. See also the health impact assessment, below.

Enforcement, monitoring and evaluation of the policy

100. Government will need to decide what regulatory processes and bodies we should task with monitoring and enforcing compliance with allowable solutions. We will wish to put in place a process which is as streamlined as possible and which does not place unrealistic expectations upon either building control bodies or local planning authorities (LPAs). It may be that there is a role for other parties here – for example, the growing industry associated with providing energy advice and certifying the energy performance of buildings.

101. Allowable solutions will not be needed at mass scale until 2016. The detailed mechanisms will need to be designed in further detail, and will be consulted upon at a later date. This will include consideration of what further powers are needed, if any, over and above existing legislation in order to give effect to the allowable solutions (and, potentially, carbon compliance too).

102. An implementation survey of the 2006 Part L amendments was carried out in the run up to the consultation on proposed changes to Part L in 2010 and helped to inform proposals for further improving compliance. A similar approach will be adopted in the run-up to the 2013, 2016 and subsequent reviews of Building Regulations beyond that date. The aim of these surveys is to determine how the regulatory provisions are working, whether the projected carbon savings are being achieved, and to tailor the new amendments accordingly. Further evaluation will be undertaken, for example making use of EPCs and other existing information-gathering mechanisms.

Implementation

103. The detailed implementation of the policy will be taken forward as part of the regular three year cycle of reviews of Part L of the Building Regulations. On 18 June 2009 Government issued a consultation on the revisions to be made to Part L of the Building Regulations in 2010. Extensive modelling of detailed technical considerations has been undertaken to support the Part L work and future versions of this impact assessment will reflect that analysis. There will be similar processes of consultation in advance of the detailed amendments to the regulations to be made in 2013 and 2016. The Government will also ensure that planning policies which support the policy are kept up to date[58].

104. Government is supporting the Zero Carbon Hub to steer delivery of this agenda. The work of the delivery body is overseen at a strategic level by the 2016 Task Force which is co-chaired by the Minister for Housing and Planning and the Executive Chairman of the Home Builders Federation.

105. The 2016 Task Force and the delivery body should not need to continue indefinitely, as eventually implementation of the zero carbon homes agenda will be become 'business as usual' for the delivery body and industry in turn. Government will, therefore, keep its participation in and support for these bodies under review as implementation proceeds.

Competition assessment and small firms impact test

106. The proposed policy should not have a significant impact on competition in the affected industries.

107. Small and medium-size (SME) firms (who employ up to 250 people) make up almost 60 per cent of the construction market by turnover, and there are around 140,000 SMEs employing 937,000 people in 2007[59].

108. It is possible that smaller builders and developers may find it more difficult to adjust to the new regulations. Larger firms tend to have an employee dedicated to ensuring regulations are met and at the lowest cost, whereas smaller firms may have to spend more time on it – using someone less expert – or hire consultants. Larger firms also benefit from economies of scale, lowering the average cost of building as more developments or dwellings are built.

109. The work of the Zero Carbon Hub will be available to support smaller house builders and they will be establishing a workstream to engage with the house building sector. The structuring of the policy to include allowable solutions also diminishes the impact of the policy on small sites and therefore small builders (since smaller builders tend to develop smaller sites).

[58] Communities and Local Government (2007): *Climate Change Planning Policy Statement* http://www.communities.gov.uk/publications/planningandbuilding/ppsclimatechange

[59] http://stats.berr.gov.uk/ed/sme/smestats2007.xls

110. The energy efficiency task group recommended that industry should develop design guidance to help industry (and in particular smaller builders) develop practical solutions to implement the energy efficiency and carbon compliance requirements. CLG will work with industry in taking these proposals forward.

Carbon assessment

111. Electricity savings result in financial benefits but not carbon benefits as emissions from this sector are fixed by the EU ETS. As such, carbon benefits from reductions in electricity demand/decarbonised electricity supply are instead quantified in terms of the value of EU allowances saved, according to DECC guidance[60].

112. Heat savings result directly in carbon savings as they are not covered by the ETS (i.e. they are non-ETS) and are monetised using carbon values from DECC guidance.

113. It is to be noted that reductions in carbon associated with energy efficient fabric relate largely (but not entirely) to the non-traded sector since many homes rely on gas central heating. So, including a high energy efficiency standard within the zero carbon homes definition means that a significant proportion of the carbon reductions will be realised in the non-traded sector.

Environmental impact test

114. Assisting in mitigating the causes of climate change by reducing carbon emissions from new homes is the primary purpose of this policy. This will be achieved through higher carbon performance standards for new homes from 2016 which will have an increasingly positive impact as more new homes are built over time and as zero carbon technologies and learning are transferred to existing homes.

115. In continuing to develop the zero carbon homes policy, we will have regard to other potential environmental impacts, in particular:

- the need not to unduly prejudice the development of smaller brownfield sites in favour of larger greenfield sites
- the implications of the possible large scale adoption of biomass energy and the possible consequences of this for land and water use biodiversity; air quality; and the transportation of biomass fuel

Sustainable development impact test

116. In addition to environmental impacts, the zero carbon homes policy will have an influence on wider aspects of sustainable development:

- the policy will contribute to wider national, regional and local sustainability goals by promoting innovation and by providing opportunities for new 'green' businesses and employment

60 http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/greengas-policyevaluation.pdf Updated energy prices available from BERR website; updated carbon values published alongside DECC's July 2009 UK *Low Carbon Transition Plan*

- social sustainability will be enhanced by new homes in all sectors to have improved levels of thermal comfort and energy efficiency which may also improve affordability of energy
- research undertaken by the Sustainable Consumption Roundtable[61] indicates that the presence of onsite renewables can bring about behaviour change towards energy use among householders

117. The energy efficiency standard is being consulted upon as part of the consultation on the Code for Sustainable Homes. The Code includes a wide range of sustainability criteria – not only carbon reduction and climate change adaptation but also broader environmental and sustainability features.

118. In addition, sustainability principles will be taken into account in developing the range of allowable solutions permitted in taking this policy forward.

Health impact assessment

119. The energy efficiency standard proposed in this consultation has a number of implications for health. First, experience from programmes such as Decent Homes and Warm Front suggests that improving the thermal comfort of dwellings (which will be a direct result of the proposed improvements to Building Regulations) has direct health benefits and can improve the quality of life for the occupants of the dwellings.

120. On the other hand, further research is needed to ensure that high levels of energy efficiency do not have unintended adverse consequences for health. The need for research on indoor air quality and ventilation has been noted further above. It should be noted that the implications for indoor air quality and health may potentially be positive. For example, the use of properly installed and maintained Mechanical Ventilation Heat Recovery (MVHR) may lead to reduced pollen and other airborne allergens within the home.

121. Another area where further research is required is on the potential for highly energy efficient homes to overheat in summer. This research requirement will be taken forward in collaboration with the Zero Carbon Hub and other relevant industry and research bodies.

[61] http://www.sd-commission.org.uk/pages/sustainable-consumption.html

122. More generally, the policy results in lower demand on the centralised energy network and greater deployment of on-site renewables. As noted in previous impact assessments, this may have positive and negative impacts on air quality in the form of reduced emissions of pollutants from centralised electricity generation but production of emissions associated with on-site biomass. The carbon compliance requirement has been set at a level which should generally enable technologies other than biomass to be adopted in those situations where local air quality considerations are likely to be a constraint on use of biomass technology.

Legal aid

123. There would be no impact on legal aid.

Equalities and human rights assessments

124. The policy would affect all parties the same regardless of race.

125. The policy would affect all parties the same regardless of gender.

126. The proposed policy would have the same effect on all parties regardless of disabilities. There is already a level of accessibility required by the current Building Regulations so zero carbon homes would still need to meet these. The responses to the consultation did not raise any issue of potential unequal impact on gender, ethnic/racial or disabled groups.

Rural proofing

127. The policy would not apply differentially to rural areas compared to urban. However, it may have different impacts in the two as follows:

- the zero carbon technologies which are most appropriate to rural and urban areas may differ (e.g. onsite wind power may be more appropriate in rural areas and district heating solutions less so)
- economies of scale may be harder to achieve in rural housing developments which will usually be smaller and often of lower density
- local learning rates are likely to be slower in rural areas and, in scarcer rural markets, it may take longer to develop sufficient numbers of service and maintenance engineers with skills in new technologies and
- in some rural areas (e.g. Areas of Outstanding Natural Beauty and National Parks), there may be restrictions on permitted design, building materials, etc which will make development in these areas more expensive

Specific Impact Tests: Checklist

Type of testing undertaken	Results in Evidence Base?	Results annexed?
Competition Assessment	Yes	No
Small Firms Impact Test	Yes	No
Legal Aid	Yes	No
Sustainable Development	Yes	No
Carbon Assessment	Yes	No
Other Environment	Yes	No
Health Impact Assessment	Yes	No
Race Equality	Yes	No
Disability Equality	Yes	No
Gender Equality	Yes	No
Human Rights	Yes	No
Rural Proofing	Yes	No

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Table A17: Cost effectiveness of Reference case and Options

Annex 1: List of related publications

- Communities and Local Government (July 2009) *Definition of Zero Carbon Homes: Impact Assessment* http://www.communities.gov.uk/publications/planningandbuilding/impactzerocarbon
- Communities and Local Government (November 2009) John Healey statement on Building Momentum for Homes of the Future http://www.communities.gov.uk/news/corporate/1391989
- Communities and Local Government (December 2008): *Definition of Zero Carbon Homes and Non-Domestic Buildings: Consultation* (http://www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinition).
- Communities and Local Government (December 2008): *Definition of Zero Carbon Homes: Impact Assessment* (http://www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinitionia).
- Cyril Sweett (February 2009): *Costs and Benefits of Alternative Definitions of Zero Carbon Homes: Project report* (http://www.communities.gov.uk/publications/planningandbuilding/definitionszerocarbonhomes).
- Communities and Local Government (September 2008): *Research to Assess the Costs and Benefits of the Government's Proposals to Reduce the Carbon Footprint of New Housing Development* (http://www.communities.gov.uk/publications/planningandbuilding/housingcarbonfootprint).
- Communities and Local Government (July 2007): *Building a Greener Future: Policy Statement* (http://www.communities.gov.uk/publications/planningandbuilding/building-a-greener).
- Communities and Local Government (July 2007): *Building a Greener Future: Final Regulatory Impact Assessment* (http://www.communities.gov.uk/publications/planningandbuilding/final-regulatory).
- Zero Carbon Hub (2009) *Defining Zero Carbon Homes: Have Your Say* http://www.zerocarbonhub.org/cons000001.php.

- Renewables Advisory Board, RAB (August 2007): *The Role of Onsite Energy Generation in Delivering Zero Carbon Homes* (www.renewables-advisory-board.org.uk/vBulletin/attachment.php?attachmentid=324&d=1195637587).
- Renewables Advisory Board 'Financial incentives for a major energy retrofit strategy for English homes' (July 2009) http://www.renewables-advisory-board.org.uk/vBulletin/showthread.php?t=208
- Communities and Local Government (January 2008): Planning Policy Statement: Planning and Climate Change: Impact Assessment (http://www.communities.gov.uk/publications/planningandbuilding/climatechange).
- Department of Energy and Climate Change (2008): *Renewable Energy Strategy*

Annex 2: Model assumptions

Table A1: Housing assumptions				
Compliance and phase-in assumptions: Percentage of houses built to each Building Standard type in each year (for modelling purposes)				
	2006 Part L	**2010 Part L**	**2013 Part L**	**2016 Zero Carbon**
2008	90%	10%	0%	0%
2009	80%	20%	0%	0%
2010	70%	30%	0%	0%
2011	60%	40%	0%	0%
2012	40%	60%	0%	0%
2013	10%	90%	0%	0%
2014	0%	60%	40%	0%
2015	0%	40%	60%	0%
2016	0%	10%	90%	0%
2017	0%	0%	60%	40%
2018	0%	0%	40%	60%
2019	0%	0%	10%	90%
2020	0%	0%	0%	100%
2021	0%	0%	0%	100%
2022	0%	0%	0%	100%
2023	0%	0%	0%	100%
2024	0%	0%	0%	100%
2025	0%	0%	0%	100%

Table A2: Housing Assumptions – Total houses built of each type, by year				
Total houses built of each type, by year[62]				
	Detached	**End terrace/semi**	**Mid terrace**	**Flat**
2008	43,000	42,000	32,000	54,000
2009	44,000	43,000	32,000	55,000
2010	44,000	43,000	33,000	56,000
2011	45,000	44,000	33,000	57,000
2012	46,000	45,000	34,000	59,000
2013	48,000	47,000	35,000	60,000
2014	49,000	48,000	36,000	62,000
2015	52,000	51,000	38,000	65,000
2016	55,000	54,000	41,000	70,000
2017	55,000	54,000	41,000	70,000
2018	55,000	54,000	41,000	70,000
2019	55,000	54,000	41,000	70,000
2020	55,000	54,000	41,000	70,000
2021	55,000	54,000	41,000	70,000
2022	55,000	54,000	41,000	70,000
2023	55,000	54,000	41,000	70,000
2024	55,000	54,000	41,000	70,000
2025	55,000	54,000	41,000	70,000
Proportion	**25%**	**25%**	**19%**	**32%**

Table A3: Housing Assumptions – Baseline energy demand				
Baseline energy demand in 2008 for a dwelling built to 2006 Part L standards				
	Detached	**Semi**	**Mid terrace**	**Flat**
Gas (kWh)	10,021	7,589	6,767	6,337
Electricity (kWh)	3,919	3,172	3,099	2,546
Biomass (kWh)	0	0	0	0

[62] Note this is simply an illustration of a trajectory that would see us meeting the Government's housebuilding targets, and the split between dwelling types is based on a historical average used in previous Part L and Zero Carbon Homes impact assessments. All figures have been rounded, so may not add.

Table A4: Technologies selected for the reference case (2010 and 2013 build standards)

Technologies selected and capital costs for Part L 2013 standard homes				
	Detached	**Semi**	**Mid terrace**	**Flat**
Primary electricity technology:	None	None	PV	PV
Annual production (kWh)	0	0	629	516
Primary heat technology:	Solar thermal	Solar thermal	None	None
Annual production (kWh)	1,519	1,300	0	0
Electricity required (kWh)	0	0	0	0
Biomass required (kWh)	0	0	0	0
Annual reduction in electricity demand due to energy efficiency measures (kWh)	314	240	246	142
Annual reduction in heat demand due to energy efficiency measures (kWh)	1,716	2,143	3,100	1,111
Upfront capital cost per dwelling (£)	**4,515**	**3,488**	**4,647**	**3,775**
of which: Energy Efficiency	1,419	938	839	440
of which: Carbon Compliance	3,906	2,550	3,808	3,335
Technologies selected and capital costs FOR PART L 2010 STANDARD HOMES				
Primary electricity technology:	None	None	None	None
Annual production (kWh)	0	0	0	0
Primary heat technology:	None	None	None	None
Annual production (kWh)	0	0	0	0
Electricity required (kWh)	0	0	0	0
Biomass required (kWh)	0	0	0	0
Annual reduction in electricity demand due to energy efficiency measures (kWh)	314	240	246	142
Annual reduction in heat demand due to energy efficiency measures (kWh)	1,716	2,143	3,100	1,111
Upfront capital cost per dwelling (£)	1,454	961	860	451

Table A5: Technologies selected for Option 2

Technologies selected and capital costs for zero carbon homes (2016 standard)

	Detached	**Semi**	**Mid**	**Flat**
Primary electricity technology:	Wind	PV	Biomass CHP	Biomass CHP
Annual production (kWh)	1562	1230	1114	684
Primary heat technology:	GSHP	Solar thermal	Biomass community heating	Biomass community heating
Annual production (kWh)	6910	1467	4953	3041
Electricity required (kWh)	2395.2704	0	0	0
Biomass required (kWh)	0	0	7429	4562
Annual reduction in electricity demand due to energy efficiency measures (kWh)	314	240	246	142
Annual reduction in heat demand due to energy efficiency measures (kWh)	3,603	2,862	3,635	1,359
Upfront capital cost per dwelling (£)	Detached	Semi	Mid-terrace	Flat
Total	**14,111**	**9,502**	**5,684**	**5,094**
Of which Energy Efficiency	5,371	2,041	1,492	887
Of which Carbon Compliance	8,740	7,461	4,191	4,207

Table A6: Technologies selected for Option 3 (APEE energy efficiency standard)

Technologies selected and capital costs for zero carbon homes (2016 standard)

	Detached	**Semi**	**Mid-terrace**	**Flat**
Primary electricity technology:	Wind	PV	Large Wind	Large Wind
Annual production (kWh)	1273	823	1115	681
Primary heat technology:	GSHP	Solar thermal	Biomass community heating	Biomass community heating
Annual production (kWh)	6910	1467	4954	3028
Electricity required (kWh)	2395	0	0	0
Biomass required (kWh)	0	0	7431	4542
Annual reduction in electricity demand due to energy efficiency measures (kWh)	–209	–102	–97	–36
Annual reduction in heat demand due to energy efficiency measures (kWh)	5,902	4,861	5,459	2,164
Upfront capital cost per dwelling (£)	**Detached**	**Semi**	**Mid-terrace**	**Flat**
Total	**16,541**	**11,670**	**9,605**	**9,300**
Of which Energy Efficiency	9,112	5,984	4,325	3,722
Of which Carbon Compliance	7,429	5,686	5,280	5,578

Table A7: Assumed energy prices (p/kWh)

	Variable element (for policy appraisal)						Retail price (for distributional analysis)					
	Electricity			Gas			Electricity			Gas		
	Low	Central	High	Low	Central	High	Low	Central	High	Low	Central	High
2008	9.6	9.6	9.6	2.2	2.2	2.2	15.3	15.3	15.3	3.7	3.7	3.7
2009	6.9	7.4	8.1	1.7	2.0	2.5	13.7	15.0	16.3	3.2	3.5	4.0
2010	5.2	7.8	8.1	1.3	2.2	2.6	12.7	15.4	16.2	2.7	3.7	4.1
2011	4.8	7.6	8.0	1.3	2.3	2.7	11.8	14.6	15.3	2.7	3.8	4.2
2012	4.8	7.7	8.2	1.3	2.3	2.8	11.8	14.7	15.6	2.7	3.8	4.3
2013	4.8	7.7	8.4	1.3	2.3	2.9	11.9	15.0	16.0	2.7	3.8	4.4
2014	4.8	7.8	8.7	1.3	2.3	3.0	12.1	15.2	16.4	2.8	3.8	4.5
2015	4.8	7.9	8.9	1.3	2.4	3.1	12.2	15.4	16.7	2.8	3.9	4.6
2016	4.9	8.0	9.3	1.3	2.4	3.1	12.4	15.7	17.2	2.8	3.9	4.7
2017	5.0	8.1	9.5	1.3	2.4	3.2	12.6	16.0	17.6	2.8	3.9	4.8
2018	5.0	8.2	9.8	1.3	2.4	3.3	12.8	16.2	18.0	2.8	3.9	4.9
2019	5.0	8.3	10.1	1.3	2.5	3.4	13.0	16.5	18.5	2.8	4.0	5.0
2020	4.9	8.3	10.4	1.3	2.5	3.5	13.1	16.8	18.9	2.8	4.0	5.1
2021	4.9	8.4	10.4	1.3	2.5	3.5	13.4	17.0	19.0	2.8	4.0	5.1
2022	4.9	8.5	10.3	1.3	2.5	3.5	13.6	17.2	19.0	2.8	4.1	5.1
2023	4.9	8.6	10.4	1.3	2.6	3.5	13.9	17.5	19.2	2.8	4.1	5.1
2024	4.9	8.7	10.4	1.3	2.6	3.5	14.4	17.8	19.3	2.8	4.1	5.1
2025	5.0	8.7	10.4	1.3	2.6	3.5	14.9	18.1	19.4	2.8	4.1	5.1
2026	5.0	8.9	10.4	1.3	2.6	3.5	15.2	18.5	19.5	2.8	4.2	5.1
2027	5.0	9.0	10.4	1.3	2.7	3.5	15.5	18.7	19.6	2.8	4.2	5.1
2028	5.0	9.1	10.4	1.3	2.7	3.5	15.8	19.0	19.7	2.8	4.2	5.1
2029	5.0	9.2	10.4	1.3	2.7	3.5	15.7	18.9	19.4	2.8	4.2	5.1
2030	5.1	9.3	10.4	1.3	2.7	3.5	16.0	19.1	19.4	2.8	4.3	5.1

Source: DECC

Table A8: Assumed biomass prices

Biomass prices (p/kWh)			
	Biomass (retail element)		
	Low	Central	High
2008	2.3	3.7	5.0
2009	2.3	3.7	5.0
2010	2.3	3.7	5.0
2011	2.3	3.6	4.9
2012	2.3	3.6	4.9
2013	2.3	3.6	4.9
2014	2.3	3.6	4.9
2015	2.3	3.6	4.8
2016	2.3	3.6	4.8
2017	2.3	3.6	4.8
2018	2.3	3.6	4.8
2019	2.3	3.5	4.7
2020	2.3	3.5	4.7
2021	2.3	3.5	4.7
2022	2.3	3.5	4.7
2023	2.3	3.5	4.7
2024	2.3	3.5	4.7
2025	2.3	3.5	4.7
2026	2.3	3.5	4.7
2027	2.3	3.5	4.7
2028	2.3	3.5	4.7
2029	2.3	3.5	4.7
2030	2.3	3.5	4.7

Table A9: carbon values (£/tCO_2)

	Traded			Non-traded		
	Low	Central	High	Low	Central	High
2008	12	21	26	25	50	75
2009	12	21	27	25	51	76
2010	12	22	27	26	52	78
2011	12	22	27	26	52	79
2012	13	22	28	27	53	80
2013	13	23	28	27	54	81
2014	13	23	29	27	55	82
2015	13	23	29	28	56	84
2016	13	24	29	28	57	85
2017	14	24	30	29	57	86
2018	14	24	30	29	58	87
2019	14	25	31	30	59	89
2020	14	25	31	30	60	90
2021	16	30	39	31	61	92
2022	18	34	46	31	62	93
2023	20	39	53	32	63	95
2024	23	43	61	32	64	96
2025	25	48	68	33	65	98
2026	27	52	76	33	66	99
2027	29	57	83	34	67	101
2028	31	61	90	34	68	102
2029	33	66	98	35	69	104
2030	35	70	105	35	70	105
2031	38	77	115	38	77	115
2032	42	83	125	42	83	125
2033	45	90	134	45	90	134
2034	48	96	144	48	96	144
2035	51	103	154	51	103	154
2036	55	109	164	55	109	164
2037	58	116	173	58	116	173
2038	61	122	183	61	122	183
2039	64	129	193	64	129	193
2040	68	135	203	68	135	203

Table A9: carbon values (£/tCO_2) *(continued)*						
	Traded			Non-traded		
	Low	Central	High	Low	Central	High
2041	71	142	212	71	142	212
2042	74	148	222	74	148	222
2043	77	155	232	77	155	232
2044	81	161	242	81	161	242
2045	84	168	251	84	168	251
2046	87	174	261	87	174	261
2047	90	181	271	90	181	271
2048	94	187	281	94	187	281
2049	97	194	290	97	194	290
2050	100	200	300	100	200	300

Source: DECC

Table A10: Learning rates	
Technology	**Scale of reduced costs in 2020**
GSHP	0.84
Micro Wind	0.92
Solar Thermal	0.80
PV	0.52
Biomass Combined Heat & Power	0.87
Energy Efficiency Measures (Option 2)	0.80
Energy Efficiency Measures (Option 3)	0.74
Energy Efficiency Measures (Reference Case)	0.85
	Scale of reduced costs in 2013
Solar Thermal	0.91
PV	0.76
Energy Efficiency Measures	0.90

These learning rates were taken directly from the Cyrill Sweett model for a predicted cost in 2020.

Table A11: Zero Carbon Hub model – assumptions for renewables		
Renewables Technical Data	**Units**	**Units**
Ground Source Heat Pump	**3.20**	COP
Air Source Heat Pump	**2.50**	COP
COP Derating for Hot Water	**0.70**	
Micro CHP	**3.0**	Heat:Power
Micro CHP electrical efficiency	**20%**	
Large CHP	**1.57**	Heat:Power
Large CHP electrical efficiency	**30%**	
Biomass CHP	**4.0**	Heat:Power
Biomass CHP electrical efficiency	**15%**	
Solar thermal	**400**	kWh/m²/yr
% heat delivered by solar (Solar Fraction)	**50%**	
PV	**800**	kWh/kWp/yr
Small Wind capacity factor	**20%**	
Large Wind	**30%**	
Renewables Resources Limits	**Units**	Units
Hot Water by Solar Thermal (Solar Fraction)	**50%**	
Max space on roof for solar – all sloping south	**20.00**	m^2
Size of small wind generator	**1.50**	kW
Carbon Factors	**Units**	**Units**
Elec to CO_2 factor	**0.430**	kg/kWh
Gas to CO_2 factor	**0.194**	kg/kWh
Heat by gas to CO_2 factor	**0.229**	kg/kWh
Elec to CO_2 factor- off grid	**0.430**	kg/kWh
Biomass CO_2 factor	**0.019**	kg/kWh
Heating Load Factors	**Units**	**Units**
CapCost Diversity Factor for Community Schemes	**60%**	
Domestic average to peak heat requirement	**20%**	
Thermal Storage (Operational Hours)	**17**	hours/day
Heating (and Cooling)	**Units**	**Units**
Boiler Efficiency (Seasonal)	**90%**	
Biomass Boiler Efficiency (Seasonal)	**85%**	
Design and Initial Fabric Quality		
Design Roof $W/m^2/^oK$	**0.13**	
Design Wall $W/m^2/^oK$	**0.18**	

Table A11: Zero Carbon Hub model – assumptions for renewables *(continued)*		
Design Floor W/m²/°K	**0.18**	
Design Windows W/m²/°K	**1.4**	
Airtightness m³/m²/hr	**3**	
Initial Roof W/m²/°K	**0.16**	
Initial Wall W/m²/°K	**0.28**	
Initial Floor W/m²/°K	**0.20**	
Initial Windows W/m²/°K	**1.8**	
Wall type (Masonry)	**Full Fill**	
Costs	**Units**	**Units**
Solar thermal active surface	**1000**	£/m²
Photovoltaics	**6000**	£/kWp
Cost of Small Wind Generator	**3500**	£/kWp
Cost of Large (Centralised) Wind Generator	**1500**	£/kWp
Cost of Ground Source Heat Pump	**1750**	£/kW heat
Cost of Air Source Heat Pump	**750**	£/kW heat
Cost Small Biomass	**550**	£/kW heat
Cost Centralised Biomass	**200**	£/kW heat
Micro Combined Heat & Power Cost	**3000**	£/kW elec
Large Combined Heat & Power Cost	**1000**	£/kW elec
Cost Biomass CHP	**4000**	£/kW elec
Cost Thermal storage	**1**	£/litre
Cost of MVHR & airtightness	**2264**	£
Cost of Footprint (land) lost	**200**	£/m²
Cost of wall, outer skin	**40**	£/m²
Cost of extra foundation width	**40**	£/m²
Community Heating Distribution Costs	**Units**	**Units**
Average Cost High Density	**400**	£/m
Average Cost Medium Density	**450**	£/m
Average Cost Low Density	**500**	£/m
Average Pipe Length High Density	**8**	m
Average Pipe Length Medium Density	**13**	
Average Pipe Length Low Density	**20**	kWh/m²/annum

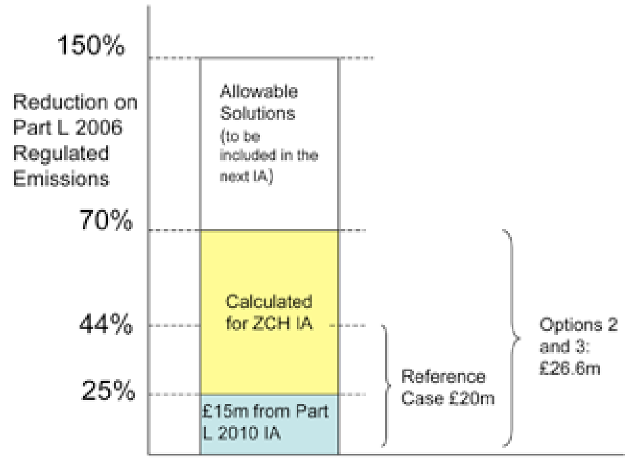
Table A12: Ongoing servicing and maintenance costs
Technology costs – ongoing servicing/maintenance and lifetime assumptions

	Lifetime (years)	Annualised servicing/ maintenance cost (£)
Energy efficiency measures	40	
PV (optimum)	30	110
Wind	20	110
Large wind	25	150
Solar thermal Flat Plate	20	44
GSHP for heat	20	44
ASHP for heat	12	44
Small biomass	20	220
Biomass CHP	20	220
Large biomass	30	220
large CHP	25	110

Annex 3: Administrative costs calculations

The diagram bellow represents the administrative burden associated with each component of the Zero Carbon Homes policy.

Diagram A1: Representation of administrative cost calculations for Building Regulations Part L 2010, 2013 and 2016 zero carbon homes



Reference Case (44 per cent carbon compliance)

The June 2009 Part L Impact Assessment[63] estimated an on-going administrative burden of £15m relating to changes to the Building Regulation in 2010. There will be a further change to Part L in 2013 which will result in additional administrative burdens. These form part of the reference case described below.

For the purposes of this impact assessment, the administrative burden from 2010 to 2013 is assumed to be half of that calculated from 2010 to 2016 (i.e. half the value of the yellow box above). The calculation of which is detailed below. This results in an estimated on-going admin burden for the reference case of £20m per annum.

Options 2 and 3: 70 per cent carbon compliance

The administrative burdens associated with the carbon compliance level of 70 per cent include the on-going £15m per year figure from the June 2009 Part L impact assessment. The additional administrative burdens caused by the 2013 Building Regulations Part L change and the 2016 step to the 'zero carbon homes' carbon compliance level are represented by the yellow box above and are estimated to be around £11.6m per year. Therefore, the total on-going administrative burden of the 'zero carbon homes' carbon compliance level of 70 per cent (the sum of the blue and yellow boxes above) is approximately £26.6m per year.

[63] Proposals for Amending Part L and Part F of the Building Regulations – Consultation: Volume 1, Annex B, page 156

The additional administrative obligations result from potential new information requirements around increased complexity of SAP, increased testing of building performance and a manual for homeowners, and are purely for illustrative purposes and do not set the future direction of policy in this area.

Assumptions have been made on the time and wage rates assumed for the incremental burden that occurs in addition to that associated with Part L 2010 up to 70 per cent carbon compliance. The burden associated with allowable solutions will be included in forthcoming impact assessments once the delivery mechanism is clearer and we can have greater certainty over the robustness of the calculations.

Table A13: Admin burden calculations for Zero Carbon Homes impact assessment (December 2009)

Admin Burden associated with the increase from 25 per cent Carbon Compliance to 70 per cent Carbon Compliance			
Information Obligation 1: Increase in complexity of SAP			
	Time (hours)	**Wage (£ per hour)**	**Total**
Calculation/reporting	0.5	16.2	8
Familiarisation	0.5	16.2	8
Gathering/ Preparing	1	16.2	16
Inspections	0	16.2	0
Meetings	0	16.2	0
Preparing/Submitting	0.5	16.2	8
Total			£41
Total inc 30% overheads			£53
Population			65,000
Annual total (£)			£3,422,250
Information Obligation 2: Increased Testing			
	Time (hours)	**Wage (£ per hour)**	**Total**
Calculation/reporting	0	16.2	0
Familiarisation	0	16.2	0
Gathering/Preparing	0.5	16.2	8
Inspections	1.5	16.2	24
Meetings	0.5	16.2	8
Preparing/Submitting	0.5	16.2	8

Table A13: Admin burden calculations for Zero Carbon Homes impact assessment (December 2009) *(Continued)*			
Total			£49
Total inc 30% overheads			£63
Population			65,000
Annual total (£)			£4,106,700
Information Obligation 3: Providing a manual to homeowners			
	Time (hours)	**Wage (£ per hour)**	**Total**
Calculation/reporting	0.5	16.2	8
Familiarisation	0	16.2	0
Gathering/Preparing	2	16.2	32
Inspections	0	16.2	0
Meetings	0	16.2	0
Preparing/Submitting	0.5	16.2	8
Total			£49
Total inc 30% overheads			£63
Population			65,000
Annual total (£)			£4,106,700
Combined annual total per application (£)			£179
Combined annual total for population (£)			**£11,635,650**
Part L 2010 Admin Burden			£15,000,000
Total Admin Burden			**£26,635,650**

Summary Sheets: Reference Case			**5,817,825**
Summary Sheet: Option 2 and 3			**11,635,650**

To Note:

Wage rates are in 2005 prices

The summary sheets do not include the £15m associated with Part L 2010 to avoid double counting with administration burdens currently contained within the Administrative Burden Reduction Programme (ABRP).

Part L 2010. The 15m administrative burden figure will be recalculated using the standard cost model as part of the Impact assessment for Part L 2013.

The information obligations included are for illustrative purposes and do not set the future direction of policy.

Population is average annual planning applications which tends to have the ratio of one application requesting permission for three dwellings, based on CLG housebuilding statistics.

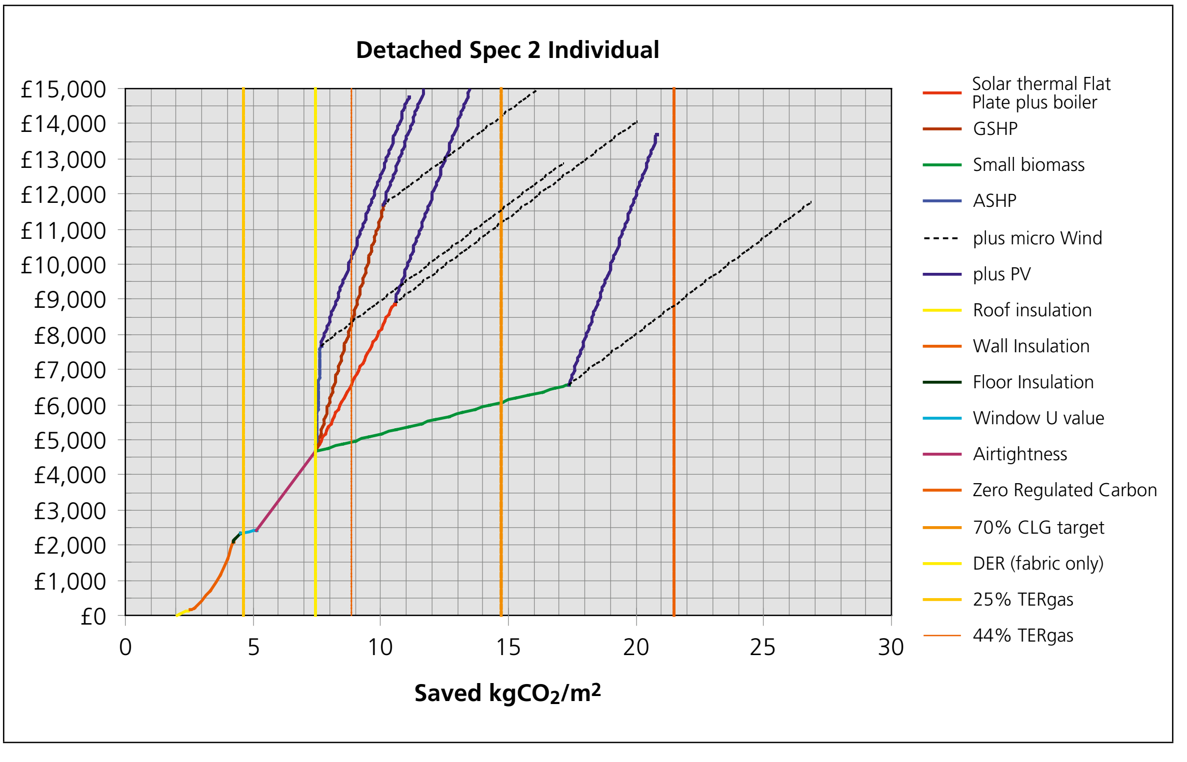
Annex 4: Inputs on costs and capacities of renewables for dwelling types

The Zero Carbon Hub modelling work[64] is set up to model a range of dwelling types and assumptions about their heating systems. Some example cost curves – as well as the inputs selected for each of the four main house types – are shown below. The left hand axis is the additional cost (over 2006 Building Regulations) of meeting the 70% carbon compliance standard (shown in orange).

All of the following are modelled with the proposed Hub/Taskforce energy efficiency standards, which are 'Spec B & natural ventilation' for semi-detached and mid terraced houses, and flats; and 'Spec C- with natural ventilation' for detached houses (see Table 1 at the beginning of this document).

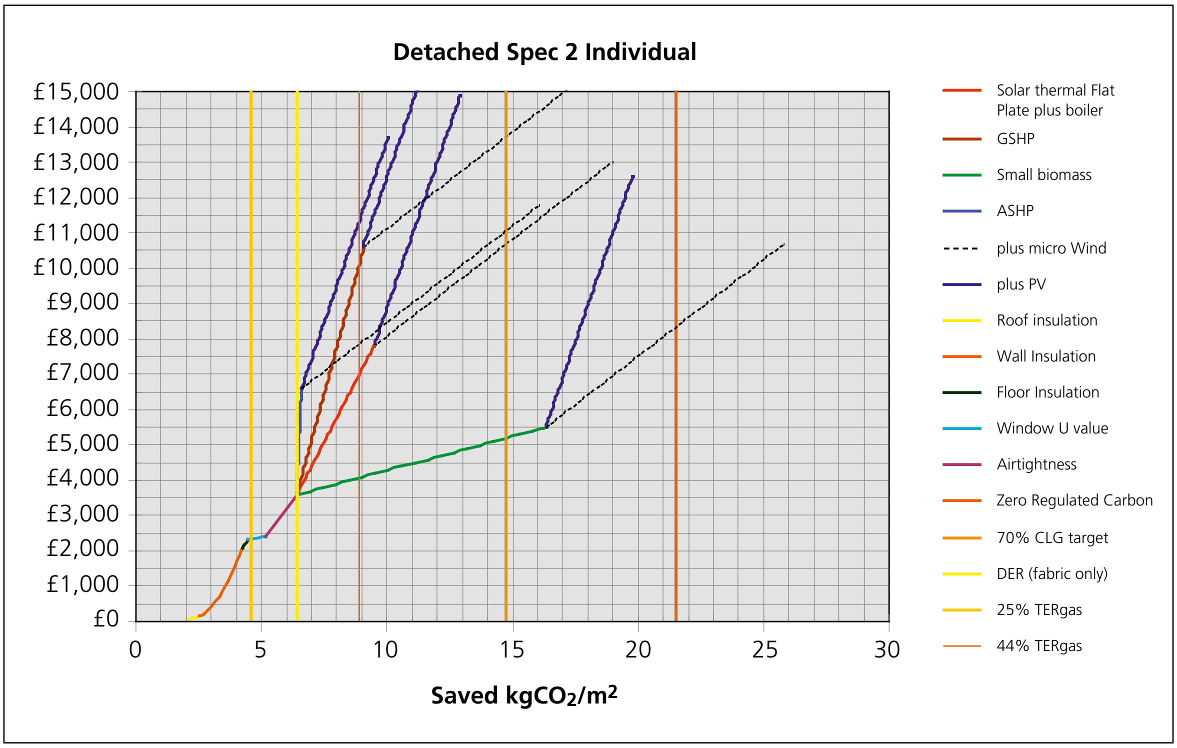
Detached house

The following diagram illustrates the additional cost of saving CO_2 in a detached house, assumed to have an individual (i.e. not shared) heating system and where Mechanical Ventilation Heat Recovery (MVHR) is assumed to be available. Carbon factors are assumed to be 0.43kgCO_2/kWh for electricity and 0.194kgCO_2/kWh for gas:

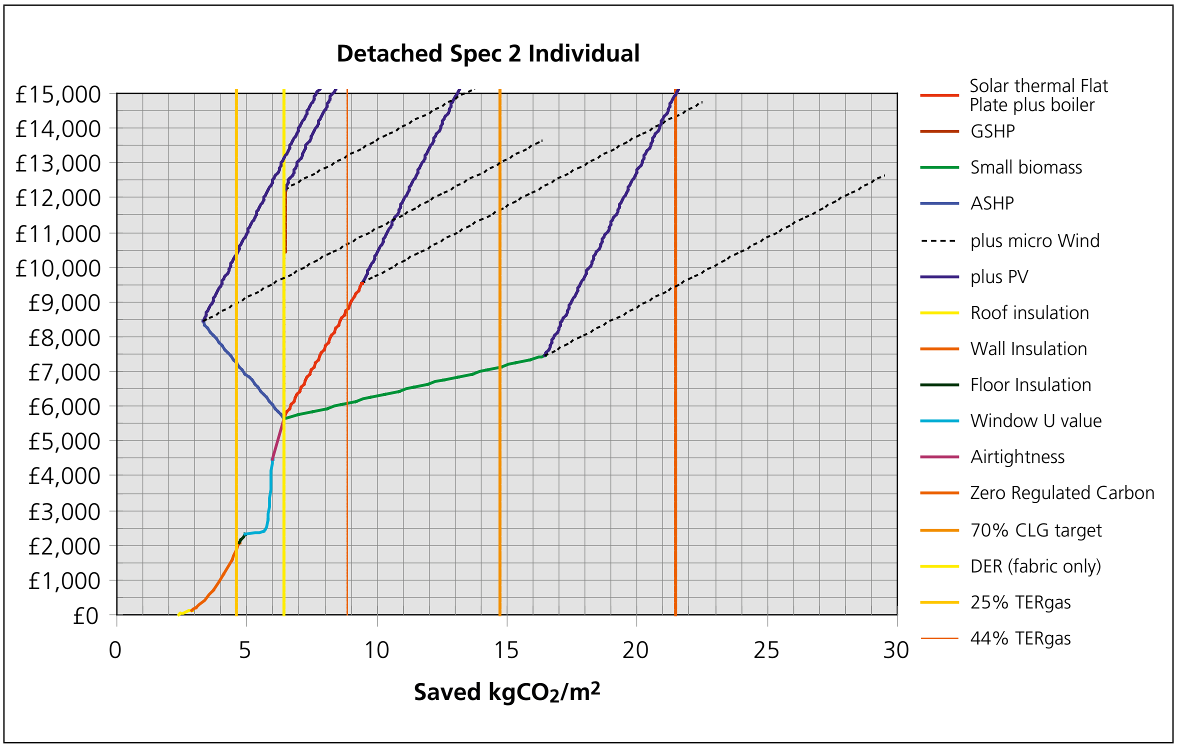


The same detached house with individual heating system (and same carbon factors) has the following cost curves when MVHR is *not* used:

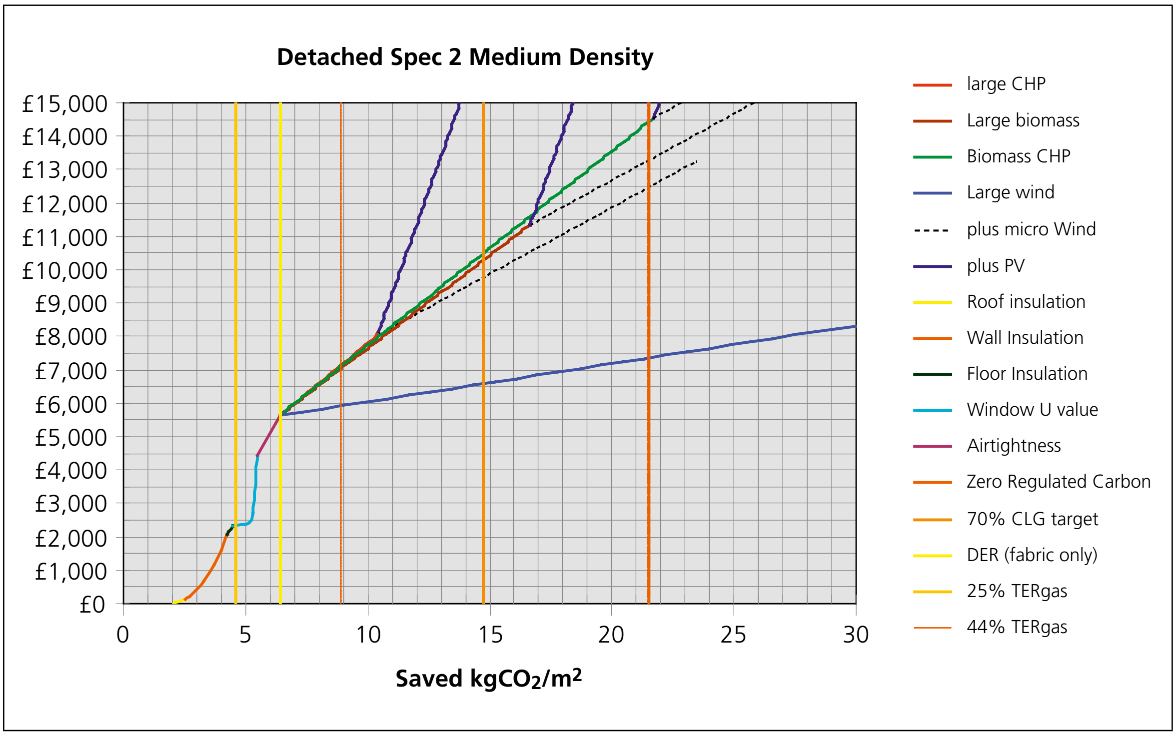
64 Not yet published separately: modelling assumptions and results set out in this impact assessment



If we use the carbon factors consulted on in SAP, 0.591kgCO_2/kWh for electricity and 0.206kgCO_2/kWh for gas, the cost curve slopes shift:



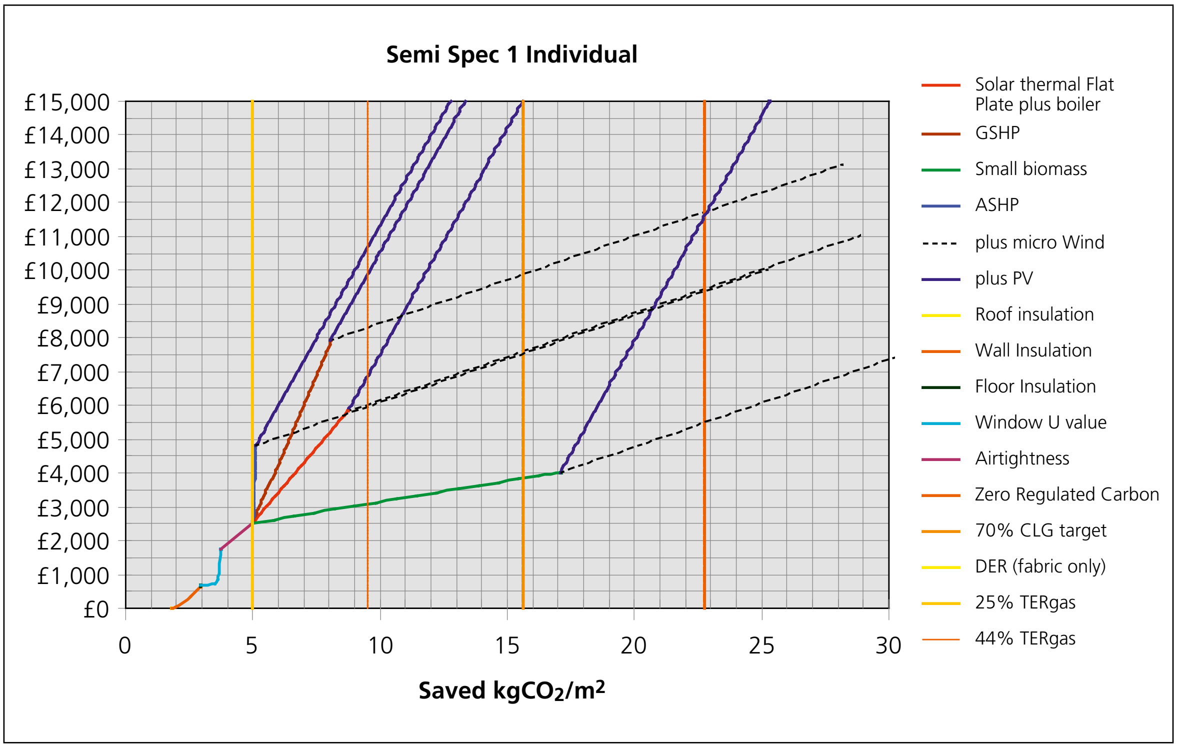
If a shared heating scheme – for example at medium density – is available then the costs (assuming MVHR is not used, and the 0.43 and 0.194 carbon factors are used) become:



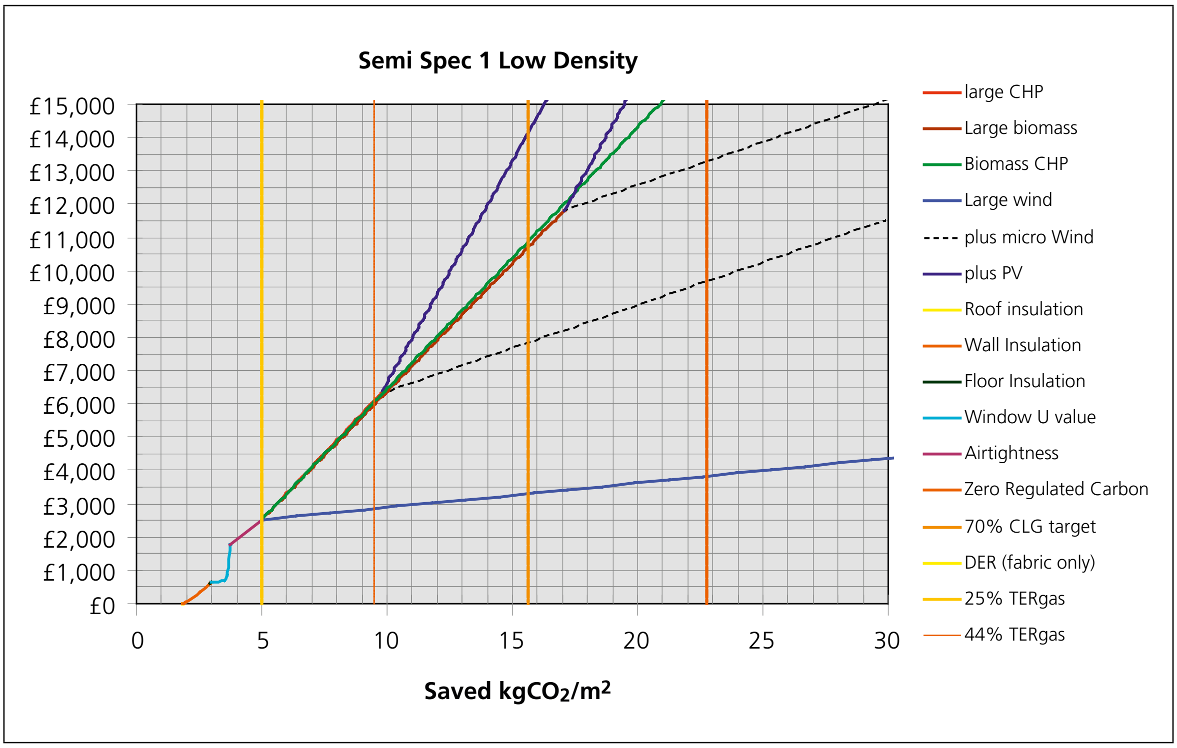
For the cost-benefit analysis in this impact assessment, we modelled a detached house as having a Ground Source Heat Pump as its [individual] heating system, with a wind turbine, without MVHR and using the 0.43kgCO_2 (electricity) and 0.194kgCO_2/kWh (gas) carbon factors. It is not the cheapest approach based on the assumptions used in the model. For example cheaper alternatives include biomass CHP, large wind or a biomass boiler. It is simply a generalised (as we do not expect all detached houses built from 2016 to be built with such renewable technologies on them) and illustrative example, for cost-benefit analysis purposes.

Semi-detached

If MVHR is not used, for a semi-detached house[65] built with an individual heating system, the cost curve is:



If a community heating system – for example at low density – were available (and no MVHR), then:

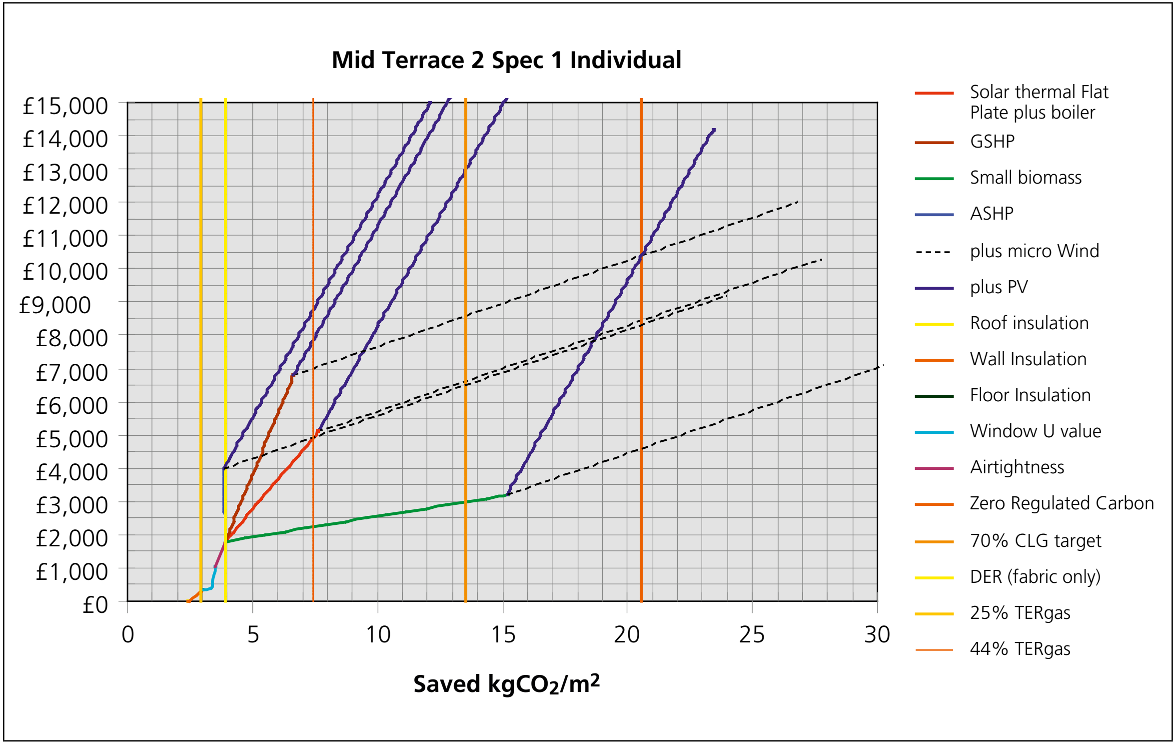


65 Unless otherwise stated, all diagrams assume carbon factors of 0.43kgCO_2/kWh for electricity and 0.194kgCO_2/kWh for gas

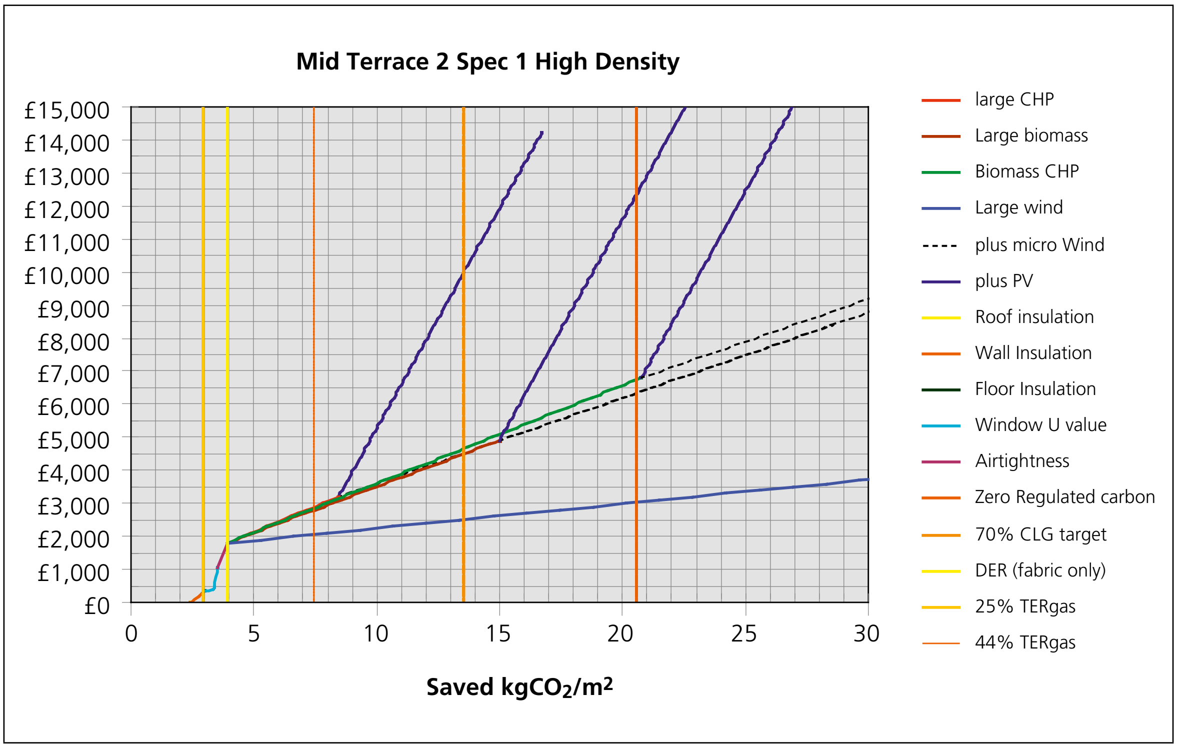
For the cost-benefit analysis in the impact assessment, a semi with an individual heating system and no MVHR was assumed, using solar thermal for renewable heat and PV panels for renewable electricity. This is an illustrative example for purposes of costing.

Mid-terrace

With an individual heating system and no MVHR, the mid-terrace cost curve is:



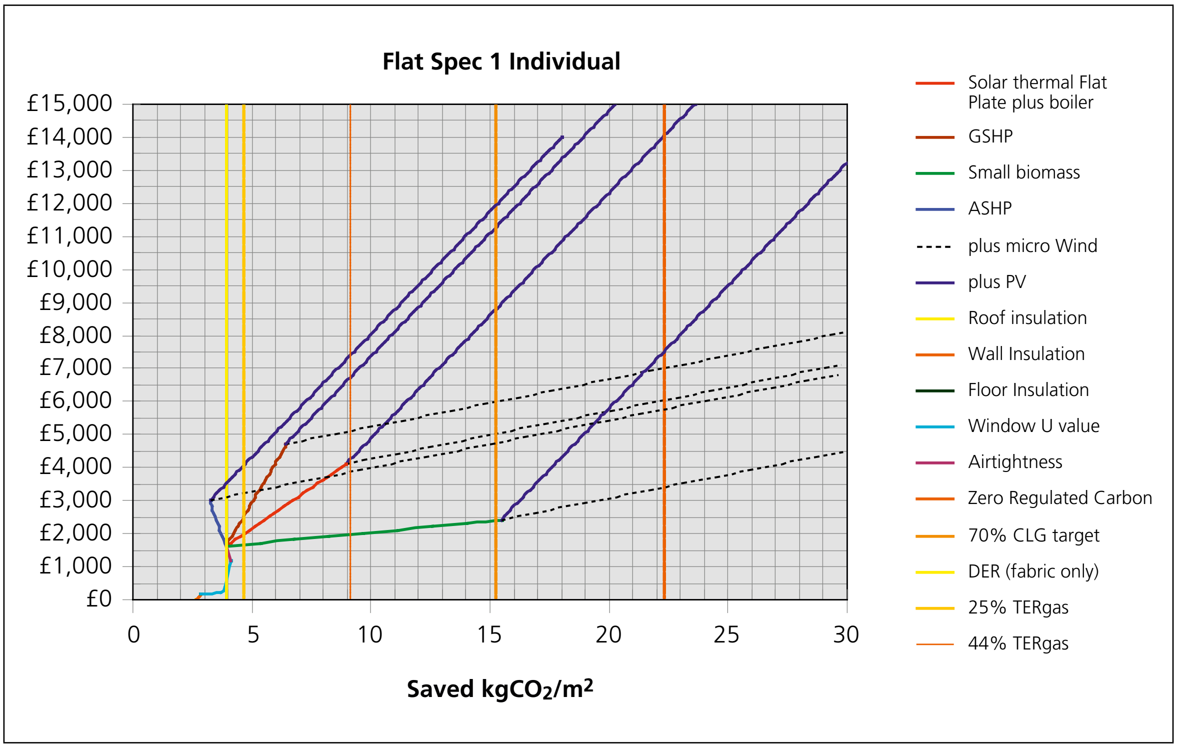
Using a high density shared heating system leads to the cost curve looking like this:



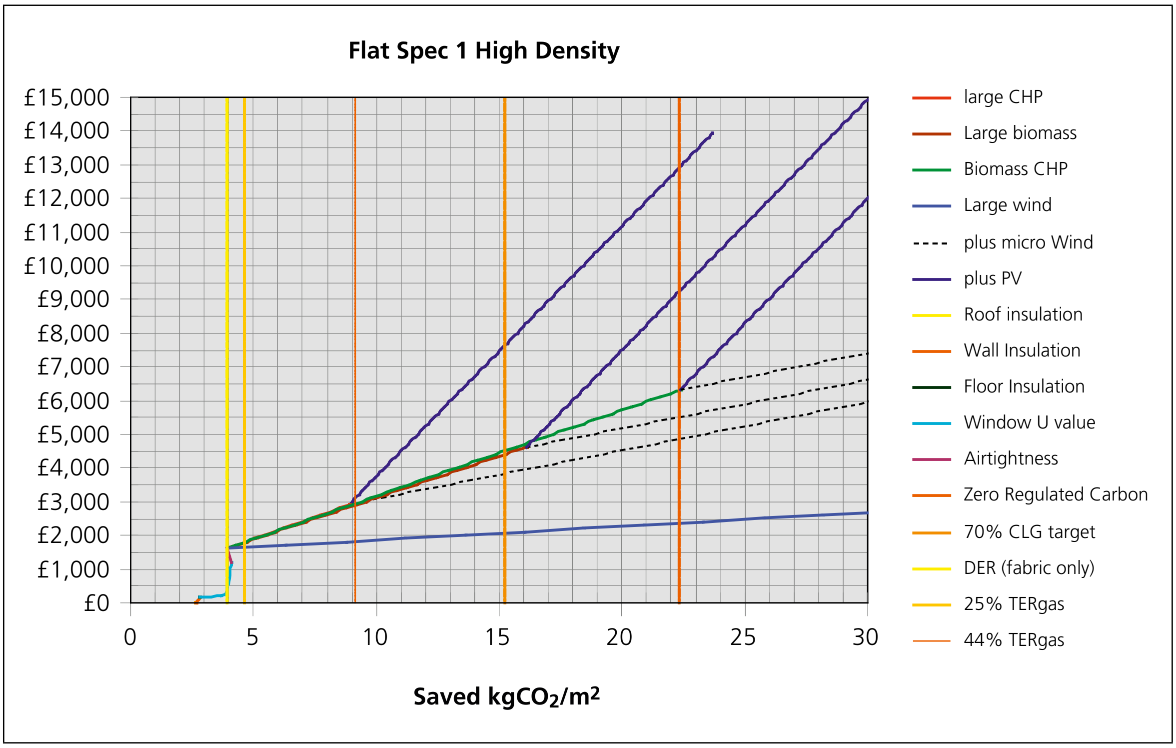
For purposes of the impact assessment, mid-terraces were assumed to be heated using a shared, medium density biomass combined heat and power (CHP) renewable heat source.

Flat

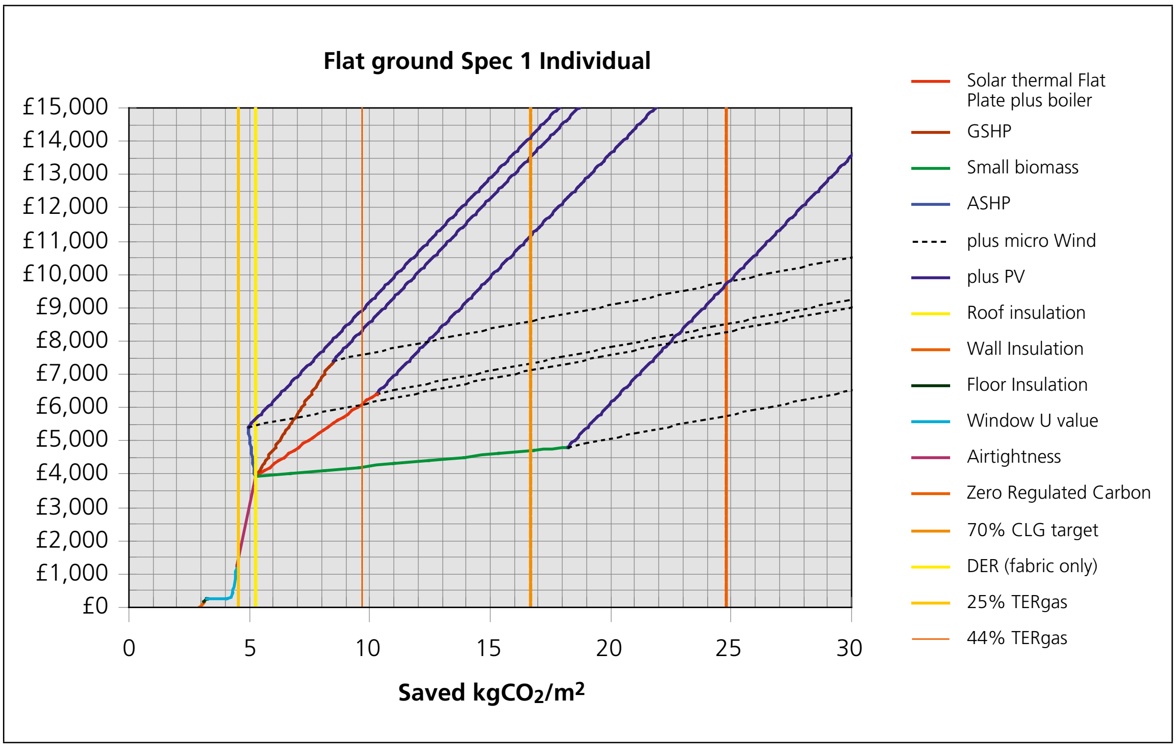
An individually-heated flat with no MVHR:



When high-density shared heating is available, the costs fall:



For a ground-floor flat with individual heating system and MVHR:



For the impact assessment's cost-benefit analysis, the flat was modelled (rather than the ground-floor flat specifically), using a shared, medium density biomass combined heat and power (CHP) renewable heat source.

Annex 5: Carbon compliance and allowable solutions

Under the proposals put forward in the December 2008 consultation and confirmed in July 2009, a zero carbon home must:

- achieve very high standards of energy efficiency (which is the subject of this impact assessment)
- achieve at least a 70 per cent reduction in carbon emissions compared to current Building Regulations through a combination of energy efficiency, onsite low and zero carbon energy (including directly connected offsite heat) technology (known as 'carbon compliance')
- include a combination of other measures from a list of 'allowable solutions' to deal with the remaining carbon associated with all energy use in the home (both energy uses that are currently regulated by Building Regulations and other energy use such as cooking and appliances)

Carbon compliance

The minimum level of carbon reduction to be achieved through carbon compliance, following the December 2008 consultation, was set at 70 per cent compared to Part L 2006 regulations.

The 70 per cent reduction was based on the assumptions set out in the December 2008 consultation. These included, in particular, certain amendments made to the 2005 version of the Standard Assessment Procedure (SAP) to take account some of the changes to SAP that might be foreseen in the future, such as using the same carbon emissions factor for imported and exported electricity. The key assumptions made were described in Annex E of the consultation document.

The viability and cost of achieving a given level of carbon compliance will be sensitive to the assumptions that are made regarding SAP and it is recognised that the precise assumptions and methodology of the version of SAP that will apply from 2016 are not yet known. Therefore, in announcing the 70 per cent carbon compliance level, the July Ministerial Statement clarified that Government would consider updating the carbon compliance level, as necessary, in light of technical changes, such as developments to SAP, to maintain the overall level of ambition implied by the 70 per cent announcement and provide continued certainty to industry.

Since the December 2008 consultation was undertaken, DECC has consulted on a revised version of SAP that will apply from 2010. However, for purposes of carbon compliance calculations, this impact assessment is based on the same key assumptions that were made regarding SAP as were made in the December 2008 consultation. Therefore no adjustment is made, or needs to be made, to the 70 per cent figure for purposes of this impact assessment.

Use of allowable solutions

As set out in the July 2009 Written Ministerial Statement, any carbon not mitigated on site will be dealt with through a range of good quality allowable solutions. The allowable solutions will cover carbon emitted from the home for 30 years after build.

Responses to the consultation took different views about some of the solutions suggested. The July 2009 written ministerial statement set out the allowable solutions that commanded broad support in the consultation:

- further carbon reductions on site beyond the regulatory standard
- energy efficient appliances meeting a high standard which are installed as fittings within the home
- advanced forms of building control system which reduce levels of energy use in the home
- exports of low or renewable heat from the development to other developments
- investments in low or zero carbon community heat infrastructure

Other allowable solutions remain under consideration.

Government will consider with stakeholders the practical arrangements that would be required to permit allowable solutions to be put in place and to ensure that standards are achieved in practice. It is recognised that not all of the allowable solutions are equally amenable to performance directly by the house builder and that there is an appetite from industry for delivery mechanisms that make implementation of allowable solutions as straightforward as possible.

The cost of the allowable solutions in a given place is currently hard to assess – not least because the markets for heat and renewables are likely to change substantially as a result of other policy changes. It is also necessary to take into account the search costs, transaction costs and administrative costs for the delivery mechanisms that will apply. For purposes of this impact assessment, we have retained the assumption from the earlier impact assessment that residual emissions can be abated at a net cost[66] of between £50/tCO^2 and £100/tCO_2[67].

£50/tCO_2 was used as the average net cost of renewable heat technologies per tonne of carbon dioxide saved (calculated after allowing for the revenues that the sale of heat should generate). This figure was arrived at from internal analysis based on Poyry's

[66] These £50/tCO_2 and £100/tCO_2 figures are expressed here in 2008 prices, but all of the relevant costs and benefits presented in the tables are calculated in 2009 prices, having been increased by 2.5 per cent (the Gross Domestic Product (GDP) deflator between 2008 and 2009).

[67] The central case models 50% of allowable solutions being renewable electricity at £100/tCO_2 and 50% of renewable heat at £50/tCO_2, as in July 2009.

study[68] on different types of district heating networks, and has been used to analyse the 'renewable heat' elements of the allowable solutions[69].

100/tCO_2 was used for modelling renewable electricity elements of the allowable solutions. It was based on an average renewable electricity cost of £43/MWh in 2016 (figure taken from RES analysis[70]), and the average carbon content of grid electricity being 0.43kgCO_2/kWh[71], putting the cost in the region of £100/tCO_2.

In order to allow developers the certainty to plan ahead, the December 2008 consultation proposed a maximum cost that Government would expect developers to bear in mitigating residual emissions via allowable solutions. The July 2009 Written Ministerial Statement confirmed that Government would set a guideline maximum price we expect industry to bear in implementing allowable solutions, following further work (not yet completed) on costs.

The July 2009 Written Ministerial Statement confirmed that 30 years of residual carbon would need to be abated via the allowable solutions. The earlier consultation sought opinions on 30 versus 60 years, the rationale for these figures being as follows:

- whilst a home can last 100 years or more, 60 years is often seen as the minimum design life (for example based on Council of Mortgage Lenders guidance). So, one approach for allowable solutions would be to deal with 60 years of residual emissions, representing residual emissions over the lifetime of the home
- however, there are arguments against that approach. First, the purpose of allowable solutions is to deal with those emissions that cannot be abated on-site. Many of the energy supply technologies which might be adopted on-site are likely to have a design life of less than 60 years, so it would be arguably harsh to require allowable solutions to cover a longer period of emissions
- given that the majority of residual emissions will be associated with electricity use (given that a high proportion of regulated emissions will be dealt with via carbon compliance measures), it is relevant to take into account the progressive decarbonisation of the electricity grid. Setting a life of 30 years for residual emissions provides an approximation of the period beyond which the electricity grid will have been substantially decarbonised.

[68] Poyry et al. (2009) *The Potential and Costs of District Heating Networks* http://www.ilexenergy.com/pages/documents/reports/electricity/A_report_providing_a_technical_analysis_and_costing_of_DH_networks.pdf

[69] It should be noted that DECC analysis for the Renewable Energy Strategy suggests the costs of renewable heat incentive policies for both residential and industrial/commercial sectors could be around £80/tCO_2 and renewable electricity incentives could cost at least £105/tCO_2.

[70] See *UK Renewable Energy Strategy* (2008) *http://www.berr.gov.uk/whatwedo/energy/index.html* and Implementation of EU 2020 Renewable Energy Target in the UK Electricity Sector: Renewable Support Schemes

[71] Carbon intensity of grid electricity of 0.43kgCO_2/kWh follows DECC (December 2008) guidance on appraising greenhouse gas policies

Annex 6: Costs and benefits tables

Table A14 – Costs and Benefits of Reference case

	PV capital cost (£m)	PV ongoing costs (£m)	PV financial benefits (£m)	Financial NPV (£m)	PV traded carbon benefits (£m)	PV non-traded carbon benefits (£m)	*Total NPV (£m)*
2010 Part L standards	526	292	884	66	61	400	***528***
2013 Part L standards – for houses built between 2013 and 2016	1,960	910	1,111	–1,759	112	444	***–1,203***
2013 Part L standards – for houses built from 2016 onwards	3,562	2,070	2,585	–3,047	298	1,239	***–1,509***
Total	***6,048***	***3,271***	***4,580***	***–4,739***	***471***	***2,084***	***–2,184***

Table A15 – Costs and Benefits of Option 2 and Reference case

	PV capital cost (£m)	PV ongoing costs (£m)	PV financial benefits (£m)	Financial NPV (£m)	PV traded carbon benefits (£m)	PV non-traded carbon benefits (£m)	*Total NPV (£m)*
Reference Case	6,048	3,271	4,580	–4,739	471	2,084	***–2,184***
2016 Zero Carbon: onsite measures – For houses built from 2016 onwards	5,780	4,640	3,169	–7,250	319	1,280	***–5,651***
2016 Zero Carbon: allowable solutions – For houses built from 2016 onwards	2,122	–	–	–2,122	1,253	1,375	***506***
Total (just 2016 step to Zero Carbon)	***7,902***	***4,640***	***3,169***	***–9,372***	***1,572***	***2,655***	***–5,145***
Total (all steps to Zero Carbon)	***13,950***	***7,911***	***7,749***	***–14,112***	***2,043***	***4,739***	***–7,330***

(i) Capital costs reflect the upfront build cost of homes in order to reach a particular standard for energy efficiency and (from 2013) carbon compliance, with additional allowable solutions net costs from 2016.

(ii) Ongoing costs reflect the servicing and maintenance of renewable energy and efficiency measures installed in the home. This additionally includes fuel requirements for selected technologies e.g. biomass for combined heat and power, and electricity required to run a Ground Source Heat Pump (GSHP)

(iii) Carbon benefits are derived from energy efficiency savings (due to decreased energy demand within the home), and heat and electricity generation from renewable sources.

Table A16 – Costs and Benefits of Option 3 and Reference case

	PV capital cost (£m)	PV ongoing costs (£m)	PV financial benefits (£m)	Financial NPV (£m)	PV traded carbon benefits (£m)	PV non-traded carbon benefits (£m)	*Total NPV (£m)*
Reference Case	6,048	3,271	4,580	–4,739	471	2,084	***–2,184***
2016 Zero Carbon: onsite measures – For houses built from 2016 onwards	9,280	4,635	3,209	–10,706	23	2,219	***–8,465***
2016 Zero Carbon: allowable solutions – For houses built from 2016 onwards	2,122	–	–	–2,122	1,253	1,375	***506***
Total (just 2016 step to Zero Carbon)	***11,402***	***4,635***	***3,209***	***–12,829***	***1,276***	***3,594***	***–7,959***
Total (all steps to Zero Carbon)	***17,450***	***7,906***	***7,789***	***–17,568***	***1,748***	***5,678***	***–10,144***

Table A17 – Costs effectivness[72] of Reference Case and Options

	Traded sector cost – effectiveness (£/tCO_2)	Non-traded sector cost – effectiveness (£/tCO_2)
Reference Case	–204	–87
Option 2	–185	–120
Option 3	–248	–121

[72] Cost effectiveness of traded sector calculated according to DECC guidance i.e. Net Present Value of financial costs and benefits plus present value of non-traded carbon, divided by lifetime carbon saved in traded sector.

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