Zero carbon homes

Impact assessment

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May 2011
Department for Communities and Local Government

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Title: Zero Carbon Homes Lead department or agency: Department for Communities and Local Government	Impact assessment
	IA No: 0038
	Date: 04/05/2011
	Stage: Development
	Source of intervention: Domestic
	Type of measure: Primary legislation
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Summary: Intervention and options

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

Homes have a long lifespan, and represent more than a quarter of the UK's carbon dioxide (CO_2) emissions,so it is important that new homes have a minimal impact on long term carbon emissions in order to acheive the UK's climate change, renewable energy and energy security goals. There is no evidence that emissions from new homes would reduce to the level required in the absence of government intervention, and it is desirable to avoid lock-in of emissions through suboptimal design of the house from a carbon perspective. The Stern Review recognises that government intervention via regulation is an essential part of climate change policy and can reduce uncertianty, complexity and transaction costs and induce technical innovation. Government needs to set out the framework for enabling reductions in emissions from new homes while not imposing an excessive burden on industry and this impact assessment is concerned with an update to that framework following work by the Zero Carbon Hub.

What are the policy objectives and the intended effects?

To ensure that from 2016 new homes do not add additional carbon to the atmosphere but contribute to the UK meeting its climate change targets. This will be achieved by improving the fabric energy efficiency of new homes and through driving increased use of low and zero carbon technologies. Requiring developers to reduce the carbon emitted by homes when they are built avoids the need for them to be retrofitted with low carbon technologies at a later date. The localist approach to policy seeks to empower localities by promoting local ownership of climate change mitigation and making the most of local potential for reductions. The policy will contribute to the UK meeting its climate change goals and renewable energy commitments, it will also reduce energy bills for consumers, promote innovation in low carbon technologies and benefit the long-term energy security of the UK. This policy seeks to minimise burdens on industry.

What policy options have been considered? Please justify preferred option (further details in Evidence Base)

Option 1: Do nothing – this assumes no change to current 2010 building regulations.

Option 2: Zero Carbon Hub's recommended onsite carbon abatement levels and allowable solutions payment to cover all remaining regulated[1] emissions – introduce a minimum Fabric Energy Efficiency Standard from 2013 and an overall requirement for 100 per cent of regulated emissions to be abated from 2016, with an absolute on-site reduction target of 14kgCO_2/m²/yr for flats, 11kgCO_2/m²/yr for attached houses and 10kgCO_2/m²/yr for detached houses and.

Option 3: Minimum onsite abatement at previous level (70 per cent reduction on 2006 levels) and allowable solutions payment covering all regulated and unregulated emissions – modelled as the introduction of the Fabric Energy Efficiency Standard from 2013 and from 2016 an absolute target for onsite emissions of 6kgCO_2/m²/yr for all dwelling types and an overall

[1] Regulated emissions relate to space and water heating and fixed lighting. Unregulated emissions cover appliance use.

Will the policy be reviewed? Yes **What is the basis for this review?** PIR	**If applicable, set review date:** 2021 (To be confirmed) **If applicable, set sunset clause date:** N/A
Are there arrangements in place that will allow a systematic collection of monitoring information for future policy review?	Yes

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: 10 May 2011 ....

Summary: Analysis and evidence — Option 1 (do nothing)

Description: The 'do nothing' option would entail no further changes to Building Regulations Part L or any other requirements to improve the energy performance of new homes above the current implemented 2010 standards.

Price Base Year N/A	PV Base Year N/A	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
			Low:	High:	Best Estimate: £0m

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	-	-		
High	-			
Best Estimate	-			£0

Description and scale of key monetised costs by 'main affected groups'

No monetised costs.

Other key non-monetised costs by 'main affected groups'

The 'do nothing' option would not lead to achievement of government's carbon reduction targets, as existing policies would not prevent new homes adding significant carbon dioxide to the atmosphere. There would be substantial missed opportunity to make sensible carbon reductions in new homes, and each new home would add to the government's carbon mitigation burden and cause climate change externalities. Doing nothing would mean that approximately an extra 30 million tonnes of carbon ($MtCO_2$) would be added to the UK's carbon account over the appraised lifetime of this policy (covering homes built until 2023), let alone for homes built after this date. The additional energy demand would place an increasing strain on the UK's energy infrastructure. This would result in the UK being required to adopt increasingly expensive technologies to achieve its legal obligations on renewable energy supply.

EU has committed to tightening standards on the energy performance on new build. There is a risk of EU infractions proceedings and fines if requirements in the Energy Performance of Buildings Directive Recast are not implemented, specifically that all new buildings should be nearly zero energy (where a substantial amount should come from renewables) after 2020.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	-	-		
High	-			
Best Estimate	-			£0

Description and scale of key monetised benefits by 'main affected groups'

No monetised benefits.

Other key non-monetised benefits by 'main affected groups'

The house building industry has been expecting the zero carbon policy for five years, and many have been pricing it into strategic land purchases, so not continuing with the policy would give a windfall benefit to those who had already factored it into long-term investment decisions.

Key assumptions/sensitivities/risks	Discount rate (per cent)	N/A

Direct impact on business (Equivalent annual) (£m):			In scope of OIOO?	Measure qualifies as
Costs: 0	Benefits: 0	Net: 0	No	

Summary: Analysis and evidence Policy Option 2 (preferred option)

Description:

As a basis for future consultation, from 2013 introduce the Fabric Energy Efficiency Standard and from 2016 require an absolute target for regulated emissions ('carbon compliance') on-site of 14kgCO_2/m²/yr for flats, 11kgCO_2/m²/yr for attached houses and 10kgCO_2/m²/yr for detached houses. All regulated emissions must be dealt with either onsite or through allowable solutions. Localities can go further on-site or off-site.

Price Base Year 2010	PV Base Year 2011	Time Period Years 39-49	Net Benefit (Present Value (PV)) (£m)		
			Low: -£2,053m	**High:** £643m	**Best Estimate: -£421m**

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	£10m	1	£139m	£3,416m
High	£10m		£179m	£4,151m
Best Estimate	£10m		£158m	**£3,780m**

Description and scale of key monetised costs by 'main affected groups'

Upfront capital costs for developers (present value of £2,273m) and cost of allowable solutions payments (£735m) occur for house building between 2014 and 2023, with allowable solutions required for 30 years, for 2016 standard homes only. Ongoing servicing and maintenance costs for the renewables are borne by occupants/owners (£677m) and occur between 2017 and 2047 (when the longest-lived technology expires). Administrative costs (£95m) borne by construction industry. Average annual cost calculated over the period costs occur 2014-2052. Upper/lower bound of range based on allowable solutions price sensitivity.

Other key non-monetised costs by 'main affected groups'

The administrative costs of setting up and managing the allowable solutions, through careful design (e.g. the possibility of using a pre-existing mechanism, Community Infrastructure Levy) would minimise these.

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	-	1	£61m	£2,098m
High	-		£152m	£4,059m
Best Estimate	-		**£104m**	**£3,358m**

Description and scale of key monetised benefits by 'main affected groups'

Energy bill savings for home occupants, from 2014 to 2062 i.e. for as long as the energy efficiency technologies are in place (present value of £443m through the Fabric Energy Efficiency Standard plus £1,660m through the renewable energies). Value of carbon savings in traded sector (£178m) benefit energy generators, and carbon saved in the non-traded sector (£341m from energy efficiency plus £737m from allowable solutions) benefits society generally for the abatement to reach greenhouse gas targets. Average annual benefit calculated over the period benefits occur 2014-2062. Upper and lower bound of range based on energy and carbon price sensitivity.

Other key non-monetised benefits by 'main affected groups'

Many benefits of reducing household energy consumption, including helping government achieve legal targets for decarbonising energy supply and meeting renewables targets; increased innovation in renewable technologies; helpful spill-over effects to industry in retrofitting existing stock; reduced dependence on fossil fuels and diversification of energy supply; and international leadership on climate change. Increased business and employment opportunities of developing and deploying low carbon solutions, and driving lower energy prices for consumers. Benefits of increased public engagement with measures to combat climate change and getting people familiar with low carbon housing/lifestyles.

Key assumptions/sensitivities/risks	**Discount rate (per cent)**	3.5 / 3

Central electricity, gas and carbon price assumptions from interdepartmentally-agreed guidance; biomass prices agreed with Department for Energy and Climate Change; house building assumptions detailed in annex; energy efficiency savings based on analysis underlying Zero Carbon Hub Taskforce report on Fabric Energy Efficiency Standard. Assumption that developers are currently building to the minimum Part L 2010 standards. Regulatory step in 2013 modelled as introduction of the Fabric Energy Efficiency Standard. Costs incurred over ten years which reflects the upfront capital cost only since there are no ongoing fuel or maintenance costs assumed for the Fabric Energy Efficiency Standard. Benefits occur over 49 years in the form of energy savings from the renewables and the energy efficiency measures (which have an assumed lifetime of 40 years). Key risks include the economics of housing development, future technology costs, enforcement and industry preparedness. Energy savings and renewable energy costs based on Zero Carbon Hub's carbon compliance work, with industry involvement. This analysis does not take account of a Green Deal type mechanism, Feed-In Tariffs or the Renewable Heat Incentive but these would mitigate costs so are considered in the distributional analysis section, and will be considered in future impact assessments.

Direct impact on business (Equivalent annual) (£m):			**In scope of OIOO?**	**Measure qualifies as**
Costs: £133m	**Benefits: £8m**	**Net: -£125m**	Partially–significant overlap with EU requirements	IN

Summary: Analysis and evidence — Policy Option 3

Description:

As a basis for future consultation, introduce the Fabric Energy Efficiency Standard in 2013 and from 2016 require an absolute target of 6kgCO_2/m²/yr for flats, attached and detached houses (equivalent to an onsite 70 per cent reduction of regulated emissions compared to Part L 2006). All regulated and unregulated emissions must be dealt with either onsite or through allowable solutions.

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
2010	2011	39-49	**Low: -£5,320m**	**High: -£1,327m**	**Best Estimate: -£3,015m**

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	£10m	1	£176m	£7,109m
High	£10m		£247m	£8,345m
Best Estimate	£10m		£211m	**£7,713m**

Description and scale of key monetised costs by 'main affected groups'

Upfront capital costs for developers (present value of £4,502m) and cost of allowable solutions payments (£1,426m) occur for house building between 2014 and 2023, with allowable solutions being required for 30 years for 2016 standard homes only. Ongoing servicing and maintenance costs for the renewables are borne by occupants/owners (£1,690m) and occur between 2017 and 2047 (when the longest-lived technology expires). Administrative costs (£95m) borne by construction industry. Average annual cost calculated over the period costs occur 2014-2052. Upper and lower values in range based on allowable solutions price sensitivity.

Other key non-monetised costs by 'main affected groups'

The administrative cost of setting up and managing the allowable solutions – though option to use pre-existing mechanism will minimise additional administrative costs.

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	-	1	£83m	£3,025m
High	-		£215m	£5,782m
Best Estimate	-		£163m	**£4,698m**

Description and scale of key monetised benefits by 'main affected groups'

Energy bill savings for home occupants, from 2014 to 2062 i.e. for as long as the energy efficiency technologies are in place (present value of £443m through the energy efficiency standard introduced, plus £2,050m through the renewables and further energy efficiency measures introduced in 2016). Value of carbon savings in traded sector (£151m) benefit energy generators and carbon saved in the non-traded sector (£341m from 2013 energy efficiency plus £1,713m from further energy efficiency, renewables and allowable solutions) benefits society. Average annual benefit calculated over the period benefits occur 2014-2062. Range based on energy/carbon prices.

Other key non-monetised benefits by 'main affected groups'

As per Option 2, and additional help towards achievement of government renewable energy targets.

Key assumptions/sensitivities/risks — **Discount rate (per cent)**: 3.5 / 3

As per Option 2. Regulatory step in 2013 modelled as introduction of the Fabric Energy Efficiency Standard. Energy savings and renewable energy costs based on Zero Carbon Hub's carbon compliance work, with industry involvement. This analysis does not take account of a Green Deal type mechanism, Feed-In Tariffs or the Renewable Heat Incentive but these would mitigate costs so are considered in the distributional analysis section, and will be considered in future impact assessments.

Direct impact on business (Equivalent annual) (£m):			In scope of OIOO?	Measure qualifies as
Costs: £259m	**Benefits: £6m**	**Net: -£253m**	Partial – significant overlap with EU requirements	IN

Enforcement, implementation and wider impacts

What is the geographic coverage of the policy/option?			England		
From what date will the policy be implemented?			2016 (interim step in 2013 also modelled)		
Which organisation(s) will enforce the policy?					
What is the annual change in enforcement cost (£m)?			N/A		
Does enforcement comply with Hampton principles?			Yes		
Does implementation go beyond minimum EU requirements?			N/A		
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)			**Traded:** 0[2]	**Non-traded:** 23.3 Million tonnes of carbon dioxide	
Does the proposal have an impact on competition?			No		
What proportion (per cent) of Total PV costs/benefits is directly attributable to primary legislation, if applicable?			**Costs:**	**Benefits:**	
Distribution of annual cost (per cent) by organisation size	**Micro**	**< 20**	**Small**	**Medium**	**Large**
Are any of these organisations exempt?	No	No	No	No	No

Specific Impact Tests: Checklist

Does your policy option/proposal have an impact on…?	Impact	Page ref within IA
Statutory equality duties[3] Statutory Equality Duties Impact Test guidance	No	44
Economic impacts		
Competition Competition Assessment Impact Test guidance	No	44
Small firms Small Firms Impact Test guidance	Yes	44
Environmental impacts		
Greenhouse gas assessment	Yes	45
Wider environmental issues	Yes	46
Social impacts		
Health and well-being Health and Well-being Impact Test guidance	Yes	46
Human rights Human Rights Impact Test guidance	No	47
Justice system Justice Impact Test guidance	No	47

[2] 5.8 million tonnes of carbon dioxide equivalent are estimated to be reduced in terms of UK industry not having to purchase EU emissions trading system permits. A zero has been placed in this box because the EU emissions trading system operates as a cap and trade system so any carbon savings within the UK can be offset by increases in emissions elsewhere in the EU.

[3] Race, disability and gender Impact assessments are statutory requirements for relevant policies. Equality statutory requirements will be expanded 2011, once the Equality Bill comes into force. Statutory equality duties part of the Equality Bill apply to GB only. The Toolkit provides advice on statutory equality duties for public authorities with a remit in Northern Ireland.

Rural proofing Rural Proofing Impact Test guidance	No	47
Sustainable development Sustainable Development Impact Test guidance	Yes	47

Evidence base (for summary sheets) – notes

References

These are the links to relevant legislation and publications, such as public impact assessment of earlier stages.

No.	Legislation or publication
1	Zero Carbon Hub (February 2011) Carbon Compliance: Setting An Appropriate Limit For Zero Carbon New Homes www.zerocarbonhub.org/definition.aspx?page=8
2	DCLG (July 2010) Written Ministerial Statement on Zero Carbon Homes
3	DCLG (March 2010) The Building and Approved Inspectors (Amendment) Regulations 2010 www.opsi.gov.uk/si/si2010/pdf/uksi_20100719_en.pdf
4	DCLG (December 2009) *Zero Carbon Homes: Impact Assessment* www.communities.gov.uk/publications/planningandbuilding/zerocarbondec09
5	Zero Carbon Hub (November 2009) *Defining a Fabric Energy Efficiency Standard for Zero Carbon Homes* www.zerocarbonhub.org/building.aspx?page=2
6	DCLG (July 2009) *Definition of Zero Carbon Homes: Impact Assessment* www.communities.gov.uk/publications/planningandbuilding/impactzerocarbon
7	DCLG (December 2008) Definition of Zero Carbon Homes: Impact Assessment www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinitionia

Evidence base summary tables

The annual profile of monetised costs and benefits over the life of the preferred policy are in the attached spreadsheet as the period under consideration is longer than 10 years.

The spreadsheet also contains an emission changes table regarding impact on greenhouse gas emissions.

Profile of costs and benefits

Evidence base

Introduction to impact assessment

1. This impact assessment follows detailed technical work done by the Zero Carbon Hub on the optimal level at which to set the on-site requirement for emissions reductions as part of zero carbon homes policy, the so called carbon compliance level[4]. The impact assessment accompanies an announcement in the update to the Growth Review of how government expects the policy to take shape in its entirety from 2016.

2. Doing analysis so far in advance of policy implementation gives clear direction to the house building industry on the anticipated requirements for new build homes in 2016, and has allowed industry to contribute to and shape the policy direction. This gives industry an understanding of future regulatory requirements and as enable it to price land accurately, invest in appropriate products and technologies, and gear up supply chains in advance of regulatory uplifts. Such ongoing dialogue with industry to shape policy detail will improve the effectiveness and minimise the regulatory burden of the zero carbon homes policy. Whilst most of the ground this policy covers will be required under European law (as part of the European Union Energy Performance of Buildings Directive recast), we will ensure that ‘one in, one out’ requirements are met at the appropriate points. We will be taking this forward within our wider frameworks to reduce burdens on house builders and to protect viability, such as the streamlining of requirements through the local standards framework.

3. Since this is, ultimately, about asking industry to build better-performing homes, it will inevitably come at a cost. This could be in the region of £3,000 to £8,000 per house by the time the policy starts to have an effect, depending on the dwelling type (for example just over £4,000 for a typical semi-detached house built in 2017). These are significantly reduced costs from the previous definition of the policy – which had costs of £8,000 to £12,500 per house.

4. Zero carbon homes have greater energy efficiency with the means to both lower energy bills and generate a guaranteed income stream through renewable energy exports. In addition, financial incentives for renewables may be available, meaning hundreds of pounds of savings on energy bills each year, more so as energy prices rise. If home buyers did not readily value this in the sale price, a mechanism like the Green Deal could be used to recoup a significant proportion of the additional build costs and we expect this to be part of our answer to the ‘one in, one out’ demands.

5. It is anticipated that there will be a change in the Building Regulations in 2013. For the purposes of this impact assessment we have modelled the introduction of the agreed fabric energy efficiency standard in 2013 in both Options 2 and 3, however this is for illustrative purposes only and does not prejudge the analysis and consultation that will inform the 2013 step. Option 1, do nothing, has zero monetised costs and benefits. Options 2 and 3 are compared to the ‘do nothing option’, i.e. to a counterfactual of continuing current mandated Part L 2010 building standards.

What is the problem and why is Government intervention necessary?

6. Government has agreed to an 80 per cent reduction of greenhouse gas measures in carbon dioxide equivalent, emissions by 2050 relative to 1990 levels, which is legally binding under the Climate Change Act. This is in response to the overwhelming body of scientific evidence that indicates that climate change poses one of the greatest threats to modern society, with long term and persistent effects. It is predominantly caused by emissions of greenhouse gases from human activities, particularly carbon dioxide (which represented 85 per cent of all greenhouse gas emissions in 2008[5]).

[4] http://www.zerocarbonhub.org/definition.aspx?page=8
[5] www.decc.gov.uk/assets/decc/statistics/climate_change/1_20100202104722_e_@@_ghgnatstats.pdf

7. Carbon dioxide (CO_2) emissions resulting from energy use within the home account for 27 per cent of total UK CO_2 emissions[6]. In order to reduce total greenhouse gas emissions by 80 per cent, new dwellings will need to have significantly reduced carbon emissions, in order to minimise their contribution to the UK's carbon mitigation burden. The Committee on Climate Change have concluded that emissions from the housing stock need to fall to near zero if we are to meet the 2050 goal[7]. This is in the context of requiring additional new homes[8] in order to support a growing number of households in the UK. In its Low Carbon Construction Innovation and Growth Team Report[9], Government highlighted the construction industry's pivotal role in the UK's carbon reduction programme.

8. The Stern Review[10] recognised that Government intervention via regulation and equivalents is an essential part of climate change policy, and can reduce uncertainty, complexity and transaction costs, and induce technological innovation. There is no evidence that emissions from new homes would reduce to the level required in the absence of government intervention. Barriers and market imperfections inhibit investment in energy efficiency measures in homes. As set out in the review, these include:

- **Poorly aligned incentives** – 'Incentive failures restrict the effectiveness of price instruments.'
  Uncertainty over savings on energy bills from higher energy efficiency standards means that homeowners do not value such measures in the market, giving developers little incentive to install such measures in new homes. Similarly, occupants incur no private cost for the wider impacts of carbon emissions (negative externalities) that are attributable to their home and felt by society as whole, rather than themselves, as they have no incentive to reduce them.

  The combination of these split incentives mean a house builder would only benefit from building a new home to a very carbon efficient standard if incremental construction costs were more than fully offset. This may be through a premium on the price at which the home can be sold. However, it is not yet apparent that in England the energy and carbon efficiency of homes has a significant impact on the market price (however there is evidence from Australia that this is the case[11]). Alternatively the offset may be through a reduced price for the land when it is bought and/or recouping the additional build cost through a charge on the home paid for by the savings from the energy efficiency or renewable energy measures.

  In addition, it could be argued that the costs of low/zero carbon homes are currently impeded from falling due to a number of reasons. One reason may be that there is under-investment in innovation due to developers 'free-riding' or gaining the benefits from others investments without contributing to the investment themselves. Another reason is that not all costs (negative externalities) are factored into the market price of new homes. If they were to be, then innovation would occur in the market to reduce the price of low carbon technologies. The fact that these incentives are poorly aligned slows down the speed at which new homes become lower carbon as the incentives to reduce the costs of building them don't exist.

- Behavioural barriers – Individuals and firms are not always able to make effective decisions involving complex and uncertain outcomes. For example, many people are unable to calculate the long-run value of energy savings or have difficulties determining

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[6] Department of Energy and Climate Change (DECC)
[7] Committee on Climate Change (2008) www.theccc.org.uk/reports/building-a-low-carbon-economy
[8] 'Additional' is to differentiate between new homes which add to the stock of carbon emissions that need to be abated; and homes which are built to replace existing homes that are demolished, or new homes from conversions.
[9] HM Government (2010) Low Carbon Construction Innovation and Growth Team Report www.bis.gov.uk/constructionigt
[10] 'The Stern Review into the Economics of Climate Change (2006) www.sternreview.org.uk Chapter 17
[11] www.nathers.gov.au/about/publications/eer-house-price-act.html

the appropriate responses to risks and uncertainties around the future energy costs or the potential impacts of climate change. As a result, individuals and firms commonly make decisions which simply meet their needs, rather than undertaking complex analysis to determine the best possible action. Social and institutional norms and expectations strongly influence decision making, although these norms are not immutable.

- Lack of information – 'Reliable, accessible and easily understandable information is important in making consumers and firms aware of the full lifetime costs and benefits of an economic decision, and hence supporting good decision making. Whilst there are information difficulties in many or most markets, they may be particularly powerful in relation to energy efficiency measures'. For example, individuals do not know the total financial benefit that will accrue to them as a result of investment in energy efficiency measures and technologies. Similarly, developers cannot easily ascertain the true extent of demand and individual willingness to pay for energy efficiency measures in homes.
- Risks and uncertainty – For the most part, investment decisions in energy using technologies rest on the balance of financial costs and benefits facing an individual or a firm. However, consumers and firms frequently do not make energy efficiency investments that appear cost effective. This may in part be explained by a response to the risk and uncertainties associated with such investment.
- Basic financial barriers – Capital and/or asset market failures also inhibit action. For example, a lack of available capital prevents people investing in more energy efficient processes which typically have higher upfront costs (but are cheaper over a longer period). Restricted access to capital is especially common among poorer households.
- Hidden and transaction costs – these are difficult to measure, yet an assessment of the full costs and benefits of investment in energy using technologies requires them to be accounted for. Such costs include researching different options, taking time off work to wait in for a tradesman and these may be counterbalanced by benefits such as reduced risk of exposure to energy price volatility or reputation benefits from demonstrating environmental responsibility.

9. Some of the above market failures relate to a demand side problem, where consumers perhaps do not have full information on the technologies and are uncertain about the associated cost savings. Influencing such behaviour through improving information may go some way to improving this. At present, information provision for improving energy efficiency is being pursued by measures such as the requirement for an Energy Performance Certificate for every new home, more informative energy bills and the nationwide roll-out of smart meters. There is already a voluntary approach in the Code for Sustainable Homes, a recognised set of standards for homes with improved energy performance (amongst other environmental improvements). Fiscal incentives to increase uptake of renewable energy technologies and energy efficiency measures include the current Stamp Duty Land Tax exemption for the most environmentally friendly homes, though only a handful of new homes have so far qualified for this. Financial incentives for renewables exist in the form of Feed-In-Tariffs and the forthcoming Renewable Heat Incentive. Behavioural measures like encouraging homebuyers' valuations of new homes to reflect lower running costs are underway, through our work with the Royal Institute of Chartered Surveyors.

10. The proposed approach to improve energy performance of homes will be delivered alongside these demand side measures, since by themselves they do not ensure the delivery of zero carbon homes and therefore contributions to meeting the UK's carbon budgets cannot be relied on. Moreover, a prominent barrier to energy efficiency investments is the supply side of the market. Consumers consider a wide range of housing characteristics when purchasing a house and anecdotal evidence suggests that demand for energy efficiency is a relatively low priority. Therefore as set out above

developers who are concerned primarily about maintaining profit margins, do not incorporate such investments into the house. Regulating the building industry by requiring zero carbon homes will ensure that these carbon savings materialise.

11. Zero carbon homes policy is concerned with ensuring that all new homes are built to a minimum standard and that developers are able to make use of the technologies available to reduce a dwellings emissions to the required levels set nationally. Within the overall level of carbon reduction required in national building regulations, this policy sets a requirement for a national emissions level/carbon compliance standard developers must achieve onsite. At the development level, small- and medium-scale solutions are deemed appropriate to help reduce UK emissions levels, even if they are arguably not as cost effective as large-scale solutions. From an economy wide perspective, we would want developers to install such onsite technologies to meet our emissions reductions. The arguments for this include; ensuring the security of energy supply within the UK; promoting innovation in low carbon technologies; and encouraging low carbon lifestyles. It is at developers' discretion as to which technologies they adopt to meet that emissions level, and at what point beyond the minimum onsite carbon abatement level they choose to take up allowable solutions to pay for emissions reductions elsewhere. This offsite element of the policy aims to cover the remaining emissions externality that is caused by additional new homes and is required to be dealt with under the proposed definition of zero carbon homes.

12. While actual energy use when the home is occupied is determined by the actions of the residents, the developer can influence it through the technologies adopted when building the property, for example how much heating and lighting it requires and the efficiency of these. This puts the onus on developers to deliver the reductions needed with regards to regulated[12] emissions within the built environment and is a further justification for acting at point of build. The principle of the developer being responsible for the standards of performance of homes has been long established and accepted through the Building Regulations regime. The proposed approach to defining zero carbon homes (regarding only covering regulated emissions, rather than unregulated emissions as well) is in line with other countries' building standards and ambitions, as evidenced in the Zero Carbon Compendium[13] produced by industry. While it is difficult to make direct international comparisons owing to different climates and energy mixes, implementing these zero carbon proposals would lessen the energy requirements for heating which the Compendium notes have been lagging behind other countries, including those with colder climates.

13. New buildings have a considerable level of 'lock-in'. This means that once built, a certain level of energy efficiency, or inefficiency, is locked into the building, which cannot be dramatically altered without significant additional costs. As a result, inefficient building materials and methods employed at the time of build remain present in the building stock for the lifetime of the home. Building in energy efficiency and carbon reduction measures at point of build avoids the need for subsequent retrofitting and refurbishment which will be more costly and potentially less effective. By way of example, retrofitting ground source heat pumps or connections to district heating networks for existing homes is significantly more costly and disruptive than installing such measures at the outset. Solar technologies are best employed if the building is orientated to optimise the use of that technology. Similarly, optimal design of a house can make the most of natural lighting and ventilation.

14. The issue of 'locking-in' measures and technologies to new build houses is key to the rationale of regulating through building standards to ensure as a high a standard of energy efficiency as possible. Climate change externalities are unique compared to other

[12] Regulated emissions refer to all emissions that are an outcome of fixed lighting, ventilation and space and water heating in dwellings. Unregulated emissions are those that relate to appliances in dwellings.
[13] NHBC and Zero Carbon Hub (2008) Zero Carbon Compendium: Who's Doing What In Carbon Worldwide http://www.zerocarbonhub.org/news_details.aspx?article=7

market failures in that they have extremely long lead-in times with lasting effects. Regulation for new homes will shape the future of the UK's building stock for decades to come. It is estimated that the current housing stock will increase by almost 200,000 per year by 2020. Whilst the oldest homes in the housing stock represent some of the biggest challenges in terms of reducing carbon emissions, new homes could be expected to last 60 to 100 years or more, so it is crucial to act at the point of build as well as reducing emissions from the existing stock.

15. We recognise that the issue of 'lock-in' points to regulation as an appropriate policy for delivering cost effective onsite measures; but the most appropriate policy to deliver the necessary carbon reductions above that level, through offsite abatement, is unclear. Our proposed definition of zero carbon homes requires all emissions which arise as a result of space/water heating and lighting of a dwelling ('regulated' emissions) to be dealt with/priced into the market. If we didn't account for these emissions then the policy would not be zero carbon. More new homes will result in more carbon emissions being released into the atmosphere and this carbon must be paid for, for the same externality argument as set out above. The abatement of this carbon need not necessarily be paid for by developers, they could be funded by Government for example. However, there are certain advantages from requiring the developers to pay via regulation. Firstly, some developers will have access to certain offsite abatement measures that are cost effective at the point of build, which they should be incentivised to employ. Secondly, developers should also be incentivised to achieve higher levels of onsite abatement if they are able to do cost effectively, an additional requirement allows this to happen. In addition, the Growth Review committed to off-site abatement that is cost effective with respect to the Government's long term value of carbon, this means the cost incurred by developers will not exceed the long term average cost of alternative abatement measures in the UK.

16. Due to lack of certainty over the mechanism by which these residual/offsite emissions are best dealt with, we have assumed in this impact assessment that allowable solutions will be adopted. This carbon dealt with in this way must be priced appropriately, reflecting the opportunity cost or next best alternative for reducing these emissions. We therefore propose to set allowable solutions as equivalent to the long term abatement cost of carbon[14], as a way of addressing the externality created by these additional emissions. If developers can abate the carbon more cheaply by abating further onsite, that will be open to them. Whichever mechanism is taken forward for dealing with these residual emissions, can be assumed to be at least as cost effective as what has been modelled for this impact assessment.

17. In the absence of a zero carbon homes policy, the energy efficiency of new homes can realistically be assumed to remain at the current regulated level, which does not mitigate all emissions associated with the home and so results in an additional burden of carbon emissions over time. Doing nothing would mean that approximately 30 million[15] tonnes of carbon dioxide[16] would be added to the UK's carbon account, relative to the other options, over the appraised lifetime of this policy, assuming 120,000 houses are built in 2013 rising to 190,000 per year by 2020. These are notional, stylised assumptions and do not represent official government targets, and are just assumptions for modelling purposes. The additional energy demand would place an increasing strain on the UK's energy infrastructure, and not contribute to improving UK energy security. This would result in the UK being required to adopt increasingly expensive technologies to achieve its legal obligations on renewable energy supply. This policy gives rise to an 'avoided cost of

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[14] There are several ways of setting this numerical value; more work will be done to ascertain the anticipated prices but for the cost modelling in this impact assessment, the average long-term cost of carbon over the policy lifetime is used (the government's carbon cost-effective benchmark for this policy), which is £46/tonne when considered now (discounted) but input to the model as £97/tonne to avoid double-discounting.
[15] Using a 2010 Part L baseline.
[16] Throughout the document reference to tonnes of carbon/carbon dioxide/CO_2 is at all times a reference to greenhouse gas emissions/carbon equivalents.

renewables' as the increased deployment of renewable energy technologies count towards accounting for the UK's required proportion of energy consumption to come from renewable sources as set by the EU Climate and Energy Package[17].

18. Under the proposed option for zero carbon policy, the requirement to mitigate emissions is limited to those covered by Buildings Regulations. These are broadly equivalent to two thirds of total emissions of a typical home. The remaining emissions that not covered by Building Regulations are made up of energy use from cooking and electrical plug-in appliances. There are already a number of existing policies which deal with emissions from appliances, including the EU Emissions Trading Scheme and product energy efficiency measures. The operation of these policies, cumulatively and in combination with the proposed zero carbon homes definition, should have the result that the carbon footprint of new homes does not add to overall carbon reduction burdens.

What are the policy objectives and intended effects?

19. The primary objective of the policy is to set a clear, ambitious and realistic trajectory to reduce the carbon emissions resulting from energy use in new homes. This regulation gives a signal to market actors to invest early with confidence, and is an incentive for developers and their supply chain to innovate to achieve the most cost-effective way of meeting these targets.

20. The zero carbon homes policy is intended to address the emissions from all regulated energy use in the home over the course of a year. This includes space heating, ventilation, hot water and lighting. It recognises the need for a home to use fossil fuels or grid electricity, as long as this is matched by an equivalent export of low or zero carbon energy.

21. In practice, achieving the zero carbon standard will in most cases need a combination of on-site measures such as energy efficiency and small scale renewable energy, and off-site measures. In line with the policy described in the Localism Bill[18], the Government wishes local areas to benefit from development. Accordingly, it wants the off-site measures to be local to the area of development, so that local people see the benefits. In practice, such off-site measures will rely on local support in order to operate successfully. Accordingly, Government intends to provide local choice about the extent to which carbon is reduced above the requirements set out in national building regulations, and the way in which that carbon is reduced. The policy provides local authorities with two routes to mitigate more carbon, if they wish to do so – to set higher on-site requirements, based on local circumstances, or to use allowable solutions to raise funds from new development for investment in larger-scale local renewables project for local benefit.

22. The options presented in this impact assessment use a combination of the following components:

- An overall standard for carbon to be mitigated, from a combination of on site and off site measures. Ministers may also wish to give local authorities choice to go further than the national standards either on-site or off-site or both, subject to viability and these sensitivities are modelled in this impact assessment.
- Regulation requiring a high level of fabric energy efficiency as confirmed in July[19], as consulted upon[20] in December 2009. All homes would have to meet a minimum level of fabric energy efficiency in order to achieve part of the total reduction in carbon emissions. Developers would have the choice to go beyond this minimum level to

[17] www.decc.gov.uk/en/content/cms/what_we_do/change_energy/european/cepackage/cepackage.aspx
[18] Localism Bill available from www.communities.gov.uk/localgovernment/decentralisation/localismbill/
[19] Department for Communities and Local Government (July 2010) Written Ministerial Statement on Zero Carbon Homes www.communities.gov.uk/newsstories/newsroom/16527871
[20] www.communities.gov.uk/planningandbuilding/theenvironment/zerocarbonhomes/

maximise cost effective carbon abatement. Local authorities would also be able to require, through planning, achievement of higher standards[21].

- A carbon compliance level which sets a minimum national standard for onsite carbon emissions reductions.
- A menu of off site measures ('allowable solutions') designed to mitigate the residual carbon up to the overall national standard. Developers would be given a choice as to how to do this, but the intention is to put in place a mechanism that allows house builders to meet their commitments at a cost no higher than the Government's long-term value of carbon. This ensures that the offsite requirement of the policy will be delivered cost effectively. There are many ways to go about valuing the carbon a house emits over 30 years in order to accurately price the upfront cost a developer must pay to reflect the value of that carbon. This impact assessment adopts the average discounted abatement cost of non-traded carbon which is £46 based on current figures from the Department of Energy and Climate Change. This upfront cost incurred is the cumulative value of the carbon emitted from a house in present value terms over 30 years.
- The Government will work with industry on options for a mechanism to deliver these offsite measures, which will be made available to all developers operating in England; be cost effective by ensuring offsite measures are no higher than the Governments' long term value of carbon; and ensure that any funds raised will be dedicated to carbon abatement. We will also review the measures which can be supported under these approaches and will consult further with industry, local government and other partners on these.

23. The optimal level of carbon compliance recommended by the Hub is less than the level under the previous definition of zero carbon homes, and it is a more nuanced approach that recognises differences between dwelling types and considers viability and technical feasibility. This previous definition of zero carbon homes, as set out under Option 3, has a much higher cost policy than the preferred option (Option 2), both in terms of requiring more onsite carbon compliance (meaning more renewable energy onsite), and in terms of having a larger scope of emissions that must be abated (inclusive of unregulated emissions, from appliances). It is this change in the policy framework for zero carbon homes that this impact assessment seeks to draw out.

24. The combination of measures comprising zero carbon homes policy will achieve:

- a reduction in the energy demand of new buildings, along with generation of renewable energy, both of which result in reduced fuel bills for occupants and lower demand on national energy supplies
- helping the Government to meet its domestic carbon reduction targets and show international leadership in the fight against climate change
- driving local engagement with the need to act against anthropogenic climate change, and local ownership of levers through which to do so
- creating a level playing field between all market actors in particular areas, requiring high technical standards and pushing innovation whilst reducing the threat of free-riding[22]

[21] This is not modelled in the central case because alternative standards are not being proposed now, and there is not sufficient evidence on what proportion of developments are already being required to go beyond the national minimum, and how much further.

[22] Free riding in this sense refers to actors who don't shoulder their fair share of emissions reductions yet benefit from others efforts to reduce their own emissions.

- future-proofing new homes, reducing the potential need to retrofit at a higher cost later on
- developing a low carbon economy and increasing the scope for skills and jobs needed in construction and supporting industries
- increasing uptake of distributed renewable energy technologies, helping to meet the UK renewable energy targets and increasing energy security; and
- raising awareness amongst homebuyers of renewable energy measures and high performing buildings, and encouraging behaviour change to reduce energy demand generally

25. The headline costs and benefits do not include the non-monetised elements of the policy. These include elements such as meeting the UK's renewable energy targets (the 'avoided cost of renewables'), boosting innovation in the affected sectors, improving energy security, increasing the scope for reduced costs and learning benefits, and introducing occupants to a low carbon lifestyle.

26. The decarbonising of the existing stock of houses is a significant challenge. However, implementing a high build standard for new homes will help to drive the demand for better materials and technologies, most of which can also be employed for retrofit of the existing building stock. Therefore building more energy efficient homes will support innovation and help drive down the cost of these materials and technologies. As a result, the process of decarbonising existing homes will benefit from new homes being built to more demanding levels of carbon reduction. Similarly, new homes built to a higher specification can help to get people used to, and foster demand for low carbon living from occupants of existing homes. By way of example, central heating retrofitted to existing homes was a significant spill-over from what was originally a measure solely introduced into the new build market i.e. it had benefits for other sectors too.

27. A zero carbon homes policy can create significant additional opportunities for existing development through proactive spatial planning. For example, existing housing or non-domestic buildings can be made more energy efficient by locating a new residential development adjacent to it and connecting both via a district heating network.

28. The government has a demanding renewables target as a result of the European Union Renewables Directive[23]: that 15 per cent of UK energy consumption in 2020 is to be from renewable sources. This will to a significant extent be met from relatively large scale schemes such as offshore wind. However, the Renewable Energy Action Plan[24] also describes the contribution of community and domestic scale renewables as a way of generating support for renewables in general (which is important for planning) and engaging citizens in energy and climate change issues. The policy set out here, by driving carbon reduction through on-site technologies, plays a strong part in supporting rollout of domestic level renewables.

29. The market for renewable heat is much less developed than that for renewable electricity generation. However, heat networks do have substantial potential to be implemented cost effectively[25]. The fact that these technologies have not yet been brought forward at significant scale suggests there are market failures getting in the way of realising that potential. The amount of co-ordination required across multiple parties to synchronise heat demand and infrastructure delivery, and the lack of a regulatory framework providing ongoing protection to all parties, are significant barriers to such developments. Zero carbon homes policy represents an opportunity to address these barriers, for example through providing incentives to local authorities to overcome information failures by developing robust evidence bases to underpin local energy plans. Similarly, aggregation

[23] www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx
[24] www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/ored/uk_action_plan/uk_action_plan.aspx
[25] Poyry (April 2009) *The Potential and Costs of District Heating Networks*, available from DECC

of funds from multiple developments will help to overcome co-ordination failures and achieve economies of scale. Allowable solutions offer a route to achieving this.

Description of options considered

OPTIONS

30. The options have been summarised in the following table, and are explained below.

Table A: Description of options

	Minimum fabric standard (energy efficiency)	Onsite abatement (carbon compliance) level ($kgCO_2/m^2/yr$)		
		Detached houses	Attached houses	Flats
Option 1: Do nothing	Not applicable (N/A)	N/A	N/A	N/A
Option 2: Zero Carbon Hub's recommended level carbon compliance level	The consulted-on and agreed Fabric Energy Efficiency Standard	10	11	14
Option 3: previous carbon compliance level (70 per cent reduction on 2006 levels)	As above	6	6	6

31. This impact assessment is based on the following options:

- **Option 1** - do nothing. In reality this means continuing with the Part L 2010 Building Regulations which have already come into effect, requiring a 25 per cent improvement in regulated emissions compared to Part L 2006 Building Regulations. This forms the baseline of the policy against which all costs and benefits are compared.
- The following options represent variations of zero carbon homes policy that could be adopted in 2016. These options both require all regulated emissions to be dealt with, and Option 3 also required unregulated emissions to be dealt with.
- **Option 2** – introduction of the Zero Carbon Hub's proposed Fabric Energy Efficiency Standard from 2013 and onsite abatement ('carbon compliance') levels of $10kg_{CO2}/m^2/yr$ for all new detached homes, $11kgCO_2/m^2/yr$ for attached homes and $14kgCO_2/m^2/yr$ to flats from 2016. In addition all regulated emissions must be dealt with, either onsite or through payment for allowable solutions. Local authorities have freedom to ask for further effort on-site or off-site.
- **Option 3** - introduction of Fabric Energy Efficiency Standard from 2013 and carbon compliance levels equivalent to that which was formerly set at a 70 per cent reduction on 2006 regulated emissions, which has been modelled as equivalent absolute target of $6kgCO_2/m^2/yr$ for all dwelling types from 2016. In addition all regulated and unregulated emissions must be dealt with onsite or through allowable solutions.

32. The options are modelled with energy efficiency and renewable energy components making up the mechanisms through which dwellings achieve onsite emissions reductions to the level specified by the carbon compliance level. The only specification on how this should be achieved is the introduction of a minimum energy efficiency standard, that being the Fabric Energy Efficiency Standard – this is based on the Zero Carbon Hub's recommendations in their November 2009 task group report[26]; was consulted on in December 2009; and endorsed by the Government in July 2010. Other than this, it is at the developer's discretion as to which technologies they adopt to meet the required on-

[26] Zero Carbon Hub (2009) www.zerocarbonhub.org/news_details.aspx?article=5

site carbon compliance levels. The remaining residual emissions above the carbon compliance level which must be dealt with to achieve zero carbon as defined under each option, have been modelled as being achieved through payment for off-site allowable solutions.

33. Option 3 is consistent with the previous definition of zero carbon homes. The figures in this document differ from previous ones as new evidence has come to light through ongoing work with industry, and policy decisions on scope and coverage of the policy have since been made. For example the cost figures used are based on work from the Zero Carbon Hub and the allowable solutions cost is now assumed to be set at the cost effective level equal to the average long-term abatement cost of carbon over the lifetime of the policy[27].

Energy efficiency

34. One component of zero carbon homes is the introduction of an energy efficiency standard. This will get some way to achieving the required carbon compliance level. We have assumed that there will be the introduction of a mandatory Fabric Energy Efficiency Standard in 2013. In practice 2013 has not yet been finalised, but for modelling purposes Fabric Energy Efficiency Standard has been assumed as a proxy for the 2013 policy. This standard is intrinsic to the zero carbon homes definition and thus it is pertinent to consider the costs and benefits of building regulation changes in 2013 and 2016 together, from the 2010 baseline.

35. In summary, the Zero Carbon Hub task groups recommendations for energy efficiency 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/m^2/year)
- a different level of kWh/m^2/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, the energy standard applicable from 2016 should be 39 kWh/m^2/year for apartments and mid-terrace houses; and 46 kWh/m^2/year for end-terrace, semi-detached and detached houses. This standard is more demanding than current practice but less demanding than standards such as Passivhaus[28]; and
- the performance standard should be re-based, as necessary, to take account of any further revisions made to the Standard Assessment Procedure so as to hold the level of ambition constant in terms of the building specifications required to achieve the standard

36. To reiterate, the detail of requirements for changes to Part L of the Building Regulations in 2013 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 the

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[27] Carbon values can be found in the Department of Energy and Climate Change's Interdepartmental Analysts Group (IAG) guidance: www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx

[28] Passivhaus requires extremely demanding levels of insulation, air tightness and energy use. The Fabric Energy Efficiency Standard stops short of the less cost-effective steps and is at a level where natural ventilation is still possible, rather than effectively requiring mechanical ventilation and pre-fabricated manufacturing processes.

purposes of this impact assessment that the 2013 requirements for on-site energy efficiency will be for all new homes to introduce Fabric Energy Efficiency Standard. It is worthwhile noting that the costs and benefits of 2016 will change if the 2013 step deviates from this Fabric Energy Efficiency Standard, as the larger the step taken by industry to ready themselves for the 2016 final zero carbon step, the smaller the costs of that step. This is a modelling assumption undertaken for illustrative purposes and does not represent government policy for 2013.

Carbon compliance

37. Another component of the zero carbon homes definition is the introduction through regulations a national standard for on-site carbon mitigation, known as the carbon compliance level. This refers to the maximum amount of regulated energy – i.e. energy from heating, lighting and hot water – that can be attributed to a new home, represented in $kgCO_2/m^2/yr$ to be abated by on site measures. Although this sets an absolute target, the way developers decide to achieve this level is at their discretion so as to maintain flexibility and ensure developers can achieve abatement in the most cost-effective way available.

38. Based on recommendations from the Zero Carbon Hub, the following assumptions regarding carbon compliance have been made in this impact assessment:

- different levels of carbon compliance will be set for different housing types to reflect a consistent level of effort across all new homes; and
- in the preferred Option 2, a national carbon compliance level of $10kgCO_2/m^2/yr$ will apply to all new detached homes, $11kgCO_2/m^2/yr$ for attached homes and $14kgCO_2/m^2/yr$ to flats from 2016. This represents a minimum reduction in emissions from heating, hot water and lighting and is supported by a minimum standard for fabric energy efficiency. The differing compliance levels are a result of the differing difficulty of achieving emissions reductions in different building types. The levels are set to reflect a consistent level of effort across all building types and significant input from industry has informed these levels.

Allowable solutions

39. The final component of zero carbon homes policy is a mechanism to deal with the residual emissions between the carbon compliance level and 100 per cent of regulated emissions. 'Allowable solutions' has been the term previously used to describe the offsite mechanism used to deal with residual emissions, although few details of this mechanism have been outlined. Strong arguments support a mechanism that has certain characteristics:

- It maintains flexibility, is not prescriptive and is not overly burdensome.
- Gives the developer choice to use either offsite and onsite solutions or a combination.
- The Growth Review stated that the onsite requirement *"…will be complemented by cost-effective options for off-site carbon reductions, relative to the Government's pricing of carbon."* This means the cost incurred by developers should not exceed the average cost of alternative abatement measures in the UK. We have modelled this by applying the allowable solutions cost at the Government's carbon price for 30 years abatement. The cost of abating offsite emissions does not exceed the average long-term abatement cost of non-traded carbon over the period 2017-2052, weighted for when carbon savings occur, which has been calculated to be £97/tonne over the period calculated in this impact assessment but which might differ in practice. This cost reflects the fact that allowable solutions must pay for emissions for thirty years. This time period covers when houses are built to 2016 zero carbon standards (and therefore incurring allowable solutions costs between 2017 and 2023, when sunsetting would apply), and the amount of time their associated costs and benefits occur for. The average discounted abatement cost of carbon figure for the period of the policy following HM Treasury

Green Book guidance is £46/tonne. It is this £46/tonne figure which will be quoted in this impact assessment (however to produce the discounted £46/tonne figure here, the modelling input was the undiscounted £97/tonne[29]). It therefore ensures cost effective abatement as the cost of such residual emissions will be set at the theoretical market price for non-traded carbon, according to the Department of Energy and Climate Change values.

- It is anticipated that additional costs of zero carbon homes will largely be passed back to landowners in reduced land value uplift. Future assessments of zero carbon homes policy will look further into assessing the options for such residual emissions, and at the evidence base. There is an argument for mechanisms that would pass back additional build costs to the home owner or occupant, since they are the beneficiaries of lower running costs, and there is anecdotal evidence of higher prices being paid for greener homes, however for this impact assessment we are assuming zero cost pass-through to home owners/consumers.

40. In the modelling, we have assumed that wherever allowable solutions are used, these are priced at the equivalent of abating thirty years of the dwelling's emissions (taking grid decarbonisation into account). This is an upfront payment at the time the dwelling is built. The cost incurred is the cumulative value of the carbon emitted from a house over 30 years and this is in present value terms as the payment is made upfront:

- The price is an illustrative £46 per tonne of carbon dioxide equivalent in present value terms[30] (£97/tonne in undiscounted terms).
- Sensitivity analysis considers a price of £23/tonne and £70/tonne in present value terms for all options (£49/tonne and £146/tonne respectively in undiscounted terms). This is based on the current Department of Energy and Climate Change estimations of the potential range for abatement cost of carbon and following the same method as set out above.

Methodology and key assumptions

41. In order to produce aggregate impact assessment costs and benefits of the options for zero carbon homes policy, the Department for Communities and Local Government has produced an economic model that aggregates dwelling level costs and energy saving/generation to estimate the costs and benefits to society (as set out in the cover sheets).

42. The key assumptions underpinning any assessment of the future costs and benefits[31] of house building are:

    a) The number and type of homes built (detached, semi-detached/end-terrace, mid-terrace or flats)

    - The number of homes assumed to be built each year does not change to reflect the cost of the policy option. These house building numbers are not a target or forecast but are simply a rounded number of homes, assumed purely for modelling purposes[32]. For this impact assessment we modelled a house building scenario (detailed in Table AB 2 in the annex), whereby 120,000 new homes are built in 2013, rising to 190,000 per year by 2020. These are notional, stylised assumptions and do not represent official government targets. Sensitivity analysis

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[29] http://www.decc.gov.uk/assets/decc/Statistics/analysis_group/81-iag-toolkit-tables-1-29.xls

[30] This is entered into the model as £97/tonne so that when discounted to today's present value, the cost-effectiveness is the desired £46/tonne

[31] All costs and benefits are discounted to 2011 following HM Treasury Green Book guidance: www.hm-treasury.gov.uk/data_greenbook_index.htm i.e. a discount rate of 3.5 per cent for the first thirty years and 3 per cent for the remainder of the appraisal period (to 2062).

[32] In previous published versions of the impact assessment, we had assumed 219,083 new homes per year from 2016 (with lower but rising numbers between 2010 and then). This reflected the new build homes element of the previous Government's house building target which no longer exists.

was performed for 25 per cent more and fewer homes per year. The year 2023 was chosen as a cut-off point for building as it would reflect seven years since the 2016 policy was introduced and could potentially reach the end of sunset phase. The policy would be reviewed in advance of this sunset date. Ongoing costs and benefits of the policy continue after this point, and analysis is done up until 2062 which is when the longest-lived element modelled of the homes built in 2023 expires[33].

- The mix of dwelling types used in the model is the same each year and is based on the historical average. The assumptions are given in Annex B Table AB 1.

b) The speed of introduction of new build standards ('phase-in' transition periods)

- The phase-in assumptions are in Annex B, Table AB 3 and are the same as used in previous analysis of zero carbon homes and changes to Part L of the Building Regulations. The key point is that the zero carbon homes changes are introduced in 2016 but the first homes would not be built to this standard until 2017 due to build-out times and phase-in of the new regulations, with the proportion of completions at this level rising over several years. All homes would be completed to zero carbon standards by 2020.

c) The baseline energy use for each dwelling type

- The baseline annual energy demand for each dwelling type is given in Annex B Table AB 4 and is based on the Zero Carbon Hub's analysis. When using the government greenhouse gas policy appraisal guidance this gives rise to the following annual carbon emissions per dwelling (repeated in Table AB 5):

Table B: Baseline annual carbon emissions for a Part L 2010 building regulations dwelling

	Detached	Semi-detached	Mid-terrace	Flat
Regulated emissions (tonnes of carbon dioxide, tCO_2 per year)	1.9	1.3	1.2	0.8
Unregulated emissions (tCO_2 pa)	1.4	1.1	1.1	0.7
Total carbon per dwelling	*3.3*	*2.4*	*2.3*	*1.5*

d) The projected carbon content of the fuels used

- The technology choices to meet the carbon compliance target, termed in carbon emissions per square metre of the new property, depend on developers' calculations made using the Standard Assessment Procedure[34] software which is used for compliance. It is not yet clear what the 2016 Standard Assessment Procedure software will look, so the Zero Carbon Hub used forward-looking carbon factors in an amended version of the Standard Assessment Procedure.

- For the carbon figures in this impact assessment, we take the energy savings from the technology specifications in the Hub's modelling, and follow the carbon intensity assumptions given in the aforementioned government guidance. According to this guidance the marginal carbon intensity of electricity is 0.39 kilograms of carbon dioxide per kilowatt hour ($kgCO_2$/kWh), falling to 0.04

[33] This is not to say that energy efficiency elements of the building are expected to last only 40 years, but that when quantifying the benefits of long-lived technologies like energy efficiency measures, we assume their effectiveness stops once their lifetime is over. The 40 year lifetime is a conservative estimate representing an average for all energy efficiency measures used in the house, and no replacement cost is factored in. This is the modelling convention used in previous versions of the impact assessment.

[34] The standard methodology to determine the energy efficiency of new buildings is to follow the Standard Assessment Procedure, this gives buildings a Standard Assessment Procedure energy efficiency rating out of 100, 100 being the most energy efficient and 0 being the least energy efficient.

$kgCO_2/kWh$ in 2040 and to 0.02 $kgCO_2/kWh$ in 2050. The carbon intensity of natural gas is a constant 0.184 $kgCO_2/kWh$.

e) The additional capital build costs and the rate at which these are expect to fall over time, and their associated energy savings, generation capacity and (where applicable) fuel inputs

- Energy efficiency inputs on capital costs and energy savings come from the Zero Carbon Hub's research[35] on the proposed levels of the energy efficiency standard. The kilowatt hour (kWh) savings and upfront capital costs for the 2013 energy efficiency standard are in Annex B, Table AB 6.
- The costs of renewable energy inputs come from the Zero Carbon Hub's carbon compliance work, while assumptions on technology lifetimes and servicing/maintenance costs are consistent with Department of Energy and Climate Change research and modelling[36] and are given in Annex B, Table AB 7. These operation and maintenance costs are based on their research on renewable electricity[37] (with updated solar photovoltaic costs approved by Element Energy) and their research on renewable heat[38].
- The learning rates applied in our modelling – the reduction in capital costs over time – are in Annex B, Table AB 8 and are based on the Hub's analysis. They vary by technology, and the two technologies modelled most heavily in the preferred option are Fabric Energy Efficiency Standard – which the cost of falls 30 per cent by 2017 – and solar photovoltaics, whose costs almost halve by 2017. These learning rates take account of both global and local learning, i.e. the cost of the technology falling over time as more people use it, and the cost of designing and installing it falling as the UK construction industry gains more experience. Sensitivity analysis is available showing what costs look like if there is no learning.

f) Technology specifications

- The technology choices for each of the dwelling types are indicative of what might be needed in order to reach the regulated level of carbon compliance. They have been chosen based on the Zero Carbon Hub's work on the most cost-effective means to achieve the necessary carbon compliance level, and are not the only route to meeting the targets.
- The modelling does not optimise each technology by dwelling type. As technology choices can be subjective, we have also modelled as part of sensitivity analysis the most cost effective renewable heat-heavy route (i.e. removing or minimising solar photovoltaic electricity generation to the extent possible) based on the Hub's work.

g) The illustrative allowable solutions price

- The allowable solutions price assumed is £46/tonne in present value terms. This is an illustrative price and is not set in stone. This figure is the average discounted long-term abatement cost of non-traded carbon over the assumed lifetime of the policy.

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[35] Elemental cost models were produced by Davis Langdon and Fulcrum Consulting.

[36] Renewable electricity assumptions are based on Element Energy work (2009) and renewable heat assumptions are from NERA-AEA work (2009).

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

[38] www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/policy/incentive/supply_curve/supply_curve.aspx

h) Energy prices and carbon values

- These are given in the government carbon appraisal guidance[39]. Domestic biomass prices are consistent with the Department of Energy and Climate Change's assumptions[40].

i) Risks and uncertainties in modelling

- There is a risks and uncertainties section later in the impact assessment, however, it is worth highlighting some specific uncertainties around the input assumptions and modelling here. Firstly, the amount of effort required and the corresponding costs are on the pessimistic side. This is because we modelled from a set energy demand baseline based on Part L 2010 building regulations which effectively means our counterfactual is developers building to the exact minimum to satisfy Part L 2010 building regulations. In reality they overshoot, mainly to ensure compliance, but also because developers – not least those building social homes – had been building to standards higher than Part L 2006 for years. While some account is taken of this in terms of the transition times for each set of regulations to be taken up, the method we have used will nonetheless bias our costs and benefits upwards.
- Another upward bias in costs comes from the assumption that when meeting the carbon compliance (onsite abatement) requirements, developers will do the minimum fabric energy efficiency standard required, and use renewable energy for the remainder rather than further increase levels of energy efficiency. This was partly due to modelling difficulties of what proportion of developers would 'go further' on energy efficiency (and to what extent), but also because we did not want to imply tighter standards than the 2016 energy efficiency minimum standard. Also, it is possible the developer might find it more financially beneficial to put more renewables in and arrange a mechanism to claim any available subsidies, (for example the current Feed-In Tariff[41]). However, the impact assessment summary sheets do not pick this up because the future availability of subsidies is uncertain, and in addition subsidies are viewed as a transfer between economic agents, rather than a true economic cost or benefit.
- It is assumed that developers will always build to the lowest mandated carbon compliance or energy efficiency standard set out in that policy option. It is perfectly possible developers would prefer to abate further onsite, at a lower marginal cost than paying for allowable solutions, however we have modelled that all developers stop at the minimum onsite requirements and buy allowable solutions at the set cost. This is another assumption that makes the costs on the pessimistic (high) side.
- The impact assessment is at risk of double counting costs and benefits already stated elsewhere, specifically in the Feed-In Tariffs and Renewable Heat Incentive impact assessments. If new homes (whether through the developers or the home owners) are eligible for these incentives and developers claim them then their costs and benefits should be removed from this analysis. As the policy on Renewable Heat Incentive is not yet final, and for the sake of consistency and understanding what future build homes would look like in their entirety (rather than just their energy efficiency and allowable solutions payments) we have presented the costs and benefits of the renewable energy technologies here and based our

[39] www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx
[40] The central estimate is 5p/kWh, declining to 4.7p/kWh by 2020
[41] The Feed-In Tariff is a system to incentivise small scale (less than 5MW), low carbon electricity generation and RHI the Renewable Heat Incentive provides incentives for the generation of heat from renewable sources at all scales. Levels of the Renewable Heat Incentive for new build homes are not yet certain.

net present values on the basis that new homes are not claiming Feed-In Tariffs or Renewable Heat Incentive. However, we have made clear in the costs/benefits tables what occurs because of the energy efficiency elements of the policy and what occurs because of the renewable energy and allowable solutions elements. This enables the scale of any potential overlap to be clearly understood – for example there is no overlap risk for the energy efficiency elements of the policy. The treatment of funds raised through any allowable solution mechanism will depend to an extent on how they are used, which will be looked at in more detail in future.

j) Other cost considerations

- An estimate of administrative costs of the policy is in Annex B, Table AB 9. Due to the uncertainty around the change to the building regulations in 2016, we have assumed that such administrative costs for zero carbon homes policy will be equal to the costs estimated from the previous change to the building regulations in 2010. Administrative costs associated with the 2013 step have not been quantified as it has been assumed that the required administration requirement, notably the need for a Standard Assessment Procedure output, is already undertaken through Part L building regulations requirements. Any additional costs would be subsumed within the uncertainty around the administrative costs of the 2016 step, which is appropriate for the purposes of this impact assessment.
- These costs are included in our modelling and have been reflected in the headline net present values and the summary sheets. These costs will be the same for each policy option and therefore the figures in the summary sheets still reflect the relative cost of each option accurately. These costs fall to industry and not to local authorities or householders. We do not anticipate any new burdens on local authorities.
- Valuation of ancillary impacts covers the avoided cost of renewables and the value of air quality impacts. This has been done according to government appraisal methodology, and the results can be found in the distributional impacts section. These costs and benefits are not reflected in the headline net present values or summary sheets.

Costs and benefits of options considered

43. The headline costs and benefits stated in the summary sheet are a best estimate based on central setting of all variables impacting zero carbon homes policy. The lower and upper bound estimates are calculated based on higher and lower estimations of carbon and energy prices in conjunction with variation in the cost of allowable solutions. These have been chosen because they are able to provide a range and also because they impact costs and benefits respectively in isolation. Further sensitivity is set out in Annex C.

OPTION 1 – DO NOTHING

44. Option 1 considers the impacts of no change to the current 2010 Part L building regulations. It can be assumed that the medium-term costs and benefits of this ‘do nothing’ scenario are zero.

45. ‘Do nothing’ does however carry an opportunity cost of foregone carbon and fuel bill savings (which are reflected as benefits under the other options), higher total energy demand, less innovation and technological improvement, and it makes it more difficult to meet legally binding climate change and renewable energy targets (none of these impacts are monetised here).

46. Furthermore, the ‘do nothing’ option would not lead to us meeting EU Directives requiring ‘near zero energy buildings’ by 2020 which could have unquantifiable infractions fines and damage to the UK governments reputation if not adequately transposed.

OPTION 2 - FROM 2013, REQUIRE A FABRIC ENERGY EFFICIENCY STANDARD; AND FROM 2016 INTRODUCE A CARBON COMPLIANCE LEVEL OF 10KGCO$_2$/M²/YR FOR ALL NEW DETACHED HOMES, 11KGCO$_2$/M²/YR FOR ATTACHED HOMES AND 14KGCO$_2$/M²/YR TO FLATS. REQUIRE ALL REMAINING REGULATED EMISSIONS TO BE DEALT WITH VIA ALLOWABLE SOLUTIONS.

47. Option 2 assumes the introduction of a mandatory Fabric Energy Efficiency Standard for all new dwellings in 2013. This standard is intrinsic to the definition of zero carbon homes although Ministers have yet to decide whether it will be introduced fully in 2013; they may decide to introduce an interim energy efficiency standard in 2013 with the full Fabric Energy Efficiency Standard deferred until 2016.

48. Option 2 assumes the introduction of carbon compliance levels in 2016. These carbon compliance levels differ for each dwelling type. This is so as to allow developers to undertake a consistent level of effort to achieve on-site emissions reductions across different dwelling types. Local authorities have at their discretion the opportunity to require developers to go further on Fabric Energy Efficiency Standard, Carbon Compliance or ask for more than 100 per cent reductions in regulated emissions i.e. require unregulated emissions reductions.

49. Using the Hub's work, the most cost-effective technology combination applicable to all dwellings to reach the 14/11/10kgCO$_2$/m²/yr target in 2016 (in conjunction with Fabric Energy Efficiency Standard in 2013) is solar photovoltaic panels alongside a gas boiler, as shown in Table C:

Table C: Renewable energy technology combinations for each dwelling type, when using Fabric Energy Efficiency Standard from 2013 and Hub recommended carbon compliance levels from 2016

	Detached	Semi	Mid	Flat
Renewable energy technology:	Photovoltaics	Photovoltaics	Photovoltaics	Photovoltaics
Annual generation capacity (kWh)	1,046	1,315	1,090	666

50. The per dwelling cost of achieving 14/11/10kgCO$_2$/m²/yr using the technologies set out in three tables Table D are presented below. It is broken down into the onsite (energy efficiency and renewable energy) and offsite (allowable solutions payment) components, using the central cost estimates for achieving the required carbon compliance level. The three tables represent the cost to build to the proposed standard now, in 2017 and in 2020, all in constant (today's) prices. The difference between costs in the three tables illustrates the effect of learning rates and (to a lesser extent) the smaller amount of renewables that must be abated by allowable solutions, the later the house is built, owing to projected grid decarbonisation. The allowable solutions payment is called 'approximate' as it depends on the exact cost per tonne of carbon charged, and while government is clear this should be equivalent to the long-term cost of carbon, the fine details on how this is counted are still to be resolved.

Tables D1, D2 and D3: Per dwelling costs for optimal cost case: Fabric Energy Efficiency Standard 2013 and 14/11/10kgCO_2/m²/yr from 2016 where the impact of when the cost is incurred is shown, in constant prices

Table D1: Per dwelling cost if meeting the proposed standard in 2010 (constant prices, no learning rates)

	Detached	Semi	Mid-terrace	Flat
Onsite abatement: energy efficiency	£1,913	£80	£0	£159
Onsite abatement: renewables	£7,809	£6,632	£5,752	£2,161
Offsite abatement (approximate allowable solutions payment)	£1,095	£751	£671	£457
Total	*£10,818*	*£7,463*	*£6,423*	*£2,778*

Table D2: Per dwelling cost if meeting the proposed standard in 2017 (constant prices)

	Detached	Semi	Mid-terrace	Flat
Onsite abatement: energy efficiency	£1,339	£56	£0	£110
Onsite abatement: renewables	£3,971	£3,372	£2,925	£1,099
Offsite abatement (approximate allowable solutions payment)	£1,062	£725	£645	£441
Total	*£6,371*	*£4,153*	*£3,570*	*£1,650*

Table D3: Per dwelling cost if meeting the proposed standard in 2020 (constant prices)

	Detached	Semi	Mid-terrace	Flat
Onsite abatement: energy efficiency	£1,263	£53	£0	£102
Onsite abatement: renewables	£3,520	£2,989	£2,593	£974
Offsite abatement (approximate allowable solutions payment)	£1,047	£714	£634	£433
Total	*£ 5,829*	*£ 3,756*	*£ 3,226*	*£ 1,509*

51. When aggregated over the total numbers of homes built per year between now and 2025, the costs and benefits of the cost optimal case are shown below. Note that the numbers shown below are costs and benefits to society. The individual household and developer-level costs and benefits are explored in the distributional impacts section.

52. For the purposes of our modelling we have had to make an assumption about the level of carbon compliance developers will achieve on-site. We have assumed that they will go no further than that which is required and the remaining emissions will be dealt with through allowable solutions. For Option 2 this means that developers achieve a level of 14/11/10kgCO_2/m²/yr of regulated emissions on-site and the remaining additional emissions through to 100 per cent of regulated emissions are dealt with off-site.

Table E1: Costs of Option 2

	Present value capital cost (£m)	Present Value ongoing costs (£m)	Present Value admin costs (£m)
2013 regs - energy efficiency	425	0	0
2016 - administrative costs	0	0	***95***
2016 - renewables	1,848	677	0
2016 - allowable solutions	735	0	0
TOTAL	***3,008***	***677***	***95***

Table E2: Benefits and net present value of Option 2

	Present Value financial benefits (£m)	Financial Net Present Value (£m)	Present Value traded carbon benefits (£m)	Present Value non-traded carbon benefits (£m)	***Total Net Present Value (£m)***
2013 regs - energy efficiency	443	18	0	341	***359***
2016 - administrative costs	0	**-95**	0	0	***-95***
2016 - renewables	1,660	-865	178	0	***-687***
2016 - allowable solutions	0	-735	0	737	***2***
TOTAL	***2,102***	***-1,678***	***178***	***1,078***	***-421***

53. Option 2 has a net cost of £0.4bn as shown in Table E2. Allowable solutions assumed to be set at a price of £46/tonne (modelled as £97/tonne to avoid double discounting). This figure has been chosen as it is equal to the average discounted abatement cost of non-traded carbon over the assumed lifetime of the policy. The best estimate net present value of £421m is expected because this is based on central estimates for all variables. This is by definition the best estimate of costs and benefits that can be assumed for this policy.

54. Note that in Table E1 the bulk of costs come under 2016 changes. These are indicative scenarios. If the step in 2013 is more than the assumed Fabric Energy Efficiency Standard, this will mean that less has to be done in 2016 regulations to achieve zero carbon as fewer emissions will need to be dealt with relative to 2013 Part L of the Building Regulations. This will be considered further in future impact assessments once the course of action for changes to 2013 building regulations is better known. It is for this reason that the 2013 and 2016 steps should be considered together.

55. As with the other options, homes built to this standard reduce their energy demand (e.g. through better insulation and improved air tightness). This gives rise to an 'avoided cost of renewables' through reducing total energy consumption and the renewable deployment needed to hit targets set by The EU Climate and Energy Package. This option leads to:

- 39 TWh decrease in gas demand over the policy lifetime, which has a present value of £443m
- 27 TWh of renewable electricity generated over the policy lifetime which has a present value of £1.7bn

56. This means householders spend less on their bills, electricity generators need to spend £178m less on EU Emissions Trading Scheme carbon permits, as well as less on generation. The value of the non-traded carbon saved from allowable solutions is £737m, which is a benefit to businesses in the UK and society generally since less carbon needs abating elsewhere.

Table F: Carbon benefits and cost effectiveness of Option 2

	Lifetime Million tonnes of carbon dioxide (traded)	Lifetime Million tonnes of carbon dioxide (non-traded)	Cost-effectiveness: traded (£/tCO_2)	Cost-effectiveness: non-traded (£/tCO_2)
2013 regs - energy efficiency	0.0	7.1	NA	2
2016 – renewables	5.8	0.0	-150	NA
2016 - allowable solutions	0.0	16.2	NA	-45
TOTAL	***5.8***	***23.3***	-150	-31

57. The cost effectiveness[42] indicator is intended to quantify to what extent the monetary costs and benefits of individual elements of the policy represent value for money in terms of carbon savings. However, cost-effectiveness does not include the other non-monetised elements of the policy as set out above. The Department of Energy and Climate Change's guidance provides a methodology for producing a cost comparator[43], against which cost effectiveness calculations should be based.

58. The cost-effectiveness is most meaningful when split out between traded and non-traded as there is no overlap in costs. Table F shows that the non-traded sector cost-effectiveness (the energy efficiency and allowable solutions elements of the policy) is a net cost of £31/tonne and the traded sector cost-effectiveness (the renewable electricity, in this example) is a net cost of £150/tonne. Simply dividing the financial net present value (excluding the value of carbon saved) by the quantity of carbon saved in both the traded and non-traded sector shows that it is costing £58 to abate each tonne of carbon.

59. Carbon savings from the zero carbon homes policy amount to 5.8 million/mega tonnes of carbon dioxide (in terms of reduced EU Emissions Trading System permits required to be purchased) the traded sector and 23.3 million/mega tonnes of carbon dioxide in the non-traded sector. This has a present value benefit of £1.3bn.

60. Current estimates of net present values and cost effectiveness for the policy contain the costs and benefits of renewable energy technologies. As previously mentioned, renewable energy technologies may be subject to Feed-In Tariffs and Renewable Heat Incentives. As these are quantified (subject to the Department of Energy and Climate Change's policy) within Impact Assessments for these individual policies, the inclusion of renewable costs and benefits here give rise to the possibility of double-counting. The use of renewable technologies currently account for the most expensive elements of the zero carbon homes policy. Any future iteration of this impact assessment will consider the problem of double-counting with revised headline figures and changes to cost effectiveness of the overall package of the policy.

61. Further work should be done on the operational and maintenance costs for photovoltaics, which has a notable impact on the cost-effectiveness for the traded sector. Current estimates are based on a single report[44] and the impact assessment would benefit from a wider evidence base.

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[42] Cost Effectiveness (£/tCO_2e) = NPV – PVB carbon (either traded or non traded sector)/-(Total carbon saved either in the traded or non traded sector (tonne of CO_2e))

[43] The cost comparators for this policy are calculated at £45/tonne however it is also illuminating to compare the cost-effectiveness to the carbon values at such times as 2030 (£70/tonne) and 2050 (£200/tonne) since the benefits from the policy will still be occurring throughout the century.

[44] Renewable electricity assumptions are based on Element Energy work (2009) and renewable heat assumptions are from NERA-AEA work (2009).

Sensitivity analysis for Option 2

62. There are a number of factors affecting costs and benefits for this policy making sensitivity analysis more complex. It was deemed appropriate to isolate the impact of certain key variables for use in the summary sheets. More complex compound sensitivity analysis is set out in Annex C. Any costs and benefits of this policy that arise as a result of local authority choice are not included as we are solely concerned with the impact of the setting of a national standard for new build homes.

63. Some consideration of variables impact on the policy in isolation is done below:

- **Carbon values and energy prices**. These have been considered jointly, i.e. when carbon prices are high, energy prices are high; and vice versa. High carbon prices increase the benefits of saving carbon (or penalise falls in carbon saved), however high energy prices can in some instances have a double effect. They increase the financial benefits in terms of energy bill savings, but as some renewable energy technologies use electricity or biomass as fuel, the ongoing costs would also rise. On balance though, high energy and carbon prices improve the 2016 step of the policy's net cost from £0.8bn to a net cost of £0.4bn. Low energy and carbon prices worsen it to a net cost of £1.7bn.
- It is worthwhile noting that high energy prices lead to a combined net benefit of £0.3bn, whilst low energy/carbon prices lead to the net cost remaining around £1.7bn. This highlights the sensitivity of zero carbon homes policy to the 2013 step but also energy prices. A less stringent step in 2013 would mean more energy efficiency was required in 2016 and thus there would be additional net benefits of energy efficiency transferring onto the 2016 step. Fabric Energy Efficiency Standard is intrinsic to the zero carbon homes policy and therefore it is pertinent to consider the net present value of building regulation changes in 2013 and 2016 in conjunction, from the baseline 2010.
- **The number of homes built per year**. In the central scenarios for all options, we assume 120,000 homes are built in 2014 rising to 190,000 p.a. from 2020. These are notional, stylised assumptions and do not represent official government targets. Since the model primarily works on a 'per dwelling' cost basis, there is a linear effect of changing house building numbers. Reducing build rates by 25 per cent improves the net cost of the 2016 step from a net cost of £0.8bn to a net cost of £0.6bn. Whilst increasing build rates by 25 per cent increases the net cost to £1bn. The model does not take account of dynamic learning rates (whereby the more houses built increases the rate of learning and costs falling), this is a simple linear change.
- **The level of technological learning rates and hence future costs.** The central assumption assumes some 'learning rates' whereby technology costs fall over time. Just looking at the capital cost element of the results table, the central scenario has a present value cost of £2.6bn (excluding the 2013 step). Removing learning rates increases this to £4.9bn. However the research and costing work we have done over the last few years of zero carbon policy development indicates learning rates are happening in the real world and often exceed expectations.
- **Low cost versus high cost technology specifications.** As an illustration, Table G shows the per dwelling cost of developers adopting a higher-cost route to achieving 14/11/10kgCO_2/m²/yr which assumes the introduction of Fabric Energy Efficiency Standard in 2013 but with renewable heat and a more demanding being adopted in 2016, solar thermal for detached/semi-detached houses and flats and biomass community heating system for mid-terrace houses in 2016.

Table G: Sensitivity - Technology combinations for cost optimal case with more costly measures (more renewable heat): Fabric Energy Efficiency Standard from 2013 and 14/11/10kgCO_2/m²/yr from 2016

	Detached	Semi	Mid	Flat
Primary electricity technology:	Photovoltaics	None	None	None
Annual capacity (kWh)	128	0	0	0
Primary heat technology:	Solar thermal	Solar thermal	Biomass community heating	Solar thermal
Annual capacity (kWh)	1,040	949	2,574	657
Biomass required (kWh)	0	0	3,143	0

64. Table H sets out the estimated per dwelling cost of meeting the Option 2 requirement with minimal renewable electricity. It is broken down into the energy efficiency and renewable energy components. This is a central cost estimate for achieving the required carbon compliance level.

Table H: Sensitivity - High per dwelling capital costs for cost optimal case with more costly measures (more renewable heat): Fabric Energy Efficiency Standard from 2013 and 14/11/10kgCO_2/m²/yr with more demanding energy efficiency from 2016 (costs given at 2010 levels i.e. today's build cost, not reflecting learning and experience benefits)

	Detached	Semi	Mid	Flat
Energy efficiency (£)	7,957	5,413	4,780	3,626
Renewable energy (£)	6,884	4,904	7,400	3,274
Total (£)	14,841	10,317	12,180	6,900

Table I1: Costs of Option 2 with more costly measures (more renewable heat): Fabric Energy Efficiency Standard from 2013 and 14/11/10kgCO_2/m²/yr with more demanding energy efficiency from 2016

	Present Value capital cost (£m)	Present Value ongoing costs (£m)	Present Value admin costs (£m)
2013 regs - energy efficiency	415	0	0
2016 - administrative costs	0	0	***95***
2016 - energy efficiency	2,381	0	0
2016 - renewables	2,575	1,237	0
2016 - allowable solutions	735	0	0
TOTAL	***6,106***	***1,237***	***95***

Table I2: Benefits and net present value of Option 2 with more costly measures (more renewable heat): Fabric Energy Efficiency Standard from 2013 and 14/11/10kgCO_2/m²/yr with more demanding energy efficiency from 2016

	Present Value financial benefits (£m)	Financial Net Present Value (£m)	Present Value traded carbon benefits (£m)	Present Value non-traded carbon benefits (£m)	***Total Net Present Value (£m)***
2013 regs - energy efficiency	443	28	0	341	***369***
2016 - administrative costs	0	**-95**	0	0	***-95***
2016 - energy efficiency	553	-1,828	-33	743	***-1,118***

2016 - renewables	405	-3,408	6	192	***-3,210***
2016 - allowable solutions	0	-735	0	737	***2***
TOTAL	***1,401***	***-6,038***	***-27***	***2,013***	***-4,052***

65. For the purposes of our modelling we have had to make an assumption about the level of carbon compliance developers will achieve on-site. We have assumed that they will go no further than that which is required and the remaining emissions will be dealt with through purchasing allowable solutions. For Option 2 this means that developers achieve a level of 14/11/10kgCO_2/m²/yr of regulated emissions on-site.

66. Table I2 shows that achieving emissions reductions to 100 per cent of regulated emissions without adopting any renewable electricity technology leads to the net present value worsening from a net cost of £0.4bn to a net cost of £4.1bn.

Table J: Carbon benefits and cost effectiveness of Option 2 with more costly measures (more renewable heat and energy efficiency): Fabric Energy Efficiency Standard from 2013 and 14/11/10kgCO_2/m²/yr from 2016

	Lifetime Million tonnes of carbon dioxide (traded)	Lifetime Million tonnes of carbon dioxide (non-traded)	Cost-effectiveness: traded (£/tCO_2)	Cost-effectiveness: non-traded (£/tCO_2)
2013 regs - energy efficiency	0.0	7.1	-	4
2016 - energy efficiency	-1.1	15.4	n/a	-127
2016 - renewables	0.2	4.7	n/a (increases traded emissions)	-727
2016 - allowable solutions	0.0	16.2	-	-45

Table K1: Sensitivity for Option 2 – cost impact of individual variables

	Present value capital cost	Present Value ongoing cost	Present Value administrative cost	**Present Value Cost**
	£m	£m	£m	£m
High Energy/Carbon Prices *and* Low allowables price	2,644	677	95	**3,416**
Low Energy/Carbon Prices *and* High allowables price	3,379	677	95	**4,151**
Fabric Energy Efficiency Standard plus Carbon Compliance, no Allowable Solutions.	2,273	677	95	**3,044**
Fabric Energy Efficiency Standard plus Allowable Solutions to 100%. No Carbon Compliance	1,554	0	95	**1,648**

Table K2: Sensitivity for Option 2 – benefit and net present value impact of individual variables

	Present Value financial benefit	Present Value traded carbon benefit	Present Value non-traded carbon benefit	**Present Value Benefit**	**Total Net Present Value (incl. carbon)**
	£m	£m	£m	£m	**£m**
High Energy/Carbon Prices *and* Low allowables price	2,546	262	1,251	**4,059**	**643**
Low Energy/Carbon Prices *and* High allowables price	1,103	89	906	**2,098**	**-2,053**
Fabric Energy Efficiency Standard plus Carbon Compliance, no Allowable Solutions.	2,102	178	341	**2,622**	**-423**
Fabric Energy Efficiency Standard plus Allowable Solutions to 100%. No Carbon Compliance	443	0	1,473	1,915	**267**

67. The figures used in the summary sheets as sensitivity for the costs and benefits for Option 2 are shown in the top two rows in Table K1 and K2. Further sensitivity analysis for individual variables is shown in Annex C, Table AC [1].These variables have an independent impact on costs and benefits and are therefore relatively easily analysed. Compound sensitivity analysis on Option 2 has been done in Annex C, Table AC [3] to AC [6].

68. As an illustration, Table K1 sets out the costs and benefits if we were to require developers to only meet the carbon compliance level of 14/11/10kgCO_2/m²/yr and go no further off site through allowable solutions. Note that this scenario does not satisfy zero carbon homes requirements as it requires emissions to be dealt with only to the carbon compliance level. Not all regulated emissions are dealt with. The net present value for this scenario is -£423m, only marginally different from the preferred Option 2 which ensures 100 per cent of regulated emissions are dealt with. This reflects the fact that the allowable solutions price is set at a cost effective level.

69. Table K1 also sets out a case where developers are required to meet Fabric Energy Efficiency Standard and then are able to pay for allowable solutions to deal with the carbon up to the required 100 per cent of regulated emissions produced by a house. This scenario fails to provide the homeowner with the financial benefits of renewable energy technologies and the occupants' house will continue to emit emissions onsite above the level that Fabric Energy Efficiency Standard reduced the dwellings emissions to. This is harder to justify to the consumer that their house is zero carbon. This option will also not benefit from any financial incentives such as Feed-In Tariffs and Renewable Heat Incentive should they be available for new build. Retrofitting to gain these benefits will be a more costly route to reducing carbon.

Table L: Sensitivity around price of allowable solutions and level of local authority ambition to give total net present value of achieving zero carbon homes as defined under Option 2

		Level of ambition			
		Scenario 1: 14/11/10kgCO_2/m²/yr onsite and allowable solutions to 100 per cent regulated		**Scenario 2:** 14/11/10kgCO_2/m²/yr onsite and 100 per cent regulated and 100 per cent unregulated Total net present value of 2016 zero carbon homes (£m)	
		Cost (£)	Net Present Value (£)	Cost (£)	Net Present Value (£)
Discounted (Present Value) price of Allowable Solutions (£)	23	£3.4bn	-£57m	£3.9m	£204m
	46	£3.8bn	-£421m	£4.7bn	-£612m
	70	£4.2bn	-£792m	£5.5bn	-£1,445m

70. Table L, Scenario 1 is that local authorities will require developers to reach the carbon compliance level through on site measures and then employ the allowable solutions (‘allowables’) to reach 100 per cent of regulated emissions. Scenario 2 assumes that in addition local authorities will require developers to use allowables to pay for unregulated emissions as well.

71. The net present value for Scenario 2 at a low allowables price is much higher. This is because there is relatively more carbon saved than in Scenario 1. With allowables at a cost of £23/tonne of carbon dioxide, because there is relatively more carbon saved in Scenario 2, the net present value comes out very favourably as the carbon is undervalued. Whereas at higher prices the same amount of carbon saved, costs proportionately more and is overvalued relative to the benefits.

72. The costs to reach 100 per cent regulated at an allowables price of £23/tonne, giving a net present value of -£57m are £3.4bn whereas the costs to reach 100 per cent regulated and unregulated at an allowables price of £23/tonne, giving a net present value of £204m is £3.9bn. The same cost when allowables price is £70/tonne is £4.2bn for 100 per cent regulated and £5.5bn for 100 per cent regulated and unregulated. The higher costs of reaching 100 per cent regulated and unregulated at low allowables prices are offset by proportionately higher benefits as the allowable solutions price is undervaluing the carbon, giving a more favourable net present value. This offsetting of costs is slowly diminished as the allowables price rises relative to the abatement cost of carbon used in our modelling which gives the stock value of the carbon saved for both scenarios in Table M.

73. The analysis for Scenarios 1 and 2 assume that the costs and benefits arising from allowables are confined to the non-traded sector. Further analysis may be done once the policy around allowables is more certain. This may consider a split of costs and benefits between the traded and non-traded sectors.

74. Local authorities may decide to go beyond the national on-site carbon compliance standard of 14/11/10kgCO_2/m²/yr. Table M illustrates the net present value for different options. Zero uptake assumes that local authorities only require developers to meet the national standards, namely that they achieve 14/11/10kgCO_2/m²/yr onsite emissions and employ allowables to 100 per cent of regulated emissions. This gives the same net present value for all options. Fifty per cent uptake assumes that half of local authorities have more stringent requirements and the other half continue with requiring national standards only.

Table M: Sensitivity around local authority requirements

		Requirements		
		More Offsite: Fabric Energy Efficiency Standard plus 14/11/10kgCO_2/m²/yr onsite and allowables to 100 per cent regulated and unregulated, net present value (£m)	**More Onsite**: Fabric Energy Efficiency Standard plus 6kgCO_2/m²/yr onsite and allowables to 100 per cent regulated, net present value (£m)	**More On-Site and Offsite:** Fabric Energy Efficiency Standard plus 6kgCO_2/m²/yr on-site and allowables to 100 per cent regulated and unregulated, net present value (£m)
Local Authority Uptake (per cent)	0	-£421m	-£421m	-£421m
	50	-£517m	-£1,623m	-£1,718m
	100	-£613m	-£2,824m	-£3,015m

75. Table M does not show the costs associated with local authorities requirements to go beyond national standards. The cost of doing more offsite with 100 per cent uptake is £4.7bn doing more on-site is £6.8bn and doing more on-site and off-site is £7.7bn. Local authorities will take these costs into account when setting the requirements for developers to achieve in their authority.

OPTION 3 – BUILDING ON FABRIC ENERGY EFFICIENCY STANDARD FROM 2013 BY INTRODUCING A CARBON COMPLIANCE LEVEL EQUIVALENT TO THAT WHICH WAS FORMERLY SET AT 70 PER CENT OF 2006 REGULATED EMISSIONS (EQUIVALENT TO AN ABSOLUTE TARGET OF 6KGCO_2/M²/YR FRO ALL DWELLING TYPES) FROM 2016. IN ADDITION ALL REGULATED AND UNREGULATED EMISSIONS MUST BE DEALT WITH.

76. Option 3 has been drawn up because it provides consistency with the previous impact assessment which assumed that the 2016 carbon compliance level would be 70 per cent or 6kgCO_2/m²/yr in absolute terms. Using the Hub's work, the most cost effective means of reaching this 6kgCO_2/m²/yr is to adopt photovoltaics and gas boiler for detached/semi-detached/mid-terrace and biomass community heating schemes for flats. This is illustrated in Table N below:

Table N: Technology combinations for 70 per cent equivalent cost case: Fabric Energy Efficiency Standard from 2013 and 6kgCO_2/m²/yr from 2016

	Detached	Semi	Mid	Flat
Primary electricity technology:	Photovoltaics	Photovoltaics	Photovoltaics	None
Annual capacity (kWh)	1,625	1,269	1,131	0
Primary heat technology:	None	None	None	Biomass community heating
Annual capacity (kWh)	0	0	0	2,518
Biomass required (kWh)	0	0	0	3,619

77. Table N sets out the estimated per dwelling cost of meeting the Option 3 requirement with minimal renewable electricity. It is broken down into the energy efficiency and renewable energy components. This is a central cost estimate for achieving the required carbon compliance level.

Table O: Per dwelling capital costs for 70 per cent equivalent cost case: Fabric Energy Efficiency Standard from 2013 and 6kgCO_2/m²/yr from 2016 (costs given at 2010 levels i.e. today's build cost, not reflecting learning and experience benefits)

	Detached	Semi	Mid	Flat
Energy efficiency (£)	1913	5,413	4,780	159
Renewable energy (£)	11,316	6,450	5,911	7,400
Total (£)	13,229	11,863	10,691	7,560

78. When aggregated over the total numbers of homes built per year between now and 2025, the costs and benefits of the 70 per cent equivalent case are shown below. Note that the numbers shown below are costs and benefits to society.

Table P2: Costs of Option 3

	Present Value capital cost (£m)	Present Value ongoing costs (£m)	Present Value admin costs (£m)
2013 regs - energy efficiency	424	0	0
2016 - administrative costs	0	0	***95***
2016 - energy efficiency	1,086	0	0
2016 - renewables	2,992	1,690	0
2016 - allowable solutions	1,426	0	0
TOTAL	***5,928***	***1,690***	***95***

Table P2: Benefits and net present value of Option 3

	Present Value financial benefits (£m)	Financial Net Present Value (£m)	Present Value traded carbon benefits (£m)	Present Value non-traded carbon benefits (£m)	***Total Net Present Value (£m)***
2013 regs - energy efficiency	443	18	0	341	***359***
2016 - administrative costs	0	**-95**	0	0	***-95***
2016 - energy efficiency	268	-818	-15	347	***-485***
2016 - renewables	1,782	-2,900	166	130	***-2,604***
2016 - allowable solutions	0	-1,426	0	1,236	***-190***
TOTAL	***2,493***	***-5,221***	***151***	***2,054***	***-3,015***

79. Table P2 shows that the net present value of Option 3 is a cost of £3bn. The cost of reaching this higher level of on-site and off-site ambition with a more ambitious carbon compliance level is £7.7bn as shown in Table P1.

80. For the purposes of our modelling we have had to make an assumption about the level of carbon compliance developers will achieve on-site. We have assumed that they will go no further than that which is required and the remaining emissions will be dealt with through purchasing allowable solutions. For Option 3 this means that developers achieve a level of 6kgCO_2/m²/yr of regulated emissions on-site and the remaining 6kgCO_2/m²/yr as well as unregulated emissions are bought out.

81. There is no sensitivity around the allowable solution price or level of ambition. These are set at £46/tonne and all emissions (regulated and unregulated) are dealt with through allowable solutions. This is because this option has been created so as to be consistent with what was assumed in the previous impact assessment. The figures for this Option have changed from those in the previous impact assessment for a number of reasons. Since the last impact assessment there has been a change in evidence used such an updated valuation of greenhouse gas emissions and carbon intensity of fuels. We have

also benefited from the work of the zero carbon hub and there has been a change in the baseline as the 2010 Part L building regulations have come into effect.

Table Q: Cost Effectiveness and carbon benefits of Option 3

	Lifetime million tonnes of carbon dioxide, (traded)	Lifetime million tonnes of carbon dioxide (non-traded)	Cost-effectiveness: traded (£/tCO_2)	Cost-effectiveness: non-traded (£/tCO_2)
2013 regs - energy efficiency	0.0	7.1	-	3
2016 - energy efficiency	-0.5	7.2	N/A	-128
2016 - renewables	5.4	3.2	-518	-862
2016 - allowable solutions	0.0	28.4	-	-50
TOTAL	***4.9***	***45.9***	-648	-110

82. From Table Q, we can see the policy as defined under Option 3 is less cost effective than the preferred option with £648/tonne in the traded sector and £110/tonne in the non-traded sector. Option 3 is estimated to save 45.9 million tonnes of carbon dioxide in the non-traded sector over the lifetime of the policy, and 4.9 million tonnes of carbon dioxide in the traded sector.

Table R1: Sensitivity for Option 3 – cost impact of individual variables

	Present Value capital cost	Present Value ongoing cost	Present Value admin cost	Present Value **Cost**
	£m	£m	£m	£m
Low Energy/Carbon Prices *and* High allowables Price	6,649	1,601	95	**8,345**
High Energy/Carbon Prices *and* Low allowables Price	5,223	1,791	95	**7,109**

Table R2: Sensitivity for Option 3 – benefit and net present value impact of individual variables

	Present Value financial benefit	**Financial Net Present Value (excl. carbon)**[45]	Present Value traded carbon benefit	Present Value non-traded carbon benefit	**Present Value Benefit**	***Total Net Present Value (incl. carbon)***
	£m	**£m**	£m	£m	£m	***£m***
Low Energy/Carbon Prices *and* High allowables Price	1,307	-7,037	76	1,641	**3,025**	**-5,320**
High Energy/Carbon Prices *and* Low allowables Price	3,091	-4,018	222	2,468	**5,782**	**-1,327**

The figures used in the summary sheets as sensitivity for the costs and benefits Option 3 are those in Table R1 and R2. Further sensitivity analysis for individual variables is shown in Annex C, Table AC 2.These variables have an independent impact on costs and benefits and

[45] Financial NPV is the PV of financial benefits (from energy bill savings) less the PV of capital, ongoing and admin costs. The column of admin costs is not shown here as it does not vary between the sensitivities.

are therefore relatively easily analysed. Compound sensitivity analysis on Option 2 has been done in Annex C, Table AC 7 to AC 10.

Distributional impacts

83. The additional capital cost of building a new home, reflected in the above analysis, is the cost borne by the developer. However, it is possible that the house builder may be able to offset some of these costs via several financial mechanisms (such as a potential Green Deal type approach, Feed-In Tariffs and the Renewable Heat Incentive) in order to reduce the burden of meeting the upfront cost of meeting the new standards.

84. These offsets, in addition to any additional value the house builder may be able to extract from the sale price of the home, or potential reduction in land values (see: sectors and groups affected by the policy), may allow them to build at considerably lower cost than that shown in the dwelling cost and benefit figures. They are not included in cost/benefit analysis as these are transfers from one economic agent to another, but nevertheless reflect that the direct cost of meeting the policy can be distributed from developers to other agents in the economy.

85. Under a possible version of the Green Deal (whereby the developer might put a 'charge' on the energy bill of the home paying an amount no greater than the savings due to the improved energy efficiency or renewable energy generation), developers may be able to recoup some or all of the additional cost.

86. The introduction of the Feed-In Tariff on 1 April 2010 and the expected introduction of the renewable heat incentive provide the opportunity for a revenue stream to be extracted from the use of renewable electricity and heat generation on-site. It is not yet clear to what extent developers currently claim Feed-In Tariffs[46] – but this may allow them to recoup some investment in renewable electricity which might be required to reach the on-site requirement of 14/11/10kgCO_2/m²/yr and beyond. The Feed-In Tariff may provide electricity generation onsite as a more cost-effective solution than paying for allowable solutions (priced at £46 per tonne of CO_2), inducing developers to go further on-site beyond the minimum regulated requirement.

87. The policy gives rise to an 'avoided cost of renewables'. The EU Climate and Energy Package create a target proportion of energy consumption which is to be delivered by renewable sources. As the policy generates energy savings (thereby reducing total energy consumption), and increases deployment of renewable energy technologies (reducing the renewable deployment needed to hit targets), the effects of these can be monetised, accounting for the UK's Renewable Energy Strategy[47]. For reduced energy consumption, this is £18/MWh, and £118/MWh for energy generation[48]. These are then discounted in the usual way. These figures are not included in the overall headline figures as benefits to the policy, owing to the uncertainty inherent in the estimates of these values.

88. The avoided cost of renewables for reduced energy consumption in the preferred option is valued at a present value of £0.4bn. The value of reduced energy consumption is attributable to the high level of on-site energy efficiency achieved through Feed-In Tariffs. The avoided cost of renewables for renewable energy generation in the preferred option is valued at a present value of £1.4bn. The value of renewable energy generation is attributable to the renewable technologies deployed to achieve carbon compliance.

89. In practice, developers may not always build to the lowest energy efficiency standard possible (as is assumed here), preferring to use high fabric standards to achieve carbon compliance. As such, these estimates reflect the extreme end of costs and benefits.

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[46] Current take-up of feed-in tariffs available, showing new build solar panels are being done already: www.renewablesandchp.ofgem.gov.uk/

[47] www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx

[48] DECC guidance on *Greenhouse Gas Policy Evaluation and Appraisal*

Administrative burdens

90. An estimate of administrative costs of the policy is in Annex B, Table AB 9. Due to the uncertainty around the change to the building regulations in 2016, we have assumed that the costs will be equal to the costs estimated from the previous change to the building regulations in 2010. These costs are included in our modelling and have been reflected in the headline net present values and the summary sheets. These costs will be the same for each policy option and therefore the figures in the summary sheets still reflect the relative cost of each option accurately. These costs fall to industry and not to local authorities or householders. We do not anticipate any new burdens on local authorities.
91. Significant new burdens on local authorities are not anticipated through the introduction of allowable solutions. The impact on administrative burdens will continue to be assessed up towards the implementation of the policy, at which point better information will exist on the sort of additional burdens industry may face through the new standards.

Cost to business/One-In-One-Out

92. For One-In-One-Out purposes the burden on business has been calculated by adding the cost of the energy efficiency standard, the upfront capital costs and the cost of allowable solutions. It is calculated on an equivalent annual cost basis over the lifetime of the policy. The benefit to business, calculated using the same equivalent annual cost methodology, only reflects the value of traded carbon since these are a direct benefit to the energy companies selling or buying fewer of the EU emissions permits. No other benefits, for example lower bills for households, feature in the One-In-One-Out calculations, and no ways of mitigating the costs to business – like a potential Green Deal for new build of claiming of renewable financial incentives – are included either. No account is taken of the fact that some land purchases will already have been made, factoring in earlier and more costly definitions of zero carbon, where change to the definition will lead to a windfall bonus.
93. The One-In-One-Out burden relates to the net burden on business. However, it does not account for the fact that zero carbon homes policy is to a great extent going to satisfy transposition of an EU Directive – the extent of any potential ‘gold plating’ is not yet clear as it is subject to legal interpretations of the EU requirements on ambition and timing of implementation. The lack of inclusion of cost mitigations like a potential Green Deal for new build or Feed-In Tariffs, and no netting off of the European requirements, means the current estimates for the One-In-One-Out burden can be considered at the costly, pessimistic end of the scale.

Risks and uncertainties

94. Changes to the Standard Assessment Procedure leading to confusion over effort required to meet new standards. The modelling in this impact assessment is based on the consultation version of the Standard Assessment Procedure 2009 software and should not be taken as the final energy reduction requirements. These may be refreshed in order to maintain parity with the level of effort originally intended when compared to a Part L 2006 building regulations baseline (where previous versions of the impact assessment used a modified Standard Assessment Procedure 2005).
95. 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, industry have been receiving signals about this policy for several years and clear advice will be given 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. The need for industry to follow a trajectory to the zero carbon homes standard, via the interim changes in 2013, also reduces the risk that industry takes no steps to prepare.

96. Learning rates. The analysis in this impact assessment assumed that costs will decline over time as energy efficiency and low and zero carbon technologies are deployed (with sensitivity analysis on learning rates). Costs falling should not fundamentally affect the ability of the industry 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.

97. 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). See the 'sectors and groups affected by the policy' section for more detail on the impact on house builders and housing supply. Evidence informing the carbon compliance level considered implications for viability with care. Beyond carbon compliance, viability safeguards exist within Community Infrastructure Levy, and the long lead-in time for the policy leaves open the option to introduce further protection for viability should this prove necessary.

98. 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. However, the preferred approach in prioritising local agency, and local delivery of renewable energy, has the potential to deliver benefits in terms of engaging the public with domestic carbon reduction and driving behaviour change towards low-carbon lifestyles. Significant work to understand the challenges posed by consumer acceptance in this sector has been taken forward with industry through the Zero Carbon Hub.

99. 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, by ensuring that there is straightforward guidance on how to comply, and effective and transparent accountability/certification mechanisms in place. Use of existing mechanisms – Building Regulations and Community Infrastructure Levy – mean that robust means of testing compliance are already embedded, and further work will be done to ensure that a suitable yet minimally burdensome regime is in place for 2016.

100. 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. Our analysis has explored the implications of high and low cost scenarios, whereby certain technologies are implicitly unavailable (such as wind and biomass). The Zero Carbon Hub analysis has similarly focused on proven technologies rather than potential future options. 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. Conversely, it can be expected that in practice regulatory requirements will incentivise development and bringing to market of innovations which can deliver regulatory requirements more economically. This will be complemented by the introduction of other policies aimed at stimulating such technologies, for example Feed-In Tariffs. 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.

101. Unintended health consequences. If not carefully designed and built, buildings with high levels of air-tightness could have moisture and air quality issues if not correctly ventilated. For this reason, Part F (Ventilation) of the building regulations is reviewed in parallel with

Part L of the building regulations, so as to ensure that there are no negative impacts on occupants' health as a result of energy efficiency measures. 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 relevant industry and research bodies to ensure that these research needs are met. See also the health impact assessment, below.

Sectors and groups affected by the policy

HOUSE BUILDERS AND LANDOWNERS

102. The capital costs in this impact assessment reflect the extent that the zero carbon policy 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 through allowable solution payments; and
- increased compliance costs to ensure high performing homes are built as designed

103. Government considers that by announcement of the policy in advance of its introduction, some of these 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
- industry can focus on 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

104. The economic effect of low- and zero-carbon policy is to reduce the value of land. As a result, it is already being factored into business decisions. This was clear in the previous Government's consultation and responses to it. Larger builders are looking to replenish their land banks with strategic sites that will be built out over the period to 2016 and beyond. For development to be commercially viable, the costs of development need to be factored into the price that builders pay for the land.

105. In an environment of economic caution, there is a natural tendency to factor in the most conservative assumptions as to future regulation in land prices. In the absence of certainty on this policy, this means that house builders will have been factoring into their strategic land purchases the costs of the zero carbon policy announced by the previous Government. Our preferred approach will significantly reduce the regulatory cost, by reducing the expectations of future costs.

106. The 2013 energy efficiency standard proposed has a lower upfront capital cost than the Advanced Practice standard that was used in previous iterations of the policy. It is anticipated that costs of high levels of energy efficiency can be progressively reduced. Developers also have the choice to go beyond the minimum standards as part of their strategy of meeting carbon compliance requirements.

107. It is anticipated that additional costs of 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 impact of other claims on land value uplift (whether through Building Regulations e.g. water efficiency or other policies such as Section 106 agreements) that may be passed back to land-owners and reflected in land values
- any reduction in negotiable costs and planning obligations
- 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 a 'derived demand'
- the extent to which home builders are able to pass back (to landowners) or pass forwards (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; and
- any change in landowner expectations (as to land values)

108. As such, some of the net costs of meeting the lower carbon 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 the analysis of costs and benefits as it represents a transfer from one economic agent to another, rather than being additional.

109. It is possible that different land would be brought forward for development with the policy in place. Some sites might be less suitable for on-site low and zero carbon energy supplies, 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 low or zero carbon homes.

110. Housing supply is influenced by many different variables as set out above, making an accurate analysis of the impact of Zero Carbon Homes policy on future housing supply difficult. We have attempted to quantify an impact based on high level assumptions of the costs of Zero Carbon Homes and its impact on supply of land/housing. All other variables affecting housing supply have been assumed to remain constant.

111. Estimates of the cost of meeting zero carbon homes standards are an additional £3,000-£8,000 per house from 2016. If builders were unable to absorb these costs, they could seek to pass them onto landowners by paying a reduced price for land. This could mean that landowners would be less willing to sell, so reducing the supply of available land. We roughly estimate that - in a scenario where house building and house prices continue their long-term trends, the cost of miscellaneous other regulations is £5,000 per house and costs are not mitigated in any way or passed through to home buyers in terms of price - the zero carbon homes policy could have an additional impact of between 0.5 per cent and 1.3 per cent on the supply of new homes, on top of the 1.2 per cent impact on supply caused by the other policies. This assumes a median level of land values and minimum landowner profits in addition to all other variables remain unchanged. Government has committed to reducing the impact of regulation on house builders over the spending review period so will be finding ways of reducing the overall cost impact of regulation to avoid impacts on supply.

SUPPLY CHAIN

112. 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 future homes. This may in turn require manufacturers to invest in research and development and in new or expanded production facilities.

113. 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 future home. This should in turn give supply chains confidence to invest in production facilities for the necessary materials and equipment.

HOME BUYERS

114. As noted above, buyers of new lower or zero carbon homes may bear some proportion of the cost of meeting the 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 these homes rather than a straightforward cost pass-through from house builders.

115. 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[49]. It is possible that growing consumer awareness of energy costs and environmental issues, and the introduction of Feed-In Tariffs, will mean that consumers will be prepared to pay a premium for zero carbon homes. Government is also working with the Royal Institute of Chartered Surveyors to improve the way energy efficiency is reflected in a home's valuation[50].

116. In the longer term, better use 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 lower carbon homes should enable the housing market to price in the attributes on which consumers might place a value.

ENERGY COMPANIES AND CONSUMERS

117. In the absence of the policy, new homes every 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 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.

118. By conserving energy and providing renewable energy supply, there is an avoided cost of renewables and energy infrastructure for the energy sectors.

119. The reduction in fossil fuels used for electricity generation should mean that electricity generators should be able to buy fewer EU Emission Trading Scheme 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.

120. Reductions in energy bills as a result of energy efficiency measures and renewable technologies will benefit consumers and increase their real income. As the UK moves through a demographic transition to a more elderly population, the total demand for a higher level of warmth within a dwelling will arguably rise. This makes no assumption about future climate change.

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[49] http://environmentpsychology.com/green_building_demand.htm
[50] www.rics.org/site/scripts/press_article.aspx?pressReleaseID=208

LOCAL AUTHORITIES

121. The proposed approach gives local authorities new responsibilities for shaping the approach to zero carbon development in their areas. It provides flexibility for local authorities to decide how new houses in their areas should meet the national minimum, and whether they should be pushed towards achieving zero-carbon; and to use the proceeds of the energy component of their local development tariff on offsite carbon reduction projects in the locality and reflecting local circumstances.

122. Taken together, these measures give local authorities significant powers to shape the approach to carbon of new housing development in their areas, enabling them to tailor the policy approach to reflect local circumstances and opportunities, and the wishes of local people.

Enforcement and implementation

123. Government will need to decide what regulatory processes and bodies we should task with monitoring and enforcing compliance with the need to abate carbon with the proceeds of the local development tariff energy component. 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. 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. 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.

124. An implementation survey of the 2006 Part L of the building regulations amendments was carried out in the run up to the consultation on proposed changes to Part L of the building regulations in 2010 and helped to inform proposals for further improving compliance. A similar approach should 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, which is outlined in the Post-Implementation Review plan in Annex A.

Specific impact tests

STATUTORY EQUALITY DUTIES IMPACT TEST

125. The policy would affect all parties the same regardless of race, gender or disabilities. There is already a level of accessibility required by the current Building Regulations so any future homes would still need to meet these. The responses to the consultations did not raise any issue of potential unequal impact on gender, ethnic/racial or disabled groups. An Equalities Impact Assessment screening has been undertaken and is available upon request.

COMPETITION ASSESSMENT AND SMALL FIRMS IMPACT TEST

126. The proposed policy should not have a significant impact on competition in the affected industries. Whilst it is acknowledged that the market may be affected due to increased demand in higher specification construction materials, suppliers should be able to switch to these higher specifications. There is additional potential for new firms to enter the market to increase competition on energy efficiency and provision of low and zero carbon energy sources, with added benefit of innovation.

127. Small and medium-size firms (who employ up to 250 people) make up approximately 50 per cent of the construction market by turnover, and there are around 151,000 small and medium-size firms employing 984,000 people in 2008[51].

128. 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 with less expertise – or hire consultants. Larger firms also benefit from economies of scale, lowering the average cost of building as more developments or dwellings are built. That said, anecdotal evidence from industry suggests many small firms are more flexible in their designs and supply chains than large firms, so may be able to adapt more quickly and easily.

129. Government intends to give as much notice of the changes to building regulations as possible. There is a general level of awareness within the industry about building regulations and how they are met. The minimum regulatory requirement of Part L building regulations are consulted on separately; specific impacts on small and medium-size firms as a result of the minimum regulatory standard in 2013 will be looked at in greater detail as part of consultation and implementation of 2013 Part L building regulations[52].

130. Responses to past consultations[53] suggest the majority of industry show strong support for requiring high levels of energy efficiency, in order to reduce emissions from new homes.

131. Whilst engagement with local authorities on local plans may be challenging for small and medium-sized firms, the opportunity to purchase allowable solutions offers a potentially much more straightforward approach for small and medium-size firms than having to undertake all action on site, or get involved in complex off site arrangements.

132. 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. The Department will work with industry in taking these proposals forward, for example there are frequent discussions with the House Builders Association, which represents a number of small firms in the construction industry.

GREENHOUSE GAS ASSESSMENT IMPACT TEST

133. Electricity savings result in financial benefits but not carbon benefits as emissions from this sector are capped by the EU Emissions Trading Scheme. 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 the Department of Energy and Climate Change's guidance.

134. Heat savings (modelled on dwellings that use gas rather than any other fuel or electricity for heating) result directly in carbon savings as natural gas (and other non-electricity fuels for households) are not covered by the emissions trading scheme (i.e. they are 'non-traded') and are monetised using carbon values from government guidance.

135. 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.

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[51] http://stats.berr.gov.uk/ed/sme/smestats2008.xls

[52] The recent implementation stage Impact Assessment to Parts F and L of building regulations from 2010 performed its own small firms impact test www.communities.gov.uk/documents/planningandbuilding/pdf/1531558.pdf

[53] *Definition of zero carbon homes and non-domestic buildings - consultation*

WIDER ENVIRONMENTAL ISSUES IMPACT TEST

136. 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.

137. 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

138. The policy is likely to have knock-on effects in terms of air quality impacts. Through the increased use of renewable energy sources, there is a corresponding reduction in electricity demand from fossil fuel generation. These can have a positive impact on air quality and therefore on health.

139. Indicative estimates of 'damage costs' suggest that the policy would realise air quality benefits from reduced electricity generation in the region of £3m[54] over the lifetime of the policy. This is based on the assumption that the marginal electricity generator is a combined cycle gas turbine plant[55].

140. However, the use of biomass fuels can have an adverse effect on air quality and health. This impact assessment does not carry out detailed modelling of these damage costs at this stage – and is clearly dependent on the extent to which biomass technologies are employed, the emissions standards of the boilers, and their location.

HEALTH AND WELL BEING IMPACT TEST

141. The energy efficiency standard proposed in this consultation has a number of potential health implications. Firstly, 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.

142. 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 may lead to reduced pollen and other airborne allergens within the home.

143. Higher levels of thermal efficiency also have the potential to result in heat being trapped inside the building during the summer. Further research is required is on the potential for highly energy efficient homes to become overly warm in summer.

144. 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.

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[54] These costs and benefits are not included in headline figures.
[55] Reduced consumption of energy would deliver a benefit in terms of damage avoided of 0.11p/kWh, based on a gas fired combined cycle gas turbine being the marginal plant.

HUMAN RIGHTS AND JUSTICE SYSTEM IMPACT TESTS

145. There would be no impact on human rights or the justice system.

RURAL PROOFING IMPACT TEST

146. 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
- 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

SUSTAINABLE DEVELOPMENT IMPACT TEST

147. 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
- 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; and
- research undertaken by the Sustainable Consumption Roundtable indicates that the presence of onsite renewables can bring about behaviour change towards energy use among householders.

Annexes

Annex A: Post Implementation Review Plan

Basis of the review:

This policy is concerned with the regulatory and policy changes from now including any change to Part L of the building regulations in 2013. As such, the proposed post-implementation review of zero carbon homes will cover the introduction of the fabric energy efficiency standard, the carbon compliance standard for onsite measures and the 'allowable solutions' mechanisms for off site measures, including changes made to Part L in 2013.

An implementation review and monitoring for the 2006 changes to Part L has been undertaken and we intend to continue such monitoring for 2010 and 2013 changes. Evaluations for the costs of building to the voluntary Code for Sustainable Homes have also been undertaken, including the cost of building to a zero carbon standard and it is intended to produce future evaluations. The 2013 Part L changes will have been examined as part of consultation, implementation and post-implementation review in the 2013 package.

The post implementation review for the 2016 step will aim to commence three to five years after implementation of the policy in 2016.

Review objective:

The review will consider to what extent the 2016 zero carbon homes policy is tackling the problem of carbon emissions from new homes, and that it is an appropriate and proportional response to the problem. The review may also include wider exploration of the policy approach – such as the minimum level of carbon compliance, and the cost to developers of remaining emissions to be bought out. The review will also be able to draw from lessons of Part L building regulations.

Review approach and rationale:

It is difficult to assess currently what review approach will be undertaken, as it is not known precisely what monitoring data or tools will be available until implementation in 2016. Currently, there is good data on the energy efficiency ratings of new homes through lodgements on the national Energy Performance Certificate register. This data can be used to monitor how the energy efficiency of new build housing changes. Note that the data is of completed dwellings, and it is not known what building regulations standard these have been built to (if planning permission was granted a long time before, it may be that pre-2006 standards are still being built to legitimately, however we expect the number of these to dwindle over time). This data may be able to give an indication of the extent of renewable electricity technologies that are being employed to meet minimum standards, particularly when Energy Performance Certificates and the use of their data are reviewed. The Department will also be able to work with the Department of Energy and Climate Change on the impact of its Feed-In Tariff, Renewable Heat Incentive, and potential contribution of a Green Deal type approach in order to inform this analysis.

There is data available on the numbers of new build homes at a regional scale. Whilst build costs are one of many factors which influence the viability of housing development, the review could look at house building trends to attempt to estimate the possible effects of the policy on national house building.

We will work with the industry on testing actual versus design performance and post occupancy monitoring and evaluation to understand how carbon savings are maintained over the medium and longer terms.

Potential monitoring of the cumulative funds received from developers paying for allowable solutions for remaining carbon emissions might indicate the extent of the on-site viability of the minimum regulated requirements for any given area, or give an indication of how appropriately the allowable solutions price level is set. This may also give the Department scope to re-examine the levels of the allowable solutions price. We also want to monitor the types of allowable solutions which are put in place and the carbon savings achieved from these.

The Department will continue to work closely with various partners in the industry to explore best practice, and to find out about the impacts on individual sectors and groups as outlined in this impact assessment. Specific impacts, such as those on small and medium sized firms, will continue to be monitored at an overall market level, to ensure policy is not disproportionate in terms of regulatory burdens. However, much of this evidence will be purely anecdotal.

Dialogue with industry may also give an indication of actual build costs, so these can be compared to the modelled costs in this impact assessment. Future technology costs – in effect forecast by the learning rates applied – will also become clearer and it will be interesting to compare these to the model.

Baseline:

At implementation, 2010 Part L building regulations will form the baseline of the policy i.e. the ‘do nothing’ approach.

Success criteria:

More detailed success criteria will be outlined at the implementation stage impact assessment of the policy, but these would be likely to be based around:

- reductions in carbon emissions resulting from energy use in new homes
- a verifiable increase in the energy efficiency of new homes
- an increase in the uptake of on-site renewable energy technologies, with corresponding growth in associated industries (in terms of jobs and output – where quantifiable)
- increased level of innovation and competitiveness in renewable energy technologies – and consequent cost reduction in meeting regulation (where quantifiable)
- the future proofing of new homes with a reduced and/or eliminated need for retrofit (where measurable); and
- benefits to occupiers in terms of energy bills, and spill-overs encouraging behaviour change and reducing energy demand generally, where benefits go to other sectors when the technology or knowledge is transferable

Monitoring information arrangements:

Existing regulations require an Energy Performance Certificate when a building is constructed, and statistics based on these are published in accordance with the Statistics Act. Any further specific monitoring arrangements will be outlined at implementation of the policy.

Annex B: Assumptions and model inputs

Table AB 1: Dwelling build mix[56]

	Detached	End terrace / semi	Mid terrace	Flat
Proportion of total dwellings	25%	25%	19%	32%

Table AB 2: Illustrative house building rates

2013	120,000
2014	130,000
2015	140,000
2016	140,000
2017	150,000
2018	160,000
2019	180,000
2020	190,000
2021	190,000
2022	190,000
2023	190,000

Table AB 3: Phase-in assumptions of new build standards (in per cent)

	2006 Part L	2010 Part L	2013 Part L	2016 Zero Carbon
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 AB 4: Baseline annual energy demand for a Part L 2010 dwelling

	Detached	Semi-detached	Mid-terrace	Flat
Gas (kWh)	9,466	6,390	5,606	3,857
Electricity (kWh)	4,066	3,138	3,147	2,022
Biomass (kWh)	0	0	0	0

[56] Figures have been rounded

Table AB 5: Baseline annual carbon emissions for a Part L 2010 dwelling

	Detached	Semi-detached	Mid-terrace	Flat
Regulated emissions (tonnes of carbon dioxide per year, tCO_2 pa)	1.9	1.3	1.2	1.0
Unregulated emissions (tCO_2 pa)	1.4	1.1	1.1	0.7
Total carbon per dwelling	*3.3*	*2.4*	*2.3*	*1.5*

Table AB 6: Energy savings and costs of the 2013 energy efficiency standard (2010 cost levels)

	Detached	Semi	Mid	Flat
Annual reduction in electricity demand due to energy efficiency measures (kilowatt hours, kWh)	0	0	0	0
Annual reduction in heat demand due to energy efficiency measures (kWh)	1,588	482	241	246
Cost (£)	1,913	80	0	159

Table AB 7: Technology maintenance and lifetime assumptions

	Lifetime (years)	Annualised servicing /maintenance cost per dwelling using the technology (£)
Energy efficiency measures	40	0
Photovoltaics (electricity)	25	50
Solar thermal flat plate	20	44
Ground source heat pump (GSHP)	23	44
Air source heat pump (ASHP)	18	44
Small biomass boiler	20	220
Biomass combined heat and power (CHP)	20	180

Table AB 8: Illustrative technology learning rates

Learning rates are based on the Zero Carbon Hub's Task Groups research and analysis of renewable technologies and energy efficiency options. These were available separately for fixed and variable costs, so to create the average learning rate to apply per technology, the typical ratio of fixed to variable elements of each renewable technology was used.

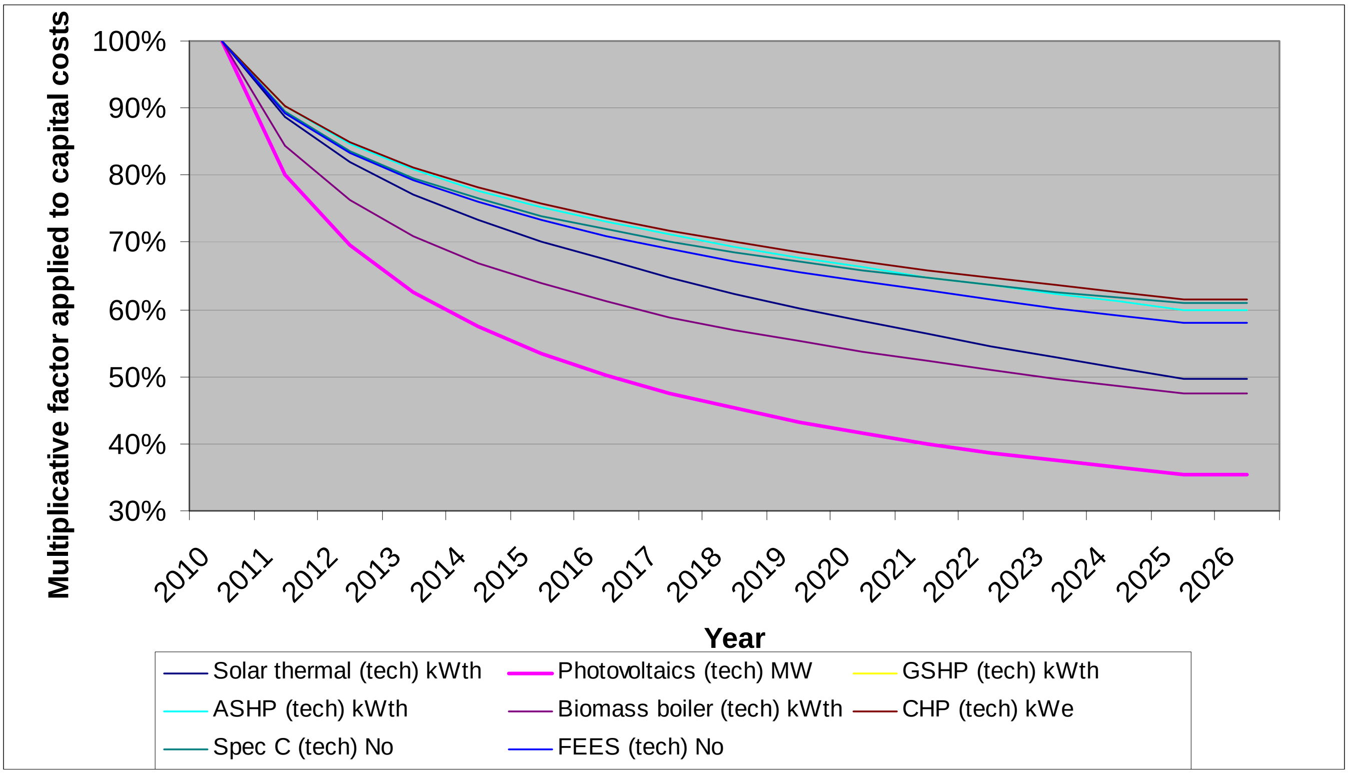

Table AB 9: Administrative costs

One-off admin cost to industry of preparing for building zero carbon homes (£m)	10
Year this one-off cost occurs in	2016
Recurring admin cost to industry from changes to building regulations (£m)	16.8
Years over which cost occurs	2017 -2023

Annex C: Sensitivity analysis tables: all options

Table AC 1a: Sensitivity for Option 2 – cost impact of individual variables

		Present Value capital cost	Present Value ongoing cost	Present Value admin cost	**Present Value Cost**
		£m	£m	£m	£m
Energy/ Carbon Prices	High	3,008	677	95	**3,780**
	Low	3,008	677	95	**3,780**
House building rates	High (+25 per cent 137.5k to 237.5k pa)	3,760	846	95	**4,701**
	Low (-25 per cent pa 82.5k to 142k in 20)	2,256	508	95	**2,859**
Technology	More expensive	6,106	1,237	95	**7,438**
Allowable Solutions Price	High at £70/tonneCO_2	3,379	677	95	**4,151**
	Low at £23/tonneCO_2	2,644	677	95	**3,416**
No Learning Rates		5,520	677	95	**6,292**

Table AC 1b: Sensitivity for Option 2 – benefit and net present value impact of individual variables

		Present Value financial benefit	**Financial Net Present Value (excl. carbon)**[57]	Present Value traded carbon benefit	Present Value non-traded carbon benefit	**Present Value Benefit**	***Total Net Present Value (incl. carbon)***
		£m	£m	£m	£m	£m	£m
Energy/ Carbon Prices	High	2,546	-1,234	262	1,251	**4,059**	**279**
	Low	1,103	-2,677	89	906	**2,098**	**-1,681**
House building rates	High (+25 per cent 137.5k to 237.5k pa)	2,628	-2,073	223	1,348	**4,199**	**-502**
	Low (-25 per cent pa 82.5k to 142k in 20)	1,577	-1,282	134	809	**2,519**	**-339**
Technology	More expensive	1,401	-6,038	-27	2,013	**3,386**	**-4,052**
Allowable Solutions Price	High at £70/tonneCO_2	2,102	-2,049	178	1,078	**3,359**	**-792**
	Low at £23/tonneCO_2	2,102	-1,314	178	1,078	**3,359**	**-57**
No Learning Rates		2,102	-4,189	178	1,078	**3,359**	**-2,933**

[57] Financial NPV is the PV of financial benefits (from energy bill savings) less the PV of capital, ongoing and admin costs. The column of admin costs is not shown here as it does not vary between the sensitivities.

Table AC 2a: Sensitivity for Option 3 – cost impact of individual variables

		Present Value capital cost	Present Value ongoing cost	Present Value admin cost	**Present Value Cost**
		£m	£m	£m	£m
Energy/ Carbon Prices	High	5,928	1,791	95	**7,815**
	Low	5,928	1,601	95	**7,624**
House building rates	High (+25 per cent 137.5k to 237.5k pa)	7,410	2,112	95	**9,618**
	Low (-25 per cent pa 82.5k to 142k in 20)	4,446	1,267	95	**5,809**
Technology	More expensive	8,359	2,733	95	**11,187**
Allowable Solutions Price	High at £70/tonneCO_2	6,649	1,690	95	**8,434**
	Low at £23/tonneCO_2	5,223	1,690	95	**7,007**
No Learning rates		9,884	1,690	95	**11,669**

Table AC 2b: Sensitivity for Option 3 – benefit and net present value impact of individual variables

		Present Value financial benefit	**Financial Net Present Value (excl. carbon)** [58]	Present Value traded carbon benefit	Present Value non-traded carbon benefit	**Present Value Benefit**	***Total Net Present Value (incl. carbon)***
		£m	**£m**	£m	£m	£m	***£m***
Energy/ Carbon Prices	High	3,091	-4,723	222	2,468	**5,782**	**-2,033**
	Low	1,307	-6,317	76	1,641	**3,025**	**-4,600**
House building rates	High (+25 per cent 137.5k to 237.5k pa)	3,116	-6,502	189	2,568	**5,873**	**-3,745**
	Low (-25 per cent pa 82.5k to 142k in 20)	1,869	-3,939	114	1,541	**3,524**	**-2,285**
Technology	More expensive	2,775	-8,412	19	2,515	**5,309**	**-5,878**
Allowable Solutions Price	High at £70/tonneCO_2	2,493	-5,941	151	2,054	**4,698**	**-3,735**
	Low at £23/tonneCO_2	2,493	-4,515	151	2,054	**4,698**	**-2,309**
No Learning rates		2,493	-9,176	151	2,054	**4,698**	**-6,971**

[58] Financial NPV is the PV of financial benefits (from energy bill savings) less the PV of capital, ongoing and admin costs. The column of admin costs is not shown here as it does not vary between the sensitivities.

Further compound sensitivity analysis has been considered through the construction of an optimistic and pessimistic scenarios resulting from the national standards. Any outcomes of this policy that arise as a result of local authority choice are not included. The figures in this Annex are not used in the summary sheets as although they maximise and minimise the net value of each option and may be considered a better reflection of the possible range of costs and benefits, the costs and benefits are not maximised in isolation. (As a result these compound sensitivities are inappropriate for use in the summary sheets.) Therefore for example, in Option 2 a higher build rate provides an increase in costs (compared to the central scenario) but also provides a proportionately greater reduction in benefits, making the net present value higher despite costs being higher than in the central scenario. These contradictory effects make the analysis more complex and it was considered appropriate to put these results in an annex. There is no probability attached to each variable within each scenario.

The scenarios differ for each Option for the reason set out above.

Option 2

Scenarios:

	Pessimistic	Optimistic
Technology	Renewable heat heavy in 2016	Cheapest
Energy and Carbon Price	Low	High
Allowable Solutions Price	High	Low
Housing Assumptions	High	High
Learning Rates	Not applied	Applied

Table AC 3a: Option 2 - Optimistic scenario costs

	Present Value capital cost (£m)	Present Value ongoing costs (£m)	Present Value admin costs (£m)
2013 regs - energy efficiency	531	0	0
2016 - administrative costs			***95***
2016 - renewables	2,310	846	0
2016 - allowable solutions	464		
TOTAL	***3,305***	***846***	***95***

Table AC 3b: Option 2 - Optimistic scenario benefits and net present value

	Present Value financial benefits (£m)	Financial Net Present Value (£m)	Present Value traded carbon benefits (£m)	Present Value non-traded carbon benefits (£m)	***Total Net Present Value (£m)***
2013 regs - energy efficiency	723	192	0	642	***834***
2016 - administrative costs		**-95**			***-95***
2016 - renewables	2,460	-696	328	0	***-369***
2016 - allowable solutions		-464	0	922	***457***
TOTAL	***3,182***	***-1,064***	***328***	***1,563***	***827***

Table AC 4: Option 2 - Optimistic scenario carbon benefits and cost effectiveness

	Lifetime Million tonnes of carbon dioxide (traded)	Lifetime Million tonnes of carbon dioxide (non-traded)	Cost-effectiveness: traded (£/tCO_2)	Cost-effectiveness: non-traded (£/tCO_2)
2013 regs - energy efficiency	0.0	8.9	-	21
2016 - energy efficiency	0.0	0.0	-	-
2016 - renewables	7.2	0.0	-97	-
2016 - allowable solutions	0.0	20.3	-	-23
TOTAL	***7.2***	***29.2***	69	-25

Table AC 5a: Option 2 - Pessimistic scenario costs and benefits

	Present Value capital cost (£m)	Present Value ongoing costs (£m)	Present Value admin costs (£m)
2013 regs - energy efficiency	786	0	0
2016 - administrative costs			***95***
2016 - energy efficiency	4,680	0	0
2016 - renewables	5,195	1,610	0
2016 - allowable solutions	1,384		
TOTAL	***12,045***	***1,610***	***95***

	Present Value financial benefits (£m)	Financial Net Present Value (£m)	Present Value traded carbon benefits (£m)	Present Value non-traded carbon benefits (£m)	***Total Net Present Value (£m)***
2013 regs - energy efficiency	723	-64	0	642	***578***
2016 - administrative costs		**-95**			***-95***
2016 - energy efficiency	959	-3,721	-61	1,399	***-2,383***
2016 - renewables	657	-6,149	11	360	***-5,778***
2016 - allowable solutions		-1,384	0	922	***-462***
TOTAL	***2,338***	***-11,412***	***-50***	***3,323***	***-8,140***

Table AC 6: Option 2 - Pessimistic scenario carbon benefits and cost effectiveness

	Lifetime Million tonnes of carbon dioxide (traded)	Lifetime Million tonnes of carbon dioxide (non-traded)	Cost-effectiveness: traded (£/tCO_2)	Cost-effectiveness: non-traded (£/tCO_2)
2013 regs - energy efficiency	0.0	8.9	-	-
2016 - energy efficiency	-1.3	19.3	1,769	-196
2016 - renewables	0.2	5.9	-25,090	-1,049
2016 - allowable solutions	0.0	20.3	n/a	-68
TOTAL	***-1.1***	***54.3***	7,477	-211

Option 3

Scenarios:

	Pessimistic	Optimistic
Technology	Renewable heat heavy in 2016	Cheapest
Energy and Carbon Price	Low	High
Allowable Solutions Price	High	Low
Housing Assumptions	High	Low
Learning Rates	Not applied	Applied

Table AC 7a: Option 3 - Optimistic scenario costs

	Present Value capital cost (£m)	Present Value ongoing costs (£m)	Present Value admin costs (£m)
2013 regs - energy efficiency	318	0	0
2016 - administrative costs			***95***
2016 - energy efficiency	814	0	0
2016 - renewables	2,244	1,343	0
2016 - allowable solutions	540		
TOTAL	***3,917***	***1,343***	***95***

Table AC 7b: Option 3 - Optimistic scenario benefits and net present value

	Present Value financial benefits (£m)	Financial Net Present Value (£m)	Present Value traded carbon benefits (£m)	Present Value non-traded carbon benefits (£m)	***Total Net Present Value (£m)***
2013 regs - energy efficiency	434	115	0	385	***500***
2016 - administrative costs		**-95**			***-95***
2016 - energy efficiency	277	-537	-16	392	***-161***
2016 - renewables	1,608	-1,980	183	146	***-1,650***
2016 - allowable solutions		-540	0	927	***387***
TOTAL	***2,318***	***-3,037***	***167***	***1,851***	***-1,019***

Table AC 8: Option 3 - Optimistic scenario carbon benefits and cost effectiveness

	Lifetime Million tonnes of carbon dioxide (traded)	Lifetime Million tonnes of carbon dioxide (non-traded)	Cost-effectiveness: traded (£/tCO_2)	Cost-effectiveness: non-traded (£/tCO_2)
2013 regs - energy efficiency	0.0	5.3	-	22
2016 - energy efficiency	-0.3	5.4	415	-102
2016 - renewables	4.0	2.4	-457	-756
2016 - allowable solutions	0.0	8.5	-	-25
TOTAL	***3.7***	***21.6***	-324	-83

Table AC 9a: Option 3 - Pessimistic scenario costs and benefits

	Present Value capital cost (£m)	Present Value ongoing costs (£m)	Present Value admin costs (£m)
2013 regs - energy efficiency	786	0	0
2016 - administrative costs			***95***
2016 - energy efficiency	3,611	0	0
2016 - renewables	10,451	2,884	0
2016 - allowable solutions	2,683		
TOTAL	***17,532***	***2,884***	***95***

	Present Value financial benefits (£m)	Financial Net Present Value (£m)	Present Value traded carbon benefits (£m)	Present Value non-traded carbon benefits (£m)	***Total Net Present Value (£m)***
2013 regs - energy efficiency	290	-497	0	211	***-286***
2016 - administrative costs		**-95**			***-95***
2016 - energy efficiency	299	-3,312	-17	379	***-2,950***
2016 - renewables	1,230	-12,105	29	203	***-11,874***
2016 - allowable solutions		-2,683	0	1,545	***-1,138***
TOTAL	***1,819***	***-18,692***	***12***	***2,338***	***-16,342***

Table AC 10: Option 3 - Pessimistic scenario carbon benefits and cost effectiveness

	Lifetime Million tonnes of carbon dioxide (traded)	Lifetime Million tonnes of carbon dioxide (non-traded)	Cost-effectiveness: traded (£/tCO_2)	Cost-effectiveness: non-traded (£/tCO_2)
2013 regs - energy efficiency	0.0	8.9	-	-56
2016 - energy efficiency	-1.1	16.0	2,687	-208
2016 - renewables	1.6	9.9	-7,436	-1,217
2016 - allowable solutions	0.0	35.5	-	-76
TOTAL	***0.5***	***70.3***	-32,123	-266

Table AC 11: Sensitivity analysis of all options

		Present Value Costs	**Present Value Benefit**	**Total Net Present Value (including carbon)**	Lifetime carbon saved in the traded sector	Lifetime carbon saved in the non-traded sector
		£m	**£m**	**£m**	Million tonnes of carbon dioxide	Million tonnes of carbon dioxide
Option 1		0	0	**0**	0	0
Option 2	Central estimate	3,780	3,358	**-421**	0*	23.3
Option 3	Central estimate	7,713	4,698	**-3,015**	4.9	45.9
Option 2	Optimistic	4,246	5,073	**827**	7.2	29.2
	Pessimistic	13,750	5,611	**-8,140**	-1.1	54.3
Option 3	Optimistic	5,355	4,336	**-1,019**	3.7	21.6
	Pessimistic	20,511	4,169	**-16,342**	0.5	70.3

*5.8 million tonnes of carbon dioxide equivalent are estimated to be reduced in terms of UK industry not having to purchase EU emissions trading system permits. A zero has been placed in this box because the EU emissions trading system operates as a cap and trade system so any carbon savings within the UK can be offset by increases in emissions elsewhere in the EU.

Department for Communities and Local Government

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