Europe Economics

Final Impact Assessment on Changes to Part L of the Building Regulations in Wales

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Llywodraeth Cymru
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1 Background & Scope

The Welsh Government is committed to reducing the level of carbon emissions in Wales to support its overall climate change objectives – one of which is to reduce Greenhouse Gas (GHG) emissions by 3% per annum from 2011. As part of this commitment there is a need to reduce the long-term demand for fossil fuel-based energy generation through improved energy efficiency and the development of renewable energy capacity

Building Regulations provide one mechanism through which to reduce carbon emissions. They deal with **regulated** energy - heating, cooling, lighting and ventilation – which can contribute to the reduction of the carbon footprint of new developments through improved energy efficiency standards. However, Building Regulations do not cover **unregulated** energy use, such as household electrical appliances. The Zero Carbon Hub[1] estimates that at present, around two-thirds of carbon emissions from the average house built to 2006 standards comes from regulated energy use, with the remaining third attributed to unregulated energy use.

The devolution of Building Regulations in 2011 has provided the Welsh Government with the scope to introduce a carbon standard for new domestic and non-domestic buildings that is most appropriate to Wales. Welsh National Planning Policy currently requires that all new housing developments achieve a Code for Sustainable Homes Rating at Level 3. This is equivalent to an 8% improvement on Building Regulations Part L (Conservation of Fuel and Power) 2010 requirements and represents a step on the proposed trajectory towards a 'zero carbon' approach, the eventual objective being for all new residential buildings to achieve 'nearly zero energy' as required by the recast of the EU Energy Performance in Buildings Directive 2010 via a potential mix of on-site methods and off-setting 'allowable solutions'.

The Welsh Government published a public consultation on proposed changes to Part L of the Building Regulations from 31 July 2012 to 23 October 2013; 91 responses were received. In July and September 2013 the Minister for Housing & Regeneration announced the decision to legislate for a 20% improvement in carbon emissions from new non-domestic buildings and an 8% improvement for new domestic buildings. The 8% improvement (on an aggregate basis) effectively transposes the current Planning Policy Wales expectation into the Building Regulations. The decision not to pursue the 25% and 40% consultation options reflected concerns about the impact of higher costs on a depressed housing market and related concerns about viability. It was decided that a greater improvement and cost would, at this time, have negative consequences, impacting on house building, employment and the economic position of Wales. 8% was judged to be a sensible step between the current requirements and the 25% to 40% consulted upon.

In 2016 a further review of Part L will be undertaken aimed at taking the next step towards 'zero carbon' new buildings (and nearly zero energy new buildings) as required by the Recast European Directive on the Energy Performance of Buildings 2010. The Directive requires this by 2019 for new public buildings and 2021 for all new buildings.

[1] Zero Carbon Hub: http://www.zerocarbonhub.org

2 Rationale for Intervention

In pursuing the Welsh Government's commitment to reduce carbon emissions by 3 per cent per annum from 2011amending Building Regulations is one option that can be considered in situations where the market would not deliver the carbon savings of its own accord, other existing measures (regulatory or non-regulatory) would not achieve the objectives and where it is shown to be cost-effective.

There are a number of reasons why the market may not deliver cost-effective carbon savings of its own accord; these are termed 'market failures'. In this case, the market failures include:

- Externalities – In the absence of comprehensive carbon pricing property builders and occupiers do not incur the full cost of their carbon emissions. This results in a higher level of carbon emissions than is socially optimal;
- Imperfect Information – Information is required in order for a market to operate efficiently. A lack of adequate information about future energy prices and a property's energy efficiency may prevent better performing properties being properly valued by the market. In situations where there is little prospect of receiving a price premium when they come to sell the property, property builders or those undertaking extensions or refurbishments have little incentive to invest in more energy efficient materials and products;
- A lack of capital, potentially long payback periods and general risk aversion may prevent homeowners and businesses from undertaking energy efficiency improvements to existing buildings even when these would be cost-effective in the medium or long term.

Building Regulations are considered to be an appropriate mechanism for attempting to overcome these market failures. Low carbon technologies can be 'locked in' at the point of build (assuming that the owners/tenants choose to use and maintain the fabric standards and building services), avoiding the potentially higher cost of retrofitting at a later stage. However, since the majority of emissions from domestic dwellings are currently attributed to the existing stock, retrofitting existing dwellings is proposed as an additional method for contributing to the overall reduction in carbon emissions from domestic dwellings.

3 Options Considered

The following paragraphs briefly outline the options considered at consultation and how they have been taken forward post-consultation for each building category. Further details are given in the next section which provides more detail on the costs and benefits.

3.1 Consultation stage

In addition to the 'Do Nothing' (baseline) option, three policy intervention options were assessed at the consultation stage. These can be summarised as follows:

- Low case: a 25 per cent improvement in the energy efficiency of new domestic property compared to current Part L standards, an 11 per cent improvement in the energy efficiency of new non-domestic property compared to current Part L standards, a tightening of standards for extensions to existing domestic and non-domestic property and the removal of the area threshold for consequential improvements.
- High case: a 40 per cent improvement in the energy efficiency of new domestic property compared to current Part L standards, a 20 per cent improvement in the energy efficiency of new non-domestic property compared to current Part L standards, a tightening of standards for extensions to existing domestic and non-domestic property and the removal of the area threshold for consequential improvements. This was the preferred option at the consultation stage.
- Hybrid case: a 25 per cent improvement in the energy efficiency of new domestic property compared to current Part L standards, a 20 per cent improvement in the energy efficiency of new non-domestic property compared to current Part L standards, a tightening of standards for extensions to existing domestic and non-domestic property and the removal of the area threshold for consequential improvements.

3.2 Post consultation

Following consultation it has been decided to take forward the following options:

- New domestic buildings: an 8 per cent improvement in the energy efficiency of new domestic property compared to current Part L standards.
- Existing domestic buildings: a tightening of standards for extensions, and the removal of the area threshold for consequential improvements.
- New non-domestic buildings: a 20 per cent improvement in the energy efficiency of new non-domestic property compared to current Part L standards.
- Existing non-domestic buildings: a tightening of standards for extensions (including windows for non-domestic buildings that are domestic in character, improvements in energy efficiency standards for replacement building services and the removal of the area threshold for consequential improvements.

Table 1: Present value of costs and benefits broken down into individual elements (£m)

	New domestic property (8% aggregate)	Existing domestic property	Domestic consequential improvements	New non-domestic property (20% aggregate)	Existing non-domestic property (extensions)	Existing non-domestic property (replacement services)	Non-domestic consequential improvements	Total
Energy savings (£m)	2	10	33	102	5	18	5	173
Incremental costs (£m)	8	19	19	88	4	10	3	151
Total financial cost/benefit (£m)	**(6)**	**(9)**	**13**	**14**	**1**	**8**	**2**	**23**
Carbon savings - non-traded (£m)	1	10	26	57	3	(3)	4	98
Carbon savings - traded (£m)	0	0	0	7	0	1	0	8
Total carbon savings (£m)	1	10	26	64	3	(1)	4	107
Comfort taking (£m)	-	3	11	-	-	-	-	14
Net benefit/cost exc. avoided renewables (£m)	**(5)**	**5**	**50**	**77**	**4**	**6**	**6**	**143**
Avoided renewables (£)	0	0	1	1	0	0	0	2
Net benefit/cost incl. avoided renewables (£m)	**(5)**	**5**	**51**	**78**	**4**	**6**	**6**	**145**
Cost effectiveness – non-traded (£/tCO$_2$)	249	28	(111)	(29)	(20)	177	(65)	(42)
Cost effectiveness – traded (£/tCO$_2$)	3,516	-	-	(523)	(1,069)	(124)	(2,094)	(1,350)

4 Estimation of Costs and Benefits

To estimate the costs and benefits associated with the proposed policy options the assessment compares building costs, maintenance costs, energy use and CO_2 emissions for property built to the proposed 2013 building standards with a baseline based on the current (2010) standards.

Data on traded and non-traded carbon values, emission factors, the value of avoided renewables and fuel prices has been taken from the latest Department for Energy & Climate Change (DECC) guidance "Valuation of energy use and greenhouse gas emissions for appraisal and evaluation".[2]

Energy savings are valued at the long-run variable cost of energy supply. Again, this is in line with DECC guidance. The supply cost reflects the long-term variable costs associated with energy supply but excludes costs (such as head office overheads) that will continue to be incurred at the same level in the long run regardless of changes in energy use. The cost excludes carbon costs (which are valued separately), taxes and other charges. In the future the expectation is that the value of carbon will be factored into energy prices (effectively internalising the cost of carbon in consumption decisions), however, for the purpose of this analysis (and in line with the DECC Guidance) energy and carbon savings are considered separately.

Evidence suggests that a common response to an improvement in the energy efficiency of a home is for the home owner to heat the property to a higher temperature than was previously the case. This is known as a 'rebound effect' or 'comfort factor'. As a result of this rebound effect, not all of the theoretical energy cost and carbon savings associated with energy efficiency measures are actually realised.

In the consultation stage impact assessment, a 15 per cent comfort factor was assumed when looking at the effects of tightening standards for both new and existing domestic property. The Green Deal impact assessment calculation of 15 per cent comfort taking for existing dwellings was based mostly on existing social housing rather than owner-occupiers. A further and larger extrapolation would be required to take the same conclusions to new-build homes. Since people in different situations are unlikely to perceive the same value of comfort, it is not considered reasonable to assume the same level of comfort taking for existing and new homes. The counterfactual for the new homes analysis is a Part L 2010 standard which is already a much more energy efficient standard than for a typical existing home. It is therefore much less likely that there would be substantial further comfort taking because consumers are unlikely to perceive this relatively small difference in standards. Given the lack of empirical data available no comfort taking has been applied to new dwellings in this final impact assessment. This is a change on the approach taken at the consultation stage, but it is consistent with the Department for Communities and Local Government's (DCLG) impact assessment of changes to Part L for domestic buildings in 2013.

The assessment maintains the assumption of 15 per cent comfort taking in existing dwellings. When valuing this rebound effect, the full retail price of energy/fuel is used since it is to be assumed that consumers are willing to pay at least the full retail price for the welfare gains achieved through higher energy/fuel consumption. As per the consultation stage IA, we have not included rebound effects for analysis of non-domestic buildings.

The analysis assumes that home-owners and businesses will not demand the use of higher specification fabrics, components and services in the absence of this change in regulations. In reality, the

[2] Tables supporting the DECC/HM Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions, 16 September 2013.

expectation is that rising energy prices will encourage consumers/businesses to make more energy efficient decisions in the future. The analysis may therefore overestimate the impact of the change in regulations.

The appraisal period used in this impact assessment is 70 years (2013-82). This period has been adopted to capture the costs and benefits over the lifetime of new property built in the first 10 years of the appraisal period (new buildings are typically assumed to have a life of 60 years). The costs and benefits are presented in Present Value terms with a discount rate of 3.5 per cent used for the first 30 years of the appraisal period and 3.0 per cent for the remaining years. This is in line with the guidance in HM Treasury's Green Book.

The assessment of costs and benefits is broken down between the four property categories affected by the proposals, namely:

- New domestic property;
- Existing domestic property – including extensions and consequential improvements;
- New non-domestic property;
- Existing non-domestic property – including the replacement of building services components, tightening of standards for extensions and consequential improvements.

Each of these categories is considered in turn below.

4.1 New Domestic Property

At the consultation stage, the following options were modelled for improving the energy efficiency standards of new domestic property:

- A 25 per cent improvement in energy efficiency and carbon emissions relative to the 2010 Part L building regulations; and
- A 40 per cent improvement in energy efficiency and carbon emissions relative to the 2010 Part L building regulations.

However, following consultation, it has been decided that the 2013 standards will be based on an eight per cent aggregate improvement relative to the 2010 Part L. The standard is based on an elemental recipe based on fabric and services for gas homes. The full fuel factor continues to be adopted to determine the appropriate target for other fuel types.

New homes are already required to deliver beyond Part L 2010 standards and this is accounted for in the counterfactual. Welsh national planning for sustainable building policy expects all new homes seeking planning permission to achieve an overall minimum Code for Sustainable Homes (CSH) level 3 with higher levels for both energy efficiency and CO_2 emissions (expressed through a minimum number of energy/CO_2 'credits'). Over the build mix it is estimated that this results in a similar eight per cent improvement of CO_2 emissions on Part L 2010. However, the current targets are calculated by a different approach to those proposed for Part L 2013, and thus there are benefits and costs associated with the introduction of Part L 2013.

All building modelling was carried out in cSAP 2012. SAP is the responsibility of the Department for Energy and Climate Change (DECC). The software used reflects the amendments to SAP proposed in the 2011/12 consultation. As such, the energy modelling carried out will yield different results, reflecting these modifications to SAP. One notable change is that the SAP modelling in this IA uses higher emission factors to rebase both the Part L 2010 and proposed Part L 2013 emission standards:

- Gas: 0.216 kgCO_2/kWh

- Electricity: 0.535 $kgCO_2/kWh$

The forecast of the number of new domestic properties that will be completed in Wales is unchanged from the consultation stage analysis. It is based upon average annual housing completions between 2008-09 and 2010-11 and up-rated to reflect current projections for the increase in the number of households in Wales.

Table 2: Forecast new domestic property completions in Wales

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
6,480	6,549	6,618	6,688	6,756	6,823	6,888	6,952	7,017	7,080

Source: The numbers are based on average annual housing completions between 2008-09 and 2010-11 and uprated to reflect current projections for the increase in the number of households in Wales. Data on household projections are available from StatsWales.

The standard to which new domestic property has to be built is based upon when the building plans are submitted rather than when the building work actually commences or is completed. For this reason, not all new buildings completed in or after 2013 will be built to the 2013 standards. The table below presents the phasing assumptions that have been made about the numbers of new properties which will be built to the 2013 standards.

Table 3: Phase-in assumptions for the new regulations

	2014	2015	2016	2017-23
% built to 2013 standards	40%	60%	90%	100%

Source: Welsh Government

In undertaking this analysis an aggregate approach has been adopted whereby not all new domestic property will achieve an eight per cent improvement – some property types will need to achieve higher standards and some lower standards. However, the approach means that when improvements for each domestic property type are aggregated over the predicted build mix, an eight per cent reduction is achieved overall.

The modelling work has been designed to estimate the costs and benefits associated with improved energy efficiency and reduced carbon emissions for detached, semi-detached/end terrace, mid-terrace houses and apartments. These property types are consistent with those used in the UK analysis of Part L buildings regulations undertaken by the UK Zero Carbon Hub (UKZCH).

The table below presents the new domestic property mix used in the modelling work. The mix of dwelling types to be built (e.g. detached houses, apartments etc.) has also been estimated by AECOM using historic actual completions. It is assumed to be constant over the policy period.

Table 4: Assumed new domestic property mix

House type	Fuel	% of mix
Detached	Mains Gas	25%
End of Terrace	Mains Gas	37%
Mid-Terrace	Mains Gas	12%
Apartment	Mains Gas	11%
End of Terrace	Oil	6%
End of Terrace	LPG	2%
End of Terrace	Heat pump	3%
Apartment	Direct electric	4%
		100.00%

Source: AECOM

As can be seen in the table above, the overwhelming majority of new domestic property is assumed to be connected to the gas grid. As in the consultation stage impact assessment, the modelling work has considered domestic property that is connected to the gas grid as well as 'off-gas' property.

Properties that are off the gas grid are primarily located in rural (north, mid and eastern) areas of Wales and the types of heating fuel used tend to be more carbon intensive compared to properties connected to the gas grid. Apartment blocks may also be 'off-gas' in cases where having a gas supply to each apartment is either not economically viable or not preferable. For off-gas properties, a mix of different fuel types has been considered including, oil, LPG, air source heat pump (ASHP) and direct electric solutions.

For proportionality purposes, only those property and fuel type combinations that represent over one per cent of the total build mix have been included in the modelling. To have included all property and fuel type combinations (i.e. those which represent less than one per cent of the overall mix such as biomass) in the analysis would have required a disproportionate amount of work given their likely minimal impact on the modelling results.

The second stage of the analysis considered the impact of the proposals on capital costs and energy consumption. In estimating the additional capital cost, an allowance has been made for 'learning rates' for photovoltaic (PV) reflecting the expectation that unit costs will fall as production volumes increase. There have been some amendments to the cost assumptions since consultation. In particular, thermal bridging costs have been reviewed and revised post-consultation to better reflect the associated activities in delivering improved thermal bridging standards. The costs for solar PV have also been revised to reflect the later values from DECC.[3]

In addition to the energy savings, occupiers of homes with a solar PV system (or other renewable technology) installed would be eligible for payments under the Feed-in-Tariff (FiTS) scheme. However, these payments are excluded from the analysis because they are a transfer payment. This is in line with HM Treasury Green Book methodology.

The table below presents the costs and benefits associated with an eight per cent improvement in standards for new domestic properties.

Table 5: Present values of costs and benefits: new domestic buildings (£m)

Energy savings (£m)	2
Incremental costs (£m)	8
Total financial cost/benefit (£m)	**(6)**
Carbon savings - non-traded (£m)	1
Carbon savings - traded (£m)	0
Total carbon savings (£m)	1
Net benefit/cost exc. avoided renewables (£m)	**(5)**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**(5)**
Volume of gas saved (GWh)	132
Volume of electricity saved (GWh)	17
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.02
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.00
Cost effectiveness – non-traded (£/tCO_2)	249
Cost effectiveness – traded (£/tCO_2)	3,516

Source: Europe Economics calculations

As can be seen in the table above the policy has a small net financial cost, i.e. before carbon savings are taken into account, and a small net cost overall which is close to neutral. This is not surprising given

[3] See Appendix 3 for further details:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/226965/Part_L_2013_IA.pdf

the limited changes from Welsh planning policy between 2010 and 2013 from a flat 8 per cent reduction to an aggregate 8 per cent reduction.

4.1.1 Sensitivity analysis

Sensitivity testing has been carried out on a number of the key assumptions used in the analysis. The effect of using higher and lower values of future energy prices and carbon values has been assessed using the range of values suggested in DECC's appraisal guidance. In both cases, the resulting Net Present Value (NPV) is close to neutral.

Table 6: Present values of costs and benefits: new domestic buildings – low energy and carbon value sensitivity (£m)

Energy savings (£m)	1
Incremental costs (£m)	8
Total financial cost/benefit (£m)	**(7)**
Carbon savings - non-traded (£m)	1
Carbon savings - traded (£m)	0
Total carbon savings (£m)	1
Net benefit/cost exc. avoided renewables (£m)	**(6)**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**(6)**
Volume of gas saved (GWh)	132
Volume of electricity saved (GWh)	17
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.02
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.00
Cost effectiveness – non-traded (£/tCO_2)	276
Cost effectiveness – traded (£/tCO_2)	4,490

Source: Europe Economics calculations

Table 7: Present values of costs and benefits: new domestic buildings – high energy and carbon value sensitivity (£m)

Energy savings (£m)	2
Incremental costs (£m)	8
Total financial cost/benefit (£m)	**(6)**
Carbon savings - non-traded (£m)	2
Carbon savings - traded (£m)	0
Total carbon savings (£m)	2
Net benefit/cost exc. avoided renewables (£m)	**(3)**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**(3)**
Volume of gas saved (GWh)	132
Volume of electricity saved (GWh)	17
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.02
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.00
Cost effectiveness – non-traded (£/tCO_2)	224
Cost effectiveness – traded (£/tCO_2)	2,588

Source: Europe Economics calculations

The impact of changing the number of different types of new domestic properties built each year (i.e. the build mix) has also be tested. As can be seen in the table below, relatively substantial changes in the build mix (particularly for the level of apartments built) have limited impact on the overall level of carbon reduction.

Table 8: Build mix sensitivity test

	Central scenario	High apartment scenario	Low apartment scenario
Detached	25%	30%	34%
End of Terrace	48%	38.5%	42.5%
Mid-Terrace	12%	10.5%	13.5%
Apartment	15%	21%	10%
% improvement	**7.5%**	**7.3%**	**7.7%**

Source: Welsh Government

Changing the build mix to assume a lower proportion of apartments increases energy and carbon savings slightly, but to a much lesser extent than the increase in capital costs. Consequently, the net present value falls to -£7m. Changing the build mix to assume a higher proportion of apartments results in a net present value of -£8m.

4.2 Existing Domestic Property

Following consultation, it has been decided that energy efficiency standards for extensions to existing domestic properties will be tightened from 2013. The revised regulations will relate to the fabric standards of walls, roofs and floors, as shown in the table below:

Table 9: Performance standards for 2010 and 2013 standards (u-value)

	2010	2013
Wall	0.28	0.21
Roof	0.20	0.15
Floor	0.25	0.18

Energy efficiency standards for windows and doors installed in extensions will remain at the level established under the 2010 regulations.

To analyse the impacts of the changes to standards for walls, roofs and floors, a semi-detached home with an initial total floor area of 76m^2 was modelled in the consultation version of SAP. A 12m^2 extension was then added, and the changes to energy consumption from adopting the 2010 and 2013 energy efficiency standards for the extension from the table above were determined. Cost data for these improvements was provided by Davis Langdon (cost consultants). As per the consultation stage IA, an incremental cost of £99.61 for walls, £21.01 for roofs and £87.95 for floors has been assumed.

In our analysis it has been assumed that there are approximately 11,000 extensions to domestic property in Wales each year. The results of the analysis are shown in the table below. As explained earlier in this report, comfort taking has been included in the analysis of existing dwellings. This has been valued using the retail energy price, rather than the variable energy prices used to measure the energy savings. Differences between these results and the consultation stage results are driven by changes in the IAG guidance since consultation.

Table 10: Present values of costs and benefits: existing domestic buildings (£m)

Energy savings (£m)	10

Incremental costs (£m)	19
Total financial cost/benefit (£m)	**(9)**
Carbon savings - non-traded (£m)	10
Carbon savings - traded (£m)	0
Total carbon savings (£m)	10
Comfort taking (£m)	3
Net benefit/cost exc. avoided renewables (£m)	**5**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**5**
Volume of gas saved (GWh)	1,011
Volume of electricity saved (GWh)	-
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.2
Volume of CO_2 saved - traded ($MtCO_2(e)$)	-
Cost effectiveness – non-traded (£/tCO_2)	28
Cost effectiveness – traded (£/tCO_2)	-

Source: Europe Economics calculations

The additional costs of the 2013 standards for extensions exceed the estimated energy savings by approximately £9 million. However, when carbon savings and avoided renewables are included in the calculation the revised regulations generate a small, positive NPV, close to neutral.

4.2.1 Sensitivity analysis

The results of this element of the 2013 standards are relatively sensitive to changes to some key assumptions. As is shown in the table below, adopting DECC's recommendations for low energy prices and carbon values results in a negative NPV and an increase in the cost per tonne of CO_2 abated.

Table 11: Present values of costs and benefits: existing domestic buildings – low energy price and carbon value sensitivity (£m)

Energy savings (£m)	6
Incremental costs (£m)	19
Total financial cost/benefit (£m)	**(13)**
Carbon savings - non-traded (£m)	5
Carbon savings - traded (£m)	0
Total carbon savings (£m)	5
Comfort taking (£m)	2
Net benefit/cost exc. avoided renewables (£m)	**(5)**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**(5)**
Volume of gas saved (GWh)	1,011
Volume of electricity saved (GWh)	-
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.2
Volume of CO_2 saved - traded ($MtCO_2(e)$)	-
Cost effectiveness – non-traded (£/tCO_2)	53
Cost effectiveness – traded (£/tCO_2)	-

Source: Europe Economics calculations

As expected, adopting DECC's high energy prices and carbon values increases the NPV of tightening standards for extensions to existing dwellings. The result is a positive NPV and a better cost effectiveness value.

Table 12: Present values of costs and benefits: existing domestic buildings – high energy price and carbon value sensitivity (£m)

Energy savings (£m)	14
Incremental costs (£m)	19
Total financial cost/benefit (£m)	**(5)**
Carbon savings - non-traded (£m)	15
Carbon savings - traded (£m)	0
Total carbon savings (£m)	15
Comfort taking (£m)	4
Net benefit/cost exc. avoided renewables (£m)	**15**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**15**
Volume of gas saved (GWh)	1,011
Volume of electricity saved (GWh)	-
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.2
Volume of CO_2 saved - traded ($MtCO_2(e)$)	-
Cost effectiveness – non-traded (£/tCO_2)	3
Cost effectiveness – traded (£/tCO_2)	-

Source: Europe Economics calculations

Changing the assumed number of domestic extensions that are built in Wales each year has a proportionate impact on the results, assuming a constant build mix (i.e. a 10 per cent increase (decrease) in the number of extension built will increase (decrease) the energy savings, carbon savings and incremental costs by 10 per cent).

4.3 Consequential Improvements to Domestic Property

Under existing building regulations, property owners carrying out extensions or large refurbishment projects have to make improvements to the fabric of the rest of the building to improve its energy efficiency – these are termed consequential improvements. The rationale for introducing consequential improvements is that the triggering works will generally increase the energy use and carbon emissions in the building and therefore that upgrading the energy efficiency of the rest of the building will help to offset the increase in carbon emissions. The consequential improvements will also help to mitigate some of the increase in energy costs.

Currently, the requirement to make consequential improvements only applies to buildings over 1,000m^2, a threshold which excludes the vast majority of domestic property. Following consultation, it has been decided that this area threshold should be removed. As a result, all homeowners undertaking major works, such as extensions or increases in habitable space (for example, a loft or garage conversion), will have to deliver energy efficiency improvements on the original building.

Optional finance for these consequential improvements may be available through the UK Government's Green Deal. This scheme will enable private sector firms to offer domestic and non-domestic consumers energy efficiency improvements to their property at no upfront cost and to recoup payments in instalments through an additional charge in the customer's energy bill.

Consequential improvements will be limited to cavity wall insulation, loft insulation and hot water cylinder insulation. This is intended to ensure that any required consequential improvements will be in proportion to the scale and cost of the triggering work.

Where a building has already undergone energy efficiency improvements (for example, it already has cavity wall and loft insulation etc.) or if it is a relatively new building with a high energy performance, then there will be no requirement to make consequential improvements when undertaking any further work.

To illustrate the magnitude of costs and benefits of introducing consequential improvements, these consequential improvement measures has been modelled, namely: cavity wall insulation, loft insulation and hot water cylinder insulation. All of these measures are assumed to be economically feasible.

Table 13: Cost and energy savings for measures considered in domestic consequential improvements modelling

Measure	Asset life	Capital cost per improvement (£)	Energy saving per improvement (kWh pa)
Cavity wall insulation	42	500	2,673
Loft insulation	42	300	499
Hot water cylinder insulation	30	30	490

Source: Department for Energy and Climate Change

In the modelling, an estimate has been made of the number of homes that would have each of the measures shown in the table above installed each year as a result of this policy proposal. The estimate is based on the assumed number of 'trigger events' each year, the construction type of the existing housing stock and the existing take up of each measure (i.e. the proportion with cavity walls that already have cavity wall insulation).

The table below presents the costs and benefits of consequential improvements on domestic property in Wales. As for extensions, comfort taking has been included in the analysis of existing dwellings. This has been valued using the retail energy price, rather than the variable energy prices used to measure the energy savings. Differences between these results and the consultation stage results are driven by changes in the IAG guidance since consultation.

Table 14: Present values of costs and benefits: domestic consequential improvements (£m)

Energy savings (£m)	33
Incremental costs (£m)	19
Total financial cost/benefit (£m)	**13**
Carbon savings - non-traded (£m)	26
Carbon savings - traded (£m)	0
Total carbon savings (£m)	26
Comfort taking (£m)	11
Net benefit/cost exc. avoided renewables (£m)	**50**
Avoided renewables (£)	1
Net benefit/cost incl. avoided renewables (£m)	**51**
Volume of gas saved (GWh)	2,608
Volume of electricity saved (GWh)	-
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.5
Volume of CO_2 saved - traded ($MtCO_2(e)$)	-
Cost effectiveness – non-traded (£/tCO_2)	(51)
Cost effectiveness – traded (£/tCO_2)	-

Source: Europe Economics calculations

4.3.1 Sensitivity analysis

The tables below present the costs and benefits of extending the requirements for consequential improvements on domestic property using DECC's high and low energy prices and carbon values respectively. As can be seen, even with low energy prices and carbon valuations, the NPV of this policy remains positive.

Table 15: Present values of costs and benefits: domestic consequential improvements – low energy price and carbon value sensitivity (£m)

Energy savings (£m)	20
Incremental costs (£m)	19
Total financial cost/benefit (£m)	**1**
Carbon savings - non-traded (£m)	13
Carbon savings - traded (£m)	0
Total carbon savings (£m)	13
Comfort taking (£m)	8
Net benefit/cost exc. avoided renewables (£m)	**22**
Avoided renewables (£)	1
Net benefit/cost incl. avoided renewables (£m)	**22**
Volume of gas saved (GWh)	2,608
Volume of electricity saved (GWh)	-
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.5
Volume of CO_2 saved - traded ($MtCO_2(e)$)	-
Cost effectiveness – non-traded (£/tCO_2)	(24)
Cost effectiveness – traded (£/tCO_2)	-

Source: Europe Economics calculations

Table 16: Present values of costs and benefits: domestic consequential improvements – high energy price and carbon value sensitivity (£m)

Energy savings (£m)	45
Incremental costs (£m)	19
Total financial cost/benefit (£m)	**26**
Carbon savings - non-traded (£m)	39
Carbon savings - traded (£m)	0
Total carbon savings (£m)	39
Comfort taking (£m)	13
Net benefit/cost exc. avoided renewables (£m)	**78**
Avoided renewables (£)	1
Net benefit/cost incl. avoided renewables (£m)	**79**
Volume of gas saved (GWh)	2,608
Volume of electricity saved (GWh)	-
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.5
Volume of CO_2 saved - traded ($MtCO_2(e)$)	-
Cost effectiveness – non-traded (£/tCO_2)	(77)
Cost effectiveness – traded (£/tCO_2)	-

Source: Europe Economics calculations

4.4 New Non-domestic Buildings

The main change for non-domestic buildings is the adoption of two metrics: one for primary energy and another for carbon. Analysis has therefore been undertaken, first of energy efficiency measures only (reflecting the primary energy metric) and then energy efficiency measures in combination with low carbon energy supply measures (reflecting the carbon emissions metric).

First, the scope for reducing primary energy consumption in a range of new buildings was assessed. Cost curves for primary energy reduction were compiled using capital cost data from published sources and industry based estimates. The cost curves prioritise energy saving measures by lowest capital cost to achieve a unit saving in primary energy reflecting the approach that a developer would take in meeting a given primary energy reduction target.

The national calculation methodology (NCM) that underpins the Building Regulations is reliant on the principle of comparing the actual design of the building with a notional building of the same shape and size but with a fixed specification. Under the proposed new primary energy methodology the primary energy consumption from this notional building becomes the target (the Target Primary Energy Consumption, TPEC) by which the primary energy consumption from the actual building (Building Primary Energy Consumption, BPEC) is compared.

The Welsh Government has decided to adopt the recipes proposed at consultation that achieve a 20 per cent reduction in carbon emissions when compared with the notional building for 2010. These recipes have been updated slightly following consultation but still achieve the required 20 per cent reduction in carbon emissions.

The second stage of the cost-benefit analysis then involved assessment of the impact of the new notional buildings (or recipe) on each of the assessed buildings by reference to the cost curves.

The consultation impact assessment described the development of a further notional building to include side lit cooled buildings to differentiate them from heated-only buildings. This change has been kept and is reflected in the established recipes as shown in the table below.

Table 17: Fabric specifications for new non-domestic buildings

Element	Side lit or unlit (where HVAC specification is heating only) (SLHO)	Side lit or unlit (where HVAC specification includes cooling) (SL-H&C)	Toplit (TL)
Roof U-value (W/m².K)	0.18	0.18	0.18
Wall U-value (W/m².K)	0.26	0.26	0.26
Floor U-value (W/m².K)	0.22	0.22	0.22
Window U-value (W/m².K)	1.6 (10% FF)	1.8 (10% FF)	N/A
G-Value (%)	40%	40%	N/A
Light Transmittance (%)	71%	71%	N/A
Roof light U-value (W/m².K)	N/A	N/A	1.8 (15% FF)
G-Value (%)	N/A	N/A	52%
Light Transmittance (%)	N/A	N/A	57%
Air-permeability (m³/m²/hour) Gross Internal Area less than or equal to 250m²	5	5	7
Air-permeability (m³/m2/hour) Gross Internal Area greater than 250m2 and less than 3,500m2	3	5	7
Air-permeability (m3/m²/hour) Gross Internal Area greater than or	3	5	5

equal to 3,500m²			
Air-permeability (m³/m²/hour) Gross Internal Area greater than or equal to 10,000m²	3	5	3
Lighting Luminaire (lm / circuit watt)	65	65	65
Occupancy control (Yes/No)	Yes	Yes	Yes
Daylight control (Yes/No)	Yes	Yes	Yes
Maintenance Factor	0.8	0.8	0.8
Constant illuminance control	No	No	No
Heating efficiency (Heating and hot water)	91%	91%	91%
Central Ventilation SFP (W/l/s)	1.8	1.8	1.8
Terminal Unit SFP (W/l/s)	0.3	0.3	0.3
Cooling (air-conditioned) (SEER / SSEER)	N/A	4.5 / 3.6	4.5 / 3.6
Cooling (mixed mode) (SSEER)	N/A	2.7	2.7
Heat recovery efficiency (%)	70%	70%	70%
Variable speed control of fans and pumps, controlled via multiple sensors	Yes	Yes	Yes
Demand control (mechanical ventilation only). Variable speed control of fans via CO_2 sensors	Yes	Yes	Yes

Source: AECOM

Following consultation, it was decided that two further types of warehouse should be included in the analysis to reflect the relative ease with which these building types can achieve relative levels of air-tightness. The build rates assumed in the cost-benefit analysis are as follows:

Table 18: Build rate assumptions

Building type	m²/year	Weighting
Primary School	32,431	6.7%
Office	33,404	6.9%
Hotel	28,384	5.9%
Warehouse	72,582	15.1%
Community Hospital	19,486	4.0%
Multi-Residential	15,349	3.2%
Retail	179,063	37.2%
Small Warehouse	19,993	4.1%
Large Warehouse	81,274	16.9%

Source: AECOM

The aggregate reduction in primary energy from 2010 for each notional building, given the build mix, is shown in the table below.

Table 19: Reduction in primary energy from 2010 for each notional building

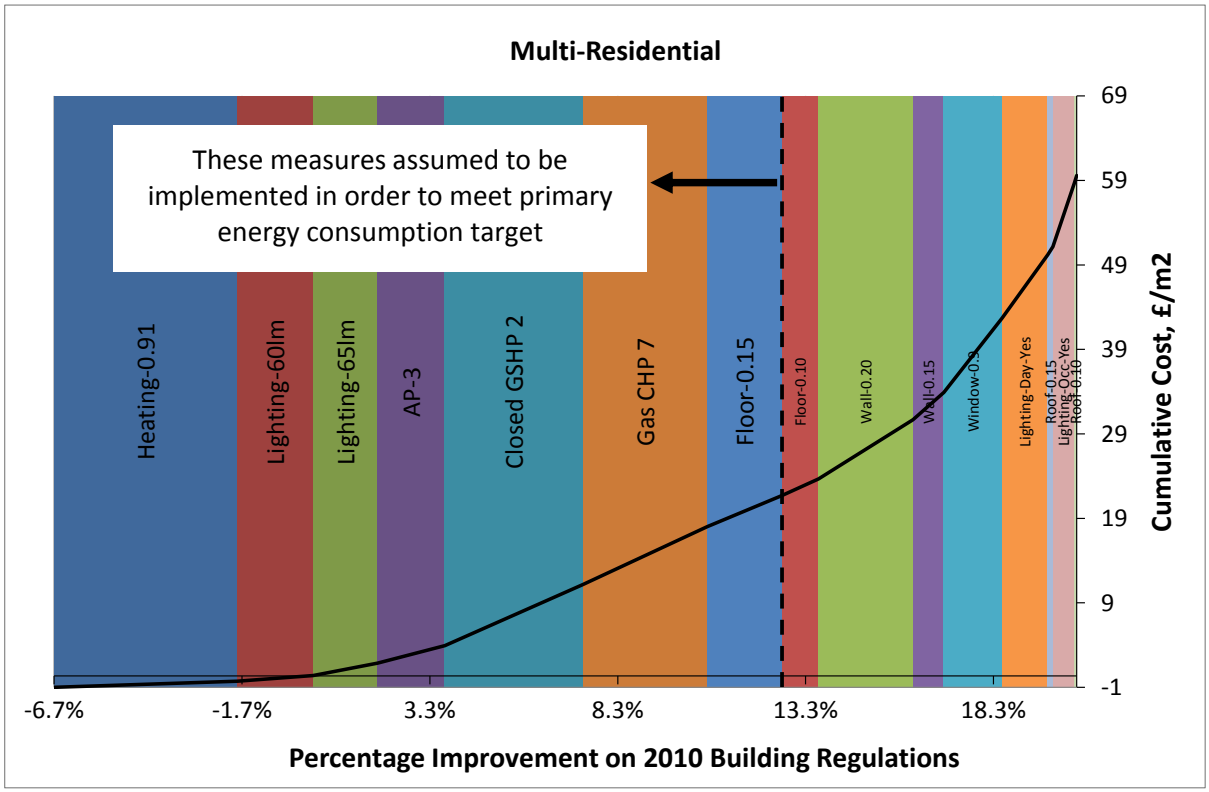
Building type	Notional building	Resultant target reduction
Primary School	SL-HO	8.5%
Office	SL-H&C	16.5%
Hotel	SL-HO	7.1%
Warehouse	TL	10.0%
Community Hospital	SL-HO	12.2%
Multi-Residential	SL-HO	10.3%
Retail	SL-H&C	11.7%

Small Warehouse	TL	0.8%
Large Warehouse	TL	8.8%
Aggregate total		**10.3%**

Source: AECOM

The target percentage reductions for each building type were then plotted on the cost curves to establish how an actual building would respond to the target. This identifies the energy efficiency measures that would be cost effectively employed in practice for each of the target reductions. The chart below shows the cost curve for the multi-residential building showing that a heating efficiency of 91 per cent, lighting efficiency of 65 luminaire lumens per circuit watt, gas CHP, an air-permeability of 3m³/m²/hour, floor U-value of 0.1 W/m².K and Wall U-value of 0.2 W/m².K would be a cost effective package of measures to meet the carbon reduction target.

Figure 1: Example of cost curve – multi-residential (modelled as a care home for the elderly



Next, the target percentages were converted to carbon for the purposes of the second TER metric. Then, the TER was stretched by adding PV to the notional building with the PV acting as proxy for a contribution from renewable technologies. The amount of PV required was determined by the shortfall in carbon emissions reductions required to meet Welsh Government's target 20 per cent reduction on 2010. This was found to be the equivalent of 5.3 per cent of each building's gross internal area (capped at 50 per cent of the roof area).

These PV proxy areas when added to the notional building give an overall carbon target as shown in the table below.

Table 20: Overall CO_2 target percentages as a result of PV being added to the fabric and services packages

Building type	Notional building	Resultant target reduction
Primary School	SL-HO	20.9%

Office	SL-H&C	27.1%
Hotel	SL-HO	10.6%
Warehouse	TL	23.9%
Community Hospital	SL-HO	21.9%
Multi-Residential	SL-HO	20.5%
Retail	SL-H&C	18.9%
Small Warehouse	TL	15.2%
Large Warehouse	TL	20.1%
Aggregate total		**20%**

Source: AECOM

It is important to note that whilst the notional building features PV to stretch the target not all buildings would necessarily choose PV to achieve their given target depending on the relative cost effectiveness of PV against other demand-side measures.

The final cost curves then consist, first, of a range of energy efficiency measures to achieve the primary energy target (TPEC) followed by a number of renewable technologies where required to achieve the carbon target (TER).

At the final third stage, the capital costs of achieving these reductions and the energy saved were used as inputs to a cost benefit model. The table below sets out the results of the cost benefit analysis for the agreed option of tightening standards to achieve a 20 per cent reduction on 2010 standards.

Table 21: Present value of costs and benefits: new non-domestic buildings (£m)

Energy savings (£m)	101.7
Incremental costs (£m)	88.0
Total financial cost/benefit (£m)	**13.7**
Carbon savings - non-traded (£m)	56.8
Carbon savings - traded (£m)	6.9
Total carbon savings (£m)	63.6
Net benefit/cost exc. avoided renewables (£m)	**77.4**
Avoided renewables (£)	0.7
Net benefit/cost incl. avoided renewables (£m)	**78.1**
Volume of gas saved (GWh)	3,840
Volume of electricity saved (GWh)	1,813
Volume of CO_2 saved – non-traded ($MtCO_2(e)$)	0.7
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.1
Cost effectiveness – non-traded (£/tCO_2)	(29)
Cost effectiveness – traded (£/tCO_2)	(523)

Source: Europe Economics calculations

As can be seen, the policy shows a net financial benefit, i.e. before the value of carbon savings is taken into account. Taking this social benefit into account yields a strongly positive net present value. The differences between these results and those arrived at in the consultation stage are driven by a change in energy modelling, which has resulted in lower incremental costs, and the inclusion of two extra building types.

4.4.1 Sensitivity tests

Sensitivity tests have been carried out for higher and lower energy prices and carbon values using the DECC IAG ranges. With the lower energy prices and carbon values, the policy still yields a positive NPV.

Table 22: Present value of costs and benefits: new non-domestic buildings – low energy price and carbon value sensitivity (£m)

Energy savings (£m)	81.0
Incremental costs (£m)	86.6
Total financial cost/benefit (£m)	**(5.6)**
Carbon savings - non-traded (£m)	17.8
Carbon savings - traded (£m)	2.1
Total carbon savings (£m)	19.9
Net benefit/cost exc. avoided renewables (£m)	**14.3**
Avoided renewables (£)	0.7
Net benefit/cost incl. avoided renewables (£m)	**15.0**
Volume of gas saved (GWh)	3,840
Volume of electricity saved (GWh)	1,813
Volume of CO_2 saved – non-traded ($MtCO_2(e)$)	0.7
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.1
Cost effectiveness – non-traded (£/tCO_2)	5
Cost effectiveness – traded (£/tCO_2)	(91)

Source: Europe Economics calculations

Table 23: Present value of costs and benefits: new non-domestic buildings – high energy price and carbon value sensitivity (£m)

Energy savings (£m)	122.0
Incremental costs (£m)	89.2
Total financial cost/benefit (£m)	**32.8**
Carbon savings - non-traded (£m)	59.0
Carbon savings - traded (£m)	7.5
Total carbon savings (£m)	66.5
Net benefit/cost exc. avoided renewables (£m)	**99.3**
Avoided renewables (£)	0.7
Net benefit/cost incl. avoided renewables (£m)	**100.0**
Volume of gas saved (GWh)	3,840
Volume of electricity saved (GWh)	1,813
Volume of CO_2 saved – non-traded ($MtCO_2(e)$)	0.7
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.1
Cost effectiveness – non-traded (£/tCO_2)	(57)
Cost effectiveness – traded (£/tCO_2)	(681)

Source: Europe Economics calculations

4.5 Existing Non-domestic Buildings

4.5.1 Extensions

The assessment has considered the impact of this policy on improvement to non-domestic building extension standards. The cost and benefits for buildings which are domestic in character have been assessed as these have seen the greatest improvement in extension standards. In particular, we have focussed on two building types: hotels and residential care homes.

Hotel and residential care home models with 'typical' energy efficiency levels have been used. An extension was then added to each model to represent an additional wing for the hotel and residential care home constructed to 2010 standards.

The first stage for assessing the impact of tightening the standards for extensions was to change each of the relevant fabric parameters in turn in the extension to those required in Part L 2013. These parameters were changed one at a time.

- Windows: From U=1.8 W/m²K to 1.6 W/m²K
- External walls: From U=0.28 W/m²K to 0.21 W/m²K
- Roofs: From U=0.18 W/m²K to 0.15 W/m²K
- Floors: From U=0.22 W/m²K to 0.18 W/m²K

From these simulations, the energy consumption by fuel type before and after each parameter change was recorded. The decrease in energy consumption was therefore calculated as a result of each parameter change. This enabled the impact of changing each parameter to be approximated.

The energy savings made per m² in a building of a specific type was then multiplied by the total floor area of buildings of that particular sector (type) that exist in Wales: as previously this was established via a dataset supplied by Building Research Establishment. This enabled an estimate of the total potential annual energy and cost savings that could be achieved in Wales by the building types analysed.

Costs for the above energy efficiency improvements were supplied by Welsh Government cost consultants (AECOM-Davis Langdon), utilising their in house cost database, SPON's price books, information direct from manufacturer's and costs from Welsh construction projects where appropriate. The assumed costs are presented in the table below.

Table 24: Capital costs for energy efficiency improvements in existing non-domestic buildings

	U-values		Cost Increase (£/m² fabric)
	2010	**2013**	
Roof	0.18	0.15	1.1
Wall	0.28	0.21	3.6
Floor	0.22	0.18	4.3
Window	1.8	1.6	16.5

Source: AECOM

To illustrate the costs and benefits of the policy on these types of building it has been assumed that 2 per cent of the total floor area of these types of building will be extended over the policy period. The table below shows the results of this analysis.

Table 25: Present value of costs and benefits: existing non-domestic buildings - Extensions (hotels and residential care homes) (£m)

Energy savings (£m)	5
Incremental costs (£m)	4
Total financial cost/benefit (£m)	**1**
Carbon savings - non-traded (£m)	3
Carbon savings - traded (£m)	0
Total carbon savings (£m)	3
Net benefit/cost exc. avoided renewables (£m)	**4**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**4**
Volume of gas saved (GWh)	326

Volume of electricity saved (GWh)	42
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.06
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.00
Cost effectiveness – non-traded (£/tCO_2)	(20)
Cost effectiveness – traded (£/tCO_2)	(1,069)

Source: Europe Economics calculations

As can be seen above, the policy yields a small net benefit for these types of extensions, but the impact is small, and close to neutral.

Sensitivity analysis

Sensitivity tests have also been carried out for higher and lower energy prices and carbon values using the DECC IAG ranges. With the lower energy prices and carbon values, the policy still yields a positive NPV when carbon savings are taken into account.

Table 26: Present value of costs and benefits: existing non-domestic buildings, extensions – low energy price and carbon value sensitivity (£m)

Energy savings (£m)	3
Incremental costs (£m)	4
Total financial cost/benefit (£m)	**0**
Carbon savings - non-traded (£m)	2
Carbon savings - traded (£m)	0
Total carbon savings (£m)	2
Net benefit/cost exc. avoided renewables (£m)	**1**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**1**
Volume of gas saved (GWh)	326
Volume of electricity saved (GWh)	42
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.06
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.00
Cost effectiveness – non-traded (£/tCO_2)	(20)
Cost effectiveness – traded (£/tCO_2)	(1,069)

Source: Europe Economics calculations

Table 27: Present value of costs and benefits: existing non-domestic buildings, extensions – high energy price and carbon value sensitivity (£m)

Energy savings (£m)	6
Incremental costs (£m)	4
Total financial cost/benefit (£m)	**2**
Carbon savings - non-traded (£m)	5
Carbon savings - traded (£m)	0
Total carbon savings (£m)	5
Net benefit/cost exc. avoided renewables (£m)	**8**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**8**
Volume of gas saved (GWh)	326
Volume of electricity saved (GWh)	42
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.06
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.00

Cost effectiveness – non-traded (£/tCO$_2$)	(45)
Cost effectiveness – traded (£/tCO$_2$)	(1,846)

Source: Europe Economics calculations

4.5.2 Fixed services replacement

In addition, the assessment estimates the costs and benefits of improvements to the replacement energy efficiencies standards for following three types of building services in the Non-Domestic Building Services Compliance Guide (NDBSCG): chiller, FCUs and lighting. (In the consultation stage IA, boilers were modelled, rather than FCUs.)

- Minimum cooling efficiency from 2.5 to 2.7
- Minimum fan coil unit (FCU) specific fan power from 0.6 to 0.5 W/l/s.
- Initial luminaire efficacy from 55 to 60 lamp lumens per circuit watt

This building services analysis was based on the same seven building types used in the new-build analysis. As for new non-domestic buildings, following consultation, it was decided that a small warehouse and a large warehouse should be added to the analysis.

- Offices;
- Warehouses (separated into small and large distribution warehouses);
- Retail (separated into general retail and retail warehouses);
- Education;
- Hotels;
- Healthcare building; and
- Residential care home.

In order to make the buildings representative of existing stock, the energy-related parameters for fabric and services were adjusted to those presented as 'typical' in the National Calculation Methodology.[4] These values are roughly equivalent to those presented in Part L 1995 and are presented in the table below.

Table 28: Parameters used to achieve the 'typical building' according to Appendix A of the 2008 NCM Modelling Guide

Parameter	Typical value
Roof U value (W/m^{2}K)	0.5
Wall U value (W/m^{2}K)	0.45
Ground floor U value (W/m^{2}K)	0.45
Window U value (W/m^{2}K)	3.3
Air permeability (m/(h.m) @ 50Pa)	15
Heating SCoP	0.55
Auxiliary energy (W/m^2)	1.23
Zonal extract SFP (W/ls)	1.1
Lighting in office & warehouse (W/m/100lux)	4.5
Lighting in other spaces (W/m^2/100lux)	6.2

Source: 2008 NCM Modelling Guide

[4] Appendix A, NCM Modelling Guide 2008

The first stage for assessing the impact of tightening the existing building regulations was to change each of the relevant service parameters (chiller, FCUs and lighting). First, to those required in Part L 2010 (the current requirements for component replacement) and then to those proposed in the Non-Domestic Building Services Compliance Guide as part of the Part L 2013 consultation. These parameters were changed one at a time, keeping all other parameters at the baseline values as defined in the table above.

From these simulations, the energy consumption by fuel type before and after each parameter change was recorded. The decrease in energy consumption was therefore calculated as a result of each parameter change. This enabled the impact of changing each parameter to be approximated.

The energy savings made per m^2 in a building of a specific type was then multiplied by the total floor area of buildings of that particular sector (type) that exist in Wales: this was established via a dataset supplied by Building Research Establishment. This enabled an estimate of the total potential annual energy and cost savings that could be achieved in Wales by the particular sectors analysed (approximately two thirds of the m^2 of total Welsh existing non-domestic stock).

Both FCUs and Chillers are assumed to have a lifetime of 15 years while Lighting is assumed to have 20 years. In line with other parts of the model, the life of building is assumed to be 60 years. Within this 60 year period it is assumed that, with a 15 year lifetime, FCUs and chillers will need to be replaced three times, and lighting, with a 20 year lifetime, will need to be replaced twice. In addition, various assumptions such as the building floor area and energy requirement per floor area are made to reflect the characteristics of each building type and fabric element.

Costs for the above energy efficiency improvements were supplied by Welsh Government cost consultants (AECOM-Davis Langdon), utilising their in house cost database, SPON's price books, information direct from manufacturers and costs from Welsh construction projects where appropriate. The assumed costs are presented in the table below.

Table 29: Capital costs for energy efficiency improvements in existing non-domestic buildings

	Cost (£/m²)		
Element	**Lighting**	**Chiller**	**FCU**
Hotel	0.3	-	-
Education	0.66	-	-
Health	0.79	-	-
Retail	0.46	0.89	1.3
Warehouse (distribution)	0.08	-	-
Residential care home	0.35	-	-
Office	0.79	0.54	1.3
Small warehouse	0.08	-	-
Large warehouse	0.08	-	-

Source: AECOM

From industry feedback received, it is estimated that on average over the 10 year policy period, only 10 to 40 per cent of FCUs specified for existing building would not achieve Part L 2013 standards if the current standard for FCUs was not changed. Similarly, the ranges for comfort cooling and lighting are 5 to 15 per cent and 10 to 30 per cent respectively. The counterfactual has been incorporated into our analysis and the ranges of counterfactual for each building service type are summarised in the table below.

Table 30: Percentage of replacement services that will be affected by the proposed standards

	Low	**Central**	**High**
FCUs	10%	25%	40%
Comfort cooling	5%	10%	15%

Lighting	10%	20%	30%

Source: Welsh Government

The results of modelling the central scenario are presented in the table below.

Table 31: Present value of costs and benefits: existing non-domestic buildings – fixed services replacement (£m)

Energy savings (£m)	18
Incremental costs (£m)	10
Total financial cost/benefit (£m)	**8**
Carbon savings - non-traded (£m)	(3)
Carbon savings - traded (£m)	1
Total carbon savings (£m)	(1)
Net benefit/cost exc. avoided renewables (£m)	**6**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**6**
Volume of gas saved (GWh)	(280)
Volume of electricity saved (GWh)	561
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	(0.1)
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.0
Cost effectiveness – non-traded (£/tCO_2)	177
Cost effectiveness – traded (£/tCO_2)	(124)

Source: Europe Economics calculations

These estimates assume that all of the existing non-domestic buildings will last for a further 60 years. While this may be true for some existing non-domestic property, it is unlikely to be true for all. The figures are therefore likely to over-estimate the net benefit from tightening the requirements for replacement fixed services in existing non-domestic property.

Sensitivity analysis

As set out in Table 30, low and high scenarios for the counterfactual were also considered, i.e. the percentage of systems that would not be affected by the proposed standards. When these low and high estimates of the counterfactual are used, the net benefits (NPV) ranges from £3m to £9m. This suggests relatively substantial variation (in proportionate terms), depending on the extent to which FCUs, comfort cooling and lighting specified for existing buildings would already meet 2013 standards without a change in the regulations, though this variation is within a positive NPV range.

Sensitivity tests have also been carried out for higher and lower energy prices and carbon values using the DECC IAG ranges. With the lower energy prices and carbon values, the policy still yields a positive NPV.

Table 32: Present value of costs and benefits: existing non-domestic buildings, fixed services replacement – low energy price and carbon value sensitivity (£m)

Energy savings (£m)	17
Incremental costs (£m)	10
Total financial cost/benefit (£m)	**7**
Carbon savings - non-traded (£m)	(1)
Carbon savings - traded (£m)	1
Total carbon savings (£m)	(1)
Net benefit/cost exc. avoided renewables (£m)	**6**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**6**

Volume of gas saved (GWh)	(280)
Volume of electricity saved (GWh)	561
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	(0.1)
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.0
Cost effectiveness – non-traded (£/tCO_2)	142
Cost effectiveness – traded (£/tCO_2)	(133)

Source: Europe Economics calculations

Table 33: Present value of costs and benefits: existing non-domestic buildings, fixed services replacement – high energy price and carbon value sensitivity (£m)

Energy savings (£m)	19
Incremental costs (£m)	10
Total financial cost/benefit (£m)	**9**
Carbon savings - non-traded (£m)	(4)
Carbon savings - traded (£m)	2
Total carbon savings (£m)	(2)
Net benefit/cost exc. avoided renewables (£m)	**7**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**7**
Volume of gas saved (GWh)	(280)
Volume of electricity saved (GWh)	561
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	(0.1)
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.0
Cost effectiveness – non-traded (£/tCO_2)	214
Cost effectiveness – traded (£/tCO_2)	(112)

Source: Europe Economics calculations

As can be seen in the tables above, using low or high energy prices and carbon valuations has limited impact on the overall viability of this policy. This is because of the nature of the energy savings, which come in the form of electricity savings which are partly offset by increased gas consumption.

4.6 Consequential Improvements to Non-domestic Property

For non-domestic buildings with a floor area greater than 1,000m², consequential improvements are required under current Part L if one of the following is carried out:

- An extension or increase in habitable area,
- The initial provision of fixed building services, or
- An increased capacity of fixed building services.

This impact assessment considers the policy proposals to remove the 1,000m² threshold and require all non-domestic property to undertake consequential improvements where an extension or new habitable space is added.

It is assumed that the majority of extensions to buildings below 1,000m² will be to domestic style constructions. About 80 per cent of buildings with floor area below 1,000m² are below 250m². Offices of that size are mainly converted Victorian houses used for professional businesses. Hotels of that size will be B&Bs or small boarding houses. Health facilities will be doctors or dentists surgeries. Retail units and warehouses below 1,000m² are unlikely to be extended – the occupier is much more

likely to trade up to a bigger unit than extend an existing one. Thus, as a first approximation for consultation, the assessment assumed that the amount of energy use is more reflective of dwellings than non-domestic buildings.

As such, the model for estimating the impact of consequential improvements in domestic property has been adapted to reflect smaller non-domestic buildings.

For the purpose of this analysis it is assumed that these non-domestic buildings have the same pattern of existing energy efficiency measures installed (e.g. levels of insulation) as the domestic housing stock but that they are, on average, larger than the typical domestic building. An average floor area of 150m^2 has been assumed compared with 95m^2 for domestic buildings. Costs and energy savings per building have been increased pro rata from the domestic model to adjust for this larger building size.

Based on work undertaken by DCLG as part of the analysis for Part L 2013, it has been assumed that extensions will be made to between 0.1 and 0.8 per cent of the existing stock of buildings each year depending on type. This is used to estimate the number of extensions to buildings that might trigger consequential improvements, suggesting that there may be about 900 extensions a year. The energy and carbon savings have been evaluated over the assumed life of each improvement without allowing for any subsequent replacement.

As is the case for domestic property, occupiers will have the option to offset the up-front capital costs of the consequential improvements through the Green Deal.

Estimates of the costs and benefits of extending the consequential improvement requirement to all non-domestic buildings are shown in the table below. Differences between these results and those arrived at in the consultation stage impact assessment are largely driven by changes in the IAG guidance.

Table 34: Present values of costs and benefits: non-domestic consequential improvements (£m)

Energy savings (£m)	5
Incremental costs (£m)	3
Total financial cost/benefit (£m)	**2**
Carbon savings - non-traded (£m)	4
Carbon savings - traded (£m)	0
Total carbon savings (£m)	4
Net benefit/cost exc. avoided renewables (£m)	**6**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**6**
Volume of gas saved (GWh)	406
Volume of electricity saved (GWh)	2
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.1
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.0
Cost effectiveness – non-traded (£/tCO_2)	(30)
Cost effectiveness – traded (£/tCO_2)	(9,746)

Source: Europe Economics calculations

4.6.1 Sensitivity analysis

Adopting DECC's lower energy price assumptions means that the increased capital costs are approximately equal to the value of the energy savings; however, the value of carbon savings (even when given a lower value) remain sufficient to generate a positive NPV (though this is small).

Table 35: Present values of costs and benefits: non-domestic consequential improvements – low energy price and carbon value sensitivity (£m)

Energy savings (£m)	3
Incremental costs (£m)	3
Total financial cost/benefit (£m)	**0**
Carbon savings - non-traded (£m)	2
Carbon savings - traded (£m)	0
Total carbon savings (£m)	2
Net benefit/cost exc. avoided renewables (£m)	**2**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**2**
Volume of gas saved (GWh)	406
Volume of electricity saved (GWh)	2
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.1
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.0
Cost effectiveness – non-traded (£/tCO_2)	(3)
Cost effectiveness – traded (£/tCO_2)	(3,411)

Source: Europe Economics calculations

As would be expected, adopting DECC's higher estimates for future energy prices and carbon values increases the NPV for non-domestic consequential improvements.

Table 36: Present values of costs and benefits: non-domestic consequential improvements – high energy price and carbon value sensitivity (£m)

Energy savings (£m)	7
Incremental costs (£m)	3
Total financial cost/benefit (£m)	**4**
Carbon savings - non-traded (£m)	6
Carbon savings - traded (£m)	0
Total carbon savings (£m)	6
Net benefit/cost exc. avoided renewables (£m)	**10**
Avoided renewables (£)	0
Net benefit/cost incl. avoided renewables (£m)	**10**
Volume of gas saved (GWh)	406
Volume of electricity saved (GWh)	2
Volume of CO_2 saved - non-traded ($MtCO_2(e)$)	0.1
Volume of CO_2 saved - traded ($MtCO_2(e)$)	0.0
Cost effectiveness – non-traded (£/tCO_2)	(57)
Cost effectiveness – traded (£/tCO_2)	(16,024)

Source: Europe Economics calculations

5 Distribution of Costs and Benefits

The costs and benefits identified for new buildings in the RIA will be incurred or will accrue to different groups. In the first instance, additional building costs are likely to be borne by the building developer; however, in the longer term developers are likely to pass the higher costs on to customers (owners/tenants) or back to landowners in the form of lower land values (where possible).

As with other sectors of the economy, the construction industry in Wales and the UK has struggled in recent years as a result of the global economic recession. The number of new dwellings started in Wales has been increasing since 2008-09; however, the figure of 5,818 new house starts in Wales in 2010-11 is still significantly below the pre-recession level of 10,135 in 2007-08.[5] Expectations are for a recovery in the UK construction sector; however, that recovery is expected to take a number of years.

The table below shows the incremental capital costs for new domestic buildings of compliance with the 2013 standards (compared to buildings compliant with current planning policy, i.e. 2010 standards). For assumed new domestic property mix, see Table 4.

Table 37: Additional capital cost for new domestic property[6]

	Incremental cost (£)	% uplift on 2010 base cost
Detached (gas)	659	0.5%
Semi-detached (gas)	(2)	(0.0)%
Semi-detached (oil)	698	0.8%
Semi-detached (LPG)	(91)	(0.1)%
Semi-detached (ASHP)	1,046	1.2%
Mid-terrace (gas)	(634)	(0.8)%
Apartment (gas)	(314)	(0.4)%
Apartment (electric)	(255)	(0.3)%

Data from AECOM suggest that the proposals will increase the capital cost for the 'superstructure' of new detached properties, but they will decrease (relative to a 2010 baseline) for other new gas heated homes. The capital cost will also increase, by a relatively large amount, for oil heated properties and new properties using an air source heat pump.

The table below shows the incremental capital costs for new non-domestic buildings of compliance with the 2013 standards (compared to buildings compliant with current planning policy, i.e. 2010 standards).

Table 38: Additional capital cost for new non-domestic property

	Increase (£/m^2)	% uplift on 2010 base cost
Primary School	10.4	0.4%
Office	26.0	1.7%
Hotel	2.7	0.2%
Warehouse	20.2	4.0%
Community Hospital	20.2	0.9%

[5] New house building in Wales, October to December 2011, Welsh Government statistical release (http://wales.gov.uk/docs/statistics/2012/120321sdr462012en.pdf)

[6] Costs relate to the property's 'superstructure' and assume that the property is connected to the gas grid.

Multi-Residential	35.7	1.5%
Retail	26.6	1.8%
Small Warehouse	16.5	2.4%
Large Warehouse	9.1	2.1%

For new non-domestic property, the proposals increase capital costs by between £2.7/m2 and £35.7/m2, depending upon property type. This is reflective of the 'aggregate' approach taken. The largest additional capital costs will be seen in the multi-residential building, offices and retail outlets, while hotels and large warehouses will face relatively small increases in capital costs. This could result in a negative incentive to develop more costly building types if it is not possible to pass this additional cost on to occupants due to informational asymmetries, whereby potential occupants are not aware of the resulting reductions in their energy bills. As set out in section 4.4, the savings in energy costs by occupants more than offsets the increases in capital costs when the policy is considered in aggregate.

6 Specific Impact Tests

6.1 Economic and Financial Impacts

6.1.1 Competition

The main markets affected by changes to Part L of the Building Regulations are those for the development of new domestic and non-domestic property and the refurbishment of existing property. The supply chains for the production of materials used in the identified markets may also be affected.

The proposed higher standards mean that building contractors will have to comply with more stringent energy efficiency and building emissions targets. As a result of this, capital costs are expected to increase. Some of this increase in costs is expected to be passed on to landowners (through reduced land values) and the eventual owners (through higher property prices). The increase in production costs is expected to affect all building contractors broadly equally and the proportion of the additional costs that cannot be passed on to landowners or the eventual purchasers is likely to represent a relatively small percentage of overall construction costs. Any potential competitive impacts on building contractors are therefore likely to be minimal. However, it is possible that smaller developers with less buying power may face proportionally higher cost increases than larger businesses. This is considered separately on the impact of the policy on small firms.

The new standards may have an impact on manufacturers and suppliers to the construction industry by increasing the demand for higher specification materials and products. Suppliers of low cost or low quality products and materials may be adversely affected by the change in regulations. However, the change in regulations is also expected to provide opportunities for manufacturers and suppliers of low/zero carbon generation technologies and high energy efficiency products.

6.1.2 Small and Medium Enterprises

The majority of businesses in the construction industry in Wales are classed as a small or medium sized enterprise (SME). Welsh Government statistics (Size Analysis of Welsh Business, 2011) show approximately 38,900 construction businesses (including self-employed individuals) operating in Wales in 2011. Of these, 97.7 per cent were micro-businesses (employing between 0 and 9 people), just under 1.8 per cent were small businesses (10-49 employees) and 0.35 per cent were medium size businesses (50-249 employees). The remaining 0.2 per cent of businesses were classified as large (250+ employees).

Although the majority of businesses in the sector are classed as SMEs, a significant proportion of construction activity (in terms of the number of new properties built) is carried out by the larger companies. The Office of Fair Trading reported that the top 10 home-builders were responsible for 44 per cent of the domestic property built in 2006 and that the top 25 were responsible for 54 per cent of the domestic property built in the UK.

Businesses affected by the proposals for 2013 will include small firms involved in the construction of new buildings and extensions, companies that manufacture building materials and installers of energy efficiency measures such as loft and cavity wall insulation.

There are a number of ways in which small firms may be disproportionately affected by the proposals when compared to larger firms.

- There may be some higher specification products which at this stage can only be produced by large manufacturers and/or it may be more difficult for smaller manufacturers to switch to producing higher specification construction materials than larger manufacturers. However, this risk will be limited by the fact that the policy for 2013 does not entail major changes to product performance standards, partly because experience of manufacturing/specifying to the current standards is limited (as these were only introduced in 2010).
- The policy for new non-domestic buildings, i.e. a 20 per cent improvement on 2010 standards, may have a larger impact on firms building small buildings, in particular small warehouses, which may be more likely to be occupied by small or start-up businesses. As set out in section 5, small warehouses will cost £10.4/m^2 extra relative to a 2010-compliant solution.
- As noted by some respondents to the consultation, there is a risk that the extension of consequential improvement requirements to properties below 1,000m^2 will dissuade some homeowners and businesses from carrying out small building projects and improvements. This could have a negative impact on small businesses. However, the availability of finance through the Green Deal to cover the capital cost of the energy efficiency improvements may reduce this risk.
- On the other hand, the requirement for consequential improvements to all domestic and smaller non-domestic buildings could create a significant new (or increased) market for smaller firms, as noted by some respondents to the consultation. Consequential improvements generally require relatively small scale works involving additional insulation and plumbing work. Much of this will either fall within or be similar to work that small firms are already carrying out, and coupled with the Green Deal could provide significant extra work for small and micro-enterprises. It is also likely to create additional demand for Green Deal assessments, where building owners opt for Green Deal finance to meet the requirements, many of which may be carried out by small businesses.

Two separate pieces of analysis were undertaken to provide an indicative comparison of the change in capital costs for both larger and smaller developers from the implementation of Part L 2013.

In the first analysis, the costs of implementing Part L 2013 for gas-fuelled homes were compared. Over 80% of new homes are fuelled by mains gas. Furthermore, the comparison focused on detached, semi-detached and mid-terraced homes, as it was considered less likely that smaller builders would construct multi-storey apartment blocks.

- Larger developers: The costs were the same as for the main cost benefit analysis. The counterfactual was assumed to be delivered through energy efficient building fabric and services. Any changes to meet Part L 2013 were achieved through improvements or easing in the fabric performance.
- Smaller developers: Based on discussions with smaller developers and building control, there appears to be a greater tendency for smaller developers currently to use solutions with renewables and ease their fabric performance (e.g. less focus on high standards of thermal bridging). Hence, as a contrast to the larger builder analysis, we assumed that the counterfactual was based on a more relaxed fabric than for larger developers and complemented by the inclusion of solar panels. Any changes to meet Part L 2013 were achieved through increasing or reducing the amount of solar PV. The cost of PV has been assumed to be continuous, although in practice PV will be purchased by the panel.

The incremental costs are shown in the table below. Increases in costs are shown in positive. As can be seen, based on these assumptions, the impact of Part L 2013 on smaller builders is less than that of larger builders.

Table 39: Comparison of incremental capital costs for larger and smaller builders for gas homes

	Larger builders	Smaller builders
Mid terrace	(£679)	(£161)
Semi-detached	(£2)	£24
Detached	£705	£242

Source: AECOM

In the second analysis, the costs of implementing Part L 2013 for different fuel types were compared. It may be expected that there is a greater tendency for smaller builders to construct new homes off of the mains gas grid compared to larger developers. For this, the off-gas results from the main cost benefit analysis were used which are for the semi-detached house only. For both oil and LPG cases, the PPW counterfactual was based on the adoption of solar panels and any changes to meet Part L 2013 were achieved through increasing or reducing the amount of solar PV.

The results are shown in the table below. As can be seen, compared to the gas scenario, there is an increase for those using oil to heat their homes[7] and potential savings for those using LPG to heat their homes.

Table 40: Comparison of incremental capital costs for different fuels for heating for semi-detached homes

	Incremental capital cost
Gas	(£2)
Oil	£923
LPG	(120)

Source: AECOM

6.2 Social Impacts

6.2.1 Health and well-being

There is a wealth of evidence available on the impact that housing quality has on health and general well-being (see for example Geddes et al 2011).[8] Research shows direct links between cold housing and cardio-vascular and respiratory problems and also winter mortality amongst the elderly. Links have also been made between housing standards and mental health and children/young people's well-being and opportunities.

It follows then that any policy aimed at raising the thermal and energy efficiency of both new and existing (when extended/renovated) property has the potential to improve health and well-being.

Some concerns have been raised about the potential impact that energy efficiency improvements may have on indoor air quality and the risk of overheating in homes. In particular it has been suggested that tightening building envelopes reduces ventilation and risks the build-up of indoor pollutants. The UK Government has announced plans for a review of the evidence on the potential impact of improvements to building specification on indoor temperatures and air quality.

[7] This increase in capital costs for oil heating, relative to gas heating, arises for several reasons including changes in the methodology for calculating the CO_2 target and that the carbon emission factor for heating oil has increased by 9% from SAP 2009 to SAP 2012.

[8] Geddes, I., Bloomer, E., Allen, J. and Goldblatt, P. The Health Impacts of Cold Homes and Fuel Poverty - Marmot Review Team , Department of Epidemiology & Public Health, University College London, May 2011

6.2.2 Equalities

The Equality Duty requires public bodies to have due regard to the need to: eliminate unlawful discrimination, harassment, victimisation and any other conduct prohibited by the Equalities Act 2010; advance equality of opportunity between people who share a protected characteristic and those who do not share it; and foster good relations between people who share a protected characteristic and people who do not share it.

These proposals have been assessed in an initial screening process which determined that the policy for 2013 will have a neutral impact in terms of race, gender, sexual orientation and religion.

The policy could be considered to have a positive impact in terms of protecting people in vulnerable age groups and people with a disability or long-term illness. As is detailed in the 'Health and Well-being' section, there is evidence of a link between cold housing and excess winter deaths – the majority of which occur amongst older age groups – and between cold housing and non-fatal adverse health consequences which again affect older age groups in particular and to a lesser extent younger children and those with a long-term illness or disability.

6.2.3 Rural

The majority of the existing 'off-gas' domestic properties are located in rural areas where connecting homes to the gas grid is not economically viable or feasible. In these locations, builders have to choose an alternative fuel such as LPG, oil or electric heating. Each of these alternative heating fuels has a higher carbon intensity than gas. For new property that uses a heating fuel other than gas, current Part L regulations include a 'fuel factor' that increases the carbon target/Target Emission Rate (TER) to make it less demanding. Without this fuel factor, builders in off-gas locations would need to build to higher and more expensive fabric and/or services standards in order to meet the same emissions target as those homes connected to the gas network.

6.2.4 Welsh language

There are no significant links between the policy proposals and the Welsh language. The proposals are not expected to have a positive impact on the promotion, support or development of the Welsh language nor are they expected to have a negative impact on Welsh speaking communities or Welsh language services.

6.3 Environmental Impacts

6.3.1 Greenhouse gas emissions

The impact of the proposed policy changes on carbon emissions have been quantified and included in the impact assessment.

6.3.2 Wider environmental impacts

The policy is expected to result in a reduction in the demand for energy (compared to the 'Do Nothing' option). Given the current 'energy mix', this is expected to result in an improvement in air quality. No attempt has been made to monetise this benefit in the impact assessment.

The policy is not expected to have any impact on water quality or quantity, biodiversity, waste management, noise pollution or the appearance of the landscape.

6.3.3 Sustainable development

The policy for 2013 is aimed at reducing Greenhouse Gas (GHG) emissions from new and existing buildings. However, the evidence suggests that this will lead to an increase in costs for developers and/or the owners of existing buildings. Given the current state of the economy, there are concerns that this increase in costs risks a reduction in construction activity in Wales and could dissuade the owners of existing buildings from extending/improving their property in the near term. If this were to occur then it may have a negative impact on the Welsh Government's policies for regeneration and the supply of affordable homes.