Communities and Local Government

Zero carbon for new non-domestic buildings

Impact Assessment

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Zero carbon for new non-domestic buildings

Impact Assessment

November 2009
Department for Communities and Local Government

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Summary: Intervention & Options

Department /Agency:	Title:	
Communities and Local Government	Impact Assessment of zero carbon energy performance build standard for new non-domestic buildings	
Stage: Consultation	**Version:** 1.0	**Date:** November 2009

Related Publications: Consultation Document: Zero carbon for new non-domestic buildings

Available to view or download at:

www.communities.gov.uk/planningandbuilding/publications/impact-assessments/

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

Greenhouse gas emissions create huge externalities. Decarbonising new buildings has particular challenges and opportunities. Construction 'locks in' structures and technologies for the lifetime of a variety of different building types which will be more expensive to retrofit.

Also future energy saving benefits are not captured by developers, partly due to lack of information and a developer/occupier split incentive, which causes a disincentive to invest in low carbon technologies. Energy security market failure is also being addressed. So regulatory policy is needed to set standards.

What are the policy objectives and the intended effects?

A clear, ambitious Government trajectory to tighten Building and related Regulation, can reduce emissions in new non-domestic buildings, in a cost effective way, consistent with Government's overall 80% reduction target by 2050, and also help meet energy security objectives.

The policy will oblige construction to zero carbon standards from 2019, so as to create a level playing field and maximise opportunities for zero carbon technologies at a local level. This will also reduce future energy costs, enhance efficiency for occupiers and be consistent with zero carbon homes policy.

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

This preliminary scoping Assessment analyses the costs and benefits for three different regulatory trajectory scenarios for zero carbon standards from 2019 and a 'do nothing' option (a reference case assumes 2010 changes are introduced). The 'aggregate' approach for carbon compliance targets, with allowable solutions from 2019 and an element to cover unregulated emissions calculated in SBEM, are assumed. Further options introduce allowable solutions from 2016 (70% or 100%) and have either no element for unregulated emissions or a flat 20% on top of regulated emissions.

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

When will the policy be reviewed to establish the actual costs and benefits and the achievement of the desired effects? This is a scoping Impact Assessment. A more detailed IA will be prepared in advance of any specific regulatory steps. It is intended that the overall policy will be reviewed in 2013.

Ministerial Sign-off For select stage Impact Assessments:

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

Signed by the responsible minister:

Date: 19 November 2009

Summary: Analysis & Evidence

Policy Option: 1	**Description: Do nothing (reference case) biomass allowed; 2010 relative to 2006**

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'
One-off (Transition)	**Yrs**	Increased building costs; operating and maintenance costs associated with energy efficiency and LZC measures; biomass fuel cost, in line with standards outlined in Part L 2010 consultation stage IA.
£		
Average Annual Cost (excluding one-off)		
£40m		**Total Cost** (PV) **£490m**

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

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'
One-off	**Yrs**	Benefits covers energy savings in new buildings, the value of reductions in CO_2 in the ETS and non-ETS sectors and the value attributable to avoided renewables, in line with benefits outlined in Part L 2010 consultation stage IA.
£		
Average Annual Benefit (excluding one-off)		
£30m		**Total Benefit** (PV) **£400m**

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

Key Assumptions/Sensitivities/Risks

As outlined in Part L 2010 consultation stage IA, which proposes an aggregate 25% tightening on 2006 Part L standards.

Price Base Year	**Time Period Years**	**Net Benefit Range** (NPV)	**NET BENEFIT** (NPV Best estimate)
2008	70	**£**	**(£90m)**

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

Impact on Admin Burdens Baseline (2005 Prices) (Increase – Decrease)

Increase of £ Decrease of £ **Net Impact £**

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

Summary: Analysis & Evidence

Policy Option: 2	Description: Progressive tightening Scenario 1 (Offsite rich) trajectory 44% aggregate carbon compliance from 2019, relative to 2010 reference case

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'	
One-off (Transition)	**Yrs**	Increased building costs; operating and maintenance costs associated with energy efficiency and LZC measures including biomass; biomass fuel cost. Allowable solutions costing £50/t for heat and £100/t for power, assuming 50% heat and 50% power.	
£			
Average Annual Cost (excluding one-off)			
£560m		**Total Cost** (PV)	**£6,800m**
Other **key non-monetised costs** by 'main affected groups'.			

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'	
One-off	**Yrs**	Benefits covers energy savings (£2,057m) in new buildings, the value of reductions in CO_2 in the ETS and non-ETS sectors (£4,395m) and the value attributable to avoided renewables (£537m).	
£0			
Average Annual Benefit (excluding one-off)			
£580m		**Total Benefit** (PV)	**£6,990m**
Other **key non-monetised benefits** by 'main affected groups'. Building to zero carbon standards will reduce potentially more expensive costs of subsequent retrofits in response to climate change pressures. Spillover effects of allowable solutions investment.			

Key Assumptions/Sensitivities/Risks
Uncertainty about future build costs, technology solutions, learning rates, energy prices, carbon prices, and allowable solution costs over an extended period. Ranges below are based on allowable solution net costs between £50/t and £200/t.

Price Base Year	Time Period Years	Net Benefit Range (NPV)	NET BENEFIT (NPV Best estimate)
2008	70	**£900m–(£3,500m)**	**£190m**

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

Impact on Admin Burdens Baseline (2005 Prices)		(Increase – Decrease)
Increase of £	Decrease of £	**Net Impact £**

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

Summary: Analysis & Evidence

Policy Option: 3	Description: Progressive Tightening Scenario 2 (Balance on and offsite) 54% aggregate carbon compliance from 2019 relative to 2010 reference case.

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'	
One-off (Transition)	**Yrs**	Increased building costs; operating and maintenance costs associated with energy efficiency and LZC measures including biomass, biomass fuel cost on trajectory to 54% (carbon compliance) from 2019. Unregulated as calculated by SBEM. Cost of allowable solutions at net £75/tonne.	
£			
Average Annual Cost (excluding one-off)			
£950m		**Total Cost** (PV)	**£11,460m**

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

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'	
One-off	**Yrs**	Benefits covers energy savings (£3,284m), the value of reductions in CO_2 (£4,319m) in the ETS and non-ETS sectors and the value attributable to avoided renewables (£586m).	
£			
Average Annual Benefit (excluding one-off)			
£680m		**Total Benefit** (PV)	**£8,190m**

Other **key non-monetised benefits** by 'main affected groups'.
Building to zero carbon standards will reduce potentially more expensive costs of subsequent retrofits in response to climate change pressures. Spillover effects of allowable solutions investment.

Key Assumptions/Sensitivities/Risks
Uncertainty about future build costs, technology solutions, learning rates, energy prices, carbon prices, and allowable solution costs over an extended period. Ranges below are based on allowable solution net costs between £50/tonne and £200/tonne.

Price Base Year	Time Period Years	Net Benefit Range (NPV)	NET BENEFIT (NPV Best estimate)
2008	70	**(£2,600m–£6,600m)**	**(£3,270m)**

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

Impact on Admin Burdens Baseline (2005 Prices)		(Increase – Decrease)
Increase of £	Decrease of £	**Net Impact £**

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

Summary: Analysis & Evidence

Policy Option: 4	Description: Progressive Tightening Scenario 3 (onsite rich) 63% aggregate carbon compliance from 2019 relative to 2010 reference case.

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'
One-off (Transition)	**Yrs**	Increased building costs; operating and maintenance costs associated with energy efficiency and LZC measures including biomass, biomass fuel cost on trajectory to 63% (carbon compliance) from 2019. Unregulated as calculated by SBEM. Cost of allowable solutions at net £75 per tonne.
£		
Average Annual Cost (excluding one-off)		
£1,300m		**Total Cost** (PV) **£15,780m**

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

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'
One-off	**Yrs**	Benefits covers energy savings (£4,143m) for occupiers, the value of reductions in CO_2 (£4,079m) in the ETS and non-ETS sectors and the value attributable to avoided renewables (£586m).
£		
Average Annual Benefit (excluding one-off)		
£730m		**Total Benefit** (PV) **£8,810m**

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

Building to zero carbon standards will reduce potentially more expensive costs of subsequent retrofits in response to climate change pressures. Spillover effects of allowable solutions investment.

Key Assumptions/Sensitivities/Risks

Uncertainty about future build costs, technology solutions, learning rates, energy prices, carbon prices, and allowable solution costs over an extended period. Ranges below are based on allowable solution net costs between £50/t and £200/t.

Price Base Year	**Time Period Years**	**Net Benefit Range** (NPV)	**NET BENEFIT** (NPV Best estimate)
2008	70	**(£6,400m–£9,900m)**	**(£6,970m)**

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

Impact on Admin Burdens Baseline (2005 Prices)		(Increase – Decrease)
Increase of £	Decrease of £	**Net Impact £**

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

Summary: Analysis & Evidence

Policy Option: 5	Description: Scenario 2 (Balance on and offsite) with introduction of allowable solutions from 2016 (to 70%) and no unregulated emissions allowance.

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'	
One-off (Transition)	**Yrs**	Increased building costs; operating and maintenance costs for energy efficiency and LZC measures including biomass, biomass fuel cost on trajectory to 54% (carbon compliance) from 2019. No unregulated emissions allowance. Cost of allowable solutions to 70% then 100% regulated at net £75 per tonne.	
£			
Average Annual Cost (excluding one-off)			
£920m		**Total Cost** (PV)	**£11,150m**

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

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'	
One-off	**Yrs**	Benefits covers energy savings (£3,284m), the value of reductions in CO_2 (£3,715m) in the ETS and non-ETS sectors and the value attributable to avoided renewables (£586m).	
£			
Average Annual Benefit (excluding one-off)			
£630m		**Total Benefit** (PV)	**£7,580m**

Other **key non-monetised benefits** by 'main affected groups'.
Building to zero carbon standards will reduce potentially more expensive costs of subsequent retrofits in response to climate change pressures. Spillover effects of allowable solutions investment.

Key Assumptions/Sensitivities/Risks
Uncertainty about future build costs, technology solutions, learning rates, energy prices, carbon prices, and allowable solution costs over an extended period. Ranges below are based on allowable solution net costs between £50/t and £200/t.

Price Base Year	**Time Period Years**	**Net Benefit Range** (NPV)	**NET BENEFIT** (NPV Best estimate)
2008	70	**(£3,000m–£6,300m)**	**(£3,570m)**

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

Impact on Admin Burdens Baseline (2005 Prices) (Increase – Decrease)

Increase of £ Decrease of £ **Net Impact £**

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

Summary: Analysis & Evidence

Policy Option: 6	Description: Scenario 2 (Balance on and offsite) with introduction of allowable solutions from 2016 (to 100%) and from 2019 (120% of regulated).

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'	
One-off (Transition)	**Yrs**	Increased building costs; operating and maintenance costs associated with energy efficiency and LZC measures including biomass, biomass fuel cost on trajectory to 54% (carbon compliance) from 2019. Cost of allowable solutions to 100% then 120% of regulated at net £75 per tonne average.	
£			
Average Annual Cost (excluding one-off)			
£990m		**Total Cost** (PV)	**£12,010m**

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

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'	
One-off	**Yrs**	Benefits covers energy savings (£3,284m), the value of reductions in CO_2 (£4,910m) in the ETS and non-ETS sectors and the value attributable to avoided renewables (£586m).	
£			
Average Annual Benefit (excluding one-off)			
£730m		**Total Benefit** (PV)	**£8,780m**

Other **key non-monetised benefits** by 'main affected groups'.
Building to zero carbon standards will reduce potentially more expensive costs of subsequent. retrofits in response to climate change pressures. Spillover effects of allowable solutions investment.

Key Assumptions/Sensitivities/Risks
Uncertainty about future build costs, technology solutions, learning rates, energy prices, carbon prices, and allowable solution costs over an extended period. Ranges below are based on allowable solution net costs between £50/t and £200/t.

Price Base Year	Time Period Years	Net Benefit Range (NPV)	NET BENEFIT (NPV Best estimate)
2008	70	**(£2,500m–£7,500m)**	**(£3,230m)**

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

Impact on Admin Burdens Baseline (2005 Prices) (Increase – Decrease)

Increase of £ Decrease of £ **Net Impact £**

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

Evidence Base (for summary sheets)

Contents

Glossary

APEE	Advanced Practice Energy Efficiency
BCHP	Biomass combined heat and power
BTgen	Biomass trigeneration – combined cooling, heat, and power
BHtg	Biomass Heating
CCA	Climate Change Agreement
CCGT	Combined Cycle Gas Turbine
CHP	Combined heat and power (usually Gas Fired, unless another source is specified)
CRC	Carbon Reduction Commitment
DECC	Department of Energy and Climate Change
EPBD	European Union Energy Performance of Buildings Directive
ESCO	Energy Services Company
EU ETS	European Union Emissions Trading Scheme
CGSHP	Closed loop ground source heat pump
OGSHP	Open loop ground source heat pump
HESS	Heat and Energy Saving Strategy
LZC	Low and Zero Carbon technologies
NCM	National Calculation Methodology
NPV	Net Present Value
Part L	The Part of the Building Regulations which covers Conservation of Fuel and Power
Tgen	Gas-fired trigeneration – combined cooling, heat and power
SBEM	Simplified Building Energy Model
SDHW	Solar Domestic Hot Water
Wind	Wind turbine
PV	Solar Photovoltaic panels
UKGBC	UK Green Buildings Council

1 Introduction

Background to the problem under consideration

1.1 This consultation impact assessment makes an inititial exploration of high level costs and benefits associated with progressive strengthening of regulatory greenhouse gas emission standards for new non-domestic buildings.

1.2 In July 2009, the Government reaffirmed its commitment, made previously in *Building a Greener Future* (July 2007) proposals that all new homes should be built to a zero carbon build standard from 2016, with progressive tightening of Part L of the Building Regulations in 2010 and 2013.

1.3 An ambition that all new non-domestic buildings be built to a zero carbon standard from 2019, was set out in the Budget Report 2008. This was accompanied by an ambition that all schools be built to a zero carbon standard from 2016 and other new public sector buildings from 2018.

1.4 The Impact Asssessment accompanying *Building a Greener Future* (July 2007 – para 18) noted that "*Many of the generic issues relating to improvements in the carbon performance of dwellings will also apply to non-residential buildings*. *However, the characteristics of these buildings are much more variable, as are issues around occupation periods, internal heat loads, hot water demands and the balance between heating and cooling*."

1.5 The diversity of non-domestic building types was reinforced by the UK Green Buildings Council in its *Report on carbon reductions in new non-domestic buidlings* published jointly by CLG and the UKGBC in December 2007. The modelling work in chapter 4 of the UKGBC report demonstrated substantial energy demand differences that can be seen even within the same building form. The UKGBC report also emphasised that economic drivers to achieve emissions reductions would require policy intervention.

1.6 The Government consultation paper *Definition of zero carbon homes and non-domestic buildings*, published in December 2008 sought, in chapter 8, further views on both the definition of zero carbon for non-domestic buildings and the trajectory to be adopted in order to achieve such a target.[1] The consultation paper also stressed that there are particular challenges for different non-domestic buildings which need to be considered carefully. It commited to consulting further in 2009 on the regulatory aim and milestones to achieving it, and to provide an impact assesment, which is the focus of this document.

[1] www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinition

1.7 The heterogeneity of the non-domestic stock is also reflected in the proposals for the 2010 change in Part L of the building regulations, in a consultation launched in June 2009. The options in the Part L consultation include a proposed 'aggregate approach' to achieve a 25 per cent reduction in emissions (compared with the current 2006 Part L standard) from new non-domestic buildings, with some buidlings achieving higher levels of reductions and others lower levels related to the lifetime cost of energy efficiency and carbon compliance measures in different circumstances. So those building types which can abate more cheaply are set higher build standards than those which are more expensive to abate.

1.8 The *Future of Building Control: Implementation Plan*, published in September 2009, has confirmed the intention to review Parts L and F to raise carbon compliance standards further from 2013, and that a public consultation will be launched in 2012. The commitment has already been made to increase standards for homes by 44 per cent compared with 2006 Part L from 2013, which represents a 25 per cent improvement on the 2010 standard. Although no firm commitment has been made, it is assumed in this Impact Assessment that an improvement in standards for new non-domestic buildings, to be introduced from 2013, will also be consulted on as part of the 2012 review. A further review after 2013 is also anticipated in the Implementation Plan in support of changes to Part L from 2016 and 2019 in support of low and zero carbon standards.

1.9 There are also other climate change and energy policies in place or under consultation which will result in reductions in emissions from new and existing buildings and so either directly or indirectly overlap with the zero carbon build standard.

1.10 These include the EU emissions trading scheme (EU ETS), Climate Change Agreements (CCAs), the development of Carbon Budgets, the Carbon Reduction Commitment (CRC), the Heat and Energy Saving Strategy (HESS) and related renewable heat and power policies, such as the Renewable Heat Incentive. Much of the impact of these policies will be seen in existing buildings, but to the extent that they will impact on emissions from new buildings, this is taken into account in setting up the counterfactual situation against which the zero carbon options are compared. A consultation will soon be launched on a revised and streamlined Planning Policy Statement on Climate Change which will set out planning's role in the delivery of the zero carbon buildings agenda.

Market failure, climate change and non-domestic buildings

1.11 Lord Stern has declared climate change the greatest market failure the world has ever seen. A huge externality is created by the fact that polluters do not pay the costs of their emissions.

1.12 As part of the international response to tackling climate change, the Government's Climate Change Act requires an 80 per cent reduction in greenhouse gas emissions, relative to 1990 levels, by 2050, with legally binding five year carbon budgets governing the trajectory to the 2050 target.

1.13 Emissions from the way we heat, cool and power buildings are important in achieving this. Twenty-seven per cent of the UK's carbon emissions are from homes and a further 17 per cent are from non-domestic buildings.

1.14 Decarbonising new non-domestic buildings presents a particular challenge, as the design and build 'locks in' structures and technologies for the lifetime of a wide variety of different building types.

1.15 It can be technically difficult or expensive to change some elements of a building once it is constructued, whilst the costs of reducing emissions through future retrofits may also be much greater than acting at the point of build to partially decarbonise the technologies and infrastructure.

1.16 Analysis by the Carbon Trust for the non-domestic stock as a whole has illustrated the need for deep cuts in emissions from both new and existing buildings between now and 2050, if the 80 per cent target is to be met.

1.17 Additional considerations include market barriers, through:

(a) split incentives between developers and future owners (or occupants), and

(b) information assymetry as building buyers and occupants have different amounts of information on future energy prices.

1.18 Whilst there is some evidence of an emerging price premium for low carbon non-domestic buildings, perhaps more so than for homes, any premium is currently inadequate to cover the initial expenditure. If the developer is unable to increase the price of the building to reflect the additional capital expenditure, then they will not have an incentive to invest at the point of build. The result will be underinvestment in low carbon innovation in construction.

1.19 Energy costs in commercial buildings are often a small proportion of an organisation's total cost base, substantially smaller, for example, than rental, operational, equipment and staff costs. This can lead to a lack of interest in taking proactive action. This lack of materiality reflects the fact that even the most cost-effective individual measures, with high rates of return, can result in relatively small savings for businesses. So action to reduce emissions is often not undertaken even where it would be rational to do so and it becomes even more difficult for low and zero carbon buildings to attract a price premium.

1.20 Consequently, a developer may not be able to capture the future revenue streams due to lower energy use, to help cover the cost of initial capital expenditure involved in construction to low and zero carbon standards.

1.21 Developers and builders suffer the upfront capital costs whilst future business and other occupiers benefit from lower energy prices over the life of the building. This results in underinvestment in action to tackle climate change and construction of carbon emitting buildings.

1.22 This effect can be mitigated to some extent by the development of a strong energy services market which could give developers the opportunity of involving a third party, such as an Energy Services Company (ESCO). Potentially an ESCO could provide energy services for the building during occupation which could mobilise revenue savings to help cover a portion of the initial capital costs of the energy infrastructure for the developer. This process is not straightforward and the market insufficiently developed, so the distributional analysis below assumes that the developer bears the up front capital cost whilst the occupant benefits from future energy savings. However, there is scope for this market to become more developed in the lead up to the introduction of a zero carbon build standard.

1.23 In addition, energy security is an important objective which can benefit from overcoming market failure in the introduction of energy efficiency and distributed generation. Intervention at the point of build, to help reduce the need for additional grid supplied power, can contribute to action to enhance energy security and enable current and future Renewable Energy targets to be met more cheaply.

1.24 Innovation in reducing emissions from new UK non-domestic buildings could also have a spill-over demonstrator effect for influencing both existing building refurbishment and international best practice. More substantial refurbishments also need building control approval, and even where refurbishments do not, they often take current building regulations into account when proposing alterations, in order to 'future proof' the building.

1.25 Depending on allowable solution options, the trajectory can help drive the development of cost effective renewable energy generating capacity, retrofits of existing buildings, introduction of innovative low carbon technologies to encourage lower in use emissions for the building and development of heat networks, at different levels.

1.26 It is important to set a clear timetable to provide the sector with the confidence it needs to deliver.

Policy options

1.27 This document therefore provides a preliminary scoping assessment of the impact of a regulatory escalator with a number of different trajectories to the stated end point ambition of zero carbon building standards for all new non-domestic buildings introduced from 2019. Against these is an option to do nothing.

Do nothing option and reference case

1.28 The main alternative to a regulatory escalator to reduce emissions for new buildings would be to leave regulatory standards at the current level whilst using other policy mechanisms to reduce emissions.

1.29 This would result in new buildings being constructed and locked in to lower emission standards with higher energy bills for future occupiers in a context of stronger regulatory action to meet the 80 per cent reduction target for all UK emissions by 2050.

1.30 Relevant Government measures, including the EU Emissions Trading Scheme, the Renewables Obligation, Supplier Obligation, Smart Metering, Climate Change Agreements, Energy Performance Certificates and Carbon Reduction Commitment, will have various impacts.

1.31 Yet even a high and stable price of carbon, which reflects its social cost, will not necessarily ensure that price differentials incentivise developers to build to low carbon standards, in the context of the market failure identified above. Developers of new buildings will still need to compete with existing buildings for buyers in a single property market. So those developers which choose to forego investment in low carbon designs and technologies may be able to undercut green developments.

1.32 **Option 1** – 'Do Nothing.' This assumes that standards remain at 2006 levels.

1.33 '**Reference Case**' is the baseline, and assumes that the 25 per cent aggregate reduction from 2010, proposed in the Consultation Stage IA for 2010 Parts L and F of the Building Regulations, is introduced from 2010 and remains in place for 2013, 2016 and 2019. To ensure consistency with other options below, it takes into account new build for a period of ten years after the introduction of any 2019 change.

Progressive strengthening trajectory options

1.34 The advantages of a progressive strengthening of regulatory standards for new buildings have been outlined above.

1.35 Commercial considerations require a clear and transparent long-term trajectory which is technically achievable, includes a degree of flexibility to take into account the heterogeneity of building types, is realistic and is commercially viable. A long lead in time is even more relevant for some non-domestic building types than for homes.

1.36 By putting escalating carbon standards onto a regulatory footing and setting clear targets and milestones to achieving them, it should be possible to give confidence to all of the relevant actors in the building process – landowners, developers, supply chain – that carbon emissions will need to be reduced according to a clear and pre-determined trajectory.

1.37 While the potential impacts of these options have been identified below, further work is planned during the consultation to take further account of complex additional impacts from other Government measures for any specific step change.

1.38 The impacts identified below must therefore be viewed as indicative at this stage to provide a degree of regulatory clarity and will be supplemented by more detailed analysis and consultation before any specific step change is introduced.

1.39 These options are based upon an assumption that the same hierarchy outlined in the zero carbon homes consultation document is used to reach zero carbon in non-domestic buildings.[2] The three elements in the hierarchy are:

(a) To ensure a minimum level of energy efficiency to reduce the demand standard for energy from the building.

(b) To incorporate a minimum level of 'carbon compliance' which will include a combination of extra energy efficiency, on-site renewables, or direct connection of heat into the building from a heat grid or local combined heat and power plant.

[2] www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinition

(c) To reach the target standard by including 'allowable solutions' as outlined in the Zero Carbon Homes consultation document.

1.40 Details of the hierarchy can be found in the Consultation document.

1.41 Given the heterogeneity of building types and data complications relating to this sector further research has been undertaken to obtain a more detailed picture of the costs and benefits involved for a range of different building types and trajectories.

1.42 The 'Aggregate Approach' outlined in the 2010 Part L consultation, applies higher carbon compliance standards for those building types which can abate carbon more cheaply. The enhanced cost effectiveness from adopting this approach to standards was outlined in the Impact Assessment which accompanied the 2010 Consultation. The approach has also been adopted in the trajectories below.

1.43 For the purposes of this initial assessment, cost benefit analysis has been undertaken for 20 different scenarios of non-domestic building types and locations. Capital cost curves have been produced for each scenario, to identify how a particular policy trajectory might have specific impacts on different building types and locations.

1.44 Each of the trajectories below assumes a strong energy efficiency backstop based upon advanced practice standards of energy efficiency. Each then assumes a range of different carbon compliance standards being introduced from 2013, 2016, and finally as part of a zero carbon build standard from 2019.

1.45 As with Zero Carbon Homes analysis, the main focus for this consultation has been on carbon compliance levels, while a more cursory modelling of Allowable Solutions has been applied. It has been assumed that allowable solutions are available at a generic net cost of £75/tonne of CO_2 avoided to make up any shortfall against the target.[3] This is consistent with the approach adopted in the zero carbon homes IA.

1.46 This should not be interpreted that costing of Allowable Solutions is less important, but reflects the initial stage of consideration of the costs and benefits associated with the menu of Allowable Solutions, so that proposals can be developed in a context of informed evidence for carbon compliance standards with which Allowable Solution costs and benefits can be compared.

[3] This is based on a net cost of £100/tCO_2 for power and a net cost of £50/tCO_2 for heat. It is assumed that heat and power are weighted equally, resulting in a net cost for allowable solutions of £75/tCO_2. The uncertainty associated with these potential costs, has been reflected in ranges between net £50 and net £200 per tonne shown in the summary sheets.

1.47 Based on this approach the three main policy options considered here are:

(a) **Option 2** – Off-site rich (scenario 1): 30% from 2013, 37% from 2016 and 44% plus Allowable Solutions to reach Zero Carbon (100% regulated and unregulated) from 2019.

(b) **Option 3** – Balancing on- and off-site (scenario 2): 44% aggregate reduction in carbon compliance standard from 2013, 49% from 2016, 54% plus Allowable Solutions to reach Zero Carbon (100% regulated and unregulated) from 2019.

(c) **Option 4** – On-site rich (scenario 3): 44% from 2013, 53% from 2016 and 63% plus Allowable Solutions to reach Zero Carbon (100% regulated and unregulated) from 2019.

1.48 Under Options 2, 3 and 4 the use of allowable solutions to meet targets is not permitted until after 2019. Two further options have been considered under which allowable solutions can be introduced from 2016 and approaches to unregulated emissions can be considered. These are:

(a) **Option 5** – Balancing on- and off-site (scenario 2): 44% aggregate reduction in carbon compliance standard from 2013, 49% carbon compliance and 21% allowable solutions from 2016 (70% total reduction regulated), 54% carbon compliance and allowable solutions to reach Zero Carbon from 2019 for regulated energy only.

(b) **Option 6** – Balancing on- and off-site (scenario 2): 44% aggregate reduction in carbon compliance standard from 2013, 49% carbon compliance and 51% allowable solutions from 2016 (100% total reduction regulated), 54% carbon compliance and allowable solutions from 2019 to reach Zero Carbon. Additional reduction of flat 20% in regulated energy using allowable solutions to offset use of unregulated energy.

1.49 The costs and benefits of each option are estimated relative to the 2010 reference case.

1.50 In modelling these trajectories it is assumed that energy efficiency and carbon compliance measures are applied to each building type in order of ascending capital cost per tonne of CO_2 saved and that minimum energy efficiency requirements are met. The extent to which this allows each building to achieve the target level of emissions reduction will vary from case to case.

1.51 The energy covered by the policy is split into two categories:

(a) Regulated energy, which is the focus of Part L of the Building Regulations, covers energy used for space heating and cooling, hot water, ventilation and fixed lighting; and

(b) Unregulated energy, which covers other energy used in buildings for electrical appliances, secondary heating and office equipment but does not cover energy used for industrial processes.

Unregulated energy

1.52 Building Regulations are only concerned (by definition) with regulated energy, currently defined as energy used for space heating and cooling, ventilation and hot water and fixed lighting. This has traditionally been seen to be influenced by building design and hence subject to building regulations whereas occupant energy, that is energy used for small power and operational equipment (computers, servers, desk lamps, phone chargers, catering etc) is seen to be influenced by building occupants and hence out of the current jurisdiction of building regulations.

1.53 Any definition of zero carbon buildings, to be consistent with zero carbon homes would need to take into consideration energy used by these unregulated loads and an assumption has had to be made for the purposes of this IA about their magnitude in different building types.

1.54 As noted in the UK-GBC *Report on carbon reductions in new non-domestic buildings* the Simplified Building Energy Model (SBEM) calculates the loads resulting from small power and operational equipment within the building and space functions using standardised use levels and hours of occupancy for different room types. These are derived from the National Calculation Method (NCM). These small power loads estimated using SBEM have been used as a proxy for non-regulated emissions for the purposes of this IA. Industrial process loads are currently completely excluded from the small power loads in SBEM and therefore such loads as food refrigeration in supermarkets or swimming pools in hotels are not counted.

1.55 The UK-GBC report notes that there are some significant differences between what the NCM calculates as occupant energy use and what ECON (energy consumption best practice guides), and the UK-Green Building Council-collected data, suggest is actual building occupant energy consumption. It is accepted that a refinement of the NCM would be required if it is to provide an accurate estimate of occupant loads in buildings for the purposes of a zero carbon building regulations policy. However, this has not yet been determined and, in the absence of an alternative methodology the existing SBEM small power loads have been used as a proxy for unregulated emissions for the purposes of the first four options in this IA. The fifth option assumes no unregulated emissions requirement in the build standard and the sixth option assumes that all buildings will add 20 per cent onto the total regulated emissions for all building types, as a more straightforward proxy for unregulated emissions.

1.56 Lastly it is important to note that Building Regulations Part L compliance takes place before a building is occupied. Indeed, in the case of speculative office buildings compliance may take place before the occupier is known. This means that predictions of occupant energy use based on standardised loads and occupancy hours for the building-type may not always reflect the final real occupancy patterns of the building and any definition of a zero carbon build standard at Building Regulations compliance may not always reflect actual energy use in operation. Part L in this context must be seen as a compliance methodology not a guarantee of energy performance in use.

1.57 The relationship between regulated and unregulated energy, as captured using SBEM small power loads, varies by building type in Table 1.1 shows the additional emissions from unregulated energy as a percentage of the emissions from regulated energy for each of the eleven building types considered here.

Table 1.1: Emissions from regulated and unregulated energy

Building type	Unregulated emissions as % regulated
City centre HQ	37
5* hotel	24
Shopping centre	7
Mini-supermarket	7
Speculative office	37
Distribution warehouse	15
Retail warehouse	5
Large supermarket	7
3* hotel	24
2* hotel	24
Small office	67

Source: AECOM

Use of biomass

1.58 Use of biomass technologies such as wood-chip boilers and biomass fuelled combined heat and power can make a difference to the ability of a building to achieve the higher targets and to the costs of doing so. As expressed in the domestic zero carbon impact assessment, concerns about air-quality from biomass plant and the finite nature of biomass resource mean that it may not be desirable or feasible to encourage all buildings to employ these technologies. For this reason two options have been considered in this IA (as in the zero carbon homes IA): the costs of a zero carbon policy both with and without the use of biomass technologies.

1.59 Furthermore, there has been considerable debate about the most economic use of biomass; whether in heat-only applications as in biomass boilers or to produce power as in purpose-built biomass power stations, biomass CHP (Combined Heat and Power) or co-firing in power stations. Biomass CHP is one of the few technologies with the potential to allow non-domestic buildings to be entirely zero carbon (regulated and non-regulated emissions). However due to the low electrical efficiency of biomass CHP a large amount of surplus heat is produced often in excess of the heat needs of the site. As pointed out in a recent Environment Agency report[4] this does not maximise the carbon saving potential of the limited biomass resource. Therefore a sensitivity analysis has been carried out on biomass CHP with and without allowance for surplus heat. First biomass plant is only used at a size justified by the building heat load (i.e. heat led CHP) and second larger biomass CHP plant is considered to meet the electricity needs of the building but with excess heat being released to the atmosphere (i.e. electricity led). Results for the scenario in which surplus heat is allowed are presented in Appendix 3.

1.60 This modelling has demonstrated that there are substantial opportunities for developers to reduce the capital costs of abating carbon from new non-domestic buildings in those locations where there is scope to export heat to existing buildings nearby.

[4] Minimising greenhouse gas emissions from biomass energy generation www.environment-agency.gov.uk/static/documents/Research/Minimising_greenhouse_gas_emissions_from_biomass_energy__generation.pdf

2 Methodology and key assumptions

2.1 In order to model the impact of a move to zero carbon emissions for new non-domestic buildings a two stage approach has been adopted. First, AECOM has carried out an analysis of the scope for reducing emissions in a range of new buildings using the available energy efficiency and Low and Zero Carbon technology (LZC) options. Cost curves for carbon reduction have been compiled using capital cost data from published sources and industry based estimates provided by Davis Langdon. The capital costs of achieving these reductions, the energy saved and the associated CO_2 reductions are then used as inputs to the cost benefit model developed by Europe Economics. This provides aggregate estimates of social costs and benefits across all new non-domestic buildings in the form required for the IA. The main assumptions required to carry out this work are set out below and the results of the analysis are provided in the following sections.

Building types

2.2 Eleven different building types have been identified covering a variety of sizes, uses and building locations. This is a wider range of types than was analysed for the Parts L and F Consultation Stage Impact Assessment and allows more detailed analysis of how the scope for emissions reductions may vary between buildings, locations and uses. The building types are shown in Table 2.1. In addition two development scenarios, stand alone buildings and buildings linked to a district heating scheme, have been included for all except the rural buildings. Taking the development scenarios into account this provides 20 building profiles.

Table 2.1: Building types			
Building type	**Location**	**Size (m² GIFA)**	**Number of floors**
Large city centre office HQ	Urban	30,000	10
5* hotel	Urban	15,200	12
Shopping centre	Urban	30,000	2
Mini-supermarket	Urban	800	4 (under block of flats)
Medium speculative office	Edge of town	4,500	3
Distribution warehouse	Edge of town	4,900	1
Retail warehouse	Edge of town	4,900	1
Large supermarket	Edge of town	5,100	1
3* hotel	Edge of town	8,000	6
2* hotel	Rural	2,550	3
Small office	Rural	1,600	2

Source: AECOM

2.3 Each building type has been analysed using the SBEM model. Specifications have been compiled for:

(a) a Part L 2006 compliant building

(b) a Best Practice energy efficiency standard

(c) an Advanced Practice energy efficiency standard.

2.4 Costs of achieving these levels of energy saving have been estimated on the basis of elemental building costs consistent with the costs used in the Parts L and F Consultation Stage Impact Assessment IA.

Low and zero carbon (LZC) options

2.5 In order to assess the LZC options advanced practice energy profiles from each of the buildings have been taken and the carbon savings that can be achieved from the application of the low and zero carbon technologies have been assessed. Examples from existing buildings have been drawn on where relevant to identify LZC options which are appropriate to individual building types. The LZC options which have been analysed are set out in Table 2.2.

Table 2.2: LZC options for use on or near new non-domestic buildings		
LZC	Assumed Efficiencies	Notes and assumptions
Gas fired combined heat and power	Output / Heat / Elec 0-50kW / 55% / 25% 50kW+ / 52 to 42% / 28% – 38%	Efficiencies vary depending on size
Biomass combined heat and power (CHP)	Output / Heat / Elec 0-500kW / 50% / 15% 500-20000kW / 63% / 17%	Small scale assumes Organic Rankine Cycle, large scale assumes steam turbine. Assesses the economic advantages/disadvantages of allowing surplus heat in pursuance of a zero carbon standard
Gas-fired trigeneration	CHP efficiencies as above Absorption chiller = 68%	Absorption chiller assumed to be low-temperature hot water fired, i.e. COP = 0.68
Biomass-fired trigeneration	CHP efficiencies as above Absorption chiller = 68%	Absorption chiller assumed to be low-temperature hot water fired
Biomass heating	86%	Urban: Wood Pellet Edge of Town: Wood Pellet Rural: Wood Chip
Solar thermal	Evacuated Tube	Limited to roof area – assume flat roof with panels tilted south. 1m^2 Solar Thermal to every 2m^2 roof area to allow for overshadowing and maintenance
Open loop ground source heating and cooling	Heating: 420% Cooling: 540%	Considered to be delivered via heat pump – no direct cooling 45°C heating flow 6°C cooling flow
Closed loop ground source heating and cooling	Under 100kW Heating: 350% Cooling: 420% Over 100kW Heating: 370% Cooling: 520%	Considered to be delivered via heat pump – no direct cooling 45°C heating flow 6°C cooling flow
Photovoltaics	15% Monocrystalline	Limited to roof area – assume flat roof with panels tilted south. 1m^2 PV to every 2m^2 roof area to allow for overshadowing and maintenance
Wind power		1) Not included in Urban Buildings or Urban Regeneration Development Scenario. Fixed average wind speeds assumed: Edge of Town: 4 m/s. Rural: 5 m/s

Source: AECOM

Development scenarios

Stand alone buildings

2.6 As described above each of the buildings in each development scenario has been analysed on a stand alone basis to establish the carbon reductions possible through building-integrated LZC technologies. The combination of technologies that achieves the highest carbon reduction for the least capital outlay has been calculated. Generally only one heating technology is included in any combination so that, for example, solar domestic hot water panels are not used in conjunction with CHP. Cost estimates for LZCs have been compiled from information available to AECOM from previous studies and from cost information provided by Davis Langdon.

2.7 Three development scenarios have been considered with each building type being analysed individually:

Urban regeneration

(a) mini supermarket below low-rise flats (considered without energy load from flats)

(b) city centre bank headquarters

(c) 5* luxury high-rise hotel

(d) shopping centre

Edge of town

(e) 3 storey speculative offices – air-conditioned

(f) new standalone medium sized supermarket

(g) edge of town 3* hotel

(h) distribution warehouse

(i) Retail warehouse

Rural

(j) rural 2* hotel

(k) small office

District heating/combined heat and power

2.8 In order to model the effect of diversity and economies of scale possible with developments linked to district heating schemes, further LZC analysis has been carried out on buildings linked to district heating schemes for the urban and edge of town development scenarios. District heating has not been considered as an option for buildings in rural areas.

2.9 The energy profiles from each of the buildings in a development scenario have been combined in order to model the economies of scale and diversities of use that can be achieved through district scale energy schemes. In both development scenarios additional heating load (and therefore economies of scale and diversity) has been provided by a residential development. In the Urban regeneration scenario a block of 800 flats has been assumed. In the edge of town scenario a development of 800 semi-detached homes has been assumed.

2.10 The following technologies are examined at this scale:

(a) Gas-fired combined heat and power + Trigeneration.

(b) Biomass combined heat and power + Trigeneration (with and without heat-dumping).

Build rates

2.11 In order to move from the analysis of individual buildings to an aggregate view for all new build it is necessary to make assumptions about the rate of new build for each of the building types analysed. Given the uncertainty in looking at building rates as far ahead as 2031 any assumptions can only be indicative of possible outcomes and not definitive projections.

2.12 In the preparation of the IA for changes to Parts L and F Consultation Stage Impact Assessment, the Building Research Establishment (BRE) carried out an analysis of building rates over the past decade for seven broad categories of non-domestic commercial buildings. This suggested that there had been an average annual building rate of about 8.2 million square metres. Over 40 per cent of this was accounted for by deep plan office space, over 35 per cent by warehouses and over 10 per cent by retail units. The remaining categories were small offices, hotels and supermarkets. These building rates have been taken as the starting point for this zero carbon IA.

2.13 In the current analysis a larger number of building types and development scenarios are being considered than in the Parts L and F Consultation Stage Impact Assessment IA. In all there are 20 categories for which build rates must be assumed in order to provide the aggregate analysis of costs and benefits. In the absence of further detail on the breakdown of past building rates a broad judgment has been made on how each building type in the current analysis relates to the BRE categories. For each building type it has also been assumed that 60 per cent (by floor area) would be built with a stand alone boiler and 40 per cent as part of a district heating scheme. It must be emphasised that these build rates and the split between stand alone and district heating provide an indicative breakdown between categories and need to be subject to sensitivity testing. Further detail on the derivations of these build rates is set out in Appendix 1.

Costings

Energy efficiency measures

2.14 The capital cost of improving fabric and building services used in the Parts L and F Consultation Stage Impact Assessment IA have been applied to the building types considered in this IA in order to provide costs for energy efficiency measures.[5]

LZCs, capital and O&M

2.15 The capital and maintenance costs for LZCs based on information on existing LZC projects and on estimates from industry sources are set out in detail in Appendix 1. Biomass fuel is assumed to cost £0.0128/kWh over the period of the analysis.

Learning effects

2.16 Learning effects reflect the reduction in the capital costs that would be expected over time as a technology matures. Learning effects were incorporated into the projections of LZCs prepared for the consultation stage impact assessment of the definition of zero carbon homes and non-domestic buildings. The same learning rate factors for capital costs have been used in the current IA. These are shown in Appendix 1.

Energy and carbon values

2.17 In order to estimate the full social costs and benefits of the scenarios it is necessary to put values on the energy savings, CO_2 reductions and other impacts over the lives of the assets covered by the policy. The Department of Energy and Climate Change (DECC) published guidance in 2008 on the appropriate values to be used prepared by the interdepartmental analysts group (IAG).[6] These values were used in assessing the costs and benefits of the proposed changes to Part L of the Building Regulations. These values were revised in 2009 with significant increases in the values to be attributed to CO_2 reductions and energy savings.[7] These revised values have been used in this IA.

5 Proposals for amending Part L and Part F of the Building Regulations – Consultation, Volume 1, Annex B, Table A2.2

6 Greenhouse Gas Policy Evaluation and Appraisal in Government Departments. DECC, December 2008.

7 Greenhouse Gas Policy Evaluation and Appraisal in Government Departments. DECC, To be Published.

Cost benefit modelling

2.18 The cost benefit model takes the energy savings and associated emissions reductions identified for each building type together with the costs of achieving those reductions and estimates the social costs and benefits which would result if those changes were aggregated across all new non-domestic new build over a period of years.

2.19 For the reference case and each policy option it is assumed that the policy will be operative for 10 years after the point at which the zero carbon target becomes a requirement for new build in 2019. Allowing for a two year build time, this means that new buildings completed up to 2031 are included in the analysis.

2.20 The savings and costs are estimated over the life of each asset and are all relative to a 2010 energy and emissions baseline. No allowance is made for the replacement of assets at the end of their life. Thus for light fittings the costs and savings are assessed over the five year life of the initial installation. For building fabric improvements a building life of 60 years has been assumed (and 30 years for windows). Further details on assumed asset lives are given in Appendix 1.

2.21 Gas and electricity savings as a result of the policy are valued at the variable element of the respective commercial price, in line with IAG guidance. Carbon savings arising from reductions in gas consumption are valued at the Shadow Price of Carbon, while carbon savings from reductions in electricity consumption are valued at the EU-ETS permit price.

2.22 The 2008 IAG guidance also contains provision for attributing an additional value to reductions in energy consumption which reduces the level of delivered renewable energy the UK is required to achieve. In line with the guidance, a value of £18/MWh is attributed to the avoided costs of renewables.

Counterfactual

2.23 In assessing the impact of a zero carbon policy it is important to differentiate between reductions in emissions which can be attributed to that policy and reductions which would have occurred anyway in response to other pre-existing policy initiatives. For the counterfactual of what would occur even without the zero carbon policy, estimates have been incorporated into the model based on assumptions agreed with CLG about the impact of other policies. The 25 per cent saving proposed for 2010 under the Part L and F Consultation is assumed to be implemented and the costs and benefits from this, modelled using the aggregate 25 per cent approach. This provides the reference case against which the policy options are compared.

2.24 Other policies that have been quantified in the counterfactual include the Carbon Reduction Commitment, the Energy Performance of Buildings Directive (EPBD), and the impacts of smart metering and the market transformation programme. Where relevant, the effects of these policies have been split into the impacts on regulated gas use, regulated electricity use and unregulated electricity use.

2.25 The gross values of carbon savings estimated for moving from the reference case to the alternative zero carbon policy options have been reduced by the value of carbon savings attributed to these other policies. The estimated gross cost of carbon compliance measures in new buildings and additional allowable solutions to meet the zero carbon targets also needs to be adjusted to reflect costs that would be incurred in response to these other policies. Overall reductions of 20 per cent in the cost of carbon compliance measures and 25 per cent in the cost of allowable solutions have been incorporated into the final analysis. These reductions are related to the levels of carbon savings attributed to other policies.

Sensitivity testing

2.26 There is considerable uncertainty surrounding many of the estimates which feed into this cost benefit analysis. In part this is addressed by the different policy options that have been outlined. In addition the results have been tested for sensitivity to:

(a) changes in energy and carbon prices
(b) use of biomass with allowance for surplus heat
(c) no use of biomass
(d) variations in the build mix and split between stand alone and district heating
(e) higher cost of Allowable Solutions.

3 Scope for emissions reductions

Review by building type and development scenario

Levels achievable by energy efficiency and carbon compliance

3.1 The 11 building types described in Table 2.1 have been analysed using the SBEM model to identify the energy savings that can be achieved through energy efficiency measures and LZC carbon compliance.

Energy efficiency

3.2 In general, the Advanced Practice Energy Efficiency standards shown in Table 3.1 have been assumed in all building types.

Table 3.1: Advanced practice energy efficiency standards

Roof	Wall	Floor	Windows	Roof lights	Air Perm.	Heating	Cooling	Fans	Lighting
W/m^2K	W/m^2K	W/m^2K	W/m^2K	W/m^2K	$m^3/h.m^2$ @ 50Pa	η(boiler)	SEER	SFP W/l/s	lm/W
0.1	0.15	0.1	0.7	0.7	3	0.91	3.5	1.8	75

Source: AECOM

3.3 The extent of emissions reductions that can be achieved relative to the 2006 Part L baseline will vary from building to building. This is shown in Table 3.2 for the eleven building types.

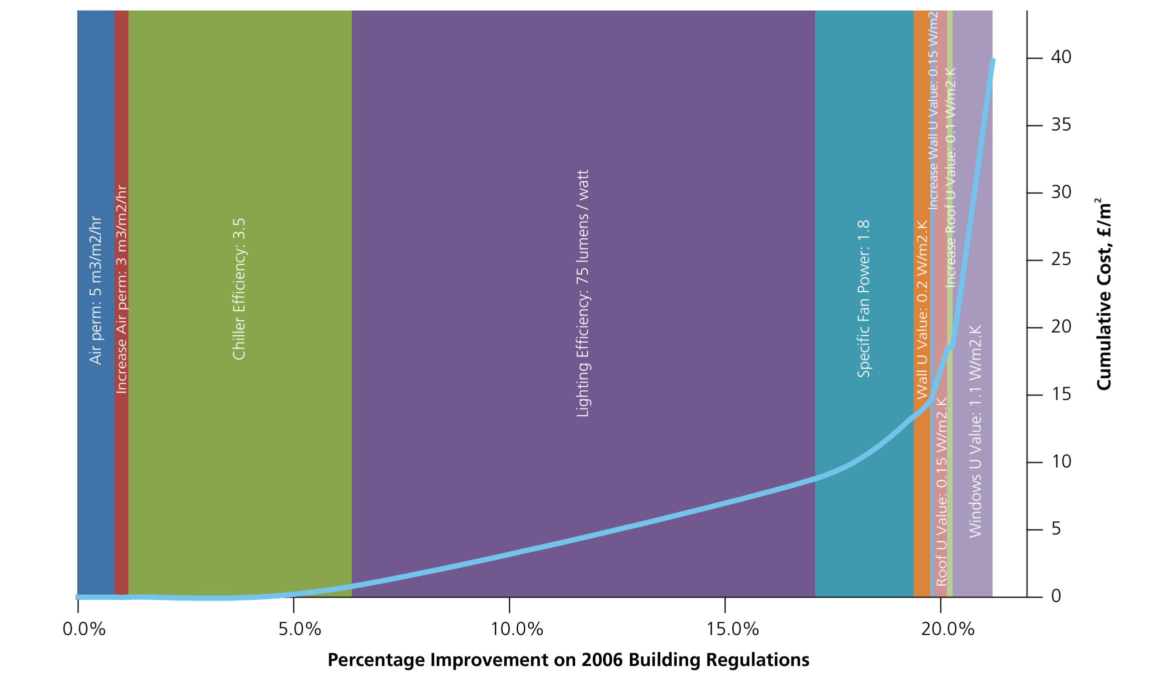
Table 3.2: Emissions reduction from energy efficiency, relative to Part L 2006

Building type	Emissions reduction achieved through energy efficiency measures
City centre HQ	21%
5* hotel	33%
Shopping centre	21%
Mini-supermarket	14%
Speculative office	21%
Distribution warehouse	55%
Retail warehouse	52%
Large supermarket	10%
3* hotel	33%
2* hotel	33%
Small office	38%

Source: Europe Economics

3.4 The combination of improved fabric and equipment specifications which delivers these increased levels of energy efficiency most cost effectively will also vary from building to building. Figure 3.1 shows the energy efficiency cost curve for a large city office. In an air conditioned building of this sort, improved chiller efficiency and improved lighting provide the bulk of the efficiency improvement at a relatively low cost.

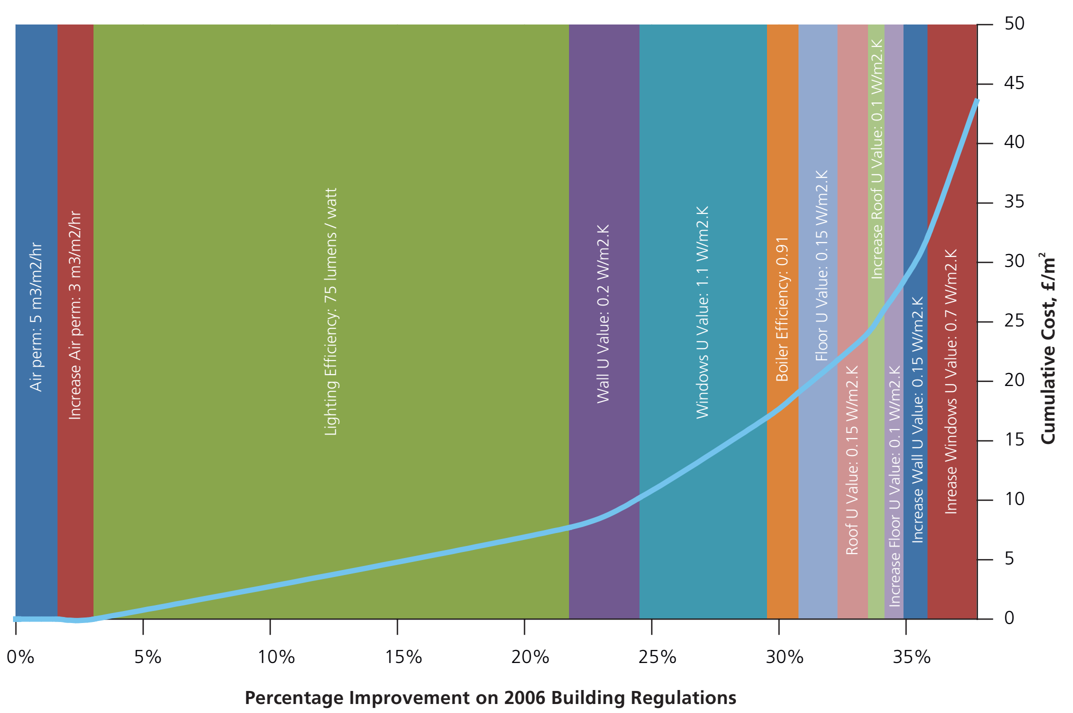
Figure 3.1: Percentage improvement on Building Regulations 2006, large office; energy efficiency measures



Source: AECOM

3.5 Figure 3.2 shows the equivalent energy efficiency cost curve for a small rural office which is naturally ventilated. Here it is the lighting and fabric measures which provide the bulk of the cost effective measures.

Figure 3.2: Percentage improvement on Building Regulations 2006, rural office; energy efficiency measures



Source: AECOM

Carbon compliance measures

3.6 The extent to which buildings are able to improve on Advanced Practice Energy Efficiency through low and zero carbon technologies also varies by building type (primarily load profile and energy density) and is dependent on location factors such as:

(a) the roof area available (as a ratio of overall floor area)

(b) the overall site area available

(c) the wind environment (suburban/rural).

Typical values for each of these factors have been applied to the building types. Hence solar photovoltaics (PV) will be able to make a greater contribution to reducing carbon emissions in a building with a large roof area in comparison to its overall Gross Internal Area (GIA) such as a warehouse.

3.7 Table 3.3 shows the percentage carbon savings possible through energy efficiency and carbon compliance including the use of biomass. Further detail on the costs and technologies assumed is set out in Appendix 2.

3.8 The results demonstrate that only a few stand alone building types can achieve a 100 per cent reduction in regulated emissions through energy efficiency and carbon compliance alone. These are limited to the distribution warehouse which has a low energy density (lights mostly off during the day) and the rural office which has access to a large roof area (in comparison to GIA) and favourable wind speeds.

3.9 With the exception of the mini-supermarket all buildings are capable of getting to about a 44 per cent improvement on the Target Emissions Reduction (TER) through energy efficiency and carbon compliance.

3.10 At the other extreme the mini-supermarket below a block of flats is only capable of achieving a 23 per cent improvement on the TER through energy efficiency and carbon compliance. This is largely due to the small roof area available for PV and the high energy density of the building type (highly lit and air-conditioned).

Table 3.3: Percentage reduction in regulated emissions achievable by stand alone building types – biomass allowed

Target reduction	25%	44%	70%	100%
URBAN				
City Centre Bank Headquarters	25%	38%		
5* Hotel	25%	44%	70%	84%
Shopping Centre	25%	38%		
Mini-supermarket	23%			
EDGE OF TOWN				
Speculative office in retail park	25%	44%	58%	
Distribution Warehouse	25%	44%	70%	100%
Retail Warehouse	25%	44%	70%	89%
Large Supermarket	25%	42%		
3* Hotel	25%	44%	70%	96%
RURAL				
2* Hotel	25%	44%	70%	93%
Small Rural Owner-Occupied Office	25%	44%	70%	100%

Source: AECOM

Savings without biomass technologies

3.11 With the exception of the large and mini supermarkets biomass technologies offer the lowest capital cost standalone means of contributing towards all carbon standards (25%, 44%, and 100%) once Advanced Practice Energy Efficiency has been applied to a building. Lower (and more costly) carbon savings will be achievable should biomass not be available at a given site or excluded as a policy decision. The savings possible in each of the building types where biomass technologies are excluded are shown in Table 3.4.

Table 3.4: Percentage reduction in regulated emissions achievable by stand alone building types – biomass not allowed

Target reduction	25%	44%	70%	100%
URBAN				
City Centre Bank Headquarters	25%	30%		
5* Hotel	25%	44%	57%	
Shopping Centre	25%	34%		
Mini-supermarket	23%			
EDGE OF TOWN				
Speculative office in retail park	25%	44%	49%	
Distribution Warehouse	25%	44%	70%	100%
Retail Warehouse	25%	44%	70%	87.5%
Large Supermarket	25%	42%		
3* Hotel	25%	44%	67%	
RURAL				
2* Hotel	25%	44%	70%	83%
Small Rural Owner-Occupied Office	25%	44%	70%	100%

Source: AECOM

District heating

3.12 In some cases buildings will be built as part of a mixed use development where a new district heating network could be built or where access to an existing district heating network is possible. District Heating and Cooling networks offer economies of scale and diversities of use that, in certain cases, allow cheaper carbon savings than through standalone technologies.

3.13 Table 3.5 shows carbon savings achievable where buildings have access to district heating with combined heat and power (both gas-fired and biomass). CHP is assumed to be heat-led (i.e. without surplus heat being generated) limiting the overall savings possible through biomass CHP.

Table 3.5: Percentage reduction in regulated emissions achievable by building types connected to district heating system – biomass allowed

Target reduction	25%	44%	70%	100%
URBAN				
City Centre Bank Headquarters	25%	36%		
5* Hotel	25%	44%	70%	91%
Shopping Centre	25%	37%		
Mini-supermarket	18%			
EDGE OF TOWN				
Speculative office in retail park	25%	44%	54%	
Distribution Warehouse	25%	44%	70%	100%
Retail Warehouse	25%	44%	70%	90%
Large Supermarket	25%	44%		
3* Hotel	25%	44%	70%	100%

Source: AECOM

3.14 As with the stand alone examples we have also examined the carbon savings possible where buildings have access to district heating but where either biomass is not available, has been excluded as a policy decision or where the technology has not yet matured. These are shown in Table 3.6.

Table 3.6: Percentage reduction in regulated emissions achievable by building types connected to district heating system – biomass not allowed

Target reduction	25%	44%	70%	100%
URBAN				
City Centre Bank Headquarters	25%	32%		
5* Hotel	25%	44%	70%	
Shopping Centre	25%	35%		
Mini-supermarket	25%			
EDGE OF TOWN				
Speculative office in retail park	25%	44%	49%	
Distribution Warehouse	25%	44%	70%	100%
Retail Warehouse	25%	44%	70%	89%
Large Supermarket	25%	42%		
3* Hotel	25%	44%	70%	78%

Source: AECOM

Surplus heat

3.15 It is considered preferable, at present, for district heating schemes to be sized according to the required heat load without the generation of significant surplus heat. Table 3.5 and Table 3.6 have been prepared on this basis. However, we have also examined the potential for carbon reductions using biomass CHP with surplus heat. This is shown in Table 3.7 and this has been included as a sensitivity test on the main findings.

Table 3.7: Percentage reduction in regulated emissions achievable by building types connected to district heating system – biomass and surplus heat allowed

Target reduction	25%	44%	70%	100%
URBAN				
City Centre Bank Headquarters	25%	44%	70%	100%
5* Hotel	25%	44%	70%	100%
Shopping Centre	25%	44%	70%	100%
Mini-supermarket	25%	44%	70%	100%
EDGE OF TOWN				
Speculative office in retail park	25%	44%	70%	100%
Distribution Warehouse	25%	44%	70%	100%
Retail Warehouse	25%	44%	70%	100%
Large Supermarket	25%	44%	70%	100%
3* Hotel	25%	44%	70%	100%

Source: AECOM

3.16 Table 3.7 shows that where district heating and biomass CHP with surplus heat is employed all buildings are able to reach full zero carbon as there is no limit to the amount of low carbon electricity that can be produced. In this case buildings make use of biomass CHP or trigeneration as the cheapest capital cost means of saving carbon.

3.17 Due to the low overall electrical efficiency of biomass CHP both development scenarios result in large amounts of surplus heat, shown in Table 3.8 in reaching full zero carbon (regulated and unregulated emissions). It is possible that additional demand for heat may develop in future which will take up some or all of this surplus.

Table 3.8: Scale of surplus heat		
Development Scenario	Percentage biomass CHP heat used to achieve zero carbon, %	Yearly biomass consumption, (including consumption of 800 dwellings)
Urban Regeneration	8% (i.e. 92% heat exported)	Approximately 28,000 tonnes
Edge of Town	25% (i.e. 75% heat rejected to atmosphere)	Approximately 5,500 tonnes

Source: AECOM

Abatement cost curves – rural office example

Methodology

3.18 Carbon abatement capital cost curves have been generated for each building type under each scenario (standalone/district heating, biomass/without biomass). These curves show the cumulative capital cost per square metre of building of achieving a given percentage reduction in regulated energy. This is illustrated here using the rural office as an example.

3.19 Figure 3.2 above shows in detail the energy efficiency measures that can be taken. These are based on the capital cost of saving 1kg of CO_2. Capital cost has been chosen over lifetime cost as this is most commonly the approach that a commercial property developer would take given a requirement to meet a given carbon target.

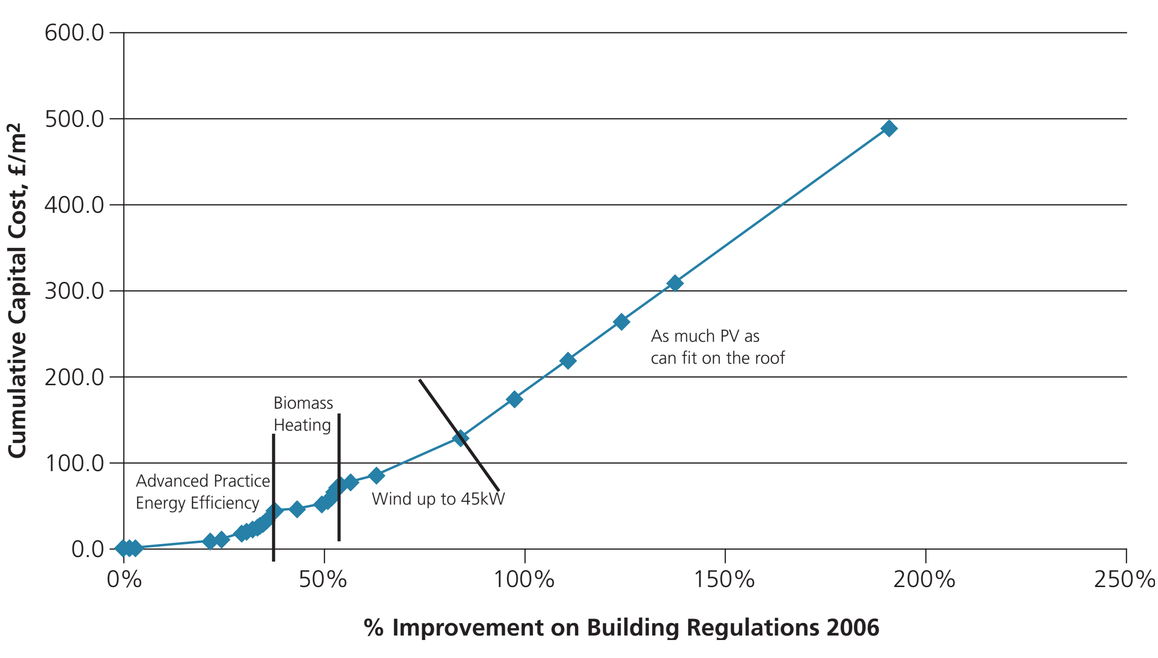
3.20 Towards the end of the energy efficiency cost curve some measures are more expensive (per kg.CO_2 saved) than low and zero carbon technologies (see below). It has been assumed, however, for the purposes of this modelling that all energy efficiency measures will be implemented first. This reflects the aspiration for a minimum energy efficiency standard to be implemented prior to carbon compliance. This is justified given the passive nature of fabric measures compared with LZCs which have a risk of not being maintained in the future.

3.21 In the case of the rural office all low and zero carbon technologies have been examined with the exception of cooling technologies such as gas-fired and biomass trigeneration since the building is naturally ventilated.

3.22 The energy efficiency and carbon compliance cost curves can be combined to give the cumulative cost of achieving a certain reduction in carbon emissions. The overall carbon abatement cost curve for the rural office is shown in Figure 3.3.

3.23 It should be noted that emissions reductions beyond 100 per cent show reductions once 100 per cent of regulated emissions have been mitigated. In the case of the rural office zero carbon is reached beyond 167 per cent reduction on 2006 Building Regulations.

Figure 3.3: Carbon abatement capital cost curve – rural office



Source: AECOM

3.24 Carbon abatement capital cost curves for other building types equivalent to Figure 3.3 are given in Appendix 2.

4 Cost-benefit analysis

4.1 Costs and benefits have been estimated for the reference case and each of the policy options outlined above following the methodology and key assumptions set out in Section 2. The targets for individual building types under the aggregate approach have been prepared by reference to the costs of CO_2 reduction discussed in Section 3. However this has not been a detailed analysis (of the sort carried out for the Parts L and F Consultation Stage Impact Assessment IA) and should only be considered as a first indication of the scope for variation between buildings at this stage.

Option 2: Off-site rich (scenario 1)

4.2 Under Option 2 the stepping stones to meeting the zero carbon target are a 30 per cent aggregate reduction in carbon compliance standard from 2013, 37 per cent from 2016 and 44 per cent plus Allowable Solutions to reach Zero Carbon (100 per cent regulated and unregulated) from 2019.

4.3 The target carbon compliance reductions for individual building types under Option 2, with and without the use of biomass are shown in Table 4.1 and Table 4.2. For those buildings which do not reach 100 per cent of regulated emissions from 2019 under the aggregate approach, the remainder of the emissions to include all regulated and unregulated emissions will need to be abated through allowable solutions.

Table 4.1: Assumed regulated emissions reductions by building type, energy efficiency and carbon compliance – biomass allowed – Option 2

Building type	2013 30%	2016 37%	2019 44%
Small office rural	27%	37%	53%
City centre HQ large office	19%	22%	28%
Spec office retail park	19%	22%	27%
Shopping centre	33%	33%	33%
Mini supermarket	11%	11%	16%
Distribution warehouse	51%	76%	85%
Retail warehouse	51%	57%	59%
5* hotel	25%	40%	79%
3* hotel	25%	48%	72%
2* hotel	25%	37%	71%
Large supermarket	11%	11%	11%

Source: Europe Economics

Table 4.2: Assumed regulated emissions reductions by building type, energy efficiency and carbon compliance – biomass not allowed – Option 2			
Building type	**2013 30%**	**2016 37%**	**2019 44%**
Small office rural	27%	38%	39%
City centre HQ large office	19%	23%	29%
Spec office retail park	19%	23%	30%
Shopping centre	33%	33%	33%
Mini supermarket	11%	16%	16%
Distribution warehouse	47%	72%	93%
Retail warehouse	52%	56%	60%
5* hotel	29%	44%	51%
3* hotel	29%	41%	53%
2* hotel	29%	39%	51%
Large supermarket	11%	11%	11%

Source: Europe Economics

4.4 Tables 4.3 and 4.4 set out the costs and benefits associated with the Option 2 using energy efficiency and carbon compliance, with and without the use of biomass, for reductions up to the 44 per cent target level and allowable solutions to achieve the zero carbon target from 2019. These tables show the incremental costs and benefits of each step towards achieving the full zero carbon target relative to the Reference case of continuing with the 25 per cent target from 2010 onwards.. For the final step the tables distinguish between the target applied to regulated and unregulated energy and show. The costs and benefits attributable to allowable solutions are shown separately.

4.5 All values are expressed in net present value terms. The final total covers the incremental costs and benefits associated with new non-domestic buildings started in the period 2013 to 2029. Energy and emissions savings from buildings started prior to 2013 are attributable to the planned changes to Part L of the Building Regulations and are taken into account in the Reference Case. The costs and benefits have been adjusted for the estimated impact of other policies already in place (see paragraphs 2.23-2.25 above).

4.6 This analysis, with biomass as an allowed option, shows that over the policy period up to 2029 the incremental cost of this option would be about £6.8 billion NPV. This would be partly offset by energy savings valued here at £2 billion NPV. There is a further benefit of £4.4 billion attributable to the value of CO_2 reductions. This leaves a net cost for Option 2 of about £0.3 billion NPV. If value is attributed to avoided renewables then this Option would show a small net benefit.

Table 4.3: Costs and benefits relative to Reference Case; Option 2, biomass allowed. £m NPV

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg		2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	30%	37%	44%	A/S	A/S	
Target reduction unregulated (%)	0%	0%	0%			100%	
Energy savings	0	179	401	1477	0	0	2,057
Incremental costs	(0)	(37)	(670)	(3870)	(1,609)	(613)	(6,799)
Sub-total	**0**	**142**	**(269)**	**(2394)**	**(1,609)**	**(613)**	**(4,742)**
Carbon savings – ETS	0	16	38	138	1,282	482	1,955
Carbon savings – non-ETS	0	71	126	435	1,314	494	2,440
Total carbon savings	0	86	164	573	2,596	977	4,395
Net benefit/ cost excl. avoided renewables	**0**	**229**	**(105)**	**(1821)**	**987**	**364**	**(347)**
Avoided renewables	0	85	118	334	0	0	537
Net benefit/ cost incl. avoided renewables	**0**	**313**	**13**	**(1487)**	**987**	**364**	**190**

Source: Europe Economics

4.7 If biomass is not allowed (Table 4.4) the incremental costs are lower at £5.7 billion NPV. This largely reflects the additional fuel costs associated with the biomass option. However without biomass the fuel savings and the CO_2 values are also lower. The net cost of the policy option without biomass is not significantly different from the option with biomass.

Table 4.4: Costs and benefits relative to Reference Case; Option 2, biomass not allowed. £m NPV							
	2010 – 2013 (incl. in c/f)	**2013 – 2016**	**2016 – 2019**	**2019 – 2029 reg**		**2019 – 2029 unreg**	**Total (2013-2029)**
Target reduction regulated (%)	25%	30%	37%	44%	A/S	A/S	
Target reduction unregulated (%)	0%	0%	0%			100%	
Energy savings	0	168	248	1115	0	0	1,531
Incremental costs	0	49	548	2965	1,513	652	5,727
Sub-total	**0**	**120**	**(300)**	**(1850)**	**(1,513)**	**(652)**	**(4,195)**
Carbon savings – ETS	0	18	20	132	1,256	518	1,944
Carbon savings – non-ETS	0	49	78	203	1,287	531	2,149
Total carbon savings	0	68	99	335	2,543	1,049	4,093
Net benefit/ cost excl. avoided renewables	**0**	**188**	**(202)**	**(1516)**	**1,030**	**397**	**(102)**
Avoided renewables	0	67	96	271	0	0	434
Net benefit/ cost incl. avoided renewables	**0**	**255**	**(106)**	**(1244)**	**1,030**	**397**	**331**

Source: Europe Economics

Option 3: Balancing on- and off-site (scenario 2)

4.8 Under this Option the intermediate steps towards meeting the zero carbon target are higher than for Option 2 with a 44 per cent aggregate reduction in carbon compliance standard from 2013, 49 per cent from 2016, 54 per cent plus Allowable Solutions to reach Zero Carbon (100 per cent regulated and unregulated) from 2019.

4.9 The target emissions reductions for individual building types for Option 3 are shown in Table 4.5 and Table 4.6.

Table 4.5: Assumed regulated emissions reductions by building type, energy efficiency and carbon compliance – biomass allowed – Option 3

Building type	2013 44%	2016 49%	2019 54%
Small office rural	53%	70%	91%
City centre HQ large office	28%	31%	36%
Spec office retail park	27%	33%	42%
Shopping centre	33%	33%	33%
Mini supermarket	16%	17%	22%
Distribution warehouse	85%	98%	100%
Retail warehouse	59%	63%	68%
5* hotel	79%	84%	84%
3* hotel	72%	80%	86%
2* hotel	71%	79%	86%
Large supermarket	11%	11%	13%

Source: Europe Economics

Table 4.6: Assumed regulated emissions reductions by building type, energy efficiency and carbon compliance – biomass not allowed – Option 3

Building type	2013 44%	2016 49%	2019 54%
Small office rural	39%	84%	100%
City centre HQ large office	29%	29%	29%
Spec office retail park	30%	41%	49%
Shopping centre	33%	33%	33%
Mini supermarket	16%	22%	22%
Distribution warehouse	93%	100%	100%
Retail warehouse	60%	66%	79%
5* hotel	51%	56%	56%
3* hotel	53%	62%	66%
2* hotel	51%	69%	82%
Large supermarket	11%	14%	20%

Source: Europe Economics

4.10 As a result the incremental costs of Option 3, with biomass allowed are significantly higher than Option 2 by nearly £5 billion NPV as shown in Table 4.7. Energy and CO_2 reductions are also lower but, overall, Option 3 has a net cost of about £4 billion NPV. The net cost is slightly lower on the biomass not allowed scenario.

Table 4.7: Costs and benefits relative to reference case; Option 3, biomass allowed. £m NPV

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg		2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54%	A/S	A/S	
Target reduction unregulated (%)	0%	0%	0%			100%	
Energy savings	0	584	643	2,057	0	0	3,284
Gas	0	287	256	723	0	0	1,266
Reg. electricity	0	126	210	740	0	0	1,076
Unreg. electricity	0	0	2	7	0	0	9
Exported electricity	0	171	174	588	0	0	933
Incremental costs	(0)	(1,305)	(1,806)	(6,370)	(1,380)	(603)	(11,463)
Sub-total	**0**	**(720)**	**(1,163)**	**(4,312)**	**(1,380)**	**(603)**	**(8,179)**
Carbon savings – ETS	0	54	69	238	1,103	475	1,938
Carbon savings – non-ETS	0	173	154	437	1,130	487	2,381
Total carbon savings	0	227	224	674	2,233	962	4,319
Net benefit/cost excl. avoided renewables	**0**	**(494)**	**(939)**	**(3,638)**	**853**	**358**	**(3,860)**
Avoided renewables	0	133	119	334	0	0	586
Net benefit/cost incl. avoided renewables	**0**	**(360)**	**(821)**	**(3,304)**	**853**	**358**	**(3,273)**

Source: Europe Economics

Table 4.8: Costs and benefits relative to reference case; Option 3, biomass not allowed

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg		2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54%	A/S	A/S	
Target reduction unregulated (%)	0%	0%	0%			100%	
Energy savings	0	446	455	1,551	0	0	2,452
Gas	0	118	116	308	0	0	542
Reg. electricity	0	264	255	891	0	0	1,409
Unreg. electricity	0	4	4	14	0	0	22
Exported electricity	0	60	80	338	0	0	479
Incremental costs	(0)	(1,175)	(1,385)	(5,275)	(1,367)	(599)	(9,800)
Sub-total	**0**	**(728)**	**(930)**	**(3,724)**	**(1,367)**	**(599)**	**(7,348)**
Carbon savings – ETS	0	53	55	203	1,110	477	1,897
Carbon savings – non-ETS	0	80	77	209	1,138	489	1,993
Total carbon savings	0	133	131	412	2,248	966	3,890
Net benefit/cost excl. avoided renewables	**0**	**(595)**	**(799)**	**(3,312)**	**881**	**367**	**(3,458)**
Avoided renewables	0	108	96	271	0	0	476
Net benefit/cost incl. avoided renewables	**0**	**(487)**	**(702)**	**(3,041)**	**881**	**367**	**(2,982)**

Source: Europe Economics

Option 4: On-site rich (scenario 3)

4.11 Under the Option 4 tighter carbon compliance standards to reach the zero carbon target are adopted from 2016 and 2019, compared with Options 2 and 3. In addition the final step in 2019 is assumed to require a higher level of reductions from on or near site carbon compliance options. This is the highest level of carbon compliance reductions which is deemed to be achievable on the basis of the energy modelling carried out. For the with biomass option this is assumed to be a reduction of 63 per cent, If biomass is not allowed then a slightly lower level of 57 per cent reduction is deemed to be achievable.

4.12 The target reductions for individual building types under Option 4, with and without the use of biomass, are shown in Table 4.9 and Table 4.10.

Table 4.9: Assumed regulated emissions reductions by building type, energy efficiency and carbon compliance – biomass allowed – Option 4

Building type	2013 44%	2016 53%	2019 63%
Small office rural	53%	87%	100%
City centre HQ large office	28%	36%	38%
Spec office retail park	27%	40%	58%
Shopping centre	33%	33%	39%
Mini supermarket	16%	22%	22%
Distribution warehouse	85%	100%	100%
Retail warehouse	59%	66%	89%
5* hotel	79%	84%	84%
3* hotel	72%	84%	96%
2* hotel	71%	84%	93%
Large supermarket	11%	13%	42%

Source: Europe Economics

Table 4.10: Assumed regulated emissions reductions by building type, energy efficiency and carbon compliance – biomass not allowed – Option 4

Building type	2013 44%	2016 53%	2019 57%
Small office rural	39%	100%	100%
City centre HQ large office	29%	29%	29%
Spec office retail park	30%	49%	49%
Shopping centre	33%	33%	33%
Mini supermarket	16%	22%	22%
Distribution warehouse	93%	100%	100%
Retail warehouse	60%	74%	87%
5* hotel	51%	56%	56%
3* hotel	53%	66%	66%
2* hotel	51%	80%	82%
Large supermarket	11%	18%	42%

Source: Europe Economics

4.13 In the biomass allowed case (Table 4.11) the incremental costs are nearly 40 per cent higher than Option 3. There are some additional energy and carbon savings from the higher emissions reductions in the early years but these by no means offset the higher costs. Overall the net cost of £7.5 billion NPV is about 50 per cent higher than for Option 3 and substantially above the net cost of Option 2.

Table 4.11: Costs and benefits relative to Reference Case; Option 4, biomass allowed. £m NPV							
	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg		2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	53%	63%	A/S	A/S	
Target reduction unregulated (%)	0%	0%	0%			100%	
Energy savings	0	584	713	2846	0	0	4,143
Incremental costs	(0)	(1,305)	(2,256)	(10,481)	(1,136)	(603)	(15,781)
Sub-total	**0**	**(720)**	**(1,543)**	**(7,635)**	**(1,136)**	**(603)**	**(11,638)**
Carbon savings – ETS	0	54	81	371	912	475	1,893
Carbon savings – non-ETS	0	173	155	437	935	487	2,186
Total carbon savings	0	227	236	808	1,847	962	4,079
Net benefit/cost excl. avoided renewables	**0**	**(494)**	**(1,307)**	**(6,827)**	**711**	**358**	**(7,559)**
Avoided renewables	0	133	119	334	0	0	586
Net benefit/cost incl. avoided renewables	**0**	**(360)**	**(1,189)**	**(6,493)**	**711**	**358**	**(6,973)**

Source: Europe Economics

4.14 For Option 4 the biomass not allowed case has a significantly lower net cost of £4 billion NPV than with biomass (Table 4.12). This is a reflection of the lower level of emissions reductions achievable from carbon compliance solutions under this scenario. The additional 6 per cent of reductions assumed to be achievable from carbon compliance in the with biomass case carry a high incremental cost.

Table 4.12: Costs and benefits relative to Reference Case; Option 4, biomass not allowed. £m NPV							
	2010 – 2013 (incl. in c/f)	**2013 – 2016**	**2016 – 2019**	**2019 – 2029 reg**		**2019 – 2029 unreg**	**Total (2013-2029)**
Target reduction regulated (%)	25%	44%	53%	57%	A/S	A/S	
Target reduction unregulated (%)	0%	0%	0%			100%	
Energy savings	0	443	550	1932	0	0	2,924
Incremental costs	(0)	(1,168)	(1,806)	(5,983)	(1,324)	(581)	(10,862)
Sub-total	**0**	**(725)**	**(1,256)**	**(4,052)**	**(1,324)**	**(581)**	**(7,939)**
Carbon savings – ETS	0	52	72	268	1,065	464	1,921
Carbon savings – non-ETS	0	80	74	208	1,092	476	1,930
Total carbon savings	0	132	146	476	2,158	939	3,851
Net benefit/cost excl. avoided renewables	**0**	**(593)**	**(1,111)**	**(3,576)**	**834**	**358**	**(4,088)**
Avoided renewables	0	108	96	271	0	0	476
Net benefit/cost incl. avoided renewables	**0**	**(485)**	**(1,014)**	**(3304)**	**834**	**358**	**(3,612)**

Source: Europe Economics

Option 5: 70 per cent target in 2016 with use of allowable solutions

4.15 Using the balanced on- and off-site scenario from Option 3, Option 5 considers a 70 per cent emissions reduction target for regulated energy from 2016 to be met partly from carbon compliance and partly from allowable solutions. 100 per cent abatement of emissions from regulated energy is required from 2019 but there is no requirement to abate emissions from unregulated energy. This Option has only been analysed for the with biomass scenario.

4.16 Under this Option the emissions reductions at building level are assumed to be same as those shown in Table 4.5. The costs and benefits associated with Option 5 are shown in Tables 4.13 (with biomass).

4.17 The incremental cost of Option 5 over the reference case shown for the with biomass case is just over £11 billion NPV. This is slightly lower than for Option 3. However the estimates value of CO_2 savings is also lower for Option 5 and the net cost of this option of £3.5 billion is slightly higher than for Option 3. The introduction of allowable solutions from 2016 for Option 5 increases the present cost by approximately £290m, although this is sensitive to the assumed costs of allowable solutions. This is more than offset by the £370m present value of carbon saved.

Table 4.13: Costs and benefits; Option 5, biomass allowed, 70% regulated energy in 2016, 100% regulated 2019 with allowable solutions (at £75/tCO_2)

	2010 – 2013 (incl. in c/f)	**2013 – 2016**	**2016 – 2019**	**2019 – 2029 reg**	**Total (2013-2029)**
Target reduction regulated (%)	25%	44%	49% +21% AS	54% + 46% AS	
Target reduction unregulated (%)	0%	0%	0%	0%	
Energy savings	0	584		2,057	3,284
Incremental costs	(0)	(1,305)	(2,096)	(7,749)	(11,150)
Sub-total	**0**	**(720)**	**(1,454)**	**(5,692)**	**(7,866)**
Carbon savings – ETS	0	54		1,340	
Carbon savings – non-ETS	0	173		1,567	
Total carbon savings	0	227	581	2,907	3,715
Net benefit/cost excl. avoided renewables	**0**	**(494)**	**(872)**	**(2,785)**	**(4,151)**
Avoided renewables	0	133	119	334	586
Net benefit/cost incl. avoided renewables	**0**	**(360)**	**(754)**	**(2,451)**	**(3,565)**

Source: Europe Economics

Option 6: 100 per cent target in 2016 with use of allowable solutions, 120 per cent abatement from 2019

4.18 Again using the balanced on- and off-site scenario from Option 3, Option 6 considers a 100 per cent emissions reduction target for regulated energy from 2016 to be met partly from carbon compliance and partly from allowable solutions. 100 per cent aggregate abatement of emissions from regulated energy is required from 2019 with a further requirement to abate an additional 20 per cent of regulated energy for each building type to allow for unregulated energy.

4.19 The incremental cost of Option 6 over the reference case shown in Table 4.14 is £12 billion NPV. This is about £0.5 billion higher than Option 3 and £1 billion more than Option 5. This higher cost is partly offset by a higher value of CO_2 reductions to give a net cost of just over £3 billion NPV, very close to the net cost of Option 3. The introduction of allowable solutions from 2016 for Option 6 increases the present cost by approximately £540m, although this is sensitive to the assumed costs of allowable solutions. This is more than offset by the £580m present value of carbon saved.

Table 4.14: Costs and benefits; Option 6, biomass allowed, 100% regulated energy in 2016 with allowable solutions (at £75/tCO_2), 120% regulated from 2019

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 reg addition	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49% + 51% AS	54% + 46% AS	20% AS	
Target reduction unregulated (%)	0%	0%	0%			
Energy savings	0	584	643	2,057	0	3,284
Incremental costs	(0)	(1,305)	(2,346)	(7,749)	(608)	(12,008)
Sub-total	**0**	**(720)**	**(1,703)**	**(5,692)**	**(608)**	**(8,724)**
Carbon savings – ETS	0	54		1,340		
Carbon savings – non-ETS	0	173		1,567		
Total carbon savings	0	227	803	2,907	961	4,898
Net benefit/cost excl. avoided renewables	**0**	**(494)**	**(900)**	**(2,785)**	**353**	**(3,826)**
Avoided renewables	0	133	119	334	0	586
Net benefit/cost incl. avoided renewables	**0**	**(360)**	**(782)**	**(2,451)**	**353**	**(3,240)**

Source: Europe Economics

Cost effectiveness

4.20 Options 2, 3 and 4 can be compared using a measure of cost effectiveness. This (calculated in line with IAG guidance) provides an indicative measure of the cost per tonne of CO_2 in the ETS and non-ETS sectors. The values shown in Table 4.13 broadly follow the findings described above from the main cost-benefit tabulations. The policy shows greater cost effectiveness, (i.e. lower values), the less onerous are the carbon compliance standards in the years up to 2019. For the Option 2 and Option 3 there is no major difference between cost effectiveness whether or not biomass is allowed but with a marginal preference for the use of biomass. For Option 4, as noted above, biomass is considerably less effective in abating CO_2 in the non-ETS sector. This is a reflection of the higher level of carbon compliance which can be achieved from 2019 in this scenario with the use of biomass.

4.21 These cost effectiveness values can be compared with the value attributable to the reduction in CO_2 emissions over the life of the policy. This value is measured as the weighted average discounted (WAD) value of CO_2 in the ETS and non-ETS sectors. The structure of the models used makes it difficult to carry out a full calculation of the WAD but the cost effectiveness values shown in Table 4.15 are, for the most part, higher than the traded and non-traded price of CO_2 set out in the DECC guidance except in some cases in later years. If these CO_2 values are discounted the WAD values for these policy options are likely to be below the cost effectiveness values.

Table 4.15: Cost effectiveness of zero carbon policy options – £/tCO_2

	Option 2		**Option 3**		**Option 4**	
	Biomass	No biomass	Biomass	No biomass	Biomass	No biomass
Non-ETS (£/tCO_2)	42	42	95	108	160	123
ETS (£/tCO_2)	43	38	94	90	138	91

Source: Europe Economics

Reductions in CO_2

4.22 Table 4.16 shows the estimated reductions in the volumes of CO_2 that might be achieved under the three policy options over and above reductions achieved in the 2010 baseline. These volumes have been estimated over the life of the assets covered by the policy.

Table 4.16: Total volume of CO_2 savings over the life of assets relative to baseline. mtCO_2

	Option 2		**Option 3**		**Option 4**	
	Biomass	No biomass	Biomass	No biomass	Biomass	No biomass
Non-ETS)	66	54	65	51	61	49
ETS	54	54	62	60	69	66

Source: Europe Economics

Allowable solutions in 2016

4.23 The possibility of requiring new buildings to move towards or reach a zero carbon standard for regulated energy from 2016 has been considered in Options 5 and 6. Cost effectiveness values for these options are shown in Table 4.17. These values can be compared with the values for Option 3 in Table 4.15 of £95/tCO_2 for the Non-ETS sector and £94/tCO_2 in the ETS sector.

Table 4.17: Cost-effectiveness of introducing allowable solutions in 2016 – biomass allowed

	Option 5		Option 6	
Allowable solutions	£75/tCO_2	£100/tCO_2	£75/tCO_2	£100/tCO_2
Non-ETS (£/tCO_2)	110	121	94	107
ETS (£/tCO_2)	110	121	83	93

Impact on individual building types

4.24 Analysis has been carried out to provide more evidence on the impact of the policy for particular stakeholders. For developers, Table 4.18 and Table 4.19 show the incremental building costs to achieve carbon compliance for Option 3 (expressed in £/m^2) with and without biomass. There is considerable variation between building types. For some building types the percentage cost increase is higher with the use of biomass, for others it is higher where biomass is not allowed. This is a reflection both of the mix of technologies which has been assumed for each building type and of the differing extent to which costs have been incurred prior to 2010 (which is the reference for the comparison).

4.25 Tables 4.20 and 4.21 give the equivalent carbon compliance incremental building cost increases for the Offsite-rich scenario 1 and Tables 4.22 and 4.23 provide the same information for the Onsite-rich scenario 3. The capital cost curves in Appendix 2 provide additional information for developers. These are snapshots, excluding learning rates, of the current additional capital cost of improving on 2006 Part L standards and give an indication of the current least cost technologies identified.

Table 4.18: Option 3, Incremental building costs (based on typical build cost) – Biomass allowed

	Base build cost – 2006 standards (£/m²)	Incremental capital cost (relative to 2010 reference case) per cent		
		2013	2016	2019
Stand alone				
2* Hotel	1,120	5%	7%	11%
3* Hotel	1,830	3%	4%	7%
5* Hotel	2,375	2%	4%	3%
Convenience store	1,315	1%	6%	6%
Large office	2,250	2%	3%	5%
Medium office	940	5%	8%	12%
Shopping centre	3,560	0%	0%	0%
Small office	865	6%	9%	14%
Supermarket	1,325	0%	0%	2%
Distribution warehouse	320	19%	28%	28%
Retail warehouse	745	8%	13%	17%
District heating				
3* Hotel	1,830	2%	2%	3%
5* Hotel	2,375	2%	2%	2%
Convenience store	1,315	3%	4%	35%
Large office	2,250	2%	3%	5%
Medium office	940	6%	15%	15%
Shopping centre	3,560	0%	0%	0%
Supermarket	1,325	0%	0%	2%
Distribution warehouse	320	23%	30%	30%
Retail warehouse	745	8%	13%	17%

Source: Europe Economics

Table 4.19: Option 3, Incremental building costs (based on typical build cost) – Biomass not allowed

	Base build cost – 2006 standards (£/m²)	Incremental capital cost (relative to 2010 reference case) per cent		
		2013	2016	2019
Stand alone				
2* Hotel	1,120	7%	12%	18%
3* Hotel	1,830	4%	7%	8%
5* Hotel	2,375	3%	4%	3%
Convenience store	1,315	1%	6%	6%
Large office	2,250	3%	3%	3%
Medium office	940	7%	13%	18%
Shopping centre	3,560	0%	0%	-1%
Small office	865	4%	14%	19%
Supermarket	1,325	0%	0%	2%
Distribution warehouse	320	21%	23%	22%
Retail warehouse	745	11%	17%	30%
District heating				
3* Hotel	1,830	4%	4%	5%
5* Hotel	2,375	2%	2%	2%
Convenience store	1,315	2%	6%	6%
Large office	2,250	3%	3%	3%
Medium office	940	7%	13%	23%
Shopping centre	3,560	0%	0%	-1%
Supermarket	1,325	0%	2%	6%
Distribution warehouse	320	34%	38%	36%
Retail warehouse	745	11%	17%	31%

Source: Europe Economics

Table 4.20: Option 2, Offsite Rich - Incremental building costs (based on typical build cost) - Biomass allowed				
	Base build cost – 2006 standards (£/m2)	**Incremental capital cost (relative to 2010 reference case) per cent**		
		2013	2016	2019
Stand alone				
2* Hotel	1,120	0%	3%	5%
3* Hotel	1,830	0%	2%	3%
5* Hotel	2,375	0%	1%	2%
Convenience store	1,315	0%	0%	1%
Large office	2,250	0%	1%	2%
Medium office	940	0%	3%	5%
Shopping centre	3,560	0%	0%	0%
Small office	865	0%	3%	6%
Supermarket	1,325	0%	0%	-1%
Distribution warehouse	320	1%	12%	17%
Retail warehouse	745	1%	6%	8%
District heating				
3* Hotel	1,830	0%	2%	2%
5* Hotel	2,375	0%	1%	2%
Convenience store	1,315	0%	0%	3%
Large office	2,250	0%	1%	2%
Medium office	940	0%	3%	12%
Shopping centre	3,560	0%	0%	0%
Supermarket	1,325	0%	0%	0%
Distribution warehouse	320	1%	17%	23%
Retail warehouse	745	1%	6%	8%

Source: Europe Economics

Table 4.21: Option 2, Offsite Rich - Incremental building costs (based on typical build cost) - Biomass not allowed

	Base build cost – 2006 standards (£/m2)	Incremental capital cost (relative to 2010 reference case) per cent		
		2013	2016	2019
Stand alone				
2* Hotel	1,120	1%	3%	6%
3* Hotel	1,830	0%	2%	4%
5* Hotel	2,375	0%	2%	3%
Convenience store	1,315	0%	0%	1%
Large office	2,250	0%	1%	3%
Medium office	940	0%	4%	7%
Shopping centre	3,560	0%	0%	-1%
Small office	865	0%	3%	4%
Supermarket	1,325	0%	0%	-1%
Distribution warehouse	320	2%	12%	20%
Retail warehouse	745	1%	6%	10%
District heating				
3* Hotel	1,830	0%	3%	4%
5* Hotel	2,375	0%	2%	2%
Convenience store	1,315	0%	1%	1%
Large office	2,250	0%	2%	3%
Medium office	940	0%	4%	7%
Shopping centre	3,560	0%	0%	-1%
Supermarket	1,325	0%	0%	0%
Distribution warehouse	320	2%	18%	31%
Retail warehouse	745	1%	6%	10%

Source: Europe Economics

Table 4.22: Option 4 – Onsite Rich, Incremental building costs (based on typical build cost) - Biomass allowed				
	Base build cost – 2006 standards (£/m2)	**Incremental capital cost (relative to 2010 reference case) per cent**		
		2013	2016	2019
Stand alone				
2* Hotel	1,120	5%	10%	11%
3* Hotel	1,830	3%	7%	10%
5* Hotel	2,375	2%	4%	3%
Convenience store	1,315	1%	6%	6%
Large office	2,250	2%	5%	9%
Medium office	940	5%	12%	33%
Shopping centre	3,560	0%	0%	5%
Small office	865	6%	13%	16%
Supermarket	1,325	0%	2%	20%
Distribution warehouse	320	19%	29%	28%
Retail warehouse	745	8%	16%	38%
District heating				
3* Hotel	1,830	2%	3%	7%
5* Hotel	2,375	2%	2%	2%
Convenience store	1,315	3%	37%	35%
Large office	2,250	2%	5%	5%
Medium office	940	6%	15%	25%
Shopping centre	3,560	0%	0%	1%
Supermarket	1,325	0%	2%	23%
Distribution warehouse	320	23%	34%	34%
Retail warehouse	745	8%	16%	37%

Source: Europe Economics

Table 4.23: Option 4 – Onsite rich, Incremental building costs (based on typical build cost) - Biomass not allowed

	Base build cost – 2006 standards (£/m2)	Incremental capital cost (relative to 2010 reference case) per cent		
		2013	2016	2019
Stand alone				
2* Hotel	1,120	7%	18%	18%
3* Hotel	1,830	3%	10%	9%
5* Hotel	2,375	3%	4%	3%
Convenience store	1,315	1%	6%	6%
Large office	2,250	3%	3%	3%
Medium office	940	7%	18%	18%
Shopping centre	3,560	0%	0%	-1%
Small office	865	4%	19%	19%
Supermarket	1,325	0%	2%	20%
Distribution warehouse	320	21%	23%	22%
Retail warehouse	745	11%	27%	37%
District heating				
3* Hotel	1,830	4%	5%	5%
5* Hotel	2,375	2%	2%	2%
Convenience store	1,315	2%	6%	6%
Large office	2,250	3%	3%	3%
Medium office	940	7%	24%	23%
Shopping centre	3,560	0%	0%	-1%
Supermarket	1,325	0%	5%	25%
Distribution warehouse	320	34%	38%	36%
Retail warehouse	745	11%	27%	37%

Source: Europe Economics

Impact on building energy costs

4.26 For consumers, Table 4.24 and Table 4.25 provide an indication of how the value of the energy savings (expressed in savings in £/m^2 relative to 2013) differ between building types. Again there is considerable variation between building types and between the two scenarios. These values have been calculated using the latest DECC values for commercial energy prices. These savings only cover the reductions in energy consumption achieved through on-site Carbon Compliance measures and do not include any allowance for electricity exported.

For some building types, such as the distribution warehouse and the large office, the savings from Carbon Compliance measures are considerable greater in the with biomass case. This is a reflection of the technologies assumed to be adopted in each case to achieve the energy reductions.

Table 4.24: Option 3, Incremental energy savings £/m² – Biomass allowed

	Incremental energy savings (relative to 2010 reference case) (£/m²)					
	2013		2016		2019	
	gas	electricity	gas	electricity	gas	electricity
Stand alone						
2* Hotel	3.78	0.91	3.94	2.06	3.94	3.09
3* Hotel	3.78	0.87	3.94	1.82	3.94	2.24
5* Hotel	3.78	2.29	3.94	3.32	3.94	3.38
Mini supermarket	0.28	0.98	0.29	1.24	0.29	2.43
Large office	0.28	0.22	0.30	0.59	0.30	0.95
Medium office	0.28	-0.01	0.30	0.63	0.30	1.61
Shopping centre	0.00	0.18	0.00	0.27	0.00	0.36
Small office	0.95	0.03	1.00	0.64	1.00	1.51
Supermarket	0.00	0.01	0.03	0.02	0.03	0.48
Distribution warehouse	1.04	0.98	1.08	1.40	1.08	1.52
Retail warehouse	1.41	2.39	1.45	3.24	1.45	4.30
District heating						
3* Hotel	3.51	1.79	3.94	2.69	3.94	3.74
5* Hotel	3.38	3.49	3.60	4.18	3.60	6.17
Convenience store	0.40	0.86	0.43	1.11	0.56	1.19
Large office	0.28	0.21	0.30	0.55	0.30	0.93
Medium office	0.28	0.03	0.30	0.68	0.30	1.66
Shopping centre	0.00	0.18	0.00	0.27	0.00	0.36
Supermarket	0.00	0.01	0.03	0.01	0.03	0.07
Distribution warehouse	1.02	1.02	1.06	1.54	1.06	1.76
Retail warehouse	1.38	2.44	1.41	3.29	1.41	4.35

Source: Europe Economics

Table 4.25: Option 3, Incremental energy savings £/m² – Biomass not allowed

	Incremental energy savings (relative to 2010 reference case) (£/m²)					
	2013		2016		2019	
	gas	electricity	gas	electricity	gas	electricity
Stand alone						
2* Hotel	3.49	–1.57	3.93	0.51	3.93	2.36
3* Hotel	3.64	–1.53	3.94	–0.53	3.94	0.05
5* Hotel	–0.87	4.09	0.14	3.38	0.14	3.44
Mini supermarket	0.28	0.98	0.29	1.24	0.29	2.43
Large office	0.22	0.72	0.24	0.75	0.24	0.77
Medium office	0.21	0.83	0.23	2.01	0.30	2.75
Shopping centre	0.00	0.19	0.00	0.28	0.00	0.38
Small office	0.48	0.03	0.22	2.24	0.22	3.28
Supermarket	0.00	0.01	0.03	0.02	0.03	0.48
Distribution warehouse	0.37	1.55	0.38	1.59	0.38	2.16
Retail warehouse	1.02	3.08	1.04	4.31	1.04	6.89
District heating						
3* Hotel	–3.56	2.93	–5.46	4.39	–5.53	7.82
5* Hotel	–3.54	4.35	–3.76	4.43	–3.76	7.82
Convenience store	0.08	1.28	0.25	2.44	0.25	2.49
Large office	–0.06	1.14	–0.05	1.17	–0.05	1.20
Medium office	0.28	0.57	0.30	1.74	0.24	2.65
Shopping centre	0.00	0.18	0.00	0.28	0.00	0.37
Supermarket	0.00	0.02	0.02	0.71	0.02	2.10
Distribution warehouse	0.60	1.45	0.63	1.53	0.63	1.75
Retail warehouse	0.98	3.13	1.00	4.36	1.00	6.94

Source: Europe Economics

Sensitivity analysis

4.27 The modelling requires a number of assumptions to be made about future outcomes which are necessarily uncertain and we have carried out sensitivity tests to show how changes in key assumptions affect the costs and benefits. These cover alternative trajectories leading up to the zero carbon target in 2019, changes to the energy and carbon values, a different mix of district heating and stand alone buildings and a change in the build rate for certain building types.

Energy prices and carbon valuation

4.28 In order to provide an indication of the impact of changes in energy prices and carbon values costs and benefits have been estimated using projected low and high energy and carbon values in the revised 2009 DECC guidance.

4.29 The impact of using these alternative values can be seen in Table 4.26 by comparing the cost effectiveness values. Tables showing the full breakdown of costs and benefits for all of the sensitivity tests can be found in Appendix 3. Lower energy and carbon prices considerably worsen the cost effectiveness of all of the policy options. If higher energy and carbon values are considered more appropriate then the cost effectiveness of each of the options is improved.

Table 4.26: **Cost effectiveness of zero carbon policy; energy price and carbon valuation sensitivity**

	Option 2		Option 3		Option 4	
	Biomass	No biomass	Biomass	No biomass	Biomass	No biomass
Low energy prices and low carbon valuations						
Non-ETS (£/tCO_2)	102	103	180	203	273	229
ETS (£/tCO_2)	60	54	106	100	147	104
Central energy prices and central carbon valuations						
Non-ETS (£/tCO_2)	42	42	95	108	160	123
ETS (£/tCO_2)	43	38	94	90	138	91
High energy prices and high carbon valuations						
Non-ETS (£/tCO_2)	16	15	56	64	106	75
ETS (£/tCO_2)	19	19	89	86	142	87

Source: Europe Economics

Proportions of stand-alone and district heating in the build mix

4.30 The main analysis of options assumes that 40 per cent of new non-domestic buildings form part of a district heating scheme and that 60 per cent are stand alone. At present only a small percentage of new build is linked to district heating and in order to explore the effect of a lower level the costs and benefits have been re estimated assuming that only 30 per cent of new build is linked to district heating. Tables showing the full costs and benefits can be found in the appendix. The impact of changing this assumption on cost effectiveness is shown in Table 4.27. From this it can be seen that reducing the proportion of new buildings linked to district heating systems by one quarter has only a small effect. Surprisingly this analysis shows that a lower level of district heating improves the cost effectiveness of the policy. This finding requires further analysis during the Consultation period.

Table 4.27: Cost effectiveness of zero carbon policy; proportion of district heating sensitivity						
	Option 2		**Option 3**		**Option 4**	
	Biomass	No biomass	Biomass	No biomass	Biomass	No biomass
40% district heating						
Non-ETS (£/tCO_2)	42	42	95	108	160	123
ETS (£/tCO_2)	43	38	94	90	138	91
30% district heating						
Non-ETS (£/tCO_2)	40	40	92	104	159	118
ETS (£/tCO_2)	41	36	93	87	141	89

Source: Europe Economics

Cost of allowable solutions

4.31 Sensitivity analysis using £100/tCO_2 for allowable solutions rather than £75/tCO_2 was also carried out. The resulting cost-effectiveness numbers are set out in Table 4.28.

Table 4.28: Cost effectiveness of zero carbon policy; cost of allowable solutions						
	Option 2		**Option 3**		**Option 4**	
Allowable solutions £75/tCO_2	Biomass	No biomass	Biomass	No biomass	Biomass	No biomass
Non-ETS (£/tCO_2)	42	42	95	108	160	123
ETS (£/tCO_2)	43	38	94	90	138	91
Allowable solutions £100/tCO_2	Biomass	No biomass	Biomass	No biomass	Biomass	No biomass
Non-ETS (£/tCO_2)	54	55	106	121	169	136
ETS (£/tCO_2)	57	52	105	101	146	101

Source: Europe Economics

Use of district heating with surplus heat

4.32 The scenarios that have been analysed including connection to district heating schemes have assumed that the equipment is sized according to the expected heat load. However, as shown in Table 3.7, higher levels of emissions can be achieved at lower capital cost if the equipment is sized for the energy load and surplus heat is generated. If generation of surplus heat was allowed this would significantly reduce the cost of the policy as is shown in the lower cost effectiveness values in Table 4.29.

Table 4.29: Cost effectiveness of zero carbon policy; surplus heat allowed in district heating cases

	Option 2		Option 3		Option 4	
	Surplus heat not allowed (base case)	Surplus heat allowed	Surplus heat not allowed (base case)	Surplus heat allowed	Surplus heat not allowed (base case)	Surplus heat allowed
Non-ETS (£/tCO_2)	42	29	95	64	160	111
ETS (£/tCO_2)	43	27	94	60	138	98

Source: Europe Economics

Change in build mix

4.33 The aggregate approach to emissions reductions assumes different levels of CO_2 reduction for different building types in the run up to the zero carbon targets in 2019. The aggregate reduction achieved is then the average of these individual building types weighted by the build rate assumed for each building type. If those build rates are not achieved then the aggregate reduction will be affected. To illustrate this we have estimated the impact of a 10 per cent reduction in the build rate for distribution warehouses which is the largest building category in the analysis. Table 4.30 and Table 4.31 show how the aggregate reductions assumed for each of the policy options would be affected.

Table 4.30: Trajectories for aggregate emissions reductions with 10% reduction in distribution warehouse build, biomass allowed

	2013		2016		2019	
	Base case	10% reduction	Base case	10% reduction	Base case	10% reduction
Option 2	30%	30%	37%	36%	44%	43%
Option 3	44%	43%	49%	48%	54%	53%
Option 4	44%	44%	53%	52%	63%	63%

Source: Europe Economics

Table 4.31: Trajectories for aggregate emissions reductions with 10% reduction in distribution warehouse build, biomass not allowed

	2013		2016		2019	
	Base case	10% reduction	Base case	10% reduction	Base case	10% reduction
Option 2	30%	30%	37%	36%	44%	43%
Option 3	44%	43%	49%	48%	54%	53%
Option 4	44%	43%	53%	52%	57%	56%

Source: Europe Economics

4.34 A reduction of this scale in this one element of the build mix (which accounts for nearly 30 per cent of the total assumed new build) has a relatively small effect on the overall level of emissions reductions that would be achieved.

Grid decarbonisation

4.35 The main analysis has been carried out using an assumption of a constant level of carbon emissions from electricity. The marginal emissions savings from the policy are assumed to be related to a gas fired CCGT. Sensitivity analysis has been carried out using the assumptions for the marginal emissions factor provided for the Inter-Departmental Analysts Group by DECC. This allows for progressive decarbonisation of grid electricity over time. The sensitivity analysis, which was carried out for the Option 3, biomass allowed scenario, takes into account the lower level of emissions reductions that would be achieved by reduction in the use of grid electricity. This increases the net cost of the policy. The building standards, carbon compliance and allowable solutions assumptions for each building type have not been adjusted. The cost-effectiveness numbers for this sensitivity test are set out in Table 4.32.

Table 4.32: **Cost effectiveness; Option 3; biomass allowed; DECC 2009 grid decarbonisation assumptions**

	Option 3	
	No decarbonisation assumption (base case)	Latest IAG decarbonisation assumptions
Non-ETS (£/tCO_2)	95	141
ETS (£/tCO_2)	94	146

Source: Europe Economics

5 Specific impact tests

Competition assessment

5.1 According to the OFT competition assessment guidance[8] when analysing competition impacts the following questions should be addressed. In any affected market would the proposal:

(a) Directly limit the range of supplier?

(b) Indirectly limit the number or range of suppliers?

(c) Limit the ability of suppliers to compete?

(d) Reduce suppliers' incentives to compete vigorously?

5.2 The effect of the proposals would be to increase the costs of constructing new non-domestic buildings and to increase the demand for LZC technologies. The principal markets affected by the policy are those for the development of new non-domestic buildings and those for the production of the following LZC technologies:

(a) biomass CHP

(b) biomass heating

(c) biomass trigeneration

(d) closed GSHP

(e) gas CHP

(f) gas trigeneration

(g) open GSHP

(h) solar PV

(i) solar thermal

(j) wind.

LZC technologies

5.3 Table 5.1 gives an overview of the numbers of suppliers/ manufacturers of particular technologies. The numbers are based on the number of suppliers listed on the following two websites: The Renewable Energy Centre (www.therenewableenergycentre.co.uk/) and The Source for Renewable Energy (http://energy.sourceguides.com/index.shtml). [9]

8 OFT – Completing competition assessments in Impact Assessments, guidance for policy makers, August 2007, OFT876.

9 Note the number of suppliers listed on the Renewable Energy Centre website include retailers and manufacturers whereas those on the Source for Renewable Energy are manufacturers only. The numbers listed from the Renewable Energy Association website are numbers for businesses listed in their Members Directory as being involved in equipment/device development.

Table 5.1: Overview of market structure			
	Manufacturers Number listed in the Source for Renewable Energy online guide	**Equipment/device developers** Number listed on Renewable Energy Association website	**Suppliers/ manufacturers** Number listed on Renewable Energy Centre website
Solar PV	52 – solar energy 15 – solar water	8 – solar photovoltaic	132 – PV panel
Solar thermal		6 – solar heating	
Biomass	18 – biomass energy	5 – biomass heating 3 – biomass CHP (consumer)	58 – wood burning stoves and boilers
Closed and open GSHP	4 – heat pump	4 – ground source heating	92 – ground and air source heating system
Gas CHP and gas trigen	6 – gas turbine electric generation 6 – cogeneration system	3 – gas CHP	13 – CHP equipment
Wind	43 – wind energy	4 – wind (consumer/micro)	103 – small scale wind turbine 18 – large scale wind turbine

Source: Renewable Energy Centre website and Source for Renewable Energy online guide.

Note: The numbers of suppliers in the table should only be treated as rough approximations, as not all suppliers are listed and it has not been possible to verify whether each of the listed suppliers actually still supplies a particular product. Also some of the numbers quoted are manufacturers of the products (generally the energy source guide numbers) and other numbers also include suppliers who do not actually manufacture the product themselves (generally the renewable energy centre numbers). The numbers from the Renewable Energy Association website are those firms listed in their Members Directory as being involved in "equipment/device development".

5.4 For each of the technologies there are a number of manufacturers and suppliers with no evidence of market dominance. The proposed policy would increase demand for LZC equipment and costs are expected to fall as the volume of production rises. This is reflected in the learning effects incorporated into the modelling. Competition between suppliers should ensure that these cost reductions are passed through to end users. This is also a field in which innovation will be an important contributor to meeting the new demand.

Construction sector

5.5 The proposals would increase the cost of constructing new non-domestic buildings. As shown in Tables 4.18–4.23 the increased cost of construction would vary between building type and could be significant for some types of building. It is likely that landowners will bear some of these cost increases in reduced land value. Some costs will be passed on to the users of the new buildings. The cost increases will affect all developers equally and the proportion not passed on is likely to be small. As a result any impact on developers is likely to be small.

5.6 The policy would increase the demand for materials and equipment providing greater energy efficiency. This should encourage innovation and competition amongst suppliers.

Overall competition impact

5.7 As a result of the proposals there will be increased demand for LZCs and for products with high energy efficiency characteristics. This will provide increased opportunities for suppliers and should encourage innovation and competition. There are unlikely to be any adverse competitive effects.

5.8 The proposals would increase the cost of constructing new non-domestic buildings. The increased cost of construction would vary between building type and could be significant for some types of building. However, all developers should be affected equally (as they would all have to comply with the same regulations) and so competition between developers of new non-domestic buildings should not be affected.

Small firms impact test

5.9 The small firms impact test (SFIT) ideally involves a development of options with an initial sounding of small businesses and their representative bodies to identify/ verify the likely impacts and solutions before public consultation. The next stage would be a detailed exploration of the issues and solutions with representatives of the small firms. The representations made by the small businesses are then assessed and reflected in the final proposal.

5.10 The SFIT regards all firms with less than 50 full time employees as being small businesses. The majority of small firms have fewer than 10 employees and guidelines state that a concerted effort should be made to consult them over policy proposals.

5.11 The UK construction industry is dominated by small firms. Over 99 per cent of the around 980,000 enterprises in the construction sector in 2007, were small firms[10] with the majority being classified as sole proprietorships. In 2007 small firms accounted for 75 per cent of construction sector employment and over 54 per cent of industry turnover.

[10] BERR statistics http://stats.berr.gov.uk/ed/sme/smestats2007.xls#'UK Whole Economy'!A1
Small firms defined as firms employing less 50 employees, including sole traders.

5.12 Parties affected by the proposals would include both small firms involved in the construction of new non-domestic buildings and those involved in the production of renewables.

5.13 There are a number of ways in which small firms may be disproportionately affected by the proposals when compared to how larger firms are affected. Smaller builders and developers may find it more difficult to react to the changes than larger ones. There may be some higher specification products which 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.

5.14 A particular area where smaller firms may be affected is costs of compliance such as training staff. Larger firms may be better set up for dealing with changes in regulation at the lowest cost than smaller ones.

5.15 It has not been feasible to consult on the proposals prior to this consultation because there has been insufficient clarity on the final proposals will be. Further consideration of the impact on small firms will need to be carried out during the consultation period. This will give additional insights into the effect of the proposals on small firms. In particular the aim would be to explore any new opportunities or threats resulting from the proposals and costs of compliance.

Legal aid

5.16 The proposals would have no impact on Legal Aid.

Environmental impact

5.17 The policy forms part of the set of actions designed to deliver the Government's commitment to reduce emissions of greenhouse gases by 80 per cent by 2050. These emissions contribute to the adverse impact on the environment caused by climate change. A reduction in emissions relative to the reference case should have a beneficial effect on the environment.

5.18 The use of biomass as an energy source is one option considered. Concerns have been expressed that large scale use of biomass and its transportation could have adverse effects on land and water use, biodiversity and air quality. This will need further consideration. To help in further analysis this IA includes option both with and without the use of biomass.

Sustainable development

5.19 As noted above, the policy will create increased demand for new products which can deliver higher energy efficiency and LZC solutions. This should promote innovation and provide new opportunities for UK business contributing to sustainable economic development.

5.20 The development of allowable solutions, which have only been treated in stylised form in this IA, should provide a further contribution to sustainable development.

Carbon assessment

5.21 The reductions in CO_2 emissions from lower energy consumption and the move to LZCs and allowable solutions have been taken into account in the main cost benefit analysis.

5.22 Emissions in the electricity sector are fixed by the EU ETS and reduction in electricity consumption as a result of this policy does not affect the EU ETS levels. The CO_2 reduction in this sector produce a financial benefit which has been quantified in terms of the EU ETS allowances saved. These have been valued using the DECC guidance.[11]

5.23 Other savings, principally from reduced gas consumption have been valued using the Shadow Price of Carbon in the DECC guidance.

Health impact

5.24 Reducing demand for electricity from fossil fuel generation results in lower emissions of a range of by-products and has a positive impact on air quality and therefore on health. However use of biomass fuels can have a significant adverse effect on air quality and on health.

5.25 The DECC guidance provides estimates of the health related damage costs associated with use of different fuels. These are expressed in terms of p/kWh. Reduced consumption of energy would deliver a benefit in terms of damage avoided of 0.11p/kWh, based on a gas fired CCGT being the marginal plant. The damage cost associated with biomass varies depending on the location of the plant. The cost could be as high as 33p/kWh for uses in inner city areas or as low as 4p/kWh in rural areas. These costs are expected to rise over time.

[11] Greenhouse Gas Policy Evaluation and Appraisal in Government Departments. DECC, To be Published

5.26 We have not carried out a detailed modelling of these damage costs for all building types at this stage. However as an indication of the scale of the possible impact we have looked at the energy savings and biomass use for the edge of town speculative office building with district heating. In 2020 this building type is expected to have reduced its consumption of conventional energy by 142kWh/m^2 and be producing 20kWh/m^2 of energy from biomass. Using the DECC 'urban medium' damage cost for biomass of 18.9p/kWh in 2020 and the avoided damage cost for conventional energy of 0.11p/kWh, the net cost in that year could be about £3.60/m^2 from the use of biomass.

5.27 The policy options considered here have been modelled both with and without the use of biomass. If, following consultation, the decision is taken to allow the use of biomass then further modelling of the potential health impacts will be necessary.

Equalities assessment

5.28 There is a statutory duty to consider the impact of a policy on race, disabilities and gender equality:

(a) The policy would affect all parties the same regardless of race, gender and disability.

(b) The proposed policy will not have a negative impact on any racial or gender groups.

(c) The proposed policy would have the same effect on all parties regardless of disabilities.

(d) There would not be any impact on human rights.

5.29 An initial screening has been carried out and did not identify a need for a full equalities impact assessment. If the consultation raises any additional issues, or if there are any changes in circumstances or policy development, a further screening will be carried out and a full equalities impact assessment will follow if needed.

Rural proofing

5.30 Rural proofing involves a commitment by the government to ensure its domestic policies take account of specific rural circumstances and needs (Rural White Paper 2000). As a result policy makers should:

(a) Consider whether their policy is likely to have a different impact in rural areas from elsewhere, because of the particular characteristics of rural areas.

(b) Make a proper assessment of these impacts if they are likely to be significant.

(c) Adjust the policy, where appropriate, with solutions to meet rural needs and circumstances.[12]

5.31 The policy would not apply differently to rural and urban areas. However, it may impact differently on the two groups due to the fact that it may be easier to use particular renewables in the construction of rural buildings than in the urban areas. As noted above the rural office building is one of the few building types that would be able to achieve the zero carbon target without recourse to allowable renewables. This may mean that the cost of the policy, measured in unit building costs, may be lower in rural areas.

Administrative burdens

5.32 Detailed proposals for the implementation process for this new policy have not yet been determined and it is not possible to make an assessment of the administrative burden that might be involved at this stage. Administrative burdens will be analysed when more detailed proposals are developed in advance of specific policy changes.

5.33 Clearly, existing building control and development control structures are likely to play an important role in implementing this policy, but are likely to need strengthening, for instance through training.

[12] DEFRA rural proofing – policy makers' checklist.

Appendices

Appendix 1

Cost assumptions and new build rates

Cost assumptions for LZC options

Table A1.1: Capital costs of LZCs										
	£ per kW(e)	£ per kW(e)	£ per kW(e)	£ per kW(e)	£ per m²	£ per m²	£ per kW	£ per kW	£ per ltr/sec	£ per kW
Size	Gas CHP	Biomass CHP	Gas Trigen	Biomass Trigen	Solar Thermal	Solar PV	Wind	Biomass Heating	Open GSHP	Closed GSHP
0.6	N/A	N/A	N/A	N/A	850	720	13000	600	500000	1000
2.5	N/A	N/A	N/A	N/A	850	720	5000	600	120000	1000
5	N/A	N/A	N/A	N/A	850	720	5000	600	60000	1000
6	N/A	N/A	N/A	N/A	850	720	3000	600	50000	1000
10	N/A	N/A	N/A	N/A	850	720	2500	600	30000	1000
15	2000	N/A	2050	N/A	850	720	2000	600	20000	1000
20	2000	N/A	2050	N/A	850	720	2000	600	20000	1000
30	1800	N/A	1850	N/A	850	720	2000	600	15000	1000
40	1600	N/A	1650	N/A	850	720	2000	600	12000	1000
50	1500	N/A	1550	N/A	850	720	2000	500	18000	1000
60	1400	N/A	1450	N/A	850	720	2000	500	15000	1000
70	1400	N/A	1450	N/A	850	720	2000	500	N/A	1000
80	1400	N/A	1450	N/A	850	720	2000	500	N/A	1000
90	1400	N/A	1450	N/A	850	720	1500	500	N/A	1000
100	1200	4000	1250	4050	850	720	1500	500	N/A	1000
110	1200	4000	1250	4050	850	720	1500	500	N/A	1000
120	1200	4000	1250	4050	850	720	1500	500	N/A	1000
130	1200	4000	1250	4050	850	720	1500	500	N/A	1000
140	1200	4000	1250	4050	850	720	1500	500	N/A	1000
150	1200	4000	1250	4050	850	720	1500	500	N/A	1000
160	1200	4000	1250	4050	850	720	1500	500	N/A	1000
170	1000	4000	1050	4050	850	720	1500	500	N/A	1000
180	900	4000	950	4050	850	720	1500	500	N/A	1000
190	900	4000	950	4050	850	720	1500	500	N/A	1000

Table A1.1: Capital costs of LZCs *(continued)*

	£ per kW(e)	£ per kW(e)	£ per kW(e)	£ per kW(e)	£ per m²	£ per m²	£ per kW	£ per kW	£ per ltr/sec	£ per kW
Size	**Gas CHP**	**Biomass CHP**	**Gas Trigen**	**Biomass Trigen**	**Solar Thermal**	**Solar PV**	**Wind**	**Biomass Heating**	**Open GSHP**	**Closed GSHP**
200	900	4000	950	4050	850	720	1500	400	N/A	1000
300	900	4000	950	4050	850	720	1500	400	N/A	1000
400	900	4000	950	4050	850	720	1000	400	N/A	1000
500	900	4000	950	4050	850	720	1000	400	N/A	1000
600	900	4000	950	4050	850	720	1000	400	N/A	1000
700	900	4000	950	4050	850	720	1000	400	N/A	1000
800	900	4000	950	4050	850	720	1000	400	N/A	1000
900	900	4000	950	4050	850	720	1000	400	N/A	1000
1000	900	4000	950	4050	850	720	1000	400	N/A	1000
2000	800	4000	850	4050	850	720	1000	400	N/A	1000
3000	800	4000	850	4050	850	720	1000	400	N/A	1000

Source: Aecom

Table A1.2: Maintenance costs LZCs – £/year

	O&M cost (fixed + variable)	Source
+	**Per year**	
Gas CHP – Building Scale	£80/kW(e)	DECC Potential and Costs of District Heating
Gas CHP – District Scale	£48/kW(e)	DECC Potential and Costs of District Heating
Biomass CHP – Building Scale	£180/kW(e)	DECC Potential and Costs of District Heating
Biomass CHP – District Scale	£80/kW(e)	DECC Potential and Costs of District Heating
Gas Trigen – Building Scale	£100/kW(e)	DECC Potential and Costs of District Heating / BSRIA Introduction to Absorption Cooling
Gas Trigen – District Scale	£68/kW(e)	DECC Potential and Costs of District Heating / BSRIA Introduction to Absorption Cooling
Biomass Trigen – Building Scale	£100/kW(e)	DECC Potential and Costs of District Heating / BSRIA Introduction to Absorption Cooling
Biomass Trigen – District Scale	£200/kW(e)	DECC Potential and Costs of District Heating / BSRIA Introduction to Absorption Cooling
Solar Thermal	£8.50/m^2	1% capital cost rule of thumb
Solar PV	£7.50/m^2	1% capital cost rule of thumb
Wind	£15/kW(p)	SPONS M&E price guide
Biomass Heating	£15/kW(th)	DECC Potential and Costs of District Heating
Open GSHP	£150/l/s	DECC Potential and Costs of District Heating
Closed GSHP	£6/kW	DECC Potential and Costs of District Heating

Source: AECOM

Table A1.3: LZC capital costs learning effects

	Gas CHP	Biomass CHP	Gas Trigen	Biomass Trigen	Solar Thermal	Solar PV	Wind	Biomass Heating	Open GSHP	Closed GSHP
2008	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2009	99%	99%	99%	99%	98%	98%	99%	98%	98%	98%
2010	98%	98%	98%	98%	96%	96%	97%	97%	97%	97%
2011	97%	96%	97%	96%	94%	94%	96%	95%	95%	95%
2012	96%	95%	96%	95%	92%	92%	95%	94%	94%	94%
2013	95%	94%	95%	94%	91%	91%	94%	94%	93%	93%
2014	94%	93%	94%	93%	89%	89%	93%	93%	92%	92%
2015	93%	92%	93%	92%	87%	87%	92%	92%	90%	90%
2016	92%	91%	92%	91%	86%	86%	91%	91%	89%	89%
2017	91%	90%	91%	90%	84%	84%	90%	90%	88%	88%
2018	90%	89%	90%	89%	83%	83%	89%	89%	87%	87%
2019	89%	88%	89%	88%	81%	81%	89%	88%	85%	85%
2020	88%	87%	88%	87%	80%	80%	88%	87%	84%	84%
2021	87%	86%	87%	86%	78%	78%	87%	86%	83%	83%
2022	86%	85%	86%	85%	77%	77%	86%	85%	82%	82%
2023	85%	84%	85%	84%	75%	75%	86%	85%	81%	81%
2024	84%	83%	84%	83%	74%	74%	85%	84%	80%	80%
2025	83%	82%	83%	82%	73%	73%	84%	83%	79%	79%

Source: Cyril Sweett

Table A1.4: Assumed asset lives

PV	20
Solar water heating	20
Gas CHP	15
Ground source heat pump	15
Biomass boiler	30
Biomass CHP	20
Biomass Trigeneration	20
Wind	20

Source: AECOM

New build estimates for non-domestic buildings

For the Parts L and F Consultation Stage Impact Assessment IA BRE provided a breakdown of build rates for eight building types. These were derived principally from ABI Planning application data, CLG floor space statistics and BERR construction statistics. BRE recommended that given uncertainty about future build rates it would be sensible to use the average annual build rate of the past 5 – 10 years as a basis for projection rather than the higher rates which had been achieved more recently.

In order to maintain consistency with the Parts L and F Consultation Stage Impact Assessment IA these estimates have also been used in the current IA. The build rates have been further broken down into the 20 new build categories that have been being modelled.

These 20 build types are shown below with the average building size being modelled. Two further assumptions have been used to derive estimates of new build in each of the categories.

First an assumption has been made on the split between new buildings which stand alone and those which form part of a district heating scheme. For each category where district heating is an option (all expect the two rural categories) it has been assumed that 60 per cent will be stand alone and 40 per cent will be part of district heating scheme.

Second an assumption has been made on how each of these building types relate to the categories in BRE's estimates. For example it has been assumed that the City centre HQ type of building will account for 60 per cent of the annual deep plan (>1,000 m2) new build. The build rates for each of the 20 building types is shown in Table A1. 5

It should be noted that three categories, deep plan offices, warehouse and retail account for over 75 per cent of new build.

Table A1. 5: Annual new build rates – 20 categories of non-domestic buildings			
Building type	**Av size m²**	**% of BRE m²**	**M² new build pa**
City centre HQ s/alone	30,000	60%*60% deep plan	1,240,200
City centre HQ d/heat	30,000	40%*60% deep plan	826,800
5* hotel s/a	15,200	60%*50% hotel	163,200
5* hotel d/h	15,200	40%*50% hotel	108,800
Shopping centre s/a	30,000	60%*40% retail	371,900
Shopping centre d/h	30,000	40%*40% retail	247,900
Mini-supermarket s/a	800	60%*20% retail	247,920
Mini-supermarket d/h	800	40%*20% retail	165,300
Spec office retail park s/a	4,500	60%*40% deep plan	826,800
Spec office retail park d/h	4,500	40%*40% deep plan	551,200
Distribution warehouse s/a	4,900	60%*80% warehouse	1,392,600
Distribution warehouse d/h	4,900	40%*80% warehouse	928,400
Retail warehouse s/a	4,900	60%*(20% warehouse + 40% retail)	596,100
Retail warehouse d/h	4,900	40%*(20% warehouse + 40% retail)	397,400
Large supermarket s/a	5,100	60%*100% supermarket	116,400
Large supermarket d/h	5,100	40%*100% supermarket	77,600
3* hotel s/a	8,000	60%*40% hotel	130,600
3* hotel d/h	8,000	40%*40% hotel	87,000
2* hotel rural s/a	2,500	10% hotel	54,400
Small office rural s/a	1,600	100% small office	133,000
			8,663,520

Appendix 2:

Carbon Reduction Costs for Building Types

CO_2 reduction costs and technologies

A2.1: Percentage reduction in regulated emissions achievable by building types – biomass allowed					
	Target Reduction	25%	44%	70%	100%
URBAN REGENERATION					
City Centre Bank Headquarters	Percentage reduction achieved	25%	38%		
	Cost, £/m²	£44	£254		
	Lowest Cost Technology Combination	APE + BHtg	APE + PV + Btgen + OGSHP		
5* Hotel	Percentage reduction achieved	25%	44%	70%	84%
	Cost, £/m²	£7	£41	£53	£97
	Lowest Cost Technology Combination	APE	APE + BHtg	APE + BHtg	APE + BTgen + PV
Shopping Centre	Percentage reduction achieved	25%	38%		
	Cost, £/m²	£129	£475		
	Lowest Cost Technology Combination	APE + CGSHP + Btgen	APE + PV + OGSHP + BTgen		
Mini-supermarket	Percentage reduction achieved	23%			
	Cost, £/m²	£612			
	Lowest Cost Technology Combination	APE + PV + OGSHP			

A2.1: Percentage reduction in regulated emissions achievable by building types – biomass allowed *(continued)*					
	Target Reduction	25%	44%	70%	100%
EDGE OF TOWN					
Speculative office in retail park	Percentage reduction achieved	25%	44%	58%	
	Cost, £/m²	£53	£159	£445	
	Lowest Cost Technology Combination	APE + BHtg	APE + BHtg + PV	APE + PV + Wind + Btgen + OGSHP	
Distribution Warehouse	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£0.4	£4	£28	£108
	Lowest Cost Technology Combination	APE	APE	APE + BHtg + PV	APE + BHtg + PV
Retail Warehouse	Percentage reduction achieved	25%	44%	70%	89%
	Cost, £/m²	£0.24	£1.30	£175	£341
	Lowest Cost Technology Combination	APE	APE	APE + BHtg + PV	APE + PV + BHtg + Wind
Large supermarket	Percentage reduction achieved	25%	42%		
	Cost, £/m²	£345	£487		
	Lowest Cost Technology Combination	APE + CGSHP + PV	APE + PV + Wind + OGSHP		
3* Hotel	Percentage reduction achieved	25%	44%	70%	96%
	Cost, £/m²	£7	£39	£57	£211
	Lowest Cost Technology Combination	APE	APE + BHtg	APE + Btgen	APE + Btgen + PV + Wind

A2.1: Percentage reduction in regulated emissions achievable by building types – biomass allowed *(continued)*

	Target Reduction	25%	44%	70%	100%
RURAL					
2* Hotel	Percentage reduction achieved	25%	44%	70%	94%
	Cost, £/m²	£7	£41	£61	£204
	Lowest Cost Technology Combination	APE	APE + BHtg	APE + Bhtg + wind	APE + BHtg + PV + Wind
Small Rural Owner-Occupied Office	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£11	£46	£97	£177
	Lowest Cost Technology Combination	APE	APE + BHtg	APE + BHtg + Wind	APE + BHtg + wind + PV

Source: AECOM

KEY:
APE: Advanced Practice Energy Efficiency
CHP: Gas-fired combined heat and power
Tgen: Gas-fired trigeneration
BCHP: Biomass combined heat and power
BTgen: Biomass trigeneration
BHtg: Biomass Heating
SDHW Solar Domestic Hot Water
Wind: Wind turbine
PV: Photovoltaic panels
CGSHP: Closed loop ground source heat pump
OGSHP: Open loop ground source heat pump

A2.2: Percentage reduction in regulated emissions achievable by building types – biomass not allowed					
	Target Reduction	25%	44%	70%	100%
City Centre Bank Headquarters	Percentage reduction achieved	25%	30%		
	Cost, £/m²	£53	£96		
	Lowest Cost Technology Combination	APE + CHP + PV	APE + CHP + PV + OGSHP		
5* Hotel	Percentage reduction achieved	25%	44%	57%	
	Cost, £/m²	£7	£49	£100	
	Lowest Cost Technology Combination	APE	APE + CHP	APE + CHP + PV + OGSHP	
Shopping Centre	Percentage reduction achieved	25%	34%		
	Cost, £/m²	£131	£264		
	Lowest Cost Technology Combination	APE + CHP + PV	APE + CHP + PV + OGSHP		
Mini-supermarket	Percentage reduction achieved	23%			
	Cost, £/m²	£612			
	Lowest Cost Technology Combination	APE + PV + OGSHP			
Speculative office in retail park	Percentage reduction achieved	25%	44%	49%	
	Cost, £/m²	£60	£165	£273	
	Lowest Cost Technology Combination	APE + CHP + PV	APE + CHP + PV + Wind	APE + CHP + PV + Wind	
Distribution Warehouse	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£4	£10	£45	£89
	Lowest Cost Technology Combination	APE	APE	APE + CHP + PV	APE + CHP + PV
Retail Warehouse	Percentage reduction achieved	25%	44%	70%	87.5%
	Cost, £/m²	£0.24	£1.30	£188	£352

A2.2: Percentage reduction in regulated emissions achievable by building types – biomass not allowed *(continued)*

	Target Reduction	25%	44%	70%	100%
	Lowest Cost Technology Combination	APE	APE	APE + SDHW + PV	APE +SDHW + PV + Wind
Large supermarket	Percentage reduction achieved	25%	42%		
	Cost, £/m^2	£345	£487		
	Lowest Cost Technology Combination	APE + CGSHP + PV	APE + PV + Wind + OGSHP		
3* Hotel	Percentage reduction achieved	25%	44%	67%	
	Cost, £/m^2	£7	£52	£210	
	Lowest Cost Technology Combination	APE	APE + CHP	APE + SHW + PV + OGSHP	
2* Hotel	Percentage reduction achieved	25%	44%	70%	83%
	Cost, £/m^2	£7	£55	£157	£252
	Lowest Cost Technology Combination	APE	APE + CHP	APE + SHW + Wind + PV	APE + SHW + Wind + PV
Small Rural Owner-Occupied Office	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m^2	£11	£106	£107	£202
	Lowest Cost Technology Combination	APE	APE + SHW + Wind	APE + SHW + Wind	APE + SHW + Wind

Source: AECOM

A2. 3: Percentage reduction in regulated emissions achievable by building types – district heating with biomass allowed					
	Target Reduction	25%	44%	70%	100%
City Centre Bank Headquarters	Percentage reduction achieved	25%	36%		
	Cost, £/m²	£47	£134		
	Lowest Cost Technology Combination	APE + BHtg	APE + PV + Btgen + OGSHP		
5* Hotel	Percentage reduction achieved	25%	44%	70%	91%
	Cost, £/m²	£7	£41	£52	£94
	Lowest Cost Technology Combination	APE	APE + BHtg	APE + BHtg	APE + Btgen + PV
Shopping Centre	Percentage reduction achieved	25%	37%		
	Cost, £/m²	£131	£309		
	Lowest Cost Technology Combination	APE + CGSHP + Btgen	Btgen + PV + CGSHP		
Mini-supermarket	Percentage reduction achieved	18%			
	Cost, £/m²	£590			
	Lowest Cost Technology Combination	APE + Btgen + PV + OGSHP			
Speculative office in retail park	Percentage reduction achieved	25%	44%	54%	
	Cost, £/m²	£55	£162	£294	
	Lowest Cost Technology Combination	APE + BCHP	APE + BHtgen + PV	APE + PV + Wind + Btgen + OGSHP	
Distribution Warehouse	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£0.4	£4	£39	£121
	Lowest Cost Technology Combination	APE	APE	APE + BHtg + PV	APE + BHtg + PV
Retail Warehouse	Percentage reduction achieved	25%	44%	70%	90%
	Cost, £/m²	£0.24	£1.30	£176	£338

A2. 3: Percentage reduction in regulated emissions achievable by building types – district heating with biomass allowed *(continued)*

	Target Reduction	25%	44%	70%	100%
	Lowest Cost Technology Combination	APE	APE	APE + BHtg + PV	APE + BHtg + PV + Wind
Large supermarket	Percentage reduction achieved	25%	44%		
	Cost, £/m^2	£227	£465		
	Lowest Cost Technology Combination	APE + CGSHP + BTgen + PV	APE + BHtg + PV + Wind + OGSHP		
3* Hotel	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m^2	£7	£39	£45	£164
	Lowest Cost Technology Combination	APE	APE + BHtg	APE + Btgen	APE + Btgen + PV + Wind

Source: AECOM

A2.4: Percentage reduction in regulated emissions achievable by building types – district heating with biomass not allowed

	Target Reduction	25%	44%	70%	100%
City Centre Bank Headquarters	Percentage reduction achieved	25%	32%		
	Cost, £/m^2	£71	£125		
	Lowest Cost Technology Combination	APE + SDHW + CHP	APE + PV + Tgen + OGSHP		
5* Hotel	Percentage reduction achieved	25%	44%	70%	
	Cost, £/m^2	£7	£55	£104	
	Lowest Cost Technology Combination	APE	APE + CHP	APE + Tgen + PV	
Shopping Centre	Percentage reduction achieved	25%	35%		
	Cost, £/m^2	£160	£303		
	Lowest Cost Technology Combination	APE + SDHW + CGSHP + PV	APE + PV + OGSHP + Tgen		

A2.4: Percentage reduction in regulated emissions achievable by building types – district heating with biomass not allowed *(continued)*

	Target Reduction	25%	44%	70%	100%
Mini-supermarket	Percentage reduction achieved	25%			
	Cost, £/m²	£157			
	Lowest Cost Technology Combination	APE + Btgen + PV + OGSHP			
Speculative office in retail park	Percentage reduction achieved	25%	44%	49%	
	Cost, £/m²	£59	£162	£292	
	Lowest Cost Technology Combination	APE + SDHW + PV	APE + SDHW + PV + Wind	APE + PV + Wind + Trigen + OGSHP	
Distribution Warehouse	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m2	£3	£10	£66	£146
	Lowest Cost Technology Combination	APE	APE	APE + PV	APE + PV
Retail Warehouse	Percentage reduction achieved	25%	44%	70%	89%
	Cost, £/m²	£0.24	£1.30	£189	£377
	Lowest Cost Technology Combination	APE	APE	APE + SDHW + PV	APE +SDHW + PV + Wind + CHP
Large supermarket	Percentage reduction achieved	25%	42%		
	Cost, £/m²	£225	£522		
	Lowest Cost Technology Combination	APE + PV	PV + Wind + CHP + OGSHP		
3* Hotel	Percentage reduction achieved	25%	44%	70%	78%
	Cost, £/m²	£7	£75	£133	£175
	Lowest Cost Technology Combination	APE	APE + CHP	APE + Trigen + PV	APE + Trigen + PV + Wind

Source: AECOM

A2. 5: Percentage reduction in regulated emissions achievable by building types – district heating with biomass allowed and surplus heat					
	Target Reduction	25%	44%	70%	100%
URBAN REGENERATION					
City Centre Bank Headquarters	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£45	£64	£86	£113
	Lowest Cost Technology Combination	APE + Btgen	APE + Btgen	APE + Btgen	APE + Btgen
5* Hotel	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£7	£41	£55	£86
	Lowest Cost Technology Combination	APE	APE + BHtg	APE + BHtg	APE + Btgen
Shopping Centre	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£102	£110	£121	£135
	Lowest Cost Technology Combination	APE + Btgen	APE + Btgen	APE + Btgen	APE + Btgen
Mini-supermarket	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£54	£68	£90	£115
	Lowest Cost Technology Combination	APE + Btgen	APE + Btgen	APE + Btgen	APE + Btgen
EDGE OF TOWN					
Speculative office in retail park	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£40	£43	£47	£79
	Lowest Cost Technology Combination	APE + Btgen	APE + Btgen	APE + Btgen	APE + Btgen
Distribution Warehouse	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£0.4	£4	£17	£37
	Lowest Cost Technology Combination	APE	APE	APE + BHtg	APE + BCHP
Retail Warehouse	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£0.27	£4.11	£80	£152
	Lowest Cost Technology Combination	APE	APE	APE + BCHP	APE + BCHP

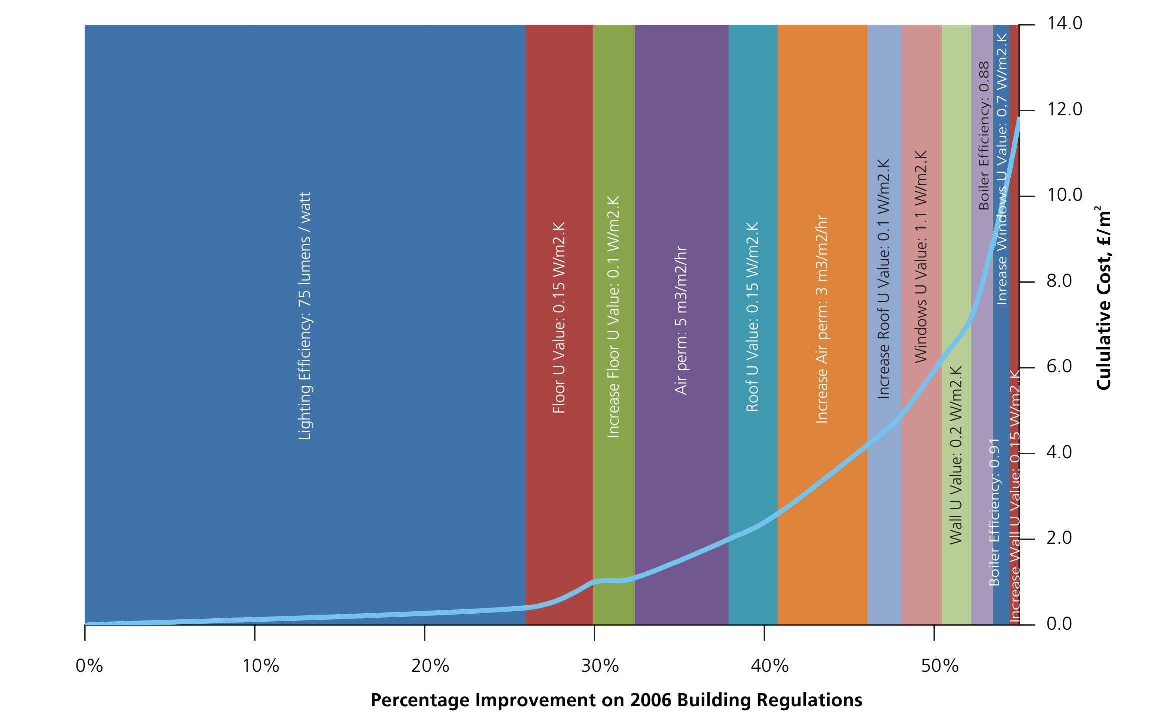
A2. 5: Percentage reduction in regulated emissions achievable by building types – district heating with biomass allowed and surplus heat *(continued)*					
	Target Reduction	25%	44%	70%	100%
Large Supermarket	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£54	£63	£75	£89
	Lowest Cost Technology Combination	APE + Btgen	APE + Btgen	APE + Btgen	APE + Btgen
3* Hotel	Percentage reduction achieved	25%	44%	70%	100%
	Cost, £/m²	£7	£39	£43	£53
	Lowest Cost Technology Combination	APE	APE + BHtg	APE + BHtg	APE + Btgen

Source: AECOM

Energy efficiency capital cost curves by building types

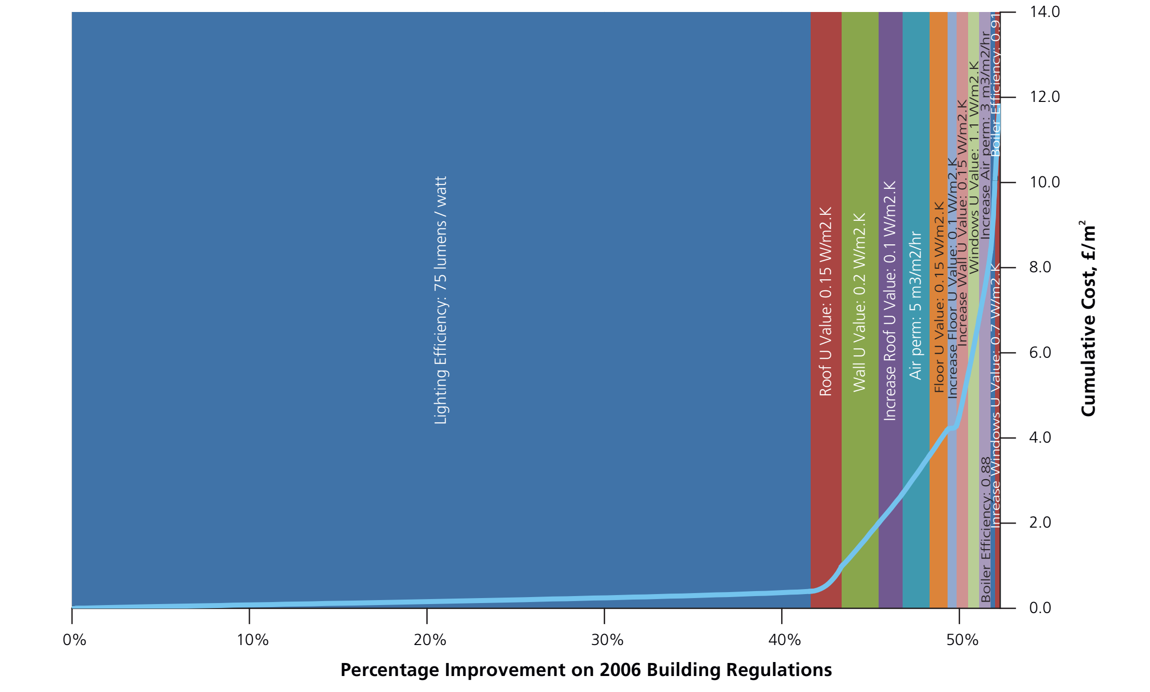
In addition to the energy efficiency capital cost curves for a large air conditioned office and a rural naturally ventilated office shown in Figures 3.1 and 3.2, energy efficiency capital cost curves are set out below for six further building types.

Figure A2.1: Percentage improvement on Building Regulations 2006, distribution warehouse; energy efficiency measures



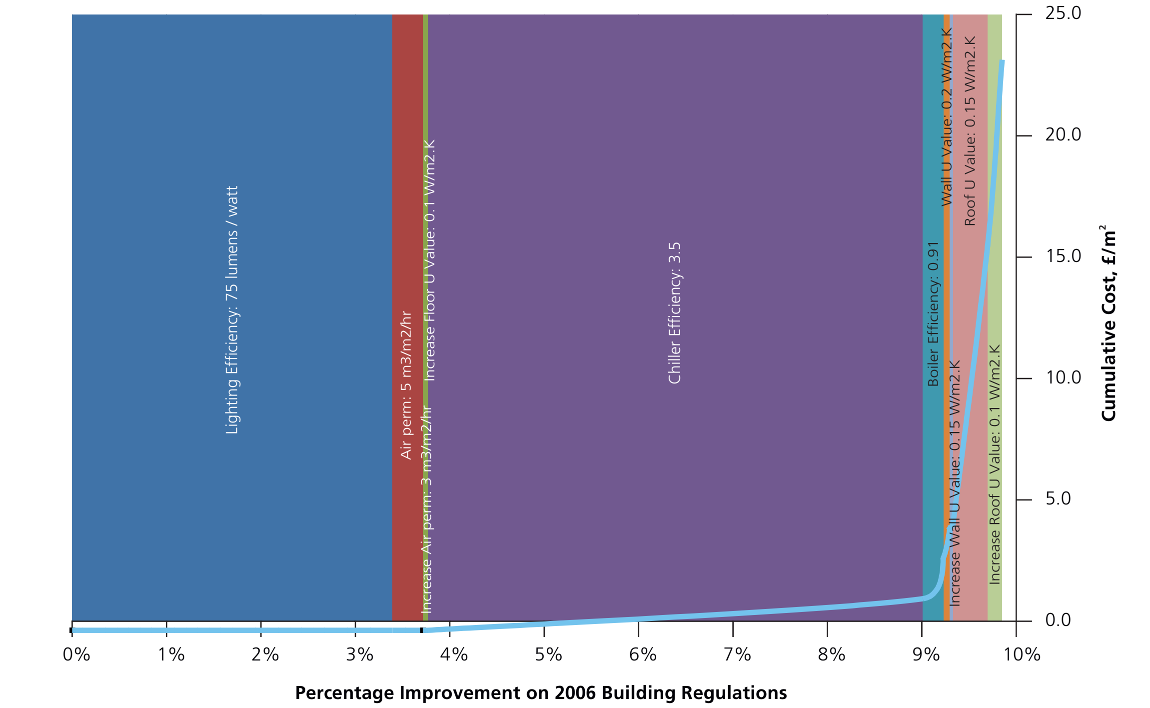
Source: AECOM

Figure A2.2: Percentage improvement on Building Regulations 2006, retail warehouse; energy efficiency measures



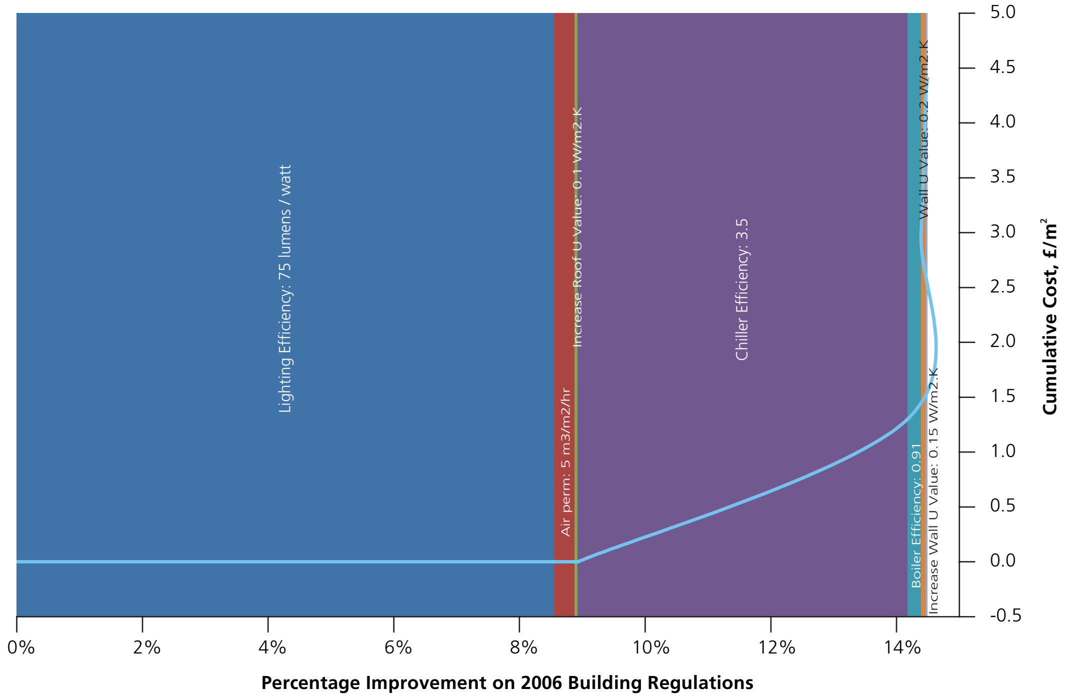
Source: AECOM

Figure A2.3: Percentage improvement on Building Regulations 2006, supermarket; energy efficiency measures



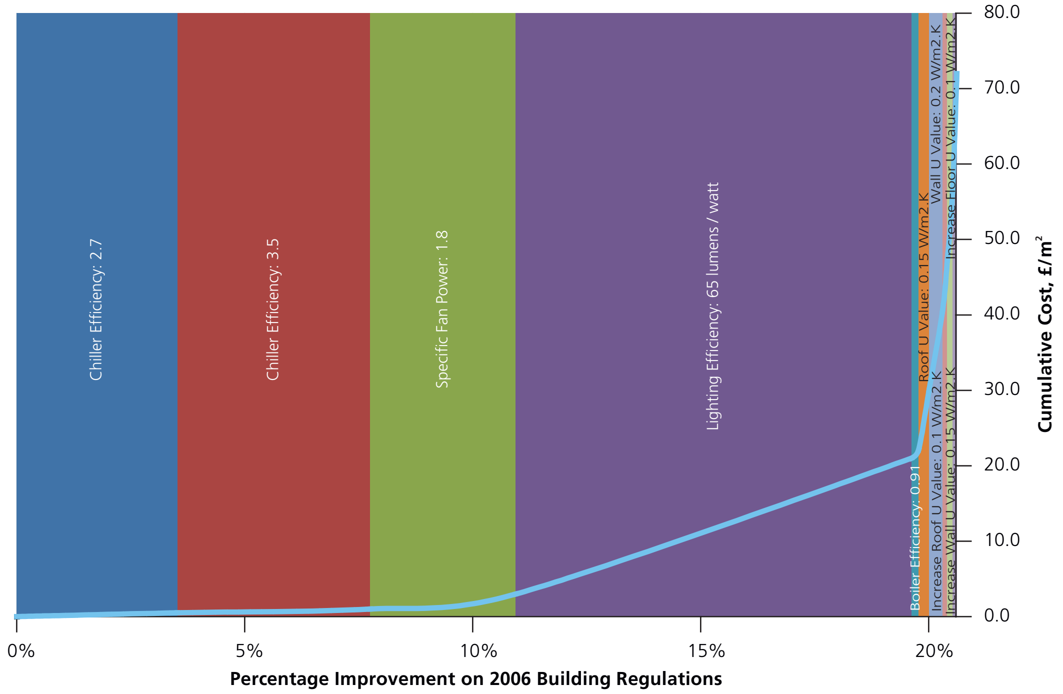
Source: AECOM

Figure A2.4: Percentage improvement on Building Regulations 2006, mini-supermarket; energy efficiency measures



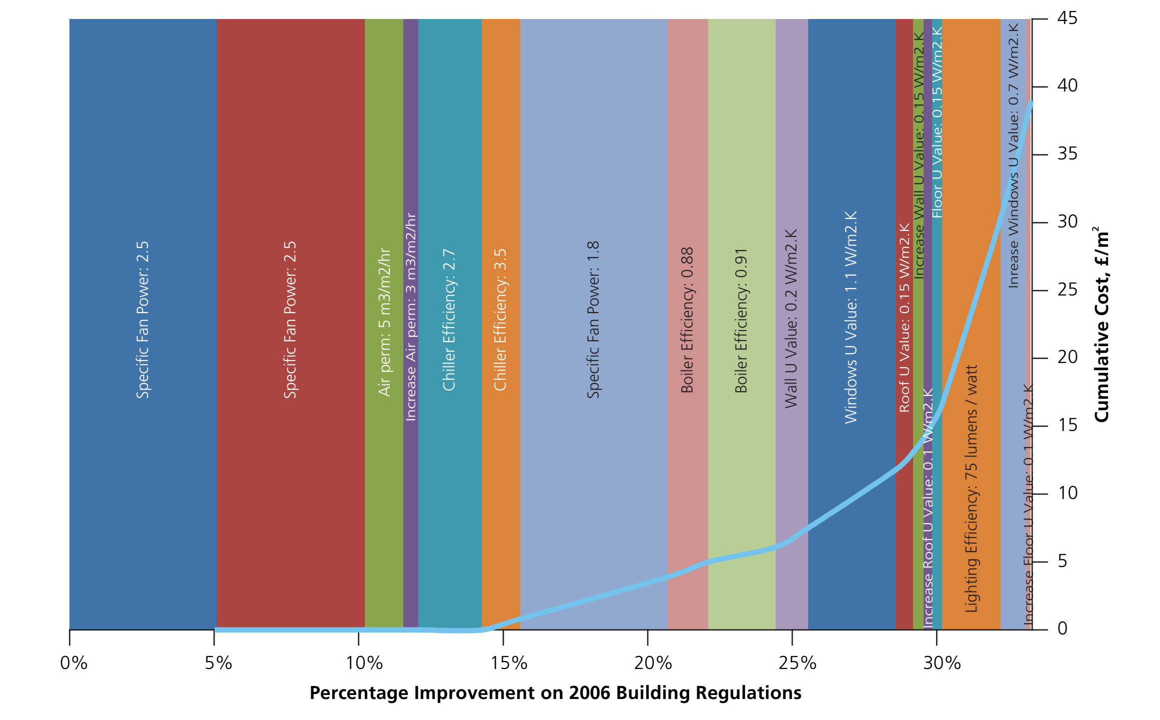
Source: AECOM

Figure A2.5: Percentage improvement on Building Regulations 2006, shopping centre; energy efficiency measures



Source: AECOM

Figure A2.6: Percentage improvement on Building Regulations 2006, hotel; energy efficiency measures



Source: AECOM

Energy efficiency and carbon compliance capital cost curves by building type

Figure A2.7: Cumulative cost of improving on 2006 Building Regulations Large City Office/Standalone/With biomass

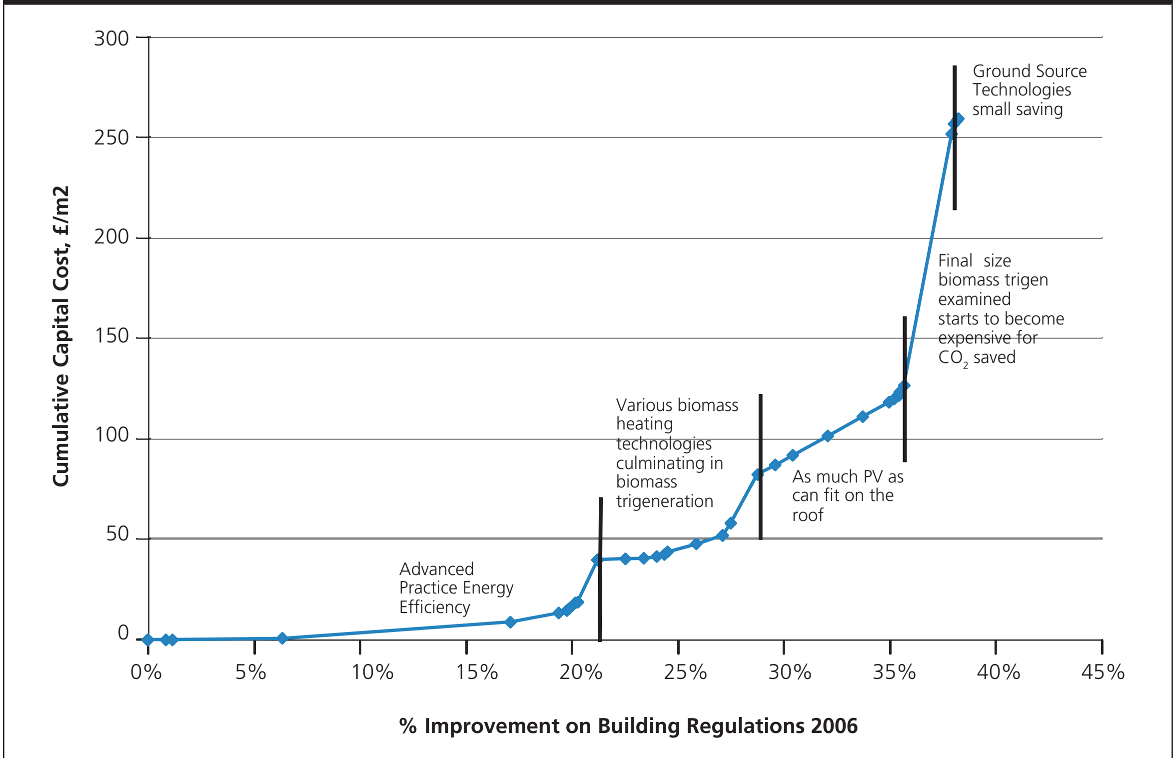


Figure A2.8: Cumulative cost of improving on 2006 Building Regulations Large City Office/Standalone/Without biomass

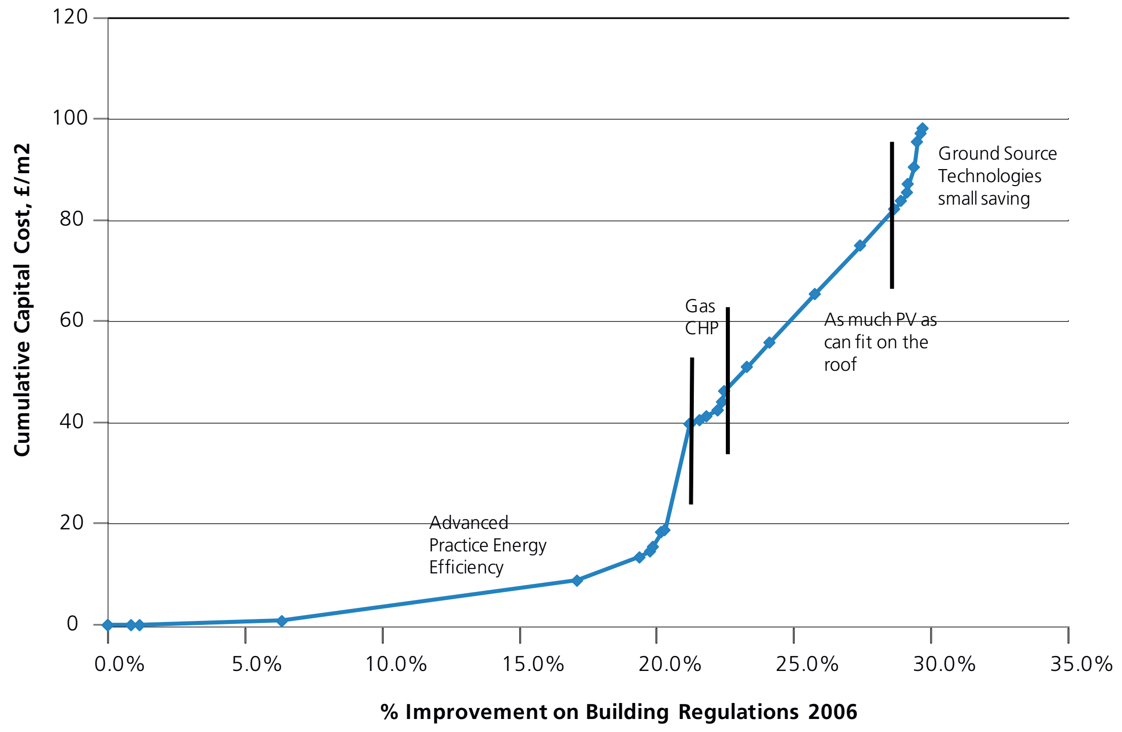


Figure A2.9: Cumulative cost of improving on 2006 Building Regulations Large City Office/All Scenarios

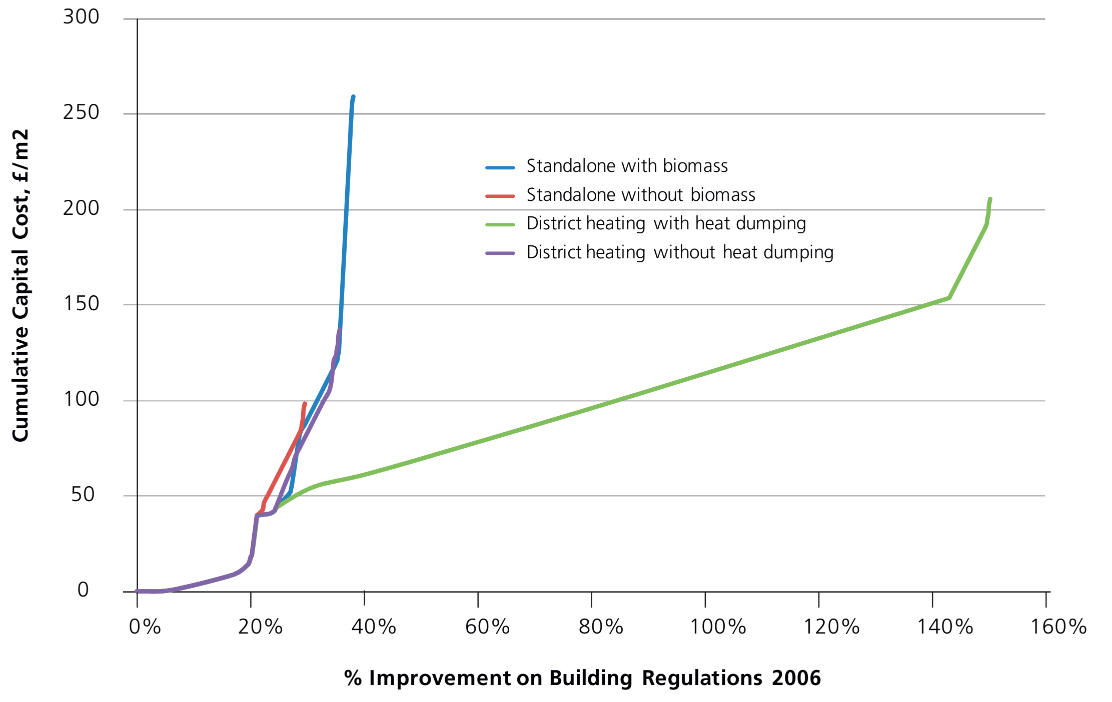


Figure A2.10: Cumulative cost of improving on 2006 Building Regulations Medium Suburban Office / Standalone / With biomass

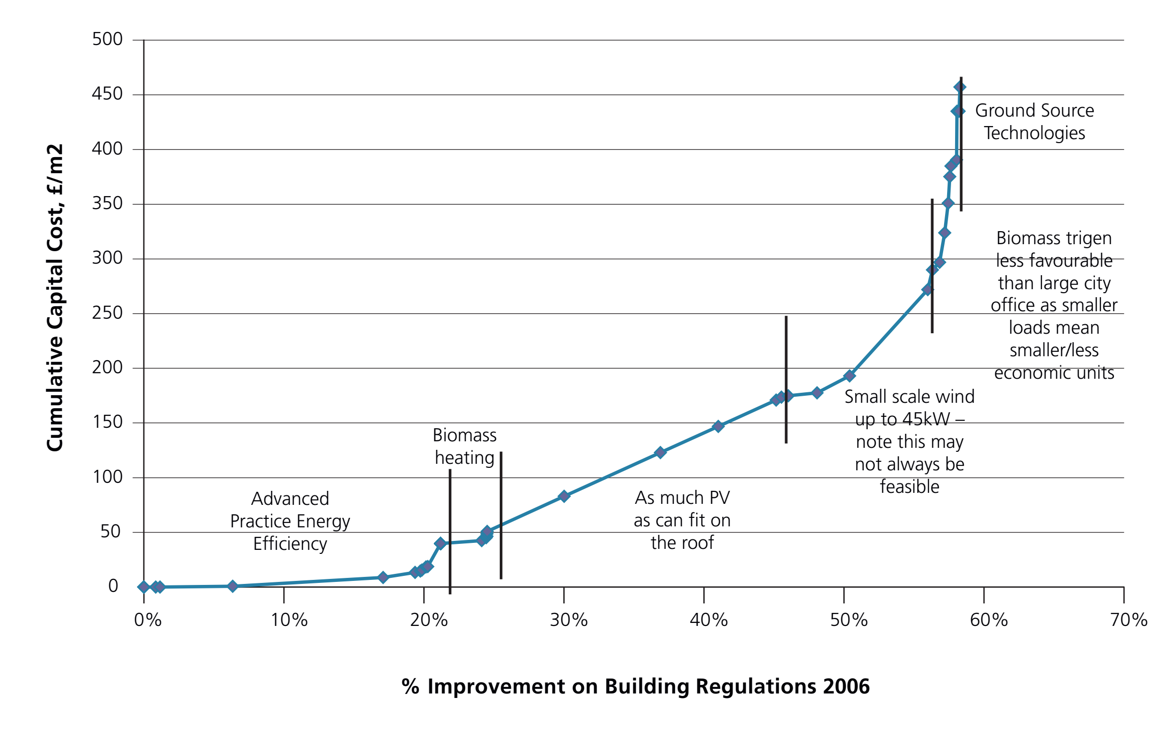


Figure A2.11: Cumulative cost of improving on 2006 Building Regulations Medium Suburban Office / Standalone / Without biomass

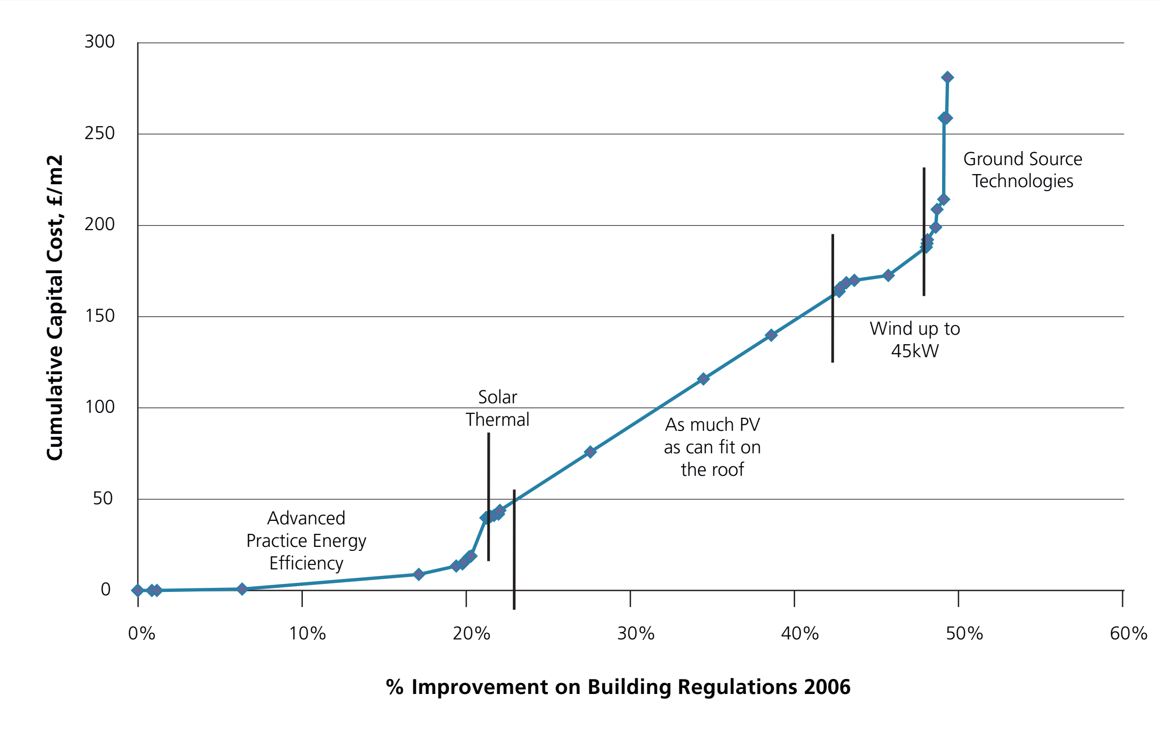


Figure A2.12: Cumulative cost of improving on 2006 Building Regulations Medium Suburban Office / All Scenarios

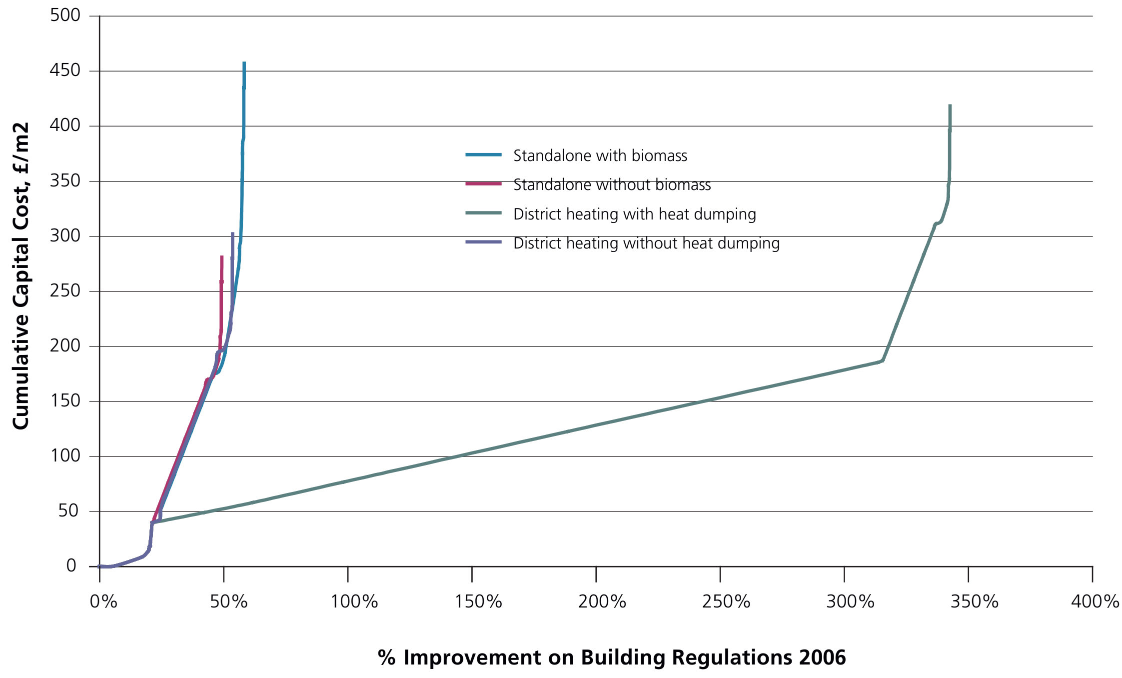


Figure A2.13: Cumulative cost of improving on 2006 Building Regulations 5 star hotel / Standalone / With biomass

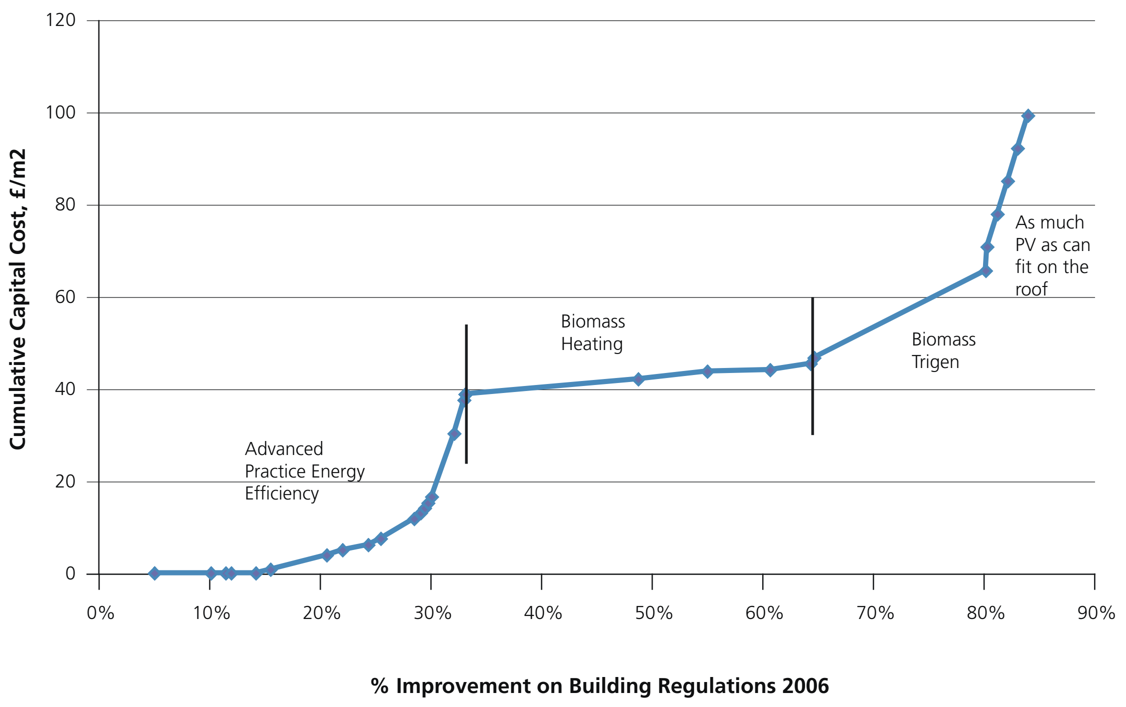


Figure A2.14: Cumulative cost of improving on 2006 Building Regulations 5 star hotel / Standalone / Without biomass

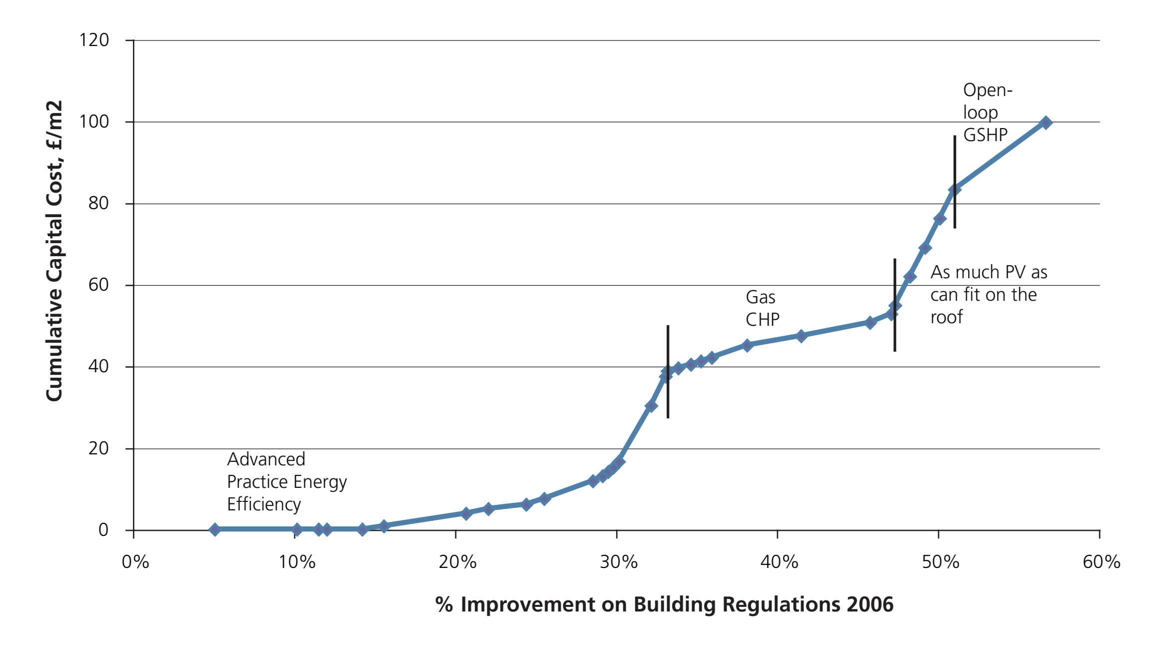


Figure A2.15: Cumulative cost of improving on 2006 Building Regulations 5 star hotel / All Scenarios

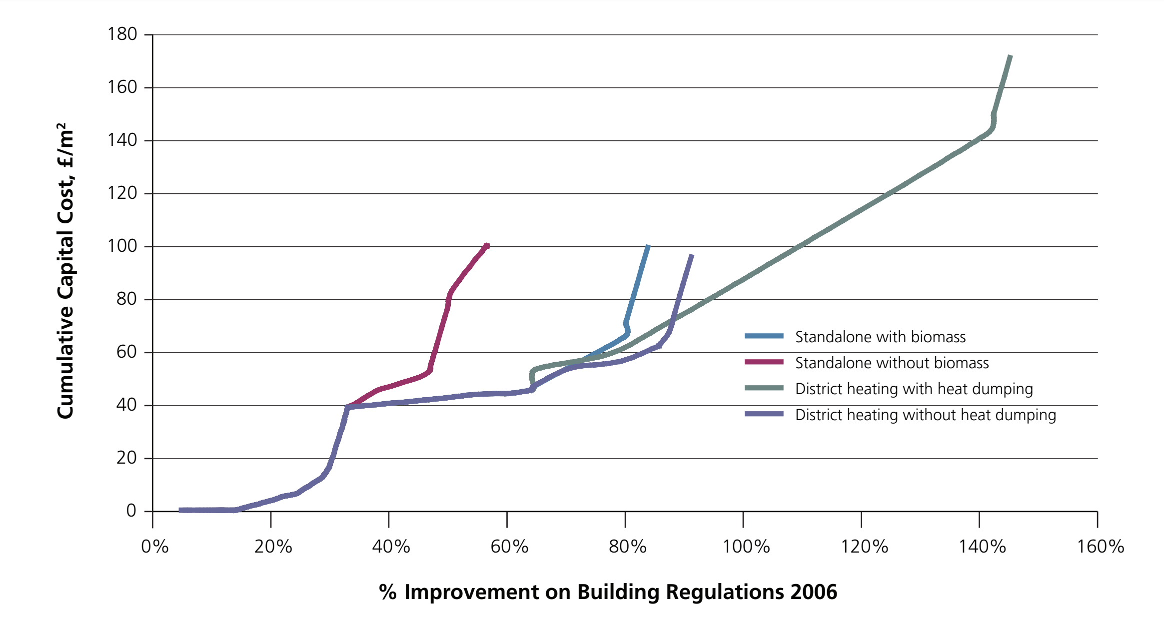


Figure A2.16: Cumulative cost of improving on 2006 Building Regulations Distribution Warehouse / Standalone / With biomass

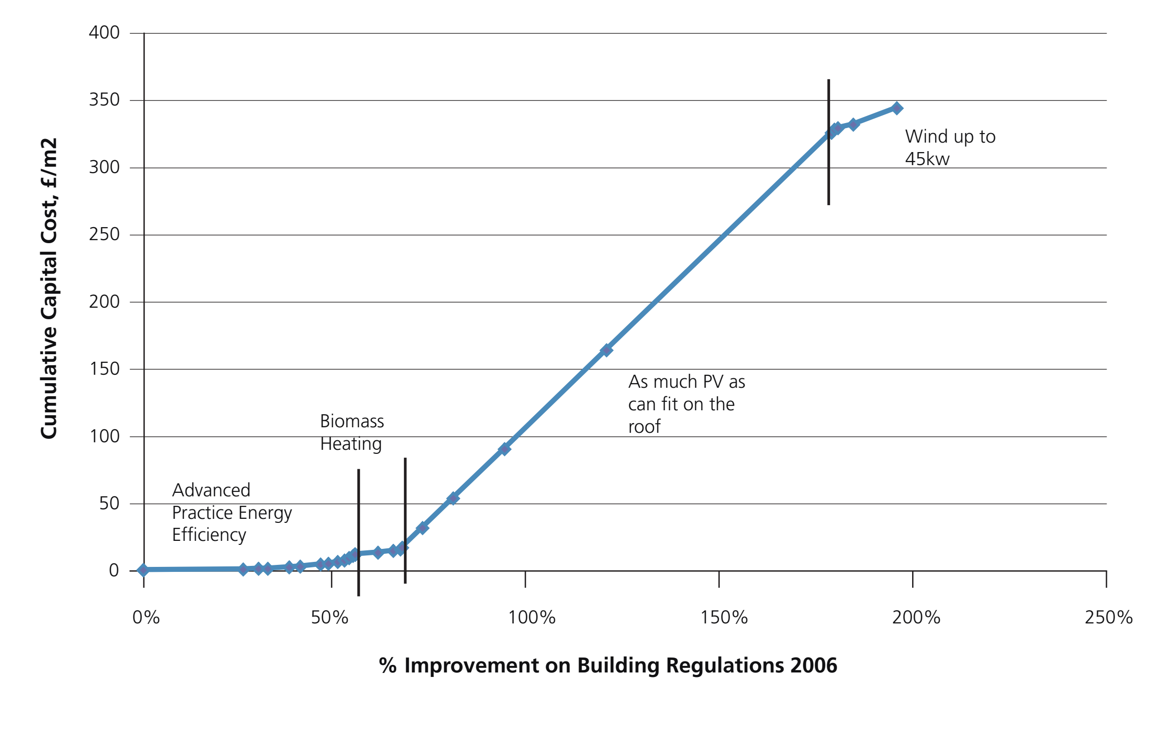


Figure A2.17: Cumulative cost of improving on 2006 Building Regulations Distribution Warehouse / Standalone / Without biomass

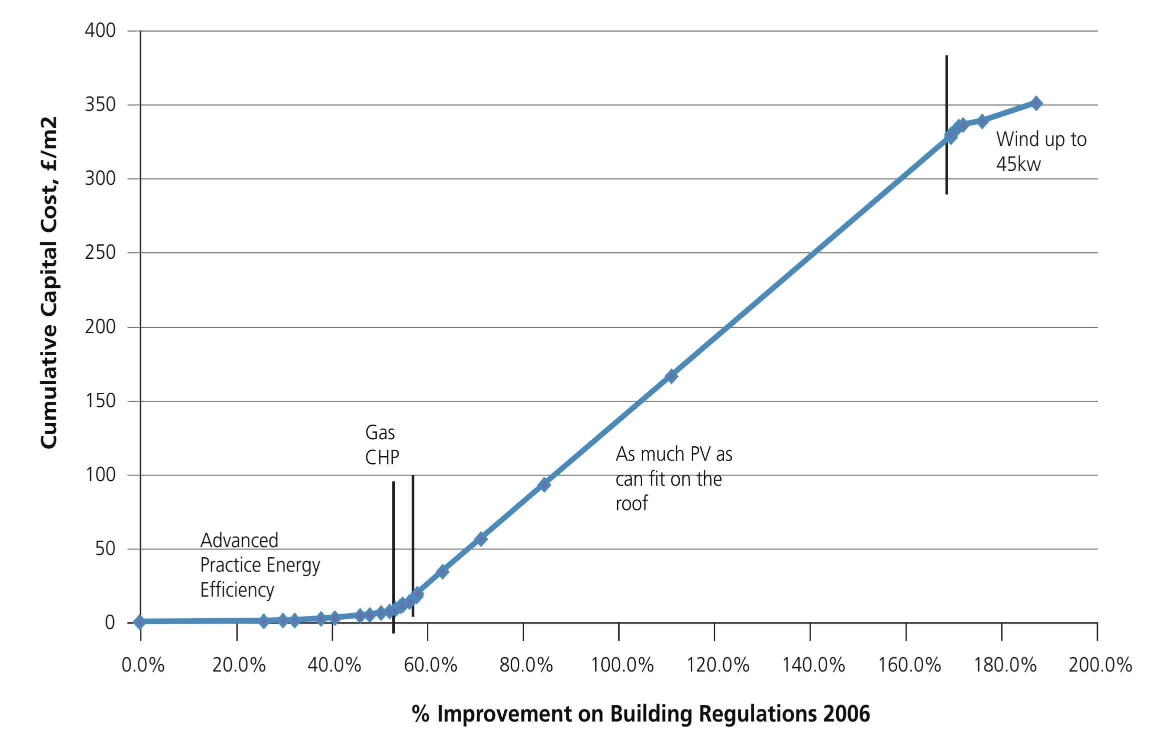


Figure A2.18: Cumulative cost of improving on 2006 Building Regulations Distribution Warehouse / All Scenarios

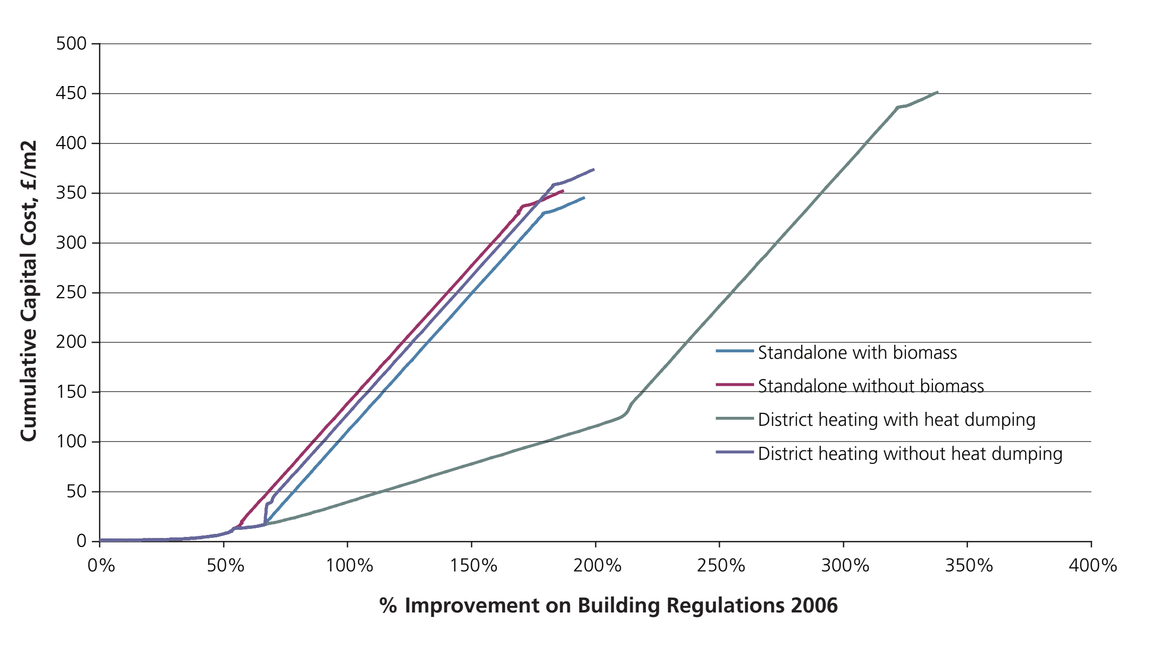


Figure A2.19: Cumulative cost of improving on 2006 Building Regulations Retail Warehouse / Standalone / With biomass

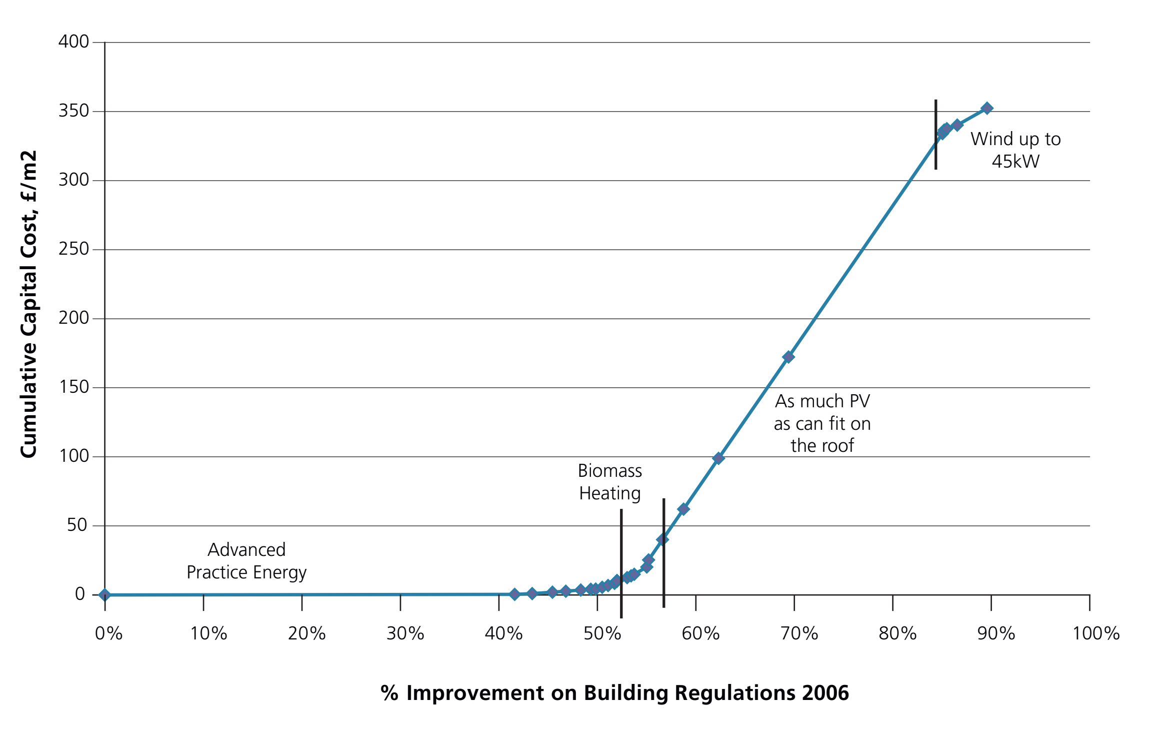


Figure A2.20: Cumulative cost of improving on 2006 Building Regulations Retail Warehouse / Standalone / Without biomass

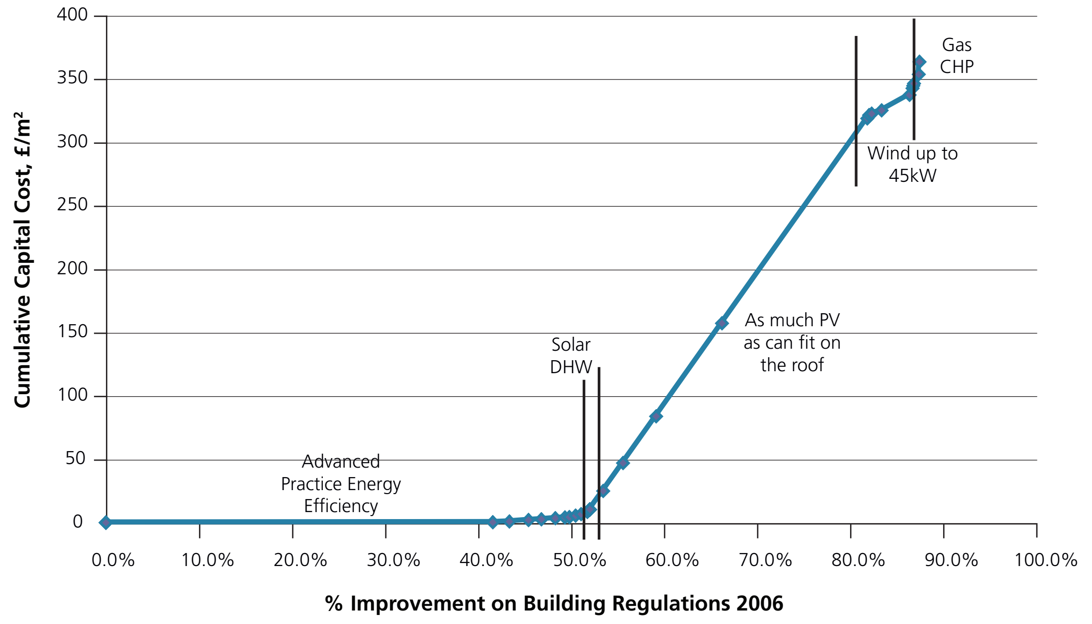


Figure A2.21: Cumulative cost of improving on 2006 Building Regulations Retail Warehouse / All Scenarios

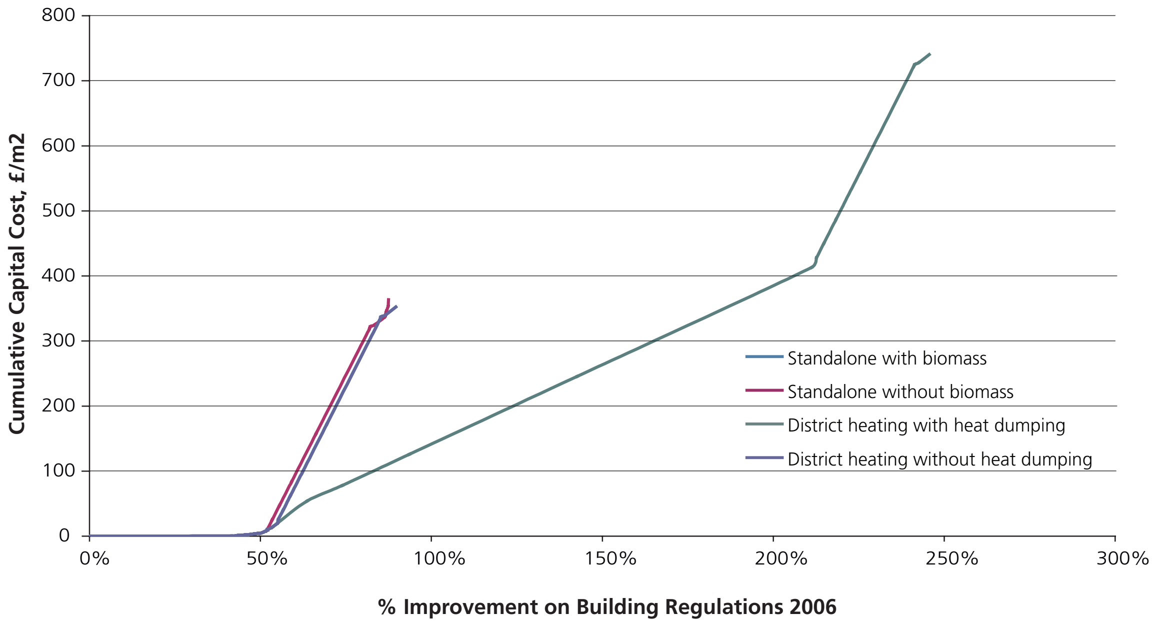


Figure A2.22: Cumulative cost of improving on 2006 Building Regulations Shopping Centre / Standalone / With biomass

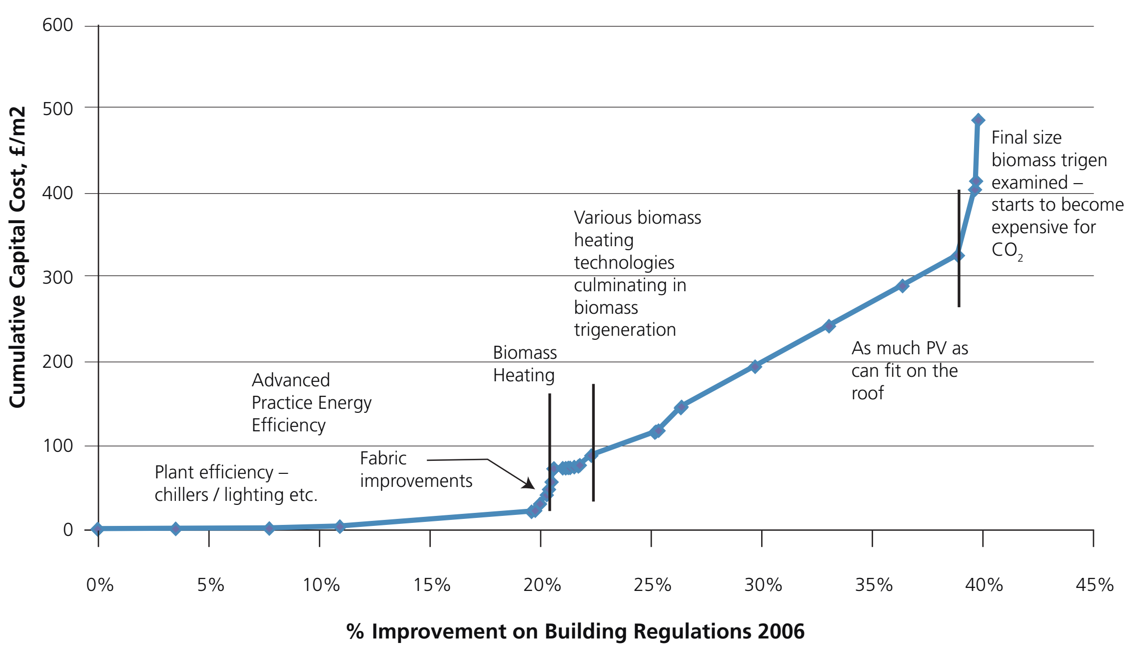


Figure A2.23: Cumulative cost of improving on 2006 Building Regulations Shopping Centre / Standalone / Without biomass

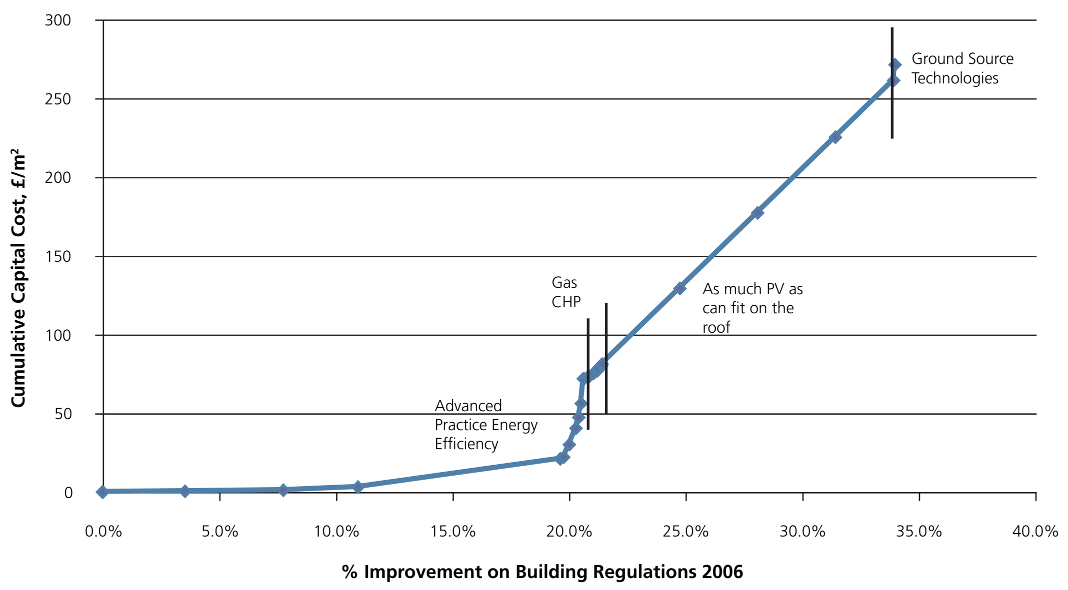
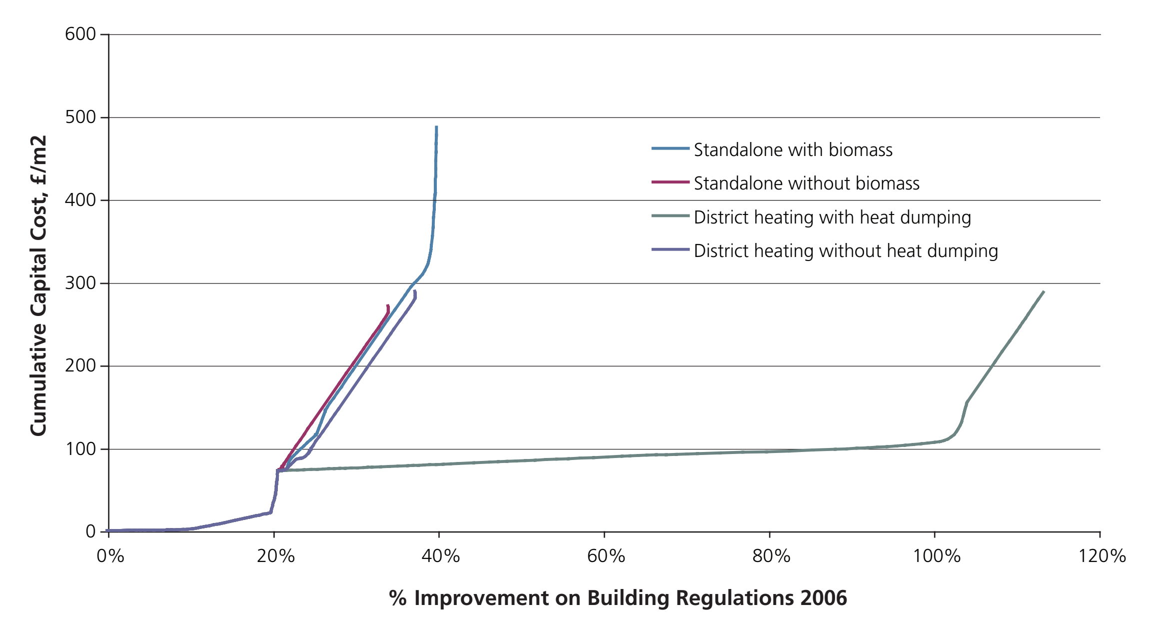
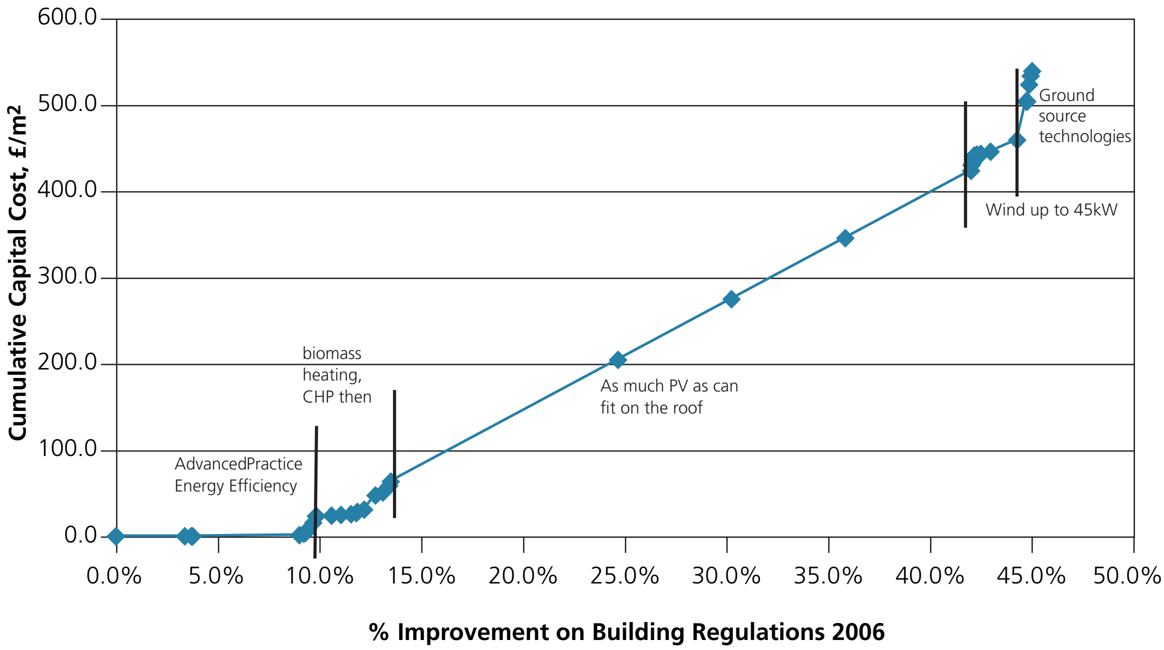


Figure A2.24: Cumulative cost of improving on 2006 Building Regulations Shopping Centre / All Scenarios



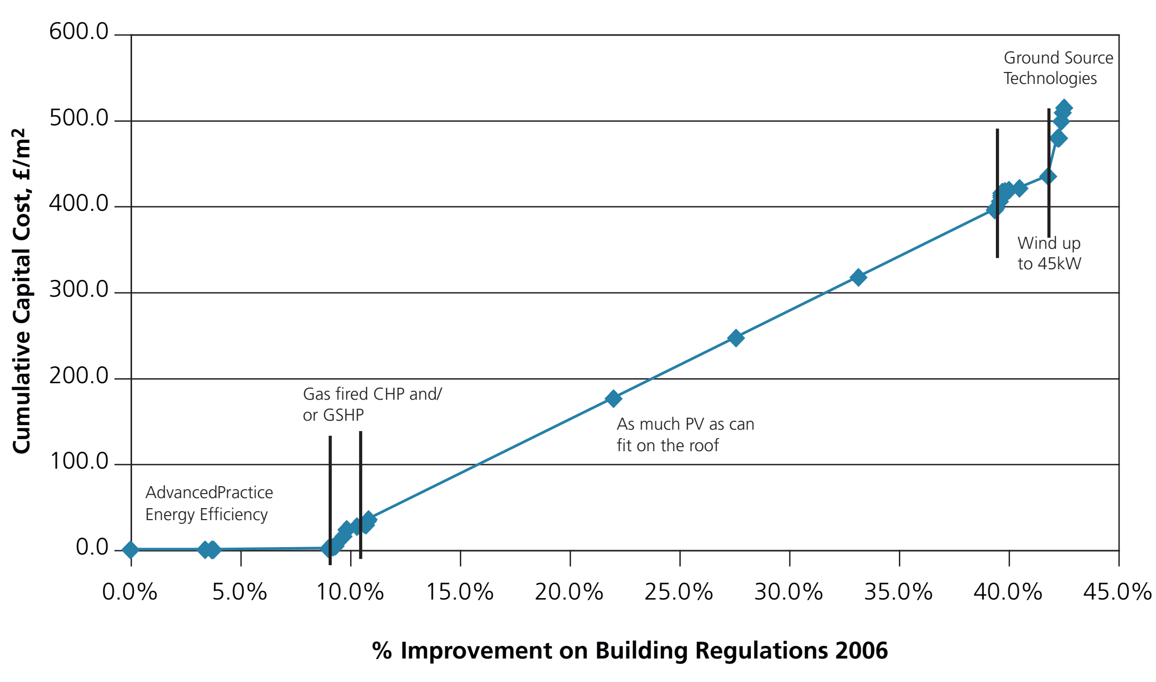
Source: AECOM

Figure A2.25: Cumulative cost of improving on 2006 Building Regulations Large Supermarket / District Heating / With biomass



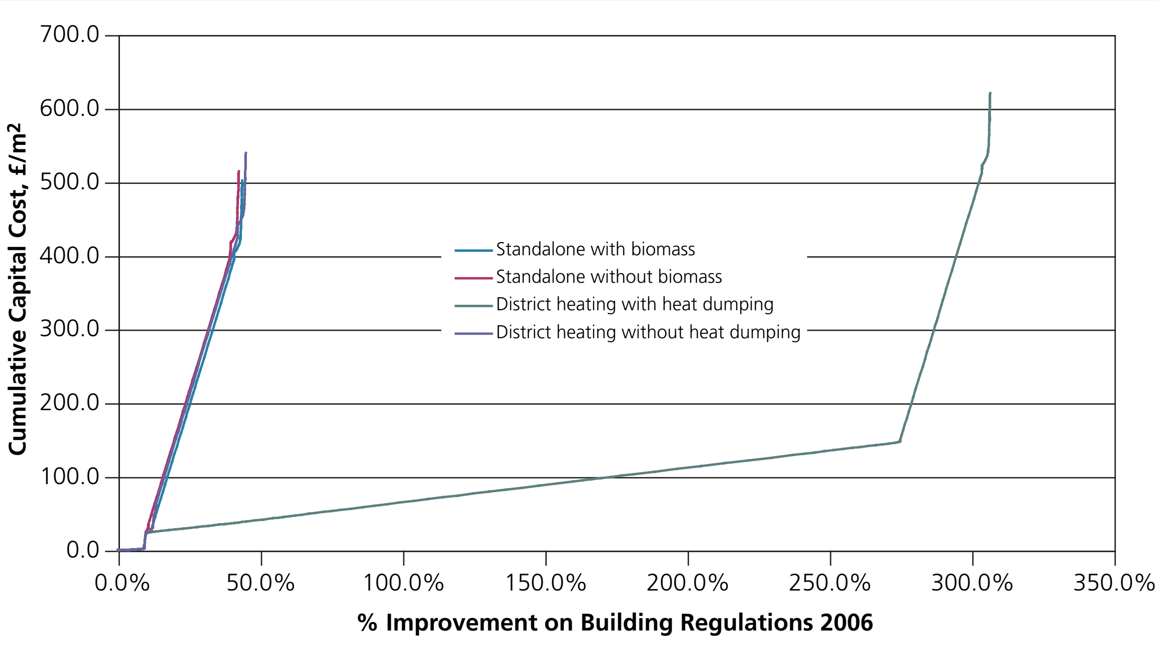
Source: AECOM

Figure A2.26: Cumulative cost of improving on 2006 Building Regulations Large Supermarket / Standalone / Without biomass



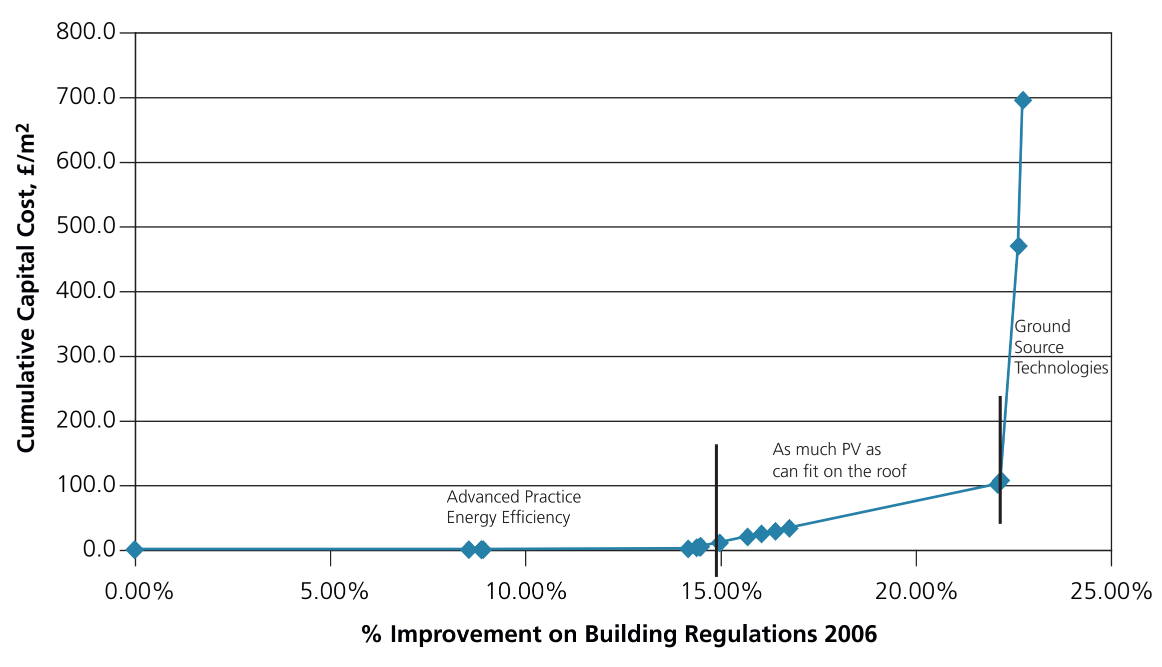
Source: AECOM

Figure A2.27: Cumulative cost of improving on 2006 Building Regulations Large Supermarket / All Scenarios



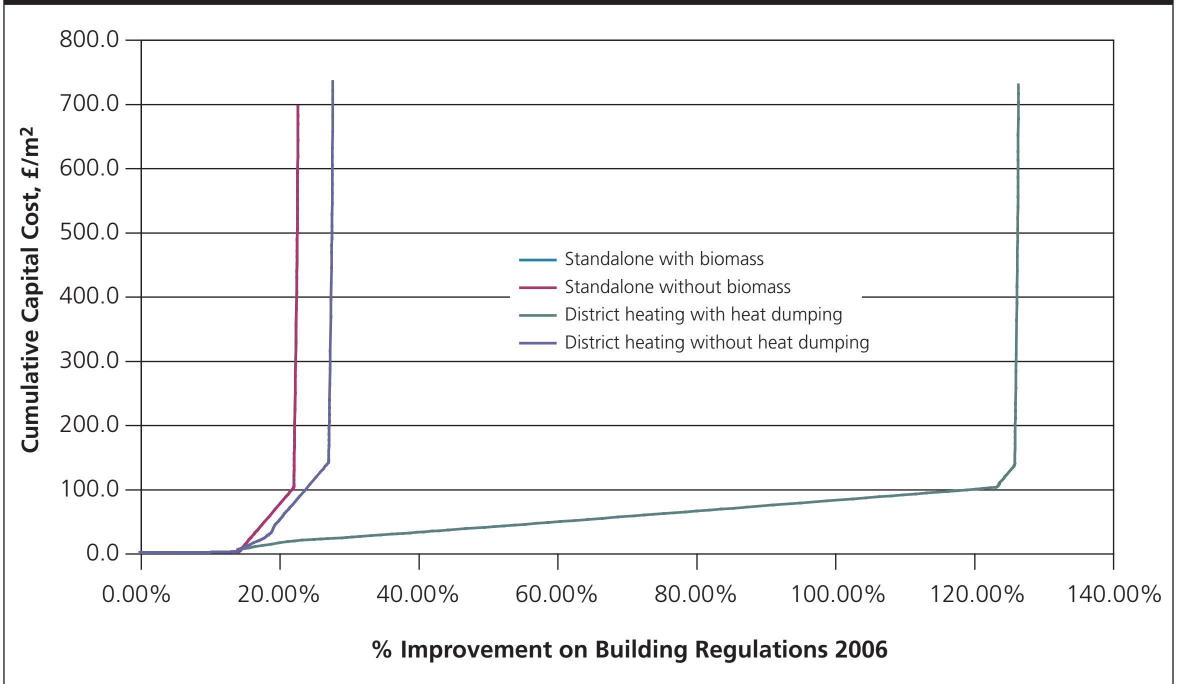
Source: AECOM

Figure A2.28: Cumulative cost of improving on 2006 Building Regulations MIni supermarket / Standalone



Source: AECOM

Figure A2.29: Cumulative cost of improving on 2006 Building Regulations MIni supermarket / All Scenarios



Source: AECOM

Appendix 3

Cost benefit sensitivity analyses

A3.1 Detailed cost benefit tables for the sensitivity analyses described in Section 4 are set out below. All values are relative to the corresponding 2010 Reference Case.

Energy prices and carbon valuation

Low energy and carbon values

Table A3.1: Costs and benefits; Option 2, biomass allowed, low energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	30%	37%	44% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	99	222	821	0	1,143
Incremental costs	(0)	(37)	(670)	(5,479)	(613)	(6,799)
Sub-total	**0**	**62**	**(447)**	**(4,658)**	**(613)**	**(5,656)**
Carbon savings – ETS	0	8	20	716	242	986
Carbon savings – non-ETS	0	36	63	877	248	1,223
Total carbon savings	0	44	83	1,593	490	2,209
Net benefit/cost excl. avoided renewables	**0**	**106**	**(364)**	**(3,066)**	**(123)**	**(3,447)**
Avoided renewables	0	85	118	334	0	537
Net benefit/cost incl. avoided renewables	**0**	**191**	**(246)**	**(2,731)**	**(123)**	**(2,910)**

Source: Europe Economics

Table A3.2: Costs and benefits; Option 3, biomass allowed, low energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	325	361	1,163	0	1,849
Incremental costs	(0)	(1,305)	(1,806)	(7,749)	(603)	(11,463)
Sub-total	**0**	**(980)**	**(1,445)**	**(6,587)**	**(603)**	**(9,615)**
Carbon savings – ETS	0	29	37	680	238	984
Carbon savings – non-ETS	0	87	77	785	244	1,193
Total carbon savings	0	115	115	1,465	482	2,178
Net benefit/cost excl. avoided renewables	**0**	**(864)**	**(1,330)**	**(5,121)**	**(121)**	**(7,437)**
Avoided renewables	0	133	119	334	0	586
Net benefit/cost incl. avoided renewables	**0**	**(731)**	**(1,212)**	**(4,787)**	**(121)**	**(6,851)**

Source: Europe Economics

Table A3.3: Costs and benefits; Option 4, biomass allowed, low energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	53%	63% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	325	403	1,627	0	2,355
Incremental costs	(0)	(1,305)	(2,256)	(11,617)	(603)	(15,781)
Sub-total	**0**	**(980)**	**(1,854)**	**(9,990)**	**(603)**	**(13,426)**
Carbon savings – ETS	0	29	44	657	238	967
Carbon savings – non-ETS	0	87	77	687	244	1,095
Total carbon savings	0	115	121	1,344	482	2,063
Net benefit/cost excl. avoided renewables	**0**	**(864)**	**(1,732)**	**(8,645)**	**(121)**	**(11,363)**
Avoided renewables	0	133	119	334	0	586
Net benefit/cost incl. avoided renewables	**0**	**(731)**	**(1,614)**	**(8,311)**	**(121)**	**(10,777)**

Source: Europe Economics

Table A3.4: Costs and benefits; Option 2, biomass not allowed, low energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	30%	37%	44% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	96	140	642	0	878
Incremental costs	(0)	(49)	(548)	(4,567)	(562)	(5,727)
Sub-total	**0**	**47**	**(409)**	**(3,925)**	**(562)**	**(4,848)**
Carbon savings – ETS	0	10	11	736	224	982
Carbon savings – non-ETS	0	25	39	783	230	1,077
Total carbon savings	0	35	50	1,519	455	2,058
Net benefit/cost excl. avoided renewables	**0**	**82**	**(358)**	**(2,406)**	**(108)**	**(2,790)**
Avoided renewables	0	67	96	271	0	434
Net benefit/cost incl. avoided renewables	**0**	**149**	**(263)**	**(2,135)**	**(108)**	**(2,356)**

Source: Europe Economics

Table A3.5: Costs and benefits; Option 3, biomass not allowed, low energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	257	262	899	0	1,419
Incremental costs	(0)	(1,175)	(1,385)	(6,687)	(553)	(9,800)
Sub-total	**0**	**(917)**	**(1,123)**	**(5,788)**	**(553)**	**(8,381)**
Carbon savings – ETS	0	29	30	685	221	964
Carbon savings – non-ETS	0	40	38	693	226	999
Total carbon savings	0	69	68	1,378	447	1,962
Net benefit/cost excl. avoided renewables	**0**	**(848)**	**(1,054)**	**(4,410)**	**(106)**	**(6,419)**
Avoided renewables	0	108	96	271	0	476
Net benefit/cost incl. avoided renewables	**0**	**(740)**	**(958)**	**(4,139)**	**(106)**	**(5,943)**

Source: Europe Economics

Table A3.6: Costs and benefits; Option 4, biomass not allowed, low energy and carbon values						
	2010 – 2013 (incl. in c/f)	**2013 – 2016**	**2016 – 2019**	**2019 – 2029 reg**	**2019 – 2029 unreg**	**Total (2013-2029)**
Target reduction regulated (%)	25%	44%	53%	57% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	255	319	1,123	0	1,697
Incremental costs	(0)	(1,168)	(1,806)	(7,335)	(553)	(10,862)
Sub-total	0	(913)	(1,487)	(6,212)	(553)	(9,165)
Carbon savings – ETS	0	28	39	691	221	979
Carbon savings – non-ETS	0	40	37	664	226	967
Total carbon savings	0	69	76	1,354	447	1,946
Net benefit/cost excl. avoided renewables	0	(844)	(1,411)	(4,857)	(106)	(7,219)
Avoided renewables	0	108	96	271	0	476
Net benefit/cost incl. avoided renewables	0	(736)	(1,315)	(4,586)	(106)	(6,743)

Source: Europe Economics

High energy and carbon values

Table A3.7: Costs and benefits; Option 2, biomass allowed, high energy and carbon values						
	2010 – 2013 (incl. in c/f)	**2013 – 2016**	**2016 – 2019**	**2019 – 2029 reg**	**2019 – 2029 unreg**	**Total (2013-2029)**
Target reduction regulated (%)	25%	30%	37%	44% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	218	489	1,803	0	2,510
Incremental costs	(0)	(37)	(670)	(5,479)	(613)	(6,799)
Sub-total	**0**	**181**	**(180)**	**(3,676)**	**(613)**	**(4,288)**
Carbon savings – ETS	0	21	51	2,100	720	2,892
Carbon savings – non-ETS	0	106	189	2,616	738	3,649
Total carbon savings	0	127	240	4,716	1,459	6,542
Net benefit/cost excl. avoided renewables	**0**	**308**	**59**	**1,040**	**846**	**2,253**
Avoided renewables	0	85	118	334	0	537
Net benefit/cost incl. avoided renewables	**0**	**393**	**177**	**1,374**	**846**	**2,790**

Source: Europe Economics

Table A3.8: Costs and benefits; Option 3, biomass allowed, high energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	714	777	2,472	0	3,962
Incremental costs	(0)	(1,305)	(1,806)	(7,749)	(603)	(11,463)
Sub-total	**0**	**(591)**	**(1,029)**	**(5,277)**	**(603)**	**(7,501)**
Carbon savings – ETS	0	72	94	1,966	709	2,841
Carbon savings – non-ETS	0	260	232	2,344	727	3,562
Total carbon savings	0	332	325	4,310	1,436	6,403
Net benefit/cost excl. avoided renewables	**0**	**(259)**	**(704)**	**(967)**	**833**	**(1,097)**
Avoided renewables	0	133	119	334	0	586
Net benefit/cost incl. avoided renewables	**0**	**(126)**	**(586)**	**(633)**	**833**	**(511)**

Source: Europe Economics

Table A3.9: Costs and benefits; Option 4, biomass allowed, high energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	53%	63% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	714	858	3,379	0	4,950
Incremental costs	(0)	(1,305)	(2,256)	(11,617)	(603)	(15,781)
Sub-total	**0**	**(591)**	**(1,398)**	**(8,238)**	**(603)**	**(10,831)**
Carbon savings – ETS	0	72	109	1,860	709	2,751
Carbon savings – non-ETS	0	260	232	2,052	727	3,271
Total carbon savings	0	332	341	3,912	1,436	6,022
Net benefit/cost excl. avoided renewables	**0**	**(259)**	**(1,057)**	**(4,326)**	**833**	**(4,809)**
Avoided renewables	0	133	119	334	0	586
Net benefit/cost incl. avoided renewables	**0**	**(126)**	**(939)**	**(3,991)**	**833**	**(4,223)**

Source: Europe Economics

Table A3.10: Costs and benefits; Option 2, biomass not allowed, high energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	30%	37%	44% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	199	300	1,317	0	1,816
Incremental costs	(0)	(49)	(548)	(4,567)	(562)	(5,727)
Sub-total	**0**	**151**	**(249)**	**(3,250)**	**(562)**	**(3,911)**
Carbon savings – ETS	0	25	27	2,154	669	2,874
Carbon savings – non-ETS	0	74	117	2,336	686	3,213
Total carbon savings	0	99	144	4,489	1,355	6,087
Net benefit/cost excl. avoided renewables	**0**	**249**	**(104)**	**1,239**	**792**	**2,176**
Avoided renewables	0	67	96	271	0	434
Net benefit/cost incl. avoided renewables	**0**	**316**	**(9)**	**1,510**	**792**	**2,610**

Source: Europe Economics

Table A3.11: Costs and benefits; Option 3, biomass not allowed, high energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	527	537	1,821	0	2,885
Incremental costs	(0)	(1,175)	(1,385)	(6,687)	(553)	(9,800)
Sub-total	**0**	**(648)**	**(848)**	**(4,866)**	**(553)**	**(6,915)**
Carbon savings – ETS	0	69	72	1,981	658	2,780
Carbon savings – non-ETS	0	121	115	2,069	674	2,980
Total carbon savings	0	190	187	4,051	1,332	5,760
Net benefit/cost excl. avoided renewables	**0**	**(458)**	**(661)**	**(815)**	**779**	**(1,155)**
Avoided renewables	0	108	96	271	0	476
Net benefit/cost incl. avoided renewables	**0**	**(350)**	**(564)**	**(544)**	**779**	**(680)**

Source: Europe Economics

Table A3.12: Costs and benefits; Option 4, biomass not allowed, high energy and carbon values

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	53%	57% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	522	645	2,259	0	3,426
Incremental costs	(0)	(1,168)	(1,806)	(7,335)	(553)	(10,862)
Sub-total	**0**	**(646)**	**(1,161)**	**(5,077)**	**(553)**	**(7,436)**
Carbon savings – ETS	0	68	95	1,982	658	2,803
Carbon savings – non-ETS	0	120	111	1,981	674	2,886
Total carbon savings	0	189	205	3,963	1,332	5,689
Net benefit/cost excl. avoided renewables	**0**	**(457)**	**(955)**	**(1,114)**	**779**	**(1,747)**
Avoided renewables	0	108	96	271	0	476
Net benefit/cost incl. avoided renewables	**0**	**(349)**	**(859)**	**(843)**	**779**	**(1,271)**

Source: Europe Economics

Proportions of stand-alone and district heating in the build mix

Table A3.13: Costs and benefits; Option 2, biomass allowed, 30% district heating

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	30%	37%	44% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	181	368	1,380	0	1,929
Incremental costs	(0)	(37)	(636)	(5,214)	(618)	(6,505)
Sub-total	**0**	**(144)**	**(268)**	**(3,834)**	**(618)**	**(4,576)**
Carbon savings – ETS	0	16	30	1,401	486	1,933
Carbon savings – non-ETS	0	72	128	1,761	498	2,460
Total carbon savings	0	88	158	3,162	985	4,393
Net benefit/cost excl. avoided renewables	**0**	**231**	**(109)**	**(672)**	**367**	**(183)**
Avoided renewables	0	86	120	340	0	545
Net benefit/cost incl. avoided renewables	**0**	**317**	**10**	**(332)**	**367**	**362**

Source: Europe Economics

Table A3.14: Costs and benefits; Option 3, biomass allowed, 30% district heating

	2010 – 2013 (incl. in c/f))	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	547	614	1,981	0	3,142
Incremental costs	(0)	(1,256)	(1,722)	(7,537)	(609)	(11,124)
Sub-total	**0**	**(709)**	**(1,107)**	**(5,557)**	**(609)**	**(7,982)**
Carbon savings – ETS	0	45	63	1,324	479	1,911
Carbon savings – non-ETS	0	176	157	1,577	491	2,402
Total carbon savings	0	221	220	2,901	971	4,312
Net benefit/cost excl. avoided renewables	**0**	**(488)**	**(887)**	**(2,656)**	**362**	**(3,669)**
Avoided renewables	0	136	121	340	0	596
Net benefit/cost incl. avoided renewables	**0**	**(352)**	**(767)**	**(2,316)**	**362**	**(3,073)**

Source: Europe Economics

Table A3.15: Costs and benefits; Option 4, biomass allowed, 30% district heating

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	53%	63% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	547	686	2,808	0	4,041
Incremental costs	(0)	(1,256)	(2,169)	(11,698)	(609)	(15,731)
Sub-total	**0**	**(709)**	**(1,482)**	**(8,890)**	**(609)**	**(11,690)**
Carbon savings – ETS	0	45	75	1,270	479	1,870
Carbon savings – non-ETS	0	176	157	1,378	491	2,203
Total carbon savings	0	221	232	2,649	971	4,073
Net benefit/cost excl. avoided renewables	**0**	**(488)**	**(1,250)**	**(6,241)**	**362**	**(7,617)**
Avoided renewables	0	136	121	340	0	596
Net benefit/cost incl. avoided renewables	**0**	**(352)**	**(1,130)**	**(5,901)**	**362**	**(7,021)**

Source: Europe Economics

Table A3.16: Costs and benefits; Option 2, biomass not allowed, 30% district heating						
	2010 – 2013 (incl. in c/f)	**2013 – 2016**	**2016 – 2019**	**2019 – 2029 reg**	**2019 – 2029 unreg**	**Total (2013-2029)**
Target reduction regulated (%)	25%	30%	37%	44% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	167	248	1,122	0	1,536
Incremental costs	(0)	(48)	(529)	(4,425)	(630)	(5,632)
Sub-total	**0**	**119**	**(282)**	**(3,303)**	**(630)**	**(4,096)**
Carbon savings – ETS	0	18	21	1,402	503	1,944
Carbon savings – non-ETS	0	49	77	1,501	516	2,143
Total carbon savings	0	67	98	2,903	1,019	4,087
Net benefit/cost excl. avoided renewables	**0**	**186**	**(184)**	**(401)**	**389**	**(9)**
Avoided renewables	0	66	95	270	0	431
Net benefit/cost incl. avoided renewables	**0**	**253**	**(89)**	**(131)**	**389**	**422**

Source: Europe Economics

Table A3.17: Costs and benefits; Option 3, biomass not allowed, 30% district heating						
	2010 – 2013 (incl. in c/f)	**2013 – 2016**	**2016 – 2019**	**2019 – 2029 reg**	**2019 – 2029 unreg**	**Total (2013-2029)**
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	449	460	1,562	0	2,471
Incremental costs	(0)	(1,143)	(1,359)	(6,545)	(588)	(9,635)
Sub-total	**0**	**(694)**	**(898)**	**(4,984)**	**(588)**	**(7,164)**
Carbon savings – ETS	0	53	55	1,313	471	1,892
Carbon savings – non-ETS	0	79	78	1,351	483	1,991
Total carbon savings	0	133	133	2,665	953	3,883
Net benefit/cost excl. avoided renewables	**0**	**(562)**	**(766)**	**(2,319)**	**365**	**(3,281)**
Avoided renewables	0	108	96	270	0	473
Net benefit/cost incl. avoided renewables	**0**	**(454)**	**(670)**	**(2,049)**	**365**	**(2,808)**

Source: Europe Economics

Table A3.18: Costs and benefits; Option 4, biomass not allowed, 30% district heating						
	2010 – 2013 (incl. in c/f)	**2013 – 2016**	**2016 – 2019**	**2019 – 2029 reg**	**2019 – 2029 unreg**	**Total (2013-2029)**
Target reduction regulated (%)	25%	44%	53%	57% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	445	553	1,952	0	2,950
Incremental costs	(0)	(1,135)	(1,765)	(7,207)	(575)	(10,682)
Sub-total	**0**	**(691)**	**(1,212)**	**(5,255)**	**(575)**	**(7,732)**
Carbon savings – ETS	0	53	72	1,332	461	1,917
Carbon savings – non-ETS	0	79	75	1,302	473	1,929
Total carbon savings	0	132	147	2,634	934	3,846
Net benefit/cost excl. avoided renewables	**0**	**(559)**	**(1,065)**	**(2,621)**	**359**	**(3,886)**
Avoided renewables	0	108	96	270	0	473
Net benefit/cost incl. avoided renewables	**0**	**(451)**	**(969)**	**(2,351)**	**359**	**(3,413)**

Source: Europe Economics

Allowable solutions cost

Table A3.19: Costs and benefits; Option 2, biomass allowed, £100/tCO_2 allowable solution cost						
	2010 – 2013 (incl. in c/f)	**2013 – 2016**	**2016 – 2019**	**2019 – 2029 reg**	**2019 – 2029 unreg**	**Total (2013-2029)**
Target reduction regulated (%)	25%	30%	37%	44% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	179	401	1,477	0	2,057
Incremental costs	(0)	(37)	(670)	(6,016)	(817)	(7,539)
Sub-total	**0**	**142**	**(269)**	**(4,539)**	**(817)**	**(5,482)**
Carbon savings – ETS	0	16	38	1,419	482	1,955
Carbon savings – non-ETS	0	71	126	1,749	494	2,440
Total carbon savings	0	86	164	3,168	977	4,395
Net benefit/cost excl. avoided renewables	**0**	**229**	**(105)**	**(1,371)**	**160**	**(1,087)**
Avoided renewables	0	85	118	334	0	537
Net benefit/cost incl. avoided renewables	**0**	**313**	**13**	**(1,036)**	**160**	**(551)**

Source: Europe Economics

Table A3.20: Costs and benefits; Option 3, biomass allowed, £100/tCO_2 allowable solution cost

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	584	643	2,057	0	3,284
Incremental costs	(0)	(1,305)	(1,806)	(8,209)	(804)	(12,124)
Sub-total	**0**	**(720)**	**(1,163)**	**(6,152)**	**(804)**	**(8,840)**
Carbon savings – ETS	0	54	69	1,340	475	1,938
Carbon savings – non-ETS	0	173	154	1,567	487	2,381
Total carbon savings	0	227	224	2,907	962	4,319
Net benefit/cost excl. avoided renewables	**0**	**(494)**	**(939)**	**(3,245)**	**157**	**(4,521)**
Avoided renewables	0	133	119	334	0	586
Net benefit/cost incl. avoided renewables	**0**	**(360)**	**(821)**	**(2,910)**	**157**	**(3,934)**

Source: Europe Economics

Table A3.21: Costs and benefits; Option 4, biomass allowed, £100/tCO_2 allowable solution cost

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	53%	63% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	584	713	2,846	0	4,143
Incremental costs	(0)	(1,305)	(2,256)	(11,996)	(804)	(16,361)
Sub-total	**0**	**(720)**	**(1,543)**	**(9,150)**	**(804)**	**(12,218)**
Carbon savings – ETS	0	54	81	1,283	475	1,893
Carbon savings – non-ETS	0	173	155	1,372	487	2,186
Total carbon savings	0	227	236	2,655	962	4,079
Net benefit/cost excl. avoided renewables	**0**	**(494)**	**(1,307)**	**(6,495)**	**157**	**(8,139)**
Avoided renewables	0	133	119	334	0	586
Net benefit/cost incl. avoided renewables	**0**	**(360)**	**(1,189)**	**(6,161)**	**157**	**(7,552)**

Source: Europe Economics

Table A3.22: Costs and benefits; Option 2, biomass not allowed, £100/tCO_2 allowable solution cost

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	30%	37%	44% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	168	248	1,115	0	1,531
Incremental costs	(0)	(49)	(548)	(5,101)	(750)	(6,448)
Sub-total	**0**	**120**	**(300)**	**(3,986)**	**(750)**	**(4,917)**
Carbon savings – ETS	0	18	20	1,457	448	1,944
Carbon savings – non-ETS	0	49	78	1,562	459	2,149
Total carbon savings	0	68	99	3,019	907	4,093
Net benefit/cost excl. avoided renewables	**0**	**188**	**(202)**	**(967)**	**157**	**(824)**
Avoided renewables	0	67	96	271	0	434
Net benefit/cost incl. avoided renewables	**0**	**255**	**(106)**	**(696)**	**157**	**(390)**

Source: Europe Economics

Table A3.23: Costs and benefits; Option 3, biomass not allowed, £100/tCO_2 allowable solution cost

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	446	455	1,551	0	2,452
Incremental costs	(0)	(1,175)	(1,385)	(7,158)	(738)	(10,455)
Sub-total	**0**	**(728)**	**(930)**	**(5,607)**	**(738)**	**(8,003)**
Carbon savings – ETS	0	53	55	1,350	440	1,897
Carbon savings – non-ETS	0	80	77	1,384	452	1,993
Total carbon savings	0	133	131	2,733	892	3,890
Net benefit/cost excl. avoided renewables	**0**	**(595)**	**(799)**	**(2,873)**	**154**	**(4,113)**
Avoided renewables	0	108	96	271	0	476
Net benefit/cost incl. avoided renewables	**0**	**(487)**	**(702)**	**(2,602)**	**154**	**(3,637)**

Source: Europe Economics

Table A3.24: Costs and benefits; Option 4, biomass not allowed, £100/tCO_2 allowable solution cost	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	53%	57% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	443	550	1,932	0	2,924
Incremental costs	(0)	(1,168)	(1,806)	(7,786)	(738)	(11,497)
Sub-total	**0**	**(725)**	**(1,256)**	**(5,854)**	**(738)**	**(8,574)**
Carbon savings – ETS	0	52	72	1,356	440	1,921
Carbon savings – non-ETS	0	80	74	1,325	452	1,930
Total carbon savings	0	132	146	2,681	892	3,851
Net benefit/cost excl. avoided renewables	**0**	**(593)**	**(1,111)**	**(3,173)**	**154**	**(4,723)**
Avoided renewables	0	108	96	271	0	476
Net benefit/cost incl. avoided renewables	**0**	**(485)**	**(1,014)**	**(2,902)**	**154**	**(4,247)**

Source: Europe Economics

Surplus heat allowed

Table A3.25: Costs and benefits; Option 2, surplus heat allowed in district heating cases	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	30%	37%	44% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	220	366	1,302	0	1,888
Incremental costs	(0)	(59)	(601)	(4,490)	(618)	(5,768)
Sub-total	**0**	**160**	**(235)**	**(3,187)**	**(618)**	**(3,880)**
Carbon savings – ETS	0	24	30	1,424	482	1,960
Carbon savings – non-ETS	0	76	126	1,792	495	2,488
Total carbon savings	0	100	156	3,216	977	4,448
Net benefit/cost excl. avoided renewables	**0**	**260**	**(79)**	**29**	**359**	**569**
Avoided renewables	0	86	117	333	0	537
Net benefit/cost incl. avoided renewables	**0**	**346**	**38**	**362**	**359**	**1,105**

Source: Europe Economics

Table A3.26: Costs and benefits; Option 3, surplus heat allowed in district heating cases

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	517	655	2,096	0	3,267
Incremental costs	(0)	(1,107)	(1,399)	(6,424)	(614)	(9,545)
Sub-total	**0**	**(591)**	**(745)**	**(4,329)**	**(614)**	**(6,278)**
Carbon savings – ETS	0	40	70	1,414	479	2,003
Carbon savings – non-ETS	0	174	155	1,641	491	2,460
Total carbon savings	0	214	224	3,055	970	4,463
Net benefit/cost excl. avoided renewables	**0**	**(377)**	**(520)**	**(1,274)**	**357**	**(1,815)**
Avoided renewables	0	133	118	333	0	584
Net benefit/cost incl. avoided renewables	**0**	**(244)**	**(402)**	**(941)**	**357**	**(1,230)**

Source: Europe Economics

Table A3.27: Costs and benefits; Option 4, surplus heat allowed in district heating cases

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	53%	63% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	517	728	2,680	0	3,924
Incremental costs	(0)	(1,107)	(1,708)	(9,480)	(614)	(12,909)
Sub-total	**0**	**(591)**	**(980)**	**(6,800)**	**(614)**	**(8,985)**
Carbon savings – ETS	0	40	82	1,359	479	1,961
Carbon savings – non-ETS	0	174	155	1,484	491	2,304
Total carbon savings	0	214	237	2,844	970	4,265
Net benefit/cost excl. avoided renewables	**0**	**(377)**	**(743)**	**(3,956)**	**357**	**(4,720)**
Avoided renewables	0	133	118	333	0	584
Net benefit/cost incl. avoided renewables	**0**	**(244)**	**(625)**	**(3,623)**	**357**	**(4,136)**

Source: Europe Economics

Grid decarbonisation

Table A3.28: Costs and benefits; Option 3, biomass allowed, latest IAG grid decarbonisation assumptions

	2010 – 2013 (incl. in c/f)	2013 – 2016	2016 – 2019	2019 – 2029 reg	2019 – 2029 unreg	Total (2013-2029)
Target reduction regulated (%)	25%	44%	49%	54% + a/s		
Target reduction unregulated (%)	0%	0%	0%		100%	
Energy savings	0	584	643	2,057	0	3,284
Incremental costs	(0)	(1,305)	(1,806)	(7,749)	(603)	(11,463)
Sub-total	**0**	**(720)**	**(1,163)**	**(5,692)**	**(603)**	**(8,179)**
Carbon savings – ETS	0	53	65	827	263	1,207
Carbon savings – non-ETS	0	173	154	1,076	270	1,673
Total carbon savings	0	225	219	1,902	533	2,880
Net benefit/cost excl. avoided renewables	**0**	**(495)**	**(944)**	**(3,789)**	**(70)**	**(5,299)**
Avoided renewables	0	133	119	334	0	586
Net benefit/cost incl. avoided renewables	**0**	**(361)**	**(826)**	**(3,455)**	**(70)**	**(4,713)**

Source: Europe Economics

Appendix 4

New public sector buildings

A4.2 This Impact Assessment has focused upon a progressive regulatory tightening for private sector new non-domestic buildings in line with an ambition to introduce zero carbon build standards from 2019.

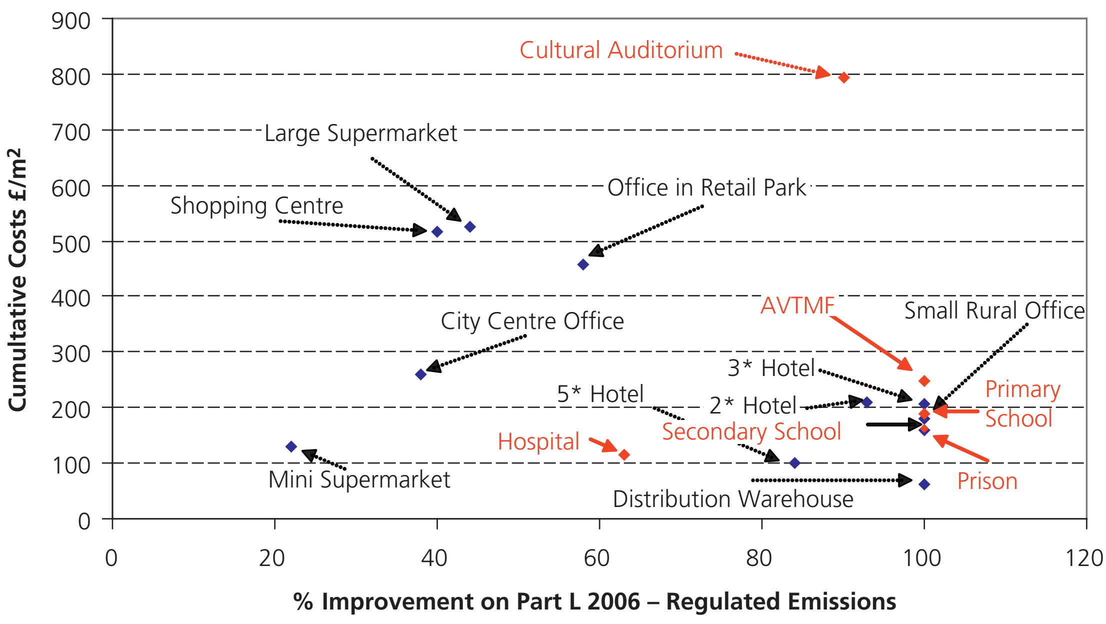
A4.3 However, much of the analysis is also relevant to the public sector building stock and especially to the ambition that the public sector should show leadership through ensuring that every new public sector building is zero carbon from 2018.

A4.4 An important area of overlap is the work on the capital cost curves for offices above, which will be relevant to public sector offices as well as commercial. Although there are overlaps, it has been suggested that there would be particular challenges for some public sector building types in particular sectors. There may also be distinctive issues relating to the introduction of offsite allowable solutions for public sector buildings.

A4.5 Clearly the aggregate approach will help ensure that those public sector buildings which are able to abate carbon more cheaply would be expected to reach a higher level of abatement, through carbon compliance, than those for which it is more expensive. In addition, the discussion on inclusion of unregulated emissions for non-domestic buildings will also be relevant to public sector buildings.

A4.6 Some initial work has been done to model the capital costs for a small range of distinctive public sector building types to reach deeper abatement through carbon compliance.

Figure A4.1: Regulated Energy and Carbon Compliance – Stand Alone with Biomass



A4.7 Figure A4.1 above shows, on the horizontal axis, for each building type, the highest practical level of carbon compliance abatement compared with 2006 Part L standards, up to abatement of 100 per cent of regulated emissions.

A4.8 The vertical axis shows the cumulative capital cost in £ per m2 to achieve this level. It contains the results for the 11 building typology outlined in this IA plus a small range of different public sector building types. This includes a Hospital, Prison, Secondary School, Primary School, Defence Armoured vehicle training and maintenance facility (AVTMF) and a Cultural Auditorium.

A4.9 The initial results so far show that some public sector buildings examined are able to reach higher levels of carbon compliance. For instance all types of public sector buildings modelled are able to reach over 80 per cent reduction through carbon compliance, with the exception of an acute hospital.

A4.10 This is generally because many public sector buildings tend to be less energy intense and have larger roof areas in comparison to Gross Internal Floor Area than other non-domestic buildings. This enables them to attach a higher quantity of solar photovoltaics. They also tend to have larger boiler loads which can be dealt with by biomass heating options.

A4.11 The non-biomass figures show a drop in the carbon compliance achievable (as expected) but the results are still better than the commercial buildings.

A4.12 We are now undertaking more detailed cost benefit analysis consistent with the ambition that every new public sector building be zero carbon from 2018, based upon the initial approach in this Impact Assessment.

A4.13 This is also considering the potential for introducing or expanding the use of third party finance, such as Revolving Funds or the introduction of Energy Services Companies for new public sector buildings.

A4.14 This will help inform a more detailed consideration of the 2018 ambition in the light of the responses to this consultation.

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