element energy

A Renewable and Low Carbon Energy Study

for

Chesterfield Borough Council

Final Report

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Glossary

AAC	Autoclaved aerated concrete
AAP	Area action plan
AGL	Above ground level
AMR	Annual Monitoring Report
ASHP	Air source heat pump
BERR	Department for Business, Enterprise and Regulatory Reform
BM	Biomass
CBC	Chesterfield Borough Council
CHP	Combined heat and power
CSH	Code for Sustainable Homes
DCLG	Department for Communities and Local Government
DER	Dwelling emission rate
DHW	Domestic hot water
EA	Environment Agency
FiT	Feed-in tariff
GDF	General Development Framework
GIS	Geographic Information Systems
GSHP	Ground source heat pump
HOB	Heat only boiler
kW	Kilowatt (unit of power)
kWh	Kilowatt hour (unit of energy)
LZC	Low and zero carbon
MW	Megawatt (1MW = 1,000kW)
MWh	Megawatt hour (1MWh = 1,000kWh)
MVHR	Mechanical ventilation with heat recovery
NOABL	Numerical Objective Analysis of Boundary Layer (Wind speed model)
PPS	Planning Policy Statement
PV	Photovoltaics
RDF	Refuse derived fuel
RHI	Renewable heat incentive
SAP	Standard assessment procedure
SH	Space heating
SHLAA	Strategic housing land availability assessment
SRC	Short rotation coppice
UDP	Unitary Development Plan

Contents

1 Summary

1.1 Overview

The introduction of national planning guidance such as the Supplement to PPS1 (on Climate Change) and PPS22 (on renewables) has greatly increased the role and responsibility regions have in reducing CO_2 emissions and meeting renewable energy requirements. Planning authorities are required to understand the potential for low and zero carbon technologies within their jurisdictions and to set informed targets for renewable energy in new developments.

This study provides the evidence base for setting targets for the CO_2 performance of new developments in Chesterfield borough. It includes an assessment of the local context in terms of development plans and existing policies, and an opportunity assessment for decentralised, renewable and low carbon technologies. These assessments are complemented by an analysis of the technical feasibility and economic implications of low carbon development in Chesterfield borough. This provides the basis upon which the policy recommendations for the Council's planners are based.

1.2 Renewable energy resource assessment: highlights

1.2.1 Biomass

An assessment of the potential energy supply from locally grown biomass led to the following key conclusions:

- The potential biomass resource from existing woodlands in the borough is highly constrained. Similarly, land available for energy crop production is limited, which means that the yield from realistic levels of new energy crop plantations in the borough would only meet the thermal demands of a few hundred existing homes.
- Fuel supplies from the wider area are therefore required for biomass to make a significant contribution to CO_2 reduction in the borough. This means that regional and national biomass supply chains will be important if use of this fuel is to increase.
- There is currently very little production of biomass for fuel in the borough. Incentives to bring woodland into managed production or to change use of arable land will depend on the market value of biomass fuel relative to alternative outputs from the land.
- For any new biomass energy project careful consideration of the full impacts is required, particularly for large scale schemes. Impact assessments should consider local air quality, vehicle movements for fuel delivery, security of heat supply and on-going operation and management of the system.

1.2.2 Hydro electric power

Major rivers that run through the borough include the River Rother and the River Hipper. An estimation of the available hydropower resource in Chesterfield borough based on data from an Environment Agency study revealed:

- The total number of sites in the borough with potential for hydropower installations is around 27. Hydropower installations at all of these sites could see the deployment of around 365kW of hydro turbines.
- Based on an average capacity factor of 50% this maximum installed capacity could produce an electricity output of 1,600MWh/yr, which is equivalent to the electricity demands of 430 average homes.
- Whilst hydropower schemes offer some potential to provide low carbon energy and hence reduce overall CO_2 emissions, this technology is likely to remain niche and should not be regarded as a central feature of the low carbon development strategy.

1.2.3 Wind

A high-level assessment of the wind resource in the borough was completed based on data from a national wind speed database that provides estimates of mean annual wind speed in 1km square grids. This is an appropriate metric to assess the potential since power output of wind turbines scales with the cube of wind speed. Potential sites for medium to large scale turbines were identified by defining likely turbine exclusion areas (based on separation distances from buildings, roads and railways). The key conclusions are:

- The mean annual wind speed in Chesterfield borough is relatively low, which suggests that taller turbines are likely to be required for economically viable projects.
- The wind resource in Chesterfield borough is highly constrained due to the urban nature of large areas of the borough. This means that there are limited opportunities for delivering large scale wind turbines.
- The optimum sites in terms of wind resource and freedom from constraints lie on land to the north of the borough, north of Barrow Hill.

1.2.4 Decentralised energy

Policies at the national level promote decentralised energy in the form of community heating schemes based on combined heat and power or low carbon heating plant (e.g. PPS1). The economics of district heating schemes depend on the density of heat demand, which in turn depends on density and type of buildings in an area. There are a number of existing district heating schemes in Chesterfield borough. A heat density mapping exercise was undertaken to assess the potential to expand existing schemes or to establish new systems to connect new development to existing heat consumers. The main conclusions are:

- The majority of the borough is characterised by areas of low heat density, which means district heating is unlikely to be economically feasible in most areas.
- The areas of highest heat density are generally in and around the town centre, and in isolated locations where high heat consumers are situated.
- In terms of connecting major new development to existing heat consumers, the most promising opportunities are the Northern Gateway development and sites on land south of Chatsworth Road. Opportunities for using existing consumers to act as heat anchors to improve the viability of district heating systems in new developments should be investigated as the sites come forward.

1.3 Policy recommendations

A set of policy recommendations has been drafted following completion of:

- A review of national and local policy, including emerging policies currently under public consultation.
- A high-level renewable energy resource assessment to determine the potential for key technologies across the borough.
- A review of anticipated development in the borough in the period to 2026.
- Site-specific assessment for a selection of major sites in the borough.

On the basis of this analysis we recommend that the following policies are considered as Chesterfield Borough Council develops its LDF.

1.3.1 Cross-cutting policies

Policy CC1: Carbon emissions reduction targets

Chesterfield Borough Council is working toward a long-term goal of reducing the borough's carbon footprint in line with a national target of reducing total CO_2 emissions by 34% by 2020, on the path to an 80% reduction by 2050.[1] The Council has signed the Nottingham Declaration on Climate Change, which represents a pledge to tackle the issue by addressing the causes and preparing for the impacts of climate change. Ensuring that carbon emissions associated with growth within the authority area are minimised is key to this objective.

Accordingly, all development proposals should, as far as possible, contribute towards reduction of CO_2 emissions and generation of renewable energy.

Policy CC2: Provision of community heating networks

i. New developments shall connect to existing community heating networks in close proximity to the site, unless it can be demonstrated that to do so does not deliver the most beneficial solution in terms of CO_2 reduction.
ii. Where there are definitive proposals for a district heating system within close proximity of a new development, the development should be designed to facilitate future connection to the network.
iii. Where no district heating scheme exists or is proposed in the proximity of a major new development, the potential for developing a new scheme on the site should be explored and pursued where feasible. Priority sites for district heating include Staveley Works, Town Centre Northern Gateway, and South of Chatsworth Road.
iv. Where a new district heating scheme is developed, the opportunity for use of renewably fuelled CHP should be fully explored. Due regard should be paid to any constraints on fuel choice, such as proximity to air quality management areas.
v. New development should be designed to maximise the opportunity for development of a district heating solution, for example in terms of density, layout, phasing and mix of uses.

[1] Emission reduction targets set out in the Climate Change Act 2008 are relative to 1990 levels.

Policy CC3: Sustainable design and construction

Developments should meet the highest practicable standards of sustainable design and construction, including resource and energy efficiency and should aim to maximise reductions of carbon emissions.

All new development, and major refurbishment, will be required to demonstrate that:

- It makes effective use of resources and materials through sustainable construction, minimises water use, provides for waste reduction / recycling and reduces carbon emissions.
- It uses an energy hierarchy that seeks to:
  - use less energy, in particular by adopting sustainable design and construction measures,
  - supply energy efficiently, including by prioritising decentralised energy generation using low carbon or renewable technologies, and
  - make use of renewable energy, including but not limited to: solar technologies, wind power, hydro-electric power, and renewable fuel sources.
- It is sited and designed to withstand the long-term impacts of climate change, particularly the effect of rising temperatures on mechanical cooling requirements.

Sustainability standards for residential development or schemes which include residential development will be dictated by the standards of the Code for Sustainable Homes. BREEAM standards, or any scheme which supersedes it, will apply to non-residential proposals. All major development (ten or more homes or 1,000m^2 gross internal floor area) will be expected to meet the following standards.

Development type	Up to 2013	2013–2016	2016 onwards
Residential development	CSH level 4	CSH level 4	CSH level 5*
Commercial development	BREEAM Very Good	BREEAM Very Good	BREEAM Excellent

** Development will be expected to attain Code level 5 except in cases where it can be demonstrated that site viability will be undermined by this target.*

Elsewhere, all other development proposals, both new build and conversions, should demonstrate how sustainability issues have been considered; specifically this should include details of options considered to reduce CO_2 emissions beyond the minimum levels required by Building Regulations.

The Council will promote and support individual schemes that showcase best practice in sustainable construction and renewable energy generation where appropriate.

There will be a presumption that the targets will be met in full except where developers can demonstrate that in the particular circumstances there are compelling reasons for the relaxation of the targets. The onus will be on developers to robustly justify why full compliance with policy requirements is not viable.

Developments that fail to meet the required levels of carbon emissions reductions may be required to make a one-off financial contribution to be used to achieve equivalent emissions savings through off-site measures. In the first instance, however, the Council envisages that carbon growth resulting from new development will be minimised by requiring on-site carbon reduction measures. The amount of this payment, where applicable, will be determined on a site-by-site basis and calculated in line with a methodology to be set out in an updated Sustainable Design and Construction SPD.

1.3.2 Site-specific policies

SS1: Staveley Works Corridor

i. Staveley Works Corridor (SWC) is a priority site for development of a community heating network. An energy master plan for SWC should be developed that includes a community heating network across all phases of the development.
ii. An alternative energy strategy will be acceptable only where it can be demonstrated that an equivalent or greater level of CO_2 reduction (see iii below) can be delivered in a more beneficial fashion, for example, more cost-effectively, lesser environmental impact etc.
iii. Residential phases of the development constructed post-2016 should achieve the Code level 5 mandatory Energy & CO_2 standard or a Carbon Compliance level of 100%, whichever is the greater reduction.
iv. Non-residential development exceeding 1,000m^2 gross area developed prior to 2016 will achieve BREEAM 'Very Good' and BREEAM 'Excellent' thereafter.

SS2: Town Centre Northern Gateway

i. Town Centre Northern Gateway (TCNG) is a priority site for development of a community heating network. An energy master plan for TCNG should be developed that includes a community heating network across all phases of the development.
ii. The opportunity for extension of a heat network developed at the TCNG development to link to existing thermal loads or other new development in close proximity should be explored.
iii. Residential development should achieve a minimum of Code level 4.
iv. Non-residential development should achieve a minimum of BREEAM 'Very Good'.

SS3: South of Chatsworth Road

i. South of Chatsworth Road is a priority site for development of a community heating network. An energy master plan for the site should be developed that includes a community heating network across all phases of the development.
ii. The South of Chatsworth Road site is situated in close proximity to significant existing thermal loads. The opportunity for export of heat from the site to existing loads or other new development in the area should be explored.
iii. All residential development should achieve a minimum of Code level 4. Residential development constructed post-2016 should achieve the Code level 5 mandatory Energy & CO_2 standard or a Carbon Compliance level of 100%, whichever is the greater reduction.
iv. Non-residential development should achieve a minimum of BREEAM 'Very Good'.

2 Introduction

2.1 Aims of study

The aims of the study are to:

- Assess the potential for low carbon and renewable energy systems in Chesterfield borough.
- Provide an evidence base for planning policies relating to decentralised renewable and low carbon technologies in new development sites.
- Provide advice on the development of planning policy and identify additional supportive measures to achieve policy goals.

This study has been carried out in accordance with the requirements of paragraph 4.36 of PPS12, which sets out a requirement for Core Strategies to be justifiable, founded on a robust and credible evidence base and the most appropriate strategy when considered against the reasonable alternatives. This evidence base must contain two elements:

- ***Participation***: evidence of the views of the local community and others who have a stake in the future of the area.
- ***Research / fact-finding***: evidence that the choices made by the plan are supported by the background facts.

This report provides the evidence base for Chesterfield Borough Council to adopt robust and justified planning policies in its Core Strategy in respect of energy efficiency and decentralised low carbon and renewable energy. It also makes recommendations in respect of additional work that is required to support these policies.

2.2 Climate change, renewable energy and low carbon policy framework

2.2.1 National and international climate change legislation

Climate change is regarded as 'the *greatest long-term challenge facing the world today*'[2] and is a principal concern for sustainable development. A number of key legislative changes and studies have taken place that highlight the importance of reducing CO_2 emissions and increasing the supply of electricity from renewable energy. These include:

Stern Review, 2006 – outlined the economic impacts of climate change and concluded that 'the benefits of strong, early action considerably outweigh the costs'

Climate Change Act, 2008 – sets out a target to reduce carbon emissions by 80% by 2050 from 1990 levels.

UK Low Carbon Transition Plan, 2008 – the national strategy for climate and energy seeks to deliver emission cuts of 18% on 2008 levels by 2020 (and over a one third reduction on

[2] Consultation on a Planning Policy Statement: Planning for a Low Carbon Future in a Changing Climate (2010) p. 14.

1990 levels). One of the key steps is to source 40% of the UK's electricity demand from low carbon sources by 2020 with policies to:

- Produce around 30% of our electricity from renewables by 2020 by substantially increasing the requirement for electricity suppliers to sell renewable electricity.
- Fund up to four demonstrations of capturing and storing carbon emissions from coal power stations.
- Facilitate the building of new nuclear power stations.

EU Renewable Energy Directive, 2009 – requires 15% of all UK energy to come from renewables (electricity, heat and transport) by 2020.

UK Renewable Energy Strategy, 2009 – outlines how the UK aims to move towards generating 15% of its energy (including electricity, heat and transport) from renewable sources by 2020. The strategy is part of the Government's UK Low Carbon Transition Plan, which plots how a 34% reduction in emissions on 1990 levels by 2020 will be achieved.

The strategy suggests that to achieve the EU target, more than 30% of electricity must be supplied by renewables by 2020 (compared to 5.5% supplied in 2009). Of this, 2% is expected to be met by small scale generation technologies, while the remaining bulk of the target will be met through a combination of larger scale technologies such as onshore and offshore wind, biomass, hydro and wave power.

The strategy also states that a Heat and Energy Saving Strategy is being developed and suggests that 12% of heat will be supplied by renewables by 2020. In addition, the strategy:

- Introduces Feed-in-Tariffs (2010) and a Renewable Heat Incentive (2011), which will provide guaranteed payments to individuals, business and communities for renewable heat and small scale electricity generation.
- Suggests that a strategic approach to planning is required to ensure that regions can deliver their renewable energy potential in line with the 2020 targets (p. 15).
- States the need for a swifter delivery of renewable projects through the planning system and quicker, smarter grid connection (p. 15).

The UK Renewable Energy Strategy also states:

"*At the heart of our Strategy is an approach that is based on an assessment of the renewables capacity and constraints to deployment in each region and which seeks to ensure willing engagement by regional bodies, local authorities and communities. Through the planning system, communities will play an integral role in decisions on where renewable energy is located.*" (P. 18, paragraph 4.3)

Regional and local planning authorities are expected to observe the two key planning and renewable energy policy documents, that is **PPS1 Supplement on Climate Change** and **PPS22 Renewable Energy** (considered below) when preparing local strategies and when taking planning decisions. The Strategy also expects regional bodies to set targets for renewable energy capacity and states that:

"…*we expect regions to set targets for renewable energy capacity in line with national target, or better where possible*." (P. 75, paragraph 4.23, see also paragraph 4.33)

It goes on to state that:

"…*applicants for renewable energy should no longer be questioned about the energy need of their project either in general or in particular locations*" (P. 76, paragraph 4.23).

2.2.2 Building Regulations: Part L

In terms of energy use and CO_2 emissions the relevant aspect of the Building Regulations is Part L. This sets minimum standards for new homes in the form of a ***dwelling emission rate*** (DER), measured as kilograms of CO_2 per square metre of floor area per year ($kgCO_2/m^2.yr$). Periodic reviews and changes to the regulations are necessary and the current revision is Part L 2006.

The current Building Regulations, while ensuring a decent level of construction in terms of insulation standards and air-tightness, do not demand any particular innovation in terms of building services, beyond efficient thermal plant (e.g. condensing gas boilers).

The Government has committed to introducing zero carbon homes policy from 2016. To deliver this vision Part L1A (covering new dwellings) is due to be changed in 2010, 2013 and 2016, with each revision stipulating more stringent standards in terms of carbon emissions. Similarly, revisions to Part L2A (which covers buildings other than dwellings) are also expected, with a current target date of zero carbon non-domestic buildings from 2019. The proposed changes to Part L1A are summarised in the following figure.

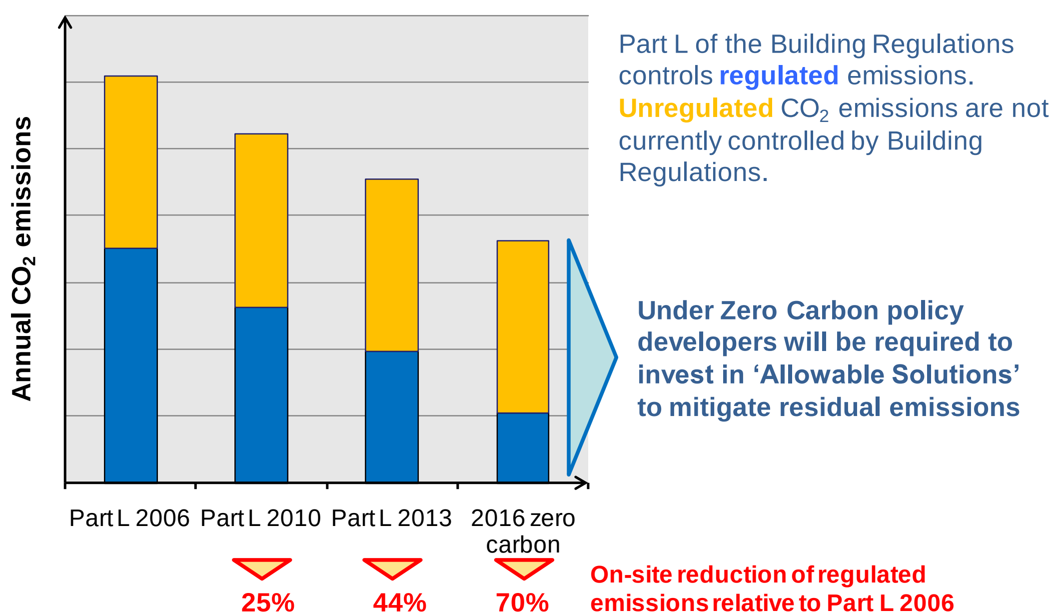

Figure 1: Graphic representation of proposed changes to the Building Regulations

Building Regulations split total CO_2 emissions from dwellings into two types: ***regulated*** and ***unregulated*** emissions. Regulated emissions are those arising from fuel use for space and water heating, any fixed cooling systems, fixed lighting and fans and pumps installed. Unregulated emissions include those arising from energy used for cooking and any electricity for appliances.

Traditionally Part L has only dealt with buildings' regulated emissions. However, zero carbon homes policy requires all regulated and unregulated emissions to be offset, either through on-site measures or through investment in Allowable Solutions, which will be used to achieve equivalent carbon savings elsewhere.

As indicated by Figure 1 future changes to Part L are measured relative to Part L 2006, with reductions in regulated emissions of 25%, 44% and 70% required by on-site means from 2010, 2013 and 2016 respectively.

2.2.3 Zero carbon policy

Zero carbon homes

Zero carbon policy aims to eliminate or mitigate (offset) all CO_2 emissions from a new building, regulated and unregulated. It has been recognised that to eliminate all emissions through provision of on-site low carbon and renewable energy is prohibitively expensive and may not be technically achievable in certain types of development. In light of this, Government proposes that the zero carbon standard will be based on a hierarchy of CO_2 reduction through energy efficiency, CO_2 reduction through provision of on-site low carbon energy supply and finally, offsetting the remaining CO_2 emissions from the development by investing in carbon reduction projects elsewhere. This hierarchy is shown in the diagram below.

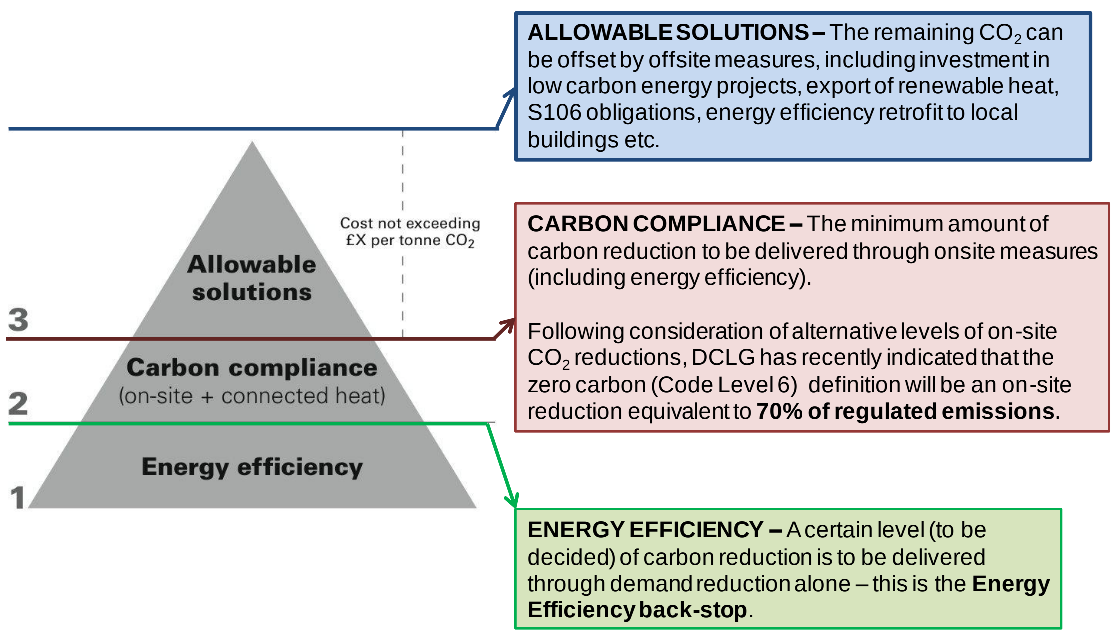

Figure 2: Schematic describing the hierarchical approach to CO_2 emissions reduction used in the definition of zero carbon homes and buildings

Energy efficiency back-stop levels, based on the work of the Zero Carbon Hub[3], are included in the Department of Communities and Local Government (DCLG) consultation on zero carbon homes.[4] The recommended levels are not yet part of formal policy and are therefore

[3] See www.zerocarbonhub.org/news_details.aspx?article=5.
[4] DCLG consultation: *Sustainable New Homes: The Road to Zero Carbon: Consultation on the Code for Sustainable Homes and the Energy Efficiency standard for Zero Carbon Homes*. See www.communities.gov.uk/planningandbuilding/buildingregulations/legislation/codesustainable/

subject to change. However, they give an indication of the preferred metrics and likely level of improvement that will be required.

The hierarchical structure of the zero carbon policy is expected to be applied to domestic and non-domestic buildings alike. However, the level of carbon compliance may differ between building types (potentially even between various types of non-domestic building), to reflect the differing challenges of reducing CO_2 with different building forms and uses.

Zero carbon non-domestic buildings

The proposed definition of the zero carbon standard in non-domestic buildings is less developed than that for zero carbon homes. Government recognises the differing technological challenges in achieving carbon reductions between domestic and non-domestic buildings, the diversity of the non-domestic building stock and therefore its carbon impact and the higher chance of a change of building use that could have an impact on carbon emissions.

As a starting point, the zero carbon consultation states that the zero carbon standard for non-domestic buildings should at least cover regulated emissions and that following a hierarchical approach, similar to that proposed for zero carbon homes, would be sensible. However, there is still uncertainty over whether the levels of the hierarchy should be the same as those adopted for homes.[5] A summary of the recent consultation on zero carbon for non-domestic buildings is given in the appendix, section 9.1.2.

The Government is committed to revising Part L for non-domestic buildings in 2010 to require a 25% reduction in CO_2 compared to Part L 2006. It is proposed that a Forward Thinking paper on the possible changes to be made in the 2013 revision of Part L could be published alongside the 2010 amendments. The detail of the 2013 amendments would then be consulted on in due course.

The trajectory beyond 2013 will be informed by the availability and viability of technical solutions and the range of allowable solutions. Current research by the UK Green Building Council suggests that moving beyond a 44% reduction on Part L 2006 will require a step-change in the availability of technical solutions and the cost-effectiveness of those measures. At this stage, Government will consider whether interim steps should be introduced between 2013 and 2019.

Allowable solutions

The Government is yet to define what the range of allowable solutions for offsetting any residual CO_2 emissions will be, or the practical implementation measures. However, the following possible allowable solutions received broad support in the December 2008 consultation on zero carbon homes:[6]

- Further CO_2 reductions (beyond the mandatory minimum level) through onsite measures.

[5] In particular the carbon compliance level which sets the CO2 reduction to be delivered through energy efficiency and onsite measures.

[6] *Sustainable New Homes – The Road to Zero Carbon: Consultation on the Code for Sustainable Homes and the Energy Efficiency standard for Zero Carbon Homes*, p.32. www.communities.gov.uk/publications/planningandbuilding/futureofcodeconsultation.

- Energy efficient appliances that meet a high standard installed as fittings in the home.
- Advanced building control systems to reduce energy use in the home.
- Export of low carbon or renewable heat to other developments.
- Investment in low and zero carbon community heating infrastructure.

This list is by no means finalised and other allowable solutions remain under consideration.

2.2.4 Codes and certificates

Codes and certificates relevant to new building development are summarised in the following table. Further details are provided in the appendix, section 9.2.

Table 1: Codes and certificates – overview

Code / certificate name	Overview
The Code for Sustainable Homes (CSH)	National standard for sustainable building based on a six star system with criteria in nine design categories from Energy / CO_2 to Water, Materials, and Ecology.
BREEAM	Environmental assessment methodology that sets sustainable design standards for a range of building types.
Energy performance certificates (EPCs)	EPCs show the performance of a building in terms of energy efficiency and CO_2 emissions on a scale from A to G, similar to the system for rating white goods.

2.2.5 Low and zero carbon technology support mechanisms

In addition to regulation to drive through CO_2 reductions in new buildings, Government is introducing further policies to support installation of new renewable energy generating capacity. These policies include changes to planning policy to facilitate development of renewables and also a range of financial incentives which improve the business case for investing in renewable technologies and could help to mitigate the additional cost to developers associated with meeting regulations.

Renewable Obligations Certificates

ROCs are tradable certificates which are issued to generators of renewable electricity for every MWh of electricity generated. The certificates must be purchased by electricity supply companies to prove they have invested sufficiently in renewable generation. The value of the certificates, which can be sold alongside sale of the actual power, fluctuates due to demand, but is typically in the region of £40/MWh. To date the RO system has mainly supported growth of large scale wind turbines, as it has proved to be an insufficient incentive for more expensive or riskier technologies. To help overcome this issue the Government has proposed a ROC banding system, with four bands:

- Established: 0.25 ROCs/MWh.
- Reference: 1 ROC/MWh.
- Post-demonstration: 1.5 ROCs/MWh.

- Emerging technologies: 2 ROCs/MWh.

The following table summarises which technologies are currently allocated to each band.

Table 2: ROC banding proposals[7]

Band	ROCs / MWh	Technologies
Established	0.25	Landfill gas.
Reference	1	Hydro-electric, onshore wind, geopressure, energy from waste with CHP, energy crop co-firing, biomass co-firing with CHP
Post-demonstration	1.5	Offshore wind, energy crop co-firing with CHP, dedicated biomass
Emerging technologies	2	Wave, tidal, solar PV, geothermal, gasification / pyrolysis, anaerobic digestion, dedicated energy crops, dedicated biomass with CHP, dedicated energy crops with CHP

In April 2010 the feed-in tariff was introduced in the UK to offer greater support to small scale renewable electricity generators. The FiT applies to sub-5MWe generators, and payments began from April 2010. ROCs are set to remain in place as the primary support mechanism for larger scale generators. FiT levels are included in the appendix.

Feed-in tariff

The FiT differs from ROCs support in that it provides guaranteed, fixed tariff payments for every unit of renewable electricity generated. The FiT represents a higher level of financial support than ROCs as it has been designed to offer a return on investment of 5-8%.

Feed-in tariff payments vary by technology and by installed capacity. However, the FiT applicable at the date a system is commissioned is guaranteed over the defined tariff payment lifetime. Furthermore, both export and tariff payments are linked to inflation (the RPI) for new and existing installations.

The FiT applies to Great Britain and forms a key part of the Government's strategy to meet renewable energy generation and CO_2 reduction targets. This support mechanism is expected to be in place for at least the next decade. However, a review of the tariffs is due in 2013, at which point the support levels could be reduced. Having said this, the overall aim of the FiT is to encourage the uptake of renewable energy technologies by making them an attractive financial proposition, and the review should therefore only adjust for changes in technology costs and other relevant developments.

Renewable Heat Incentive

The introduction of a renewable heat incentive (RHI) to support the development of low carbon and renewable heating technologies lags behind the FiT by around a year. Work is on-going within Government to define the scope of the RHI, to set the support levels and design the payment structure. Proposed levels of support have been published by DECC in the RHI

[7] From http://chp.decc.gov.uk/cms/roc-banding/. Sewage gas and biomass co-firing are eligible for 0.5ROCs / MWh.

consultation, which ran from February to April 2010.[8] RHI payments are expected to come in from around April 2011. The proposed support levels are summarised in the appendix.

[8] Proposed tariff levels are set out in the consultation document (p.46-47), which is available for download from the DECC website: www.decc.gov.uk/en/content/cms/consultations/rhi/rhi.aspx.

2.3 National, regional and local planning policy framework

2.3.1 Overview

In recognition of the importance of tackling climate change the **Planning Act 2008** introduced a new requirement for Regional Spatial Strategies (RSS) (to be replaced by Regional Strategies under the Local Democracy, Economic Development and Construction Act) and Development Plan Documents (DPD) to include policies designed to ensure that the development and use of land contributes to the mitigation of, and adaptation to, climate change (paragraphs 181 and 182).

The Planning Act 2008 established a new system for the approval of major infrastructure projects, which would include major renewable energy schemes, through the Infrastructure Planning Commission. To enable this, a series of National Policy Statements for nationally significant infrastructure projects was proposed. The National Policy Statement for Energy (EN-1) was published for consultation in November 2009. The Act also introduced the Community Infrastructure Levy as a means of raising a charge from development to fund infrastructure projects.

Alongside the Planning Act, the **Planning and Energy Act 2008** enabled local planning authorities to set requirements for energy use and energy efficiency in local plans. Its states that planning authorities may set a reasonable requirement for:

a) '*a proportion of energy used in development in their area to be energy from renewable sources in the locality of the development;*

b) *a proportion of energy used in development in their area to be low carbon energy from sources in the locality of the development;*

c) *development in their area to comply with energy efficiency standards that exceed the energy requirements of building regulations*.' (paragraph 1)

Planning Policy Statements (PPS) set out the Government's national policies on land use in England. Local authorities must take the PPSs into account when developing their Development Plan Documents (DPDs), including Regional Spatial Strategies and the various documents that constitute Local Development Frameworks.

The existing PPSs that inform local planning policy with respect to energy and sustainability are:

- PPS1: Delivering Sustainable Development
- Supplement to PPS1: Planning and Climate Change
- PPS22: Renewable Energy

At the time of writing the Government is running a consultation on a new PPS: Planning for a Low Carbon Future in a Changing Climate. This new PPS is expected to replace the existing supplement to PPS1 and PPS22 as it brings together key aspects of both. These Planning Policy Statements are described in more detail below.

2.3.2 PPS1 Delivering Sustainable Development

PPS1 provides a set of over-arching principles to guide sustainable development in terms of land-use, where sustainable development is broadly defined as social inclusion, protection and enhancement of the environment, prudent use of natural resources and economic development.

PPS1 is not specific on what actions local authorities should take, but makes general statements on what outcomes development plan policies should seek to encourage. For example, development plan policies should:

- Seek to promote and encourage, rather than restrict, the use of renewable resources (for example by the development of renewable energy).
- Promote resource and energy efficient buildings, community heating schemes, the use of combined heat and power, small scale renewable and low carbon energy schemes in developments.
- Encourage reduced waste production and the use of waste as a resource wherever possible.

2.3.3 Supplement to PPS1: Planning and Climate Change

The supplement to PPS1 on climate change is more specific on how regional and local authorities should frame policies to ensure the objectives of PPS1 are delivered. The PPS covers development of the Regional Spatial Strategy and the Local Development Documents and gives the local authorities the remit to ensure that maximising the opportunities for low carbon and renewable energy generation, reducing additional transport emissions and adapting to the impacts of climate change are enforced through Development Plan Documents.

An important aspect of this PPS is the role given to planning authorities in setting targets for low carbon and renewable energy generation, at the regional level and within individual developments. Planning authorities have a responsibility to ensure that the targets set are evidence-based (both at the regional and local level) and consistent with economic and housing objectives.

Some of the key elements of the PPS that planning authorities must consider in development of their Local Development Documents are as follows:

- Ensure that the local approach to protecting landscape and townscape does not preclude supply of any type of low carbon or renewable generation, other than in exceptional circumstances.
- Consider identifying areas for renewable and low carbon energy sources and supporting infrastructure.
- Take account of the extent to which low carbon or renewable energy sources could contribute to the needs of a development and the capability of a development to adapt to the effects of climate change when selecting land for development.

- Planning authorities should set out a percentage of the energy to be used in a new development to come from decentralised, low carbon or renewable sources and bring forward development areas where there is potential to exceed regional targets.
- Where there are existing decentralised energy supply systems, or firm proposals, planning authorities can expect proposed developments to connect to an identified system or be designed to connect in the future.
- Implement policies that help to achieve the national timetable for reducing CO_2 emissions from new domestic and non-domestic buildings (as set out in the Building a Greener Future policy statement and to be introduced through Building Regulations).
- Where appropriate, set targets for levels of building sustainability in advance of those set nationally. In these instances planning authorities must demonstrate that there are particular local circumstances that justify the higher targets.
- Specify requirements for building sustainability in terms of nationally recognised standards, such as the Code for Sustainable Homes and BREEAM.

2.3.4 PPS22: Renewable Energy

PPS22 sets a positive tone for how renewable energy developments should be encouraged through regional and local planning policies and how local planning authorities should set the criteria for assessing planning applications for renewable energy projects.

At a regional level, PPS22 calls for targets to be set for installed capacity of renewable energy within defined timeframes. Locally, planning authorities are handed the power to require a certain percentage of a development's energy consumption to be sourced from on-site renewables systems, where installation of the renewable generation systems is feasible and where the target does not place an undue burden on the developer.

2.3.5 Planning for a Low Carbon Future in a Changing Climate

Given the rapidly changing policy landscape over the past couple of years the Government is consulting on a new PPS: Planning for a Low Carbon Future in a Changing Climate.[9] The new PPS is expected to bring together the Planning and Climate Change supplement to PPS1 (2007) and PPS22 on renewable energy (2004) and replace both as a consolidated supplement to PPS1. The introduction of a new PPS is proposed in order to keep pace with the changing legislative and policy landscape (Part 1, paragraph 3) and to provide a more focussed PPS with clearer outcomes (Part 1, paragraph 8).

The draft PPS Supplement sets out a range of key Government objectives concerning the role of plan making and development in supporting the transition to a low carbon future. According to the new PPS, planning should:

- '*Shape places so as to help secure radical cuts in greenhouse gas emissions. This requires the location and layout of new development to be planned to deliver the highest viable energy efficiency, including through the use of decentralised energy, reducing the need to travel, and the fullest possible use of sustainable transport.*

[9] The consultation will run from 9th March 2010 to 1st June 2010. Full documentation relating to the consultation is published here: www.communities.gov.uk/publications/planningandbuilding/ppsclimateconsultation.

- *Actively support and help drive the delivery of renewable and low carbon energy.*
- *Shape places and secure new development so as to minimise vulnerability and provide resilience to impacts arising from climate change, and do so in ways consistent with cutting greenhouse gas emissions.*
- *Ensure local communities are given real opportunities to take positive action on climate change; in particular by encouraging community-led initiatives to reduce energy use and secure more renewable and low-carbon energy.*' (Part 2, p.15)

The national planning policies from **Planning for a Low Carbon Future in a Changing Climate** relevant to this study are summarised in the table below.

Table 3: Overview of relevant consultation planning policies from Planning for a Low Carbon Future in a Changing Climate

Policy	Description
LCF1 Evidence based planning	LCF 1.4 requires local planning authorities to assess opportunities for decentralised energy in their area.
LCF4 Local planning approach for renewable and low carbon energy and associated infrastructure	LCF 4.1 seeks policies to support renewable and low carbon energy developments. Requires information on how opportunities for district heating (identified through heat mapping) will be supported, and supports decentralised energy and community led renewable and low carbon energy developments, where appropriate. LCF 4.2 states that strategic sites central to delivering decentralised energy should be allocated in the core strategy.
LCF6 Local planning approach for selecting sites for new development	LCF 6.1 states that in selecting new sites planning authorities should consider the extent to which decentralised energy could contribute to the site's energy demands and the potential to connect to an existing or planned decentralised energy network.
LCF7 Local planning approach to setting requirements for using decentralised energy in new development	LCF 7.1: local requirements are to be derived from an assessment of local opportunities, which should be consistent with national policy on allowable solutions (LCF 7.2). Developments should connect to existing or envisaged decentralised energy supply (LCF 7.3). LCF 7.4: targets for new developments should be expressed either as percentage reduction in CO_2 emissions or an amount of decentralised energy generation (kWh).
LCF8 Local planning approach to setting authority-wide targets for using decentralised energy in new development	LCF 8.1 states that authority-wide targets for decentralised energy will be required until 2013 when changes to Part L of the Building Regulations are implemented.
LCF9 Local planning approach to setting requirements for sustainable building	Local requirements should relate to development area or specific sites and be specified in terms of nationally described sustainable building standards (for housing CSH) except where an energy/CO_2 standard is justified (LCF 9.1).

LCF 11 Testing local planning requirements	LCF 11.1: local requirements relating to decentralised energy, sustainability or electric vehicle charging infrastructure must not make new development unviable due to higher costs. Targets must be shown to be consistent with housing trajectory targets required by PPS3 and must not inhibit the provision of affordable housing.
LCF13 Designing for a low carbon future in a changing climate	Sets out the expectations of local planning authorities for the incorporation of wide-ranging carbon reduction measures in the design of development and the weight to be given to these criteria in determining proposals for major development.
LCF14 Renewable and low carbon energy generation	Sets out local planning authorities' expectations in respect of mitigation measures, the weight to be given to wider environmental, social and economic benefits, the role of targets and broad areas of search. It also considers proposals within the Green Belt.
LCF15 Safeguarding renewable and low carbon energy supplies	Confirms that planning authorities should consider the impacts of proposed development on existing or proposed development of decentralised, renewable or low carbon energy and the potential for amendments to be made in the event of adverse effects.

2.3.6 **Other relevant Planning Policy Statements**

PPS3: Housing sets out government policy on the provision of housing in England. Paragraph 15 states that '*Local Planning Authorities should encourage applicants to bring forward sustainable and environmentally friendly new housing developments, including affordable housing developments, and in doing so should reflect the approach set out in the forthcoming PPS on climate change, including on the Code for Sustainable Homes*.'

PPS4: Planning for Sustainable Economic Development makes reference at paragraph 10 to the need to deliver more sustainable patterns of development, reduce the need to travel, especially by car, and respond to climate change. In determining planning applications Policy EC10 of PPS4 states that:

'*All planning applications for economic development should be assessed against the following impact considerations:*

a) *whether the proposal has been planned over the lifetime of the development to limit carbon dioxide emissions, and minimise vulnerability and provide resilience to, climate change*'.

2.4 Local planning policy

The Planning Policy Statements delegate responsibility to regional and local planning authorities to develop the specifics of policies concerning sustainability and renewable energy in local developments. Planning authorities must develop an evidence base, specific to their local circumstances, to justify these policies.

Regional planning bodies, through the Regional Spatial Strategy, set the framework in which local authorities develop their local development documents. In particular the RSS sets regional targets for renewable energy generation, informed by an assessment of regional opportunities and consistent with national government commitments. In turn, local authorities have the following key powers in developing local development documents:

- Select development areas on the basis of maximising opportunity to exploit renewable or low carbon resources and their adaptability to the effects of climate change.
- A remit to set targets for the percentage of a development's energy requirements to be supplied from renewable or low carbon sources, provided that the renewable generation technologies can be shown to be feasible and that the target does not undermine viability of the site.
- To require developments to connect to existing or planned decentralised energy systems or to be designed to connect in the future.
- To specify levels of sustainable building that are in advance of nationally set targets, where an evidence base has been developed that demonstrates the local opportunities justify an advanced target.

Key regional and local strategy and planning policy documents are summarised below.

2.4.1 East Midlands Regional Plan (RSS)

The East Midlands Regional Plan (March 2009) is the Regional Spatial Strategy for the East Midlands. It replaced the previous RSS issued in March 2005. The Plan sets out the development strategy for the East Midlands for the period to 2026 and comprises four sections:

- **Core Strategy** – establishes the context for delivering sustainable development in the region.
- **Spatial Strategy** – provides the framework for meeting the Region's development needs in a sustainable way and outlines regional priorities for development.
- **Topic Based Priorities** – sets out specific targets against a number of themes: housing, economy and regeneration, natural and cultural resources, transport, and implementation, monitoring and review.
- **Sub-Regional Strategies** – contains polices and proposals for four sub-regions: Milton Keynes South Midlands, Three Cities (Derby, Leicester, Nottingham), Northern, and Lincoln Area.

The relevant policies for renewable energy and low carbon building are summarised below.

Policy 1: Regional Core Objectives

Policy 1 sets out eleven core objectives, from ensuring that the housing stock extends choice and addresses needs in all communities in the region to reducing social exclusion to improving economic prosperity. The key objectives relating to low carbon development and renewable energy are:

***i) To reduce the causes of climate change** by minimising emissions of CO_2 in order to meet the national target through:*

- *maximising 'resource efficiency' and the level of renewable energy generation;*
- *making best use of existing infrastructure;*
- *promoting sustainable design and construction; and*
- *ensuring that new development, particularly major traffic generating uses, is located so as to reduce the need to travel, especially by private car*

***j) To reduce the impacts of climate change**, in particular the risk of damage to life and property from flooding and sea level change and the decline in water quality and resources.*

***k) To minimise adverse environmental impacts of new development and promote optimum social and economic benefits** through the promotion of sustainable design and construction techniques*.[10]

Policy 2: Promoting Better Design

The Regional Plan recognises that while the East Midlands has benefitted from some outstanding new development in recent years, some has been of an 'unacceptably low standard'.[11] Policy 2 is designed to promote high standards of design and construction, including:

- Adaptability to climate change.
- Improving resource efficiency and making greater use of local materials.
- Reducing CO_2 emissions.
- Meeting the needs of an ageing population.

Policy 2 states that '*the layout, design and construction of new development should be continuously improved, including in terms of reducing CO_2 emissions and providing resilience to future climate change, by:*

- *design led approaches which take account of local natural and historic character;*
- *minimising energy use, reducing the heat impact of urban areas, using sensitive lighting, improving water efficiency, providing for sustainable drainage (SUDS) and management of flood water, reducing waste and pollution, securing energy from decentralised and renewable or low carbon energy technologies, incorporating sustainably sourced and recycled materials wherever possible, and considering building orientation at the start of the design process;*

[10] East Midlands Regional Plan, p.17 (2009).
[11] East Midlands Regional Plan, paragraph 1.4.1, p.17 (2009).

- *ensuring that all urban extensions that require an Environmental Impact Assessment achieve the highest viable levels of building sustainability;*
- *making the most efficient use of land;*
- *locating and designing access from new development to local facilities on foot, by cycle, or by public transport;*
- *highway and parking design that improves both safety and the quality of public space;*
- *design which helps to reduce crime and fear of crime, supports community safety, promotes vitality, maintains amenity and privacy, and benefits the quality of life of local people; and*
- *taking account of the need to develop carbon sinks and 'green infrastructure' networks and provide for access to open space and the enhancement of biodiverstiy and landscape quality'*.[12]

Policy 39: Regional Priorities for Energy Reduction and Efficiency

This policy states that '*Local Authorities, energy generators and other relevant public bodies should:*

- *promote a reduction of energy usage in line with the 'energy hierarchy', and*
- *develop policies and proposals to secure a reduction in the need for energy through the location of development, site layout and building design*.'

It is noted that the UK Government has signalled a need to increase the amount of distributed energy generation (paragraph 3.3.81). For example, CHP schemes can be an effective way of increasing the efficiency of resource consumption. Regional targets for installed CHP capacity in the East Midlands were for 511MW_e by 2010 and 1,120MW_e by 2020 (paragraph 3.3.83), this is against installed capacity of 237MW_e of CHP in the East Midlands in 2004. According to the Plan '*suitable locations for large-scale CHP developments are likely to be urban areas or associated with new development*' (paragraph 3.3.83).

Paragraph 3.3.87 highlights the 'pressing need' for decentralised renewable energy and states that local development documents should encourage such schemes, taking into account the advice in PPS22, the Companion Guide to PPS22 and the climate change supplement to PPS1.

Chesterfield borough is located in the north western part of the 'Northern Sub-area' as defined in the East Midlands Regional Plan. Paragraph 3.3.90 notes that there are significant opportunities for coal mine methane in this sub-area, and some opportunities for wind turbine development at different scales. Medium scale renewable generation based on CHP or wind is also specifically mentioned. According to the Plan there are some opportunities for biomass in the form of wood or coppice but fewer for other forms of biomass.

Policy 40: Regional Priorities for Low Carbon Energy Generation

According to this policy: '*Local Authorities, energy generators and other relevant public bodies should promote:*

[12] East Midlands Regional Plan, p.19 (2009).

- *the development of Combined Heat and Power (CHP) and district heating infrastructure necessary to achieve the regional target of 511 MWe by 2010 and 1120 MWe by 2020; and*
- *the development of a distributed energy network using local low carbon and renewable resources*.'

This policy goes on to state that Local Authorities should:

- '*safeguard sites for access to significant reserves of coal mine methane;*
- *identify suitable sites for CHP plants well related to existing or proposed development and encourage their provision in large scale schemes;*
- *consider safeguarding former power station and colliery sites for low carbon energy generation;*
- *support the development of distributed local energy generation networks; and*
- *develop policies and proposals to achieve the indicative regional targets for renewable energy'.*

Appendix 5 (p.179) sets out indicative renewable energy targets for 2010, 2020 and 2026 for the East Midlands region. Specific technologies identified include on shore wind, biomass (wet agricultural waste, poultry litter and energy crops), hydro, microgeneration from wind and PV, landfill gas and anaerobic digestion.

2.4.2 Chesterfield Borough Council policy documents

Local Plan

The Replacement Chesterfield Borough Local Plan was adopted in June 2006 and sets policies for development and land use in the borough to 2016. The Local Plan will be replaced by the Local Development Framework documents currently under development, which are expected to be adopted in 2011.

Local Plan policies are grouped into chapters, including General Strategy, Housing, Employment, Environment, Transport, etc. Policy **GEN10: Sustainable Design**, (General Strategy), puts a clear focus on good design, stating that '*planning permission will only be granted for development which makes a positive contribution to the quality of the environment in the borough through good design*'. It goes on to state that new development should minimise the production of waste and pollution and optimise energy efficiency and the use of renewable energy sources. Policy GEN10 is supported by the Council's Sustainable Design SPD (see below).

The existing policy relating to renewable energy development in the borough is in Chapter 5 (Environment) of the Local Plan and is entitled **EVR22: Renewable Energy**. It states:[13]

'*Planning permission will be granted for development required in connection with the generation of renewable energy provided that:*

[13] www.cartoplus.co.uk/chesterfield/text/05_evr_environment.htm.

a) *The impact on the natural and built environment, especially the cumulative effect on a number of such projects, is acceptable and takes into account the potential effect on the landscape character of the site and its surrounding area.*

b) *Sufficient mitigation measures or design solutions can be incorporated so that the development does not create unacceptable living conditions or disturbance for nearby residents; and*

c) *The development provides economic and social benefits which outweigh any disturbance caused*.'

Supplementary Planning Document on Sustainable Design

In support of the policies in the Local Plan and to provide additional guidance to local developers, Chesterfield Borough Council has produced a Sustainable Design SPD (dated October 2008). The SPD provides guidance on a range of aspects of sustainable design for residential and non-residential development, including energy and water efficiency, renewable energy, accessibility, waste reduction and recycling. The Sustainable Design SPD is available from CBC's website.[14]

[14] www.chesterfield.gov.uk/default.aspx?CATID=557&CID=4938.

3 Local context

3.1 Development in Chesterfield borough

3.1.1 Population and housing stock growth

County Council level data indicate that population growth in the East Midlands region between 2010 and 2030 is expected to be around 20%.[15] The equivalent figures for Derbyshire and Chesterfield borough are 15.5% and 12% respectively. These projections are consistent with the Borough Council's latest forecasts, which predict a population growth of 12% between 2008 and 2026 (from 108,000 people in 2008 to 112,600 in 2026). A significant level of building development is expected to support this population growth. The following figure summarises the expected growth in population and total number of dwellings in Chesterfield borough to 2026.

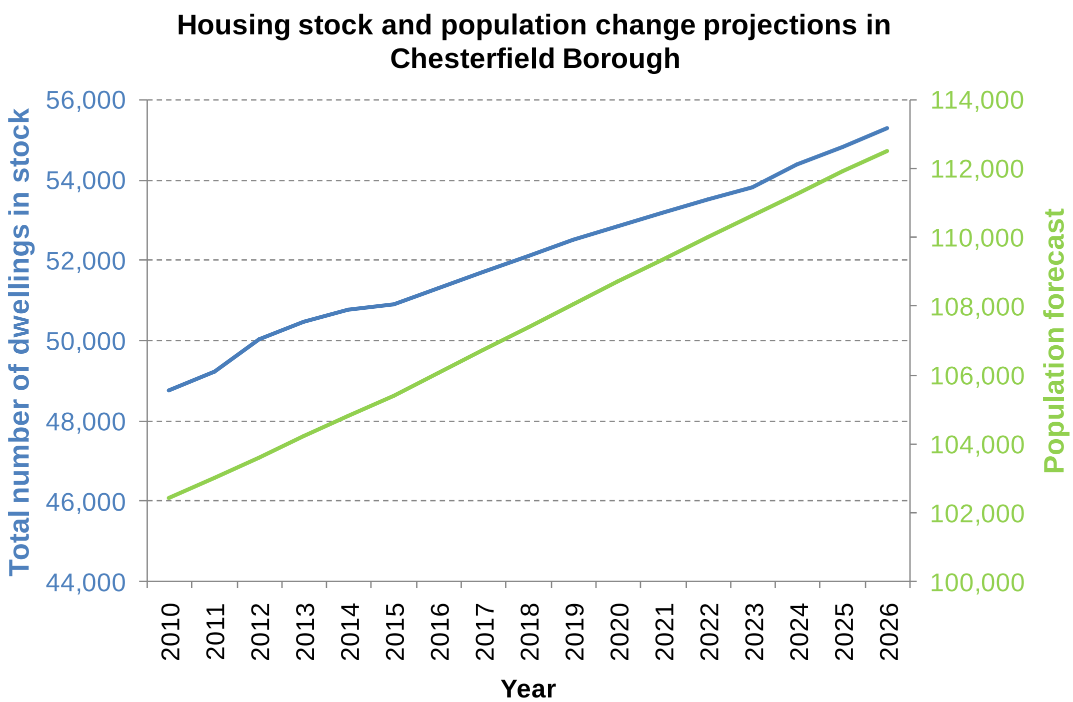

Figure 3: Population and housing growth forecast for Chesterfield borough[16]

3.1.2 Housing delivery by site type

The data presented in Figure 3 suggest that around 6,750 new homes are expected in Chesterfield borough in the period to 2026. Housing trajectory data held by CBC include expected number of dwellings to be delivered on a site-by-site basis.

[15] Data from: www.derbyshire.gov.uk/community/about_your_county/population/population_forecasts/default.asp
[16] Housing growth forecast from data provided by CBC.

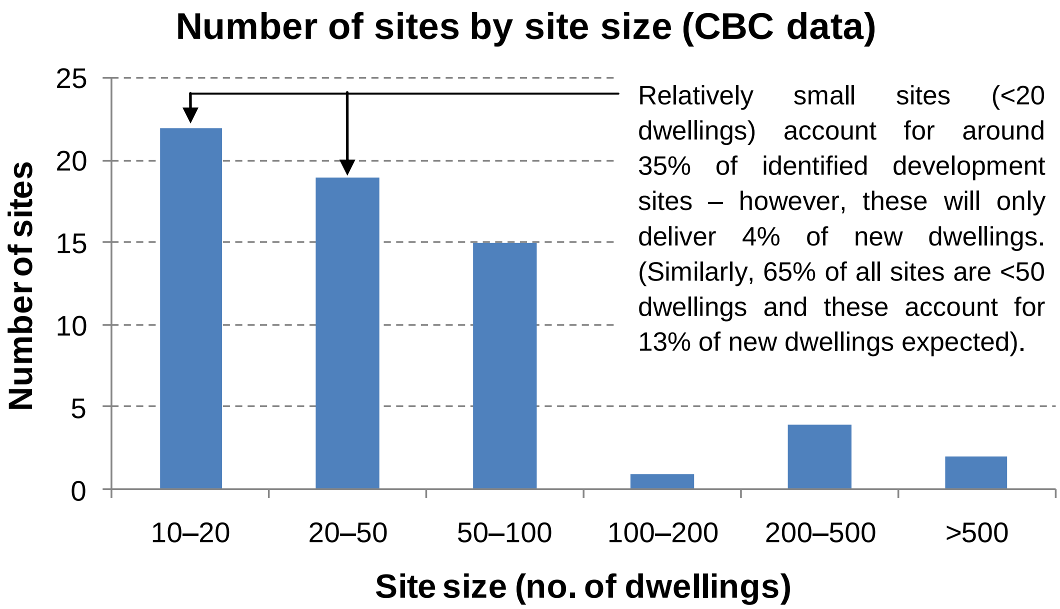

Figure 4: Number of development sites by site size expected in Chesterfield borough in the period to 2026

Although the number of large sites is relatively low, the majority of new housing is expected to be delivered through these sites, as shown in the following figure.

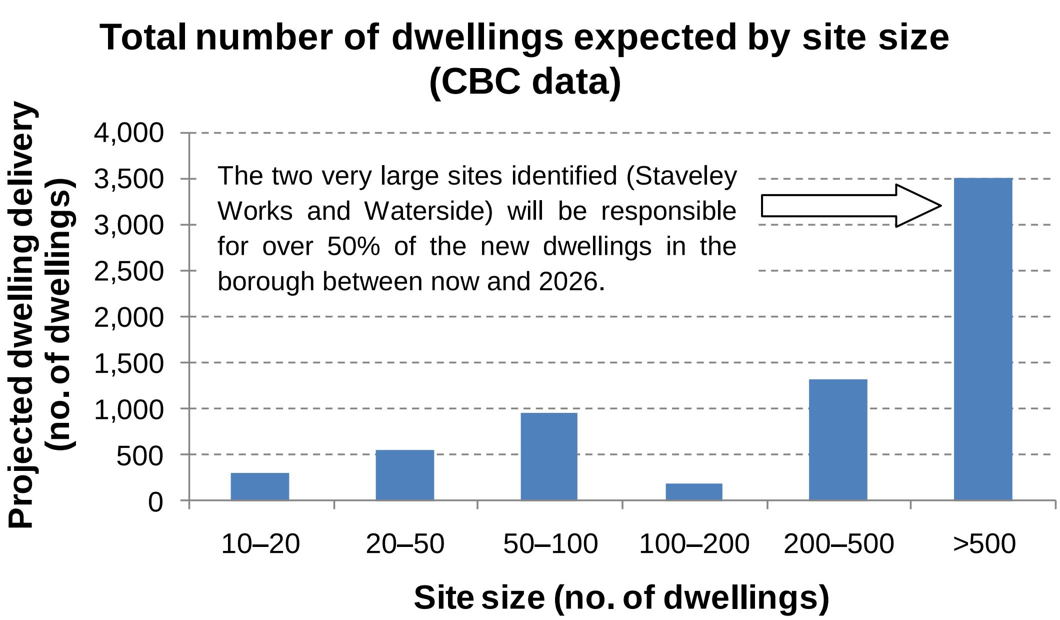

Figure 5: Forecast housing delivery in Chesterfield borough by site size

These graphs demonstrate the significance of large development sites and highlight the importance of developing site-specific policies for major developments. An analysis to support site-specific target setting has been completed as part of this study (see section 6).

3.1.3 Non-residential development

A range of non-residential development is expected to support the population and housing stock growth in the borough over the next fifteen years. The main data sources for forecasting non-residential development in the borough include the Retail Capacity Study and Employment Land Review. Data provided by CBC on the potential delivery of new employment areas are presented graphically below.

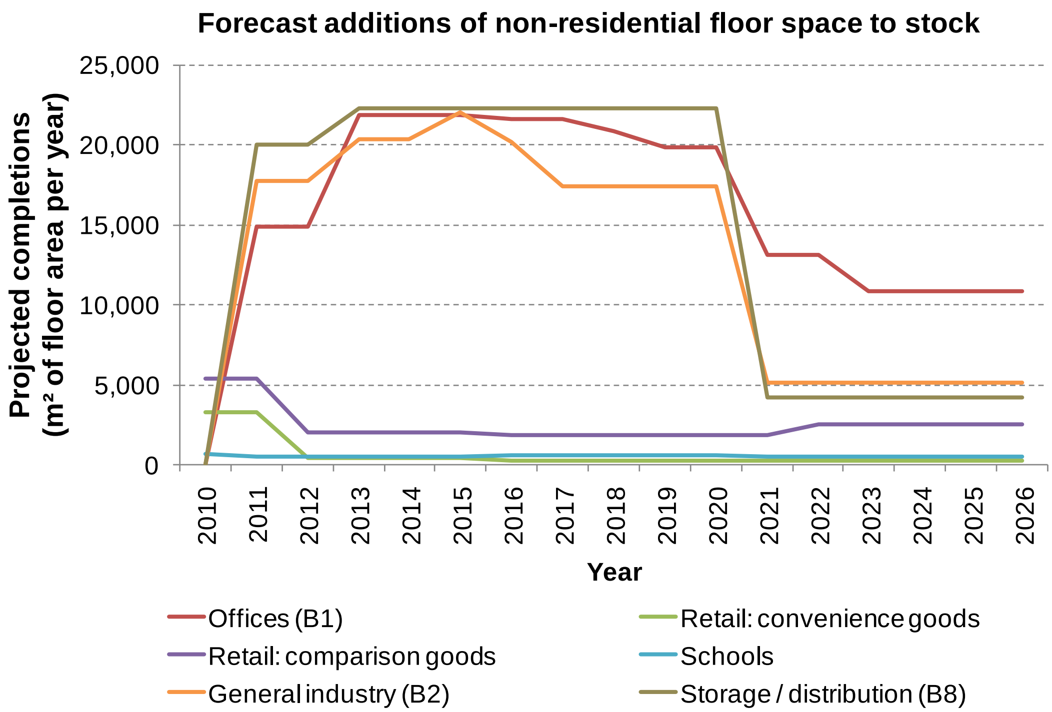

Figure 6: Non-residential building development in Chesterfield borough

Data relating to the usage categories B1, B2 and B8 were provided by CBC. Forecast retail floor area additions were taken from the Retail Capacity Study Update (2008)[17] and the requirement for new school floor area was inferred based on population growth forecasts. This potential new development can be put in context through comparison with estimates of the existing stock of each of these building usage types in the borough.

[17] *Chesterfield Borough Council and North East Derbyshire District Council Retail Capacity Study*, Nathaniel Lichfield and Partners, April 2008.

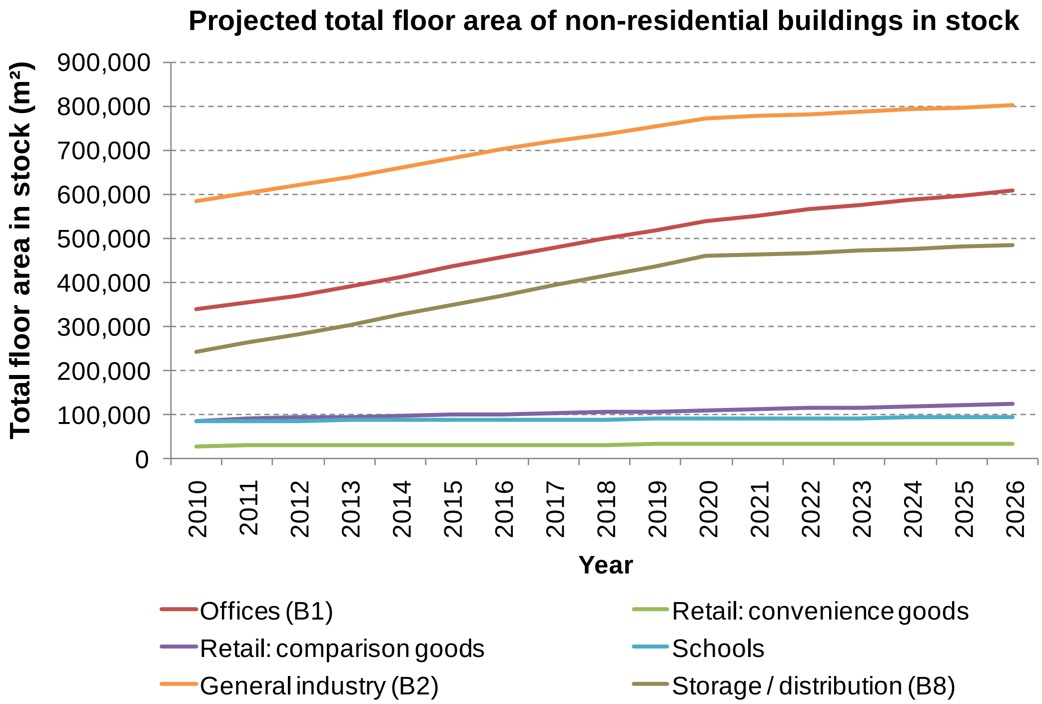

Figure 7: Forecast growth in non-residential buildings in Chesterfield borough

Estimations of the existing stock are based on ONS statistics and data from the Retail Capacity Study.[18] These data suggest that the growth in floor area for B1, B2 and B8 uses to 2026 would be around 80%, 37% and 100% respectively if all the identified non-residential development were to come forward.

3.2 CO_2 emissions trajectory

Provided expected changes to national policy (discussed in section 2.2, above) come into effect, the emissions growth from new buildings will be curbed relative to past trends. If effective, the introduction of zero carbon homes policy in 2016 and zero carbon building policy in 2019 will mean that new additions to the building stock will produce no net increase in CO_2 emissions.

The emissions trajectory resulting from new building in the borough has been estimated based on the expected completions over time presented above and typical emissions data for each building type. The graph below shows the projected growth in CO_2 emissions from the total building stock in Chesterfield borough, assuming that the new development outlined above is delivered and that all new buildings comply with the relevant Part L standard in force.

[18] ONS neighbourhood statistics for Chesterfield: http://www.neighbourhood.statistics.gov.uk. Retail Capacity Study (2008), paragraph 6.16, p.62.

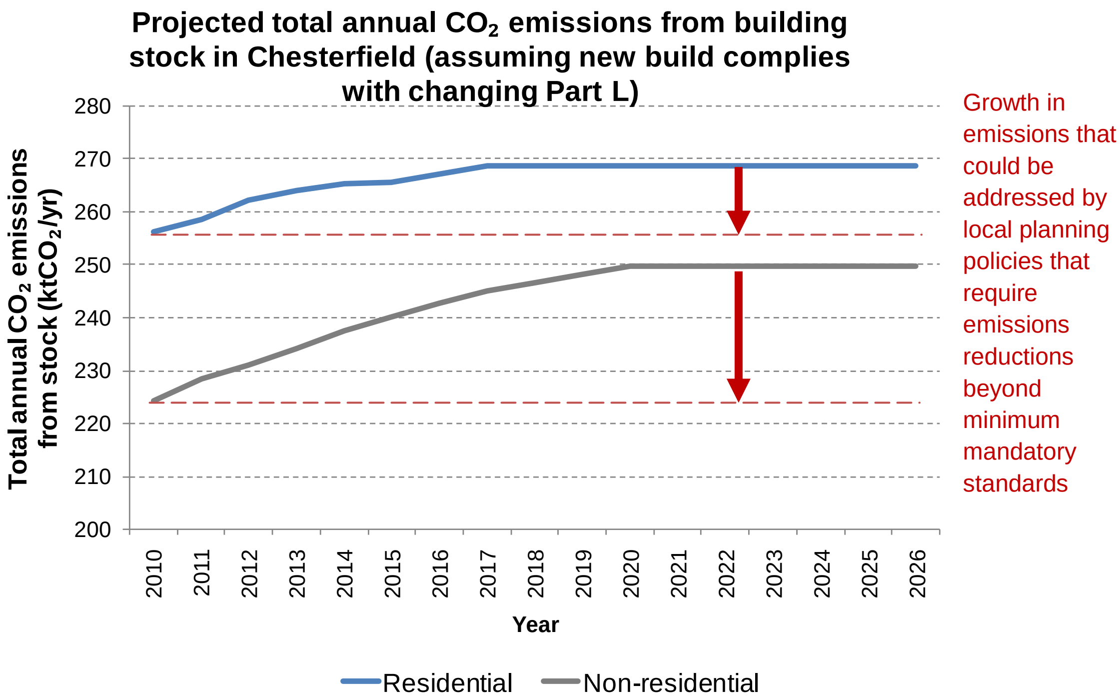

Figure 8: Emissions trajectory for Chesterfield borough's building stock based on anticipated new completions being delivered to changing Part L standards

The graph above includes an implicit assumption that all new buildings comply with the minimum regulatory standards. It is likely that allowable solutions will play a role in achieving the zero carbon standard, and depending on the final definition of allowable solutions, this might mean that not all of the CO_2 saving is delivered locally. Even so, on an aggregate basis changes to Part L of the Building Regulations are expected to greatly restrict emissions growth resulting from new additions to the building stock.

Local planning policy could be used to limit emissions growth prior to the implementation of zero carbon standards, for example by seeking emissions saving beyond the minimum requirements over the next ten years. This study examines the opportunities for renewable energy projects in the borough and assesses the potential impacts of planning policies that demand advanced levels of carbon saving.

4 Strategies for delivering low carbon development

4.1 Overview of technologies

Low carbon building development can be achieved through various means. It is widely accepted that the first priority for any efficient new building is to reduce demand for energy through advanced standards of energy efficiency (insulation measures). A building's in use carbon emissions ultimately depend on the amount and type of fuel used to meet the energy demands, which means the next step is to select a highly efficient heating system and to consider the fuel options available. The carbon impact of fuels varies by fuel type (i.e. using one unit of a given fuel leads to a certain level of CO_2 emissions, expressed as $kgCO_2/kWh$), for example biomass is considered a 'low carbon' fuel in these terms relative to fossil fuels (and electricity derived from fossil fuels). Finally, some or all of a building's energy demand can be met by renewable energy technologies such as solar thermal to meet hot water demands and photovoltaics to generate low carbon electricity. The following table summarises the principal technologies available for low carbon building development that are considered in this study.

Table 4: Overview of technologies for low carbon building

Technology	Description
Solar photovoltaics	PV panels based on semi-conductor materials convert sunlight into electricity.
Solar thermal	Roof-mounted panels capture energy from sunlight which is typically used to meet a portion of a building's hot water demands.
Building-mounted wind	Micro wind turbines can be mounted on top of buildings and generate electricity. Electricity output is a strong function of wind speed.
Small / medium / large scale wind	Pole or tower mounted turbines benefit from access to higher average windspeeds. However, siting is restricted by considerations such as distance from buildings and environmental impacts.
Ground source heat pumps (GSHP)	Collect thermal energy from the ground via deep vertical boreholes or shallow buried ground loops. Low grade heat from the ground is upgraded to a useful temperature by an electrically powered heat pump. Qualify as renewable technology due to very high efficiency.
Air source heat pumps (ASHP)	Identical principle to GSHP, except that heat is taken from surrounding air. Potential for lower capital cost, as less expensive equipment for heat extraction from the air (similar to air conditioning unit).
Biomass boilers	Burn solid biomass fuels such as wood pellets or wood chips to produce heat. Available at various scales, from individual building level to large boilers for community heating schemes.
Micro CHP	Gas-fired CHP at the scale of an individual dwelling (1–3kW_e). Primarily heating technologies, but generate some electricity that offsets grid electricity, resulting in carbon saving.
Medium / large scale CHP	Based on electricity generators (usually a reciprocating engine or a turbine), with use of the heat produced to meet local thermal demands. Increase overall efficiency of fuel consumption by use of heat and therefore result in CO_2 savings.

4.2 The role of energy efficiency

4.2.1 Introduction

As mentioned in section 4.1, improving the thermal performance of buildings by specifying high levels of insulation and other energy efficiency measures is a key first step for any new building. The main areas that can be addressed are:

- Improving insulation levels for key building elements (i.e. selecting materials with low U-values), including external walls, doors, windows, roof, floor.
- Reducing uncontrolled air exchanges between the building and the environment by reducing air permeability.
- Addressing thermal bridging by focusing on details of joints in the building.

Achieving high levels of thermal performance must be balanced against other factors such as the additional cost of better performing materials and the physical space implications of thicker insulation for example. The fact that achieving lower U-values generally leads to an increase in build costs suggests that there may be an optimal level of building fabric improvement. A cost-benefit analysis of improving the thermal performance of a selection of a typical end of terrace house is explored in this section.

4.2.2 Fabric packages

In order to illustrate the potential costs and benefits of improving the building fabric in residential development a total of four fabric packages are considered, as defined below.

Table 5: Improved fabric packages

		Reference	Basic	Good	Advanced
U values of major building elements ($W/m^2.K$)	**External doors**	1.8	1.5	1.1	0.7
	Windows	1.8	1.5	1.1	0.7
	Ground floor	0.20	0.20	0.15	0.10
	External wall	0.30	0.25	0.20	0.15
	Roof	0.18	0.15	0.13	0.10
Air permeability, q50 ($m^3/m^2.hr$)		10	7	4	1
Thermal bridging y value ($W/m^2.K$)		0.09	0.08	0.04	0.02
Type of ventilation system		Natural ventilation	Natural ventilation	Natural ventilation	MVHR

In all cases the thermal demands of the dwelling are met by a high efficiency condensing gas boiler. The 'Reference' fabric package is defined such that the dwelling complies with current standards (Part L 2006). The 'Advanced' fabric standard corresponds to a super insulated house, similar to the passiv haus standard. With this level of insulation it is assumed that there is no need for a full house wet central heating system, which means that some of the additional expense of the higher levels of insulation is offset by this cost saving. Full details of the cost assumptions behind this analysis are given in the appendix.

The results in this section are for a typical end-of-terrace house, with two different construction methods: traditional cavity masonry and timber frame. These construction techniques represent the current mainstream methods of house building in the UK. Many other construction systems are also available, but for the purposes of demonstration this section is restricted to the two main types.[19]

4.2.3 Cost and performance of fabric improvement

Impact on energy demands and CO_2 emissions

The performance of higher fabric standards can be measured in a number of ways. Key metrics include the reduction in thermal demands and CO_2 emissions achieved. The dwelling's energy demands and resultant CO_2 emissions were calculated following the SAP 2009 methodology.[20] The following graph summarises the effect of each fabric package on thermal and electricity demands, and CO_2 emissions in terms of dwelling emission rate (DER).

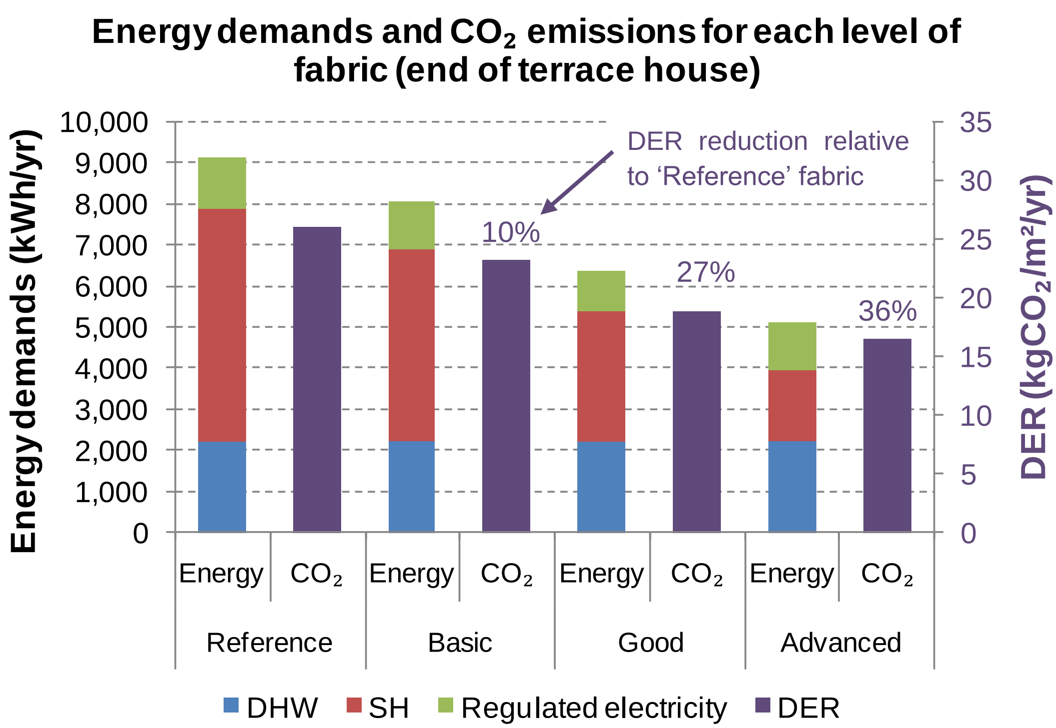

Figure 9: Performance of improved fabric packages

Requirements for thermal energy are broken down into space heating (SH) and domestic hot water (DHW) demands. According to the SAP methodology hot water demands depend mainly

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[19] Other construction systems include Insulated Concrete Framework, Structural Insulated Panels, single skin block with external wall insulation etc.

[20] The consultation version of SAP (cSAP, March 2010) was used, as at the time of writing the final methodology is yet to be finalised.

on the assumed occupancy of the dwelling, which in turn is dictated by floor area. Improving the building's fabric is therefore not expected to have a significant impact on demand for hot water. Figure 9 shows that the main effect of improving the fabric is to reduce the space heating demands. Relative to the Reference fabric package, Basic, Good and Advanced fabric levels lead to space heating demand reductions of around 17%, 44% and 70% respectively.

The effect of fabric on regulated electricity demands depends on the proportion of space heating demands met by electric (secondary) heating.[21] A second effect is due to the mechanical ventilation system specified in the Advanced fabric package, which requires an electrically powered fan to control air exchange. This leads to an increased demand for electricity, the extent of which depends on the fan's specific power.[22]

The overall impacts of these changes in demand in terms of carbon emissions are shown by the dwelling emission rate (DER) values plotted in Figure 9. These data suggest that relative to the Reference fabric (Part L 2006) the Advanced fabric (similar to passiv haus standards) could lead to a reduction of around 35%. This demonstrates that significant CO_2 savings are possible through fabric measures along, without the need to install LZC technologies.

Economic impacts

The benefits of reducing a building's energy demands and CO_2 emissions through improved fabric must be balanced against the cost implications of specifying materials with lower U values, and reducing air permeability and thermal bridging. The following graph shows estimations of the capital cost implications of each level of improved fabric, expressed as costs in addition to the Reference fabric package. It should be noted that these are generic cost figures for a typical end of terrace dwelling. In practice costs are sensitive to many factors; however these results give an indication of typical additional costs of fabric improvement. Full details of the cost assumptions are given in the appendix.

[21] In the example presented here it is assumed that there is no need for secondary space heating – i.e. the primary heating system meets all of the dwelling's thermal demands.

[22] The standard assumption in SAP is that where an MVHR system is specified the specific fan power (SFP) is 2W/litre/second. However, fans of higher efficiency are available and in this example a SFP value of 1W/litre/second has been assumed.

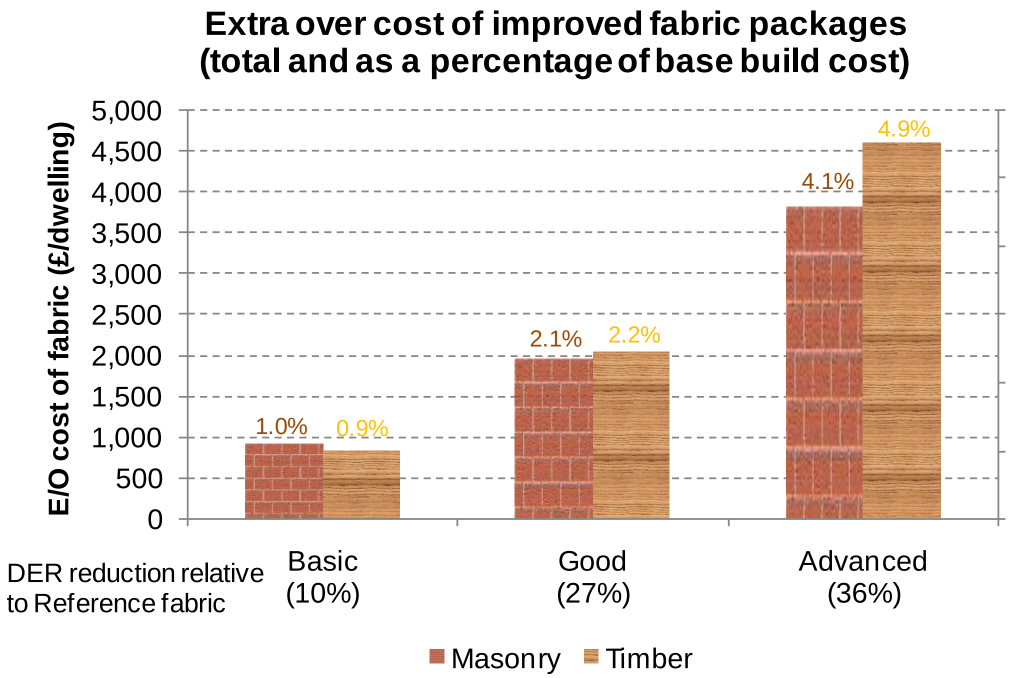

Figure 10: Additional capital cost of improved fabric packages

These results suggest the additional capital expenditure for the fabric packages considered range from c.£1,000 to c.£4,500 per dwelling. As mentioned above, these costs apply to generic new build dwellings and the financial impacts in individual cases will vary. The results suggest that there is little difference in the percentage increase in cost between the two methods of construction considered.

An obvious advantage of a more efficient home is reduced fuel bills for the occupants. The energy demands predicted by the energy modelling (SAP) were translated into approximate fuel bills, from which estimations of annual savings can be made.

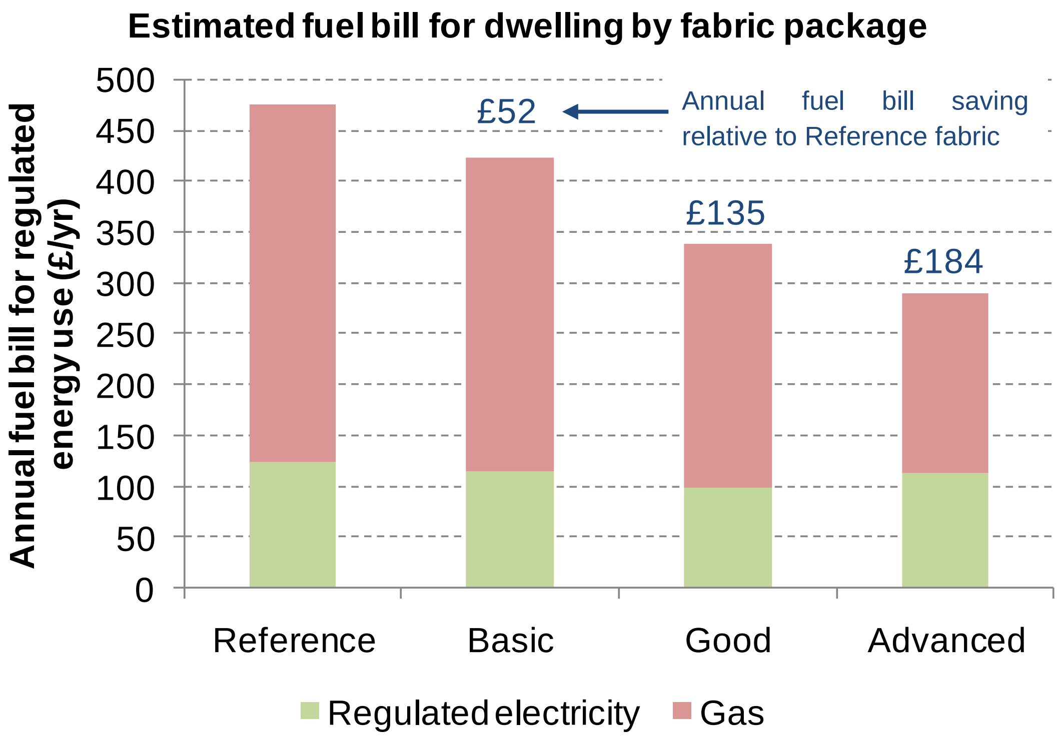

Figure 11: Representative fuel bills (regulated energy demands only) by fabric package for the end of terrace house considered

The results presented above are based on thermal demands met by an 85% efficient gas boiler, with gas and electricity prices of 4p/kWh and 10p/kWh respectively. These are indicative current prices, and clearly the fuel bill savings would be greater if energy prices were to rise (and lower if they fall).

4.2.4 Practical implications of fabric improvement

The results presented above show that there is considerable opportunity to improve on current building standards in terms of thermal performance of dwellings. However, a number of associated issues with improving a building's fabric must also be considered. This section gives an overview of some of the main considerations.

Space requirements of increased insulation

Achieving the increasingly low U values summarised in Table 5 involves specifying thicker insulation in the case of the ground floor, walls and roof, and selecting higher performing windows and doors. The impact in cost terms of the increased space required, particularly for the external wall insulation, is not included in the above analysis. With traditional insulating materials lower U values means thicker insulation, which necessitates thicker walls. The effect of this is to either reduce the internal floor area of the building or reduce the number of dwellings that can be accommodated on a site. The following figures show the increase in insulation thickness required to achieve the stated U values.

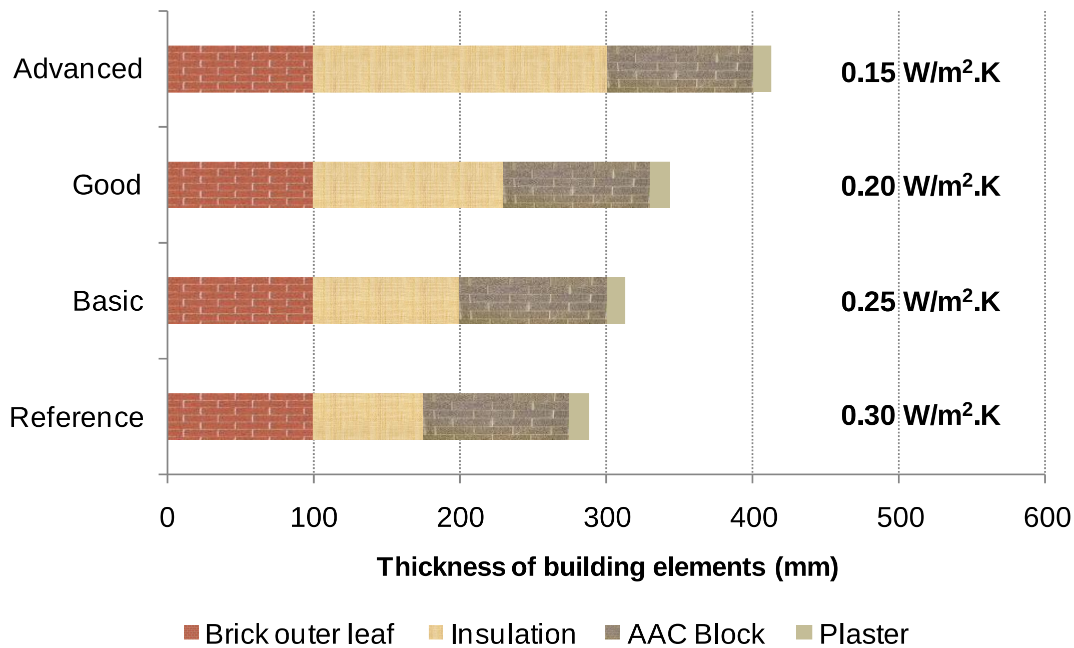

Figure 12: Masonry cavity wall insulation cross sections[23]

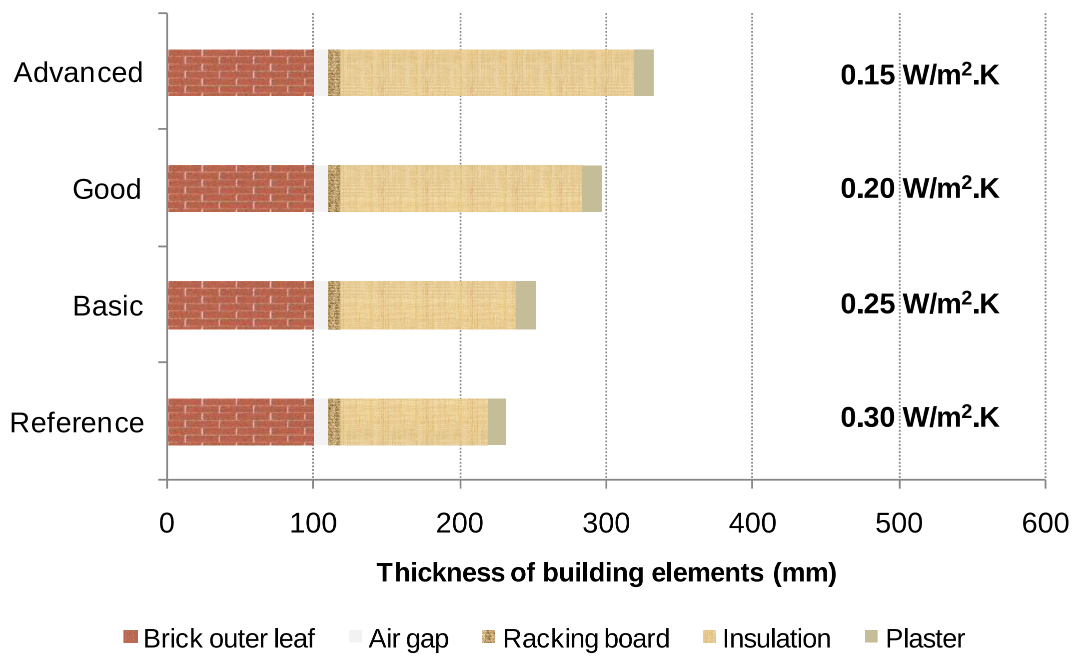

Figure 13: Timber frame construction – wall insulation cross sections

For the dwelling type considered in this analysis (an 88m^2 end of terrace house), the impact of improving the U values from the Reference fabric to Basic, Good and Advanced could be to reduce the dwelling's internal floor area by around 1%, 3% and 5% respectively.

[23] AAC block refers to autoclaved aerated concrete blocks.

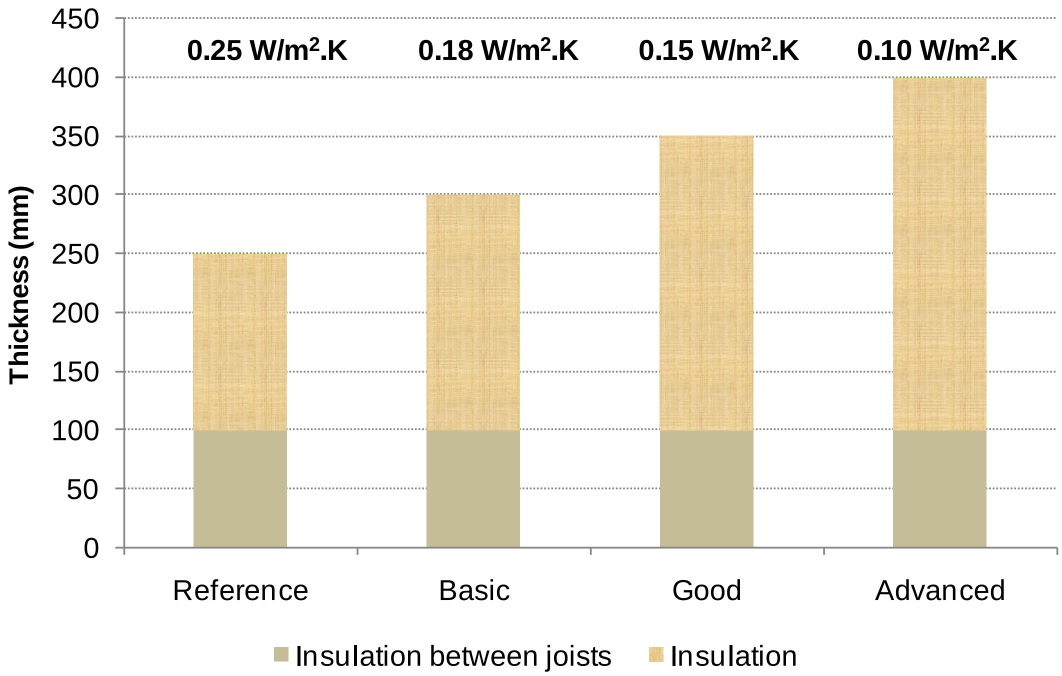

Figure 14: Thickness of loft insulation (based on cold loft construction) for each fabric package

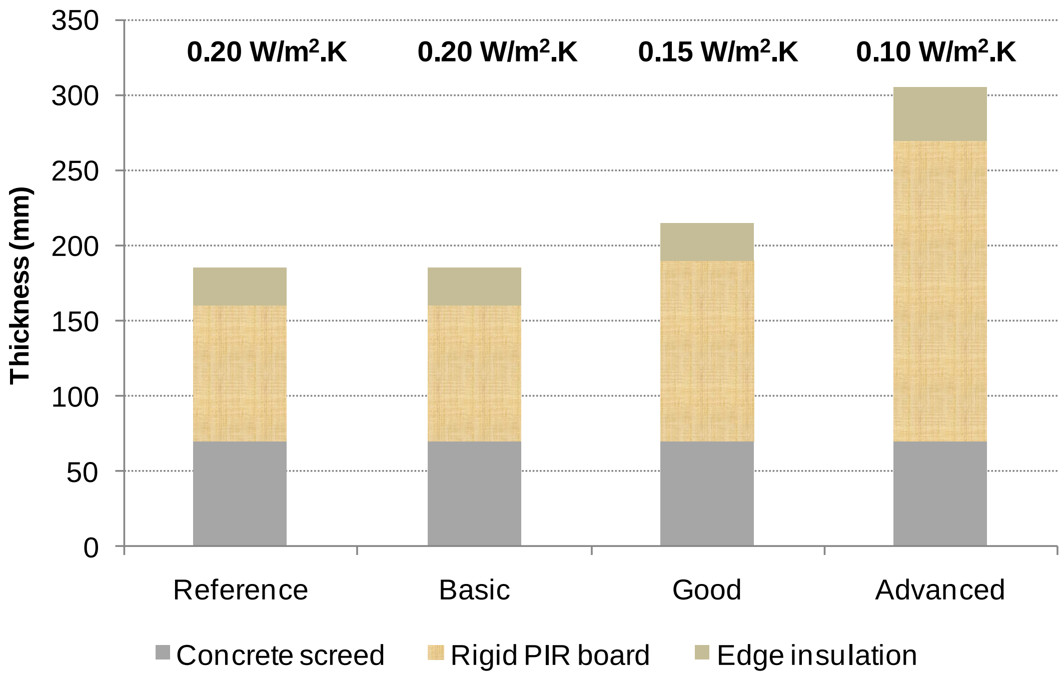

Figure 15: Thickness of floor insulation for each fabric package

Greater space requirements for floor and roof insulation can in general be more easily accommodated than the additional wall thickness required to achieve low U values. Incorporating thicker walls in a new building with no impact on internal floor area can be achieved by using a greater area of land (i.e. higher building footprint). However, the opportunities to employ this approach are more limited in urban areas, where space is at a premium and the economics of development projects may be highly sensitive to the number of dwellings that can be built on a site.

Buildability and installation issues

The term 'buildability' refers to the extent to which a design is realisable in practice. In construction a potential gap exists between the building as designed and the finished structure. This is particularly true with aspects such as air permeability and thermal bridging, for which it can be difficult to achieve the exact design value. The gap between as-designed and as-constructed performance must be minimised for mass market solutions.

Where U values of building elements are to be lowered with thicker insulation no particular installation challenges exist.[24] However, a change in installation practice may be required for some building elements, notably windows and doors of very low U values. Triple glazing adds significant weight to windows, which means mechanically assisted installation may be required. This represents a change from traditional installation practices but is not an insurmountable barrier.

Other issues

Further issues that should be considered when specifying an approach to energy saving and CO_2 reduction in new buildings include the impacts on the internal environment and on-going maintenance burdens. For example, in highly air tight homes thought must be given to air circulation to avoid potentially negative health impacts of inadequate fresh air exchange. In terms of maintenance, improving the building fabric will not generally lead to a higher burden on the occupiers. This makes emissions reduction through fabric improvement an attractive solution relative to LZC technologies from an on-going operation and maintenance point of view.

4.2.5 The role of energy efficiency: conclusions

The analysis presented above shows that significant energy demand and CO_2 emission reductions are possible through improvements to building fabric. While there is an additional capital cost associated with realising these savings, the increase relative to baseline build costs is relatively modest (of the order of a few percent). Advocating improved energy efficiency levels through enhanced building fabric is appropriate for the following reasons:

- Energy demand reduction is a logical first step in any low carbon building strategy. This is recognised by Government, for example by the proposed energy efficiency backstop measures proposed for Code level 4 and above of the Code for Sustainable Homes.[25]
- Construction represents the prime opportunity to influence how a building will perform throughout its lifetime. Improving building fabric buffers occupants from fluctuations in

[24] Provided that studs of appropriate dimensions can be sourced in the case of timber frame construction, for example.
[25] See the DCLG consultation on the Code for Sustainable Homes, and the work by the Zero Carbon Hub on energy efficiency backstop levels.
www.communities.gov.uk/planningandbuilding/buildingregulations/legislation/codesustainable/
www.zerocarbonhub.org/news_details.aspx?article=5.

fuel prices (energy demand reduction is beneficial from this point of view irrespective of the fuel used to meet the demands).

- Energy efficiency measures are amongst the most cost effective means of saving CO_2 and should therefore be encouraged. Practical and economic considerations mean that the level of building fabric improvement appropriate will vary on a site-by-site basis.

4.3 Low carbon development strategies: economic analysis

4.3.1 Introduction

The current definition of zero carbon homes, which will be enforced through changes to the Building Regulations in 2016, includes a minimum mandatory reduction in CO_2 emissions through on-site measures and an option to achieve the remainder of the savings through on-site or off-site means (see section 2.2.2). This approach recognises that achieving the 'zero carbon' standard through on-site technologies only can be highly costly in some circumstances and not technically possible in others. This section presents an analysis of the capital cost implications of building to the higher standards that future Building Regulations will demand. Results are given for a range of technical options and selection of development types representative of expected development in Chesterfield borough.

4.3.2 Methodology

Overview

Combinations of improvements to the basic building fabric and low carbon technologies (see Table 4, above) were defined to meet specific CO_2 reduction targets for each dwelling type. The energy/CO_2 modelling was performed using the latest version of the Government's Standard Assessment Procedure (SAP), which at the time of writing is being revised.[26] **Further changes to SAP are possible before it is introduced along with Part L 2010 standards which could impact the results presented below**. These results should be taken as indicative only as they relate to generic dwelling and development types. In practice costs will vary on a site-by-site basis. Full assumptions behind the cost and performance analysis presented in this section are given in the appendix.

Development and dwelling types

The development and dwelling types considered are summarised below.

Table 6: Dwelling types

Metric	Flat	Terraced house	Semi-detached house	Detached house
Total floor area (m^2)	61	73	88	118
Number of floors	1	2	2	2
Storey height (m)	2.5	2.5	2.5	2.5
Roof area (m^2)	0	36.5	44	59
Window area (m^2)	6	10	14	18
External wall area (m^2)	33	38	84	133
Base build cost (£)[27]	59,750	86,450	93,350	99,950

[26] Modelling was performed following SAP 2009 v9.90, March 2010.
[27] Base build costs exclude cost of land, VAT, professional fees and any abnormal foundation costs such as piling works. Costs based on cost plans prepared as part of a project for DCLG on the cost of building to the Code for Sustainable Homes, see: www.communities.gov.uk/publications/planningandbuilding/codecostreview.

Table 7: Development types

Development	Dwelling density (dph)	Number of dwellings by type				Total no. of dwellings
		Flat	Terraced	Semi	Detached	
City infill	80	20	0	0	0	20
Medium urban	50	40	50	100	10	200
Greenfield	30	40	120	200	40	400
Strategic	40	600	400	800	200	2,000

This analysis considers residential development only. Clearly there is a high chance that any medium to large scale development would include some non-residential buildings. However, in the interests of transparency (and to reduce the number of assumptions that have to be made, e.g. around non-residential building forms and usage types), non-residential buildings are not included.[28]

4.3.3 Capital cost assessment

All capital costs presented in this section are *extra over* relative to a Part L 2006 compliant design. The costs are grouped into four categories:

- **Fabric** – cost of improving building fabric, including lower U value materials and reduced air permeability.
- **Thermal plant** – E/O cost of the plant specified to meet thermal demands. This figure includes an offset cost when the base case heating system (high efficiency gas boiler) is replaced. Where community heating systems are specified this figure also includes the cost of heat distribution (district heating).
- **LZC technology** – includes cost of PV system, solar thermal, and wind turbines, where specified.
- **Allowable solutions** – only applies to Part L 2016 (ZCH standards). In this analysis it is assumed that any shortfall in carbon saving (below that required to meet ZCH standards) is made up via investment in off-site carbon saving measures.[29]

Part L 2010: 25% improvement on current standards

The first revision to Part L, which is due to be introduced towards the end of 2010, will demand a 25% reduction in CO_2 emissions relative to current standards. Preferred strategies to meeting this level of improvement tend to be based on dwelling-by-dwelling approaches to meeting energy demands (rather than community heating). The following graph shows the additional cost, relative to meeting current Building Regulations, of achieving a 25% reduction in regulated emissions via alternative approaches.

[28] Both residential and non-residential development uses are included in the major sites analysis presented in section 6.

[29] Given the status of development of allowable solutions there is currently uncertainty around the level of investment that will be required. The base case assumption in this study is that the carbon savings are required to offset thirty years' worth of emissions and contributions are calculated based on £100/tCO_2.

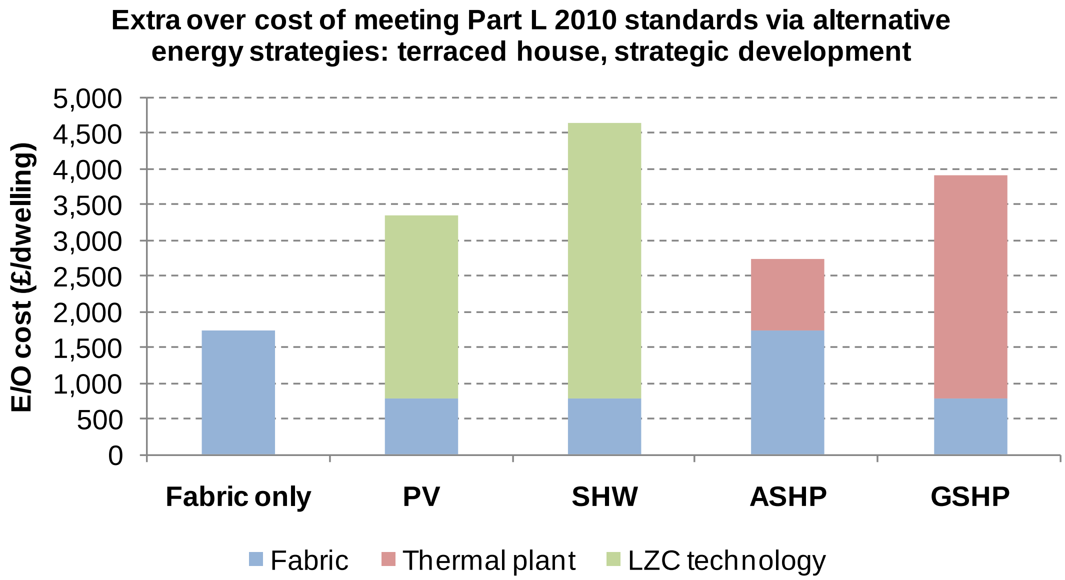

Figure 16: Extra over cost (relative to Part L 2006 standards) of meeting CO_2 reduction target of Part L 2010 – terraced house

These results suggest that the most cost effective approach to meeting Part L 2010 in this example is based on improvements to the building's fabric. Results from the current consultation version of SAP suggest that in most dwelling types it is possible to meet Part L 2010 standards with a highly efficient gas boiler heating system and improved building fabric (including lower U values of all main elements, reduced air permeability and lower thermal bridging).

An alternative approach is to achieve less CO_2 emission reduction through fabric improvement and make up the emission saving by specifying a LZC technology. The main technologies of interest for this level of CO_2 saving are photovoltaics (PV), solar thermal (solar hot water, SHW), and heat pumps (ASHP / GSHP). However, the results above show that the fabric only approach is more cost effective in capital cost terms.

Of the *technology* solutions presented above air source heat pump is the lowest cost method of achieving the 25% improvement required by Part L 2010. However, these results show that when an ASHP is implemented as the main heating technology the level of fabric improvement required is comparable to that of the *fabric only* strategy. This is a result of the relative fuel carbon intensity factors in SAP.[30] A 25% saving can be achieved with the GSHP and a lower level of fabric improvement due to its higher average efficiency (COP) relative to the ASHP. The relatively high carbon credit for electricity also explains why PV appears more attractive than SHW. Each unit of energy produced by a PV system is credited with providing a higher carbon saving than energy from SHW. This means that a relatively small (and therefore less expensive) PV system can result in the same CO_2 saving as a larger SHW system.

[30] According to the latest version of SAP the CO_2 intensities of natural gas and electricity are 0.198kgCO_2/kWh and 0.517kgCO_2/kWh respectively. This means that a heat pump (powered by grid electricity) must have a COP of at least 2.35 just to achieve parity with a 90% efficient gas boiler in CO_2 emission terms.

The following graph shows how costs vary with dwelling type for each dwelling defined in Table 6, above.

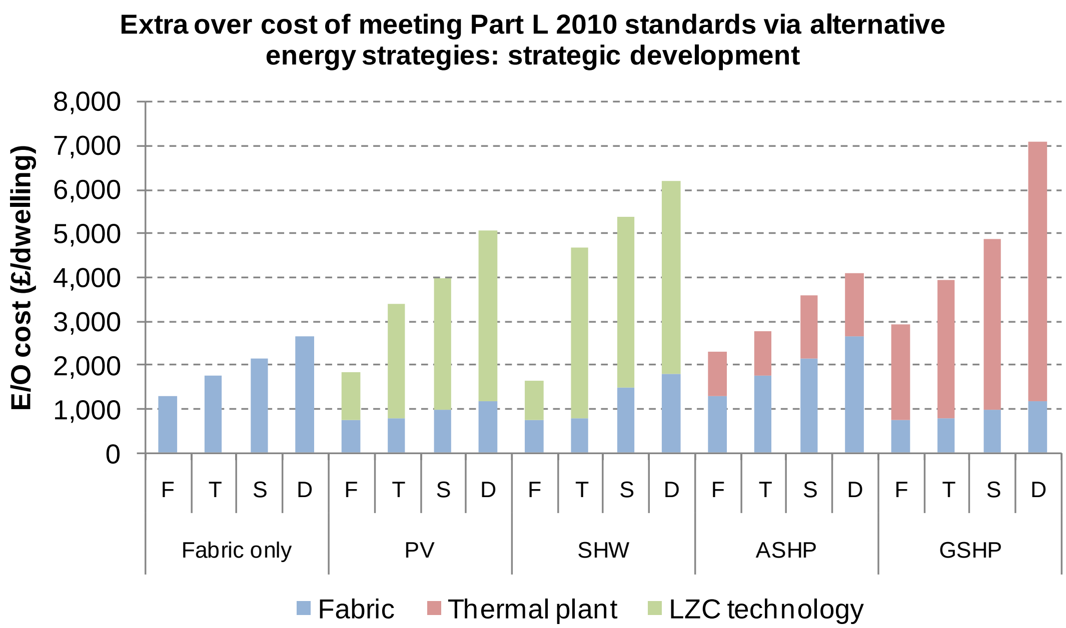

Figure 17: Extra over cost (relative to Part L 2006 standards) of meeting CO_2 reduction target of Part L 2010 – flat, terraced, semi-detached and detached houses

As one may expect, the total per dwelling costs of improving building fabric and of the technological solutions required to meet the 25% target increase with total floor area of the dwelling. These results suggest that provided the dwelling form is conducive to a 25% reduction being possible through fabric improvements only then this is the most cost-effective solution.

Part L 2013: 44% improvement on current standards

Changes to Part L in 2013 are expected to require new homes to meet a 44% improvement on current standards. In the majority of cases this will require a combination of improvements to the building's fabric, and switching to a high efficiency heating system or low carbon heating fuel. The 44% target can be met through generation of low carbon electricity (e.g. from a sufficiently large PV system, or wind or hydro power, where available).

The approaches presented in the following results represent a selection of mainstream strategies that could be employed to comply with the Part L 2013 standard.

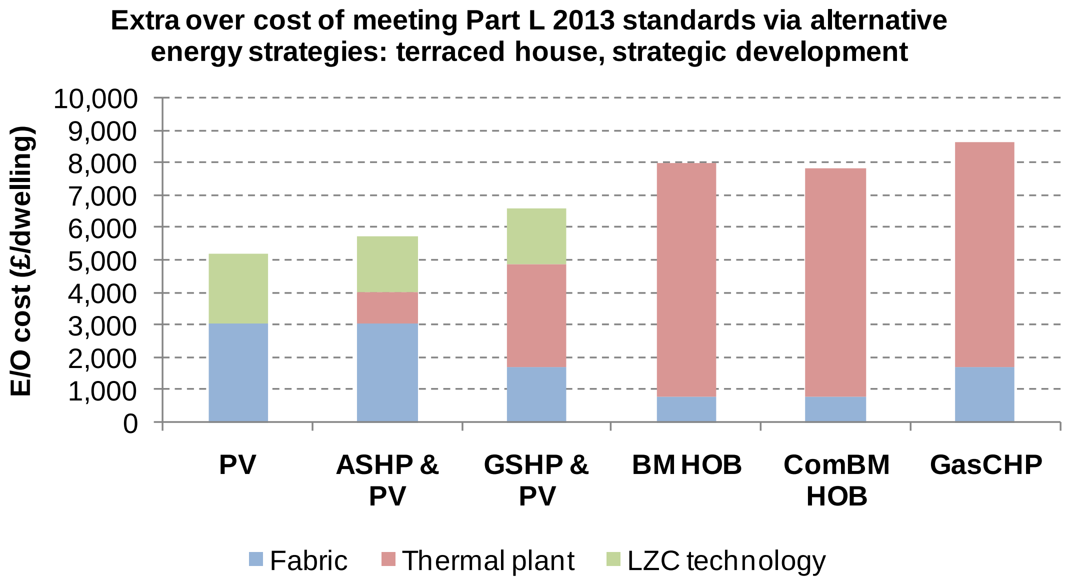

Figure 18: Extra over cost (relative to Part L 2006 standards) of meeting CO_2 reduction target of Part L 2013

In these results BM HOB refers to a biomass-fuelled heat only boiler at the individual dwelling scale.[31] 'ComBM HOB' is community heating based on biomass boilers, with a district heating system to distribute the heat. The gas CHP option is also based around plant sized based on the thermal demands of the whole development (micro gas CHP is excluded from this analysis). In terms of individual dwelling-scale technologies, the options considered here are a high efficiency gas boiler with PV, and heat pumps (ASHP and GSHP) with PV systems sized to meet the remaining CO_2 reduction.

In this development and dwelling type the most attractive strategy in capital cost terms involves a combination of improving the building fabric and specifying a PV system to meet the 44% target. The amount of PV required can be reduced slightly by substituting a higher efficiency heating system (heat pump) for the gas boiler but this is likely to lead to a higher capital cost overall.

The cost advantages of being able to specify larger heating plant by aggregating thermal demands and opting for a community heating approach rather than individual boilers are offset by the additional costs of heat distribution and metering in the community option (see the biomass results). Heat distribution costs depend on many factors, but are primarily dictated by the build density of the development. The following graph shows how the total extra over cost of each approach varies by development type for three of the representative scenarios summarised in Table 7, above.

[31] It is assumed that the 'individual' biomass boiler solution in houses involves a boiler in each house and that in flats a central boiler would be shared between all flats within the block.

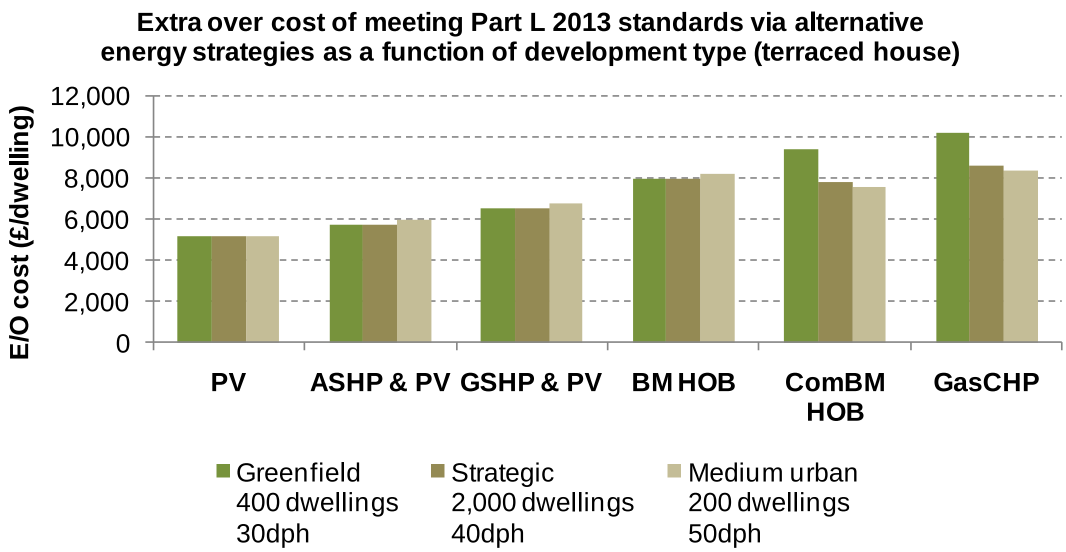

Figure 19: Extra over cost of meeting Part L 2013 standards for a range of energy options in three development types

Based on the assumptions behind the cost modelling performed there is no change in total extra over cost between development types in the PV only strategy (for which there is no change in heating system). The small variations in cost for the remaining options that do not employ community heating (ASHP, GSHP and BM HOB) are due to differing offset cost benefits from not having to provide a gas connection to each home (as the gas-fired heating system is replaced in each of these options).

The advantages of higher build density are evident from the results for community biomass heating and community gas CHP, which show a significant cost reduction as dwelling density increases.[32]

Part L 2016: ZCH standards

The ZCH energy strategies have been designed on the assumption that a 70% improvement on (Part L 2006) regulated emissions is required through on-site measures. The remaining emissions reduction, including residual regulated emissions and all unregulated emissions, is assumed to be achieved via investment in allowable solutions, as described above.

Achieving the 70% on-site target represents a significant challenge. Unless significant levels of renewable electricity generation are possible, it is likely that a switch from gas boilers to meet thermal demands will be needed. The zero carbon homes standard provides a strong incentive to consider a switch to low carbon heating fuels such as biomass. Depending on the characteristics of the technology, additional low carbon energy generation (e.g. from photovoltaics) may be required to meet the carbon compliance level.

[32] Note that accurate pricing of district heating networks requires data at a level of detail not available in this study. The cost assumptions used are based on published figures and results should be viewed as representative rather than as being definitive values. Full assumptions are provided in the appendix.

Economies of scale and practicality considerations mean that community heating technologies become increasingly prevalent as potential solutions in meeting the ZCH standard. The following results relate to a range of potential solutions to meeting the carbon reduction targets imposed through ZCH policy. It should be stressed that there is very limited experience of building to this standard to date and technological solutions are likely to develop over the coming years, i.e. the solutions presented are representative only and should not be taken as a definitive list.

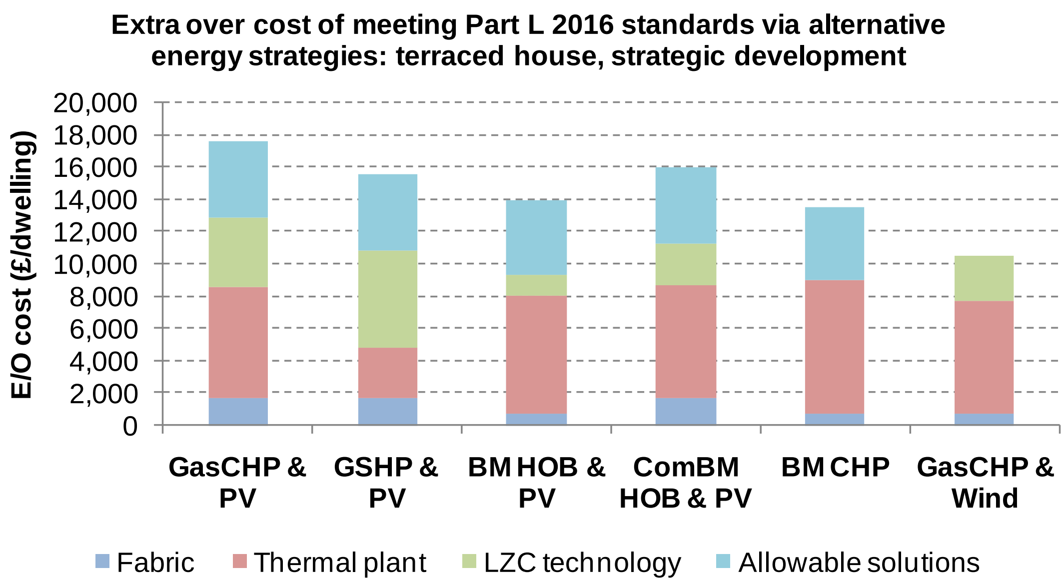

Figure 20: Extra over cost (relative to Part L 2006 standards) of meeting CO_2 reduction target of Part L 2016 (zero carbon homes standards)

The first point to note about the above results is the increase in extra over cost relative to the costs for meeting Part L 2010 or Part L 2013 standards. For example, the E/O costs of achieving a 44% reduction in CO_2 emissions were in the range £5,000–£10,000 per dwelling. The results above suggest that achieving the ZCH standard will involve a significantly higher capital outlay.

With the exception of the 'Wind' results the LZC technology costs plotted above refer to investment in photovoltaics, which for most technology solutions is required to meet the 70% on-site CO_2 saving target. The size of PV system required is lower when the CO_2 saving from the thermal plant is higher (which explains why a larger PV system is required with the electrically-powered heat pumps system compared to the biomass-fired boiler).[33]

The biomass CHP system modelled is based on organic rankine cycle (ORC) technology, of which there is very limited experience in the UK (although there are numerous installations in Europe). ORC technology is currently only commercially viable in situations with relatively high thermal loads. The scale of the strategic development is towards the lower end of what is

[33] The reason for the higher PV requirement in the community biomass heating option relative to the individual biomass boiler solution is that while in the latter it is assumed that all thermal loads are met by the biomass boiler, the community biomass boiler meets only a portion of thermal demands, with the remainder met by gas boiler backup plant.

required and this technology option is not available in the other development types considered. The operating principle of ORC-based CHP is similar to gas CHP insofar as fuel is converted into useful heat and electricity. The technology is of interest for low carbon development mainly because it provides a means of meeting the CO_2 reduction targets of ZCH policy without further investment in other technology.

The gas CHP with wind turbine option represents a (relatively) low cost approach to meeting the ZCH standard. This solution is only likely to be possible in areas where sufficient wind resource exists and where all the barriers to wind turbine siting can be overcome (see section 5.3.3). In this example it is assumed that sufficient wind resource is available to offset all remaining emissions after the implementation of a community gas CHP system (hence no requirement for further investment in allowable solutions). In this particular development type (strategic development of 2,000 homes) this would equate to around 4MW of installed wind capacity (assuming electricity production from wind at 25% load factor).

The graph below shows how the cost of each strategy varies with development type.

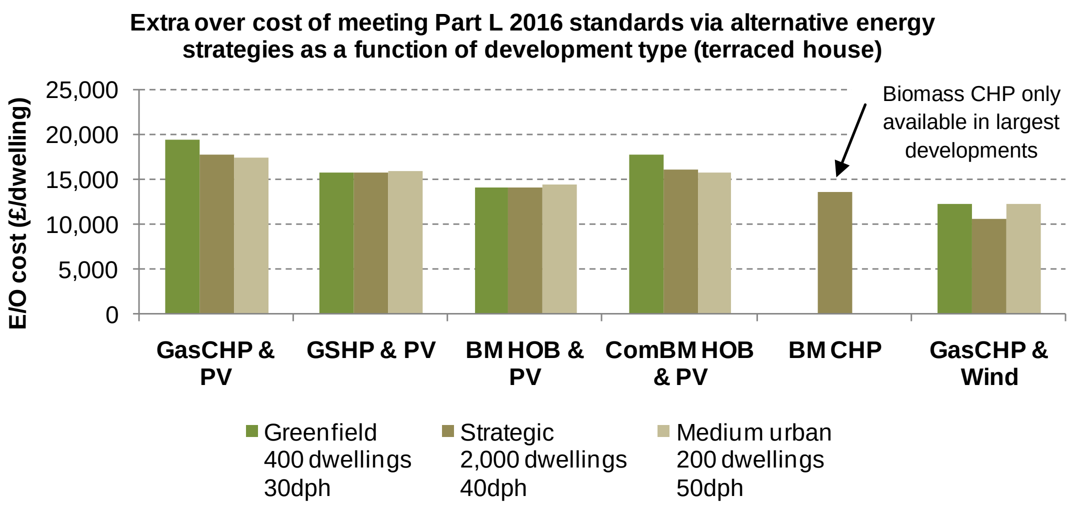

Figure 21: Extra over cost of meeting Part L 2016 standards for a range of energy options in three development types

Again the benefits of higher build density are apparent, with reduced costs of heat distribution systems in higher density sites leading to lower overall costs. The reason for the lower £/dwelling cost for the gas CHP with wind strategy in the strategic development site is the economies of scale available with larger scale wind turbines (see cost assumptions in appendix).

4.3.4 Economic analysis: summary and conclusions

This section has considered the additional cost of building new homes to increasingly stringent CO_2 emission reduction standards. A range of approaches to meeting the energy needs and carbon reduction targets has been assessed for a number of different dwelling and development types. The following graph shows the spread of average extra over costs for the energy options presented above, averaged across all four dwelling and development types.

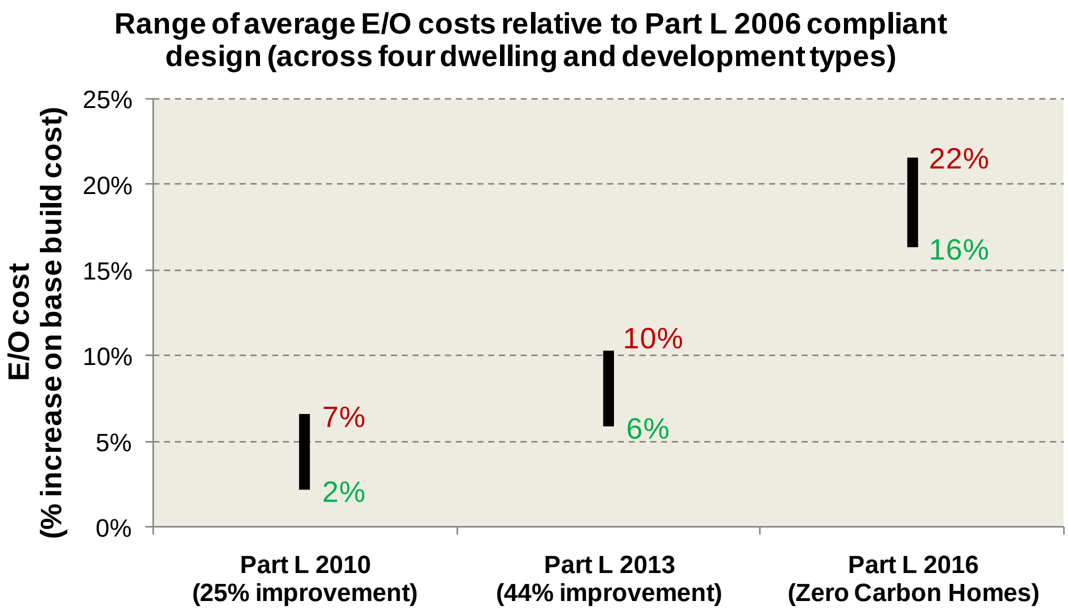

Figure 22: Range of extra over costs of complying with anticipated changes to Building Regulations for mainstream energy options considered

Based on the dwelling and development types considered in this analysis the additional costs of building homes to Part L 2010, 2013 and 2016 standards are up to around 7%, 10% and 22% of base build costs, relative to building to current standards. Note that these figures are based on a limited range of technical solutions and are indicative only. Also, the costs of meeting the ZCH (Part L 2016) standard include assumptions on the price of allowable solutions which are the subject of on-going work (i.e. buyout prices are currently uncertain).

The main conclusions from the analysis presented above are as follows.

- The most cost effective solutions to meeting Part L 2010 and Part L 2013 standards are likely to be based upon dwelling-scale approaches to meeting energy demands. The more stringent demands of Part L 2016 encourage the use of low carbon fuel sources and increase the relative economic attractiveness of community energy schemes.
- Based on cost analysis of generic dwelling and development types the extra over costs (relative to building to current standards) of achieving the CO_2 savings required by future revisions to Part L are:
  - From around 2% to 7% for Part L 2010 (25% reduction in CO_2 emissions).
  - Around 6% to 10% for Part L 2013 (44% reduction in CO_2 emissions).
  - In the region 16% to 22% for Part L 2016 (zero carbon homes standard).
- Scale and density of development are likely to have a more significant impact on costs when community energy systems are proposed. The viability of certain technologies depends on development characteristics, principally magnitude and diversity of thermal demands.

4.4 Low carbon development: Case Studies

In order to illustrate the costs and CO_2 performance of low carbon building techniques a selection of representative case studies are presented in this section. The new build examples draw on published case studies and relate to completed developments.[34]

4.4.1 New build examples

Norbury Court, Staffordshire: CSH level 3

This development, completed in 2007, consisted of nine terraced homes: seven three-bedroom houses, one two-bedroom house and a three-bedroom dormer bungalow. Affordability and sustainability were key aspects of this social housing development. Sustainability measures include passive solar design, solar thermal panels, low energy lighting, low flow rate sanitary ware, and rainwater harvesting.

Roof: cut block foam insulation ($0.20W/m^2.K$)

Windows: double glazed ($1.2W/m^2.K$)

Air permeability: first complete dwelling had value of $5.6m^3/hr$ at 50Pa

Walls: timber frame with cement particle board and phenolic foam insulation ($0.29W/m^2.K$)

Doors: average U value of $2.0W/m^2.K$

Floor: concrete beam construction with polystyrene infill ($0.21W/m^2.K$)

Figure 23: CSH level 3 case study: Norbury Court[35]

Excluding the cost of land and fees, the build costs for these homes was approximately £950/m². The developer estimated that the additional cost of building to Code level 3 was around £7,500 per home, but it was noted that this cost should fall if the same build system and technologies were to be used in future developments as a result of the lessons learnt.

Initial feedback from the occupants was positive, in particular the benefits of lower energy and water bills, good acoustic properties and enjoying a draught-free home were reported.

[34] Case studies published by the Department for Communities and Local Government: www.communities.gov.uk/publications/planningandbuilding/codecasestudies.
[35] Image and data from *The Code for Sustainable Homes: Case Studies*, DCLG (March 2009).

Mid-Street, South Nutfield, Surry: CSH level 5

This development comprised two two-bedroom flats and was built using a Structural Insulated Panel System (SIPS), with beam-and-block flooring with mineral wool and expanded polystyrene insulation. Code level 5 is a challenging target and the following sustainability features were included: passive solar design with MVHR, low energy lighting, low energy white goods, PV array, biomass boiler, low flow sanitary ware, rainwater harvesting and Forest Stewardship Council timber.

Roof: mineral wool insulation (0.13W/m^2.K)

Windows: triple glazed (0.8W/m^2.K)

Air permeability: tested valued of 4.9m^3/hr at 50Pa fell short of design value of 3m^3/hr

Walls: SIPS with 50mm external insulation (0.14W/m^2.K)

Doors: fully insulated (1.2W/m^2.K)

Floor: beam & block with 75mm added insulation (0.14W/m^2.K)

Figure 24: CSH level 5 case study: Mid-Street[36]

To achieve the CO_2 emission reduction target particular attention had to be paid to thermal bridging and air permeability during the design and construction phases. The majority of the added features performed as expected, with the exception of the biomass boiler. Biomass was used in place of gas to help achieve the carbon savings required. However, the biomass based heating system initially performed erratically and had high maintenance requirements (some sort of maintenance every week or fortnight), and relatively short servicing intervals of six months.

Construction costs were approximately £1,850/m^2 (excluding land costs and fees), and the developer estimated that this represented around a 20% increase relative to standard build costs.

[36] Image and data from *The Code for Sustainable Homes: Case Studies*, DCLG (March 2009).

4.4.2 Retrofit examples

Renewable electricity generation through photovoltaics

The introduction of the feed-in tariff has greatly improved the economic case for installing small scale renewable electricity generators. This section considers the economics of retrofitting a photovoltaic system on the roof of an existing home.

The electricity generated from a PV system depends on multiple factors, but a primary consideration is the orientation. In the UK south-facing panels receive greater levels of insolation and hence give a higher output. The example below shows the impact of alternative orientations on the electricity produced and hence economics. In each case a tilt angle of 30^o from the horizontal is assumed.

Table 8: Retrofit PV installation example

	Orientation		Notes
	South	East / West	
PV system size (kW_p)	2.5	2.5	Typical domestic system size
Total installed cost (£)	12,500	12,500	Based on capital cost of £5,000/kW_p
Electricity produced (kWh/yr)	2,146	1,826	Calculated based on SAP 2009 methodology
Proportion of electricity used in home	50%	50%	This assumption affects the benefit derived from reduced demand for grid electricity
Price of grid electricity (p/kWh)	10	10	Typical value
Export tariff (p/kWh)	3	3	Defined in FiT legislation
FiT (p/kWh)	41.3	41.3	Applies for sub-4kW_e retrofit systems
Total annual income from system (£/yr)	1,026	873	Consists of reduced grid demand, export tariff and FiT
Average annual on-going costs (£/yr)	110	110	Based on check & clean by qualified professional every five years and one inverter replacement over system lifetime
Net annual benefit (£/yr)	916	763	Difference between revenues and costs
Simple payback period (years)	13.6	16.4	Capital cost divided by net annual benefit
Effective return on investment	5.6%	3.8%	From cashflow analysis over 25 years

These results highlight the benefit of well-orientated panels. At a total installed capital cost of £5,000/kW_p a return on investment of around 5.5% is possible, but this falls to below 4% for an east or west facing PV system.

In terms of carbon savings, the latest version of SAP credits electricity generated at 0.517kgCO_2/kWh, which suggests that the annual savings from a well-orientated system as described above would be around 1.1tCO_2/yr. Compared to average emissions of a typical existing home of around 5.3tCO_2/yr, this represents a saving of around 20%.[37]

Hot water provision through solar thermal system

An alternative way of utilising the sun's energy is to provide hot water via a solar thermal system to meet some of a dwelling's annual hot water demands. There are two main types of solar thermal systems: flat plate collectors and evacuated tube collectors. While evacuated tube collectors are more expensive (due to higher manufacturing costs), they offer superior performance in terms of turning incident solar radiation into hot water. Total installed costs vary depending on numerous factors. The example below includes upper and lower cost estimates to show the impact of capital cost on overall economics.

Table 9: Retrofit solar thermal example

	No RHI		With RHI		Notes
Capex assumption	**Low**	**High**	**Low**	**High**	
Solar thermal panel area (m^2)	4	4	4	4	Size of a typical domestic system
Total installed cost (£)	2,850	3,500	2,850	3,500	Typical cost range
Useful hot water produced (kWh/yr)	2,328	2,328	2,328	2,328	Based on 582kWh/m^2.yr for evacuated tube system[38]
Solar thermal contribution to DHW demand	63%	63%	63%	63%	Assuming average home's DHW demand is 3,700kWh/yr (BRE figure)
Gas saved (kWh/yr)	2,739	2,739	2,739	2,739	Based on an 85% efficient gas boiler
RHI (p/kWh)	0	0	18	18	From RHI consultation
Total annual benefit from system (£/yr)	110	110	529	529	Gas saving + RHI payment (based on gas price of 4p/kWh)
Average annual on-going costs (£/yr)	40	40	40	40	Assume professional service every five years costing £200
Net annual benefit (£/yr)	70	70	489	489	Revenues – Costs

[37] Average emissions of typical existing home based on gas consumption of 17MWh/yr and electricity consumption of 3.67MWh/yr with emission factors as defined in latest version of SAP (0.198kgCO_2/kWh for gas and 0.517kgCO_2/kWh for electricity).
[38] Value from the Energy Efficiency Commitment Scheme (replaced by CERT in 2008).

Simple payback period (years)	41.0	50.3	5.8	7.2	Capital cost / Net annual benefit
Effective return on investment	-5.8%	-7.3%	16.6%	12.8%	From a 20 year cashflow analysis

In this example a gas-fired boiler is assumed to be the incumbent heating system as this is currently the most common type of domestic heating in Chesterfield borough, and in the UK. If the fuel displaced were more expensive than gas (e.g. oil and electricity tend to be higher priced fuels) then the annual fuel bill savings would clearly be higher and the economics would be enhanced.

For the purposes of the calculations presented above it is assumed that the solar thermal system meets around 63% of the dwelling's hot water demand over the year. However, this proportion can vary significantly depending on the hot water demand profile – i.e. volumes required and timing of the demand. Solar thermal's contribution is typically maximised when hot water is used during the day (increasing the capacity to utilise the afternoon sun), showers are taken rather than baths, and low flow fittings are installed to reduce overall hot water demand.

This simple example shows that solar thermal systems are unlikely to pay for themselves over their lifetime unless additional support is provided, for example through RHI payments. Of course this conclusion is sensitive to the capital cost of the system and the price of fuel. Increases in incumbent fuel prices tend to favour the economics of renewable energy generation systems such as solar thermal.

From a carbon point of view, the 2,740kWh/yr of gas saved translates into a carbon saving of around 550kgCO_2/yr, around 10% of a typical home's total annual carbon emissions.

5 Low carbon and renewable energy resource assessment

5.1 Biomass

5.1.1 Introduction

'Biomass' refers to a range of biologically derived material, including wood (which for heating may be in the form of logs, chips or pellets), straw, and a range of energy crops. The focus for this study is on wood-derived biomass (principally wood chips and wood pellets). Biomass is relevant to low carbon development since substituting biomass for fossil fuels in combustion for heat/power production releases far less CO_2 into the atmosphere. Total biomass availability in a region ultimately depends on the land area of forests / woodland and area of arable land used to cultivate energy crops.

5.1.2 Potential biomass supply from existing woodland

The following map shows the area of woodland in and around Chesterfield borough, based on OS Mastermap land use data.

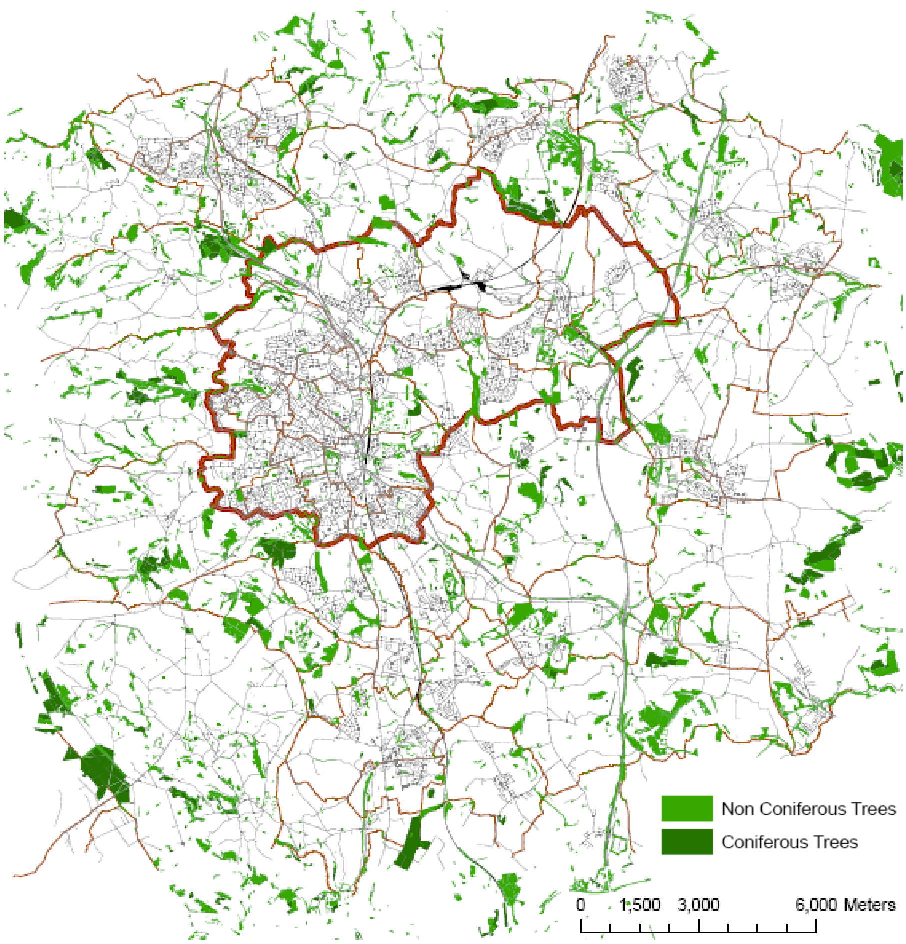

Figure 25: Woodland areas in and around the borough of Chesterfield

Excluding scattered trees, the total area of woodland in Chesterfield borough is around 435 hectares (6.5% of the borough's total land area). Of this, around 91 hectares (21%) is ancient woodland, which is unavailable for biomass fuel production. This leaves around 344 hectares as an upper estimate of woodland area that could be brought into managed production within the borough. Based on an annual wood yield figure of 4.0t/ha, the upper biomass yield from woodland within the borough is around 1,376t/yr.[39] This translates into an annual energy yield of around 4,816MWh/yr, based on an energy density of 3.5MWh/t, a typical value for wood fuel at around 30% moisture content. To put this figure in context, the average gas consumption per domestic gas meter in Chesterfield borough in 2007 was around 17MWh/yr.[40] This suggests that the maximum biomass resource available within the borough could provide an amount of energy equivalent to the gas consumption of around 280 existing homes.

Clearly the biomass resource from fuel sourced within the borough is highly constrained. However, biomass fuel supply chains are not restricted by political boundaries, and it is therefore relevant to consider the resource available in the wider area. The woodland areas shown in Figure 25, above are all within 15km of the centre of Chesterfield borough. Biomass from this area could therefore be considered a local fuel source. The following table summarises the maximum available energy resource from the total area of this woodland, were it to all be brought into managed production. The calculations are performed with alternative yield assumptions to show the sensitivity to this key figure.

Table 10: Estimation of wood fuel availability from woodlands in and around Chesterfield borough

	Low yield	High yield
Maximum managed woodland area (ha)	5,240	5,240
Estimated average annual yield of wood for biomass production (t/ha)	2.5	4.0
Annual biomass production (t/yr)	13,100	20,960
Energy available from biomass from managed woodlands based on 3.5MWh/t (MWh/yr)	45,850	73,360
Ratio of maximum energy from biomass from managed woodland to average gas consumption per domestic gas meter in Chesterfield borough	2,700	4,300

This analysis suggests that if all the woodland in the area were to be brought into managed production, the energy produced would be equivalent to the thermal demands of three to four thousand existing homes.

[39] From Forestry Commission report *Producing Fuel from London's Trees and Woodland*: www.capitalwoodlands.org/site/download/16.

[40] http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk//whatwedo/energy/statistics/regional/mlsoa-electricity-gas/page50221.html.

In practice the amount of biomass resource available to bioenergy schemes from local woodland will be dictated primarily by economic factors. Woodland owners and fuel supply companies must find sufficient financial incentive to produce woodchip or pellet fuel for the biofuel market. Fuel availability therefore depends on fuel price: higher biomass fuel prices will give greater incentive for woodland owners to consider managing their woods for fuel production.

5.1.3 Potential supply from energy crops

Energy crops are grown on agricultural land specifically as a fuel source, with an aim of achieving high production rates (tonnes per hectare). Although in general fuel production costs are higher for biomass from energy crops compared to biomass from existing woodlands, if demand for biomass fuel exceeds production possible from existing forests the economics of energy crop cultivation can become favourable.

The Energy Crops Scheme, which has been running since 2007, provides grants to farmers to encourage energy crop growth in appropriate locations.[41] The Scheme supports Miscanthus (a tall, woody grass) and Short Rotations Coppice (SRC) crops.[42] The potential for energy from energy crop production presented below is based on these two energy crops. Of course many other energy crops are available and the suitability of any particular species may vary on a site-by-site basis. However, this assessment aims to gauge the scale of the potential contribution that energy crops could make towards reducing demand for fossil fuels in the borough, and the simplifying assumption of considering only SRC and Miscanthus suffices for this purpose.

The following table summarises the data required to assess the potential for energy from energy crop cultivation in Chesterfield borough.

Table 11: Key assumptions in energy crop resource assessment

Data required	Key sensitivities	Data source for current assessment
Land area available for energy crop cultivation in the borough	Demand for land for other uses. Assessment of maximum available resource based on total arable land.	Based on generalised land use statistics and GIS-based assessment.
Annual energy crop yield (t/ha.yr)	Type of crop and various other considerations including temperature, incident radiation, pH stress, nutrient levels etc.	Typical benchmark figures taken for the energy crops considered. Sensitivity to this assumption is tested through the high and low yield scenarios.
Energy yield (MWh/yr)	Total yield depends on the above factors and the energy density of the crops (kWh/t).	Indicative figures for each type of energy crop are used.

[41] See: www.naturalengland.gov.uk/ourwork/farming/funding/ecs/default.aspx.
[42] SRC refers to the practice of harvesting fast growing trees for biomass production when they are relatively young (a few years old). Species covered under the Energy Crops Scheme include Willow, Poplar, Ash, Alder, Hazel, Silver Birch, Sycamore, Sweet Chestnut and Lime).

With estimations of each of the above variables, the potential energy available from energy crops cultivated in Chesterfield borough can be assessed, as summarised below.

Table 12: Estimation of maximum potential contribution from energy crops grown in Chesterfield borough

	Miscanthus		SRC (Willow)	
	Low yield	High yield	Low yield	High yield
Total arable land area in borough (ha)	2,000	2,000	2,000	2,000
Annual crop yield (odt/ha.yr)	12.0	14.0	10.8	16.3
Energy density of harvested crop (MWh/odt)	5.0	5.0	4.4	4.4
Overall energy yield from utilising all arable land for energy crop cultivation (GWh/yr)	120	140	96	144
Assumed proportion of arable land that could be used for energy crops	5%	5%	5%	5%
Yield from available land allocated to energy crops (GWh/yr)	6.0	7.0	4.8	7.2
Equivalent no. of average households	350	410	280	425

In the table above the annual energy yield from land dedicated to energy crop production is put into context through comparison with the average gas consumption of domestic households in Chesterfield borough. This first-order assessment suggests that if 5% of the arable land in the borough were to be set aside for energy crop cultivation the annual yield would be sufficient to meet the thermal demands of up to around 425 existing homes (assuming the fuel could be burned with an efficiency comparable to existing gas boilers).

In practice the proportion of arable land that may be set aside for energy crop production will be dictated by demand for other uses and considerations such as the impact that land use changes can have on the character of the land. Five percent represents a typical figure for the proportion of arable land that may be used for energy crop production.

5.1.4 Demand side restrictions

A key factor currently restricting demand for biomass as a heating fuel is the economics of biomass heating projects. For example, wood pellets at £190/t (a typical price for bagged pellets for domestic consumers) represent an energy cost of 4.05p/kWh (based on 4.7MWh/t energy density for wood pellets). This is roughly equivalent to current domestic gas prices. However, the capital cost of biomass boilers is significantly higher than gas boilers and domestic consumers are highly sensitive to up-front costs. Biomass fuel prices can be significantly lower for larger consumers (who can benefit from economies of scale of bulk fuel delivery for example), which suggests that the economics of biomass use are likely to be more favourable in non-domestic applications.

5.1.5 Barriers to use of biomass as a heating fuel

While biomass is potentially a useful fuel as part of cost effective strategies to deliver low carbon development, numerous barriers to the use of biomass exist (in addition to the economic barriers discussed above). These must be considered both when assessing the suitability of biomass for any particular site and when setting policies and targets for low carbon development. The main considerations are summarised in the following figure.

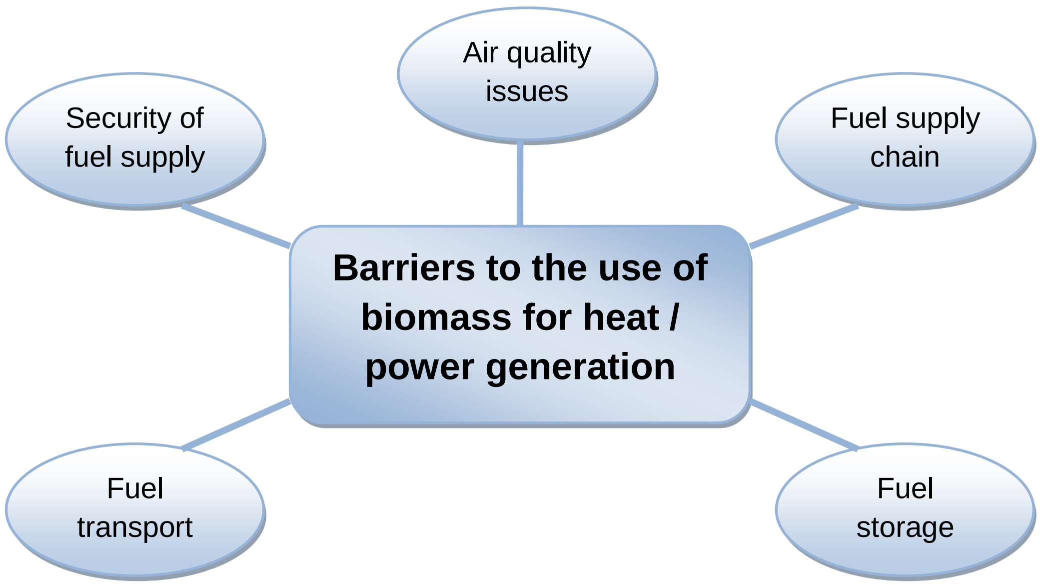

Figure 26: Non-economic barriers to biomass use

These issues are discussed further below.

Biomass fuel supply chain and security of supply

At present biomass is not widely used as a primary heating fuel in the built environment. A lack of confidence in the supply chain can act as a barrier to increased use of biomass. Discussions with fuel suppliers suggest that biomass fuel supply is constrained by demand-side rather than supply-side factors. Locally delivered fuel provided by the larger fuel suppliers is generally sourced at a regional or national level. According to these suppliers the infrastructure for biomass fuel supply is in place and there is currently plenty of fuel available. Having said this, biomass fuel supply is a constantly evolving market and much may change over the coming years.

Security of fuel supply is an important consideration for any biomass energy scheme, particularly large scale community heating systems designed to supply many buildings. However, concerns around security of fuel supply may be mitigated through long term contracts with suppliers and should diminish as regional and national biomass fuel supply chains develop over the coming years.

Transport and storage issues

The carbon benefits of using biomass in place of fossil fuels are well recognised. However, given the low carbon nature of biomass, energy used for fuel transportation and the associated CO_2 impact should be considered. In general the carbon saving benefit of using biomass is greatest when transportation distances are minimised. Any large-scale biomass heating scheme will likely require fuel deliveries by lorry. Access and vehicle movements (including associated impacts on local noise and traffic pollution) are therefore important considerations.

Biomass fuel storage systems are often bespoke solutions which vary depending on site characteristics. While the technical challenges of fuel storage and delivery system design are relatively well understood, adequate space must be allocated to store a reasonable fuel reserve. In areas of high land value allocating space to fuel storage is often not an economically attractive proposition.

Air quality considerations

Replacing fossil fuels with biomass offers significant potential for carbon savings. However, compared to natural gas, biomass combustion leads to increased pollutant emissions, notably emissions of particulates and NOx. This is mainly a barrier to biomass use in areas with existing air quality issues, for example in and around air quality management areas (AQMAs).[43] There are currently no AQMAs defined in Chesterfield borough, however in the event of an AQMA being implemented, restrictions to biomass use are likely to increase.[44] Whilst there are currently no AQMAs in Chesterfield the whole of the borough is designated as a smoke control area.

The Clean Air Act (1993) allows local authorities to declare the whole or parts of the district to be a smoke control area. Strict regulations apply in smoke control areas (relating to fuels that may be burnt and the emission of smoke) which could act as a barrier to the use of biomass as a heating fuel. The Clean Air Act stipulates that only the following may be burned:

- Authorised fuels (i.e. approved smokeless fuels).
- Other fuels in an authorised ('exempt') appliance.

No wood type (logs, woodchip, pellets or briquettes) is classified as a smokeless fuel. Exempt appliances are those which have been exempted by Statutory Instruments under the Clean Air Act 1993 (i.e. pass tests to show they can burn 'unauthorised' fuel without emitting smoke).

To burn unauthorised fuels (e.g. biomass) in a smoke control area the appliance must be on the exempt appliance list.[45] Furthermore, The Clean Air Act requires an approved chimney

[43] In order to achieve national air quality objectives local authorities are obliged to measure air quality and to attempt to predict how it might change in their region. AQMAs are declared in areas where any objectives are not likely to be achieved.
[44] AQMAs are usually defined when the levels of certain pollutants exceed recommended limits. Definition of an AQMA is usually accompanied by an action plan aimed at reducing pollutant levels. Installation of new biomass heating plant is likely to be at odds with such an action plan, particularly if the target pollutants include NOx and particulates.
[45] The list of exempt appliances in England can be found here: http://www.uksmokecontrolareas.co.uk/appliances.php?country=e.

height if the heating appliance is >366.4kWth or burns pulverised fuel, or burns any fuel at a rate above 45.6kg/hr.

5.1.6 Biomass resource assessment: conclusions

- The potential biomass resource from existing woodlands in the borough is highly constrained. Similarly, land available for energy crop production is limited, which means that the yield from realistic levels of new energy crop plantations in the borough would only meet the thermal demands of a few hundred existing homes.
- Fuel supplies from the wider area are therefore required for biomass to make a significant contribution to CO_2 reduction in the borough. This means that regional and national biomass supply chains will be important if use of this fuel is to increase.
- There is currently very little production of biomass for fuel in the borough. Incentives to bring woodland into managed production or to change use of arable land will depend on market value of biomass fuel relative to alternative outputs from the land.
- For any new biomass energy project careful consideration of the full impacts is required, particularly for large scale schemes. Impact assessments should consider local air quality, vehicle movements for fuel delivery, security of heat supply and on-going operation and management of the system.

5.2 Hydro electric power

5.2.1 Introduction

A detailed guide to hydroelectric power is available from the British Hydropower Association's website.[46] Various types of hydropower schemes exist, including: small / micro hydro, large hydro, storage, and pumped storage. In this context small / micro hydro schemes typically involve only a small dam or barrage, with little or no water stored, and these systems are referred to as run-of-river. Run-of-river schemes generally have a lower environmental impact than large hydropower installations.

The power available from a hydro turbine depends on the turbine's hydraulic efficiency, the flow rate (m^3/second) and the head (vertical fall of the water).[47] The maximum available hydropower resource therefore depends on the volume of water flowing through rivers in the borough and the height through which the water falls. However, factors that will limit the available resource include number of suitable sites for turbine siting (with sufficient head over a short distance), environmental impacts (e.g. on flood risk, fish migration, biodiversity), and financial considerations. In terms of financial aspects of hydropower, the economics of developing hydropower schemes have recently improved due to the introduction of the feed-in tariff, which provides guaranteed support levels to small scale hydro installations (see section 2.2.5).

5.2.2 Estimating available potential

Potential hydro-power sites

The maximum potential energy generation from hydro power has been estimated based on a comprehensive study commissioned by the Environment Agency.[48] The EA study mapped opportunities for hydropower throughout England and Wales, together with an assessment of the environmental sensitivity of each site. The study identified almost 26,000 sites across England and Wales with sufficient vertical drop for a hydropower opportunity to be available. The recently published report (February 2010) presents the findings of the first phase of '*a wider programme of work that aims to make information available to developers and stakeholders*'.[49]

The following map shows the approximate locations of the sites in Chesterfield borough identified as having potential for accommodating hydropower installations.

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[46] www.british-hydro.org/mini-hydro/index.html.

[47] The vertical fall of water (head) is an essential component of any hydropower scheme. The term gross head refers to the maximum available vertical fall in water from the upstream level to the downstream level. The following classifications are often used in the hydropower industry: Low Head (gross head <10m), Medium Head (gross head 10–50m), and High Head (gross head >50m).

[48] For full details of the study and reports for download see: www.environment-agency.gov.uk/shell/hydropowerswf.html.

[49] *Opportunity and environmental sensitivity mapping for hydropower in England and Wales: non technical report*, p.1.

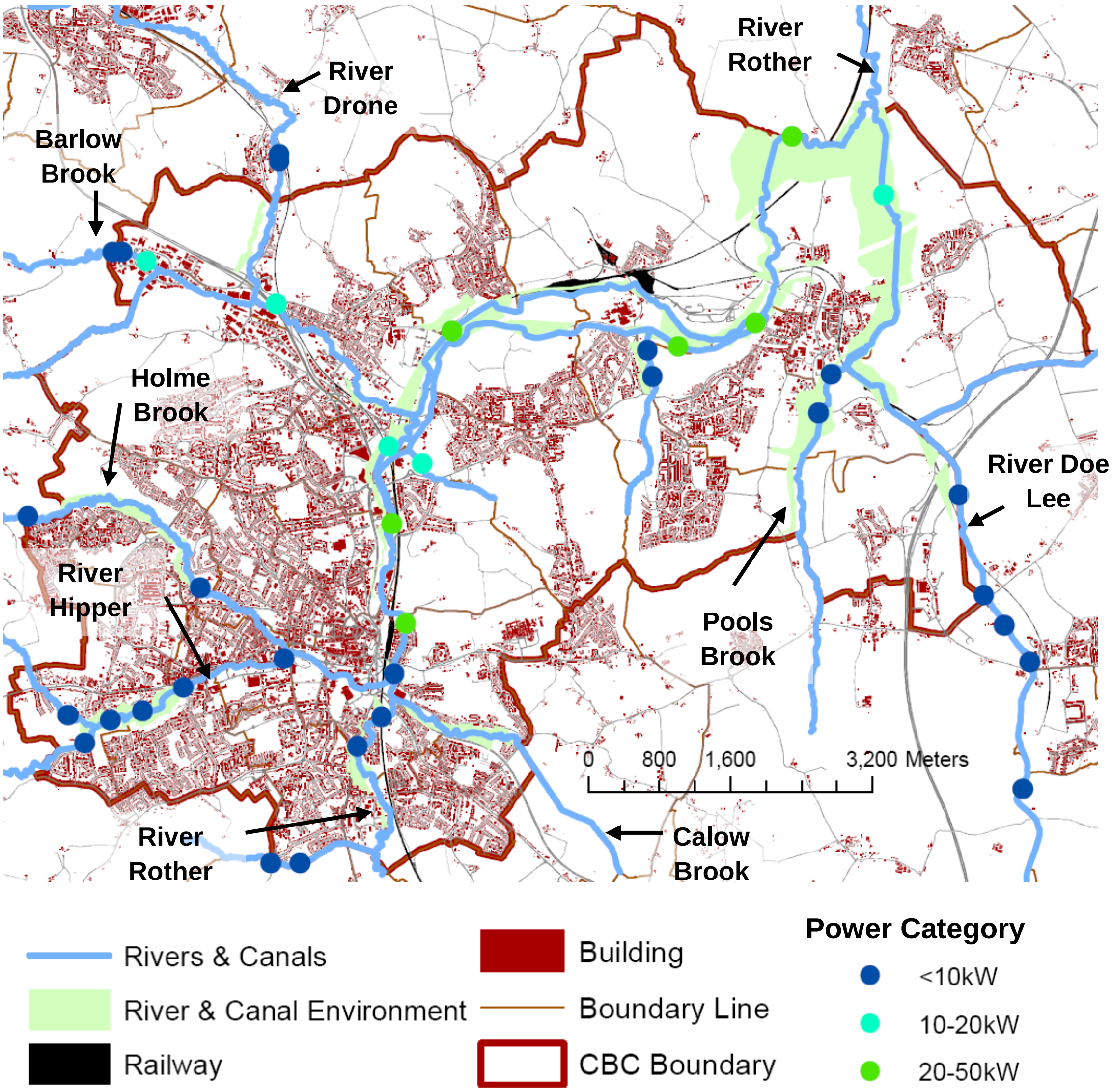


Figure 27: Potential sites for hydropower installations in Chesterfield borough[50]

The EA report also includes an assessment of the environmental sensitivity of hydropower opportunities, based on modelled fish population data and Special Areas of Conservation (SACs).[51] According to the data presented on p.13 of the EA Annex report (*Environmental Sensitivity Categorisation: East Midlands Region*), all of the sites in the borough are classified at ‘Medium’ environmental sensitivity.

Given the scope of the EA study, the environmental sensitivity assessment is indicative only and does not consider wider biodiversity issues or challenges such as water quality and flood

[50] Hydro power sites are approximate and based on mapped data from EA report by Entec: *Opportunity and environmental sensitivity mapping for hydropower in England and Wales, Annex – Regional Data Part C*, p.12 map of maximum power potential in the East Midlands Region.

[51] For full details of the sensitivity classification, see Section 5 of the report: *Opportunity and environmental sensitivity mapping for hydropower in England and Wales: technical report*, p.46.

risk. A detailed assessment of the energy generation potential and environmental impacts of any proposed hydropower scheme would be required at any proposed site.

Estimation of maximum installed capacity and energy generation potential

The data presented above can be used to estimate the maximum potential for hydropower in the borough, as shown below.

Table 13: Estimated number of sites and potential installed hydropower capacity in Chesterfield borough based on EA data

Category	Estimated no. of potential sites in Chesterfield borough	Approximate total power based on median power assumption
<10kW	16	80kW
10–20kW	5	75kW
20–50kW	6	210kW
>50kW	0	0kW
Total	**27**	**365kW**

As a first order estimation the total potential installed hydropower capacity is based on the number of potential sites and an assumption that, should these be exploited, then on average the installed capacity would be around the middle of the capacity band. This leads to a maximum capacity of 365kW for all identified hydropower schemes in the borough. Based on a typical capacity factor of 50%, this maximum capacity could provide an electricity output of around 1,600MWh/yr.[52] Government (BERR) statistics suggest that the average electricity consumption per domestic meter in Chesterfield borough in 2007 was 3,667kWh/yr. This means that if all the resource identified above were exploited, the maximum potential annual output of hydropower schemes in the borough could meet the demands of around 430 average homes.

This resource represents an upper estimate of what could be expected to be delivered in the borough. In practice many barriers to realising this potential would have to be overcome, including technical, economic, and environmental challenges.

A potential economic barrier to exploiting hydro resource is the grid connection cost, as this can be prohibitive at remote sites. The Environment Agency study did not consider grid access, so buildings have been plotted in Figure 27, above as a proxy for access to the electricity grid. This suggests that the majority of sites identified are relatively close to buildings and therefore the national grid, which means that grid access should not be a major barrier for most sites in the borough.

[52] Capacity factor is defined as annual output of a turbine divided by maximum potential output. A factor of 50% is a typical figure – see, for example p.9 of A Guide to UK Mini Hydro Developments published by the BHA: www.british-hydro.org/mini-hydro/index.html.

5.2.3 Hydro power: conclusions

Following an estimation of the available hydropower resource in Chesterfield borough based on published data the key conclusions are:

- The total number of sites in the borough with potential for hydropower installations is around 27. Hydropower installations at all of these sites could see the deployment of around 365kW of hydro turbines.
- Based on an average capacity factor of 50% this maximum installed capacity could produce an electricity output of 1,600MWh/yr, which is equivalent to the electricity demands of 430 average homes.
- Whilst hydropower schemes offer some potential to provide low carbon energy and hence reduce overall CO_2 emissions, this technology will remain niche and should not be regarded as a central feature of the low carbon development strategy.

5.3 Wind resource in Chesterfield borough

5.3.1 Introduction

The economics of wind turbine development depend strongly on available resource in terms of average annual wind speed. The physics of electricity generation from wind turbines means that the power output scales with the cube of wind speed, hence higher wind speeds are desirable. Wind speed increases with height above the ground and larger turbines are typically mounted on taller masts or towers, which means they benefit from greater average wind speeds and are often able to achieve higher load factors than smaller turbines.[53]

Average annual wind speed is not the only consideration in wind turbine siting. For example, turbines must be a safe distance from buildings and other man-made obstacles, access (for installation and maintenance) must be considered, as should distance from the electricity grid as this will impact grid connection costs. The potential impact of any proposed turbines on the local environment (e.g. wildlife, local residents) is also an important consideration.

Having said this, for the purpose of the wind resource assessment, the primary factor of interest in the first instance is the wind speed. Estimations of the wind resource available in terms of mean annual wind speed were made using the NOABL wind speed database, which gives average wind speed in square kilometre grids.[54]

5.3.2 Unconstrained wind resource

The following maps show the mean annual wind speed at different heights above the ground in 1km grid squares for the borough, based on data from the NOABL wind speed database.

[53] Load factor refers to the proportion of time through the year that a turbine produces its rated output power. For example a 1MW turbine with a load factor of 25% outputs 2,190MWh/yr (0.25 x 8,760 hours/yr).

[54] Note that the NOABL database gives indicative wind speeds, but does not account for thermally driven winds (sea/mountain/valley breezes) and takes no account of topography on a small scale or local surface roughness (e.g. due to buildings, trees etc). Detailed measurements would be required at specific sites considered potentially feasible for turbine development.

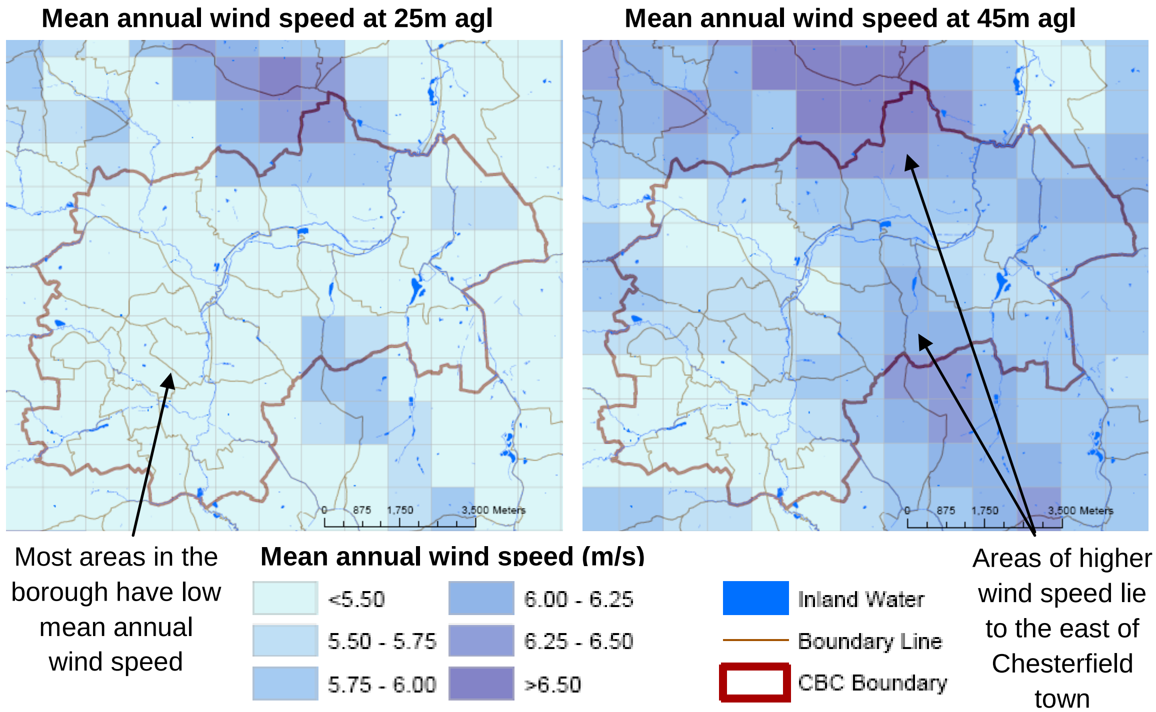


Figure 28: Unconstrained wind resource in Chesterfield borough at 25m and 45m above ground level (agl)

These maps represent the unconstrained resource in that no restrictions to wind turbine placement have been included. The benefit of increased height above the ground is evident from the maps above, with a higher concentration of windier areas at 45m compared to 25m. A typical mean annual wind speed above which the economics of wind turbine development become favourable is 6m/s. The map below highlights the 1km grid squares in which this mean wind speed is exceeded at 45m above ground level.

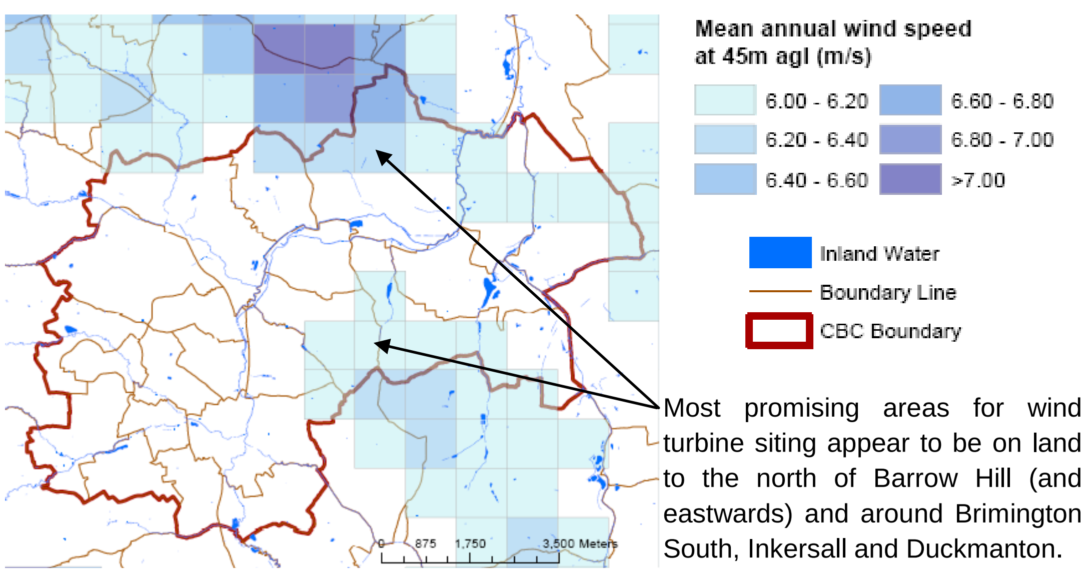


Figure 29: Unconstrained wind resource in Chesterfield borough at 45m agl

These results suggest that the greatest wind resource is towards the east of the borough, principally in the area to the north of Barrow Hill, Staveley, and around Mastin Moor. Relatively high average wind speeds are also evident in areas directly east of the town centre, in the Brimington South, Inkersall and Duckmanton region. However, exploitation of the available wind resource is subject to numerous restrictions on turbine deployment, which are examined below.

5.3.3 Constrained wind resource

Restrictions to wind turbine development

As mentioned above, there are a number of restrictions to wind turbine siting. In terms of distance from buildings, there are currently no statutory limits on separation distances between turbines and houses in the UK.[55] The primary factors that set the separation distance tend to be noise and visual impacts. Although there is no minimum separation distance in English planning law, the companion guide to PPS22 suggests a separation of 350m. However, what is considered to be an acceptable separation distance varies across the UK. For example, 500m is recommended as a typical separation distance between turbines and residential buildings in Wales, whilst in Scotland a separation distance of 2km between turbines and the edge of settlements is preferred.

In the wind resource mapping exercise buffer zones of 100m around main roads and railway lines are included. To reflect the range of possible exclusion zones around buildings separation distances of 100m, 350m and 500m have been considered. Other general restrictions to turbine siting (not mapped) include separation distances from power and communication lines, airport exclusion zones, ancient woodlands, sites of special scientific interest (SSSIs), and conservation areas. While these are the principal physical constraints on wind turbine siting, any turbine or wind farm must gain planning consent, which can be a significant obstacle.

Available constrained wind resource

The map below shows the mean annual wind speed at 45m above ground level (as in Figure 28), but with exclusion zones around physical obstacles that limit the choice of sites for turbines.

[55] See House of Commons Standard Note SN/SC/5221: www.parliament.uk/commons/lib/research/briefings/snsc-05221.pdf.

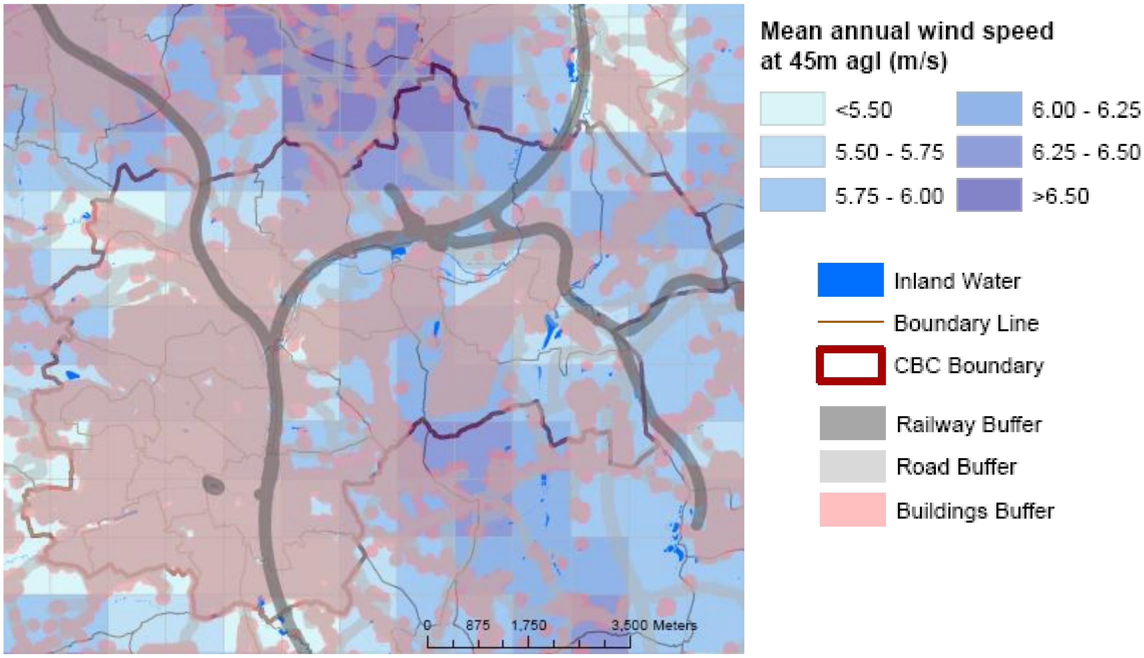


Figure 30: Wind resource in Chesterfield borough with restrictions to turbine siting – 100m buffer zone around buildings

Based on these results the highest average wind speed with potential for exploitation is in the northern part of the borough, north of Barrow Hill. There appears to be some potential for wind turbine deployment on land in the far north and north-eastern areas of the borough, where wind speeds are relatively high and constraints are not prohibitive. The other main area of interest for wind turbine development is towards the south eastern part of the borough, around Inkersall and Duckmanton. However, gaining planning permission for turbines in this area may be hampered given the proximity to Bolsover Castle, which is an English Heritage site, and Hardwick Hall, a listed building under National Trust ownership.

The map above represents relatively optimistic assumptions on buffer zones around buildings, with an exclusion zone of just 100m included. As noted above a greater separation distance is likely to be required for any medium to large scale turbines. The following maps show the impact of greater exclusion zones around buildings on the availability of suitable sites for medium or large wind turbines.

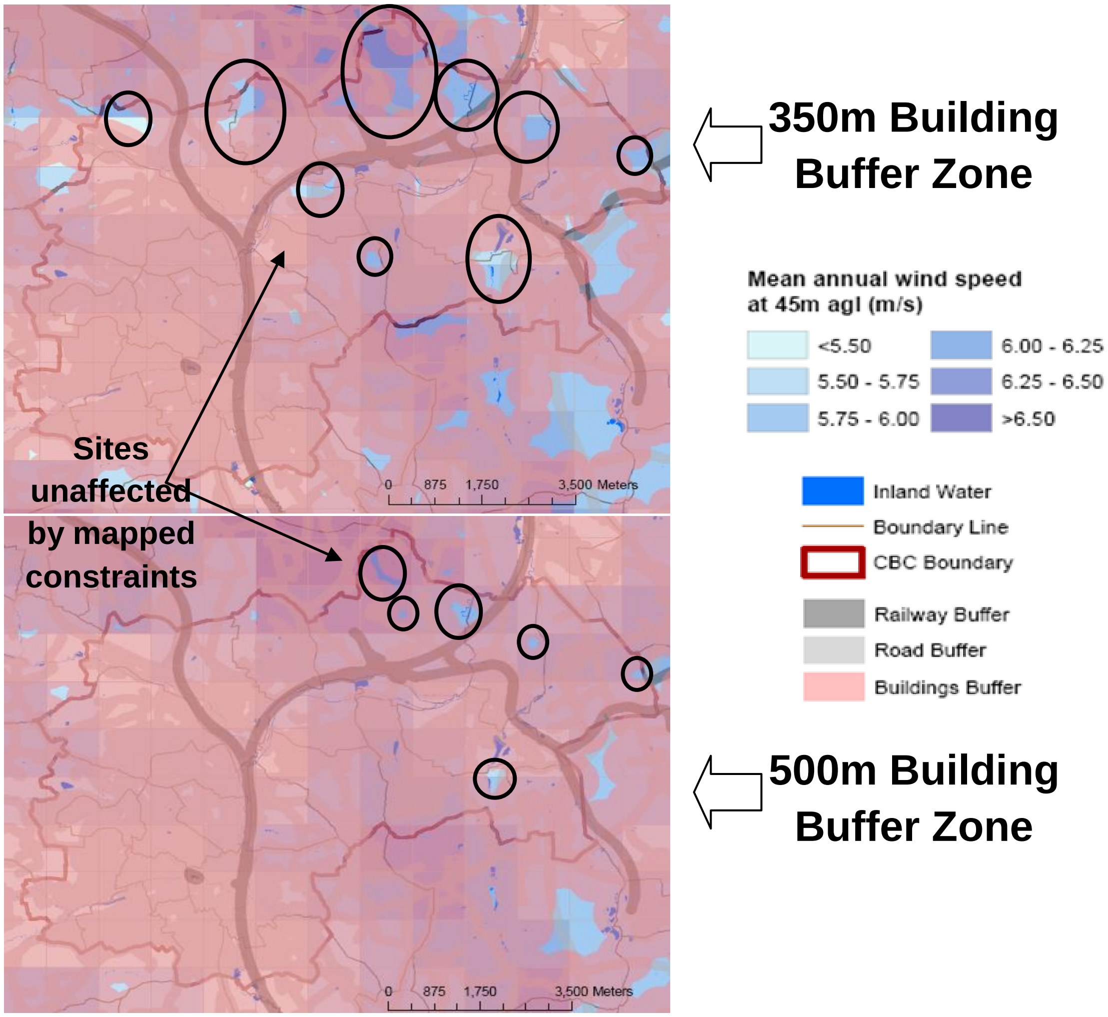


Figure 31: Wind resource in Chesterfield borough with restrictions to turbine siting – 350m and 500m buffer zones around buildings

A 500m exclusion zone around buildings leaves very few potential turbine sites within the borough. However this level of restriction is conservative (e.g. a lower separation distance is likely to be acceptable in many cases, especially when considering distance from non-residential buildings). The upper map in Figure 31 suggests that with an intermediate building buffer distance of 350m the majority of promising sites (both in terms of wind speed and constraints) are in the northern part of the borough. One further constraint that could affect sites in the north of the borough is the Hundall television transmitter, situated north of Whittington. There is some evidence that turbines can interfere with television signals, which means that this is further consideration to take into account.

Potential number of installed turbines

An estimation of the total number of installed turbines on the sites identified in Figure 31 has been made. This is based on typical separation distances for turbines, which dictates the land area required per machine.[56] The analysis is on a plot-by-plot basis to account for the fact that

[56] The calculations are based on turbine separation distances of five times the rotor diameter in the direction of the prevailing wind and three times the rotor diameter in other directions.

larger unconstrained sites may be able to accommodate larger turbines than the smaller areas. The results are summarised in the following table.

Table 14: Estimated number of turbines that could be accommodated in unconstrained sites in Chesterfield borough

Turbine size (kW)	Rotor diameter (m)	Number of turbines possible in borough based on constraint-free sites identified above		Example wind turbine for dimensions and power output
		350m building buffer zone	500m building buffer zone	
2,000	85	15	0	Vestas V90
1,500	77	2	2	1.5MW GE turbine
750	57	0	2	Unison U50
500	39	7	3	Vestas V39
400	33.5	0	5	Vestas V34

These results are derived based on the assumption that the largest turbine possible (up to 2MW) would be selected for the constraint-free sites identified in Figure 31. This analysis suggests that the total installed capacity of turbines in the borough is up to 36.5MW based on a 350m building buffer constraint, or 8MW with 500m buffer zones around buildings.

5.3.4 Wind resource: conclusions

- The mean annual wind speed in Chesterfield borough is relatively low, which suggests that taller turbines are likely to be required for economically viable projects.
- The wind resource in the borough is highly constrained due to the urban nature of large areas of the borough. This means that there are relatively few opportunities for delivering large scale wind turbines.
- The optimum sites in terms of wind resource and freedom from constraints lie on land to the north of the borough, north of Barrow Hill.

5.4 Opportunities for district heating

5.4.1 Introduction

District heating refers to using centralised heating plant to meet the thermal demands of a number of buildings. The economies of scale gained by this approach lead to potential advantages, including:

- Improved economic viability of low carbon heating plant such as biomass boilers.
- Potential to use combined heat and power (CHP), whereby carbon benefits can be achieved by generating electricity locally and making use of the associated heat produced.

An important part of any district heating system is the heat distribution network, which typically consists of insulated heat pipes buried in the ground. Such networks often involve a substantial capital outlay, and costs must be recouped through on-going heat sales. The economic viability of district heating is therefore sensitive to heat density, which is typically measured in terms of annual demand for heat per unit area (e.g. $MWh/m^2.yr$). A second consideration for community heating schemes is the mix of heat consumers, which affects the diversity of demand.[57] The economics of large scale heating plant, particularly CHP, are favoured when a reliable base heat load is present.

5.4.2 Existing district heating schemes in the borough of Chesterfield

Community heating schemes in operation in the borough include:

- Barrow hill district heating network.
- Devonshire flats district heating network, Staveley.
- Lowgates district heating network, Staveley.

There is also a district heating connection between the Winding Wheel, Stephenson Memorial Hall and St Mary and All Saints' Church near the town centre. Outlines of these networks have been plotted on the heat density maps presented below to show the extent of the existing schemes and to aid in the assessment of the potential for connection between new development and existing networks.[58]

5.4.3 Estimating heat demand density in Chesterfield borough: methodology

An estimation of heat demand density for existing buildings in the borough was made from OS Address Point data, i.e. a database of every address in the study area. Each address was assigned a usage type in order to differentiate between different energy consumers (e.g. a domestic home has a different thermal demand from commercial premises). The database includes plan area of each building type, and combined with estimations of the number of storeys and specific thermal demands ($kWh/m^2.yr$), total thermal demands of each building can be estimated. Summing demands from buildings in a given grid square using GIS

[57] Diversity in this context refers to when demand for heat occurs throughout the day.
[58] Note that the positions of the existing district heating networks are approximate and are shown to give an indication of the extent of the areas currently covered.

software allows an assessment of heat demand density at a given level of resolution. Further methodological details are given in the appendix.

5.4.4 Results of heat mapping exercise

The following map indicates the estimated gas demand throughout the borough.

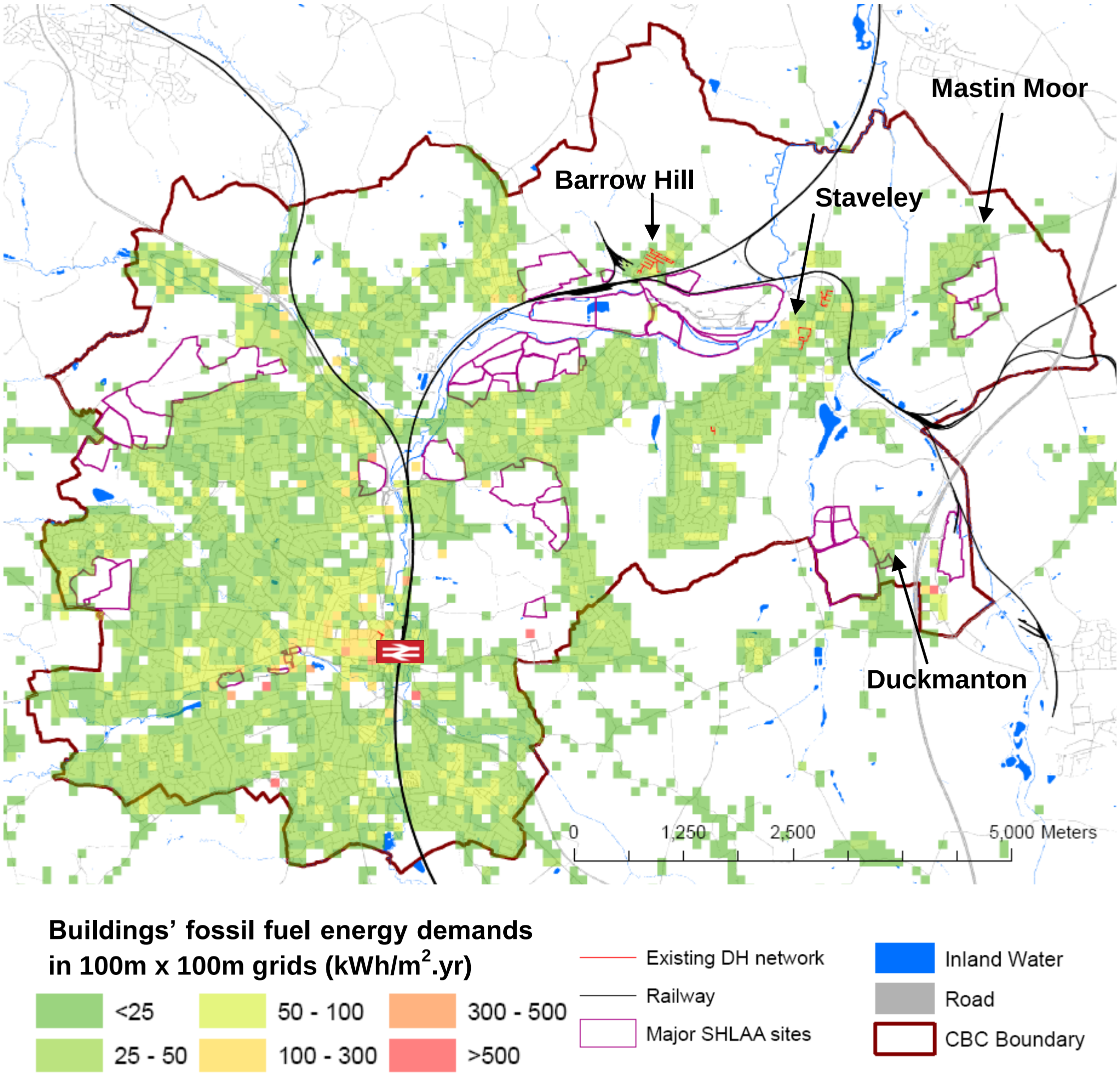


Figure 32: Heat density map for Chesterfield borough

A selection of the major SHLAA sites identified by the Council has been plotted above to indicate where the areas of potential development lie relative to existing buildings. As expected, fossil fuel (and therefore heat) density is relatively low in much of the borough. The expected heat density of a typical residential area is illustrated below.

Figure 33: Typical residential area in Chesterfield[59]

There are 26 addresses within the 100m x 100m grid square plotted on the map above. According to published Government statistics, the average gas consumption per domestic gas meter in Chesterfield borough was 17MWh/yr in 2007. Applying this average figure to the dwellings above suggests that the total gas demand from buildings within the grid square in this case is around 442MWh/yr, which equates to a heat density in the grid of 44.2kWh/m^2.yr. This example demonstrates that the majority of residential areas could be expected to be characterised by heat density of the order 50kWh/m^2.yr or below, which is consistent with the heat mapping results presented in Figure 32.

District heating business models are typically based around recouping the capital outlay of the heat distribution system through future heat sales. The economics of district heating systems are therefore favoured by higher heat densities, and generally a heat density of around 100kWh/m^2.yr or greater is required for potentially attractive returns. The following map shows the same data as plotted in Figure 32, but with the scales adjusted to show only those areas of high heat density.

[59] Image from Google maps: www.maps.google.co.uk.

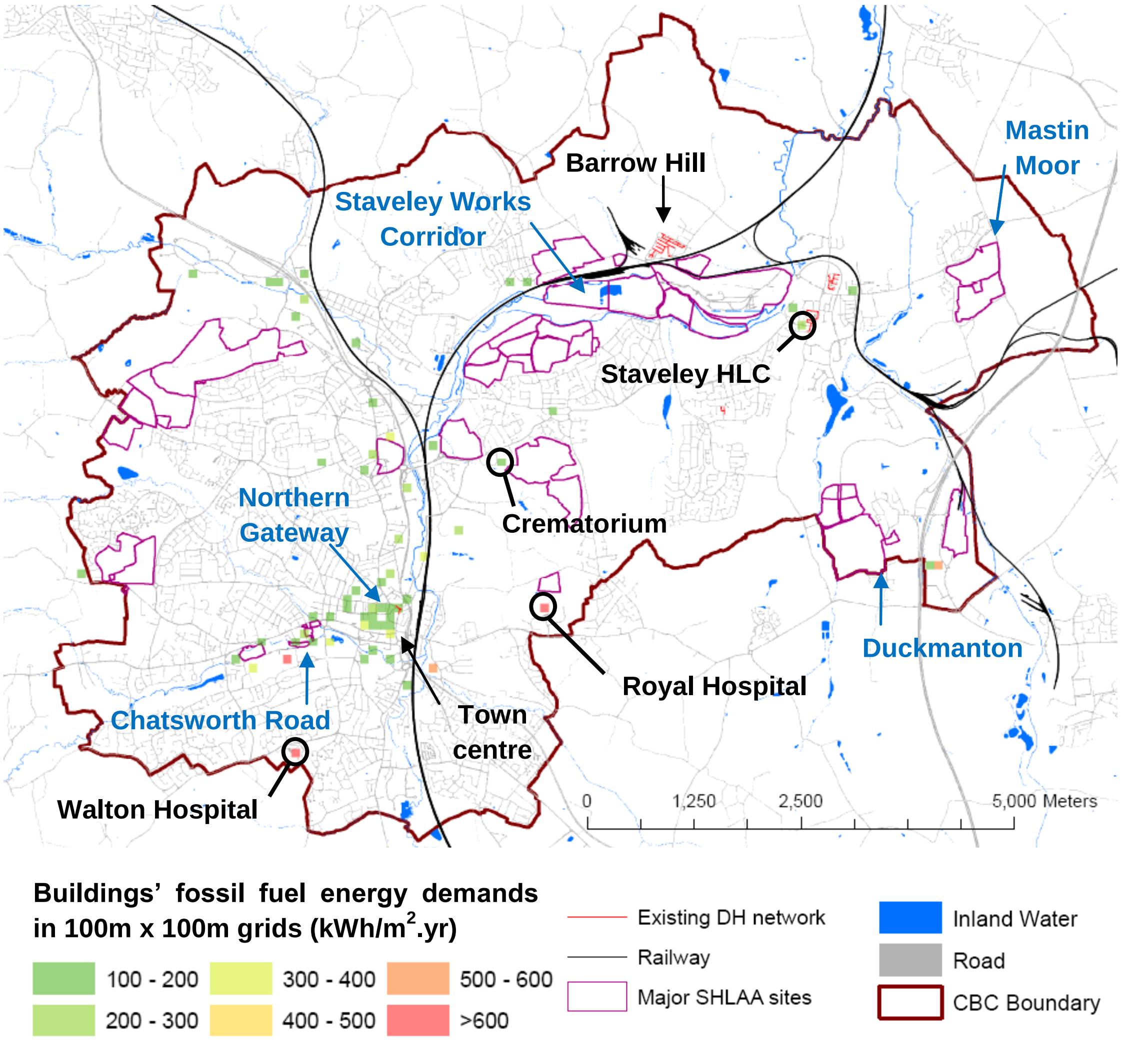


Figure 34: Areas of high heat density in Chesterfield borough

The heat density scale has been adjusted relative to the map in Figure 32 so that only regions of relatively high heat density are shown. Some of the regions of high heat demand density are caused by individual buildings, which are indicated on the map above. Development sites of particular interest to this study are also shown.

The map above suggests that most areas are characterised by relatively low heat density, which means district heating opportunities in the borough are limited. In terms of the major sites the most promising opportunities for linking new development to existing heat loads are in the Northern Gateway development and sites on land to the south of Chatsworth Road. Opportunities for district heating in new sites will depend on the specific characteristics of individual sites (see section 6).

The most likely opportunity for extending existing district heating networks in the borough is in the Barrow Hill area. The existing heat distribution system could be extended to serve the new development in the Staveley Works Corridor, depending on the form of development. This opportunity should be investigated in more detail as development plans for the area progress.

5.4.5 Opportunities for district heating: conclusions

A heat density mapping exercise has been undertaken for the borough of Chesterfield. The main conclusions are as follows.

- The majority of the borough is characterised by areas of low heat density, which means district heating is unlikely to be economically feasible in most areas.
- The areas of highest heat density are generally in and around the town centre, and in isolated locations where high heat consumers are situated.
- In terms of connecting major new development to existing heat consumers, the most promising opportunities are the Northern Gateway development and sites on land south of Chatsworth Road. Opportunities for using existing consumers to act as heat anchors to improve the viability of district heating systems in new developments should be investigated as the sites come forward.

5.5 Other low carbon / renewable energy technologies

The renewable and decentralised energy resource assessment focuses on technologies that are typically employed at a community scale. By definition there will be a relatively limited number of opportunities for such projects. There are many other low carbon / renewable technologies that can be applied at the individual dwelling / building scale and this section gives an overview of the main options.

5.5.1 Solar energy

The relevant solar energy technologies for Chesterfield borough are solar photovoltaics (PV) and solar thermal. Solar PV panels are made from semi-conductor materials and convert sunlight into electricity. Systems are typically roof-mounted and most effective when orientated to be south-facing and at an angle of around 30^{o} from the horizontal. Solar PV is a relatively expensive technology, however costs are falling over time and the technology now benefits from support from the feed-in tariff, which aims to give a return on investment (see section 2.2.5).

Solar thermal systems are also most often roof-mounted but rather than producing electricity, they capture energy from sunlight to meet a portion of the building's hot water demands. Domestic systems are typically sized to meet around 50% of a home's hot water demands over the year.[60] Financial support for solar thermal is expected from 2011 with the introduction of the renewable heat incentive.

The technical potential for energy generation from solar sources is limited mainly by suitable available roof (or other) space to accommodate the panels.

5.5.2 Heat pumps

A heat pump is a device that uses mechanical work to move heat from one location to another.[61] Heat pumps can be used to provide heating and cooling in buildings and typically

[60] Sizing solar thermal systems to meet a very high proportion of hot water demands would lead to a significantly over-sized system for the summer months (due to the changes in insolation levels through the year).
[61] Typical applications include refrigerators, freezers and air conditioners.

run from grid electricity. They are classified as a renewable technology due to the very high efficiencies achieved, which is measured in terms of a coefficient of performance (COP). The COP is the ratio of useful thermal energy provided to units of electricity consumed.

There are two main types of heat pump suitable for use in domestic and commercial buildings, differentiated by the source of the heat: ground source heat pumps (GSHP) and air source heat pumps (ASHP).[62]

GSHPs collect thermal energy from the ground via deep vertical boreholes or shallow buried ground loops. Low grade heat from the ground is upgraded to a useful temperature (up to 55°C) by an electrically powered heat pump. ASHPs work on an identical principle to GSHPs, except that heat is taken from surrounding air.

There is no need for ground works during the installation of ASHPs, which means that they are typically less expensive to install. However, the average efficiency (COP) of GSHPs tends to be higher than ASHPs, mainly due to the more stable ground temperature throughout the year.[63]

Existing GSHP installations in public buildings in the borough include:

- **Dunston Innovation Centre** – the first GSHP installation in a public sector building in Chesterfield borough.
- **Venture House** – a commercial building comprising around 3,000m^2 floorspace over three floors, with nine business units.
- **Prospect House** – a 3,000m^2 commercial property in Staveley.
- **Tourist Information Centre** – a small building near the town centre which includes a borehole-based GSHP system.

There are no major technical restrictions to the use of heat pumps, although adequate spacing between ground loops / boreholes must be provided with GSHP systems.

[62] Note that GSHPs are sometimes referred to as 'geothermal' heat pumps. This terminology can be misleading. Ground and air source heat pumps normally extract heat from the earth / air that is replaced on an annual basis by energy from the sun. Geothermal heat sources can include a certain amount of solar energy absorbed at the Earth's surface, but also encompasses thermal energy from within the Earth and energy from the radioactive decay of minerals in certain rock types. The potential for geothermal power depends on geological conditions (geothermal sources are used for electricity generation in California, Iceland, Kenya, the Philippines and Costa Rica). The potential for geothermal energy in the UK is highly constrained. The only scheme currently in place is in Southampton, where district heating is provided from geothermal heat sources.

[63] The COP depends on the temperature difference between the heat source (air / ground) and heat sink (heat deliver temperature in the building). The lower the difference in temperature the higher the COP. This is why low temperature heating systems (such as underflooor heating) are preferable with heat pump systems and explains why the efficiency of ASHPs falls in colder months.

5.5.3 Anaerobic digestion

Overview

The process of anaerobic digestion (AD) involves the decomposition of organic materials by microorganisms in the absence of oxygen. Anaerobic digestion is often used as part of waste management strategies and can convert waste streams into useful forms of energy. The overall AD process is represented in the diagram below.

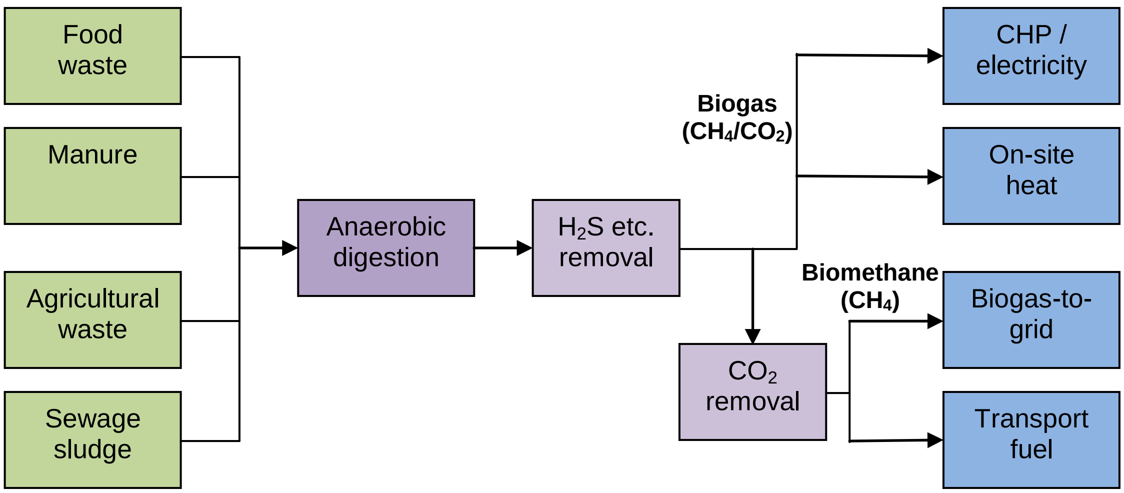


Figure 35: Schematic representation of anaerobic digestion process[64]

Figure 35 shows the range of feedstocks that can be used and the potential uses of the products. The main outputs of the anaerobic digestion process are a CO_2-rich biogas and a nutrient-rich digestate, which can be used as a fertilizer. The biogas can be burnt in a gas engine CHP unit to produce heat and electricity (often some of the heat is used to maintain the digester at an optimum temperature). Further processing (CO_2 removal) is required if the output is to be fed into the natural gas grid or used as a transport fuel.

Potential resource in Chesterfield borough

The application of anaerobic digestion technology in Chesterfield borough is most likely at relatively small scales (e.g. farm scale systems which have ready access to biological materials to form the feedstock input). The number of schemes possible will be limited by the total available waste resource. A high-level estimation of suitable waste arisings for farm-scale anaerobic digestion has been made based on farming statistics from Defra and food waste statistics from WRAP (Waste and Resources Action Programme). The results are summarised in the table below.

[64] Diagram based on Figure 1 of the Carbon Trust report ***Biogas from anaerobic digestion: CO_2 saving and economics***.

Table 15: Estimation of available resource for and energy from anaerobic digestion in Chesterfield borough

	Animal waste	Food waste	Total	Data source
Total feedstock available (t/yr)	6,352	18,086	24,439	Animal waste from animal numbers (defra) and typical manure production per animal.[65] Food waste from UK figures (WRAP) pro rated to Chesterfield borough.[66]
Availability factor	80%	50%	N/A	Recommended assumptions from renewable energy capacity methodology for England.[67]
Feedstock available (t/yr)	5,082	9,043	14,125	Calculated.
Biogas production (m^3/yr)	130,358	949,538	1,079,896	Based on benchmark figures for biogas from waste of 25m^3/t for cattle, 70m^3/t for poultry and 105m^3/t for food waste.
Biogas production (MWh/yr)	851	6,198	7,049	Based on typical calorific value of 23.5MJ/m^3 (6.5kWh/m^3).
Maximum plant capacity (kW_e)	43	310	352	Based on 40% electrical efficiency and 8,000 run hours per year.
Maximum electricity out (MWh/yr)	340	2,479	2,820	From biogas into plant and electrical efficiency of 40%.
Maximum heat out (MWh/yr)	442	3,223	3,666	Heat available if engine used in CHP mode. Based on a heat to power ratio of 1.3.
Equivalent no. of average households: electricity	90	670	760	Calculated based on average electricity consumption per home of 3.7MWh/yr.

This assessment includes waste from the borough's cattle and poultry (manure and bedding waste arisings are included) under 'Animal waste' and from total food arisings under 'Food waste'. WRAP data suggest that food waste is currently around 11.3 million tonnes per year in the UK. Pro rated based on population to Chesterfield borough gives the gross figure of around 18kt/yr. These results suggest that food waste represents a larger potential resource

[65] Defra figures suggest that there are 728 cattle and 360 poultry animals in Chesterfield (www.defra.gov.uk/evidence/statistics/foodfarm/landuselivestock/junesurvey/results.htm).
[66] *Waste arisings in the supply of food and drink to households in the UK*, WRAP, March 2010.
[67] *Renewable and Low-Carbon Energy Capacity Methodology: Methodology for the English Regions*, January 2010.

than manure from animals in Chesterfield borough, which is unsurprising given the relatively urban nature of the area.

Other feedstocks and barriers

Biomass in the form of wood chips or pellets is not suitable for processing via anaerobic digestion as it is far drier than the typical AD plant feedstock. Typical AD plants are wet systems based on a continuous process, which means the feedstock must be pumpable. A further obstacle to using wood chips or pellets in an AD process is the carbon to nitrogen ratio, which is typically far higher than standard feedstocks and could upset the bio-chemical conditions required for biogas production. However, certain types of energy crops (e.g. rye grass, miscanthus) may be used in an AD process, provided they are suitably balanced with other feedstocks.

In terms of bringing forward AD technology at suitable sites, some of the key viability factors include:

- Access to sufficient feedstock at a gate fee (the price paid to the AD plant owner / operator for accepting the waste) sufficient to support project economics.
- Ensuring there is an appropriate disposal route for the digestate produced.
- Strength of grid connection (particularly relevant for farm-scale plants).
- Technical expertise to install, operate and maintain AD plant.

Electricity from anaerobic digestion plants is supported by the feed-in tariff, and current indications are that support will also be available through the renewable heat incentive if the heat is put to good use. These tariff payments are designed to support the technology such that it represents an attractive proposition to potential investors.

6 Target setting for major development sites in Chesterfield borough

This section examines a selection of the major development sites expected to be brought forward in the borough over the coming years. Assumptions on likely development timescales have been made based on data currently available, which dictate which Part L standard(s) are likely to be relevant for each development. This sets the baseline in terms of minimum reduction of CO_2 emissions.

The potential impacts of site-specific policies have been tested by setting advanced standards for each development and analysing the effect on overall capital cost of development. Given the level of available data the impact analysis has been restricted to capital cost assessments (rather than attempting full lifecycle cost analyses, which would exceed the available data). The analysis presented below draws on the results from section 4.3 for the residential development and benchmark figures for costs of carbon saving in non-residential development (full assumptions are given in the appendix).

6.1 Staveley Works Corridor

6.1.1 Site characteristics and development programme

The Staveley Works Corridor mainly comprises former industrial land and has been identified as a potential sub-regional housing growth area. Of a total site are of over 210 hectares, much of which is currently allocated to employment development, emerging proposals for an area action plan indicate the potential for 58 hectares of residential development and around 28 hectares of commercial uses, with around 2,000 homes expected.

The site lies to the north east of Chesterfield town, and a key requirement of the development is to connect the community at Barrow Hill to the surrounding area. A feasibility and options report was published in June 2009, setting out the vision for the area, key strategic objectives and four development options that would satisfy the objectives and meet the vision.

According to the latest data available for the site some parcels of development could be delivered in the period 2012–2013, with the remaining development expected in a period of up to 15 years from 2013. There is currently significant uncertainty around the development programme due to high levels of ground contamination on the site. If this delivery programme is followed the relevant aspects of Part L of the Building Regulations will include all revisions from Part L 2010 onwards.

6.1.2 Strategic objectives for site

The area action plan identifies the following key strategic objectives for the site:[68]

- *Connecting Communities*
- *Creating Employment Opportunities*

[68] Staveley Corridor Area Action Plan Feasibility Study (June 2009), p.2.

- *Providing a range of high quality house types and tenure mix*
- *Enhancing tourism and leisure opportunities*
- *Developing a range and mix of appropriate land uses*
- *Energy generation*
- *Providing the opportunities for an integrated transport network*
- *Strengthening and enhancing the natural environment*
- *Creating something which is distinctive and unique*

The creation of employment opportunities on the site is a key requirement, as is developing high quality house types and a mix of tenures.

In terms of energy generation, the Issues and Options Paper suggests that biomass, methane gas, or water could be used to generate electricity on the site, and that proposals should make maximum use of the topography for solar gain.[69]

6.1.3 Baseline assumptions

The baseline assumptions for the Staveley Works site in terms of quantity of development by Part L standard are summarised in the tables below.

Table 16: Baseline residential build-out assumptions – Staveley Works

Part L standard	Number of dwellings by Part L standard					Preferred approach to energy
	Flat	Terrace	Semi	Detached	All dwellings	
Part L 2010	75	100	275	50	500	Fabric improvement
Part L 2013	75	100	275	50	500	Fabric & PV
Part L 2016	150	200	550	100	1,000	GSHP & PV

The preferred approaches to meeting the CO_2 reduction targets of each Part L standard are based on the capital cost analysis presented in section 4.3. Those results suggest that the lowest capital cost option to meeting Part L 2016 standards is likely to be based on biomass CHP technology (assuming that wind is not a viable option). However, this technology would only be available if the whole development were connected to a district heating system to provide sufficient thermal load. If dwelling-scale approaches to energy are employed in earlier phases (pre-ZCH policy) then biomass CHP will not be viable. The next best option (in capital cost terms) is based on individual biomass boilers (with block-scale biomass heating for flats). However, this is unlikely to be a preferred strategy for most developers given the practicality issues of using biomass in individual dwellings (fuel souring, transport, storage, on-going plant maintenance etc). A more acceptable approach is likely to be based on heating from ground

[69] Staveley Works AAP Issues and Options, p.5 (June 2009). www.chesterfield.gov.uk/default.aspx?CATID=557&CID=5981

source heat pumps with photovoltaics to provide additional CO_2 saving to meet the 70% on-site reduction target.

Table 17: Baseline non-residential build-out assumptions – Staveley Works

Part L standard	Non-residential building floor area by usage type (m^2)				
	B1a: Office	B1b: R & D	B1c: Industrial process	B2: General industrial	B8: Storage / distribution
Part L 2010	4,000	2,000	2,000	4,000	8,000
Part L 2013	4,000	2,000	2,000	4,000	8,000
Part L 2016	4,000	2,000	2,000	4,000	8,000
Part L 2019	4,000	2,000	2,000	4,000	8,000
All Part L standards	16,000	8,000	8,000	16,000	32,000

Based on these assumptions around 80,000m^2 of non-residential floor area will be delivered in the Staveley Works site.

Full details of cost and performance improvement assumptions are given in the appendix. Based on this profile of build-out, the minimum extra over cost of development relative to building to current standards is estimated to be around 11%. This provides the baseline against which policy options that require further carbon saving are tested.

6.1.4 Uplift policies

Definition

Given the scale of development at this site, policies that demand CO_2 emission reductions in advance of the requirements of Building Regulations could make a considerable contribution to limiting emissions growth from new development in the borough. However, the impact on capital costs of any policy that sets more stringent standards must be considered. The following table summarises the uplift policy scenarios considered for the Staveley Works development.

Table 18: Uplift policies for Staveley Works development

Policy	Description
Basic uplift	All buildings to achieve CO_2 emissions savings in line with Part L standards one step ahead of minimum mandatory requirements
CSH5 energy standards	All dwellings that are expected to have to comply with Part L 2016 must instead meet the Ene1 requirements of CSH level 5 (100% improvement on Part L 2006 regulated emissions through on-site means)[70]
Mandatory district heating	All development must connect to a district heating system

Impact on site energy strategy

The following table summarises the assumed energy strategies employed under each policy scenario. The baseline assumptions include different energy strategies for different phases of the development.

Table 19: Energy strategies for each phase of development in Staveley Works under different policies[71]

Policy	Energy strategy by Part L standard			Notes
	Part L 2010	Part L 2013	Part L 2016	
Baseline	Fabric improvement	Fabric & PV	GSHP & PV	Baseline assumptions
Basic uplift	N/A	Fabric & PV	GSHP & PV	All development to meet Part L 2013 standards or above
CSH5 energy standards	Fabric improvement	Fabric & PV	Community BM HOB & PV	Limited choices to meet requirements of CSH5 – assume community biomass heating is preferred on overall economic and practicality considerations
Mandatory district heating	Community BM HOB	Community BM HOB	Community BM HOB & PV	Community biomass heating chosen as an example

Impact on build costs

The impact of the policies described above on total build costs for the development are summarised in the graph below.

[70] Note that the mandatory CO_2 reduction requirements of the CSH at levels 5 and 6 as currently defined are more onerous than Part L 2016 requirements. However, DCLG has recently consulted on changing the definition to bring them in line with ZCH policy.

[71] These strategies are designed with no reliance on specific renewable energy opportunities on the site, which could include exploitation of methane gas and/or the hydro resource offered by the River Rother. Such opportunities are expected to be assessed in detail as development plans progress.

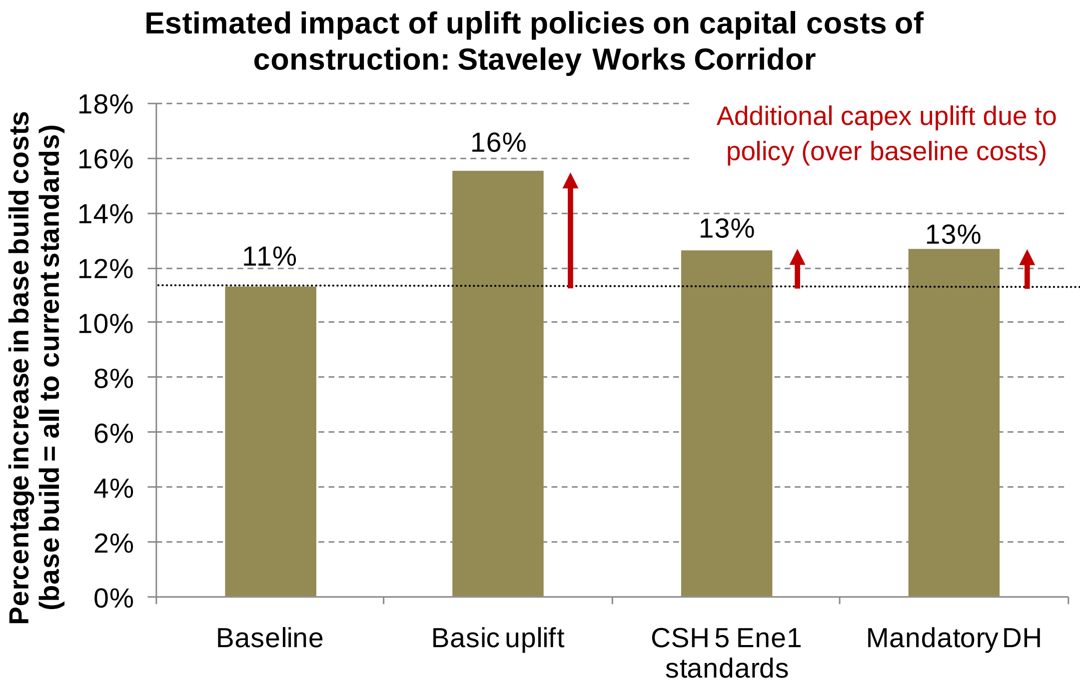


Figure 36: Uplift policies analysis – Staveley Works Corridor development

All increases in build costs presented above are expressed relative to building to current standards (Part L 2006). The costs of meeting the increasingly stringent targets of Part L revisions (baseline) are estimated at around 11% of base build costs (see appendix for full details of assumptions).

The additional cost burden from the policies assessed is between two and five percentage points. The most onerous policy is the Basic uplift policy, which requires all development to meet Part L standards one step ahead of those in place at the time of construction. This has the effect of forcing more of the development to comply with higher standards (including zero carbon policy). These results suggest that this could lead to around a 40% increase in the extra over cost burden on the developer(s). This could impact the ability of developers to deliver new buildings on the site.

The Code for Sustainable Homes policy shows the effect of making residential development that falls under Part L 2016 achieve an on-site CO_2 reduction of 100% rather than 70% of regulated emissions. Note that these results do not include the full cost of meeting Code level 5. While complying with the mandatory CO_2 reduction requirements is the largest part of the cost of building to the Code, there will be an additional cost of gaining sufficient credits against other Code issues to achieve a CSH level 5 rating.

The results above suggest that the policy that makes district heating mandatory for the whole development leads to a small increase in capital cost. However, it must be noted that these results are based on indicative figures to represent the cost of heat distribution and the feasibility of district heating will depend on site layout and build density. Having said this, provided that the site characteristics are conducive to a district heating system, a strategy based around community heating could be appropriate for this site.

Estimated carbon savings from uplift policies

The carbon impact of the development has been estimated based on benchmark emissions data for the anticipated building types. The graph below shows total emissions (regulated and unregulated) for all residential and non-residential development at the site over a thirty year period.

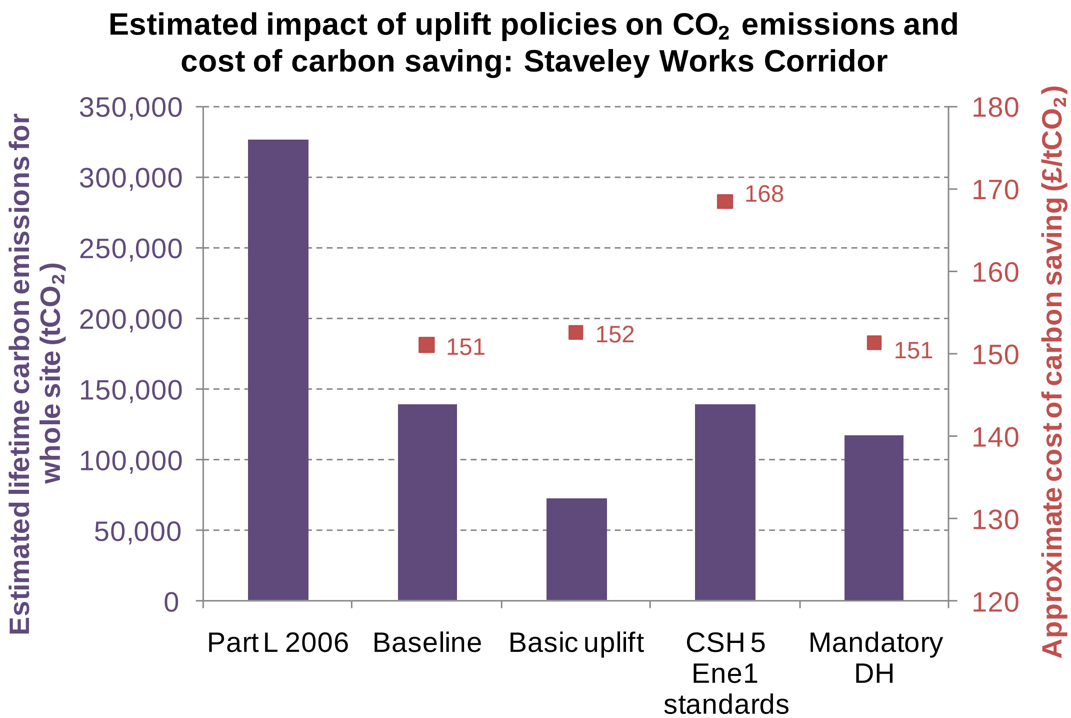


Figure 37: CO_2 emissions and cost of carbon saving under each uplift scenario: Staveley Works Corridor

The baseline includes development built to each anticipated future revision to Part L and leads to a carbon saving of around 57% relative to buildings built to current standards. These results show the costs of carbon saving, expressed as extra over cost relative to building to Part L 2006 standards divided by the lifetime carbon saving resulting from the measures implemented.

The key points from the results presented in Figure 37 are:

- The basic uplift policy gives higher CO_2 savings (78% relative to Part L 2006), which leads to a relatively high increase in capital cost seen in Figure 36. However, these results suggest the £/t cost of carbon saving is comparable to that under the baseline.
- The CSH5 Ene1 standards policy gives no additional net carbon saving compared to the baseline but leads to a higher specific cost of carbon saving due to the requirement for higher on-site reductions for homes built to Part L 2016.
- Based on this analysis, the mandatory district heating policy offers a reasonably cost effective means of achieving CO_2 savings above those that are realised in the baseline.

Implications of a district heating system in Staveley Works

Meeting the energy demands of the new development at the Staveley Works site via a district heating system offers a number of potential advantages:

- The opportunity to achieve higher levels of CO_2 saving for early phases of the development (beyond minimum standards) if low carbon heating plant such as biomass boilers are connected to the system. This would reduce reliance on costly technology solutions such as photovoltaics.
- Connecting early phases is likely to improve the economic viability of the scheme with economies of scale and higher diversity of demand. Installing a low carbon district heating system could prove advantageous for phases of the development that fall under zero carbon policy.
- There might be a chance to link to the existing scheme at Barrow Hill (subject to layout of new development and technical compatibility issues). This opportunity should be investigated as the development comes forward. Provided that the network is supplied with heat from low carbon sources, connection to existing loads would amplify the CO_2 savings if existing gas plant were to be replaced.

Under the 'Mandatory district heating' policy described above thermal demands are expected to be met by biomass boilers. Fuel supply and delivery would be an important consideration with such a strategy.

Initial estimations of potential demands at the end of the build-out suggest that total thermal demands may be around 14,500MWh/yr (for all uses across the site). With a site-wide district heating scheme with biomass boilers meeting 70% of the thermal demands on average this equates to a fuel demand of around 11,900MWh/yr.[72] This is around 3.4kt/yr of wood chip, or 65t/week on average through the year.[73] If the fuel were to be delivered by road in large trucks with 25t capacity this demand equates to around 3–4 truck deliveries per week on average.

6.1.5 Staveley Works Corridor policy analysis – conclusions

The key conclusions from the analysis presented above are as follows:

- Implementing a site-wide strategy based around district heating at the Staveley Works site is expected to lead to relatively low capital cost increases relative to the anticipated costs of meeting the changing Part L standards.
- This suggests that there is a rationale for examining the feasibility of a community energy scheme at this site. Given the proximity to the existing district heating network at Barrow Hill any feasibility assessment should consider the option of linking new and existing networks.
- The additional cost implications of achieving the CO_2 emission reduction standards of CSH level 5 are relatively low for dwellings that must meet zero carbon homes policy.

[72] To put this in context relative to the potential biomass resource in the borough, this level of demand would require around 8.5% of the total arable land area in the borough to be set aside for energy crop production (for Miscanthus – based on an optimistic yield assumption of 14odt/ha and energy density of 5MWh/odt, land area required is 170ha). See section 5.1.3.
[73] Based on a typical energy density of 3.5MWh/t for wood chip.

- There is a risk that policies that demand CO_2 reduction ahead of the Part L standards in force at the time (prior to zero carbon homes) could negatively impact housing delivery targets on the site. Note that the number of buildings that will have to comply with each Part L standard depends on the delivery programme. A delay to housing delivery would also mean that a higher proportion of the development would have to meet more stringent standards.

6.2 Town Centre Northern Gateway

6.2.1 Site characteristics and development programme

The proposed Northern Gateway development site covers an area of around six hectares, mainly on land to the north of Saltergate from the 'doughnut' roundabout and multi-storey car park to the North East Derbyshire District Council offices. The site is allocated in the Local Plan for mixed use expansion of Chesterfield town centre and is expected to provide new retail, leisure, employment and housing opportunities. According to the Chesterfield Town Centre Masterplan, the area '*has been marginalised and activity is limited to car parking and the timber merchants. This is a key opportunity to create a retail anchor in the northern part of the centre to generate footfall and attract visitors and spending*'.[74]

The Northern Gateway development will be retail-led (c.5.5ha allocated to commercial uses) and unlike some other major development sites (Staveley Corridor for example), the site is highly constrained by existing buildings. This development is expected to be delivered in the short term, most likely in the period 2012–2014, which suggests that the new buildings will have to comply either with Part L 2010 or Part L 2013 standards.

6.2.2 Strategic objectives for site

The vision for the Northern Gateway site is published on the Borough Council's website, and suggests that the development will include:[75]

- A new town centre food store
- High street shops, offices and homes
- Restaurants and cafes
- Changes to the road layout to improve pedestrian access to the town centre and market place
- Replacement car parking
- New urban open space

The masterplan for the site is integrated into the Town Centre Wide masterplan, the most recent version of which was produced by URBED and published in October 2009.[76]

6.2.3 Baseline assumptions

The majority of new buildings in the Northern Gateway development will be for commercial uses. Around 50 new residential units are also expected and these are likely to be either apartments or high density town houses. For the purpose of this assessment it is assumed that the residential units will be flats and that the development will come forward in the short term such that Part L 2010 applies.

The table below shows the assumptions made on the level of commercial development on the 5.5ha site.

[74] Chesterfield Town Centre Masterplan (October 2009), p.65.
[75] www.chesterfield.gov.uk/default.aspx?CATID=660&CID=4942.
[76] See www.chesterfield.gov.uk/default.aspx?CATID=963.

Table 20: Baseline non-residential build-out assumptions – Northern Gateway

Part L standard	Non-residential building floor area by usage type (m^2)				
	A1: Shops	A3: Restaurants / Cafes	A4: Pubs	B1a: Office	D2: Assembly & leisure
Part L 2010	11,300	500	200	14,000	1,300
Part L 2013	0	0	0	0	0
Part L 2016	0	0	0	0	0
Part L 2019	0	0	0	0	0
All Part L standards	11,300	500	200	14,000	1,300

According to these assumptions the total non-residential floor area delivered will be 27,300m^2. Compared to the site area of 5.5ha this suggests that around half of the total site area will be delivered as usable floorspace.

6.2.4 Uplift scenarios

Definition

The policy scenarios considered for this development are summarised in the following table.

Table 21: Uplift policies for Northern Gateway development

Policy	Description
Basic uplift	All buildings to achieve CO_2 emissions savings in line with Part L standards one step ahead of minimum mandatory requirements
CSH4 / BREEAM	Dwellings must meet the Ene1 requirements of CSH level 4 (44% improvement on Part L 2006 regulated emissions through on-site means) Non-residential development to achieve Very Good / Excellent BREEAM rating
Mandatory district heating	All new development in the town centre to connect to a district heating system

Impact on site energy strategy

The approach to meeting the requirements of Part L 2010 (baseline assumption) would most likely be based on improvements to building fabric and specifying high efficiency building services equipment, low energy lighting etc. Under the basic uplift policy all new buildings would have to comply with Part L 2013 and the results presented in section 4.3.3 suggest that further advanced fabric and photovoltaics could be the preferred strategy. An energy strategy based around gas CHP is assessed under the mandatory district heating policy.

Impact on build costs

Estimated impacts of the policies outlined above on the build costs of this development are summarised in the figure below.

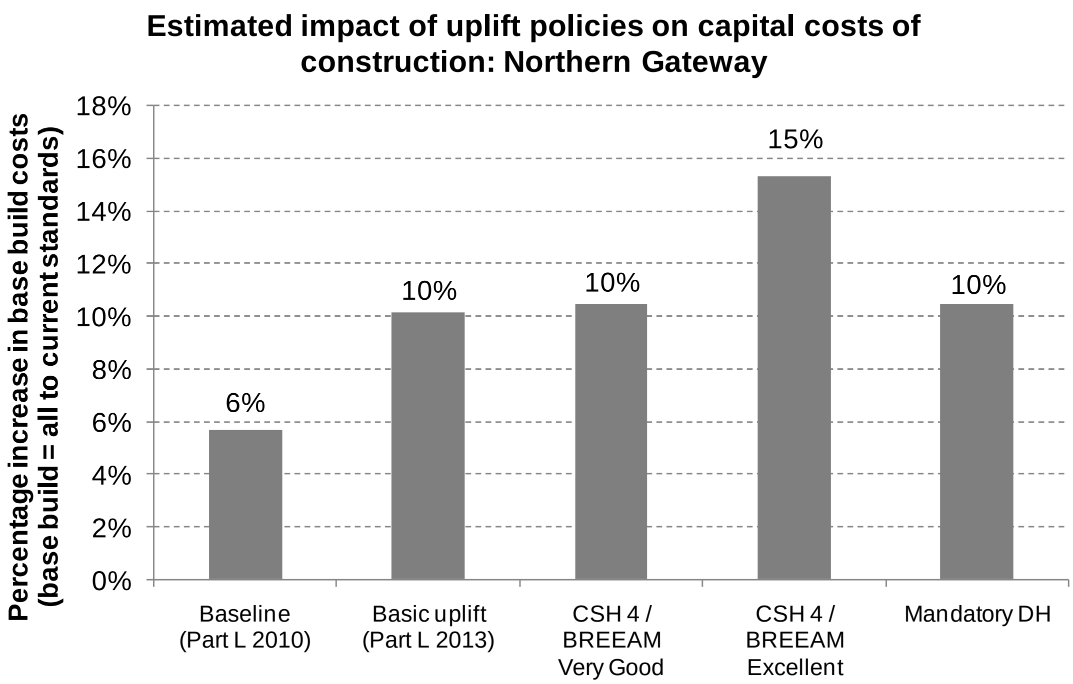


Figure 38: Uplift policies analysis – Northern Gateway development

Again, all cost increases are relative to base build costs, which relate to building to current standards.

These results show the impact of having to meet the higher CO_2 emission reductions demanded by Part L 2013 relative to Part L 2010 (Basic uplift vs. Baseline). There is no additional cost of meeting the mandatory CO_2 reduction of CSH level 4 relative to the Basic uplift policy since both require a 44% improvement on current standards. There is a very small increase in the build costs of the commercial development as a result of the BREEAM Very Good target.

While the cost uplift for meeting BREEAM Very Good may be fairly marginal, BREEAM Excellent ratings are rather more difficult to achieve. These results are based on typical benchmark cost uplift figures and should be treated as indicative only. Cost implications of exceeding minimum standards will vary in practice depending upon multiple factors, including base build specification. Policies should therefore seek to encourage developers to assess the viability of achieving high standards but should allow for the fact that the cost implications of compliance is likely to vary on a site-by-site basis.

The additional cost of the mandatory district heating policy is highly sensitive to when the development comes forward (and therefore which Part L standard is in place) (i.e. the additional cost relative to the baseline is far greater than the additional cost relative to building to Part L 2013 standards). Of the major sites considered in this study, the Northern Gateway development appears to be one of the best suited to community heating (as it is characterised by high build density in an area of reasonably high existing heat demand). Opportunities to develop a low carbon heat network and export heat therefore warrant further consideration and are considered in more detail below.

Estimated carbon savings from uplift policies

The total lifetime carbon impact of the Northern Gateway development and the savings expected from each uplift policy have been calculated and are presented below.

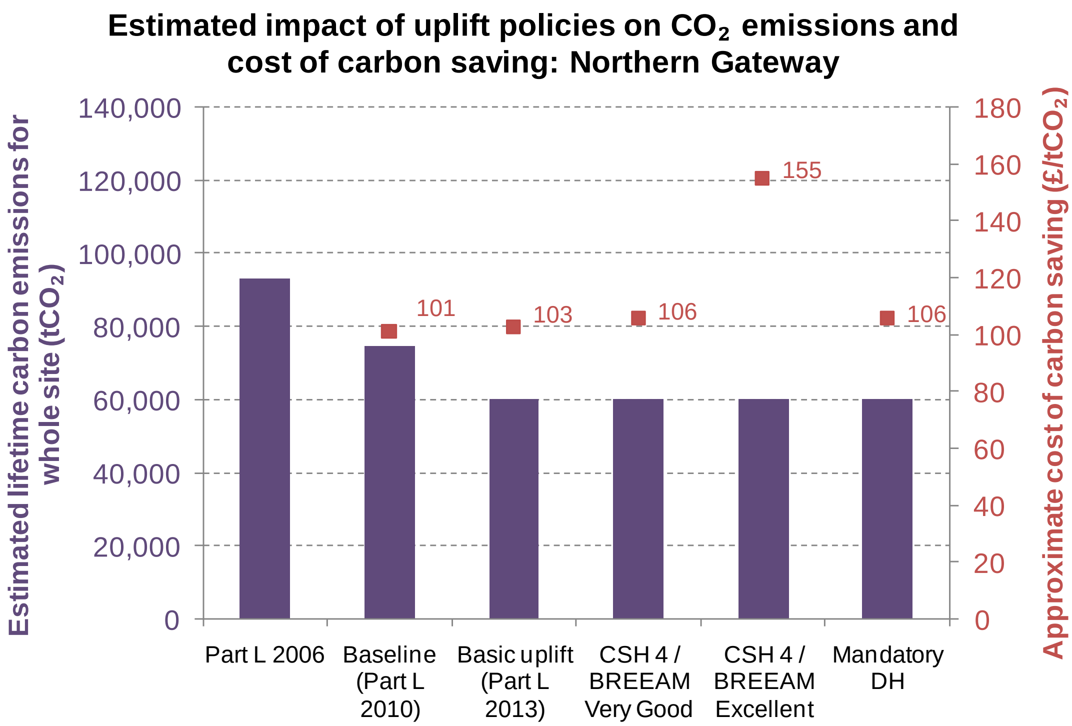


Figure 39: CO_2 emissions and cost of carbon saving under each uplift scenario: Northern Gateway

Under the baseline assumptions the new development is completed to Part L 2010, which requires a 25% improvement in regulated emissions relative to Part L 2006. These results suggest that this equates to a saving of around 20% taking into account all emissions (regulated and unregulated). The lower costs of carbon saving relative to the results for Staveley (presented above) are due to the lower overall target for this development, which means there is less need to employ more costly carbon saving technologies.

The relatively high increase in cost of carbon saving for the CSH4 / BREEAM Excellent policy is due to the fact that the cost is based on total E/O cost, which includes non-energy measures in the case of meeting BREEAM targets.

Opportunities for district heating in Northern Gateway

The heat mapping work undertaken for this study reveals that the town centre is one of only a few areas in the borough with a reasonably high heat density (see section 5.4). The viability of district heating in the Northern Gateway development could be enhanced if the system could be expanded to include existing heat consumers. Such expansion of the community heating system would reduce project risk and potentially enhance the load profile from an operational point of view with greater diversity of demand. However, there are significant barriers to linking in existing heat consumers to a new system (cost, disruption, working with a range of different owners etc), which act as a potential constraint.

The map below puts the Northern Gateway site in the context of surrounding heat users. Energy consumption of buildings are indicated by their colour (yellow to orange to red show higher annual heat demands) and the shaded squares represent areas where the average thermal demands of all buildings in the square exceed certain values. Full details of the heat mapping methodology are explained in section 5.4 and in the appendix.

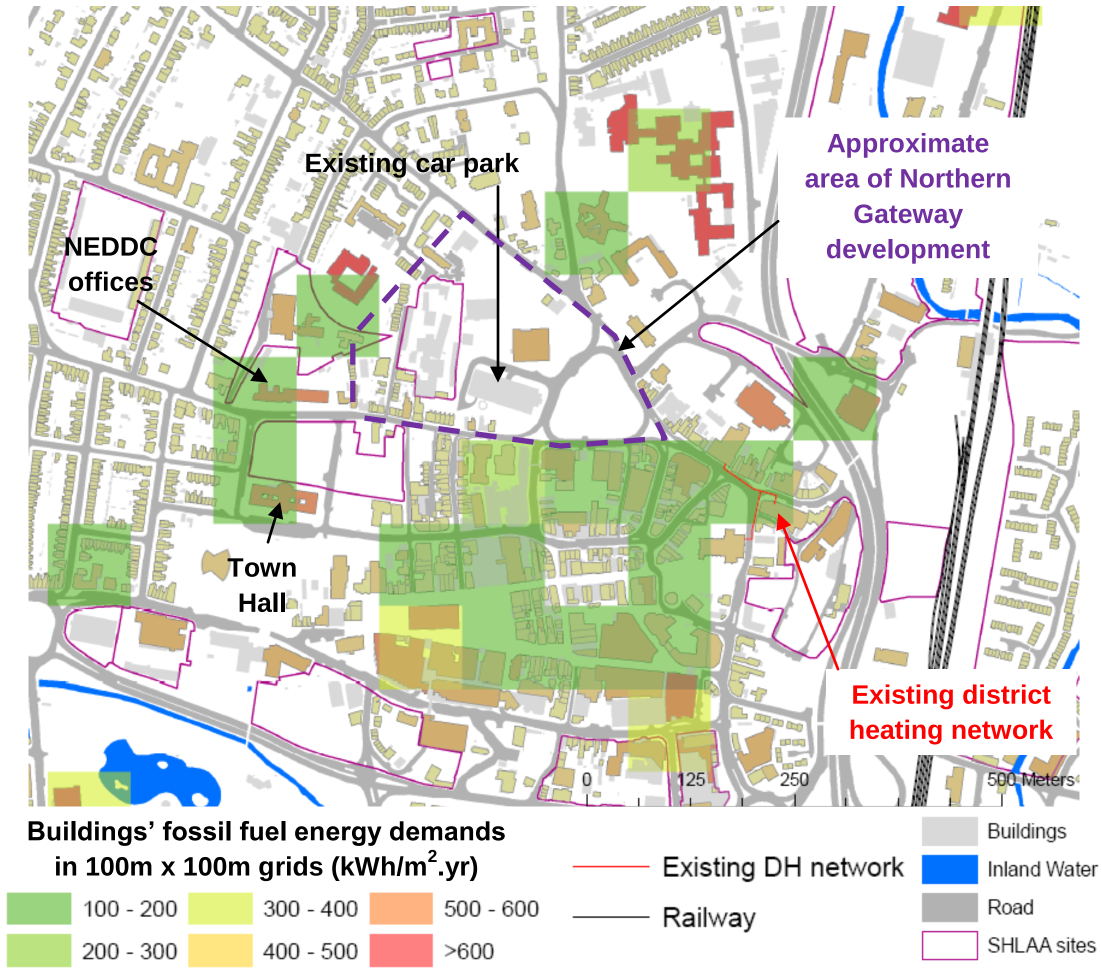


Figure 40: Heat density map of the town centre in relation to the Northern Gateway development site

The Northern Gateway site is adjacent to the town centre, where heat demands are sufficiently dense for a district heating network to be considered. There certainly appears to be potential to link existing loads into any new heat network developed at this site. Major public sector buildings in the immediate vicinity include Chesterfield Town Hall and North East Derbyshire District Council offices.

Although the capital cost increases associated with the mandatory district heating policy are potentially relatively high (up to around 5% of base build costs), this simple capital cost analysis takes no account of overall project economics. The economics of a well-designed community energy scheme serving a mix of buildings in an area of high heat density would be expected to appear more favourable on a whole-life basis.[77]

6.2.5 Northern Gateway policy analysis – conclusions

- Given the nature of this site (diverse mix of building uses and concentrated development), community heating could offer a cost-effective means of meeting the anticipated energy demands.
- Steps should be taken to minimise the carbon intensity of heat delivered through any proposed district heating scheme. This will be through appropriate thermal plant selection, subject to technical, economic, and environmental constraints.
- Any district heating feasibility study should consider opportunities to link the new development to existing thermal loads to de-risk the project and achieve carbon reductions in existing buildings.

[77] Lifecycle cost modelling (e.g. cashflow analysis) was not undertaken due to the number of uncertainties regarding the buildings to be built (such a level of detail would exceed the available data).

6.3 South of Chatsworth Road

6.3.1 Site characteristics and development programme

The proposed development site on land south of Chatsworth Road is about half a mile from the town centre, on land that is currently dominated by industrial uses. The overall development area is around 23 hectares and comprises a number of distinct sites: Walton Works, Goyt Side Mill & Boythorpe Works, Canon Mill, Griffin Mill & Wheatbridge Mill, and Land between Factory St & Furnace Hill.

One of this site's distinguishing features is that of the 220 residential units to be delivered, around 50 will come from conversion of existing buildings. This is expected to increase the cost burden on the developer(s).[78] In addition to the residential development, at least five hectares of land has been allocated to new commercial development. The river Hipper runs through the site and has been identified as having the potential to provide public amenity and act as a wildlife corridor.

Based on current plans a significant portion of the development in the area will be within the next five years, with latest available data suggesting that 150 of the 220 dwellings are expected to come from the Walton Works site in this timeframe. The remaining 70 dwellings are expected in the longer term, from around 2015/2016 onwards.

6.3.2 Strategic objectives for site

A General Development Framework has been produced for the land south of Chatsworth Road to provide guidance on the future development of the area. The GDF suggests that the development should seek to achieve dwelling densities in excess of 40 dwellings per hectare, a view supported by Chesterfield Borough Council. Chapter 5 of the GDF defines specific development areas within the site for which individual proposals are expected. Specific objectives for each area identified are summarised in the GDF.[79]

6.3.3 Baseline assumptions

The baseline assumptions for the Chatsworth Road sites in terms of quantity of development by Part L standard are summarised in the tables below.

Table 22: Baseline residential build-out assumptions – South of Chatsworth Road

Part L standard	Number of dwellings by Part L standard					Preferred approach to energy
	Flat	Terrace	Semi	Detached	All dwellings	
Part L 2010	0	0	0	0	0	Fabric improvement
Part L 2013	22	83	30	15	150	Fabric & PV
Part L 2016	12	39	13	6	70	Community BM HOB & PV

[78] Having said this there may be scope to recoup at least some of the additional cost through higher sale prices.
[79] Land South of Chatsworth Road, GDF (February 2007), p.44–46.

The preferred approaches to meeting the CO_2 reduction targets of each Part L standard are based on the capital cost analysis presented in section 4.3 and consideration of practical implications (which means that with biomass as the preferred heating fuel community rather than individual heating would be preferred).

Table 23: Baseline non-residential build-out assumptions – South of Chatsworth Road

Part L standard	Non-residential building floor area by usage type (m^2)							
	A1: Shops	A3: Restaurants / Cafes	A4: Pubs	B1a: Office	B1b: R & D	B1c: Industrial process	C1: Hotels	D2: Assembly & leisure
Part L 2010	0	0	0	0	0	0	0	0
Part L 2013	750	500	250	5,000	3,264	3,264	1,500	1,000
Part L 2016	750	500	250	5,000	3,264	3,264	1,500	1,000
Part L 2019	0	0	0	0	0	0	0	0
All Part L standards	1,500	1,000	500	10,000	6,528	6,528	3,000	2,000

Based on these assumptions around 31,000m^2 of non-residential floor area will be delivered in across the development sites on land south of Chatsworth Road.

6.3.4 Uplift scenarios

Definition

The policy scenarios considered for this development are summarised below.

Table 24: Uplift policies for South of Chatsworth Road development

Policy	Description
Basic uplift	All buildings to achieve CO_2 emissions savings in line with Part L standards one step ahead of minimum mandatory requirements
CSH5 energy standards	All dwellings that are expected to have to comply with Part L 2016 must instead meet the Ene1 requirements of CSH level 5 (100% improvement on Part L 2006 regulated emissions through on-site means)
Mandatory district heating	All development must connect to a district heating system

Impact on site energy strategy

The baseline assumption for the site is that all development is to Part L 2013 standards or above. The preferred energy strategies under each policy scenario are summarised in the table below.

Table 25: Energy strategies for each build phase in South of Chatsworth Road development under different policies

Policy	Energy strategy by Part L standard		Notes
	Part L 2013	Part L 2016	
Baseline	Fabric & PV	Community BM HOB & PV	Although the results of section 4.3 suggest that individual biomass boilers might be slightly cheaper than community heating, dwelling-scale systems are unlikely to be selected on practicality grounds
Basic uplift	N/A	Community BM HOB & PV	All development to meet Part L 2016 standards or above
CSH5 energy standards	Fabric & PV	Community BM HOB & PV	Limited choices to meet requirements of CSH5 – assume community biomass heating is preferred on overall economic and practicality considerations
Mandatory district heating	Community BM HOB	Community BM HOB & PV	Community biomass heating chosen as an example of one of the more cost-effective strategies

Impact on build costs

The impact of these policies on build costs is summarised in the graph below.

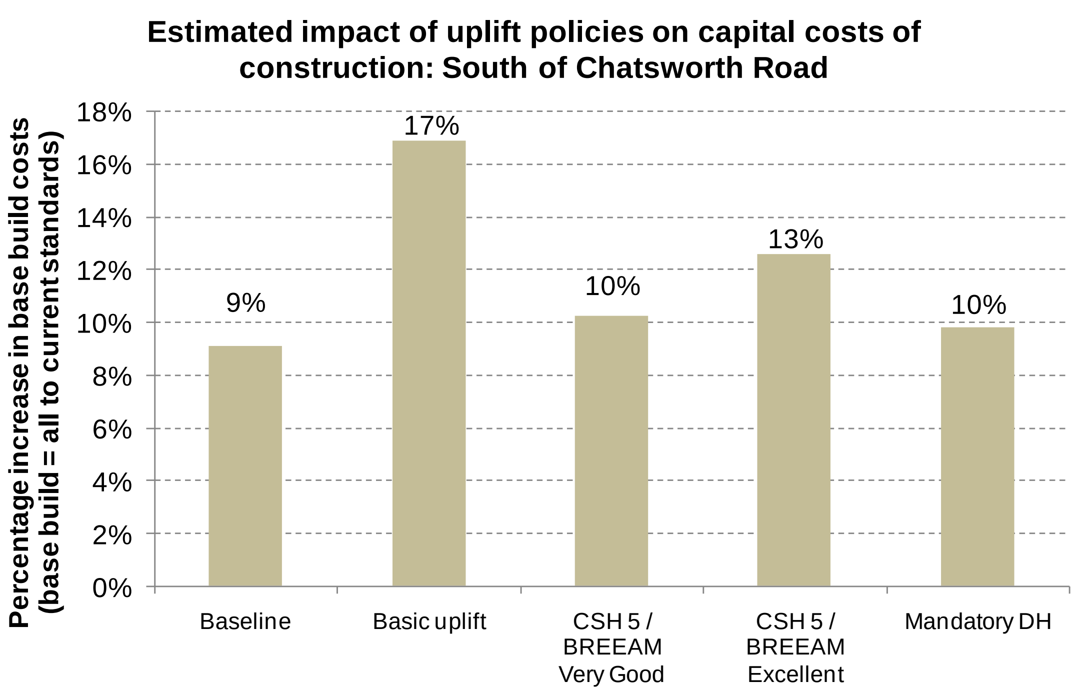


Figure 41: Uplift policies analysis – South of Chatsworth Road development

Given that a reasonably high proportion of the development is expected to fall under zero carbon policy the additional costs of the CSH level 5 energy standards and mandatory district heating policies are low.

The basic uplift policy effectively means all development must meet at least Part L 2016 standards (note that zero carbon policy for non-residential buildings is not expected until 2019). These results suggest that the additional cost relative to building to today's standards could almost double under such a policy.

Estimated carbon savings from uplift policies

The following graph shows the approximate level of carbon emission reduction expected from each policy, and the cost of carbon saving with the energy strategies outlined above.

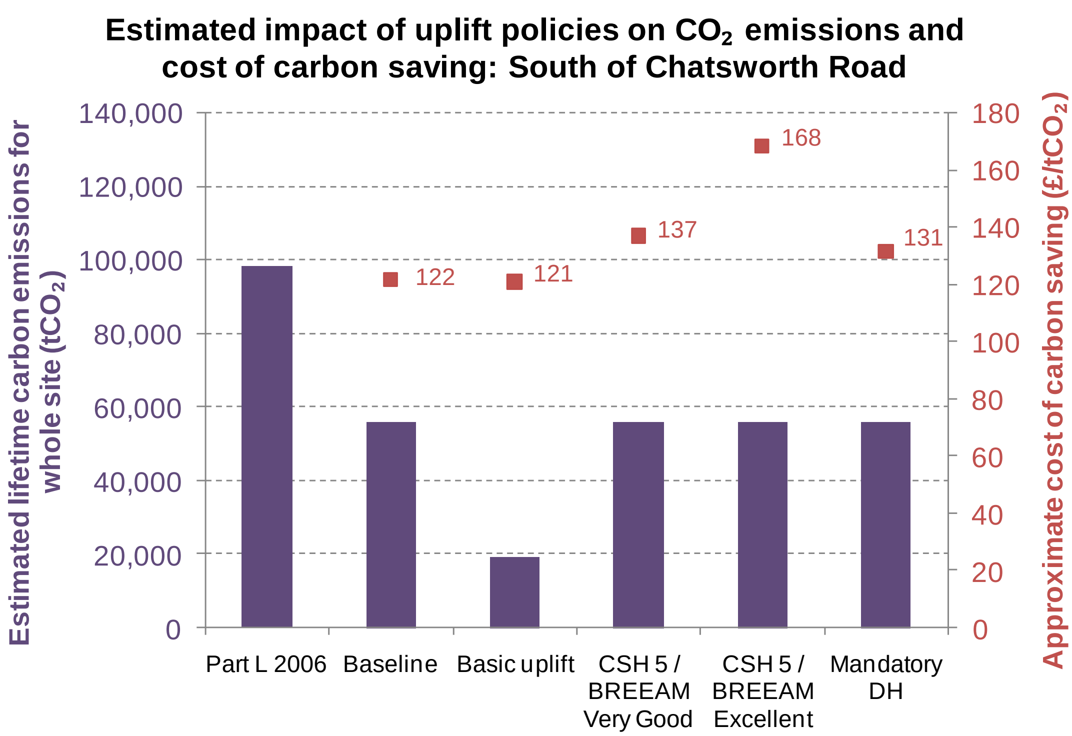


Figure 42: CO_2 emissions and cost of carbon saving under each uplift scenario: South of Chatsworth Road

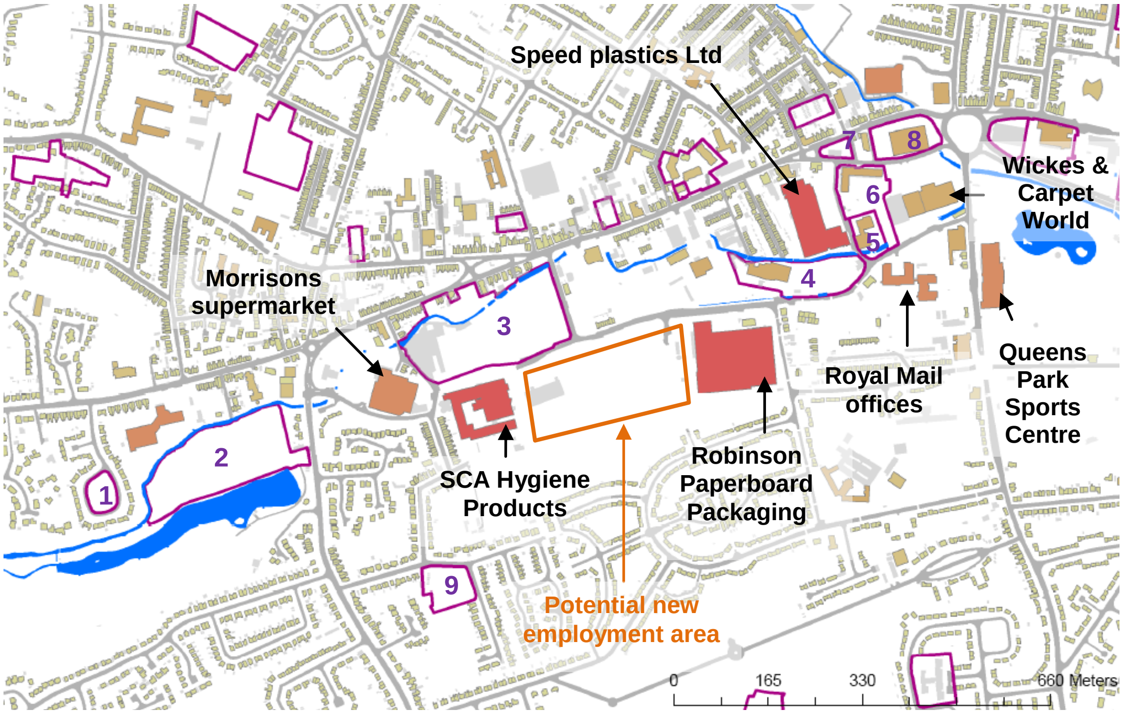
Under the assumptions behind the policies considered, the only policy that leads to additional carbon savings relative to baseline emissions is the 'Basic uplift' policy, which requires all new homes to comply with zero carbon standards, and non-residential development to exceed the minimum standards in place.[80]

The total carbon saved under the other policies considered does not change relative to the baseline case, the only difference being the means by which the savings are made (proportion on-site vs. off-site for example).

[80] Note that as more development falls under zero carbon standards, the estimated cost of carbon saving becomes more heavily dependent on the assumed allowable solutions price (taken as £100/tCO2). The results above should be interpreted with this in mind.

Opportunities for district heating in South of Chatsworth Road site

The small cost increase between the baseline and mandatory district heating policy suggests that community heating may be an appropriate energy strategy for this site. Furthermore, there are numerous relatively large heat users in the area, as indicated on the map below. However, land ownership in the area is fragmented and future development is likely to be through numerous individual sites, which presents a challenge to taking a coordinated approach to energy.



SHLAA sites key: 1 = Haddon Close, 2 = Land off Walton Road, 3 = Walton Works, 4 = Land off Dock Walk, 5 = Hipper House Dock Walk, 6 = Wheatbridge Mills, 7 = Kingdom Mills Pine, 8 = B&Q, 9 = Walgrove Road

Figure 43: Land South of Chatsworth Road development area

This map highlights the major heat consumers in the area, which could potentially be connected to a local district heating network developed in conjunction with the new building.

6.3.5 South of Chatsworth Road policy analysis – conclusions

- There is a risk that any policy that requires all new homes at this site to achieve zero carbon status would negatively impact site viability.
- However, this high-level analysis suggests that connecting all new development in the area to a district heating system would not represent an undue capital cost burden relative to the investment required to meet minimum standards.
- The feasibility of developing a local district heating system to provide low carbon heat to the site should be investigated further as development plans progress. This should include an assessment of the potential to supply heat to existing buildings that will remain after the development is complete.

6.4 Mastin Moor

6.4.1 Site characteristics and development programme

Mastin Moor is an existing village in the eastern part of the borough, close to Staveley town centre. CBC has identified the site as having potential to contribute towards the borough's long-term housing supply targets. Work to date suggests that 400 new homes could be delivered on around 17 hectares of greenfield land to the south of the main road (A619) that runs through the village. This long term development is expected to deliver residential units only, at a density of around 30 dwellings per hectare. No development is expected on this site in the short to medium term, which suggests that all new housing will be to zero carbon homes standards.

6.4.2 Strategic objectives for site

The existing housing in the village is dominated by Council-owned dwellings. The Council is keen to ensure that any new development on the site benefits the existing community and enhances the character of the area. A comprehensive list of strategic objectives is yet to be developed for this long-term site.

6.4.3 Baseline assumptions

As mentioned above, this site is expected to deliver housing only and the new development will have to comply with Part L 2016 (ZCH policy). The results from section 4.3 suggest that the most cost effective energy strategy in this development type would be based around individual biomass boilers in each dwelling (assuming wind turbines are not feasible). However, the practicality issues around using biomass on a dwelling-by-dwelling basis mean that such a solution is not likely in practice. The next most cost effective strategy is based on ground source heat pumps with photovoltaics, which forms the baseline energy strategy.

6.4.4 Policy scenarios

Given that all new development on this site is expected to have to meet zero carbon standards, this section considers the sensitivity of increases in build cost to certain key assumptions, rather than the impact of uplift policies.[81]

One of the key unknowns is the 'buy-out' price, i.e. the amount that will have to be invested in allowable solutions to offset any CO_2 emissions that cannot be achieved on site. A central figure of £100/tCO_2 is assumed in the baseline, with total CO_2 savings required calculated based on thirty years' worth of emissions. The following graph shows the effect of different allowable solutions prices on the additional cost of delivering homes on this site.

[81] Uplift policies in terms of high CSH energy standards are considered for Duckmanton in the following section. Current indications are that the characteristics of the developments at Mastin Moor and Duckmanton will be similar, so read-across between the two is possible.

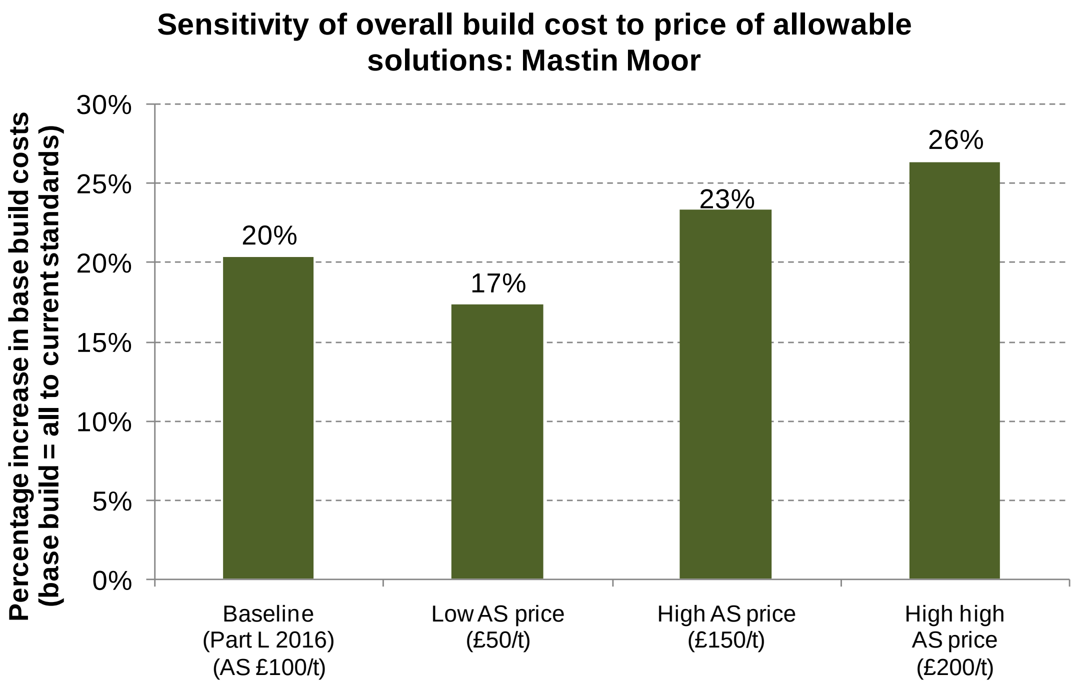


Figure 44: Sensitivity of overall build costs in Mastin Moor to allowable solutions price

The increase in capital costs in the baseline is of the order 20%, which is high relative to the baseline cost increases seen for the other major sites. This is due to the fact that all development is expected to achieve zero carbon status. The results above are based on technologies currently available (and in today's prices). Clearly there is opportunity for innovation over the coming years in the building and low carbon technology sectors which could impact the preferred technical solutions.

Given that all development at this site is expected to be to zero carbon standards, the net emissions (including offsetting) will be zero. With the baseline energy option considered (GSHP with PV) the total (capital) cost of carbon saving from the results above range from around £160 to £240/tCO_2.

The following table gives an indication of the cost of carbon saving via alternative measures, which gives context to the buy-out prices considered.

Table 26: Examples of costs of carbon saving with alternative measures[82]

Cost of carbon saving (£/tCO_2)	Typical measures
<50	Basic insulation measures (loft, cavity walls etc), large scale wind
50–100	Residential biomass heating (off-gas grid), industrial biomass boilers
100–200	GSHPs, biomass heating (on gas)
>200	Domestic ASHPs, PV, solar thermal

[82] Source: The Committee on Climate Change: ***Meeting carbon budgets - the need for a step change***, Chapter 5, (October 2009).

Opportunities to use developers' allowable solutions contributions to benefit the existing community, e.g. through improvements to the existing stock, will depend on the emerging definition of allowable solutions, particularly the scope of investment opportunities.

Some local authorities have established local carbon offset funds, which collect contributions from developers and use the funds to provide off-site carbon savings through various means. One example is Milton Keynes, which was the first local council to establish an offset fund. Developers are required to pay £200 for every tonne of CO_2 that the development is expected to emit in its first year. Milton Keynes Council has an ambition to achieve carbon neutrality and one of the policies in its new Core Strategy states that new development over five dwellings or 1,000m^2 will be expected to contribute to the carbon offset fund (policy CS 14). The Milton Keynes Carbon Offset Fund has received around £485,000 from developers since its introduction in 2008. This money has been used to insulate around 2,500 existing older private homes, as well as sheltered housing across the city. This is an example of one way in which contributions from developers have been used to provide a benefit to existing home owners.

6.4.5 Mastin Moor policy analysis – conclusions

- There is little rationale for setting advanced targets for this site since new housing is expected to have to meet zero carbon homes policy, which will involve a substantial capital cost increase relative to current build costs.
- Under zero carbon homes policy some form of buy-out mechanism to offset residual emissions is expected. The definition of what will constitute an allowable solution and how carbon savings will be delivered in practice are subject to on-going work within Government. However local planning authorities may have a role to play in identifying local opportunities for effective use of allowable solution contributions.

6.5 Duckmanton

6.5.1 Site characteristics and development programme

The village of Duckmanton, in the eastern part of the borough, is characterised by a high proportion of social housing. The existing settlement is within easy reach of the Markham Vale employment regeneration area, which suggests there could be an opportunity to provide housing within easy reach of employment sites and thus facilitate commuting by foot or bicycle.

The scale of development is similar to that proposed for Mastin Moor, with around 400 new homes to be delivered on greenfield land. The density is also expected to be similar, at around 30 dwellings per hectare. The precise siting of new development is yet to be decided as more than one plot has been identified as potentially suitable.

6.5.2 Strategic objectives for site

The Duckmanton development, like the Mastin Moor site, is a long-term ambition and full details of strategic objectives have not yet been developed. However, Chesterfield Borough Council takes the view that the new development at Duckmanton should benefit the existing community. A direct benefit of the population increase arising from expansion of the village will be to improve the viability of the primary school. In terms of energy use and CO_2 emission reduction the most appropriate measures to benefit the existing stock will be based on upgrading the buildings. Given the low build density there is unlikely to be any commercially viable opportunity to develop a low carbon district heating system to serve the existing buildings.

6.5.3 Uplift scenarios

Definition

Given that development on this site will have to meet zero carbon homes policy the policy options for enhanced building performance are limited. However, the mandatory CO_2 reduction required at CSH levels 5 and 6, as currently defined, is potentially more difficult to achieve than Part L 2016 standards since all savings must be made on site. This section examines the capital cost implications of complying with the energy requirements of the highest Code levels.

Table 27: Uplift policies for Duckmanton development

Policy	Description
CSH5 energy standards	All dwellings must meet the Ene1 requirements of CSH level 5 (100% improvement on Part L 2006 regulated emissions through on-site means)
CSH6 energy standards	All dwellings must meet the Ene1 requirements of CSH level 6 (mitigation of all regulated and unregulated emissions through on-site means)
Mandatory district heating	All development must connect to a district heating system

Impact on site energy strategy

The preferred energy strategies under each policy scenario are presented below, based on the assumption that wind turbine development at the site is not feasbile. These draw on the capital cost analysis presented in section 4.3.

Table 28: Energy strategies for each build phase in Duckmanton development under different policies

Policy	Preferred energy strategy	Notes
Baseline[83]	GSHP & PV	Although the results of section 4.3 suggest that individual biomass boilers might be slightly cheaper than community heating, dwelling-scale systems are unlikely to be selected on practicality grounds – GSHP is the next best option for this site type
CSH5 energy standards	Community BM HOB & PV	Policy increases the on-site CO_2 saving required from 70% to 100%, which results in a change of preferred strategy
CSH6 energy standards	Small scale BM CHP & PV	Achieving this level of CO_2 reduction on-site would be a significant challenge and for the purposes of illustration an emerging technological solution is represented
Mandatory district heating	Community BM HOB & PV	Same heating strategy as for CSH 5 policy, with lower PV requirement since on-site target reduction is that required by Building Regulations (70%)

The results presented in section 4.3.3 suggest that providing low carbon electricity from wind turbines could represent a lower cost solution to meeting challenging carbon reduction targets. An alternative set of results is therefore presented below in which there are no restrictions to wind turbine development, i.e. it is assumed that sufficient capacity may be installed to achieve zero carbon status without the need for further investment in allowable solutions.

Impact on build costs

The results of the capital cost impact assessment are presented in the graph below. All cost increases are relative to building to current standards (Part L 2006). At this early stage little detail is available regarding the form of the development at Duckmanton, and the same is true of the development at Mastin Moor. Given the similar characteristics of these two sites (at this stage), a certain level of read-across of results is possible.

[83] Note that there is a high degree of uncertainty around the optimum strategy on this site. Development plan in terms of layout and build density will affect the relative costs of community versus individual heating and any ground source heating system is subject to a ground survey.

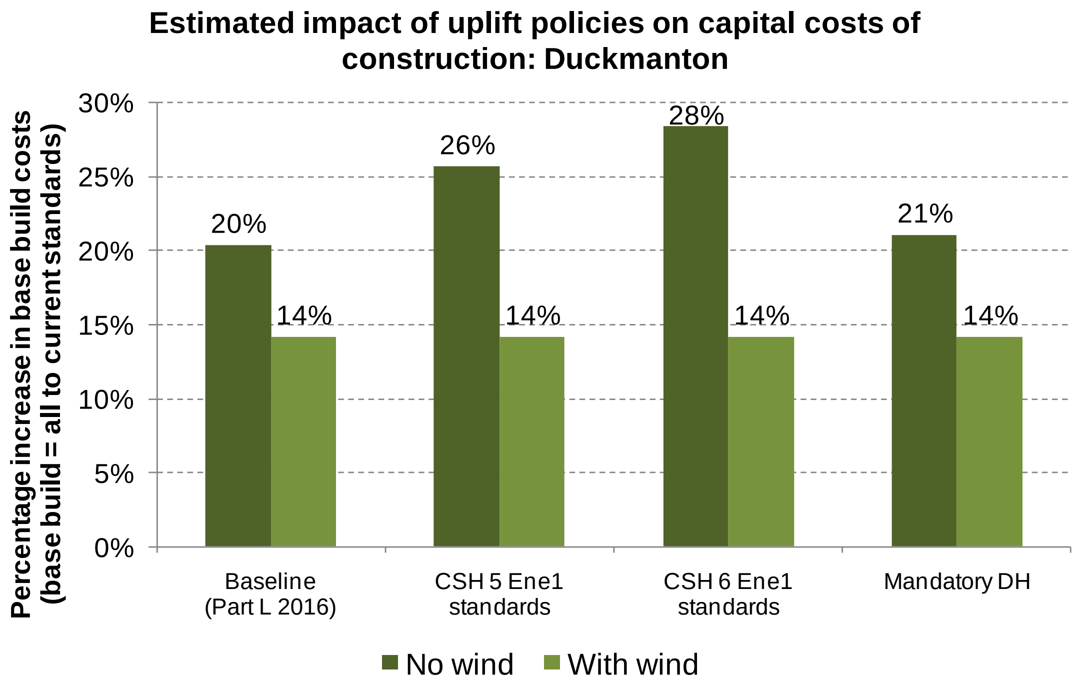


Figure 45: Uplift policies analysis – Duckmanton development

The 'With wind' strategies in the results above are based on thermal demands being met by a community gas CHP plant, with all remaining emissions to achieve zero carbon homes status saved via electricity from wind turbines. For this site this equates to around 850kW of peak turbine capacity operating with a load factor of 25%. Given that there is no change in energy strategy under the 'With wind' scenario and all emissions are saved on site, the total cost of this option is not sensitive to the policies considered here.

Under the 'No wind' scenario the additional cost associated with meeting the on-site CO_2 reduction targets of CSH level 5 arises partly from the change in heating system but mainly from the increased level of on-site electricity generation required (in this case from PV). The further cost uplift from CSH level 5 to level 6 is relatively small in this example. This is a result of optimistic assumptions regarding the cost and performance of emerging biomass CHP technology, which could provide low carbon heat and electricity, thus reducing the need to invest in other technologies.[84]

The additional cost of supplying the new dwellings with heat from a district heating network relative to the baseline is small. This demonstrates that as the carbon reduction targets increase with changes to Part L the economics of community heating become more compelling (even on low density sites).

In terms of cost of carbon saving, the capital cost per lifetime tonne of CO_2 saving for the strategies discussed above are in the range £185–£260/tCO_2.

[84] Small scale biomass CHP (around 100kW_e) was modelled, based on heat turbine technology, with quotes from Talbotts. Note that there are currently few installations of this technology as it is still in the development phase.

6.5.4 Duckmanton policy analysis – conclusions

- The additional costs of complying with zero carbon homes policy relative to today's standards are expected to be high (around a 20% increase in base build costs).
- Despite the low density of the site, an energy strategy based around community heating may be appropriate since the extra cost uplift is small relative to dwelling-scale technology solutions required to meet Part L 2016.

7 Opportunities for and barriers to low carbon development in Chesterfield borough

7.1 Key barriers to delivering low carbon development

Provided that the anticipated changes to Part L of the Building Regulations come into effect over the coming years (see section 2.2.2), all new development from the end of the decade and beyond will be net zero carbon. However, with the proposed schedule of Part L revisions opportunities to exceed minimum mandatory requirements will remain for a number of years.

A workshop was held to gain the views of local people and organisations that are likely to be impacted by the policies of the emerging LDF. The aim of the meeting was to identify barriers to the delivery of low carbon development in the borough and to consider potential mechanisms to overcome those barriers.

The reasons why developers rarely seek to exceed minimum targets in terms of CO_2 emissions include:

- Delivering lower carbon buildings typically involves additional **capital expense**. However, on the whole home buyers will not pay extra for a lower carbon home and there is very limited opportunity to demand higher rents for low carbon commercial buildings. Developers are therefore behaving in an economically rational manner.
- There are issues with **trust in new technology**. These should diminish over time with increase uptake of LZC technologies, greater familiarity with new technologies, demonstration projects etc.
- Developers view changes to Part L as challenging enough. They fear that requirements to go beyond minimum standards could affect **site viability**.
- **A lack of examples of implementation of low carbon development** is a barrier. For example if a developer makes a contribution towards a renewable energy project it is not clear who would be responsible for delivering it.

A further challenge arises when considering new commercial buildings. Often the final use of such buildings is unknown. This presents a challenge in terms of estimating the potential CO_2 impact (and therefore the level of CO_2 emission saving / offsetting required).

Another relevant piece of work that considers the obstacles to low carbon development is a study undertaken by the UK Green Building Council and Zero Carbon Hub. The Sustainable Community Infrastructure report contains the findings of this joint task group, which considered what is required to achieve cost and carbon effective community scale infrastructure solutions. The scope of this work was not limited to energy supply and CO_2 reduction, but also encompassed water, waste and communications infrastructure. Among the nine key strategic recommendations are[85]:

- Public sector buildings to provide anchor loads for heat networks, including connecting existing buildings to networks at next available opportunity.

[85] Source: ***Sustainable Community Infrastructure***, a joint report by the UK Green Building Council and Zero Carbon Hub, February 2010.

- Local authorities should develop a 'Sustainability Options Plan', which will identify availability, location and type of all relevant resource flows (water, waste and energy).
- Local authorities to take lead role in facilitating and initiating projects, and encouraging integrated delivery.

For further details, see the full report, which can be downloaded from the UK Green Building Council website.[86]

7.2 Barriers to renewable energy projects

The technical potential for renewable energy projects in the borough presented in section 5 will only be realised subject to all non-technical barriers being overcome. This section summarises the key barriers to delivering renewable energy projects in Chesterfield borough.

Biomass

The barriers to the use of biomass as a heating fuel are numerous and are discussed in section 5.1.5, above. There are a number of obstacles that act to restrict the development of local biomass supply chains, including:

- Fragmented and immature supply chain. The processes involved in fuel supply from producer to consumers include cultivation, processing, transport and distribution, and sales. Fuel producers need an understanding of the technical standards that fuels must adhere to, which is often outside of their areas of core expertise.
- Lack of motivation or interest from woodland / arable land owners for bringing forests into managed production / changing land use to energy crop cultivation.
- Uncertain economics around biomass production for use as a fuel. Especially in the case of energy crop production, there are competing uses for the land. If demand signals are weak or unclear then using land for fuel production is not an attractive prospect. Supply and demand must be developed in parallel.

Many of these issues are interrelated, for example little demand for biomass fuel (or a lack of demand signals reaching producers) may result from the fragmentary nature of the fuel supply chain.

Hydro electric power

Non-technical barriers to the development of hydro electric power schemes at sites with technical potential include:

- Land ownership and rights to use of land. Clearly projects can only be delivered with sufficient rights to use the land and river in question. Access for contractors for installation and on-going operation and maintenance must also be considered.
- Access to the national grid for grid connection. Grid connection costs may be prohibitive in some circumstances.
- Environmental impacts of the proposed scheme, including impact on character of the area and local wildlife.

[86] See www.ukgbc.org/site/resources/show-resource-details?id=642.

- Planning restrictions in terms of visual impact of the scheme, noise impacts, impacts of construction and preservation of structures of historic importance.
- As with any power-production scheme, hydro electric systems require an up-front capital investment that is recouped through electricity sales over time. Securing finance can be a barrier in some cases. However, the introduction of the FiT is intended to address this issue.

Wind energy

The principal barriers to wind turbine deployment are as follows:

- Identifying suitable sites with sufficient resource and where impacts of turbines on local residents are acceptable.
- The costs of grid connection must be considered. These can be high in more remote areas.
- Access is required for the installation and maintenance of turbines. Land ownership is therefore an important consideration.
- Planning constraints – e.g. turbine development in areas of natural beauty / historic interest / cultural heritage etc. is likely to be highly restricted or prohibited.
- Relatively high up-front costs associated with detailed resource and feasibility assessment are often required (especially for larger projects) and are paid at risk (i.e. if project does not go ahead these costs cannot be recouped).

7.3 Role of CBC in facilitating delivery of low carbon development

Chesterfield Borough Council has a proven record of showing leadership in the promotion of LZC technologies, for example through the installation of high efficiency ground source heat pumps in a number of public buildings and solar PV on the Town Hall. The Council has an on-going role to play in promoting low carbon building and facilitating the development of new renewable energy projects in the borough. Recommended actions for the Council to take to promote low carbon development are as follows:

- Address the issues of a lack of trust in / familiarity with technology by producing summaries of exemplar case studies in the area.
- Produce guidance on what technologies might be appropriate in different circumstances or provide references to such information, e.g. Energy Saving Trust.
- Raise public awareness of the options available to save energy and hence reduce CO_2 emissions. Support mechanisms such as the FiT and RHI should be promoted so that existing home owners can make informed decisions as to whether to invest in carbon saving measures.
- Further investigate local carbon saving opportunities that contributions from developers could be used to deliver, including identifying what must happen for these opportunities to be realised (e.g. delivery partners). Opportunities for local carbon offsetting are outlined below.

7.4 Carbon saving opportunities in Chesterfield borough

This section presents the main carbon saving opportunities in the borough, which could be delivered via any one of a number of mechanisms. A carbon offset fund represents one such enabling mechanism, whereby contributions from developers towards off-site carbon saving projects are centrally pooled and used to deliver the savings. Note that these opportunities could be delivered by the free market, or with support from schemes such as the FiT or RHI. For demonstration purposes the opportunities are presented in relation to the role of financial support from a central carbon offset fund.

7.4.1 Upgrade existing building stock

Given the principle that energy demand reduction should be the first measure in any CO_2 reduction strategy, retrofitting energy efficiency measure to the existing building stock is a logical first step. Cost effective measures include: improved insulation, improving air tightness, installing low energy light fittings and smarter heating controls. Carbon offsetting contributions could be used to fund such measures in Council-owned buildings in the first instance. Treating the private building stock presents a greater challenge and further work would be required to address how funds could be used most cost effectively, for example the relative merits of providing grants versus interest free / low interest loans etc.

7.4.2 Renewable electricity generation project initiation

The renewable energy resource assessment presented above shows that there are a number of potential opportunities to deliver low carbon energy projects in Chesterfield borough, principally wind and hydro power. Using central funds (provided by developers to offset carbon emissions) to initiate projects on Council-owned land would mean that the access barriers discussed above are less of an issue. Alternatively, the funds could be used to finance detailed feasibility and environmental impact assessment studies for projects at specific sites, thus reducing the risks for any project delivery company.

7.4.3 Low carbon community heating networks

The heat mapping exercise completed as part of this study highlighted a number of areas of reasonably high heat density, particularly in and around the town centre. The opportunity to achieve CO_2 savings by supplying low carbon heat to multiple buildings will only be realised upon the installation of a district heating network to distribute the heat. However, the economics of district heating projects (high initial capital costs paid off over many years of heat sales) mean that a long-term view is required. Cash from a central carbon offset fund could be used to part fund a district heating scheme with low carbon heating plant. This would reduce the project risk to the delivery partner and therefore improve the economic attractiveness of the scheme.

7.4.4 Grants for microgeneration

The latest support mechanisms for low carbon microgeneration technologies are designed to provide a reasonable rate of return for investors.[87] However, relatively high up-front capital expenditure is required for most of these technologies, which still acts as a barrier for many

[87] Feed-in tariff payments for low carbon electricity generation began in April 2010 and support for low carbon heat from the renewable heat incentive is expected from 2011.

householders / businesses. Central funds under CBC control could be used to address this by either providing low interest loans to members of the public / private businesses, or by paying for the equipment and recouping the costs by taking all or some of the tariff payments. These two approaches correspond to two ownership models:

1. The householder / business owns and operates the equipment and repays the loan provided by the Council out of tariff payments received.
2. The Council (or CBC-initiated company) owns and operates the generating equipment which is installed in / on privately owned buildings.

There are examples of businesses beginning to operate in the UK around the second of these two options. A typical arrangement in the case of technologies supported by the FiT is for the building owner to benefit from the export tariff and reduced electricity bills (from electricity used on site), while the company that paid for the generating equipment collects the FiT payments. There is a range of management, ownership and other issues surrounding this model, which would require further consideration prior to the implementation of such an initiative.

8 Conclusions and policy recommendations

8.1 Conclusions

8.1.1 Renewable energy resource assessment

Key conclusions from the renewable energy resource assessment are as follows:

Biomass

- The potential biomass resource from existing woodlands in the borough is highly constrained. Similarly, land available for energy crop production is limited.
- Fuel supplies from the wider area are therefore required for biomass to make a significant contribution to CO_2 reduction in the borough. This means that regional and national biomass supply chains will be important if use of this fuel is to increase.

Hydro electric power

- Around 27 sites in the borough have potential for hydropower installations. Hydropower installations at all of these sites could see the deployment of around 365kW of hydro turbines.
- The maximum installed capacity could produce an electricity output of around 1,600MWh/yr, which is equivalent to the electricity demands of 430 average homes.
- Whilst hydropower schemes offer some potential to provide low carbon energy and hence reduce overall CO_2 emissions, this technology will remain niche and should not be regarded as a central feature of the low carbon development strategy.

Wind

- The mean annual wind speed in Chesterfield borough is relatively low, which suggests that taller turbines are likely to be required for economically viable projects.
- The wind resource in the borough is highly constrained due to the urban nature of large areas of the borough. This means that there are few opportunities for delivering large scale wind turbines.
- The optimum sites in terms of wind resource and freedom from constraints lie on land to the north of the borough, north of Barrow Hill.

Opportunities for district heating

- The majority of the borough is characterised by areas of low heat density, which means district heating is unlikely to be economically feasible in most areas.
- The areas of highest heat density are generally in and around the town centre, and in isolated locations where high heat consumers are situated.
- In terms of connecting major new development to existing heat consumers, the most promising opportunities are the Northern Gateway development and sites on land south of Chatsworth Road. Opportunities for using existing consumers to act as heat

anchors to improve the viability of district heating systems in new developments should be investigated as the sites come forward.

8.1.2 Major sites analysis

An assessment of opportunities to exceed minimum standards in a selection of major development sites has been undertaken. The key conclusions are:

Staveley Works Corridor

- Implementing a site-wide strategy based around district heating at the Staveley Works site is expected to lead to relatively low capital cost increases relative to the anticipated costs of meeting the changing Part L standards.
- This suggests that there is a rationale for examining the feasibility of a community energy scheme at this site. Given the proximity to the existing district heating network at Barrow Hill any feasibility assessment should consider the option of linking new and existing networks.

Town Centre Northern Gateway

- Given the nature of this site community heating could offer a cost-effective means of meeting the anticipated energy demands.
- Steps should be taken to minimise the carbon intensity of heat delivered through any proposed district heating scheme. This will be through appropriate thermal plant selection, subject to technical, economic, and environmental constraints.
- Any district heating feasibility study should consider opportunities to link the new development to existing thermal loads to de-risk the project and achieve carbon reductions in existing buildings. There are a number of public sector buildings in the vicinity of the new development site that could play a role in this regard.

South of Chatsworth Road

- There is a risk that any policy that requires all new homes at this site to achieve zero carbon status would negatively impact site viability.
- However, connecting all new development in the area to a district heating system would not represent an undue capital cost burden relative to the investment required to meet minimum standards.
- The feasibility of developing a local district heating system to provide low carbon heat to the site should be investigated further as the development plans progress. This should include an assessment of the potential to supply heat to existing buildings (e.g. local businesses in the area) that will remain after the development is complete.

Mastin Moor and Duckmanton

- The additional costs of complying with zero carbon homes policy relative to today's standards are expected to be high (around a 20% increase in base build costs) on these sites.

- Despite the low density of the sites, an energy strategy based around community heating may be appropriate since the extra cost uplift is small relative to dwelling-scale technology solutions required to meet Part L 2016.
- There is little rationale for setting advanced targets for these sites since new housing is expected to have to meet zero carbon homes policy.
- Under zero carbon homes policy some form of buy-out mechanism to offset residual emissions is expected. The definition of what will constitute an allowable solution and how carbon savings will be delivered in practice are subject to on-going work within Government. However local planning authorities may have a role to play in identifying local opportunities for effective use of allowable solution contributions.

8.2 Policy recommendations

On the basis of the work of this study we recommended that the policies below are considered during the development of Chesterfield Borough Council's emerging LDF.

The suggested policies take into account the very recent consultation on PPS1 Supplement: *Planning for a Low Carbon Future in a Changing Climate*. The emerging PPS1 Supplement proposes that some policies within existing and emerging plans will not be required given the future changes to Building Regulations. However, the CBC Core Strategy will be in place prior to the implementation of these changes and it is therefore appropriate that the following policies are brought forward.

8.2.1 Cross-cutting policies

Policy CC1: Carbon emissions reduction targets

Chesterfield Borough Council is working toward a long-term goal of reducing the borough's carbon footprint in line with a national target of reducing total CO_2 emissions by 34% by 2020, on the path to an 80% reduction by 2050.[88] The Council has signed the Nottingham Declaration on Climate Change, which represents a pledge to tackle the issue by addressing the causes and preparing for the impacts of climate change. Ensuring that carbon emissions associated with growth within the authority area are minimised is key to this objective.

Accordingly, all development proposals should, as far as possible, contribute towards reduction of CO_2 emissions and generation of renewable energy.

Policy CC2: Provision of community heating networks

vi. New developments shall connect to existing community heating networks in close proximity to the site, unless it can be demonstrated that to do so does not deliver the most beneficial solution in terms of CO_2 reduction.

vii. Where there are definitive proposals for a district heating system within close proximity of a new development, the development should be designed to facilitate future connection to the network.

viii. Where no district heating scheme exists or is proposed in the proximity of a major new development, the potential for developing a new scheme on the site should be explored

[88] Emission reduction targets set out in the Climate Change Act 2008 are relative to 1990 levels.

and pursued where feasible. Priority sites for district heating include Staveley Works, Town Centre Northern Gateway, and South of Chatsworth Road.

ix. Where a new district heating scheme is developed, the opportunity for use of renewably fuelled CHP should be fully explored. Due regard should be paid to any constraints on fuel choice, such as proximity to air quality management areas.

x. New development should be designed to maximise the opportunity for development of a district heating solution, for example in terms of density, layout, phasing and mix of uses.

Policy CC3: Sustainable design and construction

Developments should meet the highest practicable standards of sustainable design and construction, including resource and energy efficiency and should aim to maximise reductions of carbon emissions.

All new development, and major refurbishment, will be required to demonstrate that:

- It makes effective use of resources and materials through sustainable construction, minimises water use, provides for waste reduction / recycling and reduces carbon emissions.
- It uses an energy hierarchy that seeks to:
    - use less energy, in particular by adopting sustainable design and construction measures,
    - supply energy efficiently, including by prioritising decentralised energy generation using low carbon or renewable technologies, and
    - make use of renewable energy, including but not limited to: solar technologies, wind power, hydro-electric power, and renewable fuel sources.
- It is sited and designed to withstand the long-term impacts of climate change, particularly the effect of rising temperatures on mechanical cooling requirements.

Sustainability standards for residential development or schemes which include residential development will be dictated by the standards of the Code for Sustainable Homes. BREEAM standards, or any scheme which supersedes it, will apply to non-residential proposals. All major development (ten or more homes or 1,000m^2 gross internal floor area) will be expected to meet the following standards.

Development type	Up to 2013	2013–2016	2016 onwards
Residential development	CSH level 4	CSH level 4	CSH level 5*
Commercial development	BREEAM Very Good	BREEAM Very Good	BREEAM Excellent

** Development will be expected to attain Code level 5 except in cases where it can be demonstrated that site viability will be undermined by this target.*

Elsewhere, all other development proposals, both new build and conversions, should demonstrate how sustainability issues have been considered; specifically this should include details of options considered to reduce CO_2 emissions beyond the minimum levels required by Building Regulations.

The Council will promote and support individual schemes that showcase best practice in sustainable construction and renewable energy generation where appropriate.

There will be a presumption that the targets will be met in full except where developers can demonstrate that in the particular circumstances there are compelling reasons for the relaxation of the targets. The onus will be on developers to robustly justify why full compliance with policy requirements is not viable.

Developments that fail to meet the required levels of carbon emissions reductions may be required to make a one-off financial contribution to be used to achieve equivalent emissions savings through off-site measures. In the first instance, however, the Council envisages that carbon growth resulting from new development will be minimised by requiring on-site carbon reduction measures. The amount of this payment, where applicable, will be determined on a site-by-site basis and calculated in line with a methodology to be set out in an updated Sustainable Design and Construction SPD.

8.2.2 Site-specific policies

SS1: Staveley Works Corridor

v. Staveley Works Corridor (SWC) is a priority site for development of a community heating network. An energy master plan for SWC should be developed that includes a community heating network across all phases of the development.
vi. An alternative energy strategy will be acceptable only where it can be demonstrated that an equivalent or greater level of CO_2 reduction (see iii below) can be delivered in a more beneficial fashion, for example, more cost-effectively, lesser environmental impact etc.
vii. Residential phases of the development constructed post-2016 should achieve the Code level 5 mandatory Energy & CO_2 standard or a Carbon Compliance level of 100%, whichever is the greater reduction.
viii. Non-residential development exceeding 1,000m^2 gross area developed prior to 2016 will achieve BREEAM 'Very Good' and BREEAM 'Excellent' thereafter.

SS2: Town Centre Northern Gateway

v. Town Centre Northern Gateway (TCNG) is a priority site for development of a community heating network. An energy master plan for TCNG should be developed that includes a community heating network across all phases of the development.
vi. The opportunity for extension of a heat network developed at the TCNG development to link to existing thermal loads or other new development in close proximity should be explored.
vii. Residential development should achieve a minimum of Code level 4.
viii. Non-residential development should achieve a minimum of BREEAM 'Very Good'.

SS3: South of Chatsworth Road

v. South of Chatsworth Road is a priority site for development of a community heating network. An energy master plan for the site should be developed that includes a community heating network across all phases of the development.
vi. The South of Chatsworth Road site is situated in close proximity to significant existing thermal loads. The opportunity for export of heat from the site to existing loads or other new development in the area should be explored.

vii. All residential development should achieve a minimum of Code level 4. Residential development constructed post-2016 should achieve the Code level 5 mandatory Energy & CO_2 standard or a Carbon Compliance level of 100%, whichever is the greater reduction.

viii. Non-residential development should achieve a minimum of BREEAM 'Very Good'.

8.3 Policy implementation, enforcement and monitoring

8.3.1 Implementation and enforcement

The success of new policies will depend on the ability of the Council to implement and enforce them in an effective manner. This section provides a recommended implementation and enforcement strategy for the policies outlined above, including evidence that should be requested to demonstrate compliance. This relates to submissions that should be required by CBC at the planning application stage.

Overview

There are two broad approaches to policy implementation in terms of how developers should demonstrate compliance, as summarised below.

Table 29: Policy implementation options

Method	Description	Advantages	Disadvantages
Self assessment	Developers demonstrate compliance by completing a standard form, or submitting evidence from accredited assessors for example.	• Lower burden on CBC. • Standardised process increases transparency.	• Higher risk of inaccurate submissions from developers.
Council appraisal	Developers submit sufficient data to the Council for CBC to assess the application against the policy criteria.	• Gives opportunity for CBC to critically assess each proposal in detail. • Less chance for developers to avoid maximising carbon saving opportunities.	• Relatively heavy burden on developers to submit all data and on CBC to assess proposals. • CBC may not have resources / expertise to assess the data submitted.

Given the higher burden on the Council associated with the Council appraisal method, this approach is recommended only for the larger sites. For example, taking this approach for sites greater than 50 dwellings would mean that a full set of data for CBC to assess would be required from around 20 sites, but these would account for around 85% of new homes delivered up to 2026 (see Figure 5, section 3.1.2).

Further work may be required to develop a standard form / set of standard forms to be used for the self assessment method outlined above. However, setting the targets in terms of nationally recognised schemes (CSH / BREEAM) means that evidence from accredited assessors may be used, for example design stage CSH assessments and post completion certificates. Details of the data that should be requested for the Council appraisal are given below.

Council appraisal – data requirements

A list of potential data that CBC should demand from developers (in order to carry out an appraisal of compliance with the policies outlined above) is given below. Note that there is a degree of overlap in data requirements to assess compliance with each of the policies and the relevant policies are also indicated below.

Data required	Relevant policies
Sustainability statement / energy strategy, which should provide details on:	
• The proposed levels of insulation for the main building elements (floors, external walls, roof, doors and windows) in terms of U-values, which may be compared against best practice values.[89]	**CC1 / CC3**
• Specific energy demands for space heating and cooling (kWh/m^2.yr), calculated via the Standard Assessment Procedure (SAP) for dwellings or Simplified Building Energy Model (SBEM) for non-residential buildings.[90]	**CC1 / CC3**
• Details of the heating system(s) that will be specified, for example technology type, system size, fuel source, and efficiency.	**CC1 / CC3**
• Details of energy options considered, including potential for DH network for the site and assessment of any opportunity to link to existing thermal loads or other new development in the vicinity.	**CC2**
• Information on how consideration of potential for DH has impacted the layout of the development.	**CC2**
• Details of any LZC technologies that will be integrated into the development, including technology size, anticipated energy output and emissions savings.	**CC1 / CC3**
• Anticipated carbon emissions from the new building expressed as mass of CO_2 per square metre of internal floor area per year (kgCO_2/m^2.yr – also calculated via SAP / SBEM). This should be reported as an absolute value and relative to baseline emissions (Part L 2006) for an equivalent building design, thus demonstrating the percentage improvement on baseline emissions.	**CC1**
• Demonstrate how the need for cooling has been considered and anticipated energy requirements for and CO_2 impact of cooling have been minimised.	**CC3**

[89] For example, as published by the Energy Saving Trust in its best practice guides: www.energysavingtrust.org.uk/business/Business/Housing-professionals/Publications.

[90] To be compared to energy efficiency backstop values, for example as defined in the proposed energy efficiency standard for zero carbon homes – see www.communities.gov.uk/publications/planningandbuilding/futureofcodeconsultation or www.zerocarbonhub.org/news_details.aspx?article=5. Non-domestic values may be compared against CIBSE benchmark figures or any subsequent best practice data which may emerge over the coming years.

Design stage CSH assessment, which should include details of approach to reducing CO_2 emissions, construction materials, water saving measures, and waste strategy.	**CC3**
BREEAM (pre assessment estimator) with indication of sustainability measures that will be incorporated into non-domestic buildings.	**CC3**

In terms of policy enforcement, the primary means of ensuring developers pay due regard to the policies is for CBC to withhold planning permission until it is satisfied that the proposal will comply with the relevant policies or that sufficient evidence has been submitted to justify non-compliance. In the case of policies for which compliance or non-compliance is easily demonstrated CBC has the option to enforce policies as planning conditions. To check policy compliance developers should be required to submit post construction certificates / assessments to demonstrate compliance with target CSH / BREEAM levels.

8.3.2 Monitoring

On-going monitoring is crucial in assessing the effectiveness of the new planning policies. The Planning and Compulsory Purchase Act 2004 stipulates that the Council must produce an Annual Monitoring Report, a document containing information about the borough and how it is changing as a result of planning policies used to determine planning applications. This section provides a recommended monitoring strategy for the policies outlined above. It is recognised that whilst policy monitoring is an important requirement, there is also a need to avoid placing an overly onerous burden on those responsible for collating and presenting the relevant data.

A potential approach to on-going policy monitoring is summarised in the following diagram.

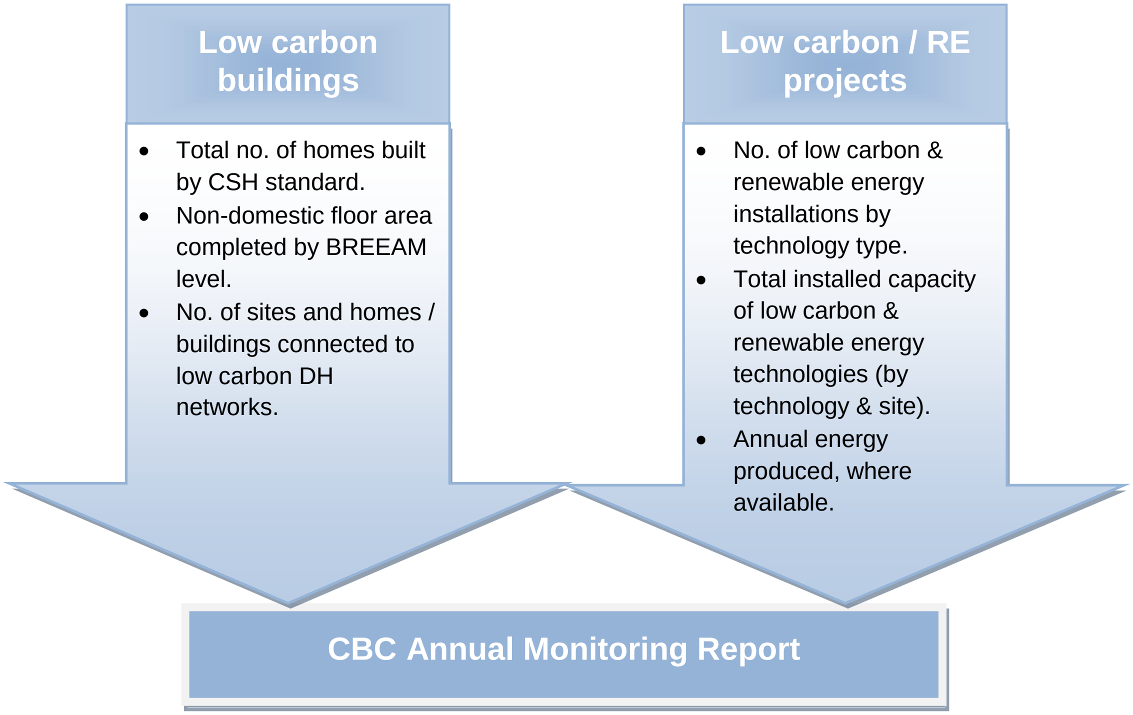


Figure 46: Overview of recommended monitoring strategy

The diagram above summarises recommended metrics to be recorded as part of on-going policy monitoring. Data on new building completions are already recorded as part of the Council's AMR production. Further delineating completions by Code / BREEAM level would allow assessment of the effectiveness of policies CC1 (CO_2 emission reduction) and CC3 (Sustainable design and construction) since minimum CO_2 reduction levels are implicit within this. Recording the uptake of low carbon technologies, including installed capacity and energy generated, will provide the Council with data relating to the level of renewable energy supply in the borough.

9 Appendices

9.1 Recent Government consultations

9.1.1 CSH and energy efficiency standard for ZCH

The Government recently consulted on policy and technical changes to the Code for Sustainable Homes, which include embedding the new definition of zero carbon for new homes. The consultation ran from December 2009 to March 2010 and sought views on the following[91]:

- Energy efficiency standards for zero carbon homes.
- Aligning with the zero carbon definition for homes i.e. the 70/30 split.
- Aligning the CSH with proposed changes to building regulations (2009), that is Code Levels 1-3 to meet 25% reduction in carbon emissions, Code Level 6 to reflect the definition of zero carbon homes (100% regulated plus appliances) and Code Level 5 to include 70% carbon compliance with 30% allowable solutions (no requirement to cover unregulated emissions).
- Producing credits for energy display devices.

It is proposed that the revised Code requirements will become effective in October 2010 alongside changes to the building regulations.

9.1.2 Zero carbon for non-domestic buildings consultation, 2009

Consultation on policy options for “Zero carbon for non-domestic buildings” commenced in November 2009 and finished at the end of February 2010. This follows the ambition set out in the Budget 2008 for all new non-domestic buildings to be zero carbon from 2019. The following hierarchy will be followed:

- Energy efficiency.
- On-site or linked low or zero carbon technologies (carbon compliance).
- Off-site (allowable solutions).

A common approach to allowable solutions is intended for domestic and non-domestic buildings. This would be introduced in 2016 for the former and 2019 for the latter although an element of allowable solutions for the latter could be introduced. Zero carbon will include regulated emissions (heating, cooling, lighting and waster heating) and unregulated emissions e.g. appliances.

Almost half of the UK’s carbon emissions come from buildings. Even with rapid decarbonising of the grid and accelerating reduction of emissions from existing buildings new non-domestic buildings need to be designed to contribute to carbon reductions.

The following measures are identified as potentially meeting the carbon compliance definition:

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[91] *Sustainable New Homes – The Road to Zero Carbon*, Consultation on the Code for Sustainable Homes and Energy Efficiency Standard for Zero Carbon Homes, Dec 2009.

- Further energy efficiency measures, beyond those selected to meet the energy efficiency standard.
- Low and zero carbon generation technologies which are directly incorporated into the fabric of the building (e.g. roof-mounted solar panels).
- Low and zero carbon energy installations built within the development (e.g. development-scale combined heat and power (CHP).
- Directly connected heat or coolth, where the 'physical connection' can be easily demonstrated through the physical pipework.

Three options for the on-site / off-site split are identified as:

- Off-site rich: this prioritises the new building's contribution to off-site measures by setting lower carbon compliance targets and increasing the use of allowable solutions.
- Balancing on-site and off-site: this sets stretching on-site targets, but at a lower capital cost per building than for the 'on-site rich' scenario, and deploys allowable solutions for the remaining emissions.
- On-site rich: this sets ambitious on-site measures, pushing almost as far as is technically possible for 2019, reflecting the principle behind the approach taken for homes.

Views were sought through the consultation as to which scenario is favoured. A range of allowable solutions are currently under consideration, including further carbon reductions on-site beyond the regulatory standard, energy efficient appliances meeting a high standard, advanced building control systems which reduce the level of energy use, exports of low carbon or renewable heat to other developments and investments in low and zero carbon community heat infrastructure.

9.2 Codes and certificates – further details

9.2.1 The Code for Sustainable Homes

The Code for Sustainable Homes (CSH) is a national standard for sustainable building. New homes are assessed against nine design categories from Energy / CO_2, to Water, Materials, Management and Ecology. Based on credits awarded under these categories an overall star-rating is awarded, from one to six stars, which are known as Code Levels (e.g. three stars is Code Level 3). Code Level 6 is the highest sustainability rating and achieving this standard represents a significant challenge.

Unless stipulated by local planning policies, building to any level of the Code remains voluntary for private development. However, gaining a Code rating became mandatory for new homes from May 1st 2008. If no target Code level is sought the dwelling is given a 'Nil Rated' status. While the Code is a voluntary standard, all public sector housing must currently achieve level 3 to obtain central government funding. This minimum standard is set to rise to level 4 from 2011.

The CSH has been designed to show the future for the building industry. For example, the mandatory requirements in terms of CO_2 reduction in the Code mirror the proposed changes to Part L in 2010 and 2013. Therefore developers building Code homes gain relevant experience that will allow them to comply with future changes to minimum mandatory standards imposed through changes to Building Regulations.

A Government consultation on proposed changes to the Code ended in March 2010. A summary of some of the proposed changes is given in the appendix, section 9.1.1.

9.2.2 BREEAM

The BRE Environmental Assessment Methodology is an internationally recognised environmental assessment method for buildings which sets standards in terms of sustainable design. The BREEAM is used to assess buildings against set criteria (in similar categories used in the CSH) and provide a score which is translated into a rating of Pass, Good, Very Good, Excellent or Outstanding.

9.2.3 Energy Performance Certificates

Energy Performance Certificates (EPCs) grade the performance of a building in terms of energy efficiency and CO_2 emissions on a scale from A to G (A being the best performing), similar to the energy performance certification of white goods. Their purpose is to provide better information to prospective buyers or tenants on the energy efficiency of the building and to advise on how the energy performance could be improved. All buildings that are newly constructed, sold or let require an EPC (with a few exceptions, including places of worship, temporary buildings and non-dwellings under 50m^2).

The energy performance of the building is rated against a common benchmark, allowing the EPC rating to be used as a comparative metric with other buildings in the stock. In the case of dwellings an energy efficiency rating and an environmental rating is given, rating the dwelling on likely running costs and CO_2 emissions respectively. For non-dwellings a single CO_2 based rating is given, taking into account the performance of the building fabric and services. In each case the EPC rating is accompanied by a recommendations report, advising on cost-effective actions that could be taken to improve the performance of the building. EPCs are valid for a period of ten years, unless part of a Home Information Pack (HIP), in which case the EPC must be less than three years old when the home is first put on the market. Example EPC ratings for a typical dwelling are shown below.

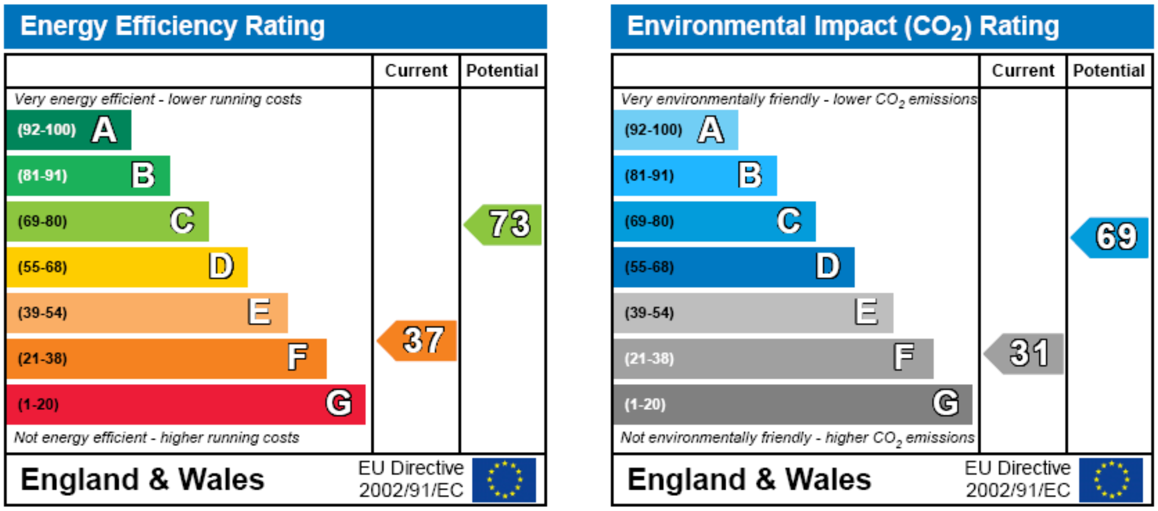

Figure 47: Energy Performance Certificate ratings for a typical home

9.3 Support levels for low carbon and renewable energy generation

9.3.1 Feed-in tariff support levels

Technology	Scale	Tariff level for new installations in period (p/kWh) [NB tariffs will be inflated annually]											Tariff lifetime (years)
	Scheme Year	1 1/4/10 – 31/3/11	2 to 31/3/12	3 to 31/3/13	4 to 31/3/14	5 to 31/3/15	6 to 31/3/16	7 to 31/3/17	8 to 31/3/18	9 to 31/3/19	10 to 31/3/20	11 to 31/3/21	
Anaerobic digestion	≤500kW	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	20
Anaerobic digestion	>500kW	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	20
Hydro	≤15 kW	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	19.9	20
Hydro	>15-100 kW	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	20
Hydro	>100 kW-2 MW	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	20
Hydro	>2 MW – 5 MW	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	20
MicroCHP pilot*	≤2 kW*	10*	10*	10*	10*	10*	10*	10*	10*	10*	10*	10*	10
PV	≤4 kW (new build**)	36.1	36.1	33.0	30.2	27.6	25.1	22.9	20.8	19.0	17.2	15.7	25
PV	≤4 kW (retrofit**)	41.3	41.3	37.8	34.6	31.6	28.8	26.2	23.8	21.7	19.7	18.0	25
PV	>4-10 kW	36.1	36.1	33.0	30.2	27.6	25.1	22.9	20.8	19.0	17.2	15.7	25
PV	>10-100 kW	31.4	31.4	28.7	26.3	24.0	21.9	19.9	18.1	16.5	15.0	13.6	25
PV	>100kW-5MW	29.3	29.3	26.8	24.5	22.4	20.4	18.6	16.9	15.4	14.0	12.7	25
PV	Stand alone system**	29.3	29.3	26.8	24.5	22.4	20.4	18.6	16.9	15.4	14.0	12.7	25
Wind	≤1.5kW	34.5	34.5	32.6	30.8	29.1	27.5	26.0	24.6	23.2	21.9	20.7	20
Wind	>1.5-15kW	26.7	26.7	25.5	24.3	23.2	22.2	21.2	20.2	19.3	18.4	17.6	20
Wind	>15-100kW	24.1	24.1	23.0	21.9	20.9	20.0	19.1	18.2	17.4	16.6	15.9	20
Wind	>100-500kW	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	20
Wind	>500kW-1.5MW	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	20
Wind	>1.5MW-5MW	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	20
Existing microgenerators transferred from the RO		9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	to 2027

* Note the microCHP pilot will support up to 30,000 installations with a review to start when the 12,000th installation has occurred

Figure 48: Generation tariffs available via the feed-in tariff to 2020[92]

[92] Table from Government's response to 2009 consultation on the FiT: www.decc.gov.uk/en/content/cms/consultations/elec_financial/elec_financial.aspx p.47.

9.3.2 Proposed support levels via the Renewable Heat Incentive

The following table summarises the proposed support levels for low carbon heat generators through the RHI. Note that these figures come from the consultation document and hence are subject to change.

Table 30: Proposed RHI tariff levels[93]

	Technology	Scale	Proposed tariff (p/kWh)	Deemed or metered	Tariff lifetime (years)
Small installations	Solid biomass	Up to 45kW	9.0	Deemed	15
	Bioliquids	Up to 45kW	6.5	Deemed	15
	Biogas on-site combustion	Up to 45kW	5.5	Deemed	10
	GSHP	Up to 45kW	7.0	Deemed	23
	ASHP	Up to 45kW	7.5	Deemed	18
	Solar thermal	Up to 20kW	18.0	Deemed	20
Medium installations	Solid biomass	45-500kW	6.5	Deemed	15
			2.0 (fuel tariff)	Optional: for metered kWh above deemed no. of kWh	15
	Biogas on-site combustion	45-200kW	5.5	Deemed	10
	GSHP	45-350kW	5.5	Deemed	20
	ASHP	45-350kW	2.0	Deemed	20
	Solar thermal	20-100kW	1.7	Deemed	20
Large installations	Solid biomass	500kW and above	1.6-2.5	Metered	15
	GSHP	350kW and above	1.5	Metered	20
Biomethane injection		All scales	4.0	Metered	15

93 Proposed tariff levels from the consultation document (p.46-47): www.decc.gov.uk/en/content/cms/consultations/rhi/rhi.aspx

9.4 Examples of local planning policy from other local authorities

This section presents a summary of local planning polices being used or under development by other local authorities across England. The policies selected are generally deemed to be at the forefront of CO_2 emissions reductions and/or renewable energy generation. This provides useful context to the current study and examples of the policies in use elsewhere have been used to inform the recommendations detailed in section 8.

Table 31: Summary of relevant local planning policies in use elsewhere in England

L.A.	Overview of local planning policies relating to CO_2 emission reduction
Ashford	Ashford Borough Council's Core Strategy was adopted in 2008. Policy CS10 aims to deliver zero carbon growth and requires all major development to incorporate sustainable design features. Minimum CSH levels, BREEAM ratings, and CO_2 reductions from on-site renewables are set for four area types. Any shortfall in the target to being carbon neutral may be met by financial contributions to enable residual carbon emissions to be offset elsewhere in the Borough. Policy CS8 (Infrastructure Contributions) states: '*a 'strategic tariff' will be used to secure contributions to help fund the strategic physical infrastructure and other facilities needed to support the sustainable growth of the Ashford Growth Area*'. The tariff is expected to be around £14,000 per dwelling (subject to viability) and may be used to fund strategic energy projects such as CHP and biomass.
Bedford Borough Council	Bedford adopted its Core Strategy and Rural Issues DPD in April 2008. Policy CP26 states that all new residential developments and non-residential developments over 500m^2 must reduce carbon emissions by a minimum of 10% against Building Regulation requirements (unless unviable). Furthermore, in developments of 50+ dwellings or over 1,000m^2, 10% of the energy consumed must be provided by de-centralised, renewable or low carbon technologies. Detailed guidance on the implementation of this policy is contained in a Climate Change and Pollution SPD, which sets out a requirement for all planning applications to be accompanied by a sustainability statement, which should include an energy audit to demonstrate the reduction of carbon emissions.

Central Bedfordshire	The Core Strategy and Development Management Policies for the North Area were adopted in November 2009. They set out the following policies: • ***Policy CS13: Climate Change*** – overarching policy that sets out the range of measures to be considered, including renewable energy, sustainable design and construction, high energy efficiency standards, tree planting etc. • ***Policy DM1: Renewable Energy*** – will consider favourably proposals for renewable energy and sets out requirements for proposals of more than ten dwellings or 1,000m^2 of non-residential floorspace to incorporate on-site or near-site renewable or low carbon energy generation. Developments should achieve 10% or more of their energy requirements through such sources unless it is demonstrated that this would be impracticable or unviable. • ***Policy DM2: Sustainable Construction of New Buildings*** – future housing development is expected to meet CSH requirements with non-residential development complying with Building Regulations. Supporting text encourages housing development to meet or exceed Code level 3 with non-residential meeting or exceeding BREEAM Excellent (for new development) or Good (refurbishments). Targets for specific developments may be pursued through the Site Allocations DPD.
Croydon	Policy EP16 of the 2006 UDP encourages developers to incorporate renewable energy technologies to reduce a development's CO_2 emissions by at least 10%. This applies to developments of 10 or more residential units or 1,000m^2 of non-residential space. Where these requirements cannot be met a planning obligation will be sought to secure savings through other local renewable energy schemes. The plan is supported by an SPG on renewable energy and also a planning advice note on 'Preparing Environmental Performance Standards' which sets out updated requirements in terms of the CSH (Code level 4) and BREEAM (Excellent). Updated policies are currently emerging through the Core Strategy Issues and Options, which is proposing even more stringent targets for major development (50% reduction in CO_2 emissions and at least 20% through renewable energy technologies). Similar targets based on CSH and BREEAM are proposed for major development prior to 2013.
Dover	Dover District Council adopted its Core Strategy in February 2010. Policy CP5 of the plan sets out the following sustainable construction standards: • New residential development permitted after the adoption of the Strategy should meet CSH level 3 (or any future national equivalent), at least Code level 4 from 1 April 2013, and at least Code level 5 from 1 April 2016. • New non-residential development over 1,000m^2 gross floorspace permitted after adoption of the Strategy should meet BREEAM Very Good (or any future national equivalent). • The Council will encourage proposals for residential extensions and non-residential developments of 1,000m^2 or less gross floorspace to incorporate energy and water efficiency measures. Where schemes are unable to comply with Policy CP5 supporting text allows for commensurate energy and water savings to be made elsewhere in the District through a financial contribution to the Council to enable it to help fund schemes that would make the savings. Specific targets have been set for the four Strategic Allocations in the district, in terms of the CSH and BREEAM.

Merton	The London Borough of Merton was the first local authority to include renewable energy targets in its UDP and is the namesake of the *Merton Rule*. The original targets of 10% of the site's energy demands to be met by on-site renewables, then 10% CO_2 reduction from on-site renewables, have been superseded by the requirements of the London Plan (see below). The emerging Core Strategy (2009) stipulates that the highest commercially viable level of the CSH should be attained.[94] Commercial development must be built to a minimum of BREEAM Very Good and incorporate renewable energy in line with the requirements of the London Plan or national guidance. Developments that fail to meet the policy requirements will be expected to make a financial contribution to the Merton Carbon Reduction Fund. It is understood that amendments to the draft policies are likely in light of emerging policies in the London Plan. A Development Control DPD and Sustainable Design and Construction SPD will be prepared to provide further policies and information aimed at carbon emissions reductions and renewable energy generation.
Milton Keynes	The current Milton Keynes Local Plan (2005) contains policies relating to sustainable construction (D4) and renewable energy (D5). All major developments (>5 dwellings / non-residential schemes > 1,000m^2) are expected to include energy efficiency and renewable energy, and achieve carbon neutrality or provide a financial contribution to a carbon offset fund. Renewable energy is expected to provide at least 10% of building energy use. Milton Keynes Borough Council published its Core Strategy (pre-submission publication) in January 2010. The existing policy has been further developed, identifying specific Code levels and BREEAM requirements for certain parts of the Borough. Carbon neutrality continues to be a requirement through a contribution to the Milton Keynes Carbon Offset Fund. A further proposed policy relates to 'Community Energy networks and Large Scale Renewable Energy Schemes', requiring that: • Developments of more than 100 homes should explore the potential for community energy networks. • Developments of more than 200 homes will require community energy networks, unless it is proven not to be feasible. • Where an existing local energy network is established developments will be expected to connect to the network where feasible. Where national standards exceed those set out in the Core Strategy the draft Core Strategy confirms that the former will take precedence. A Development Management DPD will be prepared which will include further policies on stand alone renewable energy schemes.

[94] Under Policy 9 of the draft Core Strategy point 'e' defines viability as '*an increase in cost of no greater than 3% of predicted unit sales price*'. Technical and economic viability of the targets are to be determined via the Merton Carbon Code Cost Calculator.

North Northamptonshire	The North Northamptonshire Core Strategy (2008) includes an energy target and specifies a Code level for new developments under Policy 14 (*Energy Efficiency and Sustainable Construction*). Targets are set for large developments including Urban Extensions ramping up from CSH3 until 2012 to CSH6 from 2016, with BREEAM/Eco-build ratings of at least Very Good through the plan period. Major development (10+ dwellings or 1,000+ m^2 gross floor area) '*should demonstrate that at least 10% of the demand for energy will be met on-site and renewably and/or from a decentralised renewable or low-carbon energy supply*'. A Supplementary Planning Document on Sustainable Design to help developers comply with Policy 14 was adopted in 2009. It sets out an energy hierarchy to be considered in all proposals which includes building design, energy efficiency and on-site renewables.

Originally local planning policies aimed at renewable energy / CO_2 reduction in new developments typically demanded a certain contribution to the site's anticipated energy demands from on-site renewables (e.g. Merton Rule). This is generally being replaced by a target CO_2 saving in recognition of the fact that the carbon intensity of energy from different 'renewable' technologies can vary significantly and that CO_2 emissions reduction is the ultimate goal. Feedback from developers consulted as part of this study suggests that policies that allow a more flexible approach to compliance with carbon reduction targets will be better received.

Many London boroughs draw on the London Plan in setting CO_2 reduction and renewable energy targets for new development. The key aspects of the London Plan are discussed below.

The London Plan

Responsibility for the production of planning strategy for London lies with the Mayor. The London Plan is the name given to the Mayor's spatial development strategy, which sets out '*an integrated economic, environmental, transport and social framework for the development of the capital over the next 20–25 years*'.

The London Plan has incorporated a Merton Rule-type policy into an energy hierarchy, which states that developers should seek to achieve a 20% reduction in the remaining CO_2 emissions of major new developments, once energy efficiency and efficient energy supply technologies have been employed. This approach is shown diagrammatically in Figure 49.

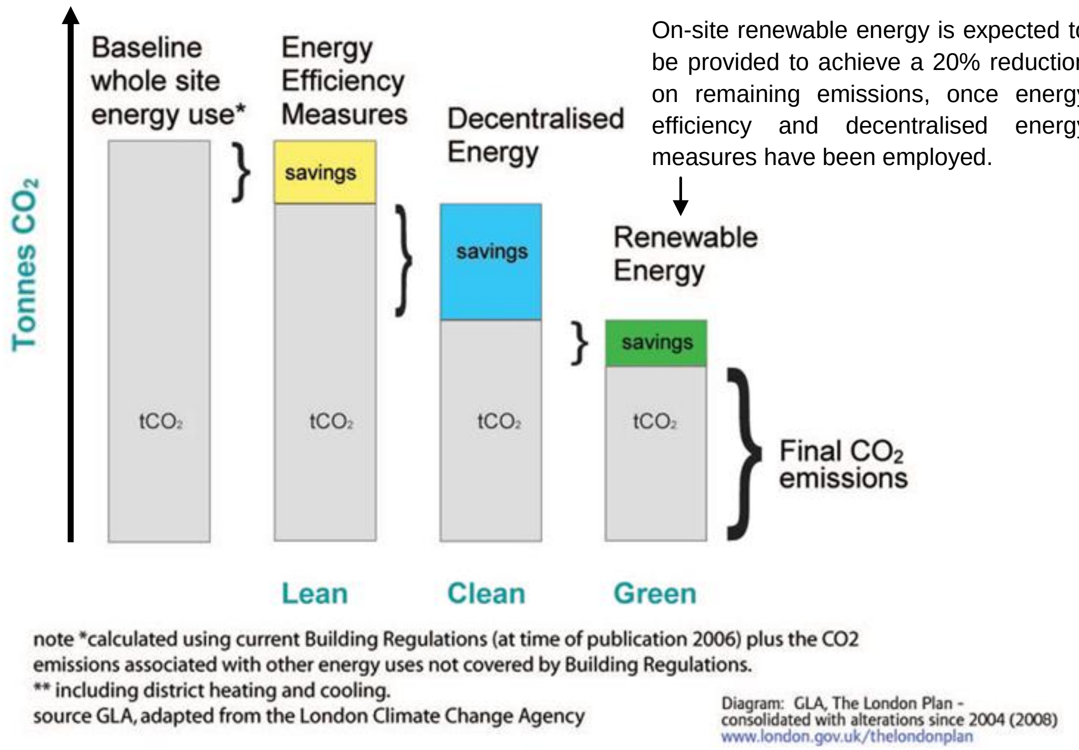

Figure 49: Hierarchy of CO_2 reduction to be followed by major developments in London, as defined by the London Plan

Emissions from whole site energy use include all regulated and unregulated CO_2 emissions. The savings from energy efficiency measures and decentralised energy are calculated relative to emissions of a Part L 2006 compliant design. The proposed replacement London Plan modifies the method summarised in Figure 49, and details are given below.

Potential changes to the London Plan

The Mayor of London published the draft replacement London Plan in October 2009 for a consultation which lasted until January 2010. Policy 5.2 relates to minimising CO_2 emissions from new developments in London, and includes the following key points:

A) Development proposals should minimise CO_2 emissions by following the be lean – be clean – be green energy hierarchy (as per the existing Plan).

B) All major developments should meet defined targets for CO_2 reduction (see below).

C) Major development proposals should include a detailed energy assessment to show how the targets will be met in line with the energy hierarchy.

D) Energy assessments should include calculation of baseline energy demand and CO_2 emissions based on all energy uses. This is to be followed by proposals to reduce emissions through energy efficient design, through decentralised energy, and through on-site renewable energy technologies.

E) CO_2 reduction targets should be met on site, unless it is clearly demonstrated that this is not feasible. In this case any shortfall may be provided off site or through a financial contribution to the relevant borough to deliver CO_2 savings elsewhere.

The defined targets for CO_2 reduction, and how they will change over time, are summarised in the figure below.[95]

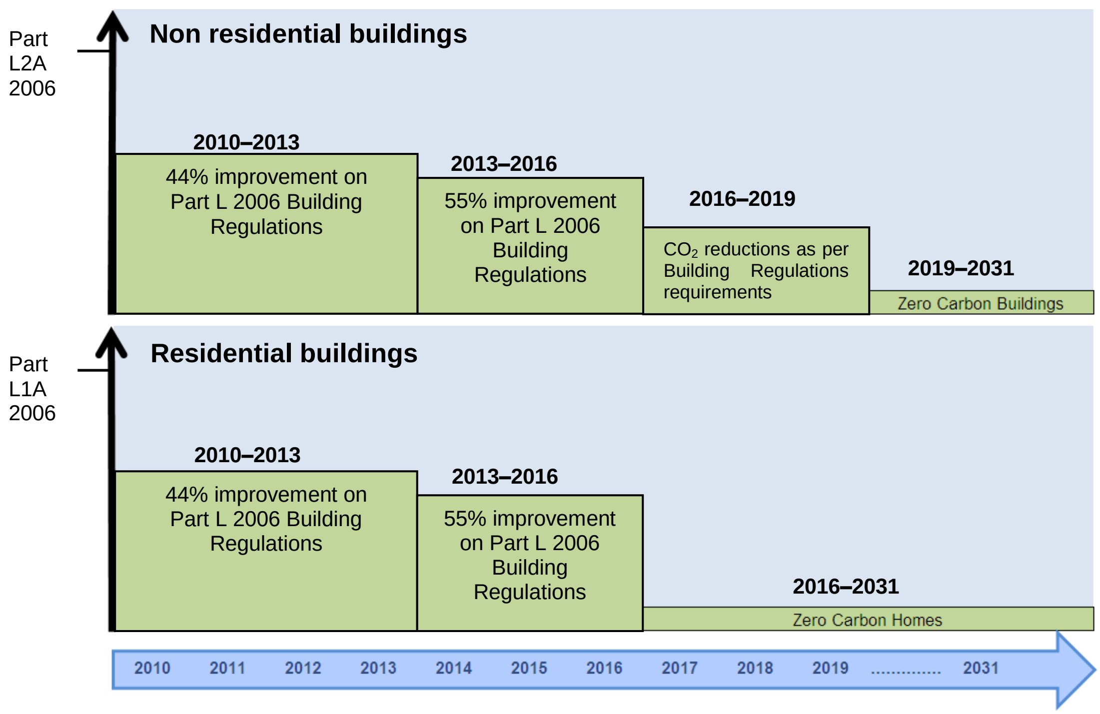

Figure 50: Summary of requirements for CO_2 reduction in the draft London Plan

The proposed changes, if adopted, will bring the London Plan into closer alignment with the Building Regulations in that the CO_2 reductions required will be calculated via a method consistent with that used to demonstrate compliance with Part L. In terms of timescales, the draft replacement London Plan is due for an Examination in Public, scheduled for summer and autumn 2010, and the final replacement London Plan is expected to be published towards the end of 2011.

[95] In line with most existing local planning policies the draft replacement London Plan includes a viability clause. Where it can be clearly demonstrated that specific targets cannot be achieved on site, any shortfall may be provided off-site or through a cash contribution in lieu to secure CO_2 savings elsewhere.

9.5 Details of emerging national planning policies

9.5.1 Planning Policy Statement 1 Supplement: Planning for a Low Carbon Future in a Changing Climate consultation

Consultation on the replacement of the PPS1 Supplement and PPS22 with a new Planning Policy Statement: **Planning for a Low Carbon Future in a Changing Climate** commenced in March 2010. The following policies are relevant:

9.5.2 Policy LCF 1

Policy LCF1.4 concerns the need for local authorities to assess their area for opportunities for decentralised energy. The focus is intended to be on opportunities at a scale, which could supply more than an individual building and include up-to-date mapping of heat demand and possible sources of supply. Local authorities will be expected to look for opportunities to secure:

i. '*decentralised energy to meet the needs of new development;*

ii. *greater integration of waste management with the provision of decentralised energy;*

iii. *co-location of potential heat suppliers and users; and,*

iv. *district heating networks based on renewable energy from waste, surplus heat and biomass, or which could be economically converted to such sources in the future*.'

At the regional level, the regional strategy will need to set ambitious targets for renewable energy, which are to be regarded as minima. These will need to be taken into account in preparing LDFs.

9.5.3 Policy LCF 4

Policy LCF4 sets out the local planning approach for renewable and low carbon energy and associated infrastructure. It is of key importance to how policies concerned with delivery through development management should be set out. It states:

'*LCF4.1 Local planning authorities should:*

i. *design their policies to support and not unreasonably restrict renewable and low carbon energy developments;*

ii. *ensure any local criteria-based policies, including local approaches for protecting landscape and townscape, that will be used to assess planning applications for renewable and low-carbon energy and associated infrastructure:*

a. *provide appropriate safeguards, so that any adverse impacts are addressed satisfactorily, but do not preclude the development of specific technologies other than in the most exceptional circumstances;*

b. *expect the scale and impact of developments in nationally recognised designations to be compatible with the purpose of the designation;*

c. *are informed by the approach and policies set out in the National Policy Statements for nationally significant energy infrastructure;*

iii. *ensure the development of renewable energy in any broad area set out in the regional strategy for where the substantial development of renewable energy is anticipated is not prejudiced by non-energy developments;*

iv. *set out how any opportunities for district heating (to supply existing buildings and/or new development) identified through heat mapping will be supported;*

v. *set out the decentralised energy opportunities that can supply new development proposed for the area; and,*

vi. *support opportunities for community-led renewable and low carbon energy developments, including the production, processing and storage of bioenergy fuels.*

LCF4.2 Strategic sites which are central to delivering the local planning approach for decentralised energy should be allocated in the core strategy.'

9.5.4 Policy LCF 6

In selecting sites for new development Policy LCF6 requires local authorities to assess their suitability for new development in respect of a range of low carbon and climate change issues, for example, the potential for decentralised energy and the potential to contribute heat demand.

9.5.5 Policy LCF 7

Policy LCF7: Local planning approach to setting requirements for using decentralised energy in new development states:

'LCF7.1 Local requirements for decentralised energy should be set out in a development plan document (DPD) and be derived from an assessment of local opportunities in line with LCF1.4. Local requirements for decentralised energy should:

i. *relate to identified development areas or specific sites;*

ii. *be consistent with giving priority to energy efficiency measures; and,*

iii. *focus on opportunities at a scale which developers would not be able to realise on their own in relation to specific developments.*

LCF7.2 Local requirements should be consistent with national policy on allowable solutions set out in support of the zero carbon homes and buildings policy.'

Where there are existing or firm proposals for decentralised energy supply systems with capacity to supply new development, LCF7.3 provides for local planning authorities to place an expectation on proposed development to connect to an identified system, or be designed to be able to connect in future. In allocating land for development, DPDs should set out how the proposed development would be expected to contribute to the decentralised energy supply system.

LCF7.4 specifies how local targets for the use of decentralised energy in new development should be expressed, that is either as:

- the percentage reduction in CO_2 emissions to be achieved. In doing so, local planning authorities should set out how the target relates to standards for CO_2 emissions set by Building Regulations; or,

- an amount of expected energy generation expressed in kWh.

LCF7.5 states that '*Where a local requirement relates to a decentralised energy supply system fuelled by bioenergy, local planning authorities should not require fuel sources to be restricted to local sources of supply*.'

9.5.6 Policy LCF 8

Given the forthcoming revisions to Part L of the Building Regulations, Policy LCF8[96] states that post 2013 the setting of targets across a local authority area will be unnecessary. In the interim the Secretary of State will support such targets in a development plan.

9.5.7 Policy LCF 9

In respect of the approach to setting requirements for sustainable buildings Policy LCF9 establishes a need for any local requirement for a building's sustainability to be set out in a DPD. It should:

i. '*relate to a development area or specific sites and not be applicable across a whole local authority area unless the justification for the requirement can be clearly shown to apply across the whole area;*

ii. *not require local standards for a building's performance on matters relating to construction techniques, building fabrics, products, fittings or finishes, or for ensuring a building's performance; and,*

iii. *be specified in terms of achievement of nationally described sustainable buildings standards. In the case of housing, this means a specific level of the Code for Sustainable Homes. Where local circumstances do not support specifying compliance with an entire Code level (because of the range of environmental categories covered) – or envisaged development could not attain the relevant Code level on all environmental categories – a local requirement can be stipulated solely in relation to the energy/CO_2 emissions standard and/ or water standard in an identified level of the Code*.'

[96] Policy LCF8: Local planning approach to setting authority-wide targets for using decentralised energy in new development.

9.5.8 Policy LCF 11

This policy relates to testing local planning requirements. Local requirements '*relating to decentralised energy, a building's sustainability or for electric vehicle charging infrastructure, will only be acceptable where the local planning authorities can demonstrate that it:*

i) *would not make new development unviable having regard to the overall costs of bringing sites to market, including the costs of any necessary supporting infrastructure;*

ii) *is, in the case of housing development, consistent with securing the expected supply and pace of housing development shown in the housing trajectory required by PPS3, and does not inhibit the provision of affordable housing; and*

iii) *will be implemented and monitored without duplication of applicable rating or assessment systems*.'

9.5.9 Policy LCF 13

Policy LCF13.2 states that local planning authorities should expect proposals to be designed to, amongst other things, reduce greenhouse gas emissions through a variety of measures including those related to:

- Site design.
- Building design.
- Adopting opportunities to support decentralised energy, to connect to an existing supply or be designed for future connection.

Proposals for major development (10 or more dwellings or 1,000sqm or more of commercial space) will be expected to demonstrate in their Design and Access Statement how the above requirements have been met. Where a proposal fails to meet criteria contained in LCF13.2 planning applications should be refused unless it can be demonstrated that meeting a criteria is not feasible. Under LCF13.4 innovation which secures well-designed, sustainable buildings is supported. It states that:

'*Planning permission should only be refused where the concern relates to a heritage asset protected by an international or national designation and the impact would cause material harm, or removal of significance in relation, to the asset and this is not outweighed by the proposal's wider social, economic and environmental benefits*.'

9.5.10 Policy LCF 14

Policy LCF14 sets out a range of requirements for local planning authorities when considering proposals for renewable energy. These are:

i. '*expect applicants to have taken appropriate steps to mitigate any adverse impacts through careful consideration of location, scale, design and other measures, including through ensuring all reasonable steps have been taken, and will be taken, to minimise noise impacts;*

ii. *give significant weight to the wider environmental, social and economic benefits of renewable or low-carbon energy projects whatever their scale, recognising that small-scale projects provide a valuable contribution to cutting greenhouse gas emissions, and not reject planning applications simply because the level of output, or number of buildings supplied, is small;*

iii. *not require applicants for energy development to demonstrate the overall need for renewable or low-carbon energy;*

iv. *expect developers of decentralised energy to support the local planning approach for renewable and low-carbon energy set out in the local development framework and, if not, provide compelling reasons consistent with this PPS to justify the departure; but, otherwise, not question the energy justification for why a proposal for renewable and low carbon energy must be sited in a particular location;*

v. *not refuse planning permission for a renewable energy project because a renewable energy target set out in the RS has been reached; but where targets have not been reached this should carry significant weight in favour of proposals when determining planning applications;*

vi. *take great care to avoid stifling innovation, including by rejecting proposals for renewable energy solely because they are outside of a broad area identified in a RS for where substantial development of renewable energy is anticipated;*

vii. *where the proposed development is for a renewable energy technology included in the National Policy Statement for Renewable Energy Infrastructure, or associated infrastructure, expect applicants to follow the approach to assessment and apply themselves as far as practicable the approach to decision making and mitigation set out in National Policy Statements; and,*

viii. *recognise that when located in the Green Belt elements of many renewable energy projects will comprise inappropriate development, which may impact on the openness of the Green Belt. Careful consideration will therefore need to be given to the visual impact of projects, and developers will need to demonstrate very special circumstances that clearly outweigh any harm by reason of inappropriateness and any other harm if projects are to proceed. Such very special circumstances may include the wider environmental benefits associated with increased production of energy from renewable sources*.'

9.5.11 **Policy LCF 15**

Policy LCF15 requires local planning authorities to consider the likely impacts of proposed development on:

i. '*existing or other proposed development and their supply of, or potential for using, decentralised energy; and,*

ii. *existing, or proposed, sources of renewable or low carbon energy supply and associated infrastructure*.'

Where proposed development would prejudice renewable or low carbon energy supply, amendments to a proposal should be considered, to make it acceptable. Where this is not achievable planning permission should be refused.

9.6 Energy strategy and major sites analysis – data and assumptions

9.6.1 Low carbon technologies – cost and performance data

Key cost and performance figures for the technologies evaluated in section 4.3 are given below. Costs are in 2010 prices and based on recent quotes from equipment suppliers and installers and benchmark figures.

Table 32: Technology cost and performance assumptions

Technology	Installed capital cost	Performance data
ASHP	£2,770–£3,445 depending on dwelling size	Space heating COP = 3.0 DHW COP = 2.0
GSHP[97]	£3,930/flat based on borehole system serving a block of 20 flats and capital cost of £1,025/kW Costs for houses based on trench systems with total installed capital cost of £800/kW and heat pump capacities between 6 and 10kW depending on dwelling size	Space heating COP = 3.5 DHW COP = 2.5
Biomass HOB (individual)	£9,000/dwelling	85% boiler efficiency
Biomass HOB (community)	Price varies with boiler size – from £600/kW_{th} for a 20kW_{th} boiler to £350/kW_{th} for a 3MW_{th} boiler or above.	85% boiler efficiency
Gas CHP	£1,000/kW_e for small systems (up to 75kW_e), £750/kW_e for medium systems (75–250kW_e), and £500/kW_e for large systems (>250kW_e)	82% overall efficiency Heat to power ratio = 1.3
Biomass CHP	£6,800/kW_e based on a 450kWe organic rankine cycle system	80% overall efficiency Heat to power ratio = 4.5
PV	£4,300/kW_p	850kWh/kW_p.yr electricity output
Solar thermal	£1,265/installation + £520/m^2	0.7kW_p/m^2 Output calculated according to SAP 2009 methodology
Wind	£3,000/kW for turbines <250kW £2,500 for 250–500kW turbines	Average load factor of 25%

[97] Cost data taken from a guidance document published by the Energy Saving Trust: ***Domestic Ground Source Heat Pumps: Design and installation of closed loop systems***. www.energysavingtrust.org.uk/Publication-Download/?p=1&pid=242. This suggests that the total installed costs of borehole systems range from £800–£1,250/kW and £600–£1,000/kW for trench systems. The mean figures were used for the purposes of this study.

	£1,500/kW for turbines >500kW	

9.6.2 Fabric improvement analysis – cost data

The energy efficiency cost analysis presented in section 4.2 is based on the data summarised below. Extra over costs relative to the 'Reference' fabric were calculated based on these data.

Table 33: Cost data for residential fabric packages (costs in £/m^2 of building element)[98]

Element	U value (W/m^2.K)	Cost of building element (£/m^2)	
		Masonry	Timber frame
Windows & Doors	1.8	255	255
	1.5	260	260
	1.1	281	281
	0.7	333	333
Ground floor	0.25	107	107
	0.20	110	110
	0.15	114	114
	0.10	123	123
External wall	0.30	118	131
	0.25	121	133
	0.20	123	137
	0.15	126	148
Roof	0.18	10	10
	0.15	12	12
	0.13	14	14
	0.10	17	17

The costs of improving air permeability from a baseline of 10m^3/m^2.hr to values of 7, 4 and 1 were taken as £500, £850 and £1,300 respectively. These are indicative figures and costs can vary on a project-by-project basis.

[98] From cost data held by Element Energy and used in recent reports for Government, e.g. in assessing the costs of building to the Code for Sustainable Homes. All U values in W/m^2.K.

9.6.3 District heating and cost of gas connection assumptions

The costs of district heating networks are sensitive to many factors, including pipe selection (pre-insulated steel vs. flexible pipework), peak thermal capacity, system layout, ground conditions etc. Community heating systems are generally characterised by some level of fixed costs (e.g. for heat interface units and heat meters) and a cost that will vary more significantly on a site-by-site basis depending mainly on build density. The data below represent generic costs and are derived from a study undertaken for the Department for Energy and Climate Change.[99]

Table 34: District heating and gas connection cost assumptions

Development	Dwelling density (dph)	Cost of district heating (£/dwelling)				Cost of gas connection (£/dwelling)
		Flat	Terraced	Semi	Detached	
City infill	80	3,800	N/A	N/A	N/A	250
Medium urban	50	4,800	6,347	7,617	7,617	300
Greenfield	30	5,300	8,217	8,217	8,217	500
Strategic	40	5,300	6,690	6,690	6,690	500

The cost of gas connection is used as an offset cost benefit for energy strategies that displace individual gas boilers in dwellings.

9.6.4 Major sites analysis – key assumptions

The major sites analysis undertaken to inform the target setting draws on the cost analysis presented in section 4.3, hence the cost data presented above are relevant.

Given the very high levels of uncertainty around the commercial development in the mixed use sites a high-level approach to estimating additional build costs was adopted. This was based on assumed levels of CO_2 saving for each Part L revision (the level of emission reduction that will be required on-site for non-residential development is currently unclear) and a conservative estimation of capital cost increase to achieve the carbon saving of £100 per lifetime tonne saving required. Key assumptions are presented in the following tables.

Table 35: Total emission reduction required by Part L standard for non-residential development

	Reduction in regulated emissions relative to Part L 2006			
	Part L 2010	Part L 2013	Part L 2016	Part L 2019
All non-residential development	25%	44%	70%	Zero carbon

The zero carbon standard requires all regulated and unregulated emissions to be offset.

[99] *The Potential and Costs of District Heating Networks*, Pöyry and Aecom for DECC (April 2009).

Table 36: Key assumptions relating to non-residential development

Building use	Base build cost (£/m^2)	Part L 2006 emissions ($kgCO_2/m^2.yr$)		Increase in base build cost to achieve BREEAM rating	
		Regulated	Unregulated	Very Good	Excellent
A1: Shops	1,315	136	13	0.5%	5.0%
A3: Restaurants / Cafes	1,000	66	31	0.5%	5.0%
A4: Pubs	1,000	66	31	0.5%	5.0%
B1a: Office	940	53	26	0.2%	7.0%
B1b: R & D	1,500	53	26	2.0%	3.4%
B1c: Industrial process	1,000	53	26	2.0%	3.4%
B2: General industrial	1,000	68	0	0.5%	5.0%
B8: Storage / distribution	745	21	5	0.5%	5.0%
C1: Hotels	1,830	57	13	0.5%	5.0%
D2: Assembly & leisure	1,500	98	14	0.0%	1.9%

These data were derived from the following published studies:

Definition of zero carbon homes and non-domestic buildings, DCLG consultation, December 2008 – for baseline CO_2 emissions (Part L 2006 compliant designs).[100]

Zero carbon for new non-domestic buildings, DCLG consultation, November 2009 – for baseline build costs.[101]

Putting a price on sustainability, BRE Centre for Sustainable Construction (2005).

[100] www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinition, Table 6, p.67.
[101] www.communities.gov.uk/publications/planningandbuilding/newnondomesticconsult, p.33.

9.7 Renewable energy resource assessment – methodology

9.7.1 Heat mapping

The methodology for generating the heat density maps presented in section 5.4 is summarised below.

- Buildings in Chesterfield borough were provided by CBC as GIS-compatible files, from which an estimate of the internal floor area of each building could be made.
- Each buildings was assigned a type, from residential to retail, office, hotel etc (a total of over thirty building types were used). Each building type was allocated a specific energy consumption figure (kWh/m^2.yr), based on published benchmark data.
- Estimates of the energy consumption of each building were made by multiplying specific energy consumption by total floor area of the building. These estimates were checked against published data on the gas consumption by MLSOA in Chesterfield borough in order to calibrate the results.[102]
- The demands of buildings within defined grids (e.g. 100m x 100m) were summed to find average heat demand at certain levels of resolution. This allows identification of areas of high heat density and hence potential opportunity for district heating networks.

9.7.2 Wind resource mapping

The wind speed maps presented in section 5.3 are based on results from the NOABL (National Oceanic and Atmospheric Administration Boundary Layer Model) database, which are available from DECC.[103] These data give estimates of mean annual wind speed in 1km square grids throughout the UK, based on an air flow model which estimates the effect of topography on wind speed. Data are held at heights of 10m, 25m and 45m above ground level. It should be noted that these data give an estimation of wind speeds and should not be relied upon for assessing the suitability of a site for wind turbine development.

[102] See, for example: http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk//whatwedo/energy/statistics/regional/mlsoa-electricity-gas/page50221.html.

[103] www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/explained/wind/windsp_databas/windsp_databas.aspx

9.8 Biomass suppliers

A list of biomass suppliers active in the local area is given in the table below.

Table 37: Biomass suppliers active in the Chesterfield borough area

Supplier	Website	Type of biomass supplied			
		Briqu-ettes	Logs	Pellets	Wood chips
Briquette and Pellet Ltd	www.briquetteandpellet.co.uk	✓		✓	
Catton Estate	www.catton-hall.com		✓		✓
English Wood Fuels Ltd	www.englishwoodfuels.co.uk			✓	✓
Logs2U	www.logs2u.co.uk		✓		
Midlands Bio Energy Ltd	www.midlandbioenergy.co.uk	✓		✓	

A further potential source of biomass for fuel is Chesterfield Borough Council itself, which currently produces around 300 tonnes of wood waste annually from management of its own estates. At present the bulk of this material is chipped and composted.

The above suppliers are based in the Derbyshire area and therefore provide a local fuel source. Biomass may also be obtained from any one of a range of national suppliers. A National Woodfuel Suppliers database is maintained by the Biomass Energy Centre and is available online.[104]

104 www.biomassenergycentre.org.uk/portal/page?_pageid=77,225275&_dad=portal&_schema=PORTAL.

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