Stroud District Council

Development Location Comparison and Carbon Footprinting Study

Final Report

AMEC Environment & Infrastructure UK Limited

September 2011

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Final Report

AMEC Environment & Infrastructure
UK Limited

September 2011

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Executive Summary

Purpose of this Report

Stroud District Council (the Council) has commissioned AMEC Environment & Infrastructure UK Ltd (AMEC) to assess the carbon footprint associated with seven different 'spatial options' to inform the preparation of the Stroud Core Strategy. The Core Strategy will be the key planning policy document guiding growth and development in the District over the next 15-20 years, with planning for carbon reductions a fundamental priority in response to national Government policy. Alongside a process of Sustainability Appraisal (SA), AMEC's assessment will help the Council understand the implications of different spatial options on carbon emissions and so inform the strategy that is ultimately adopted.

The outcomes provide a clear understanding of how the various development options might perform from the point of view of CO_2 emissions and their contribution to the renewable energy potential of Stroud District. The seven options proposed for the Core Strategy are as follows:

- **Option A** – Concentrated growth point strategy;
- **Option B** – Concentrated development strategy;
- **Option C** – Cluster strategy;
- **Option D** – Stroud Valleys strategy;
- **Option E** – Town and country combination strategy;
- **Option F** – Rural communities strategy; and
- **Option G** – Dispersal strategy.

The study has been carried out in several phases:

- **Phase 1** provides an understanding of baseline emissions in the District, current potential for renewable and low carbon energy schemes and a summary appraisal of the impact of the seven spatial options;
- **Phase 2** provides a more detailed assessment of the 'best performing' options identified from Phase 1, with consideration given to specific types of development and sites which the Council expects may come forward in the District; and
- **Phase 3** provides a summary of conclusions and key recommendations from the study.

Conclusions

Phase 1

The key findings from the Phase 1 assessment can be summarised as follows:

- Transport and opportunities for district heating are the only two factors that both have a significant impact on CO_2 emissions **and** vary significantly between options;
- Options A and B offer the greatest potential for emissions reductions due to opportunities for low carbon heating networks and the scale of each development can help minimise vehicle movements;
- Option D is the option which offers the greatest potential after Options A and B;
- The dispersed options (F and G) perform relatively poorly as the potential for district heating is low and higher vehicle movements are almost inevitable;
- Despite the differences, all options offer significant potential to reduce CO_2 emissions. However, this study focuses on the maximum CO_2 emissions reductions expected to be feasible at each option. Such reductions will only be realised with strong policy and a concerted effort by all stakeholders to ensure emissions are minimised as far as possible.

► **Although there is good scope to reduce CO_2 emissions from new growth for all options, Options A, B and D present the best opportunity.**

Phase 2

As a result of the Phase 1 findings, Options A, B and D were considered in greater detail in Phase 2. The key findings from the Phase 2 assessment can be summarised as follows:

- Options A and B have the potential to achieve greater CO_2 emissions reductions via on-site energy technologies than Option D, as they are better suited to large, low carbon district heating schemes. There is very little to differentiate between Option A and B in this regard;
- Option D requires sites to be grouped together and developers to work together in order to maximise opportunities for district heating. It is expected to be much more challenging to achieve in reality than for the large single sites under Options A and B;
- All options have similar *potential* to reduce emissions associated with transport. However, depending on which specific site is chosen Option A could have considerably higher emissions than Options B and D. Option B also varies depending on the two chosen sites, but less so than Option A. Given that Option D is centred in one location, the emissions should not vary significantly regardless of the exact

sites developed. More detailed investigation of potential travel habits is advisable if deciding between sites using this measure;

- There is a significant variation in the performance of individual sites within each option with respect to travel. Sites at Sharpness and Cam perform notably worse than the others, the majority of which are predicted to have similar associated emissions;

- There are possible opportunities at some sites to use low carbon waste heat, but there is much uncertainty at this stage. However if definite potential is identified in future (e.g. should the decision be taken to locate an Energy from Waste (EfW) plant near Whitminster or Hunts Grove), these sites would be at a significant advantage regarding CO_2 emissions. The Dairy Crest facility could potentially supply heat to development at the West or Stonehouse or Eastington sites, but the quantities of heat and whether it is recoverable is not known;

- None of the ‘other’ factors are of significance when differentiating between sites in terms of CO_2 emissions reduction potential. The flood risk potential does vary however, and should be considered carefully when selecting sites; and

- Option D allows regeneration of existing brownfield sites. However development may be much more scattered, and supplying a significant proportion of new development via low carbon district heating is likely to be challenging (more so than for Options A and B). Realisation of a widespread low carbon heating network would require careful planning.

Selection of the site at Brimscombe and Thrupp under Option B effectively results in a hybrid scenario of Options B and D. As such, development of a district heating network at this location would be more challenging than the other options, but transport performance is good.

- ► **The potential CO_2 emissions from transport are broadly similar for all Options, except if the site at Sharpness is chosen under Options A which will result in significantly higher emissions.**
- ► **The potential to reduce CO_2 emissions from on-site energy is similar for Options A and B. A large scale communal heating system, required to give higher emissions reductions, is expected to be very challenging to achieve for Option D.**

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1. Introduction

1.1 Overview

1. Stroud District Council are currently preparing a Local Development Framework (LDF) for the District and have consulted on seven potential ‘spatial options’ for the Core Strategy based around where new development might be located up to 2026. To help inform the decision as to which of these options to take forward, the Council has commissioned AMEC Environment & Infrastructure UK Ltd (AMEC) to ascertain the likely effects of each option on the District’s carbon footprint (specifically carbon dioxide [CO_2] emissions from energy use in buildings, and transport). As part of this, the impact of the options with respect to meeting objectives for sustainable construction in new developments – including energy efficiency and use of renewable and low carbon energy technologies – is also considered, alongside viability.

2. Alongside the Council’s Sustainability Appraisal (SA) this study will provide a key piece of evidence to inform the preparation of the Core Strategy and strategic decisions regarding future development and its implications for the District’s CO_2 emissions and carbon footprint. The need to reduce CO_2 emissions associated with energy generation and use is fundamental to the mitigation of future climate change, with responding to climate change central to national and local policy priorities.

3. This study therefore examines the implications of the seven spatial options in relation to:

   - Minimising or mitigating factors that contribute to climate change;
   - Adapting to the consequences of climate change; and
   - Providing energy resilience and security.

4. The outcomes provide a clear understanding of how the various development options might perform from the point of view of CO_2 emissions and their contribution to the renewable energy potential of Stroud District. It should be noted that the assessment of options is based on spatial options which are necessarily ‘strategic’ in nature and underpinned by a number of assumptions (e.g. levels of growth, location and mix). The assessment is therefore based on the level of detail available for each option at the time of the study. As more detailed options emerge the conclusions made in this assessment may therefore need to be refined.

1.2 Spatial Options Assessed in the Study

5. The seven options proposed for the Core Strategy are as follows:

- Option A – Concentrated growth point strategy;
- Option B – Concentrated development strategy;
- Option C – Cluster strategy;
- Option D – Stroud Valleys strategy;
- Option E – Town and country combination strategy;
- Option F – Rural communities strategy; and
- Option G – Dispersal strategy.

6. Each option has merits and potential drawbacks in relation to CO_2 emissions and sustainability which are considered in this study. There are, of course, a wider range of other factors that the Council will consider as part of the Core Strategy process, through Sustainability Appraisal (SA) and public consultation (e.g. economic growth, meeting housing needs, the role and function of settlements, etc). CO_2 emissions will therefore be just one of the factors that the Council will take into account in developing its spatial strategy.

1.3 Report Structure

7. This report is presented in three phases:

- **Phase 1** provides an understanding of baseline emissions in the District (Stage 1a), current potential for renewable and low carbon energy schemes (Stage 1b) and a summary appraisal of the impact of the seven spatial options (Stage 1c);
- **Phase 2** provides a more detailed assessment of the 'best performing' options identified from Phase 1, with consideration given to specific types of development and sites which the Council expects to come forward in the District; and
- **Phase 3** provides a summary of conclusions and key recommendations from the study.

PHASE 1 – OVERVIEW ASSESSMENT

2. Stage 1a: Baseline Position

2.1 Purpose of this Section

8. This section presents an overview of Stroud District with respect to its key characteristics affecting planning for carbon reductions and provides an estimate of current CO_2 emissions from the built environment; that is the energy used to heat and power the District's homes, offices, schools and other buildings.

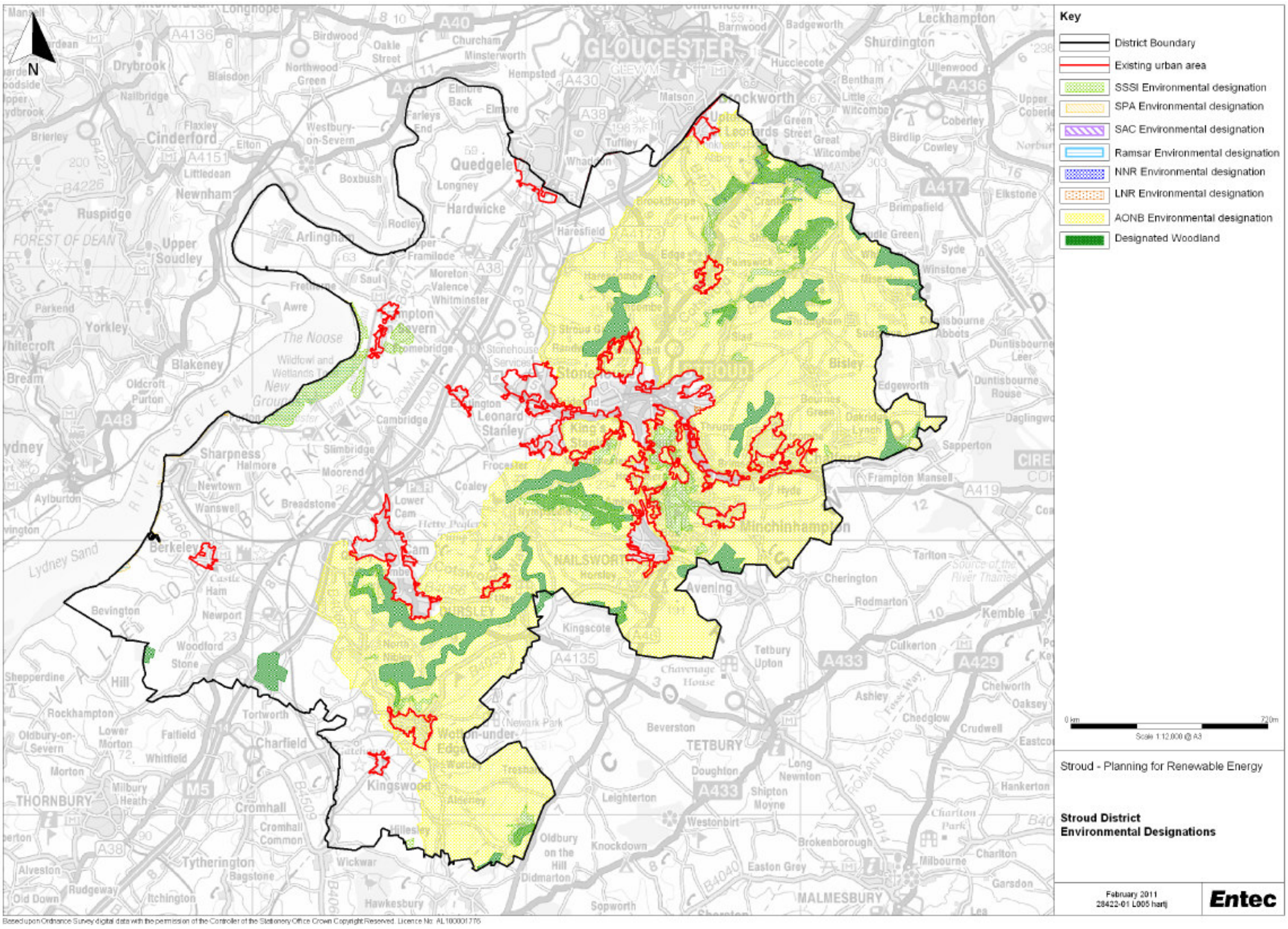
2.2 Spatial Context

9. Stroud is a predominantly rural District with varying topography: hilly in the west towards the Cotswold Hills and relatively flat and fertile in the east towards the River Severn. Figure 2.1 shows the environmental designations and urban areas located within the Stroud District boundary. These are broken down by type and proportion of total area in Table 2.1. It is important to note these designations at the outset because they will have implications for the take-up of renewable and low carbon energy projects and wider growth options proposed for the District.

Table 2.1 Environmental Designations Identified within Stroud District

Designation	Area (km^2)	Proportion of Stroud District
Area of Outstanding Natural Beauty (AONB)	234.0	51.0%
National Nature Reserve (NNR)	3.9	0.9%
Local Nature Reserve (LNR)	0.3	0.1%
Site of Special Scientific Interest (SSSI)	17.4	3.8%
Special Area of Conservation (SAC)	8.0	1.8%
Special Protection Area (SPA)	2.8	0.6%
Ramsar Wetlands of International Importance	2.8	0.6%
No Environmental Designation	188.6	41.2%

Figure 2.1 Environmental Designations and Identified Settlements



2.3 Baseline CO_2 Emissions from the Built Environment

10. Stroud District currently emits around 490,000 tonnes of CO_2 per year as a result of energy usage in the built environment (assuming no contribution from renewable or low carbon sources of energy). Energy consumption and CO_2 emissions from the built environment in Stroud District are shown in Table 2.2 for the year 2008. This is based on the latest official figures on energy consumption published by the Department of Energy and Climate Change (DECC). CO_2 emissions have been calculated assuming a carbon factor of 0.184 $kgCO_2/kWh$ for natural gas and 0.554 $kgCO_2/kWh$ for electricity (source: Defra, 2009). Though natural gas is the dominant fuel used for heating, oil is also used throughout the District although official figures are not readily available on consumption.

Table 2.2 Energy Demand and CO_2 Emissions from the Built Environment (2008 Figures)

Type		Energy Demand (GWh)	CO_2 Emissions (tonnes)
Residential	Electricity	237	131,488
	Gas	660	121,434
Commercial	Electricity	332	184,152
	Gas	274	50,436
Total	**Electricity**	**569**	**315,640**
	Gas	**934**	**171,869**

Source: Department of Energy and Climate Change (DECC)
(http://www.decc.gov.uk/en/content/cms/statistics/regional/regional.aspx)

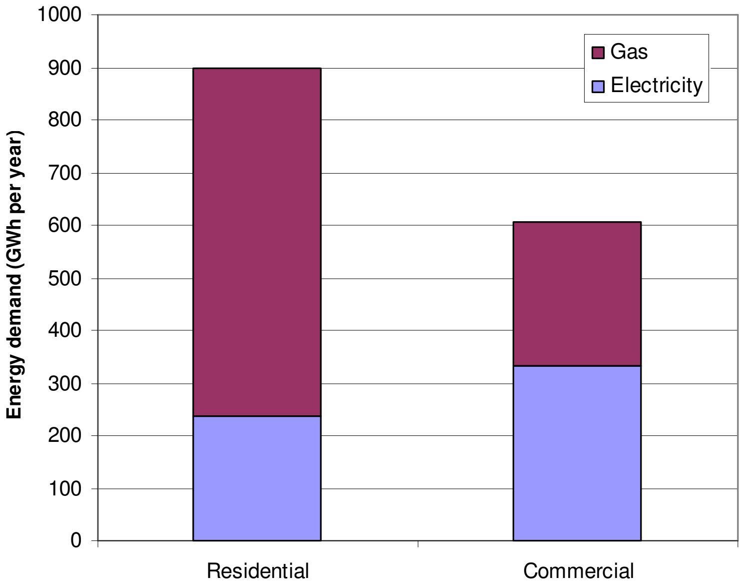
11. The average gas consumption per household in 2008 was 16,918 kWh which is consistent with the Great Britain[1] average. Average electricity consumption was 15% higher (4,823kWh compared to a Great Britain average of 4,198 kWh). The relatively high electrical consumption could be a reflection of the generally affluent nature of the District, with homes being larger on average with proportionally fewer flats and terraced properties than more urbanised areas. However gas consumption is consistent with the national average, most likely because any increased demand for heat as a result of housing size and type is offset by the relatively mild climate of Gloucestershire (and the South West region in general) in comparison to Great Britain as a whole.

2.4 Summary

12. This section demonstrates that Stroud's existing built environment accounts for CO_2 emissions totalling some 490,000 tonnes per annum, based upon reported consumption of gas and electricity alone. How these emissions can be reduced is a key consideration for the Council, both in terms of the potential for energy efficiency measures and, in planning policy, through helping to support the take-up of new renewable and low carbon energy projects. In addition, the Council needs to understand how new growth and development as a result of each strategy option will impact on these baseline emissions and contribute towards delivering a 'low carbon' District. This broad low carbon and sustainable development aspiration has been consistently expressed through Core Strategy public consultation feedback to date. In the next section the potential for renewable and low carbon energy projects is therefore explored.

[1] Note GB rather than the UK as a whole as figures exclude Northern Ireland

Figure 2.2 Energy Demand in Stroud District (2008 Figures)



3. Stage 1b: Renewable & Low Carbon Energy Potential in Stroud District

3.1 Overview

13. In addition to energy efficiency, one way to help reduce CO_2 emissions associated with new growth is to help facilitate the take-up of renewable and low carbon energy projects, and new development offers an excellent opportunity for the installation of such technologies. The potential for renewable and low carbon energy in Stroud District was considered as part of the Renewable Energy Study recently produced by AMEC for Gloucestershire County Council (GCC)[2] and this assessment builds on these results.

14. This section summarises the key opportunities and constraints for renewable and low carbon energy projects specific to Stroud District as identified by the County-wide study. The findings relate specifically to large scale wind (i.e. 2.5-3MW rated turbines), hydro schemes, biomass, large-scale solar photovoltaics and waste.

3.2 Wind

15. By mapping technical and environmental constraints across the District it is possible to identify those 'least constrained' areas (

Figure 3.3). These are not areas that are necessarily suitable in planning terms for wind development because this will need to reflect detailed appraisals at a site-specific level, but areas where the greatest potential is seen to exist. In addition, it is crucial to note that wind may have potential outside of these least constrained areas pending the results of site-specific survey work, therefore the results of the analysis should not be interpreted as meaning wind development within these areas should be resisted (note: refer to the County-wide study for further detail on AMEC's methodology for assessing wind potential).

16. Table 3.1 shows the results of the Gloucestershire-wide analysis applied only to Stroud for large-scale (rated at 2-3MW installed capacity) wind developments. Note that similar results can be expected for medium scale turbines (above 500kW installed capacity) and so these are not considered separately. Two scenarios have been used here: one where environmental designations (Figure 2.2) are interpreted as insurmountable constraints to wind development and one where they are not. At a practical level environmental constraints should not be seen as an insurmountable barrier to development, with national policy in PPS7 and PPS22 not preventing such development, subject to the application of criteria reflecting potential effects, including cumulative effects (e.g. landscape and visual impacts). In March 2010, Government launched a consultation on

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[2] Renewable Energy Study – Phase 2, AMEC, February 2011

a combined PPS[3] which suggests that "*depending on their scale and impact, renewable and low carbon energy developments should be capable of being accommodated in most locations. Planning should ensure that adverse impacts on the environment are addressed satisfactorily but applications for cutting-edge, well-designed buildings should not be turned down simply because they do not look familiar*" (para 17). The Draft National Planning Policy Framework was also published for consultation in July 2011. This is intended to replace all PPSs. As a draft this does not fundamentally change the guidance set out in current planning policy in relation to wind energy (although it should be taken as a material consideration in planning decisions) but it does state "*Local planning authorities should not refuse planning permission for well-designed buildings or infrastructure which promote high levels of sustainability because of concerns about incompatibility with an existing townscape unless the concern relates to a designated heritage asset and the impact would cause material harm to the asset or its setting, and this harm is not outweighed by the proposal's wider social, economic and environmental benefits*". The draft NPPF does not alter the outcomes of this assessment.

Table 3.1 Wind Assessment Results

Environmental Designations Considered a Constraint?	Total Area (km^2)	No. of Large Scale Wind Turbines	Installed Capacity (MW)	Estimated Yield (MWh/y)
Yes	9.82	200	500	1,314,000
No	11.17	221	553	1,452,000

Estimated yield assumes an overall capacity factor of 30% - a commonly applied industry average. Further information is available at – http://www.bwea.com/ref/capacityfactors.html

17. Figure 3.1 below shows the effect of environmental designations being considered a constraint[4] on the potential yield from developments within Stroud. Again this is based on the assumption of large-scale wind turbines (see Figure 3.2 for an indication of scale).

[3] Planning for a Low Carbon Future in a Changing Climate, CLG

[4] Environmental constraints considered here include data on SAC, SPA, SSSI, RAMSAR, NNR provided by Natural England

Figure 3.1 Annual Energy Yield Large-scale Wind for Stroud District

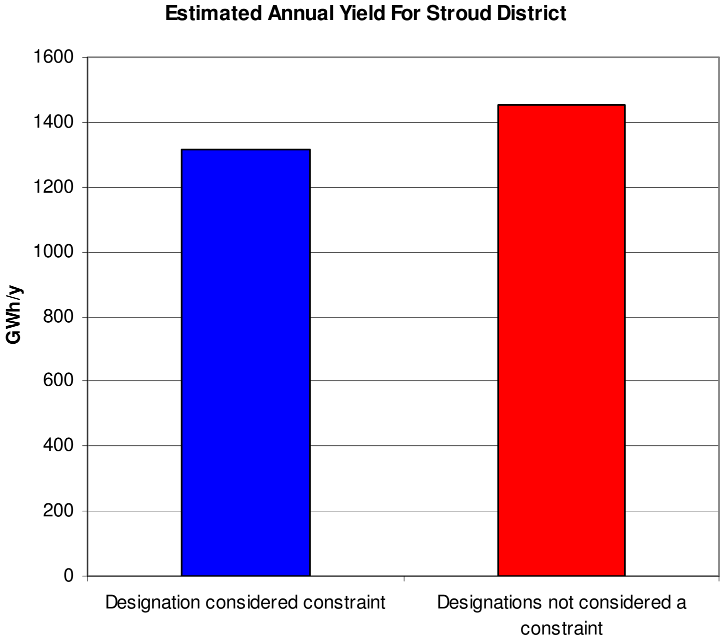
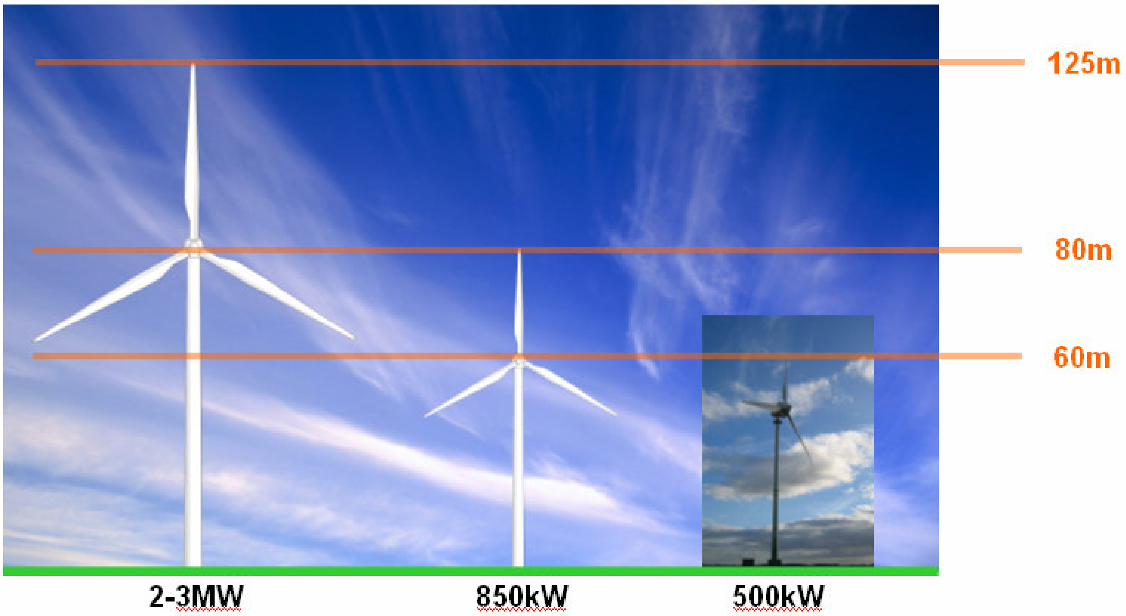


Figure 3.2 Typical rating and relative height of available wind turbines

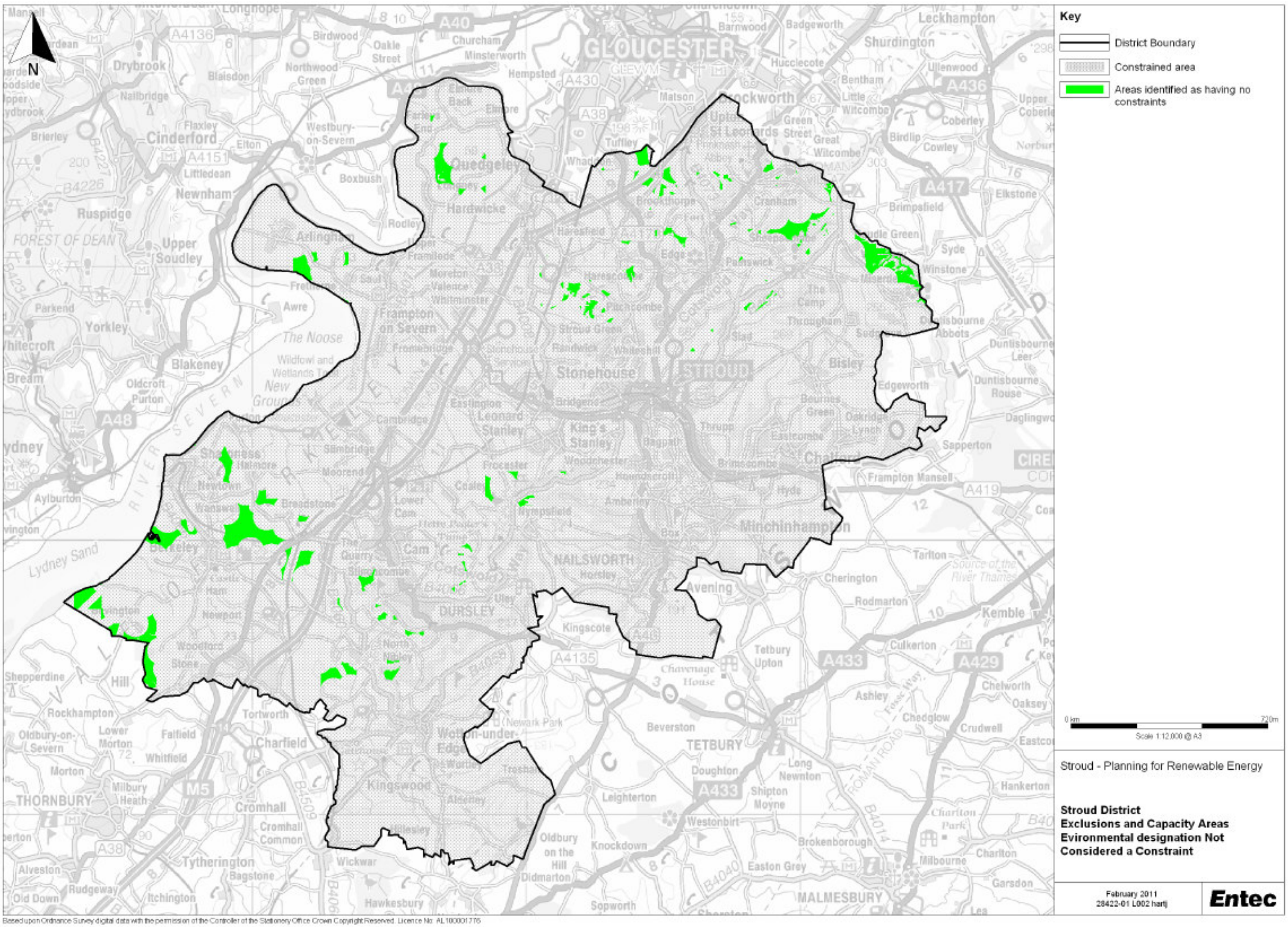


Source: AMEC. Note - The dimensions of a 3MW turbine are broadly the same as for a 2MW turbine for the purposes of this study. The 500kW turbine shown is the 500kW Enercon E-40 near Nympsfield in Stroud District, and is shown to illustrate relative turbine sizes.

18. The potential for wind development is heavily influenced by existing (or proposed) housing and businesses as noise limits are a key consideration when establishing if a particular site is developable. The constraints considered for this assessment are shown in Box 1. Other potential constraints to the development of wind turbines include shadow flicker, visual impact, impact on wildlife (bats and birds primarily) and aviation safety among others, but these constraints are generally not technical restrictions and cannot be modelled in a generic manner. A map showing the areas free from the aforementioned constraints is provided in Figure 3.3.

19. The potential for small scale turbines is limited by the number of suitable existing properties in Stroud (estimated by the Gloucestershire County Study to be of the order of up to 9,000 homes in Stroud District based purely on an estimate of properties numbers in rural areas with sufficient wind resource) and it is not possible to provide an annual yield estimate from small scale wind turbines as the output of each machine can be significantly affected by local ground conditions/obstructions.

Figure 3.3 Areas with Potential for Large-Scale Wind Turbines (where Environmental Designations are not considered a constraint)



Box 1 Overview of the wind appraisal methodology

The 'accessible wind resource' is that which could come forward pending detailed site specific consideration of national, regional and local planning policy criteria (including PPS22: Renewable Energy), the statutory planning process, Environmental Impact Assessment, site-specific wind speeds, stakeholder consultation (local planning authority, communities, town and parish councils, MOD, NATS En Route Radar Ltd and airports for example) as well as landowner and developer interest.

Accessible wind resources is identified by first agreeing the study area and then:

- **Mapping wind speeds** - a general rule of thumb is that a NOABL wind speed greater than 6 metres per second (m/s) at 45 metres height is necessary for a viable wind turbine (.NOABL is the UK Wind Speed Database, http://www.bwea.com/noabl/index.html). NOABL is used at the outset for an *initial* consideration of wind speeds in an area with a*t least* 6 m/s at 45m. More detailed data is available (e.g. Carbon Trust Model) which can also be used to assess viability and wind developers will undertake local monitoring to assess wind speeds and subsequent viability further;

- **Considering noise** - distance to sensitive receptors including houses and settlements. The ETSU R-97 report, written by the Wind Noise Working Group, recommends a night time noise limit of 43dB(A) to ensure no sleep disturbance (measured from the window or door of a house). Modelling the distance/noise relationship for a single turbine implies that beyond 360 metres from a 2-3MW turbine, noise should be below the 43dB(A) recommended limit, excluding consideration of any background noise levels. AMEC's approach applies a buffer distance of 500 metres, which also accounts for multiple turbines (noting that two turbines would not double the noise experienced). At 500 metres and beyond noise levels will be 40dB(A) or lower, excluding consideration of any background noise levels;

- **Applying a buffer to key infrastructure (roads, rail and power lines)** – turbines may be unsuitable within 125 metres of roads, rail and power lines, due to what is sometimes called the 'topple distance'. This is an engineering term reflecting the need to consider the location of wind turbines in relation to key infrastructure. It is highly unlikely that a wind turbine will actually fall over. There may be site specific cases where it is possible to locate a turbine closer to infrastructure, though 125m is a reasonable buffer for the purposes of an initial assessment;

- **Identifying environmental designations -** landscape and ecological, for example key nationally designated sites of landscape or ecological value which may be more sensitive to the potential effects of wind turbines. For the purposes of assessing the potentially accessible wind resource environmental designations are generally considered a constraint, though it is important to note that planning policy (PPS7 and PPS22) *does not* prevent wind development within such areas, subject to the application of policy criteria reflecting potential effects, including cumulative effects (e.g. landscape and visual). We have therefore undertaken the assessment in two forms: one in which such designations are considered constraints, and one in which they are not;

- **Mapping other constraints -** microwave communication links and rivers. Mapped microwave links from 2003 OFCOM database with 100m buffer – areas excluded as potential interference may preclude development;

- **Establishing areas of search -** areas with no identified constraints;

- **Estimating the accessible wind resource** - the number of turbines that could be accommodated within the unconstrained areas. It is possible to estimate the accessible potential by plotting wind turbines within the unconstrained areas. The location of these wind turbines is based on separation distances to account for turbulence (6 blade diameters by 4 blade diameters in the prevailing wind direction [310 degrees from north in the UK]).

An estimate can then be made of the level of electricity generation that could be supplied from these turbines.

Hydro

20. The number of sites with potential for hydropower schemes (termed 'barriers' as they are obstructions to the river flow) is provided in Table 3.2. This table also gives an estimate of the estimated power output from each site. The information is taken from a study carried out by AMEC on behalf of the EA[5].

Table 3.2 Number of Barriers in Power Categories

Installed Capacity (kW)	No. Barriers	Total Installed Capacity (kW)
0 - 10 kW	50	223
10 - 20 kW	23	319
20 - 50 kW	17	520
50 - 100 kW	2	129
100 - 500	0	0
500 - 1500	0	0
Total	**92**	**1191**

21. The 92 barriers identified can be classified into four categories; weirs, dams, waterfalls and sluices. The vast majority (89) of those are weirs, with the remainder consisting of one dam, one waterfall and one sluice.

22. Table 3.2 suggests that there are a number of opportunities for hydropower systems within the District; however the vast majority (89%) of sites are predicted to yield a power output of under 50kW which is small. Additionally, many of the schemes under 10kW may not be a viable proposition given the very low output. The best potential for larger schemes in the District is on the River Frome catchment that bisects Stroud town and the local historical association with watercourses for power, transport and cloth making processes.

23. The ~1MW of potential described above makes no exclusions for environmental designations. In reality a hydropower scheme might be prevented from development if it is located within a Special Area of Conservation (SAC) that is designated for fresh water habitats. Within the Stroud District boundary there are only small areas of designated SACs (less than 2% of the total area focused on the Commons and their limestone grasslands, Cotswold Beechwoods and the River Severn) and therefore these are not expected to impact significantly on the potential.

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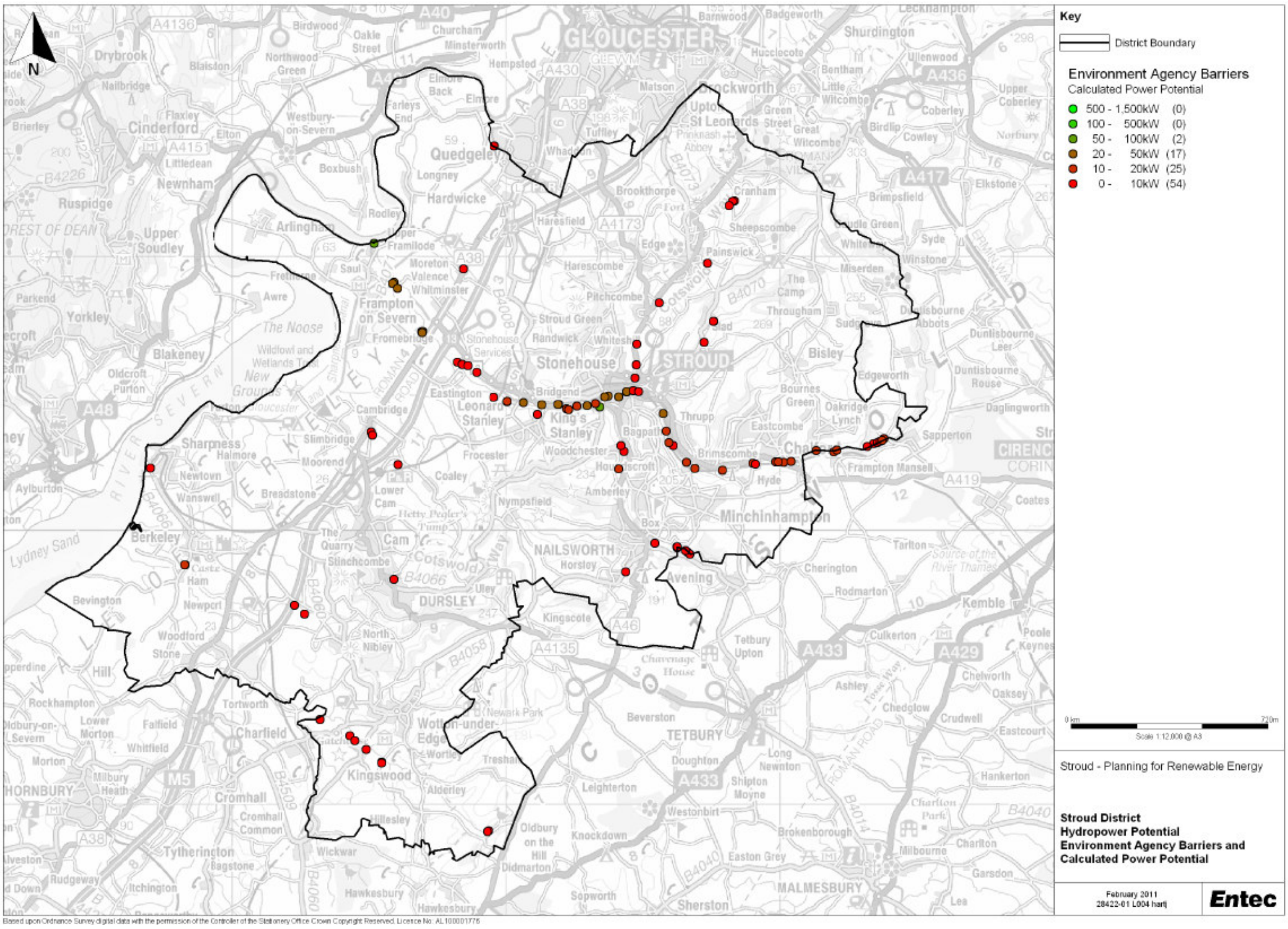
[5] http://www.environment-agency.gov.uk/shell/hydropowerswf.html

24. As Stroud District is bordered by the River Severn, there may at some time in the future be potential for the development of tidal energy opportunities. Currently however, the future for tidal energy on the Severn and the development of small scale tidal technologies that could be part of a development scheme remain highly uncertain and have thus not been included within this study.

Figure 3.4 Locations with Potential for Hydropower in Stroud District



Note – this figures shows also some barriers adjacent to but not within Stroud District

3.3 Biomass

25. Biomass for energy purposes can be obtained from a number of sources as identified below:

- Forestry and woodland management – often a significant and underused existing resource;
- Park and gardens – a potential source of woodchip;

- Agricultural arisings – straw and animal manure in particular;
- Energy crops – crops specifically grown for energy purposes; and
- Wetlands – managing habitat for reed, sedge and rush as a biomass resource.

26. The identified woodland areas are located across the District in a band passing from the north east to the south west; these areas are shown in Figure 3.5. The wooded areas cover an area of 24.7 km^2, or approximately 5% of the total District area. At present there is limited supply of or demand for biomass in Stroud, but there is potential to produce biomass fuel from existing woodlands or by growing energy crops specifically for fuel purposes. There has been some activity at small scale, such as a successful recent scheme to produce biomass briquettes from waste sawdust as a replacement fuel for use in solid fuel boilers[6]. Schemes such as this could be expanded or replicated across the district, helping to provide renewable energy and potentially alleviating fuel poverty in areas off the gas network.

27. Given the potential for long distance transportation of biomass, potential supply can be considered effectively unlimited; however the same is not true of local arisings. It should be noted that the carbon footprint of the fuel increases proportionally with transportation distance, as does the cost.

28. The Environment Agency has consulted upon proposals to manage flood risk on the Severn Estuary which includes proposals for managed realignment schemes within Stroud District (Slimbridge and Arlingham). The proposed managed realignment is likely to create large areas of mudflats and saltmarsh areas. There *may* be opportunity for biomass crops to be established but as the plans are still to be confirmed, potential sensitivity of the habitats to be created is uncertain and the timescales proposed are lengthy, this possible opportunity has not been included within this study.

29. Also of note is a recent pilot project carried out by the Farming and Wildlife Advisory Group (FWAG) to help restore Longdon Marsh, near Upton-upon-Severn in Worcestershire. The project involves growing crops in wetland areas, which can be harvested for use in an Anaerobic Digestion (AD) plant as well as helping to restore biodiversity and habitats. The AD plant in this case is to be located near Malvern, and the electricity, heat and CO_2 produced supplied to greenhouses. There may be good opportunities to replicate or carry out similar projects in wetland areas in Stroud District (particularly the Severn estuary region between Sharpness and Arlingham). AD plants using wetland biomass feedstock could be co-located with greenhouses (as per the pilot project), or supply energy to development associated with new growth in Stroud.

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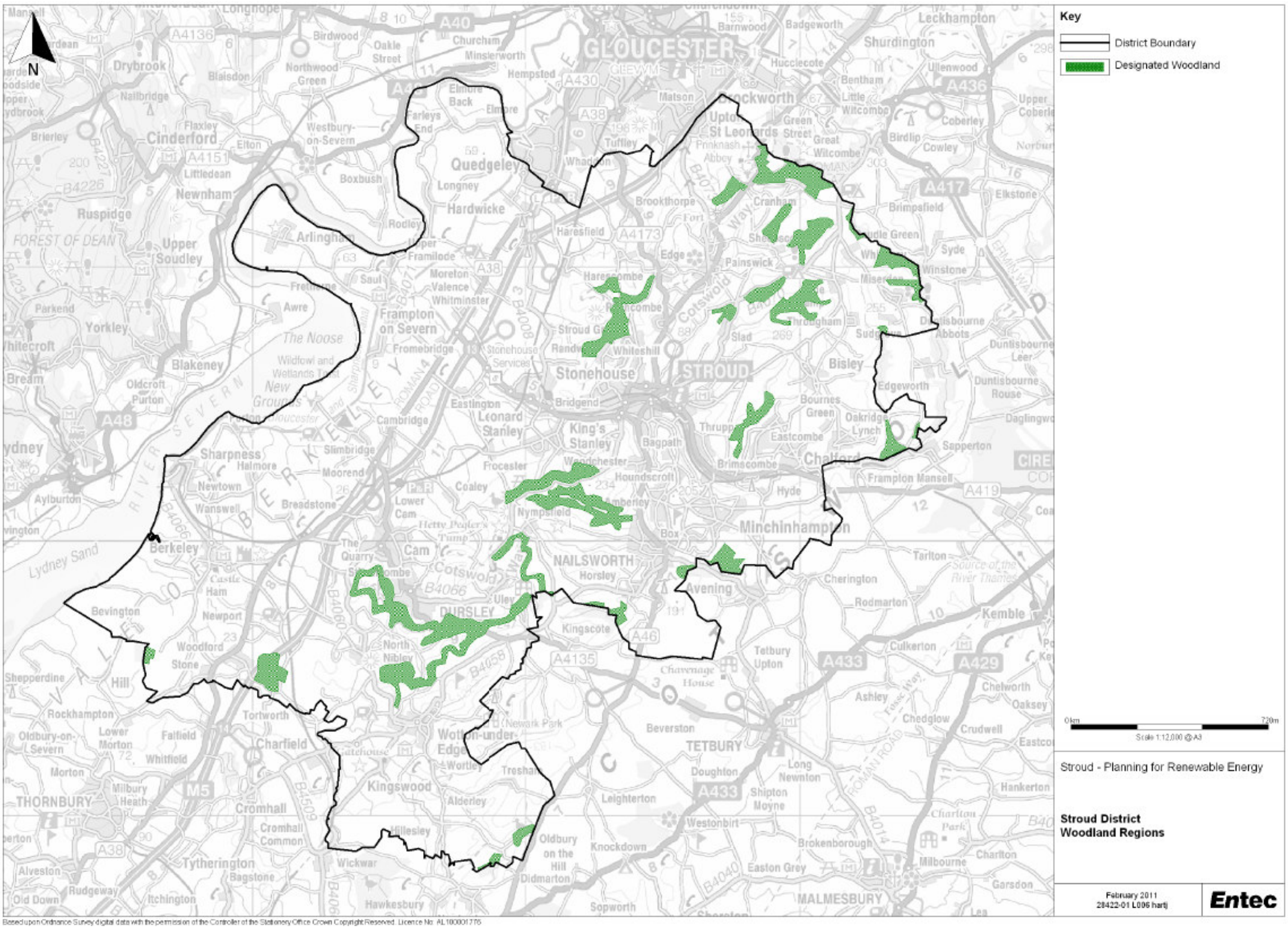
[6] http://www.stroudtown.gov.uk/index.php?option=com_content&task=view&id=168&Itemid=43

Figure 3.5 Main Woodland Areas in Stroud District



3.4 Large-Scale Photovoltaics

30. There is good potential for large scale photovoltaic (PV) arrays within the District. The requirements are relatively few; a suitable area of land and good exposure to sunlight year round with little shading being the primary requirements. However, as large PV schemes can have an obvious visual impact their development may be restricted within the AONB. The introduction of feed-in tariffs (FIT) for renewable energy generators in 2010 led to considerable interest in developing large-scale PV arrays; it is important to note however that a review of the FIT for large scale solar in March 2011 has resulted in the subsidies being reduced considerably for PV installations with an installed capacity of greater than 50kW, which has seen developer interest in projects of this nature fall considerably given that the economics are less favourable.

31. Large scale arrays have no major adverse environmental issues beyond visual impact, though this can be significant as they may take up a considerable area of land. Careful consideration of location and extensive consultation at planning stage is therefore essential in much the same way as it is for large scale wind turbines.

3.5 Waste

32. The County-wide study identified total tonnages of waste material that could be available for energy recovery in Gloucestershire. In Gloucestershire municipal waste is currently collected by the Districts with the vast majority of residual (post-recycling) material disposed of to landfill. GCC are currently involved in a procurement process for a centralised treatment facility or facilities for treating residual waste from the six Districts, which could include thermal treatment with energy recovery. As part of this process it is possible that a large scale energy from waste (EfW) plant could be built in Stroud District with two sites in the north west (Javelin Park and Moreton Valence) earmarked as possible locations for 'strategic' scale residual waste treatment plant[7]. Considerable heat would be available from such a facility, and as a waste by-product it is a low carbon source. New development in the vicinity could potentially benefit from using this heat, though until there is further clarity on the chosen site and technology it is not possible to understand the true potential.

33. In addition, there is good scope for smaller-scale AD plant in the District, which could be fed with food waste from separate household collections, or farm and industrial effluent. Such facilities could supply renewable electricity and heat to neighbouring development. As AD plants are generally much smaller scale than EfW plants, the opportunities for locating close to residential areas are generally greater with potential to use much of the available heat and electricity. In addition there is more flexibility regarding where AD plant could be located than there is for large scale EfW facilities. SDC are currently considering the potential to locate an AD plant fuelled by the District's household (and possibly some commercial) food waste next to the leisure centre at Stratford Park[8]. The plant could provide more than double the electricity required by the centre, with surplus heat contributing to heating the pool and buildings.

3.6 Micro-renewables

34. Micro-renewables are small scale renewable energy systems that are typically installed on or inside the property which they supply. Technologies include solar thermal and PV panels, ground and air source heat pumps (not strictly renewable but low carbon) and domestic biomass boilers and stoves. Roof mounted wind turbines also fall under this category, but are often ineffective particularly in built-up areas.

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[7] Strategic scale defined as treating in excess of 50,000 tonnes per year of waste (as per the Gloucestershire Waste Core Strategy – accessed from http://www.gloucestershire.gov.uk/index.cfm?articleid=17991)

[8] http://www.stroud.gov.uk/docs/press_releases.asp?doit=detail&nid=1838

4. Stage 1c: Spatial Options Appraisal

35. In this section of the report we consider the relative performance of the seven spatial options in terms of sustainability, and particularly impact on climate change mitigation and adaptation.

36. Table 4.1 sets out the options that Stroud District Council presented as part of the consultation on the Core Strategy. It is proposed that all options will have the same number of dwellings and total floor area of commercial, but the spatial distribution varies considerably from a single concentrated development to a large number of small, well scattered sites.

Table 4.1 Core Strategy Spatial Options

Strategy Option	Estimated Development Mix	
A: Concentrated Growth Point Strategy	1 mixed use development consisting of:	Residential: 2000 dwellings General industrial: 46,240 sq.m General office: 19,000 sq.m Warehousing & distribution: 50,000 sq.m Retail & leisure: 12,000 sq.m
B: Concentrated Development Strategy	2 mixed use developments consisting of:	Residential: 1,000 dwellings General industrial: 23,800 sq.m General office: 9,050 sq.m Warehousing & distribution: 25,000 sq.m Retail & leisure: 6,000 sq.m
C: Cluster Strategy	8 mixed use developments consisting of:	Residential: 250 dwellings General industrial: 5,780 sq.m General office: 2,375 sq.m Warehousing & distribution: 6,250 sq.m Retail & leisure: 1,500 sq.m
D: Stroud Valleys Strategy	3 mixed use developments consisting of:	Residential: 200 dwellings General industrial: 4,624 sq.m General office: 1,900 sq.m Warehousing & distribution: 5,000 sq.m Retail & leisure: 1,200 sq.m
	14 mixed use sites consisting of:	Residential: 100 dwellings General industrial: 2,312 sq.m General office: 950 sq.m Warehousing & distribution: 2,500 sq.m Retail & leisure: 600 sq.m

Table 4.1 cont. Core Strategy Spatial Options

Strategy Option	Estimated Development Mix	
E: Town and Country Combination Strategy	1 mixed use development consisting of:	Residential: 1,000 dwellings General industrial: 23,800 sq.m General office: 8,820 sq.m Warehousing & distribution: 25,000 sq.m Retail & leisure: 6,000 sq.m
	15 mixed use developments consisting of:	Residential: 66 dwellings General industrial: 1,526 sq.m General office: 627 sq.m Warehousing & distribution: 1,650 sq.m Retail & leisure: 396 sq.m
F: Rural Communities Strategy	25 mixed use developments consisting of:	Residential: 80 dwellings General industrial: 1,851 sq.m General office: 762 sq.m Warehousing & distribution: 2,001 sq.m Retail & leisure: 486 sq.m
G: Dispersal Strategy	40 mixed use developments consisting of:	Residential: 50 dwellings General industrial: 1,156 sq.m General office: 475 sq.m Warehousing & distribution: 1,250 sq.m Retail & leisure: 300 sq.m

Assumptions based on information contained in "Core Strategy Consultation: A mini guide to Alternative Strategies for shaping the future of Stroud District", Stroud District Council (2010)

4.1 Climate Change Mitigation

37. The size, scale and spacing of new developments can influence their CO_2 emissions. For instance, larger towns can encourage people to live nearer where they work, shop and spend their leisure time. This helps minimise emissions from travel. Also some of the most effective low-carbon technologies, such as biomass CHP, are only viable above a certain scale, implying that larger schemes have the potential to be more carbon efficient.

38. However, while location and scale affects the ability to reduce emissions in some ways, there are a number of factors that influence CO_2 emissions performance that bear very little relation to spatial location. In this section we discuss each of the key factors in turn, with typical CO_2 emissions reductions quantified where possible. The purpose is to demonstrate the impact of development scale and spatial location, and hence to compare each option in terms of potential for reducing emissions, with a summary provided in Section 4.1.7.

39. The factors considered are as follows:

i. Development mix – type and number of buildings comprising the development;

ii. Transport – travel distances;

iii. Building integrated renewable energy – micro-generation, primarily solar technologies;

iv. District heating systems – communal systems using low carbon fuel/technology;

v. Impact on renewable resource – potential to diminish resource by spatial location of development; and

vi. Construction efficiencies – potential emissions reductions as a result of bulk construction.

40. This section illustrates the strength of each of these effects on carbon emissions and shows which have the greatest overall influence. To simplify the comparison we estimate the order of magnitude of emissions for each dwelling, where an average dwelling has $90m^2$ of floor area. Though the analysis is based on residential properties, the results are also broadly applicable to commercial development.

4.1.1 Mix of Development

41. It might be intuitive to think that the mix of building types within a development affects the emissions. For instance the carbon emissions from a flat might be different to those of a house. However, data from the cost analysis of the Code for Sustainable Homes[9] show that the emissions per unit floor area are fairly constant across all main building types, as these are driven mainly by the energy efficiency rating of the buildings. In other words the efficiency ratings for different buildings do not vary substantially by their type.

42. The typical sizes and occupancy of different types of dwelling do vary. Houses typically accommodate more people than flats for instance, and similarly houses are larger than flats. However, if the same number of people are to be housed by a development and each is to have the same average floor area allocated to them, then the total floor area of the development remains the same.

43. This means that so long as the combined floor area of the whole development remains the same, the same number of people are housed and the efficiency standards of all the buildings is the same then the mix of building types does not affect the overall emissions of the development.

[9] Cost Analysis of the Code for Sustainable Homes, Communities and Local Government, July 2008

4.1.2 Travel

44. The carbon emissions from travel depend on where people live in relation to their workplaces, shops, recreation facilities and services. Typically these services are concentrated in and around centres of population. For instance a town is more likely to host facilities such as a hospital, shopping centre and a variety of businesses than a village.

45. To understand the influence of travel distances on carbon emissions we take a simple approach. We assume that each house represents a family that needs to travel to a centre of population to work, shop or recreate. Each family makes one return trip five days each week.

46. In truth not all families will travel this much and some will travel more. The exact mix will depend greatly on the demographics and industry of the area. However, these assumptions are sufficient to gauge the strength of the effect of commuting distances from towns.

47. In addition to these emissions are those from travel to other places on special occasions, such as holidays and work trips. Such trips are not included in this analysis since they can be assumed not to vary substantially with location of the dwellings themselves.

48. The typical carbon emissions for different types of vehicle over different commuting distances are detailed in Appendix A. Table 4.2 then shows the same for a family travelling five days per week for 52 weeks of the year. Further background to transport emissions is provided in Appendix D.

Table 4.2 Annual transport emissions per dwelling

	Each-way Journey Distance [miles]	Carbon Emission [kg/dwelling/year]			
		Small Car	Large Car	Bus	Train
Town	1	107	215	25	45
	2	214	431	50	89
	3	321	646	75	134
	4	428	862	100	179
	5	536	1,077	126	223
	6	643	1,292	151	268
	7	750	1,508	176	313
Village	8	857	1,723	201	358

Note: Emissions values taken from transportdirect.info March 2011. Assumes each dwelling houses one family, each family makes five return journeys each week for 52 weeks of the year.

49. This shows, for instance, that a family could save around 1 tonne of CO_2 a year from car transport emissions if they move home from a village 8 miles from a town to a home within the town. This is approximate, assuming the emissions of a typical car are towards that of the small car (figures quoted for large car are particularly high). If they used public transport then this would save them 0.2 – 0.3 tonnes per year. There is therefore a strong link between transport emissions and the development scale and location.

4.1.3 Building-Integrated Renewable Energy

50. The potential for building-integrated renewables, such as solar PV and solar hot water is similar for any dwelling in any location. Careful design is still required to ensure that each property has a suitable exposure to the resource, for instance each must have an unshaded south-facing roof.

51. Different types of dwellings offer different potential for renewable energy. For instance houses tend to have more of their own roof space that can be used, whereas flats share roof space making it more difficult to share the resource. However, so long as the mix of building types within a portfolio of developments is the same then the renewable energy potential of the portfolio is broadly the same.

52. Building-integrated renewables do offer emissions savings over non-renewable alternatives. To show the strength of this effect we compare the emissions from three different dwelling types with and without solar PV and solar hot water systems in Table 4.3.

Table 4.3 Emissions savings for solar energy systems compared to conventional systems for a 90 m^2 dwelling

CO_2 Emissions [kg per m^2]		Conventional Supply	Solar Hot Water	Solar PV	Solar Hot Water and PV
Heat		20	17	20	17
Electricity		22	22	16	16
Total Emissions		42	39	35	32
Total saved compared to conventional supply		0	3	7	10
Total per property ($90m^2$/property)	Total	3,761	3,496	3,162	2,898
	Saving	**0**	**265**	**598**	**863**

Based on emissions factors in Appendix A

53. The potential for using large-scale resource-dependent renewable energy technologies is not affected by either the size or location of the dwelling developments they serve. The potential use of building-integrated renewables is also unaffected by the size and nature of the dwelling developments.

54. Using solar PV and solar thermal systems might save a typical 90m^2 dwelling in the region of 0.2 – 0.9 tonnes of CO_2 each year.

4.1.4 District Heating

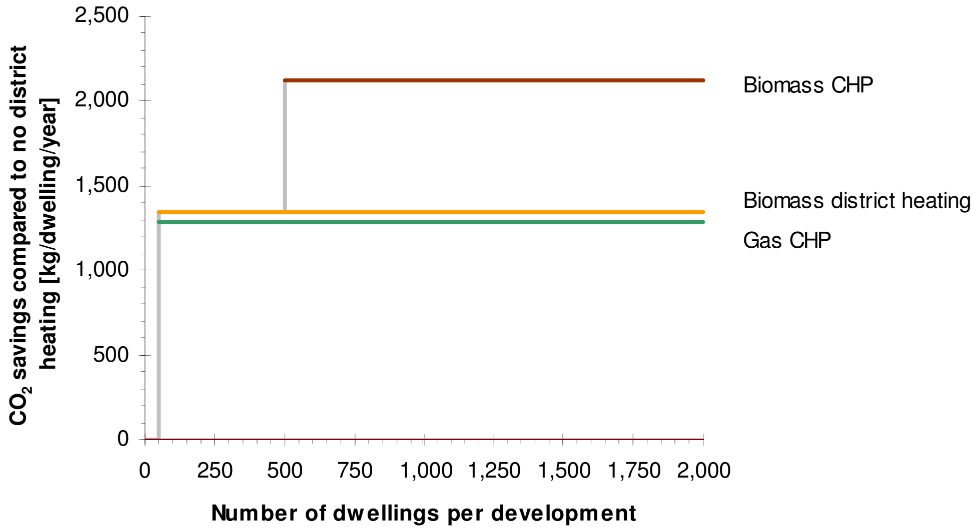
55. In order to reduce emissions beyond the level possible via technologies such as solar, low carbon heating systems can be used. Centralised heating systems fuelled by biomass or gas CHP can cut emissions considerably. However there is a minimum size at which communal heat plant coupled with district heating scheme becomes viable. A low carbon district heating system for a small number of properties is generally not feasible or cost effective, but a scheme may become viable for a development of 50 houses or more. Conventional gas CHP and biomass heating can supply relatively small developments, whereas biomass CHP is usually sensible only for large schemes, because of the additional fuel storage and infrastructure required.

56. To show the strength of this effect we assume that in the base case all houses could be supplied by mains gas and electricity. We then consider the carbon emissions savings compared to this baseline for a typical 90m^2 dwelling from using each type of technology described above. Table 4.4 shows the likely savings for a house, and which technologies are viable at each scale of development. Conventional systems are viable at all scales, whereas biomass CHP, for instance, is currently feasible only for schemes of around 500 homes of more.

Table 4.4 Emissions savings of communal district heating systems compared to conventional heating per 90 m^2 dwelling

Development Size [No. of Houses]	CO_2 Savings compared to conventional heating [kg/dwelling/year]				
	Conventional Heating	Gas CHP	Biomass Heating	Biomass CHP	Maximum
1	0	Not suitable	Not suitable	Not suitable	0
10	0	Not suitable	Not suitable	Not suitable	0
20	0	Not suitable	Not suitable	Not suitable	0
50	0	1,288	1,348	Not suitable	1,348
500	0	1,288	1,348	2,120	2,120
2000	0	1,288	1,348	2,120	2,120

Figure 4.1 Emissions savings of district heating systems compared to conventional heating for single 90 m^2 dwellings



57. Figure 4.1 summarises the information. This analysis shows that a biomass heating system could save between as much as 2 tonnes of CO_2 each year for a typical dwelling compared to a conventional system. Both biomass district heating and gas CHP could save between 1 and 1.5 tonnes per dwelling. The key outcomes are:

- For developments below 50 dwellings district heating is not usually well suited technically and will often not be economically viable;
- For developments of 50 to 100 dwellings the inclusion of a district heating network will generally be feasible, though may not always be viable;
- For developments of 100 houses and above gas CHP and biomass heating will generally be feasible and viable;
- For developments of 500 houses and above biomass CHP may be feasible and gives the highest potential emissions reductions.

58. To obtain the largest emissions reductions via district heating systems, developments of many hundreds of dwellings are needed in order that biomass CHP becomes a realistic option. Around 50% of the maximum potential benefit can be realised for developments of 50 houses and greater, although in general the greater the number of dwellings the better technically suited and economically viable a communal heating network will be (and hence the likelihood of the potential emissions reductions being realised).

59. The most cost effective time to install a district heating scheme is during the development phase when all of the required infrastructure can be put in place without disruption to residents. Costs of systems depend upon a wide range of factors, primarily the length of pipework required and the density of the dwelling within the

network. In most cases it is the pipework that constitutes the bulk of the cost of a communal heating system, typically costing in the region of £500 to £1,000 per metre installed.

4.1.5 Impact on Renewable Resource

60. The impact of new development on the renewable resource in the District is likely to be small. The main negative impact could be a reduction in potential for large and medium scale wind as a result of building on or close to land with technical potential for such turbines. More specifically, some potential may be lost if there is significant development to the north-west or north-east of Berkley (which could potentially occur under Options C, E and F), and to a lesser extent to the west of Cam, north and north-west of Wotton-on-Edge and east of Sharpness.

61. The more dispersed Options (D, F and G), could see a reduction in some very small regions (e.g. around Harescombe and Pitchcombe), but the larger unconstrained areas would most likely be unaffected.

62. In general the impact should be very small or zero with careful consideration of development sites, and it should also be noted that development located close to unconstrained areas (but not interfering with) may be able to directly connect to a potential community turbine with benefits for the local economy. It should be noted that although

Figure 3.3 gives a good indication of areas with potential as well as the constraints, the figure has been produced as part of a desk-top study and there may be potential in constrained areas and some areas identified as unconstrained may not be suitable. More detailed survey work would be necessary to ascertain the true potential in specific locations.

63. Resource areas for hydro, biomass and waste are unlikely to be adversely impacted by new development to any significant degree.

4.1.6 Construction Efficiency

64. The construction operations for building a single large development are likely to be more efficient than for multiple small ones. Efficiencies can be made through more efficient delivery of materials, onsite batching of concrete and less need to transport machinery to site. However, the emissions from construction are relatively small compared to the annual emissions in operation of a dwelling. Thus any emissions savings from more efficient construction practices are likely to be small overall.

4.1.7 Summary

65. In this section we demonstrate the comparative strengths of the effects by considering the likely CO_2 emissions reductions associated with all the factors discussed in the previous section, summarised in Table 4.5.

Table 4.5 Factors influencing CO_2 emissions

Factor	Commentary	Potential reduction in emissions (per dwelling)	Variation between options as assessed (per dwelling)
Development mix	Assuming same floor area there is minimal difference, and spatial location has no significant impact.	Proportional to total floor area	None
Transport	**Building developments within one mile of a town rather in a village 8 miles from a town might save 1 tonne of CO_2 per year per dwelling.**	**0 – 1 tCO_2/y**	**0 – 1 tCO_2/y**
Building integrated renewable energy	Installing solar panels on the roof of individual dwellings could save as much as 1 tonne of CO_2 per year, a higher concentration of flats in a given development would reduce this potential, but this is not dictated by the spatial option.	0.2 – 0.9 tCO_2/y	Small
District heating	**Switching from conventional heating to district heating could save 1 to 2 tonnes of CO_2 per year per dwelling. A one tonne reduction is achievable for 50 dwellings or more and 2 tonnes achievable for 500 dwellings or more. For developments with fewer than 50 homes it may not be practical to reduce emissions at all by this means.**	**1 – 2 tCO_2/y**	**0 – 2 tCO_2/y**
Renewable resource	Co-locating development near to areas with a favourable renewable energy resource may encourage uptake on site. Conversely development directly on such a site may reduce the opportunities for utilising the resource. The impact is considered to minimal given the relatively small scale of development however.	Small	Small
Construction efficiency	Building larger developments allows for efficiencies to be made during construction by batching concrete, minimising travel distances etc. However the impact is very small over the lifecycle of the development.	Small	Small

66. Table 4.5 demonstrates that the factors having the biggest influence on CO_2 emissions are transport, potential for micro-renewables and the potential for district heating. In terms of the variation between spatial options, only transport and potential for district heating have a significant impact, given that the opportunities for building integrated renewable energy are not especially sensitive to development scale or location.

67. The opportunities to reduce CO_2 emissions associated with each option are summarised in Table 4.6. **Note that this table is designed to differentiate between options, and a negligible difference does not mean that the potential to reduce emissions is low, rather that the potential is similar regardless of the spatial strategy adopted.** Hence there may be significant potential to reduce emissions by development mix, renewable energy etc as demonstrated in Table 4., but the potential is basically the same for each option.

Table 4.6 Relative potential to reduce CO_2 emissions by various means

	Spatial Option						
	A	B	C	D	E	F	G
Development mix	Negligible difference between options						
Transport	**High**	**High**	**Moderate**	**High**	**Moderate**	**Low**	**Low**
Renewable energy	Negligible difference between options						
District heating	**High**	**High**	**Moderate**	**Moderate**	**Moderate**	**Low**	**Very Low**
Renewable resource	Negligible difference between options - and minimal impact						
Construction efficiency	Negligible difference between options - and minimal impact						

68. The analysis here suggests that fewer larger schemes (e.g. Options A and B) would have potential for lower overall emissions than smaller, dispersed developments (e.g. Options F and G), with the difference between the two extremes being as much as 3 tonnes of CO_2 per household per year (from buildings and transport combined). Options C, D and E fall in between, though there is somewhat better scope to reduce transport emissions from Option D given the location of development in an existing built-up area with good access to public transport nodes. Potential for high emissions reductions via district heating systems at these options is not expected to be quite as high as for Options A and B as a significant proportion of the new homes are proposed in settlements with fewer than 500 homes.

69. However, all developments present opportunities to reduce emissions to some extent and even developments as small as 50 dwellings can have reasonably low emissions if they incorporate a district heating system and/or are located in or on the edge of an existing town that caters for their needs.

4.2 Climate Change Adaptation

70. The evidence that our climate is changing is now overwhelming. Given the speed and scale of the changes already observed it is highly likely that the actions of mankind are at last in part responsible and that we can thus expect our climate to continue to change. In the UK, it is likely that winters will become, on average, warmer and wetter while summers are hotter and drier. At the same time, sea levels will continue to rise and extreme events such as heat waves, storms and tidal surges are expected to occur more frequently. This means that we need to consider how the places in which we live and work can be made better suited, i.e. more resilient, to the climate we are likely to experience in the future, either through retrofit or design.

71. The nature of each strategic spatial option will shape the climate resilience challenges and opportunities for the associated developments. The main areas to consider at a site specific level are flood risk and heat. A

sustainable water supply, given increased risk of drought, should also be considered but this is a larger scale issue associated with the number of additional homes within the District.

72. Flood risk, in this context, can be considered to arise from two main sources, either from rivers or as a result of intense rainfall overwhelming drainage systems (flash flooding). Each of the spatial options includes possible sites which may be prone to flood risk from rivers. A Strategic Flood Risk Assessment (SFRA) completed in 2008 identified those areas at risk in the District and provides guidance on the exposure of those sites at risk. If flood defence schemes were required to increase flood resilience these are likely to be most easily achieved where a smaller number of sites are to be protected, for example in a concentrated development of one or a small number of sites, i.e. Options A and B, where flood defence or resilience features (attenuation zones, etc) can be integrated into the site. It is noted however that the options which are based on a greater dispersal of sites, such as Options F and G, give greater opportunity to identify sites which are not at risk. The development of any site with an identified flood risk will be subject to the guidance set out in PPS25.

73. Flood arising from intense rainfall is a result of drainage systems being unable to cope with the large volumes of rainwater over a short period of time. Surface water run-off from impermeable surfaces such as roads, roofs, patios, driveways etc (or over hardened soils in agricultural land following drought) can lead to localised flooding. Sustainable Urban Drainage Systems (SUDS) minimise this risk and increase local resilience to flood. The vulnerability of a site to surface water flooding is dependent upon not only how drainage is managed on the site but also on adjacent land. Although the effectiveness of SUDS does depend upon its capacity and the size of its catchment, there are a range of SUDS approaches which can be used and so there is typically a solution which will fit most sites, meaning that there is likely to be limited advantage of one spatial option over another for deployment of SUDS.

74. The risks and benefits of warmer temperatures can often be managed through building design and site layout, for example considering the orientation of a building or positioning of windows in order to minimise solar gain (or overheating in summer). The use of landscaping, open space and trees to create cool spaces and shading are also likely to be beneficial. Typically, the denser the development, the greater the risk associated with heat (as buildings gain heat during the day which is then released into the surroundings at night however given the variation in the spatial options this is unlikely to be a significant factor for most (if not all) of the potential sites over coming decades.

4.3 Conclusions and Implications

75. Based on the analysis in this section it can be concluded that the more concentrated development options give greater potential to reduce CO_2 emissions from buildings and lifestyle. However, it can also be concluded that there are some factors that strongly influence emissions that are largely independent of scale or location, and other factors that have a lower impact than might be expected intuitively. Hence despite the concentrated options having greatest potential, there are opportunities to reduce emissions significantly above the baseline

for all options. Inevitably though, the further emissions are reduced below the baseline, the higher the cost and greater the challenges become in all cases.

76. Development location is more important in terms of adaptation to climate change, primarily because the location with respect to flood risk areas is important. Larger concentrated developments may have better potential to incorporate defensive measures, but the impact of a flooding event may be on a larger scale, so there are advantages and disadvantages to both larger and smaller sites. However, before development, risk at any site would need to be considered and protection against flood put in place where necessary. Surface water flooding is an issue to be managed on all sites and unlikely to be a differentiating factor. Measures to mitigate warmer temperatures are largely independent of scale or location of development, although urban environments tend to pose a greater risk of overheating in buildings.

4.3.1 Impact on Achieving Sustainability Standards

77. The Code for Sustainable Homes (CSH) incorporates mandatory credits corresponding to CO_2 emissions over a baseline equivalent to 2006 building regulations. Level 3 is equivalent to 2010 building regulations, Level 5 represents zero statutory regulated emissions (mainly heating and lighting) and Level 6 represents a zero-carbon home with zero emissions from regulated and unregulated emissions (which include appliance energy use).

78. The typical emissions per unit floor area for different building types are shown in

79. There are a number of ways in which the targets can be met, but generally meeting the higher levels requires a combination of high specification building fabric and renewable and low carbon energy generation. The efficient design of the buildings, including energy efficiency lighting and insulation, will go some way to achieving the necessary emissions reductions. However, to achieve higher levels in a cost effective manner it is often appropriate (and sometimes necessary) to incorporate a district heating network (which can save 1 to 2 tonnes per home) since building integrated renewables will often struggle to provide the necessary emissions reductions.

80. Hence it will generally be easier for homes to reach higher levels (beyond Level 4 in particular) of the CSH in the more concentrated development scenarios. However, the scale and location of development is relatively unimportant when achieving Level 4 and below.

Table 4.. There is very little difference in emissions between building types (as noted in Section 4.1.1).

Table 4. shows the approximate emissions reductions compared to Level 3, equivalent to current building regulations in terms of CO_2 performance, for different building types and considering the different sizes of each.

79. There are a number of ways in which the targets can be met, but generally meeting the higher levels requires a combination of high specification building fabric and renewable and low carbon energy generation. The efficient design of the buildings, including energy efficiency lighting and insulation, will go some way to achieving the necessary emissions reductions. However, to achieve higher levels in a cost effective manner it is often appropriate (and sometimes necessary) to incorporate a district heating network (which can save 1 to 2 tonnes per home) since building integrated renewables will often struggle to provide the necessary emissions reductions.

80. Hence it will generally be easier for homes to reach higher levels (beyond Level 4 in particular) of the CSH in the more concentrated development scenarios. However, the scale and location of development is relatively unimportant when achieving Level 4 and below.

Table 4.7 Regulated emissions per unit floor area for different levels of the Code for Sustainable Homes for buildings of different types[10]

CSH Level	Detached (kg/m^2/y)	Semi-detached (kg/m^2/y)	Flat (kg/m^2/y)
Level 3	23	22	23
Level 4	17	16	17
Level 5	0	0	0
Level 6	-12	-12	-12

Source: Cost analysis of the Code for Sustainable Homes, Communities and Local Government, 2008

Table 4.8 Emissions savings over CSH Level 3 for different dwelling types

	Detached (kg/y)	Semi-detached (kg/y)	Flat (kg/y)
Floor Area m^2/dwelling	130	90	60
Level 3	0	0	0
Level 4	800	500	300
Level 5	3,000	2,000	1,400
Level 6	5,000	3,000	2,100

[10] Level 3 figures taken from "Cost analysis of the Code for Sustainable Homes, Communities and Local Government, 2008", other figures derived from required emissions reductions for higher levels

Source: Cost analysis of the Code for Sustainable Homes, Communities and Local Government, 2008

81. The nearest equivalent sustainability standard for non-domestic buildings, BREEAM, has much less weighting on energy generation, and the scale or location of development will tend to have little impact on overall BREEAM rating. Transport is a significant aspect however, with proximity to public transport a way of securing credits. This means achieving higher levels of BREEAM will be somewhat easier when commercial buildings are located in areas close to transport hubs, though the impact of development scale is small.

82. Given the aspirational move towards mandatory zero carbon homes in 2016 (level 6 CSH equivalent) and non-domestic buildings in 2019, it is expected that a more concentrated growth scenario would be preferable when attempting to meet these highly challenging targets. However it should be noted that achieving true zero carbon on-site is very challenging and in many cases impossible in a cost effective manner. Hence it is expected that a system of allowable solutions will be established, allowing developers to contribute towards funding low carbon projects outside of the development itself. There is no national policy for this as yet, and until this issue is resolved it is difficult to truly know the impact of different spatial options with regard to meeting future legislation. Further detail is presented in Section 6.

PHASE 2 – DETAILED ASSESSMENT

5. Phase 2 - Introduction

83. Phase 2 of the study considers the performance of Options A, B and D in greater detail than Phase 1. These three options were shown in the Phase 1 overview assessment to offer the best potential to reduce emissions as a result of the following:

- Option A – single large scale development offering good opportunities for on site low carbon energy systems (including district heating) and potential to minimise transport emissions;
- Option B – very similar to Option A, the potential to reduce emissions via on-site energy systems is good, as is the potential to minimise transport emissions; and
- Option D – a number of smaller sites clustered in a small area around an existing centre of population presents opportunities to minimise transport emissions and there is potential to use communal energy systems which could develop into a larger network serving Stroud town.

84. Within each Option, a number of sites have been identified that could accommodate the required growth. The location of each site is summarised in Table 5.1, with full details provided in Appendix B. Sites have been identified primarily from the Strategic Housing Land Availability Assessment (SHLAA), although some (Sharpness and Hunts Grove) have subsequently been proposed independently by developers and incorporated into an updated SHLAA Report to be published Summer 2011.

Table 5.1 Potential sites for development under each option

Option	Potential Development Sites
Option A	Cam, Eastington, West of Stonehouse, Sharpness, Hunts Grove
Option B	Cam, Eastington, West of Stonehouse, Brimscombe & Thrupp, Whitminster
Option D	Combination of large number of small SHLAA sites in the Stroud Valleys area

85. The possible sites identified under Options A and B are predominantly located to the west and north of the District where the main centres of population and transport links are located. The sites for Option D are located in a specific area by definition, though the sites vary significantly in character.

86. This more detailed assessment has been carried out in two stages:

i. Stage 2a: Detailed Options Assessment

Based on information received from SDC, a typical site for Option A, B and D has been defined and assessed using a model designed to estimate the potential contribution on-site low carbon energy generation at new developments. This gives the expected CO_2 emissions and potential for reductions via on-site technologies associated each Option. The modelling is not sensitive to the location of the site, so the same opportunities and limitations apply regardless of which specific site is considered (e.g. within Option A the results would be equally valid to a site at Cam or at Eastington). Each proposed site within each option is then considered individually in Stage 2b.

ii. Stage 2b: Detailed Site-Specific Assessment

This section compares individual sites being put forward under each option. The characteristics of each site, including specific opportunities for renewable and low carbon energy, are reviewed. Transport issues are also considered, as the other key opportunity for emissions reductions. In addition to the potential to reduce CO_2 emissions, the performance with respect to climate change adaptation is reviewed, primarily focusing on flood risk. Commentary is provided on the potential for sites to achieve higher levels of the CSH and opportunities to receive low carbon energy from, or provide to, existing or planned industry and other development.

6. Stage 2a: Detailed Options Assessment

87. The potential CO_2 emissions reductions and costs associated with incorporating on-site renewable and low carbon energy technologies have been estimated for each Option (A, B and D) using a model developed specifically by AMEC for this purpose. The model does not take into account site specific aspects (which are considered in the next section), but it does allow a comparison of each Option with regards to the opportunities to reduce emissions from the built environment.

88. In order to do this, a sample development 'typology' was assumed based on information supplied by SDC. The typologies are presented in Table 6.1.

Table 6.1 Modelling Inputs

Option	Number	Breakdown of Each Site
Option A	1 x	Residential: 2,000 dwellings General industrial: 46,240 sq.m General office: 19,000 sq.m Warehousing & distribution: 50,000 sq.m Retail & leisure: 12,000 sq.m
Option B	2 x	Residential: 1,000 dwellings General industrial: 23,800 sq.m General office: 9,050 sq.m Warehousing & distribution: 25,000 sq.m Retail & leisure: 6,000 sq.m
Option D – Type i (medium mixed use development)	3 x	Residential: 200 dwellings General industrial: 4,760 sq.m General office: 1,900 sq.m Warehousing & distribution: 5,000 sq.m Retail & leisure: 1,200 sq.m
Option D – Type ii (medium housing estate)	5 x	Residential: 100 dwellings
Option D – Type iii (medium housing estate)	10 x	Residential: 50 dwellings
Option D – Type iv (small housing estate/infill)	10 x	Residential: 25 dwellings
Option D – Type v (small housing estate/infill)	15 x	Residential: 10 dwellings
Option D – Type vi (Employment Park)	1 x	General industrial: 13,300 sq.m General office: 29,320 sq.m Warehousing & distribution: 35,000 sq.m Retail & leisure: 8,400 sq.m

89. The characteristics of each potential site, which the typologies are based on, are provided in Appendix B. Note that the total number of homes and commercial floor space is the same for each Option. For each development, the baseline energy supply is assumed to be gas boilers and electricity supplied from the grid. Buildings are assumed to be built to best practice standards of insulation, i.e. 2010 building regulations.

6.1 Outcomes

6.1.1 Comparison of Options

90. The potential to reduce CO_2 emissions via on-site renewable and low carbon energy generation is summarised in Table 6.2 with modelled outputs being included in Appendix C. This represents the level to which each technology, or combination of technologies, can reduce emissions beyond the baseline scenario where all electricity is supplied entirely from the grid and all heating from natural gas. The results illustrate what should be broadly feasible on a typical site, regardless of location. Note that for all sites it is necessary to use district heating systems fuelled by a low carbon source of heat or CHP to achieve emissions savings in excess of 20-25%.

91. The costs associated with achieving the highest savings are significant, estimated to typically be in the region of 15-20% of the total development build costs. However, support mechanisms for low carbon electricity and heat generation such as Feed-in Tariff and the Renewable Heat Incentive can help to moderate the lifetime costs and the use of Energy Services Companies (ESCOs) to deliver the systems can help reduce the initial capital outlay that would traditionally be borne by the developer, so the high upfront costs are not necessarily prohibitive. However, much is dependent on the clarification of the definition of zero-carbon, and the potential role of 'community energy funds', a mechanism effectively allowing the developer to fund off-site emissions reductions schemes rather than requiring investment in on-site energy systems. These issues are discussed later in this section.

92. The results for Options A and B are almost identical (see Appendix C) as the mix of buildings is very similar. In addition, the scale of both is sufficient to support a district heating network and both are above the threshold level for biomass CHP to be feasible (as determined in Section 4.1.4). Hence the same technologies are suitable for both options, giving similar emissions reductions and costs. Note that the potential for wind, hydro and AD have not been considered as these technologies are site specific (and therefore considered in Stage 2b).

Table 6.2 Potential emissions reductions – summary by Option

Column Heading	Maximum CO_2 emissions reductions over baseline (all technologies)	Maximum CO_2 emissions reductions over baseline (micro-generation technologies only)	Maximum Level CSH likely to be generally feasible[11]
Option A	**70%**	**18%**	**5**
Option B	**70%**	**18%**	**5**
Option D (Type i)	*43%*	*18%*	*4*
Option D (Type ii)	*49%*	*21%*	*4*
Option D (Type iii)	*49%*	*21%*	*4*
Option D (Type iv)	*24%*	*24%*	*3-4*
Option D (Type v)	*24%*	*24%*	*3-4*
Option D (Type vi)	*52%*[12]	*17%*	*n/a (no housing)*
Option D (average)	**46%**[13]	**22%**	**4**

Option A

93. Development under the Option A scenario offers good potential for incorporating on-site low carbon energy technology. Since Option A effectively results in the construction of a new community, a large scale heating network could be developed with heat supplied via biomass, gas CHP or a source of waste heat (such as that from an EfW or AD plant). It should be possible to design an energy centre and associated access and fuel storage into the layout and generally there should be sufficient space to accommodate the necessary plant. Additional micro-generation systems, such as solar PV or small scale wind, could also contribute to reducing emissions.

[11] Estimate assumes buildings constructed to typical high specification insulation, but not super high such as the Passivhaus standard. The levels shown are estimates of the maximum technically feasible level achievable based on on-site measures only (excludes allowable solutions).

[12] Note that a district heating network on this type of commercial-only site may not be realistically achievable, so the true maximum emissions reduction could be substantially lower

[13] Estimate based on all sites being developed independently. Higher emissions reductions may be possible when sites are clustered together, but achieving similar reductions to Options A and B will be very challenging, and may be impossible practically.

94. The key findings for Option A are:

- The absolute maximum CO_2 emissions reduction over the baseline level via on-site generation is approximately 70%, though this assumes biomass CHP is installed which is still a relatively immature and expensive technology;
- Using only commercially and technically proven technologies (e.g. biomass boilers or gas CHP combined with solar PV) the maximum reduction is approximately 40 – 45%; and
- Maximum CO_2 emissions reductions without using a communal heating network are approximately 20%, demonstrating the significant potential benefits associated with low carbon heating networks.

95. In terms of costs, a communal heating network fuelled by either gas CHP or biomass (or a combination of both) is expected to be the most cost effective means to reduce CO_2 emissions, though upfront costs are still high (similar capital costs to PV but with considerably greater emissions reductions; 30% rather than 10%). The potential to reduce emissions by greater than 40% over current building regulations implies meeting CSH Level 4 should be broadly achievable, particularly when coupled with high specification building fabric, and it should be technically possible to achieve Level 5 if biomass CHP is installed.

Option B

96. The results for this scenario are essentially the same as for Option A. There will be small differences in the economics as each development is half the size, but the same technologies are expected to be technically feasible. Since the mix of development and applicable technologies are essentially the same for both options, so are the potential emissions reductions.

Option D

97. For Option D the situation is more complex due to the large number of individual sites. None of the sites are expected to be large enough or have a suitable mix of uses (load diversity) to be well suited to biomass CHP which limits the maximum emissions reductions at any site type to around 50%. The smallest sites in this scenario will not generally be suited to a communal heating system of any kind (except when connected to a larger network) and it may be challenging to locate an energy centre at some site where space is at a premium. The potential for renewable and low carbon energy within Option D can be summarised as follows:

- Type i – this medium scale, mixed use development is likely to be able to support a district heating network, though is unlikely to be suited to biomass CHP which limits the maximum emissions reductions to around 40 – 45%;
- Type ii – housing only and may offer potential to install a heating network but biomass CHP is again unsuitable. Due to the higher heat use than type i, potential emissions reductions are slightly higher at 45 – 50%;
- Type iii – similar to type ii, though the smaller scale means a heating network may be slightly less well suited technically (due primarily to reduced load diversity);

- Type iv and v– likely to be too small and with insufficient mix of uses to support a low carbon heating network, hence micro-generation technologies expected to be the only realistic option, with potential emissions reductions up to approximately 25%; and

- Type vi – district heating networks may be feasible, though this will depend on the type of industry. It may be that only some units would be suitable, in which case emissions reductions potential will be lower.

98. The above analysis is valid under the assumption that each individual site is developed independently, i.e. as entirely separate projects. However, depending on the exact location it may be possible to link sites together, e.g. provide a single district heating network supplying numerous smaller sites that on their own would not support such a scheme. Many of the sites identified in the SHLAA in the Brimscombe and Thrupp area are adjacent to each other and the majority are clustered around the River Frome. Further guidance regarding the potential to maximise such opportunities is given in Section 7.

6.1.2 Impact on achieving higher levels of the Code for Sustainable Homes

99. The maximum level of the CSH expected to be achievable is shown in Table 6.2. The analysis demonstrates that it should be technically feasible to achieve CSH Level 5 on average for development under Options A and B, but may be limited, on average, to Level 4 under Option D as the smaller scale of development restricts the use of communal heating schemes. It must be stressed this is an average and some buildings may be able to achieve higher levels whereas others may struggle.

100. This is a rough guide only and assumes a typical high standard of building fabric. However, it does not apply to super-insulated buildings, such as homes designed to the Passivhaus standard. The level of insulation is not affected by location, so could be installed at any of the options. Generally, super-insulated buildings are not compatible with district heating systems due to the very low thermal energy demand and so one would expect that for a development consisting entirely of such buildings the CO_2 emissions performance will be broadly similar for each option and site within each option. Whether a low carbon communal heating system or a super-insulated building is chosen on a larger site is largely a commercial decision.

101. It is also difficult to insulate non-domestic buildings to such high standards and so for this type of use a low carbon communal heating scheme is still expected to give the greatest emissions reductions.

6.1.3 Viability and Future Legislation

102. The analysis in this section is based on the current position and timescales in relation to sustainability standards and policy, including the commitment for all new homes built from 2016 to be zero carbon. The Government is currently proposing a Zero Carbon Homes standard[14], which is expected to include a combination of minimum energy efficiency standards, on-site renewable energy and developer contributions to

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[14] http://www.communities.gov.uk/news/corporate/1905491

some form of community energy scheme. There are no firm details as yet but a move away from requiring zero carbon entirely via on-site measures is proposed. The potential to pay to effectively offset CO_2 emissions via a community energy fund may mean that achieving high levels of on-site reductions is not a requirement when designing a zero carbon development and this has a particularly significant impact on district heating schemes. If the developer can pay into a fund to offset the CO_2 emissions associated with new housing and if the price of doing so is less than that of a district heating scheme, then it is logical to conclude that developers will not generally install such networks unless it is particularly advantageous to do so (e.g. where sites are very well suited to CHP or are off the gas grid). Should this be the case then the Options with potential for supporting heating schemes will have no advantage, or much less of an advantage, over those that don't in terms of emissions reduction potential.

103. However, until details of the Zero Carbon homes standard are unveiled the impact cannot be confirmed. Much is dependent on the cost of carbon and also the support for low carbon heat in particular, since ESCOs may be keen to install communal heating systems if such schemes are financially attractive over the long term, even with a community energy fund in place.

7. Stage 2b: Detailed Site-Specific Assessment

7.1 Methodology

104. For each option, the sites are assessed using the methodology described in this section. Firstly the characteristics of each site are described, briefly summarising the location, transport links, local area and identified flood risk. A map of the location of all the sites is included for clarity.

105. In order to compare the performance of each site we consider a number of factors. As determined in Phase 1, some important factors influencing CO_2 emissions are location specific whereas others are not. There are two 'key' factors differentiating each site. These factors could have a significant impact on overall emissions from the development:

- Transport (i.e. vehicle movements); and
- Opportunities for district heating networks, in particular the potential to use sources of waste heat (e.g. EfW and other industrial processes).

106. In addition there are a number of other factors that will differ between sites but have a smaller impact on CO_2 emissions or the cost of developing a site to make it resilient to climate change. These are:

- Opportunities to develop location-specific renewable energy schemes as part of the development (e.g. hydro, medium and large scale wind);
- Removal of potential resource as a result of development at a particular site (primarily an issue for wind);
- Specific constraints or opportunities to on-site energy (e.g. ground conditions, access, ability to extend heating network to supply existing or other planned development); and
- Flood risk, primarily from rivers (including the River Severn and River Frome).

107. The main focus of this section is on the two 'key' factors. In addition, for completeness, a brief review of the 'other factors' has also been carried out.

7.1.1 Key Factor 1 – Transport

108. In terms of transport emissions the key issues are the distances residents will travel for commuting and leisure purposes. The proximity of the site to public transport hubs is also an important factor. This primarily includes railway stations and bus routes; rail is generally a more important consideration as bus services are significantly cheaper and easier to incorporate into new development than rail, which requires considerable investment and clear demand if new stations are to be developed. Specific considerations include:

- Proximity to population centres – the closer the better as commuting and other journey distances are typically reduced;
- Proximity to railway stations – the closer the better, particularly where the station is on a major line or has good connections as this will encourage less personal mileage in cars. Research carried out by Leeds University suggests mixed-use development around a transport node such as a station typically reduces emissions by 15% compared to a stand-alone development; and
- Proximity to motorways and main roads – primarily of importance for commercial transport. The closer to the major road network, potentially the lower the distance vehicles will need to travel.

109. Proximity to population centres and public transport connections are the criteria of most importance. Road links are of secondary importance in this context and are only really useful when comparing commercial traffic which is not considered in detail in this study (see Table 7.1).

110. This assessment considers transport emissions associated with the journeys described in Table 7.1. Full details of the methodology are provided in Appendix B.

Table 7.1 Road transport assessment summary

Travel type	Considered in assessment?	Reason
Commuting travel	✓	Location of site has a significant impact on distance travelled
Other local travel (Stroud District and neighbouring areas)	✓	Location of site has a significant impact on distance travelled
Long journeys (national/international)	✗	No significant difference as a result of specific location within the District
Goods/industrial travel	✗	Some difference depending on location, but relatively minor impact and difficult to assess

111. For each site, a total CO_2 emissions figure (tonnes per year) is calculated for commuting and local travel. These figures are indicative only, but are valid for comparative purposes. They do not include the contribution of commercial transport and travel significantly beyond the district. In order to understand the actual emissions associated with vehicle movements from each site a detailed transport appraisal is required, which is beyond the scope of this study. However, this analysis does clearly demonstrate that some sites perform better than others.

7.1.2 Key Factor 2 – Opportunities for District Heating

112. The decision to install a low carbon district heating network as part of a new development is largely a commercial one, since the vast majority of sites above a certain size can technically be supplied with heat in this way (as detailed in the previous section). However there may be specific opportunities or barriers associated with some of the sites, for example when it is located close to a waste treatment plant or heavy

industry there could be potential to use surplus process heat that may otherwise be rejected to atmosphere for heating part or all of the development. Hence we have reviewed each site with respect to proximity to existing and potential future industry with high heat usage or production.

7.1.3 Other Factors

113. A brief review of opportunities to develop renewable energy systems as part of the development, and conversely for areas of resource to be made unavailable if development goes ahead, has been carried out for each site. In addition the potential for flooding is considered (based on the SFRA, 2008). As previously noted, risk of flood does not preclude a site from development, but it could have implications for the cost of development with flood protection measures likely to be needed for all or part of a development. Where a flood risk is identified, location of any low carbon /renewable energy infrastructure within a site requires careful consideration in order to minimise risk of loss of supply during a flood event. Surface water management should also be designed into site development plans to minimise risk of flood of assets during heavy rainfall events.

7.2 Option A

7.2.1 Site Characteristics

Cam

114. This site consists of a number of SHLAA sites to the north east of Cam. The site is close to the M5 motorway and effectively forms a large urban extension to the settlement into predominantly □reenfield land. A small area of the site (approximately 20 ha) has been identified as being at risk of flooding from the River Cam to the west of the site. Road access is reasonable, though despite the close proximity to the M5 the closest junction is 8 km away. The Cam and Dursley railway station is situated at the northern extent of the site.

Eastington

115. This site consists of several SHLAA sites on □reenfield land surrounding the village of Eastington. Development of this site would considerably increase the population of the village. The site is adjacent to the M5, with good road links to both the motorway network and Stroud town. There is a railway station approximately 3 km from the site in Stonehouse. The site is effectively in two parts, so development would not necessarily be entirely on one unbroken area of land. Part of the northern area of the site is at risk of flooding from the River Frome.

West of Stonehouse

116. This site consists of □reenfield land to the north west of the town of Stonehouse. The site surrounds the existing Stroudwater Business Park, a large employment area including a Dairy Crest factory, and is in close proximity to the M5 with good road links to the motorway network and Stroud town. There is also a railway station located in Stonehouse (on the Cheltenham to London line). A small area of the site is at risk of flooding from a stream that feeds the River Frome, which runs across land to the north of the business park.

Sharpness

117. This site consists of a number of SHLAA sites in and around the small port of Sharpness, on the River Severn. The site is relatively remote from the major service areas, with relatively poor road links. The port formally had a railway station (on the Sharpness branch line which connects to the main Gloucester to Bristol line), but this is no longer open to passenger services. There may be potential to re-develop and restart passengers services should demand be sufficient. Land close to the River Severn is at risk from flooding and susceptible to climate change in the scenario of rising sea levels currently envisaged.

118. Outline proposals for an 'eco-town' type development on this site have been submitted. No proposal for a low carbon district heating network is included as part of the submission however.

Hunts Grove

119. This site consists of land to the south west of the Gloucester urban area. This site differs from the others in that a significant area has gained outline planning permission for development, with an initial phase of 342 homes currently under construction (by developers Crest Nicholson). The site has good road access to the motorway network and the city of Gloucester. The flood risk at the site is low.

120. The homes currently under construction are built to meet CSH Level 3, and do not include a communal heating network.

7.2.2 Site Performance

121. Each site was appraised against a range of factors as summarised in Table 7.2. Further details regarding the transport assessment is provided in the next section.

Table 7.2 Option A – Site Summary

	Cam	Eastington	West of Stonehouse	Sharpness	Hunts Grove
Rail Connections					
Nearest operational railway station	Cam & Dursley	Stonehouse	Stonehouse	Cam & Dursley	Stonehouse[15]
Distance (km)	1	4	2	11	7
Proximity to Main Population Centres (shortest distance by road)					
Distance to Stroud (km)	18.3	7.9	7.1	24.4	11.7
Distance to Gloucester (km)	20.2	14.5	14.5	29.0	7.4
Distance to Bristol (km)	39.9	44.8	44.8	37.3	49.1
Road Connections					
Nearest motorway junction	M5 J13	M5 J13	M5 J13	M5 J14	M5 J12
Distance (km)	8.3	2.0	2.0	11.4	0.8

[15] Gloucester station is approximately 8km from Hunts Grove

Table 7.2 Cont.. **Option A – Site Summary**

	Cam	Eastington	West of Stonehouse	Sharpness	Hunts Grove
District Heating					
Potential for district heating network	Good, single site.	Mostly good, but site is split – may be limited in smaller site to south	Very good – near existing employment and industry (Dairy Crest)	Mostly good, but site is split – may be limited in small sites to south	Moderate – new sites good, but virtually zero in area of site with planning permission as no network planned
Opportunity to use surplus heat from existing industry?	No	Possibly from Dairy Crest facility	Possibly from Dairy Crest facility	No	No
Opportunity to use surplus heat from possible new industry?	Unknown	Unknown	Unknown	Unknown	Very good opportunity if EfW plant built at Javelin Park nearby
Specific constraints/opportunities for energy plant	Potentially good location for AD plant using wetland biomass	None	None	Industrial location favourable, and some possibility of importing biomass via water or rail	None
Other factors					
Opportunities for renewable energy resource	Potential for medium/large scale wind identified nearby. May be potential to develop community wind farm, possibly directly supplying development	None identified	May be potential to export heat to or import heat from Dairy Crest.	A biomass plant at or near the site could receive biomass deliveries by river or train (since goods trains can still stop at port). Large scale wind maybe?	Possibility of accepting heat should a strategic-scale EfW plant be developed at Javelin Park
Site constraints	None identified	None identified	None identified	None identified	Site is partly developed so may be limited in ability to exploit existing resource
Potential to deplete existing resource	None identified	None identified	None identified	None identified	None identified
Flood risk	Small area at risk from flooding of Rover Cam	Significant area in northern part of site at risk of flood from Rover Frome	Small area at risk of flood from a tributary to the Rover Frome	Land close to the River Severn is at risk from flooding	Low risk

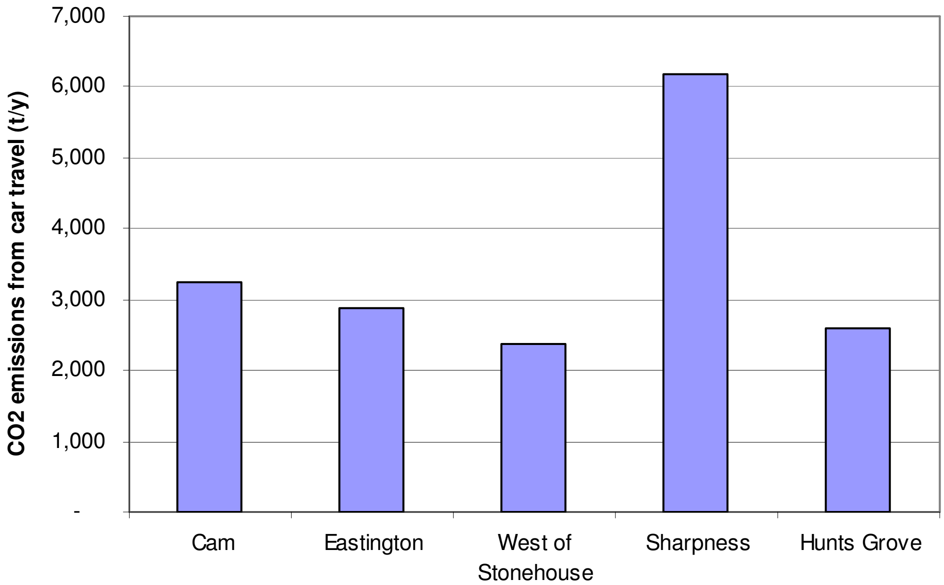
7.2.3 Transport Assessment

122. The results of the transport assessment are presented in Table 7.1 and Figure 7.1. The figures are for comparative purposes and are expected to be broadly indicative of the actual emissions; however, a detailed modelling exercise would be required to confirm the true absolute emissions associated with each site.

Table 7.3 Estimated CO_2 emissions performance for each site (commuting and local travel only)

	Cam	Eastington	West of Stonehouse	Sharpness	Hunts Grove
Vehicle CO_2 emissions (tonnes per year)	3,827	2,891	2,775	6,178	2,586
Railway station within 2km?	Yes	No	Yes	No	No
Total estimated emissions (tonnes per year)	3,253	2,891	2,359	6,178	2,586
Total per household (tonnes per year)	1.6	1.4	1.2	3.1	1.3

Figure 7.1 Estimated CO_2 emissions performance for each site (commuting and local travel only)



123. The sites at Hunts Grove and West of Stonehouse are estimated to have similar emissions. Cam and Eastington are slightly higher, but comparable. Road transport emissions associated with development at Cam are distinctly higher due to the increased distance from Stroud and Gloucester, but this is mitigated by the proximity to Cam and Dursley railway station. The site at Sharpness performs markedly worse given its distance from any major settlement and lack of (operational) rail connections.

7.3 Option B

7.3.1 Site Characteristics

Cam

124. This site consists of a number of SHLAA sites to the north east of Cam. The site is close to the M5 motorway (although with no junction adjacent) and effectively forms a large urban extension to the settlement into predominantly greenfield land. A small area of the site (approximately 20 ha) has been identified as being at risk of flooding from the River Cam which runs to the west of the site. Road access is reasonable with the closest M5 junction being a number of miles away. The Cam and Dursley railway station is situated at the northern extent of the site.

Eastington

125. This site consists of several SHLAA sites on greenfield land surrounding the village of Eastington. Development at this site would considerably increase the population of the village. The site is adjacent to the M5, with good road links to both the motorway network and Stroud town. There is a railway station approximately 3 km from the site in Stonehouse. The site is effectively in two parts, so development would not necessarily be entirely on one unbroken area of land. A significant part of the northern area of the site is at risk of flooding from the River Frome.

West of Stonehouse

126. This site consists of greenfield land to the north west of the town of Stonehouse. The site surrounds the existing Stroudwater Business Park, a large employment area including a Dairy Crest factory, and is in close proximity to the M5 with good road links to the motorway network and Stroud town. There is also a railway station located in Stonehouse which is on the Cheltenham - London line. A small area of the site is at risk of flooding from a stream that feeds the River Frome, which runs across land to the north of the business park.

Brimscombe and Thrupp

127. This site consists of a large number of smaller SHLAA sites in and around the villages of Brimscombe and Thrupp that form part of Stroud urban area, and has quite different characteristics to the other sites in Option B. The majority of the sites are brownfield, and space is generally more constrained. The topography varies significantly, with some areas of land steeply sloping. The town of Stroud lies immediately to the North West. Road connections are good, but there is little potential to upgrade the existing network (in particular the A419) should this be necessary to accommodate additional traffic associated with development in this area. Stroud railway station is approximately one mile away.

128. Areas close to the River Frome on the valley bottom are at risk of flooding, though the risk quickly drops as the land rises up the valley.

Whitminster

129. This site consists of several SHLAA sites to the north and west of the small village of Whitminster. The site is very close to the A38 and the M5 connecting Gloucester and Bristol, and is relatively close to Stroud town. There is no railway station nearby. A significant proportion of the land to the west of the site is at risk from flooding of the River Frome. The site is close to Moreton Valence, which is a possible location for a strategic-scale energy from waste plant. Were such a plant to be built in this location there could be significant potential to supply surplus heat to new development in this area.

7.3.2 Site Performance

130. The range of factors are summarised in Table 7.4 below. Further details regarding the transport assessment is provided in the next section.

Table 7.4 Option B – Site Summary

	Cam	Eastington	West of Stonehouse	Brimscombe and Thrupp	Whitminster
Rail Connections					
Nearest operational railway station	Cam & Dursley	Stonehouse	Stonehouse	Stroud	Stonehouse
Distance (km)	1	4	2	2.5	6
Proximity to Main Population Centres (shortest distance by road)					
Distance to Stroud	18.3	7.9	7.1	2.5	10
Distance to Gloucester	20.2	14.5	14.5	23.5	12.1
Road Connections					
Nearest motorway junction	M5 J13	M5 J13	M5 J13	M5 J13	M5 J13
Distance (km)	8.3	2.0	2.0	10.5	2

Table 7.4 Cont.. Option B – Site Summary

	Cam	Eastington	West of Stonehouse	Brimscombe and Thrupp	Whitminster
District Heating					
Potential for District heating network	Good, single site.	Mostly good, but site is split – may be limited in smaller site to south	Very good – near existing employment and industry (Dairy Crest)	Mixed - potential to link into existing buildings and extend network to town and likely higher density is a positive, but site consists of a large number of small sites, which means installing a large scale DH network would be challenging (non-contiguous sites, numerous developers, timescales etc)	Good
Opportunity to use surplus heat from existing industry?	No	Possibly from Dairy Crest facility	Possibly from Dairy Crest facility	Unlikely	No
Opportunity to use surplus heat from possible new industry?	Unknown	Unknown	Unknown	Unknown	Very good opportunity if EfW plant built at Moreton Valence site adjacent
Specific constraints/opportunities for energy plant	None	None	None	Space for an energy centre may be limited on some of the sites (particularly for biomass boilers)	None
Other factors					
Opportunities to tap into renewable energy resource	Good wind potential identified near May be potential to develop community wind farm, possibly directly supplying development	None identified	May be potential to export heat to or import heat from Dairy Crest.	Small hydro schemes may be possible	Potential EfW plant nearby
Site constraints	None identified	None identified	None identified	Limited space in numerous SHLAA sites may limit opportunities for on-site generation (such as biomass and ground source heat pumps)	None identified

Table 7.4 Cont.. Option B – Site Summary

	Cam	Eastington	West of Stonehouse	Brimscombe and Thrupp	Whitminster
Potential to deplete existing resource	None identified	None identified	None identified	None identified	None identified
Flood risk	Small area of the site risk of flooding from the River Cam	A significant part of the northern area of the site is at risk of flooding from the River Frome.	Small area at risk of flood from a tributary to the Rover Frome	Areas close to the River Frome on the valley bottom are at risk of flooding	A significant proportion of the land to the west of the site is at risk from flooding of the River Frome.

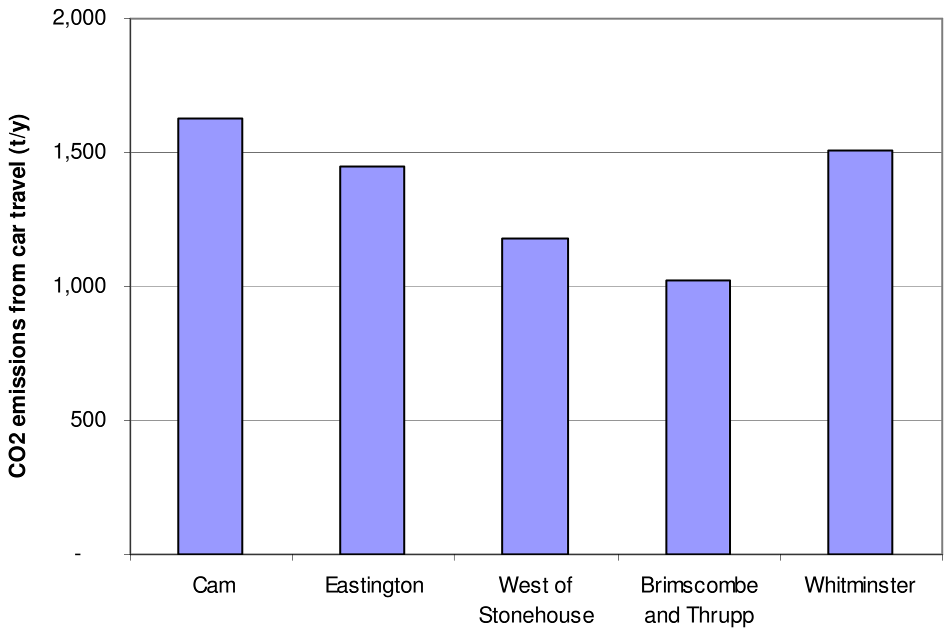
7.3.3 Transport Assessment

131. The results of the transport emissions assessment are summarised in Table 7.5 and Figure 7.2. The figures are for comparative purposes and are expected to be broadly indicative of the actual emissions; however, a detailed modelling exercise would be required to confirm the true absolute emissions associated with each site.

Table 7.5 Estimated CO_2 emissions performance for each site (commuting and local travel only)

	Cam	Eastington	West of Stonehouse	Brimscombe and Thrupp	Whitminster
Vehicle CO_2 emissions (tonnes per year)	1,914	1,446	1,388	1,200	1,508
Railway station within 2km?	Yes	No	Yes	Yes	No
Total Estimated emissions (tonnes per year)	1,627	1,446	1,180	1,020	1,508
Total per household (tonnes per year)	1.6	1.4	1.2	1.0	1.5

Figure 7.2 Estimated CO_2 emissions performance for each site (commuting and local travel only)



132. The results for Cam, Eastington and West of Stonehouse are as per Option A. Brimscombe and Thrupp is predicted to have the lowest emissions, as may be expected for a predominantly brownfield area in an existing built-up area.

7.4 Option D

7.4.1 Site Characteristics

133. Option D differs from Options A and B in that rather than several distinct sites being identified, development could be located across a number of the sites identified in the SHLAA. Based on figures provided by SDC (in Appendix B) it is anticipated that a total in the region of 40 -50 sites would be developed to give the 2,000 homes and commercial development required, though it could be possible to locate multiple smaller developments on some single SHLAA sites.

134. As such, it is not possible to compare sites in the same way as has been done for Options A and B.

7.4.2 Transport

135. The results of the transport emissions assessment are summarised in Table 7.6.

Table 7.6 Estimated CO_2 emissions performance for each site (commuting and local travel only)

	Stroud Valleys
Vehicle CO_2 emissions (tonnes per year)	1,914
Railway station within 2km?	Yes
Total Estimated emissions (tonnes per year)	1,627
Total per household (tonnes per year)	1.6

136. The emissions performance is relatively good due to the location of development in an existing built-up area with good public transport links and employment nearby. Substantial commuting to locations further afield such as Gloucester and Bristol can still be expected however.

7.4.3 District Heating

137. The potential for district heating will vary depending on where development is located. In order to maximise the potential, it will be necessary to develop sites that are in close proximity (preferably adjacent) to each other, or are of a sufficient size to justify its use. The sites must either be brought forward as a single development sharing a common heating network, or it must be ensured that new development on surrounding sites can take advantage of a network by extending it. The Local Authority will have to take a lead in co-ordinating such delivery.

138. This may be challenging to achieve, since there may be little incentive for developers to offer such schemes. One possible means to encourage this would to make the consideration of installing a district heating network (or connecting to an existing one) a requirement as part of the planning application process. This could be done via policy measures, such as a Supplementary Planning Document applied to a particular development area. This document would have to be directly related be a policy to encourage district heating within the Core Strategy or Site Allocations DPD. However whilst this can be effective, care must be exercised as it may be challenging to enforce and potentially deter developers if the connection or establishment of a heating scheme is particularly costly or onerous.

139. The SHLAA sites in the Stroud Valleys area have been reviewed with respect to opportunities for district heating. Some of the larger sites appear large enough to support a heating network, and the clustering of smaller sites in other areas could also allow the scale to exceed the threshold level at which district heating could be a consideration. These areas include:

- Large greenfield sites to the north of the town (e.g. SHLAA sites 87, 148, 91, 143 which should all be of sufficient size to accommodate a network on their own);
- Canal corridor and town centre (e.g. SHLAA sites 319, 267, 127, 194, 126, 84, 318, 295); and
- Brimscombe cluster (e.g. SHLAA sites 80, 63, 57, 285, 107, 165, 193, 109, 228).

140. A potential constraint associated with the smaller sites is the space and access requirements for an energy centre. Gaining planning permission may be more challenging, and for the sites in the bottom of the valley air quality would need to be carefully considered given the dispersal characteristics.

141. There are no known major sources of waste heat in the area. An AD plant is planned near Stratford Park, but it is planned to use the surplus heat produced at the adjacent leisure centre and hence there would be little or none available to supply to new development.

142. It is important to note that similar emissions reductions may be achievable via alternative means, such as super-insulation of buildings. However, as stated previously, the same is broadly true on all sites and for all options.

7.4.4 Other Renewable Technologies

143. This option also presents an opportunity for the development of hydropower schemes, and a number of projects are currently planned in the Stroud Valleys, including two small schemes at Dudbridge. There would be a definite opportunity to maximise the hydropower resource under this option, particularly at the barriers shown in Figure 3.4, as new development and redevelopment of existing buildings (such as former mills) could incorporate hydropower schemes to supply low carbon electricity. However the overall contribution to CO_2 emissions reductions will be low given that the potential schemes are all small scale. This resource could be exploited independently of new housing or commercial development, but high levels of regeneration in the area may help to encourage hydro power development in the Stroud Valleys.

PHASE 3 – CONCLUSIONS

8. Stage 3 – Summary of the Phase 1 and 2 Assessments

8.1 Phase 1 Conclusions

144. The Phase 1 options assessment highlighted a number of factors which then shaped the Phase 2 more detailed assessment. These were that:

- Transport and opportunities for district heating are the only two factors that both have a significant impact on CO_2 emissions **and** vary significantly between option;
- Options A and B offer the greatest potential for emissions reductions due to opportunities for low carbon heating networks and the scale of each development can help minimise vehicle movements;
- Option D is the option which offers the greatest potential after Options A and B;
- The dispersed options (F and G) perform relatively poorly as the potential for district heating is low and higher vehicle movements are almost inevitable;
- Despite the differences, all options offer significant potential to reduce CO_2 emissions. However, this study focuses on the maximum CO_2 emissions reductions expected to be feasible at each option. Such reductions will only be realised with strong policy and a concerted effort by all stakeholders to ensure emissions are minimised as far as possible.

► **Although there is good scope to reduce CO_2 emissions from new growth for all options, Options A, B and D present the best opportunities.**

145. These findings and the key factors that led to this conclusion shape the Phase 2 assessment.

8.2 Phase 2 Conclusions

146. Through considering the specifics characteristics of each site in Phase 2 it can be concluded that:

- Options A and B have the potential to achieve greater CO_2 emissions reductions via on-site energy technologies than Option D, as they are better suited to large, low carbon district heating schemes. There is very little to differentiate between Option A and B in this regard;
- Option D requires sites to be grouped together and developers to work together in order to maximise opportunities for district heating. It is expected to be much more challenging to achieve in reality than for the large single sites under Options A and B;

- All options have similar *potential* to reduce emissions associated with transport. However, depending on which specific site is chosen Option A could have considerably higher emissions than Options B and D. Option B also varies depending on the two chosen sites, but less so than Option A. Given that Option D is centred in one location, the emissions should not vary significantly regardless of the exact sites developed (see Figure 8.1 below for graphical comparison). More detailed investigation of potential travel habits is advisable if deciding between sites using this measure;

- There is a significant variation in the performance of individual sites within each option with respect to travel. Sites at Sharpness and Cam perform notably worse than the others, the majority of which are predicted to have similar associated emissions;

- There are possible opportunities at some sites to use waste heat, but there is much uncertainty at this stage. However if definite potential is identified in future (e.g. should the decision be taken to locate an EfW plant near Whitminster or Hunts Grove), these sites would be at a significant advantage regarding CO_2 emissions. The Dairy Crest facility could potentially supply heat to development at the West or Stonehouse or Eastington sites, but the quantities of heat and whether it is recoverable is not known;

- None of the 'other' factors are of significance when differentiating between sites in terms of CO_2 emissions reduction potential. The flood risk potential does vary however, and should be considered carefully when selecting sites;

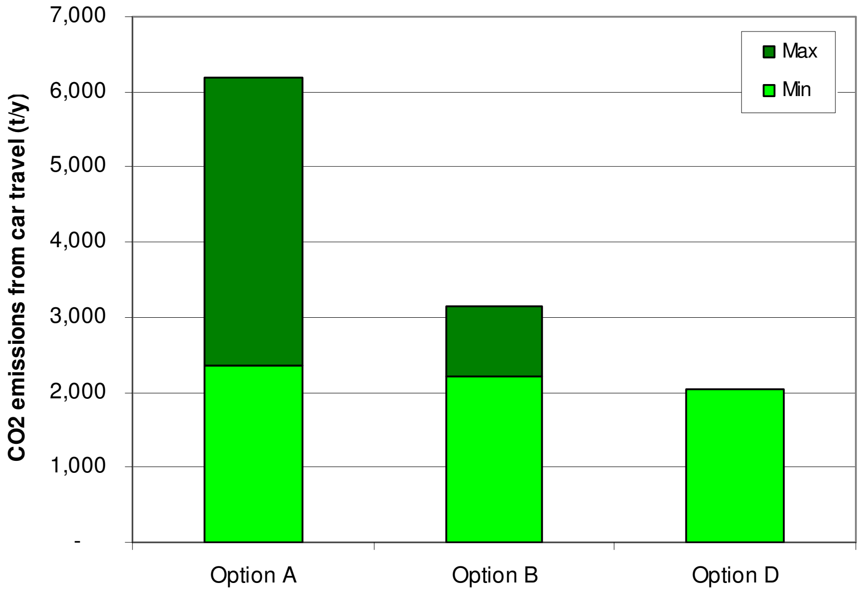
- Option D allows regeneration of existing brownfield sites. However development may be much more scattered, and supplying a significant proportion of new development via low carbon district heating is likely to be challenging (more so than for Options A and B). Realisation of a widespread low carbon heating network would require careful planning; and

- Selection of the site at Brimscombe and Thrupp under Option B effectively results in a hybrid scenario of Options B and D. As such development of a district heating network at this location would be more challenging than the other options, but transport performance is good.

► **The potential CO_2 emissions from transport are broadly similar for all Options, except if the site at Sharpness is chosen under Option A which will result in significantly higher emissions**

► **The potential to reduce CO_2 emissions from on-site energy is similar for Options A and B. A large scale communal heating system, required to give higher emissions reductions, is expected to be very challenging to achieve for Option D.**

Figure 8.1 Comparative transport performance



8.3 ## Planning Policy Considerations

8.3.1 ### Overview of Key Policy Models

147. In line with the requirements of the PPS1 Supplement on Climate Change a Council can set requirements for new developments to be connected to decentralised (i.e. local and off-grid) renewable and low carbon energy schemes. This report identifies where the opportunities exist to do so. What now needs to be considered is how this can be formalised within planning policy and what can be expected from developers.

148. As a starting point it is helpful to consider the different policy models that have been adopted by other authorities; fundamentally they fall into one of four categories:

- **Category 1:** 'Merton Rule' style policies, requiring a percentage of a development's predicted energy demands to be met via on-site renewables
- **Category 2:** Carbon reduction target – similar to the Merton rule but requiring a percentage reduction in CO_2 emissions rather than in relation to the predicted energy demands
- **Category 3:** Requiring a specific level of the Code for Sustainable Homes/BREEAM, since energy efficiency and on-site renewables are implicitly required to achieve higher levels (particularly in relation to the Code for Sustainable Homes – higher BREEAM ratings can be achieved without renewables)

- **Category 4:** An 'energy hierarchy' based approach whereby developments need to show how they have, in the first instance maximised energy efficiency (be lean), then considered the use of decentralised heating networks (be clean), then renewables (be green).

149. In some cases these options are used in combinations (i.e. a Merton rule type policy supported by an energy hierarchy). This section of the report considers the relative strengths and weaknesses of the particular policy approaches for Stroud.

Category 1: Merton Rule Style Policy

150. This is the most common type of policy adopted by local planning authorities across the country. Typical policy wording is as follows:

*"The Council will **expect** all development (either new build or conversion) with a floorspace of 1,000 m2 or more or ten or more residential units to incorporate renewable energy production equipment to provide **at least 10% of the predicted energy requirements**".*

151. In support of this policy the Planning Inspectorate published a model condition to attach to a planning consent:

*"At least **10% of the energy supply of the development** shall be secured from **decentralised and renewable or low-carbon energy sources** (as described in the glossary of Planning Policy Statement: Planning and Climate Change). **Details and a timetable of how this is to be achieved, including details of physical works on site, shall be submitted to and approved in writing by the Local Planning Authority** (as part of the reserved matters submissions required by condition x)".*

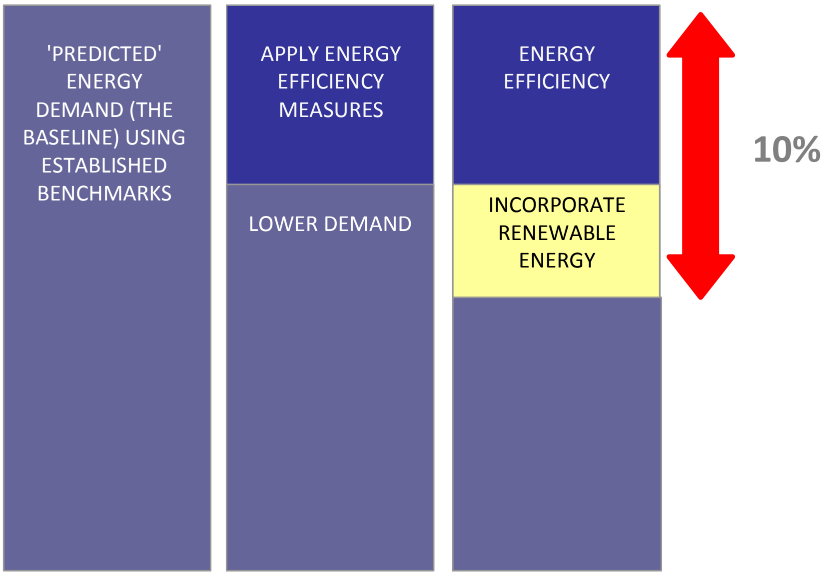
152. The key variables in this policy are the threshold to which the policy applies and the percentage target adopted. Some authorities go beyond the 10% requirement and seek 20% for example based on local evidence.

153. Figure 8.2 demonstrates how the percentage target is intended to be measured – i.e. that the 10% target also takes into account any energy efficiency measures, with energy efficiency actually reducing the level of renewables that needs to be incorporated.

Strengths and weaknesses

154. Because this type of policy is widespread, used by authorities across the country, it is perhaps the easiest to implement from a development control perspective. There are established toolkits, guidance and courses for planners and developers to implement this type of policy.

Figure 8.2 How Merton Rule type policies can be measured



155. Policies such as this are not without complexity however, with a degree of understanding necessary within the authority to assess the energy statements submitted by a developer (be it a designated energy officer or a planner trained in this area). Alternatively, some authorities use external energy consultants to help 'audit' the energy statements submitted by a developer. In addition, one major weakness of Merton Rule type policies is that they may soon become out-of-date. The recent Coalition Statement on Planning for Climate Change indicates that target driven policies such as this – which in essence sought to deliver a minimum level of on-site renewables – will soon be superseded by enhanced Building Regulations which necessarily require incorporation of on-site energy anyway (i.e. expected changes to Part L of Building Regulations planned for 2013 and 2016).

Category 2: Carbon Reduction Target

156. Following the Merton Rule this is an approach that some authorities are now adopting, with typical policy wording is as follows:

"The Council will expect all development (either new build or conversion) with a floorspace of 1,000 m2 or ten or more residential units to incorporate renewable energy production equipment to reduce the predicted CO_2 emissions by at least 10%"

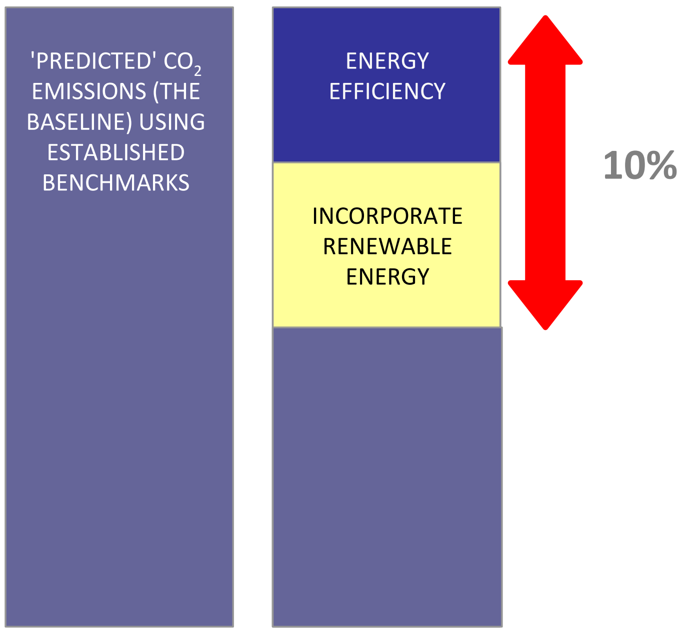
157. A similar condition could be attached to planning consents as suggested under Option 1:

"The development's predicted CO_2 emissions should be reduced by at least 10%. Details and a timetable of how this is to be achieved, including details of physical works on site, shall be submitted to and approved in writing by the Local Planning Authority (as part of the reserved matters submissions required by condition x).

The approved detailed shall be implemented in accordance with the approved timetable and retained as operational thereafter, unless otherwise agreed in writing by the Local Planning Authority"

158. The percentage reduction in emissions would be measured against a defined baseline.

Figure 8.3 How a Carbon Reduction Target can be Measured



Strengths and weaknesses

159. The strengths and weaknesses of this type of policy are broadly similar to the Merton Rule. Some developers favour this approach over the Merton Rule because they feel that it allows for greater consideration of energy efficiency and other approaches to reducing carbon emissions rather than necessarily requiring on-site energy equipment in the first instance.

Category 3: Code for Sustainable Homes/BREEAM Requirement

160. The typical wording for this type of policy is as follows:

"New residential development permitted after the adoption of the strategy should meet Code for Sustainable Homes/BREEAM level X (or any future national equivalent)"

161. Again, the Planning Inspectorate has a model condition to attached to planning consents:

"The dwelling(s) shall achieve Level X of the Code for Sustainable Homes/BREEAM. No dwelling shall be occupied until a final Code Certificate has been issued for it certifying that Code Level X has been achieved."

162. A local authority may seek a plan-wide or site-specific target for all homes to be Code for Sustainable Homes Level 4, which in terms of energy performance could be met via communal heating systems or smaller scale solutions such as ground source heat pumps or solar thermal. Others have sought to go further requesting Code Levels 5 and 6 which also require on-site electricity and heating generation.

163. Dover District Council has adopted a policy requiring levels of the CSH in its Core Strategy (Box 2).

Box 2	CSH/BREEAM Policy Case Study: Dover Core Strategy (adopted February 2010)
*"New residential development permitted after the adoption of the strategy should meet **Code for Sustainable Homes level 3 (or any future national equivalent), at least Code level 4 from 2013 and at least Code level 5 from 1 April 2016.*** *New non-residential over 1,000 square metres gross floorspace permitted after adoption of the Strategy should meet **BREEAM very good standard (or any future national equivalent).*** *Where it can be demonstrated that a development is unable to meet these standards, **permission will only be granted if the applicant makes provision for compensatory energy and water savings elsewhere** in the District…"*	

Strengths and weaknesses

164. From a development control perspective this type of policy is relatively straightforward to assess; where a policy is set the developer will typically commit to a particular level of the Code for Sustainable Homes/BREEAM at outline planning stage. The application can then be conditioned to this effect with overall implementation addressed via Building Regulations approval (design stage and post construction).

165. The main complexity with this type of policy is determining what target to set, providing sufficient evidence particularly in relation to viability. Whilst some developers are committed to Code Levels 3 and 4, the take-up of Levels 5 and 6 is not widespread at this stage. Many developers will still seek to challenge overly ambitious Code/BREEAM targets on viability grounds. In fact, the Code for Sustainable Homes is still pending review to look at how Levels 5 and 6 could be more flexible, allowing for 'off-site' (or allowable) solutions to be incorporated.

Category 4: Energy Hierarchy

166. Under this policy model there would be no specific 'target'. The policy would be assessed from a more qualitative perspective with developers required to demonstrate how they:

- **Use less energy (be lean):** via the design, layout and orientation of the development and its individual buildings.
- **Supply energy efficiently (be clean):** considering the use of combined heat and power (CHP) or combined cooling heat and power (CCHP) networks in the following order of preference:
  - connection to an existing CHP/CCHP network; or
  - establishing a site wide CHP/CCHP network; or

- incorporating a gas-fired CHP/CCHP network accompanied by renewables or communal heating and cooling fuelled by renewables (e.g. biomass)

- Use renewable or low carbon energy (be green).

167. The energy hierarchy above is based on what is included in the London Plan, although policy in the London Plan is accompanied by a 20% carbon reduction target which adds a quantitative element to the policy too.

Strengths and weaknesses

168. As a more qualitative policy it is perhaps easier for the local planning authority and developers to respond to. However without a quantitative element to the policy (i.e. specific target on what is required) it is hard for the local planning authority to enforce and monitor the policy and what the developer is proposing. In addition, the requirement to connect to existing heating networks is also really only applicable to urban areas, so would have limited potential in Stroud given that the widespread take-up of heating networks is not expected given the dispersed nature of its settlements.

8.3.2 What type of policy would work best for Stroud?

169. In considering the different policy approaches that could be taken forward in Stroud it needs to be recognised that Government policy regarding how local planning authorities and developers should plan for renewable and low carbon energy is rapidly changing. It will therefore be important to build an element of flexibility into any policy developed for Stroud. In addition, current market conditions mean that the viability of any targets related to new residential, commercial and mixed-use developments need to be carefully considered.

170. Fundamentally, AMEC suggests that any policy developed for Stroud should avoid being overly prescriptive and be less target driven given that this type of policy could be rapidly superseded by revised national planning policy (e.g. National Planning Policy Framework) and changes to Building Regulations.

171. In determining what policy approach to take in Stroud it is helpful to consider the likely direction of Government policy. Announcements by Housing Minister Grant Shapps in 2011 provide much more of an emphasis towards off-site/allowable solutions in order for a developer to meet its obligations, i.e. for zero carbon development by 2016 (informed by the work of the Zero Carbon Hub). The approach to allowable solutions is to be published shortly, but it is likely to set a price per tonne of carbon that the developer would pay to offset residual emissions once energy efficiency and/or on-site energy solutions have been incorporated (possibly £45 per tonne CO_2).

172. One policy model that the Council could take forward would be to work with Building Regulations, requiring developers to set out how they have taken into account planned changes to Part L in 2013 and 2016 as part of their schemes.

173. In response to the direction of national policy there are a number of opportunities that we have identified to inform Stroud's policy development:

- The Council could take forward preferred energy schemes, based on the evidence presented in this study, for further testing to look at how developer contributions towards allowable solutions could help to bring them forward. E.g. a 'community energy fund' could be established whereby the monies collected from developers are used to invest in a district heating network or community wind farm. Whilst the mechanism would need to be assessed further, this could also be linked to a Community Infrastructure Levy (CIL);

- A community energy fund could also be used to 'retrofit' energy saving/efficiency measures on existing developments, for example areas of social housing within Stroud where the Council may have a greater degree of control. The added benefits in terms of responding to fuel poverty and reduced energy bills could be promoted here. Although funded in a different way, there are examples of large scale retrofitting schemes pursued by authorities in the UK, such as by Birmingham City Council ; and

- Depending on political will the Council could take a proactive role in delivering renewable or low carbon energy schemes, with changes to local government possibly providing a greater opportunity for the Council to actually finance and invest in schemes. One authority that has taken significant steps in this area is Woking Council, who set up their own energy company back in 1999 to achieve their climate change objectives.

Appendix A
Overview Assessment Supporting Information

Emission Factors

Table A.1 CO_2 emissions factors

Type	Source	CO_2 Factor
Heat	Gas (assumed efficiency of boilers = 90%)	0.204
	Solar	0.000
Electricity	Grid	0.554
	Solar	0.000

Table notes here

Travel

Table A.2 Transport emissions for different types of vehicle for different commuting distances

Each-way Journey Distance [miles]		Carbon emissions [kg/journey]			
		Small Car (128g/km)	Large Car (257g/km)	Bus (30g/km)	Train (53g/km)
Town	1	0.41	0.83	0.10	0.17
	2	0.82	1.66	0.19	0.34
	3	1.24	2.49	0.29	0.52
	4	1.65	3.31	0.39	0.69
	5	2.06	4.14	0.48	0.86
	6	2.47	4.97	0.58	1.03
	7	2.88	5.80	0.68	1.20
Village	8	3.30	6.63	0.77	1.38

Emissions values taken from transportdirect.info March 2011

Building Integrated Renewables

Table A.3 Proportion of household demand met by different fuel types for various renewable energy systems

Proportion of demand met by fuel type		Conventional Supply	Solar Hot Water	Solar PV	SHW and PV
Heat	Gas	100%	85%	100%	85%
	Solar	0%	15%	0%	15%
Electricity	Grid	100%	100%	70%	70%
	Solar	0%	0%	30%	30%

District Heating

153 Table A.4 shows the typical mix of fuel use for different types of district heating system. For instance a conventional heating system, based around a gas boiler, would use mains gas for heating and grid electricity for the power. A dwelling on a biomass CHP system would obtain 75% of its heat from biomass and 25% from gas. Half its electricity demand would be met by grid electricity and the rest by the CHP system.

154 Table A.5 uses the carbon emissions factors for different fuel types to estimate the emissions for each option for a unit floor area. It also shows the savings each district heating system can make compared to a conventional system.

Table A.4 Proportion of household demand met by different fuel types for various district heating systems

Proportion of heat demand met by fuel type		Conventional Heating	District Heating		
			Gas CHP	Biomass Heating	Biomass CHP
Heat	Gas	100%	50%	10%	25%
	Gas CHP	0%	50%	0%	0%
	Biomass	0%	0%	90%	75%
Electricity	Grid	100%	0%	100%	50%
	CHP	0%	100%	0%	50%

Table A.5 Emissions from different district heating systems and savings over conventional heating

CO_2 emissions (kg per m^2)	Conventional Heating	District Heating		
		Gas CHP	Biomass Heating	Biomass CHP
Heat	20	27	5	7
Electricity	22	0	22	11
Total	42	27	27	18
Total saved against Conventional	0	14	15	24

Appendix B
Detailed Assessment Supporting Information

155 Tables B1 to B3 set out the assumed parameters of each site identified as part of each option. Following this, the inputs to the transport assessment are presented

Table B.1 Option A

2,000 dwellings at either:	Cam	Eastington	West of Stonehouse	Sharpness	Hunts Grove
Residential: Number of flats Number of 2/3 bed houses Number of 4/5 bed houses	>2,000 @ one third flats, one third 2/3 beds, one third 4/5 beds	>2,000 @ one third flats, one third 2/3 beds, one third 4/5 beds	>2,000 @ one third flats, one third 2/3 beds, one third 4/5 beds	2,000 units @ one third flats, one third 2/3 beds, one third 4/5 beds	2,500 @ one third flats, one third 2/3 beds, one third 4/5 beds
Commercial Floorspace: Offices General industrial Warehousing and distribution Retail and leisure	B1: 19,000m^2 B2: 46,240m^2 B8: 50,000m^2 A/C: 12,000m^2	B1: 19,000m^2 B2: 46,240m^2 B8: 50,000m^2 A/C: 12,000m^2	B1: 19,000m^2 B2: 46,240m^2 B8: 50,000m^2 A/C: 12,000m^2	B1: 19,000m^2 B2: 46,240m^2 B8: 50,000m^2 A/C: 12,000m^2	Outline planning permission granted for 5.75 ha of B1/B2/B8 uses and 4.83 ha for neighbourhood centre.
Site Characteristics: Greenfield or brownfield? Topography? Flood risk? (Total site area covered by flood risk)	6 Green (104.6 ha) 3 Brown (4.5 ha) 25-100m AOD Flood 2; 6.5 ha Flood 3a; 6.5 ha Flood 3b; 5.9 ha	All Greenfield (67.54ha) 10-30m AOD Flood 2; 19 ha Flood 3a; 19 ha Flood 3b; 17.5 ha	All Greenfield (104.74ha) 25-45m AOD Flood 2; 7.2 ha Flood 3a; 7.2 ha Flood 3b; 6.2 ha	6 Green (139.2ha) 5 Brown (21.7ha) 5-25m AOD Flood 2; 18.3 ha Flood 3a; 18.3 ha Flood 3b; 13.9 ha	Greenfield (26.52ha) 20-40m AOD Flood 2; 0.4 ha Flood 3a; 0.4 ha Flood 3b; 0 ha
Area: Total site area Potential developable area	109.11ha 84.76 ha	67.54ha 54.16 ha	104.74ha 79.38 ha	160.91ha 130.96 ha	131.52ha 98ha (75%)
Development Detail: Estimated housing density (dwellings per hectare) Significant development constraints?	25-55dph No known significant development constraints	25-55dph No known significant development constraints	25-55dph No known significant development constraints	25-55dph Adjacent RAMSAR site. Flood risk.	25-55dph No known significant development constraints
SHLAA Sites: List of SHLAA sites within each area (RTP ID No.)	16, 33, 313, 139, 150, 296, 151, 198, 271	64, 30, 39, 79, 112,	23, 52	321, 188, 277, 187, 190, 189, 85, 73, 158, 275, 276	9 (as extension to site with p.p. for 1,750 dwellings/ employment/ neighbourhood centre)

Table B.2 Option B

1,000 dwellings in two of:	Cam	Eastington	West of Stonehouse	Brimscombe & Thrupp	Whitminster
Residential: Number of flats Number of 2/3 bed houses Number of 4/5 bed houses	1,000 units (over multiple sites) @ one third flats, one third 2/3 beds, one third 4/5 beds	1,000 units @ one third flats, one third 2/3 beds, one third 4/5 beds	1,000 units @ one third flats, one third 2/3 beds, one third 4/5 b00s	1,000 units over multiple sites @ one third flats, one third 2/3 beds, one third 4/5 beds	1,000 units @ one third flats, one third 2/3 beds, one third 4/5 beds
Commercial Floorspace: Offices General industrial Warehousing and distribution Retail and leisure	B1: 9,050m^2 B2: 23,800m^2 B8: 25,000m^2 A/C: 16,000m^2	B1: 9,050m^2 B2: 23,800m^2 B8: 25,000m^2 A/C: 16,000m^2	B1: 9,050m^2 B2: 23,800m^2 B8: 25,000m^2 A/C: 16,000m^2	B1: 9,050m^2 B2: 23,800m^2 B8: 25,000m^2 A/C: 16,000m^2	B1: 9,050m^2 B2: 23,800m^2 B8: 25,000m^2 A/C: 16,000m^2
Site Characteristics: Greenfield or brownfield? Topography? Flood risk? (Total site area covered by flood risk)	6 Green (104.6 ha) 3 Brown (4.5 ha) 25-100m AOD Flood 2; 6.5 ha Flood 3a; 6.5 ha Flood 3b; 5.9 ha	All Greenfield (57.37ha) 10-30m AOD Flood 2; 19 ha Flood 3a; 19 ha Flood 3b; 17.5 ha	All Greenfield (104.74ha) 25-45m AOD Flood 2; 7.2 ha Flood 3a; 7.2 ha Flood 3b; 6.2 ha	9 Greenfield (18.9ha) 13 Brownfield (22.6ha) 50-150m AOD Flood 2; 13.2 ha Flood 3a; 13.2 ha Flood 3b; 11.1 ha	4 Greenfield (72.0ha) 1 Brownfield (0.5ha) 10-25m AOD Flood 2; 17.1 ha Flood 3a; 17.1 ha Flood 3b; 16.1 ha
Area: Total site area Potential developable area	109.11 ha 84.76 ha	57.37 ha 44.32 ha	104.74 ha 79.38 ha	41.51 ha 41.51 ha	72.50 ha 53.08 ha
Development Detail: Estimated housing density (dwellings per hectare) Significant development constraints?	Assumed 30-50dph No known significant development constraints	Assumed 30-50dph No known significant development constraints	Assumed 30-50dph No known significant development constraints	Assumed 30-50dph Conservation area. Flood risk. Possible land contamination	Assumed 30-50dph No known significant development constraints
SHLAA Sites: List of SHLAA sites within each area (RTP ID No.)	16, 33, 313, 139, 150, 296, 151, 198, 271	64, 30	23, 52	13, 21, 41, 49, 51, 54, 56, 57, 63, 69, 80, 106, 107, 109, 131, 136, 165, 166, 193, 228, 229, 284, 285, 286	24, 42, 44, 307, 308

Table B.3 Option D

2,000 dwellings distributed across:	Three 200-dwelling sites	Five 100-dwelling sites	Ten 50-dwelling sites	Ten 25-dwelling sites	Fifteen 10-dwelling sites
Residential: Number of flats Number of 2/3 bed houses Number of 4/5 bed houses	600 units @ one third flats, one third 2/3 beds, one third 4/5 beds	500 units @ one third flats, one third 2/3 beds, one third 4/5 beds	500 units @ one third flats, one third 2/3 beds, one third 4/5 beds	250 units @ half 2/3 beds, half 4/5 beds	150 units @ half 2/3 beds, half 4/5 beds
Commercial Floorspace: Offices General industrial Warehousing and distribution Retail and leisure	B1: 5,700m^2 B2: 14,280m^2 B8: 15,000m^2 A/C: 3,600m^2	B1: 13,300m^2 B2: 29,320m^2 B8: 35,000m^2 A/C: 8,400m^2 (in one or two locations)			
Site Characteristics: Greenfield (ha) Brownfield (ha) Topography? Flood risk? (Total site area covered by flood risk)	81.52 ha 23.44 ha A range of topographies relate to individual site characteristics Flood 2; 11.70 ha Flood 3a; 11.70 ha Flood 3b; 11.59 ha	109.45 ha 38.91 ha A range of topographies relate to individual site characteristics Flood 2; 17.33 ha Flood 3a; 17.33 ha Flood 3b; 17.00 ha	119.00 ha 51.54 ha A range of topographies relate to individual site characteristics Flood 2; 22.88 ha Flood 3a; 22.88 ha Flood 3b; 21.56 ha	126.72 ha 60.85 ha A range of topographies relate to individual site characteristics Flood 2; 26.47 ha Flood 3a; 26.47 ha Flood 3b; 24.11 ha	130.89 ha 64.36 ha A range of topographies relate to individual site characteristics Flood 2; 27.09 ha Flood 3a; 27.09 ha Flood 3b; 24.66 ha
Area: Total site area Potential developable area	104.96 ha 81.94 ha	148.36 ha 125.23 ha	170.54 ha 141.3 ha	187.56 ha 153.45 ha	195.25 ha 158.39 ha
Development Detail: Estimated housing density (dwellings per hectare) Any known restrictions to development?	Assumed 25-55dph Depends upon individual sites chosen … potential contamination, conservation area, listed buildings, flood risk, AONB relationship.	Assumed 25-55dph Depends upon individual sites chosen … potential contamination, conservation area, listed buildings, flood risk, AONB relationship.	Assumed 30-50dph Depends upon individual sites chosen … potential contamination, conservation area, listed buildings, flood risk, AONB relationship.	Assumed 30-50dph Depends upon individual sites chosen … potential contamination, conservation area, listed buildings, flood risk, AONB relationship.	Assumed 30-50dph Depends upon individual sites chosen … potential contamination, conservation area, listed buildings, flood risk, AONB relationship.
SHLAA Sites: List of SHLAA sites in Stroud Valleys (option D)	10, 13, 21, 41, 49, 53, 54, 56, 57, 58, 59, 61, 62, 63, 68, 80, 81, 87, 91, 98, 106, 107, 109, 110, 111, 126, 131, 136, 143, 144, 147, 148, 149, 160, 162, 165, 174, 178, 182, 191, 193, 225, 227, 228, 229, 238, 245, 247, 284, 285, 286, 287, 292, 318, 319, 329				
List of SHLAA sites within each area (RTP ID No.)	59, 87, 91, 143, 144, 148, 319 (incl. 126, 194, 127, 273, 267, 22, 179, 266)	10, 56, 68, 98, 111, 147, 149, 193, 285, 292, 318 (incl. 84, 254, 278, 295), 329	21, 54, 58, 63, 80, 110, 126, 165, 174, 286	13, 41, 49, 61, 62, 81, 107, 131, 162, 178, 191, 238, 247, 284	53, 57, 106, 109, 136, 160, 182, 225, 227, 228, 229, 245, 270

Data sources:

156 Stroud SHLAA (January 2010) and updates

Development representations for:

- land north of Stroudwater (Robert Hitchins) [referred to as land to the west of Stonehouse]; and
- Sharpness (Hunter Page Planning).

Transport Emission Assessment

157 The estimated emissions from transport are presented in Table B6 to Table B8. This is based on a high level estimate of car journeys associated with commuting and leisure/commercial travel. Further details on the methodology are provided in Section 4.1.2 of the main report.

Table B.6 Estimated road transport emissions (Option A)

	Tonnes CO2 per year				
	Cam	**Eastington**	**West of Stonehouse**	**Sharpness**	**Hunts Grove**
Commuting					
Commuting to Stroud	445	192	173	593	190
Commuting to Gloucester	818	587	587	1,175	360
Commuting to Bristol	646	726	726	604	796
Sub Total	**1,910**	**1,505**	**1,486**	**2,372**	**1,345**
Leisure/Commercial					
Visiting Stroud	1,100	950	854	2,934	352
Visiting Gloucester	607	436	436	872	890
Visiting Cam/Dursley	210	0	0	0	0
Sub Total	**1,918**	**1,386**	**1,290**	**3,806**	**1,242**
Grand Total	**3,827**	**2,891**	**2,775**	**6,178**	**2,586**
Tonnes per home	1.9	1.4	1.4	3.1	1.3

Table B.7 Estimated road transport emissions (Option B)

	Tonnes CO2 per year				
	Cam	**Eastington**	**West of Stonehouse**	**Brimscombe and Thrupp**	**Whitminster**
Commuting					
Commuting to Stroud	222	96	86	30	122
Commuting to Gloucester	409	294	294	666	245
Commuting to Bristol	323	363	363	-	358
Sub Total	**955**	**753**	**743**	**697**	**725**
Leisure/Commercial					
Visiting Stroud	550	475	427	150	601
Visiting Gloucester	304	218	218	353	182
Visiting Cam/Dursley	105	0	0	0	0
Sub Total	**959**	**693**	**645**	**504**	**783**
Grand Total	**1,914**	**1,446**	**1,388**	**1,200**	**1,508**
Tonnes per home	1.9	1.4	1.4	1.2	1.5

Table B.8 Estimated road transport emissions (Option D)

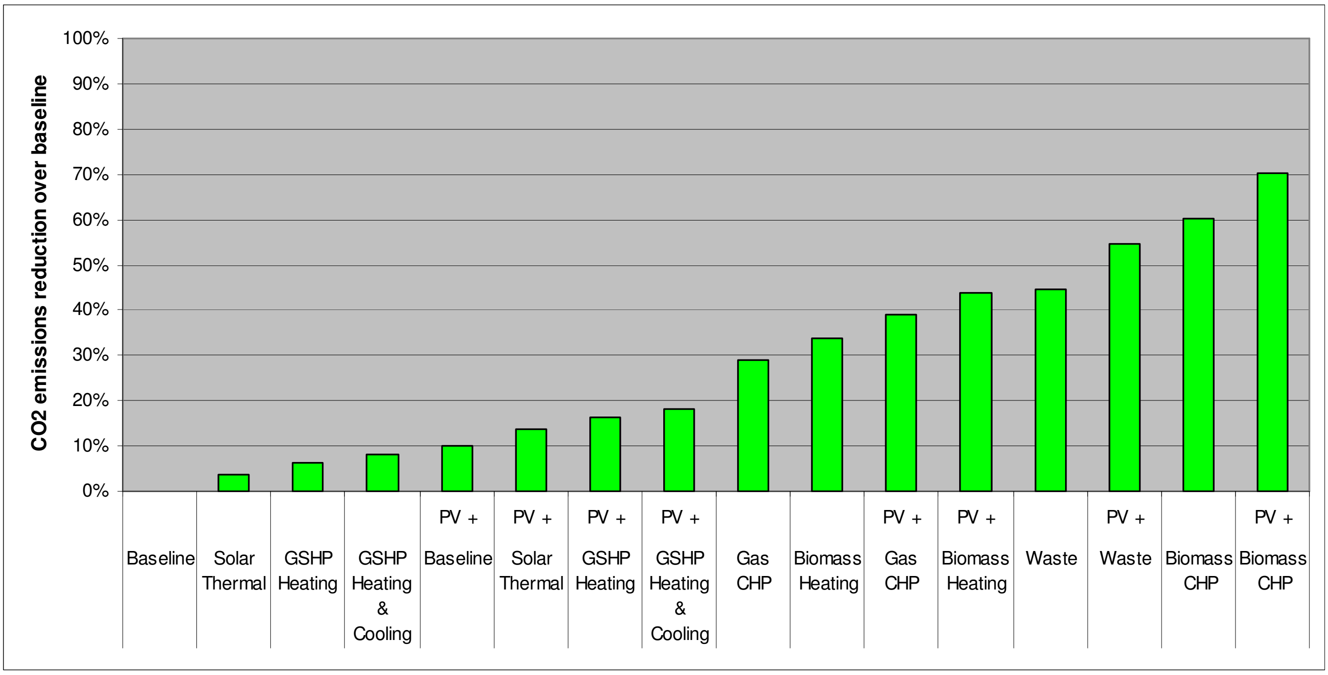
	Tonnes CO2 per year
	Stroud Valleys
Commuting	
Commuting to Stroud	61
Commuting to Gloucester	1,333
Commuting to Bristol	-
Sub Total	**1,393**
Leisure/Commercial	
Visiting Stroud	301
Visiting Gloucester	706
Visiting Cam/Dursley	0
Sub Total	**1,007**
Grand Total	**2,401**
Tonnes per home	1.2

Appendix C
Phase 2 Assessment

158 The graphs in this appendix show the estimated emissions reductions and additional build costs associated with a range of technologies identified as having potential to supply development at each site type within each Option.

159 In all cases the baseline scenario assumes all heat supplied by gas and all electricity supplied from the grid.

Figure C.1 Option A – CO_2 emissions reductions and increase in build costs by technology



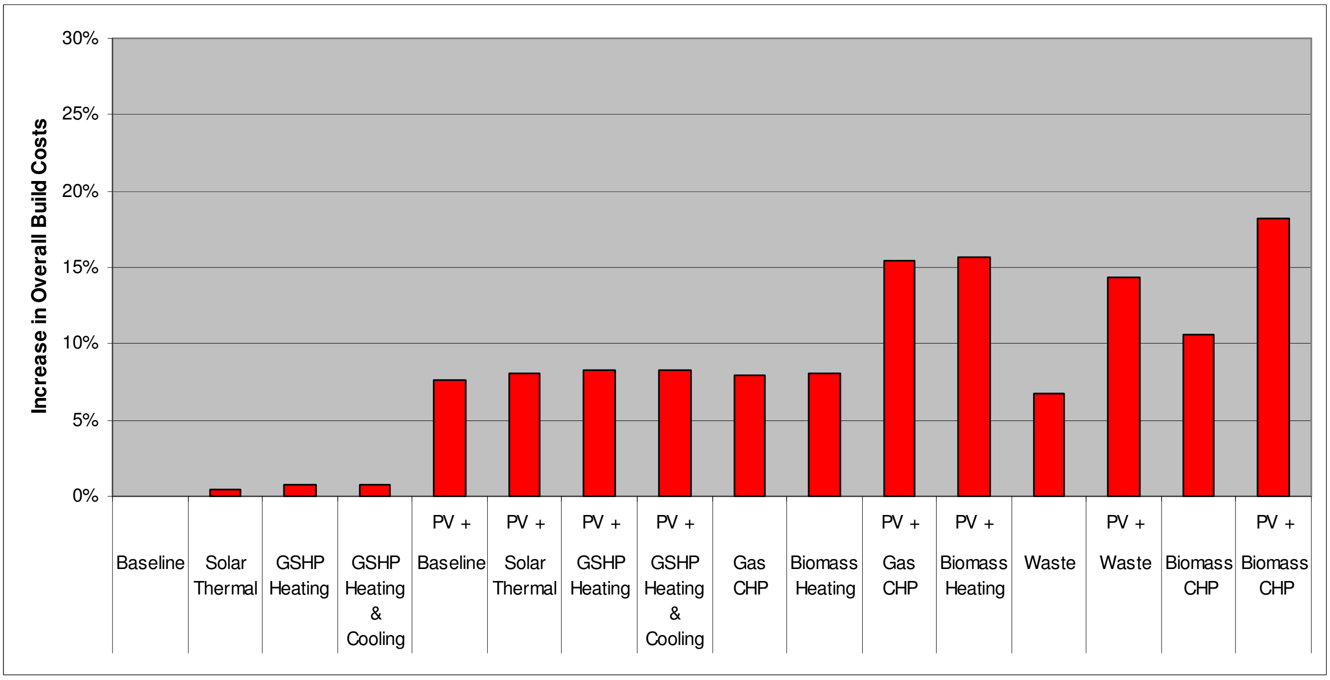


Figure C.2 Option B – CO_2 emissions reductions and increase in build costs by technology

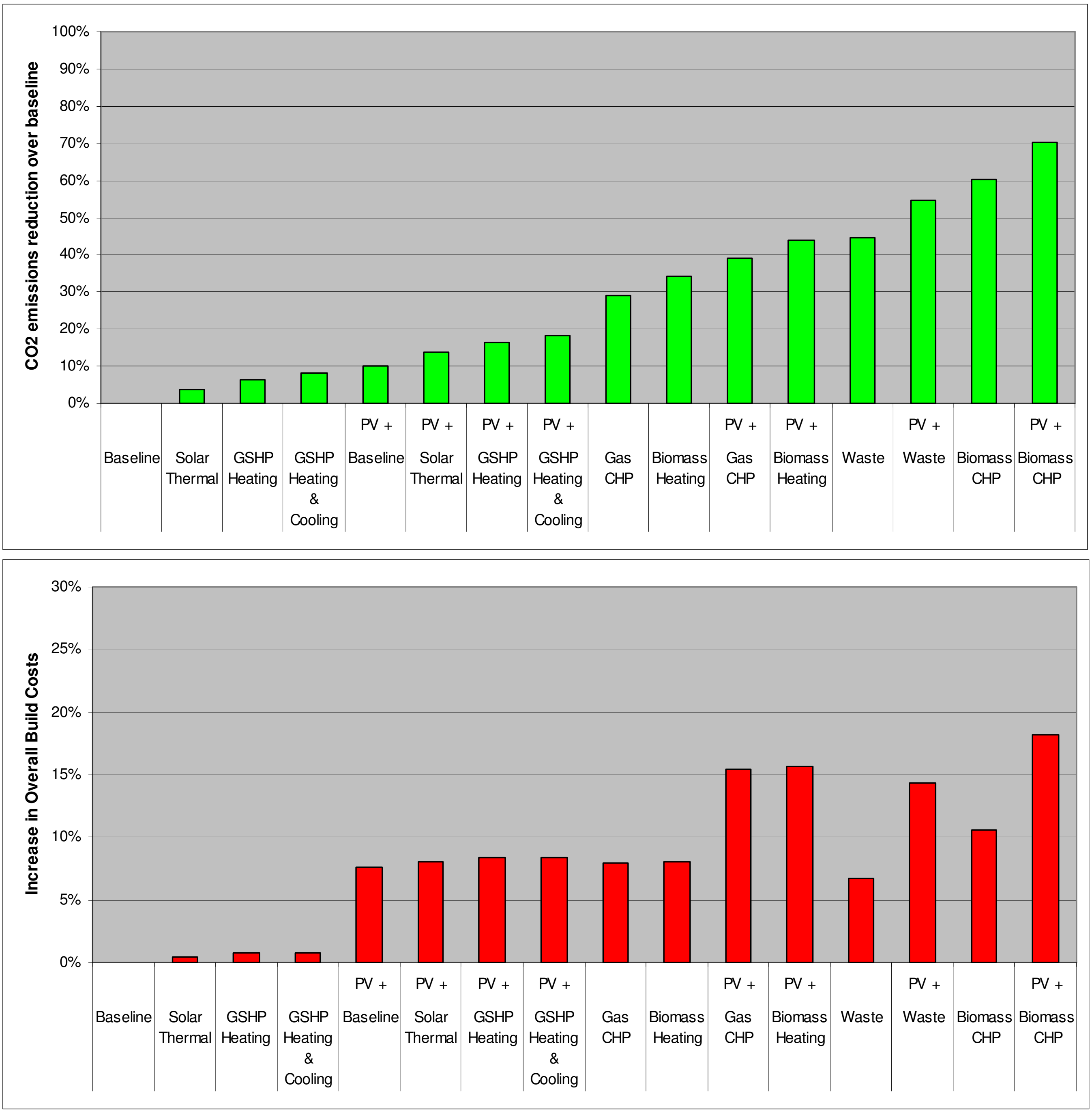
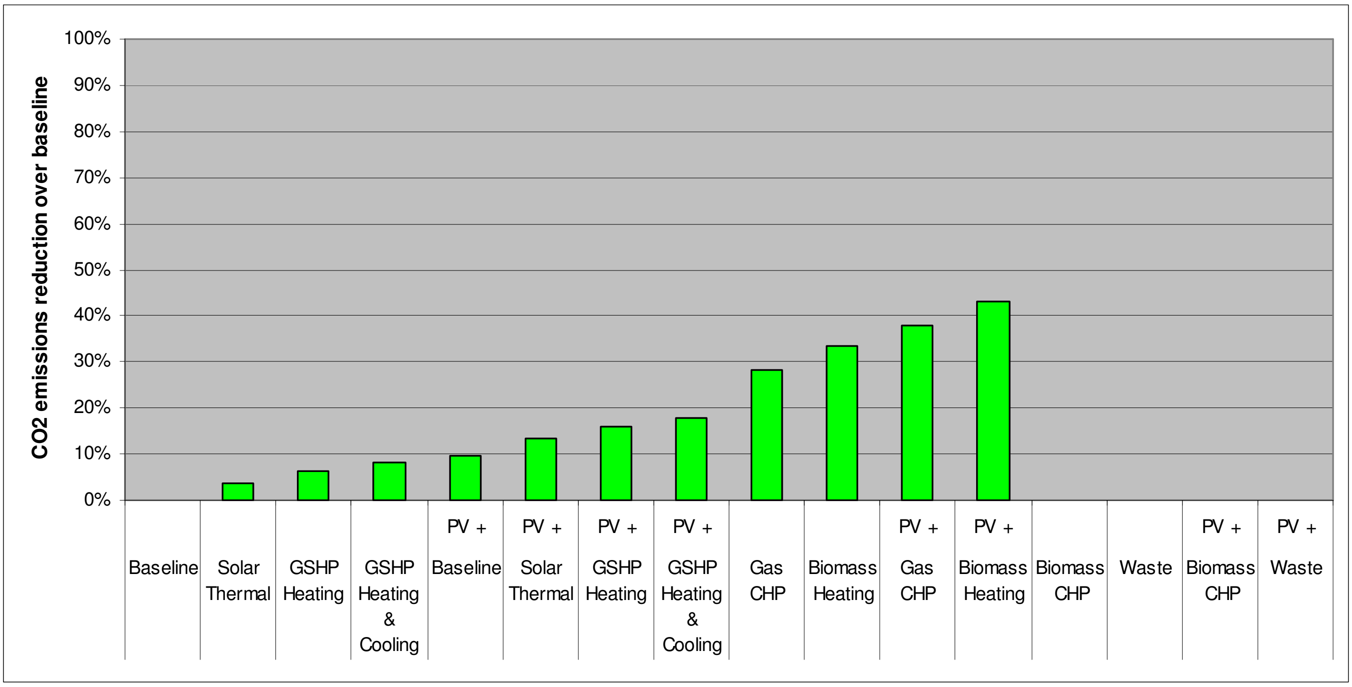


Figure C.3 Option D – CO_2 emissions reductions and increase in build costs by technology (Type i)



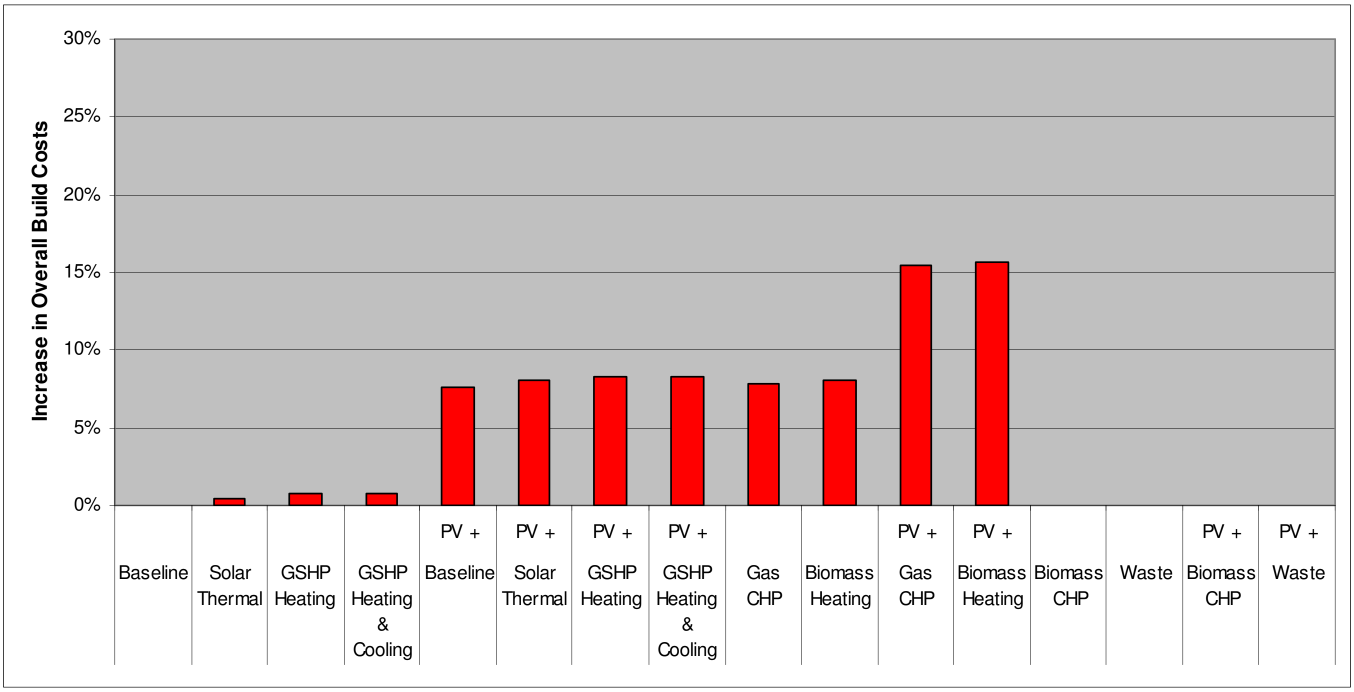
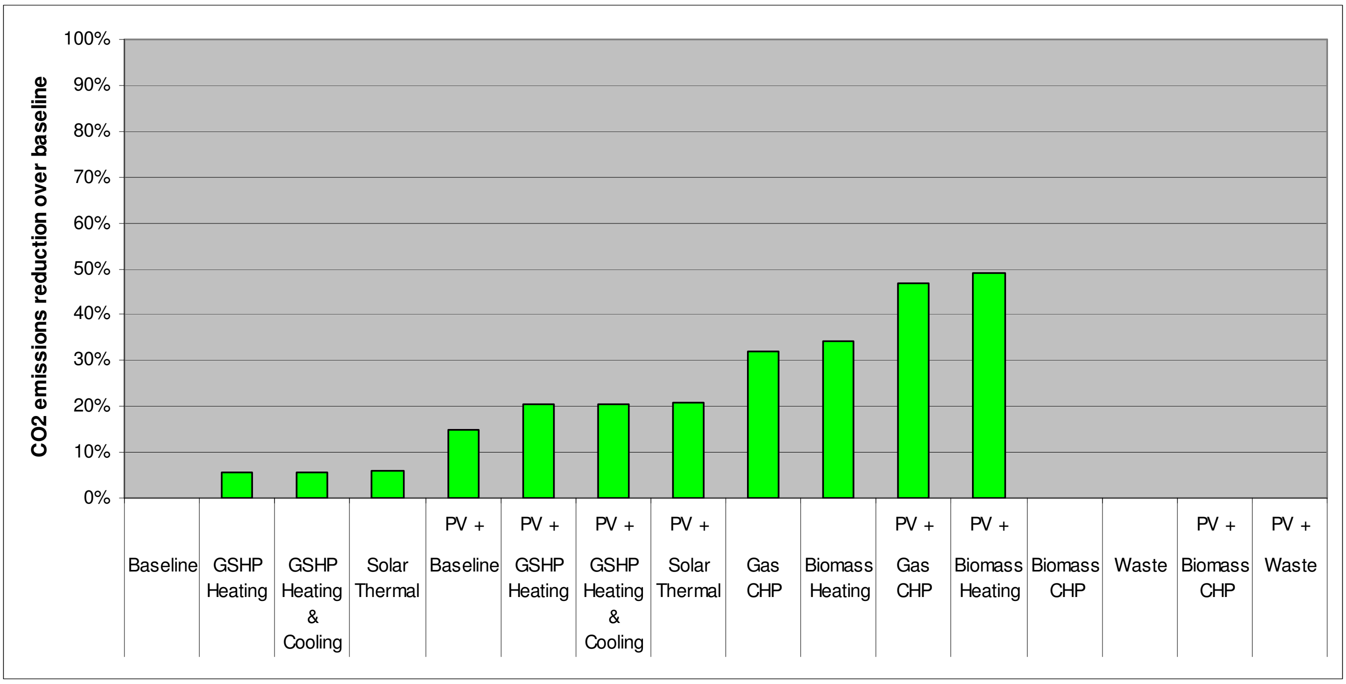


Figure C.4 Option D – CO_2 emissions reductions and increase in build costs by technology (Type ii)



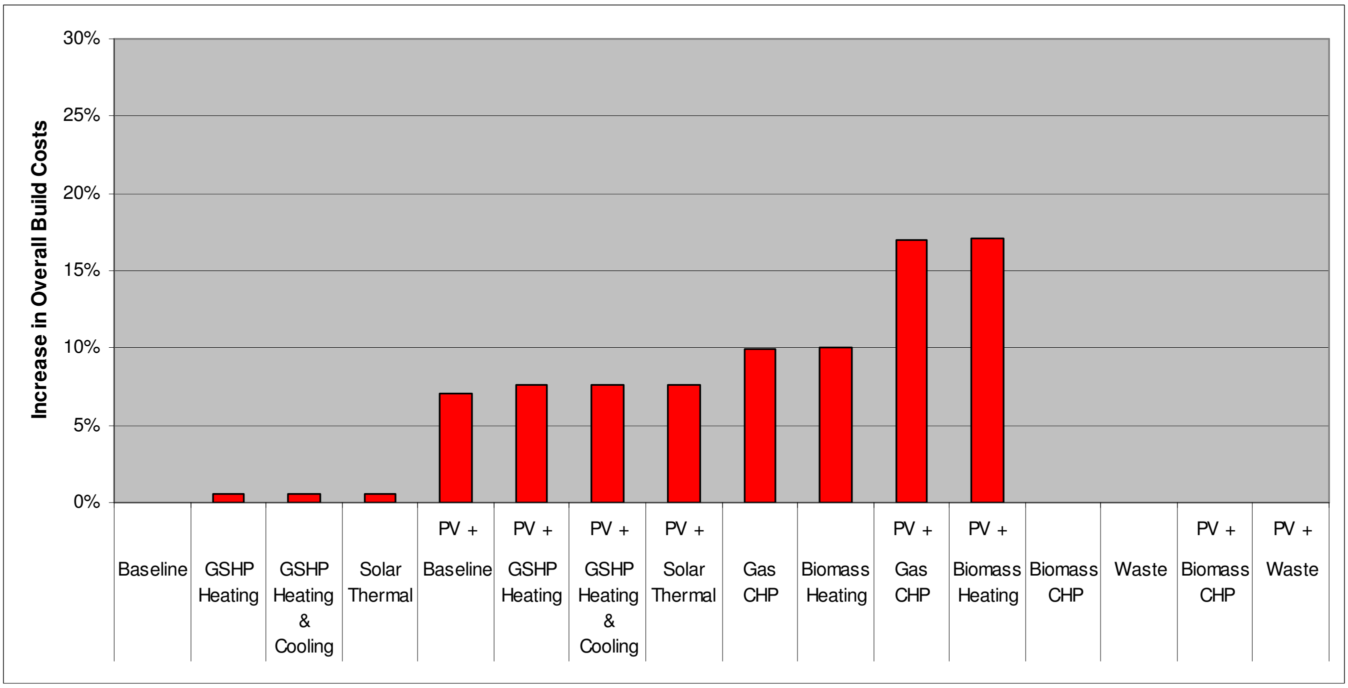
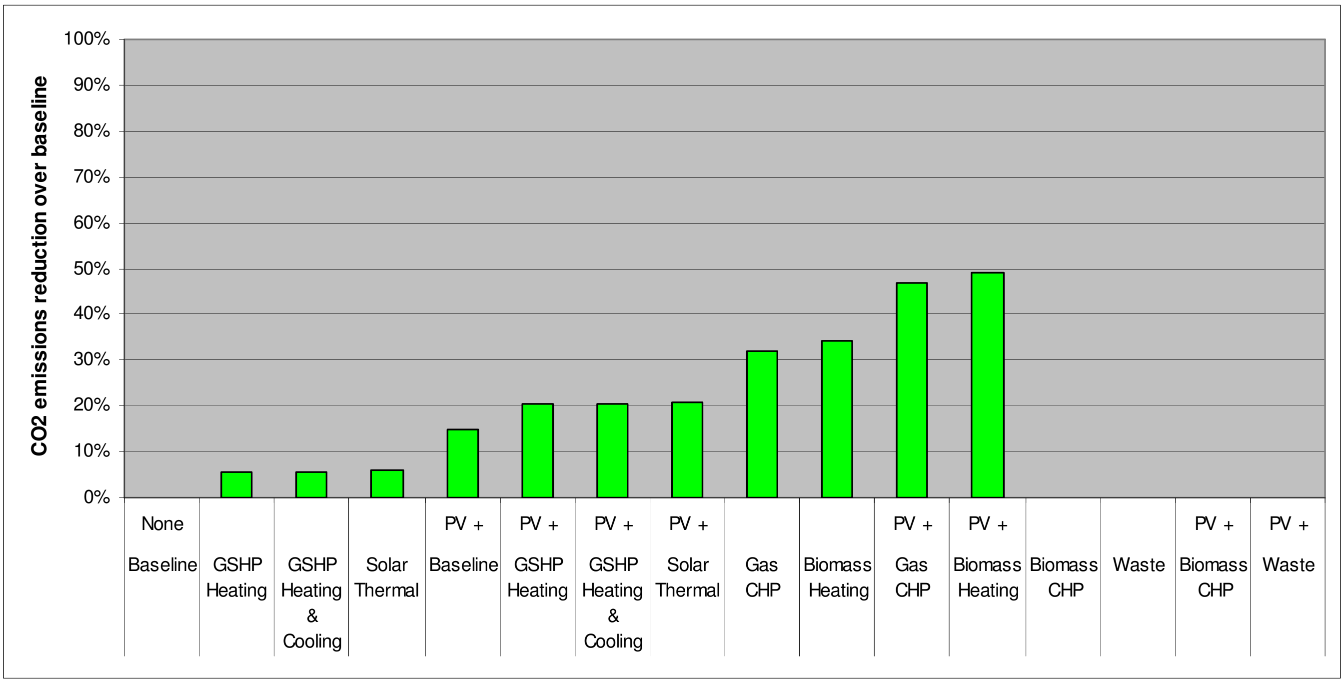


Figure C.5 Option D – CO_2 emissions reductions and increase in build costs by technology (Type iii)



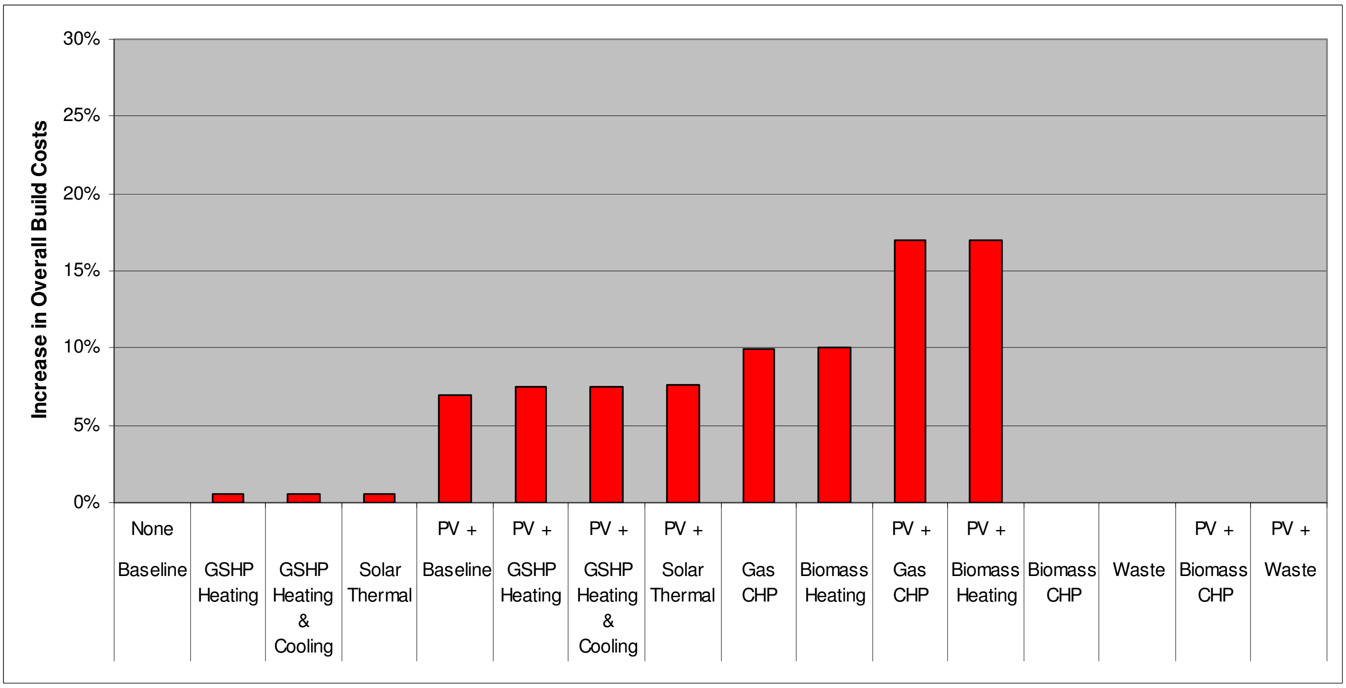


Figure C.6 Option D – CO_2 emissions reductions and increase in build costs by technology (Type iv)

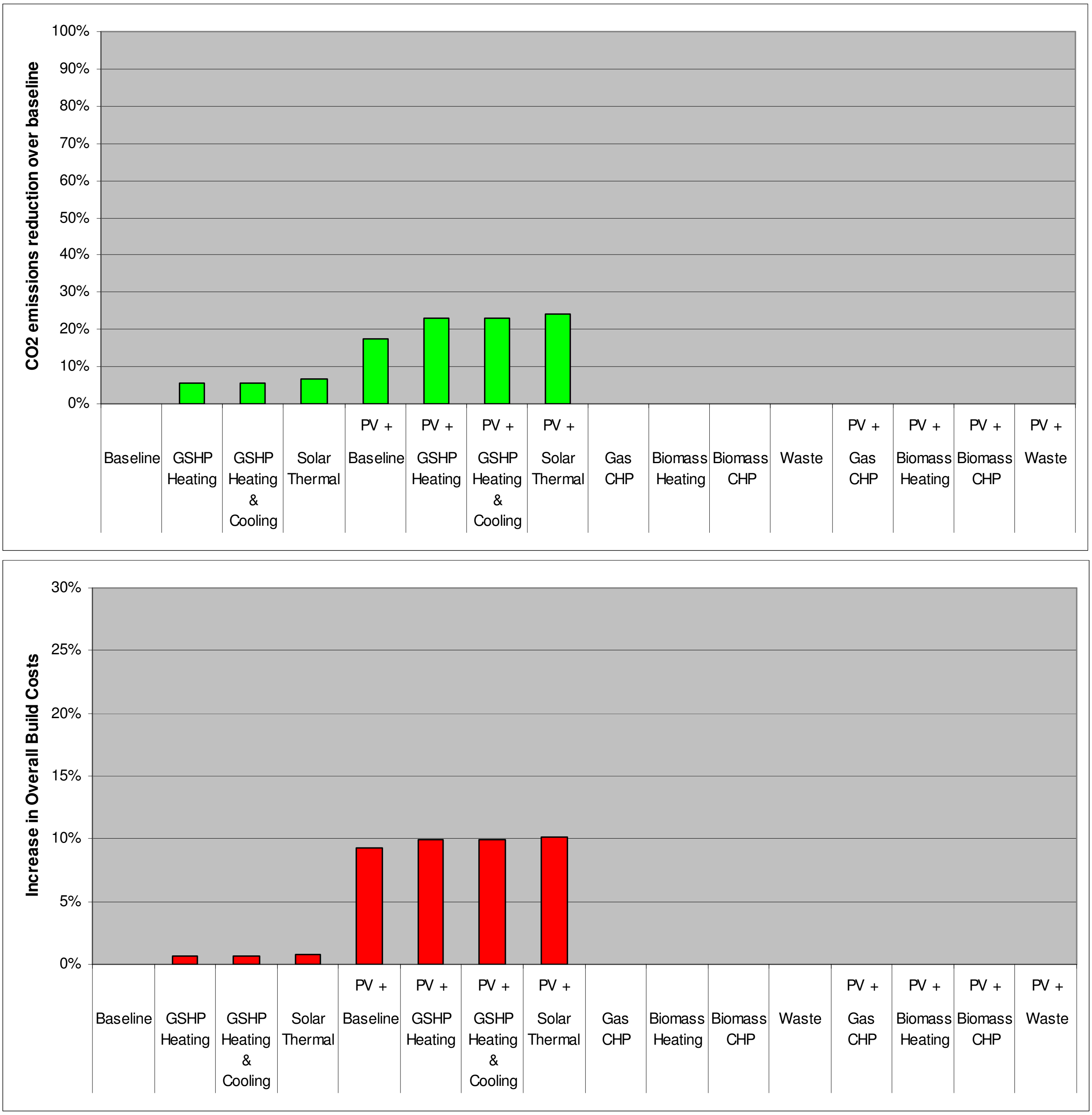
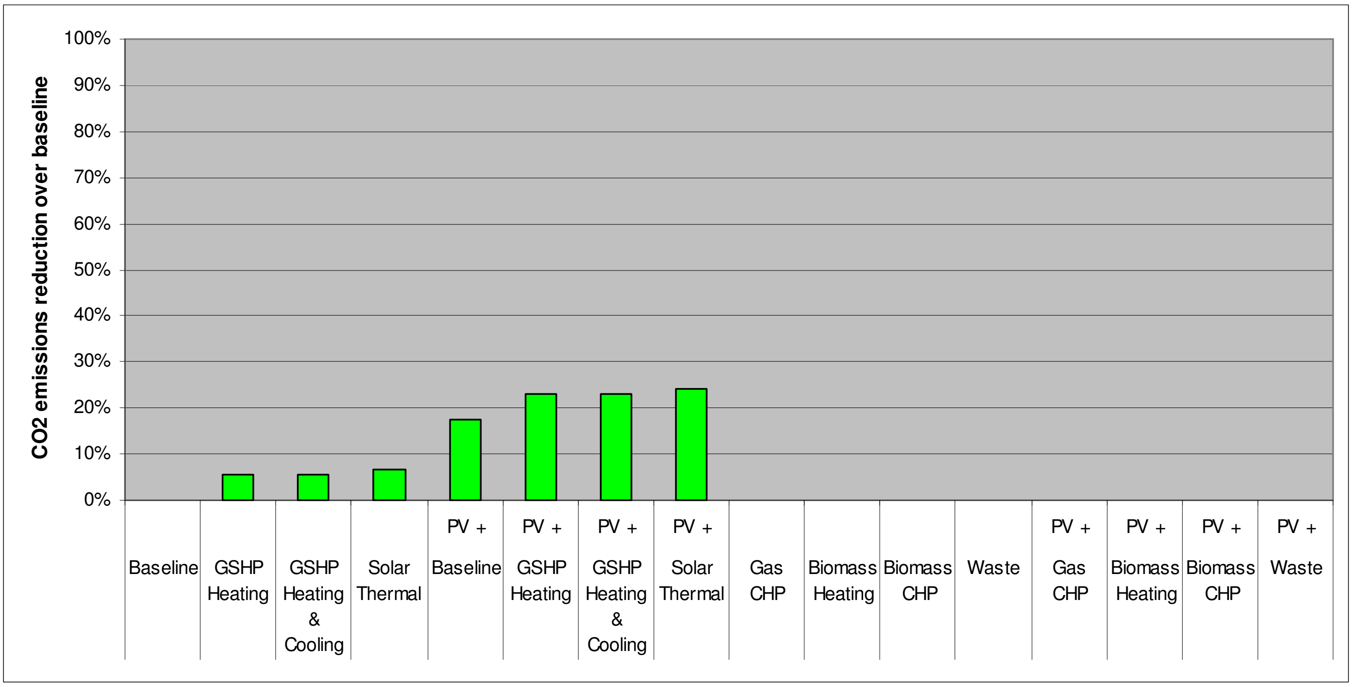


Figure C.7 Option D – CO_2 emissions reductions and increase in build costs by technology (Type v)



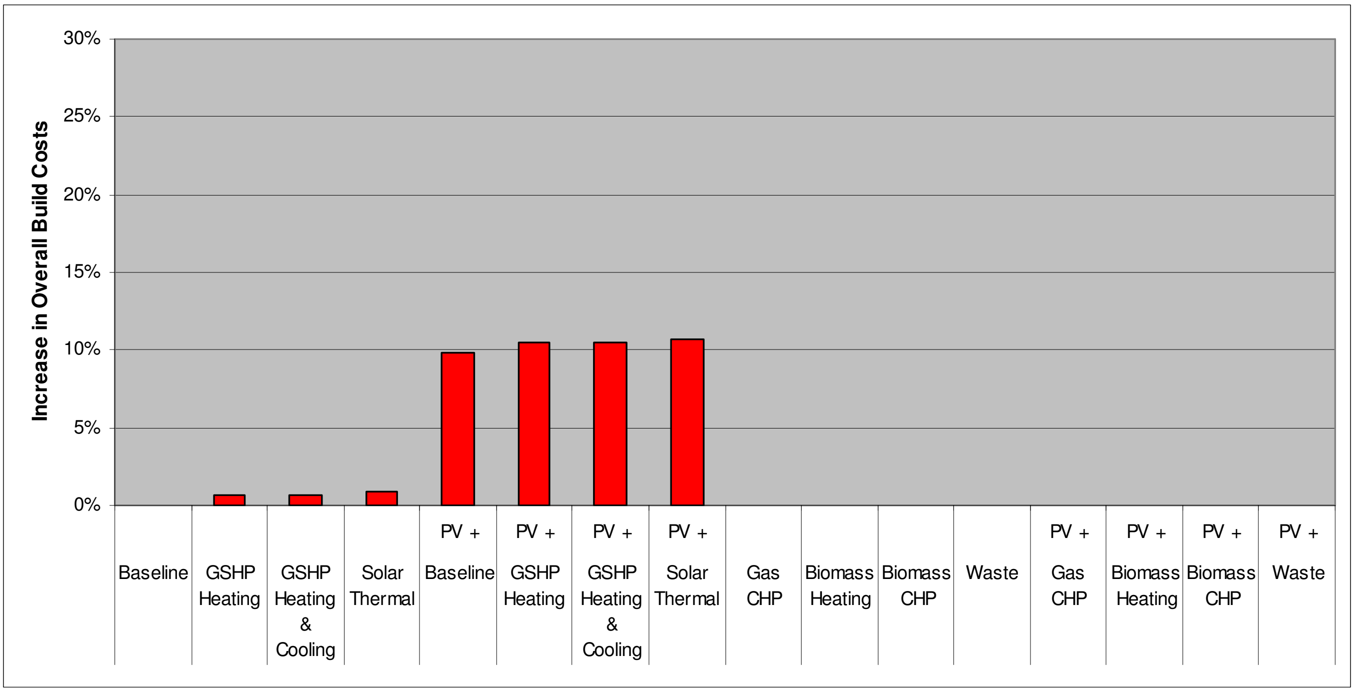
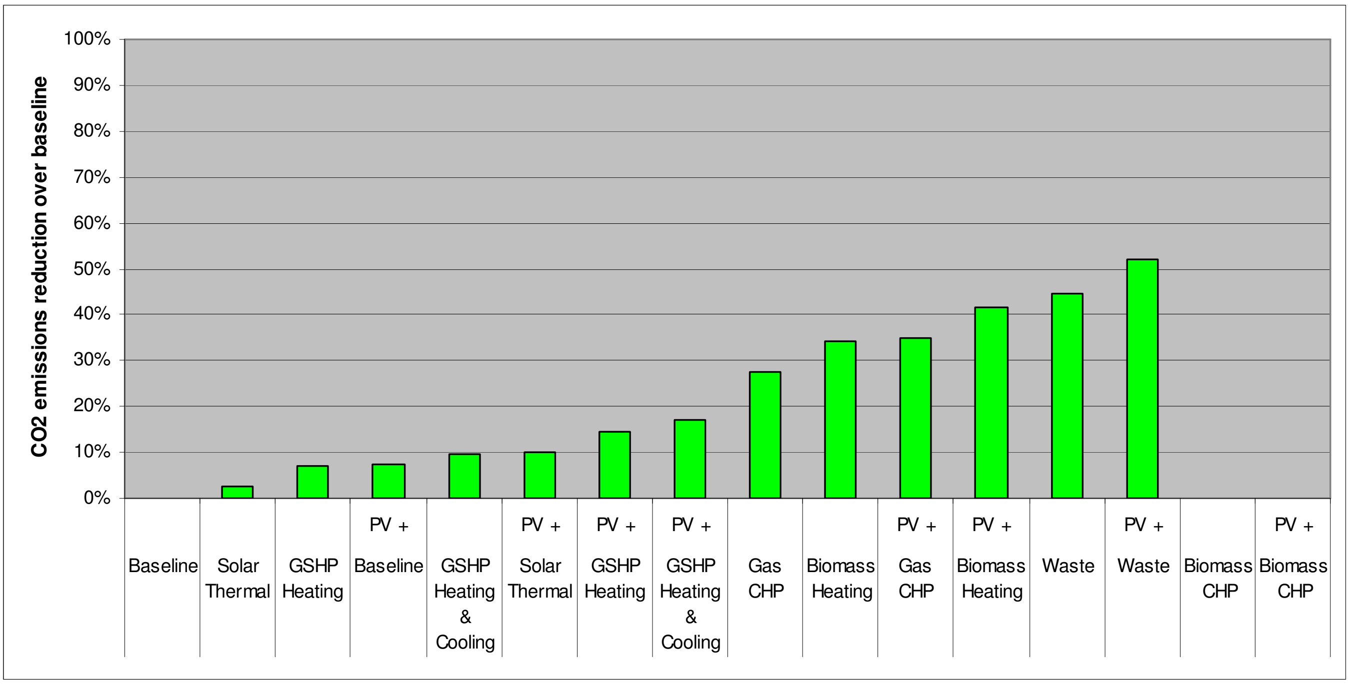
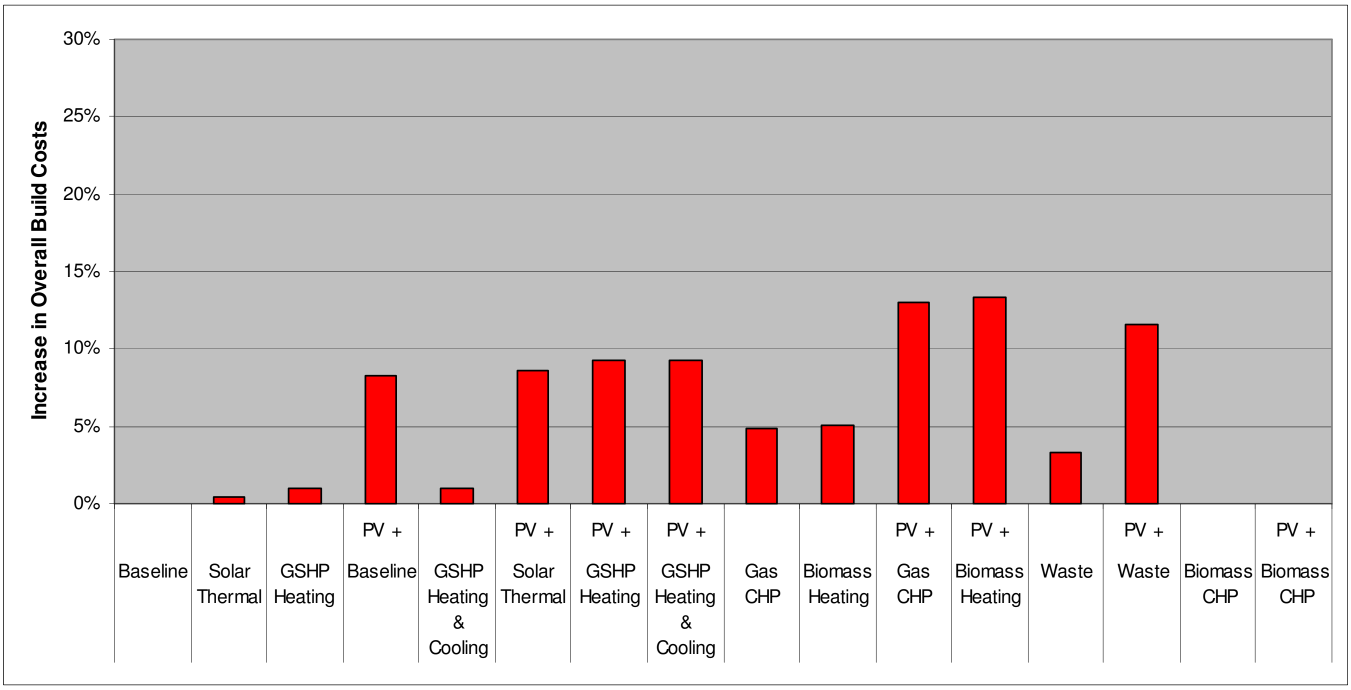


Figure C.8 Option D – CO_2 emissions reductions and increase in build costs by technology (Type vi)





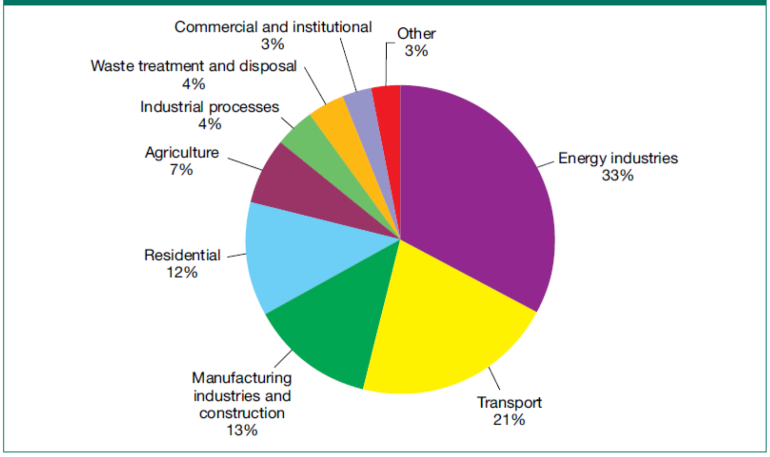
Appendix D
Transport Assessment Background Information

160 This appendix provides background to how new development influences transport emissions.

Comparative Emissions Data

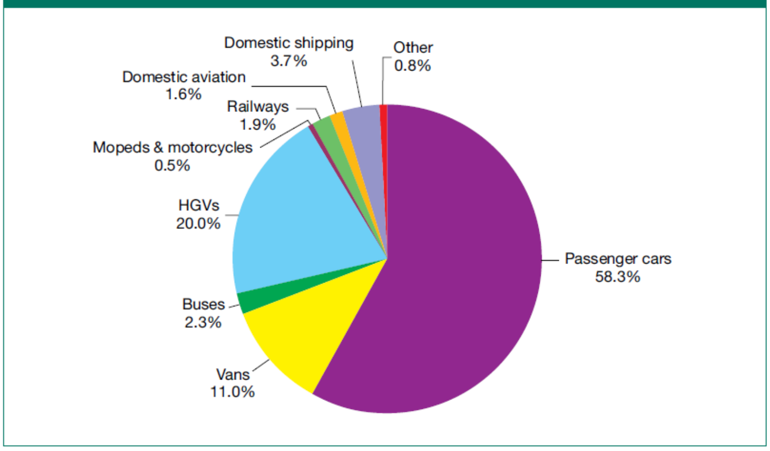
161 *a. Transport accounts for approximately one fifth of CO_2 emissions, with over 90% of this generated by road traffic*

Figure 2.2: Transport is a significant source of domestic greenhouse gas emissions



UK domestic greenhouse gas emissions by source category, 2007 'Other' includes: fugitive emissions from fuels, agriculture and forestry fuel use, military aircraft and shipping, land use, land-use change and forestry (LULUCF).
Source: National Atmospheric Emissions Inventory (IPCC categories) 2007.

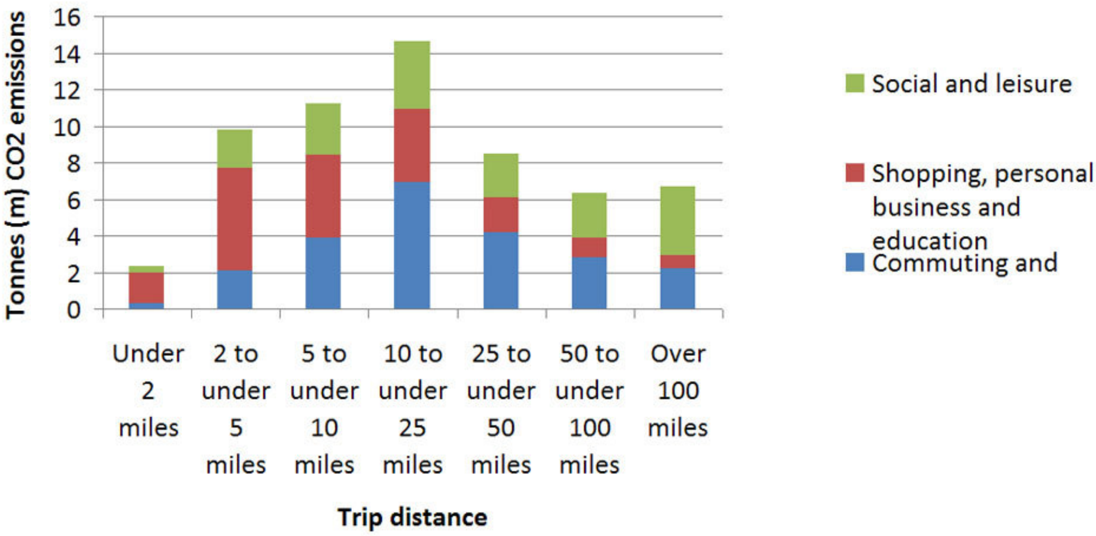
Figure 2.3: Travelling by road accounts for 92% of the domestic transport sector's greenhouse gases



Greenhouse gas emissions from UK domestic transport by source, 2007 'Other' includes LPG emissions; road vehicle engines; aircraft support vehicles.
Source: National Atmospheric Emissions Inventory (IPCC categories) 2007.

source: DfT (July 2009) Low Carbon Transport: a greener future

162 *b. The bulk of trips and emissions are centred on the 5-25 miles range*



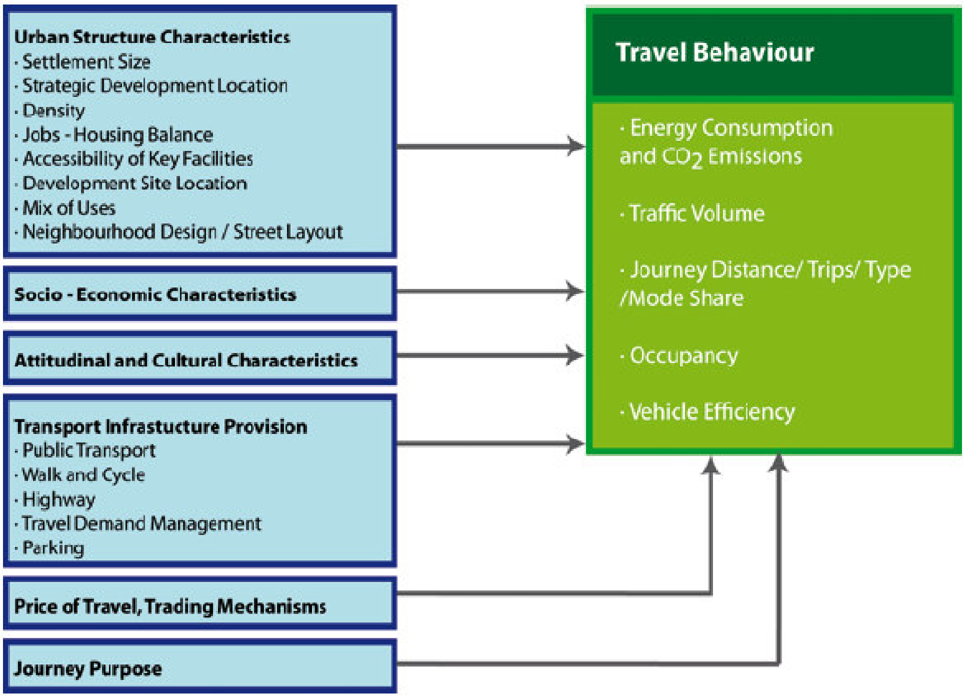
Source: Commission for Integrated Transport (October 2009) **Planning for Sustainable Travel** at http://www.plan4sustainabletravel.org/

c. Detailed assessment

163 If a detailed assessment of the emissions patterns of alternative patterns of urban development was required, this would be through modelling, such as the Estimation of Travel, Energy and Emissions Model (ESTEEM), and can be used alongside conventional multi-modal transport models and site appraisal frameworks which can take account of the availability of decentralised renewable or low carbon energy sources.

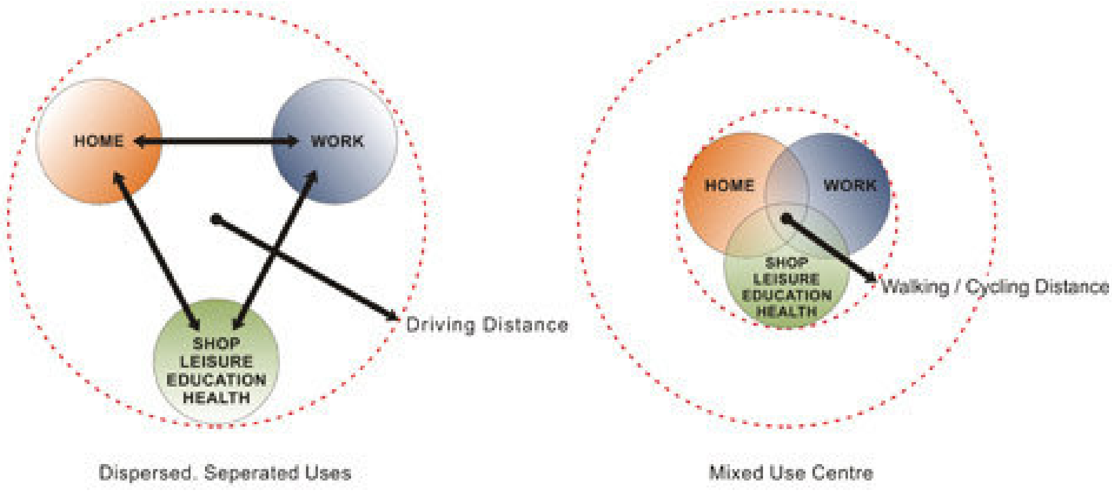
Principles of Spatial Organisation and Design

164 *a. Travel behavior is influenced by a complex mix of factors, including urban structure (itself composed of an array of factors)*

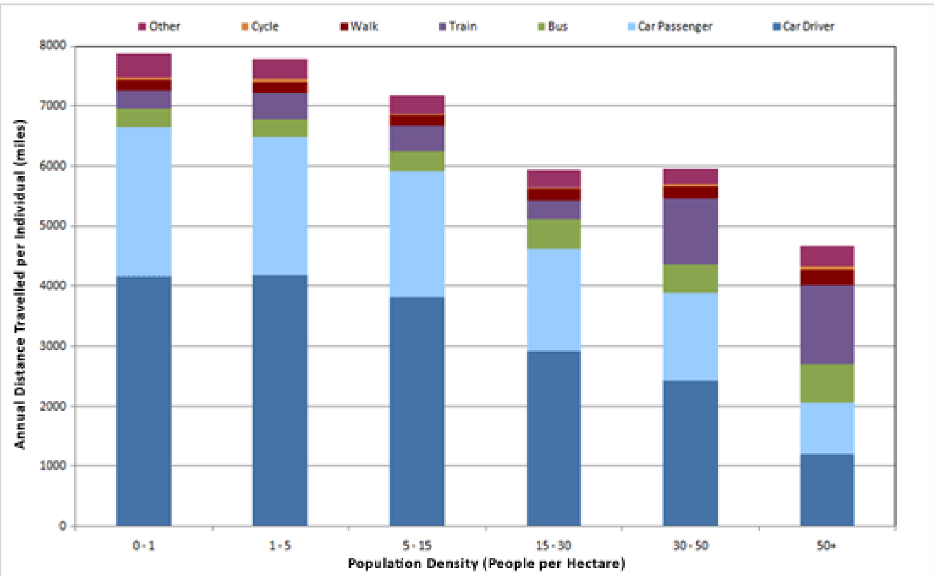


b. The impact of spatial planning

165 Most spatial planning is focused at the local level which makes it difficult to have a big impact on car use. The focus on urban form within settlements and using site travel plans to reduce driving ignores questions about the relationship of different types of land use to their wider contexts. What really matters is the strategic location of development and the balance of jobs, houses and other land uses within and between whole towns and cities at the sub-regional level. It's the longer journeys between towns, of between 5 and 25 miles, that are responsible for a much greater proportion of overall car mileage and hence CO_2 emissions (see above). However, having several land uses within a defined area is to allow multiple activities to occur from one trip, to shorten trip lengths and to encourage non-motorised trips by making common destinations available within walking / cycling distance.



Source: www.plan4sustainabletravel.org



Source: Commission for Integrated Transport (October 2009) **Planning for Sustainable Travel** at http://www.plan4sustainabletravel.org/

166 Data on travel patterns in the UK provides clear evidence of the links between density, accessibility and travel. At higher densities (especially over 30 people per hectare) the average annual distance travelled per person falls, particularly distance travelled by car. The distance travelled by public transport increases. Areas with very good levels of accessibility to public transport have lower levels of car use and higher proportions of public transport, walking and cycling.

c. The influence of land use design

167 The following table indicates how various land-use design features are estimated to reduce per capita vehicle trip generation compared with conventional development that lacks these features;

Design Feature	Reduced Vehicle Travel
Residential development around public transport nodes	10%
Commercial development around public transport nodes	15%
Residential development along public transport corridor	5%
Commercial development along public transport corridor	7%
Residential mixed-use development around public transport nodes	15%
Commercial mixed-use development around public transport nodes	20%
Residential mixed-use development around public transport corridor	7%
Commercial mixed-use development around public transport corridor	10%
Residential mixed-use development	5%
Commercial mixed-use development	7%

Source: http://www.its.leeds.ac.uk/projects/distillate/outputs/Deliverable%20F%20Appendix%20C.pdf

d. Principles of sustainable urban design

168 The aim of good development site location in relation to sustainable travel should be to locate new housing where:

- the amount of travel by car (trip length and mode share) is likely to be low;
- good accessibility is available or can be created by sustainable modes to:
  - employment and other main facilities in the town or its immediate vicinity;
  - a rail station or other public transport interchange where good services are available to other (larger) centres within the sub-region;
  - and community facilities within the development or the surrounding neighbourhood;
- opportunities exist to:
  - promote the use of walking, cycling and public transport;

- provide an attractive level of public transport service which does not depend on (additional) subsidy over the longer term;
- utilise and support existing public transport services and community facilities in the locality;
- incorporate services or facilities within the development which will improve accessibility by sustainable modes;
- in certain locations, car-free or low-car provision housing will be appropriate.

Source: Commission for Integrated Transport (October 2009) **Planning for Sustainable Travel** at: http://www.plan4sustainabletravel.org/

Conclusions

169:

- Whilst reducing the volume of local trips is important, the bulk of trips and emissions occur in the 5-25m range (i.e. inter-urban commuting and shopping)
- The broad spatial location influences short trips but not longer ones.
- Nevertheless, over the long term, access to jobs and services will have an influence over travel behaviour, and hence carbon emissions.
- Strategic modelling for each option (using census data [TTWA] and taking account of travel behaviour such as linked and pass-by trips) would yield more precise figures.
- Detailed urban design considerations could be highly influential in determining overall patterns of use and therefore emissions.