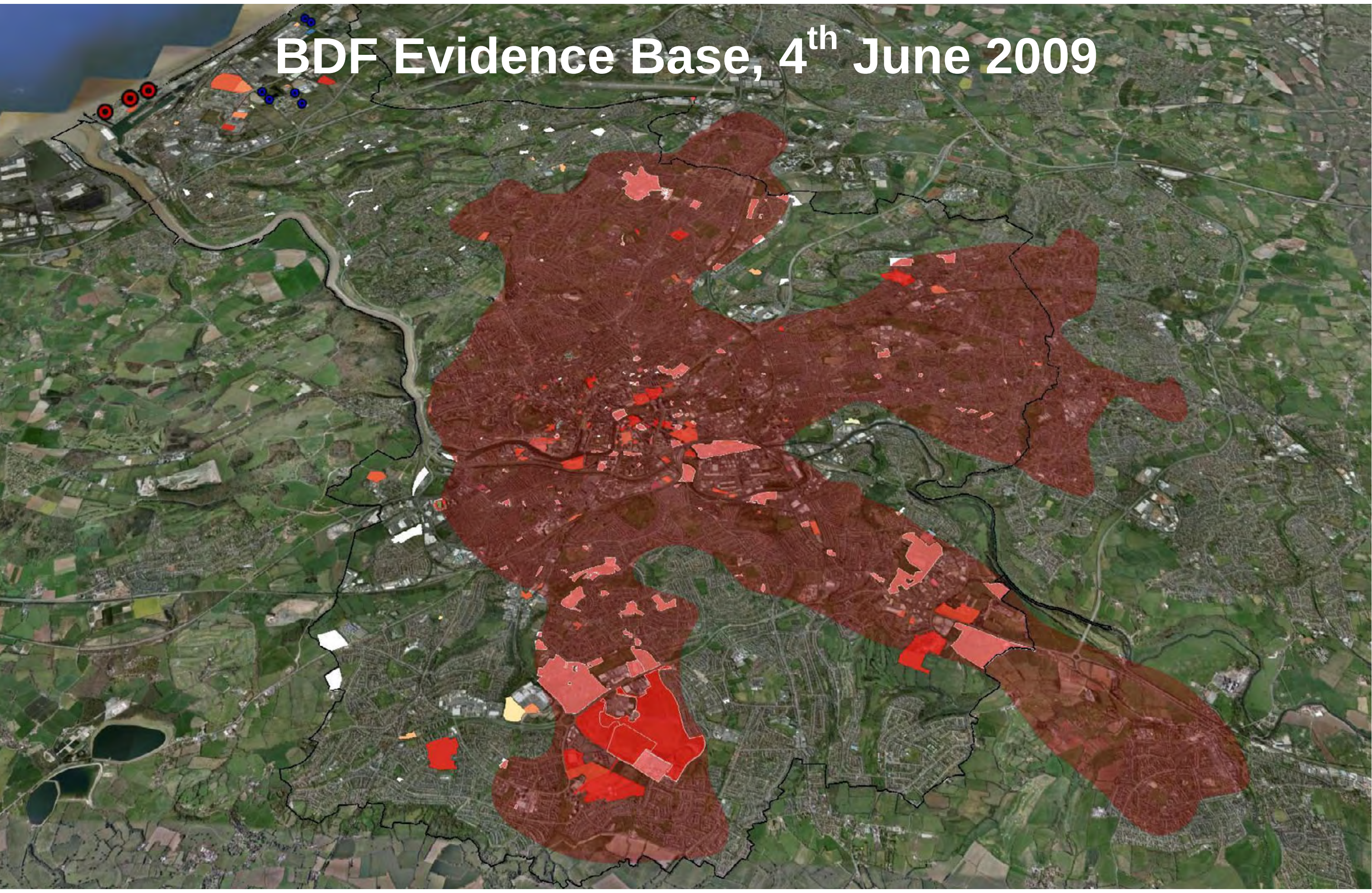
Bristol Citywide Sustainable Energy Study



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Executive Summary

This report presents the results of the Bristol Citywide Sustainable Energy Study and has been produced by the Centre for Sustainable Energy and Adrian Smith, Independent Planning Consultant. The underlying aim of this study is to assist Bristol City Council in developing LDF policies which positively encourage reduced energy consumption and carbon emissions from buildings and greater sustainable energy generation.

The Government is committed to a set of challenging sustainable energy policies including a significant tightening of Building Regulations. There is increasing evidence to suggest that progressive policies at the local level are now being successfully implemented in response to these proposals. Bristol therefore now has an opportunity to build on this evidence and identify where it can formulate policies that go beyond prevailing Building Regulation standards and encourage sustainable energy generation across the city.

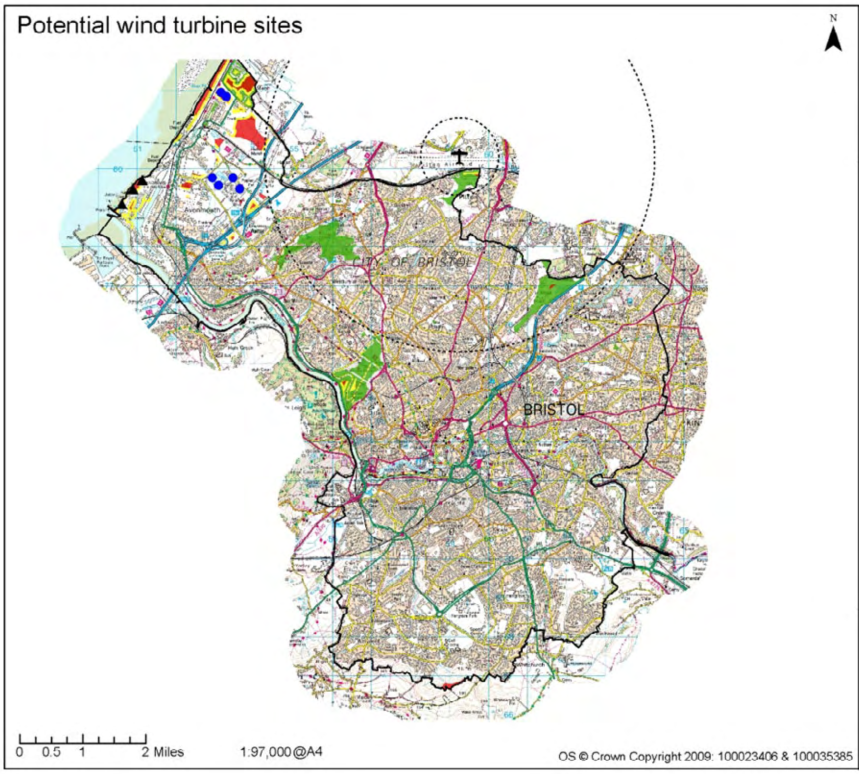
Resource assessment

Bristol will need to draw on a range of renewable and low carbon energy resources to meet the challenging targets expected from 2010 onwards. The extent to which these can be evaluated varies according to the type of resource, the technology employed and the energy end-use.

Certain resources are easier to quantify in that their potential can be independently expressed in terms of stand-alone (i.e. non-building integrated) technology capacities, although in practice their application will be linked to developments. These include wind, wood fuel and municipal, industrial and commercial solid waste. Woodfuel and waste in particular will be a key resource in meeting the higher targets contained in the scenarios modelled below due to the importance of biomass CHP and community heating systems at this level. Solar and heat pump technologies are specifically building-related and so are directly influenced by development policies.

By fully exploiting these resources – including energy recovery from all municipal solid waste (MSW) - a reduction of around 20% of Bristol's total CO_2 emissions in 2006/7 could potentially be achieved. However if MSW is excluded, the total falls considerably, to around 4%. These figures represent the maximum that could theoretically be achieved. In addition some or all of the waste resource should be considered to as an input to district heating, which would also require significant additional non-local fuel inputs.

Summary of resource assessment			
	Capacity [MW]	**Emissions savings [tonnes CO_2/yr]**	**Proportion of citywide CO_2 emissions [%] (2006 figures)**
Local sustainable electricity resource *excluding* waste	102	88,072	3.8
Electricity from waste: assuming CHP	45	201,101	8.7
Local sustainable heat resource *excluding* waste	84	20,614	0.9
Heat from waste: assuming CHP into DH network	90	145,854	3.6
Existing installations (incl. in above figures above)	*(23.9)*	*(49,787)*	*(2.2)*
Biomass heat via DH (non-local resource)	1,080	524,660	17
Biomass electricity: assuming CHP into DH network (non-local resource)	360	507,644	16

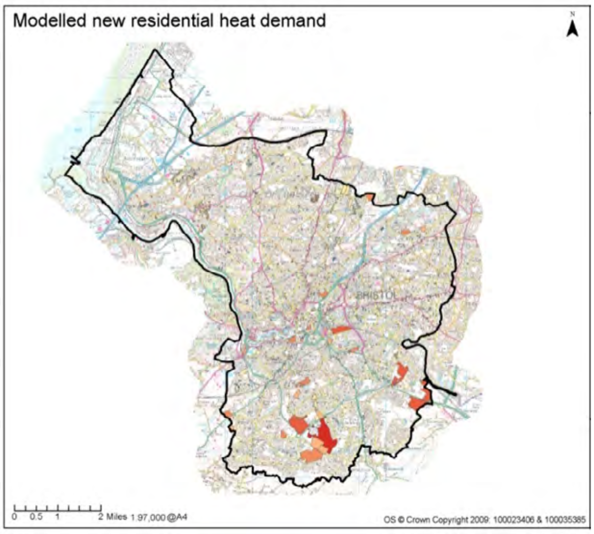


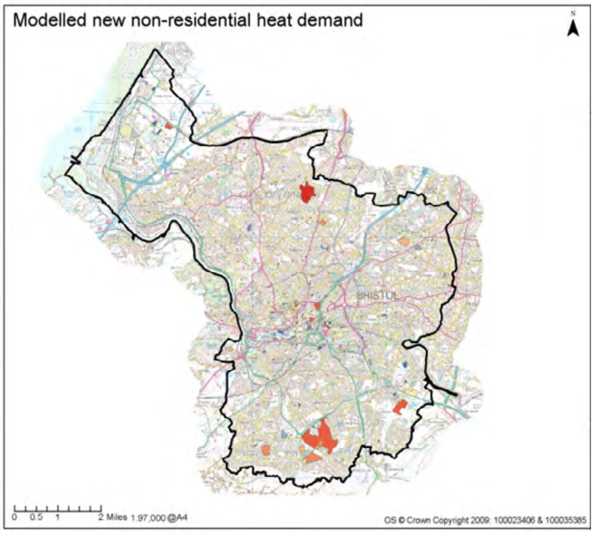
Energy demands and Heat Priority Areas

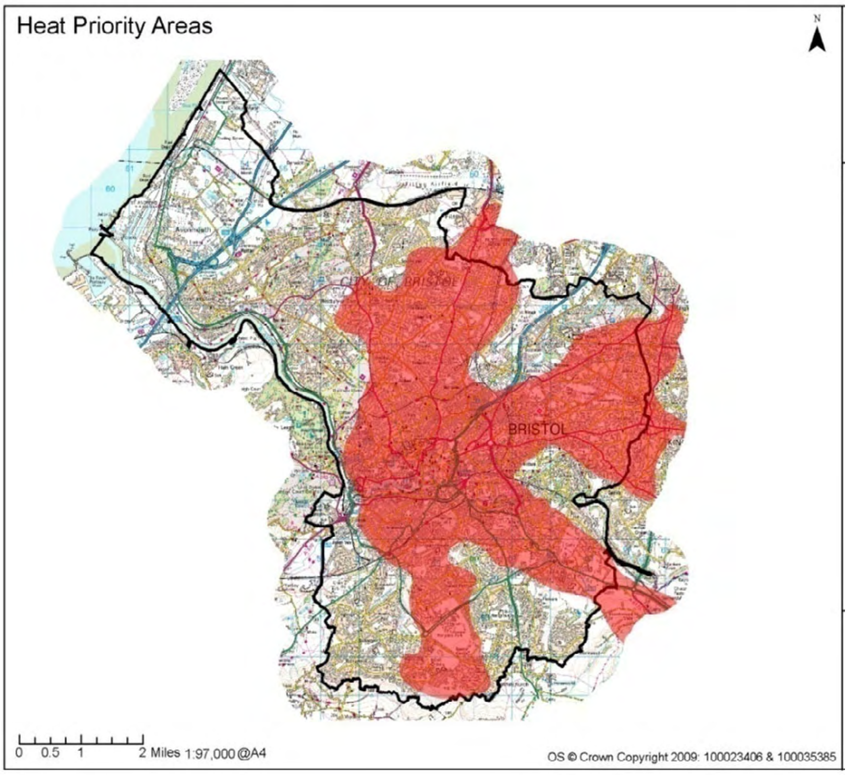
An analysis of existing heat loads in Bristol alongside those expected from new development has led to the identification of Heat Priority Areas, in which conditions are likely to favour larger scale, more economic and effective forms of sustainable energy generation such as CHP with district heating (and/or cooling).

The combined Heat Priority Area identified for Bristol captures around 70% of total heat demand in 45% of the city area. If this heat demand were supplied from biomass fuel or gas CHP, offsetting natural gas, the resulting carbon savings would be the equivalent of almost 25% of Bristol's citywide emissions.

Additional carbon savings would be achieved if the heat was produced in biomass CHP plant(s) – where zero carbon electricity would be generated along with the heat. This could potentially contribute a further 22% reduction in Bristol's citywide emissions, although this would require a very large supply of biomass fuel – equivalent to over 700,000 tonnes per year. Bristol's significant waste resource could provide a major contribution towards this figure but should also be considered alongside the woodfuel resource in the local area and gas-fired CHP, which can also offer significant savings compared to other fossil fuels.







Potential for sustainable energy supply on new development

Two main policy scenarios were developed and subsequently tested against a model developed by CSE to examine the implications for new residential development for the period up to 2026. Scenario 1 is based on standards for new developments that could be expected through future changes to Building Regulations. The scenario is informed by the current Government consultation on the Definition of Zero Carbon Homes and Buildings, which indicates that developers will be able to achieve the 2016 ‘zero carbon’ target for homes through a hierarchy of measures, with an appropriate trajectory towards this aim up to 2016. Scenario 2 sets a more ambitious set of targets over the same timeframe.

With an energy efficiency baseline, the scenarios modelled various combinations of biomass heat/ CHP with district heating, and solar PV, as these technologies have been shown to be the least cost options for the targets modelled in both Scenarios. The analysis indicates that on a least-cost basis, photovoltaics will be dominant in meeting the lower targets proposed for earlier phases, but that biomass heating and CHP/CCHP will dominate for the higher targets in later phases. However, early establishment of Heat Priority Areas will encourage the latter technologies to be deployed from the outset, with lower resulting carbon emissions.

Carbon impacts of new residential development

	Generation capacity [MW]		Gross emissions, Part L 2006 standards	Gross emissions from new development before adding renewables	Emissions savings from renewables [tonnes CO_2/yr]	Net emissions from new development	Net scenario increase in emissions, as proportion of 2006/7 [%]	Net increase @Part L 2006 Standards
	Electricity	Heat						
Scenario 1 (multiphase)	12.1	13.9	36,248	31,256	13,083.38	18,172.68	0.8%	1.6%
Scenario 2 (multiphase)	25.4	17.4			23,388.08	7,867.67	0.35%	

Viability of targets for new development

Targets proposed through future Building Regulation changes will impose additional build costs on new developments, which will need to incorporate a range of low or zero carbon energy measures to meet the targets. The analysis undertaken on new residential development (SHLAA sites) proposed in Bristol suggests additional costs for Scenarios 1 and 2, of 17% and 24% respectively. It was also showed that the additional 7% cost between these Scenarios may result in a further 28% of emissions reduction - this translates into an extra 10,000 tonnes CO_2 saved per year.

Increase in additional build cost and resulting total CO_2 reduction over Part L 2006

	Range of % additional build costs	Average across phases	% CO_2 reductions over Part L 2006	Average across phases
Scenario 1	11% – 20%	17%	26% – 61%	50%
Scenario 2	14% – 28%	24%	36% – 96%	78%

Theoretical additional costs associated with the Code for Sustainable Homes are well documented, but have yet to be fully tested in practice. There is a significant step-change in cost in achieving Code level 6 over level 5, although it is likely that the definition of Code level 6 will change following the Government's consultation on zero carbon homes and buildings. Additional costs resulting from BREEAM standards on non-residential development are much less defined.

A range of existing and emerging institutional and financial mechanisms can assist in the successful delivery of carbon reduction targets. Management and operation of district heating systems will need tailored arrangements such as the formation of an Energy Service Company (ESCo). Although no standard 'model' currently exists for ESCos, there are increasing numbers now being established for a variety of applications.

An essential element of forthcoming national policy is very likely to consist of a set of 'allowable solutions' which are currently being proposed by the Government to be implemented alongside the 2016 zero carbon homes target, to be offered to developers where zero carbon development cannot be achieved solely through on-site measures or by directly connected heat. In these cases residual emissions may be addressed through a range of off-site measures. Opportunities therefore exist for Bristol to introduce locally tailored allowable solutions in advance of Building Regulations, which could include off-site contributions for local district heating infrastructure.

Recommendations

Policy recommendations

The following recommendations are made regarding the development of Bristol's LDF Core Strategy policies on sustainable energy:

Overarching statement on climate change

To justify and contextualise the development specific policies, an overarching statement should be considered at the outset focused on climate change, CO2 reduction targets and renewable and low carbon energy targets. An overall greenhouse gas reduction target of 80% by 2050 is recommended, in line with the latest UK policy. Citywide targets for renewable and low carbon energy technologies and how they may relate to an appropriate trajectory of CO2 reduction towards the 2050 target should be the subject of further study and consultation. These should be informed by the results of the renewable energy resource assessment presented in this report.

Site sustainable energy policies

A low carbon energy policy for new residential developments should be adopted, which sets increasing standards for CO_2reduction in stepped phases up to 2026. The two scenarios tested in this report will offer a range of CO_2 savings and the Council's perception of 'undue burden' on developers of the additional cost of low carbon measures will largely dictate which scenarios to take forward.

The evidence presented in this report suggests that for an additional 7% increase in development cost between the two Scenarios, there would be a further 28% reduction in emissions from new development, and for this reason the authors recommend that Scenario 2 should be given preference over Scenario 1. However, implementation of either option must involve a degree of flexibility by including an appropriate viability clause to permit a range of 'allowable solutions' to be available to developers where targets can be shown to be unfeasible. In line with Government guidelines, targets should be set using the Code for Sustainable Homes rather than any other criteria, although it should be clear whether the requirement refers to the CO_2 emission standards in the Code, or to the whole scope of the Code.

Similar stepped targets should be set for non-residential development, but in terms of BREEAM standards. These targets should be equally challenging, but should be subject to review once the outcomes from the Government's consultation on the Code for Sustainable Buildings are known.

Experience from London strongly suggests that policies should include: (1) an explicit energy hierarchy; (2) a requirement for a Site Energy Strategy/Sustainability Statement to accompany development proposals; (3) an on-site renewable energy target; (4) a heating and cooling hierarchy, and (5) explicit clauses to address feasibility and viability issues.

Consistent with the above recommendation, an on-site renewables policy for new developments should be included. The findings of this study suggest that an on-site renewables policy requiring 20% CO_2 emissions applied to total residual emissions after the inclusion of energy efficiency, CHP and communal heating measures is appropriate.

Further consideration should be given to material to be included within Development Control DPDs, such as detailed criteria-based policies, additional details on the required structure and content of Site Energy Strategies submitted as part of a Sustainability Statement accompanying planning applications, and details on any 'allowable solutions' offered to developers. These should include increased flexibility to encourage the development of district heating in the Heat Priority Areas.
All targets and standards should be revised and updated periodically as national policy, sustainability best practice and low and zero carbon technologies develop.

Sustainable energy projects
There is a case for a policy setting out the council's vision for a low-carbon Bristol, and including key specific projects – heat networks, larger scale renewables, new build applications and retro-fitting. To support this, site and area specific proposals for sustainable energy should be added to the proposed policies and supporting text. These should include reference to identification of 'Heat Priority Areas' as described in this report, where district heating using CHP/CCHP as part of a citywide network is likely to offer opportunities to set higher standards in an earlier phases and so should be encouraged/required.

Sustainable design and construction
Although the focus of this study is sustainable energy, the broader scope of environmental benefits resulting from sustainable design and construction also needs to be considered. Areas such as water use, the life cycle of materials, biodiversity, waste recycling and sustainable drainage systems are covered within the Code for Sustainable Homes and BREEAM, so unless otherwise specified, the use of these standards to express CO_2 emissions targets will also imply certain standards for other aspects of sustainable design and construction.

It is recommended that a policy on sustainable design and construction is expressed using these standards alongside a general checklist to highlight the main areas of focus. The viability of Code level 6 should be reviewed following the Government's consultation on the definition of zero carbon homes.

General recommendations

Energy strategy priorities
Bristol City Council should focus the supply side of its energy strategy on developing the key resources of waste and biomass (woodfuel) to supply larger scale heat or CHP/CCHP plants serving what should ultimately be a citywide district heat network in the city's Heat Priority Areas. These resources, along with gas-fired CHP, have the potential to play a key role in meeting the challenging targets up to and beyond 2016, and could be instrumental in achieving substantial citywide emissions reduction targets in line with those recommended above. As an urban area, Bristol's woodfuel resource is constrained and it should therefore build on existing experience in sourcing woodfuel and encourage the development of local fuel supply chains from outside the city.

Bristol City Council as delivery partner
The strategic position within the community held by Bristol City Council provides an opportunity to facilitate multi-sector partnerships – especially for large scale mixed-use developments, where renewable energy infrastructure may be shared, or where Energy Service Companies (ESCos) may be involved to potentially reduce the additional capital cost burden.

Bristol City Council forms part of the West of England group of local authorities and hence should consider working alongside North Somerset Council, South Gloucestershire Council and Bath and North East Somerset Council in regard of opportunities for sustainable energy. This is already occurring with waste management through the identification of sites incorporating energy recovery from waste but could also include assessing the opportunities for biomass supply chains and sustainable energy supply strategies for cross-boundary urban extensions.

Avonmouth

Due to its predominantly industrial land use and excellent transport connections, the Avonmouth area has significant potential for large scale low or zero carbon energy generation such as wind and biomass plant. A more detailed local study on building energy use in the area and local heat and power demands is suggested to evaluate the potential for CHP/CCHP plant, possibly powered by biomass. It is unlikely that connection to City Centre heat loads would be economic in the short term, although this could emerge in the longer term as a citywide heat network develops. Avonmouth's wind power resource should also continue to be developed as far as possible, as it represents the vast majority of Bristol's potential for wind power.

District Heating

A strategic planning study on a citywide heat distribution network should be undertaken as soon as possible. The initial phase of a network is likely to be kick-started by a major new development with opportunities for a CHP/CCHP plant site – such as the proposed redevelopment of Southmead Hospital - and should also involve the provision of heat to nearby existing development, most likely within the Heat Priority Area. The study should also assess operational and delivery issues and the potential for ESCo partnerships, learning lessons from recent experience and current practice in London, where the London Development Agency is setting an ambitious agenda for the development of 'Energy Masterplans' for all London boroughs.

1 Introduction

This report presents the results of the Bristol Citywide Sustainable Energy Study and has been produced by the Centre for Sustainable Energy and Adrian Smith, Independent Planning Consultant. The underlying aim of this study is to assist Bristol City Council in developing LDF policies which positively encourage reduced energy consumption and carbon emissions from buildings and greater sustainable energy generation.

Planning for sustainable energy at national policy level imposes a number of requirements on local authorities to take increased action through the local planning system, and provide greater opportunities to make best use of local resources to maximise sustainable energy implementation. Alongside this, the Government is committed to a set of challenging sustainable energy policies including a significant tightening of Building Regulations.

There is increasing evidence to suggest that forward thinking policies at the local level are now being successfully implemented in response to these proposals, although it is still too early to gauge the full implications of what these policies will mean in practice. Local assessments of sustainable energy resources are crucial in preparing a policy evidence base and may identify geographical zones where targets can be extended beyond generic ones set at regional or national levels.

This evidence base therefore considers the development of local policies on renewable and low carbon energy generation in the LDF Core Strategy, taking into account anticipated national and Regional Spatial Strategy policies and targets on low carbon energy, sustainable construction, homes and jobs.

The scope of the study also includes the identification of sites where there is potential for sustainable energy generation, both on and off-site in:

- new development
- integration of sustainable energy generation with existing neighbourhoods (e.g. where urban extensions are adjacent to existing development)
- retrofitting existing buildings

2 Background

The Preferred Options Core Strategy paper for the Bristol Development Framework containing draft core policies and a spatial strategy was released for consultation in January 2008. A number of preferred development principles were proposed within the preferred options core strategy paper relating to sustainable development including:

- **BCS09 Sustainable design & construction** which will be achieved through: development of ‘Eco-neighbourhoods’, including zero carbon standards; use of the SW Sustainability Checklist for Developments; and requirement for sustainability statements to be submitted for major developments.

- **BCS10 Renewable electricity and heat targets** which suggests BCC is looking to meet or exceed requirements of RSS policy RE5, to make a contribution to region’s renewable electricity and thermal capacity targets and to seek site renewable energy generation for major developments.

- **BCS11 Climate change, CO_2 emissions & Air Quality** which suggests Bristol will contribute towards a 60% cut in CO_2 emissions by 2050, through: setting out detailed Development

Control Policies including reference to adapting to climate change integrated with mitigation; and, implementing the Joint Local Transport Plan to reduce CO_2 emissions and mitigate air quality impacts on population in central areas.

- **BCS12 Waste** which seeks to support the maximising of waste self containment within Bristol and the sub-region through land use management. This may lead to more opportunities for energy generation from residual waste.

- **BCS16 Density** which states that density of development of housing should be at least 65 dwellings per hectare with higher target densities in more accessible locations. Higher housing densities could make district heating and CHP more attractive options.

Bristol has a large housing allocation stated as being 29,500 in the preferred options core strategy paper, and the Secretary of State's proposed changes increase this figure to 36,500. The preferred options core strategy paper sets out the location of development areas, which will contain a large amount of this housing, and the document also contains the preferred split of housing to be located within each area.

In 2004 BCC published a *Climate Protection and Sustainable Energy Strategy and Action Plan*, which covered the years 2004-2006 and included both the council's own emissions and those of the wider community. The council's Energy Management Unit published a *Carbon Reduction Strategy* in 2007 which looked specifically at energy use reductions in the council's own estate.

In summer 2008 the Council's Climate Change Select Committee published a report which recommended measures to reduce both the council's own carbon emissions and city-wide emissions[1]. This included a recommendation that the council should implement RSS draft policy G (see Section 4.1), even if this policy were weakened in the RSS itself (which it subsequently was).

3 Policy context

3.1 National policy

Through its Climate Change Bill the Government is committed to meeting challenging targets for reducing carbon emissions - 26% reduction by 2020 and 60% by 2050, now 80% of greenhouse gas emissions. Alongside this, the 2007 *Energy White Paper* set out a policy of requiring 20% of electricity to be sourced from renewable energy by 2020. More recently, the *European Union Renewable Energy Directive 2009* requires that by 2020 15% of all UK energy (electricity, heat and transport) should come from renewable energy; and in the April 2009 Budget, the Chancellor committed to a 34% cut in greenhouse gas emissions by 2020.

These overall carbon reduction targets are gradually being translated into more specific national policies and targets. In *Building a Greener Future* the Government announced that all new homes in England and Wales must be zero carbon by 2016, with interim reductions in CO_2 emissions of 25% below current Building Regulations by 2010 and 44% by 2013. There are similar ambitions to cut carbon emissions from new non-domestic buildings by 2019. At the time of writing, the Government had recently issued a consultation on the definition of zero carbon homes and non-domestic buildings (see Section 4).

Local policies and strategies for carbon reduction from buildings will also be instrumental in achieving these aims and local authorities are being encouraged to adopt clear positions with respect to

[1] http://www.bristol.gov.uk/item/committeecontent/?ref=ta&code=ta000&year=2008&month=07&day=22&hour=18&minute=00

reducing carbon emissions from new developments. Guidance on this includes PPS22 on *Renewable Energy* (2004), which required regional and local planning policies to include renewable energy targets, criteria policies and the identification of broad areas for renewable energy development at regional level.

Subsequently, the supplement to the Planning Policy Statement (PPS1): on *Planning and Climate Change*[2], published by the Department for Communities and Local Government (CLG) in December 2007, made it clear that tackling climate change is central to what is expected of good planning. The PPS1 supplement highlights the following requirements:

- That it should take precedence over other PPS's if there is a policy conflict
- That Core Strategies should add to RSS policy in order to achieve progress in achieving the PPS's Key Objectives (paragraph 18)
- That Core Strategies and supporting LDDs should provide a framework that promotes and encourages renewable and low-carbon energy development (paragraph 19). These policies are to reflect local opportunities and go further than RSS policy.
- That planning authorities should "alongside any criteria-based policy developed in line with PPS22, consider identifying suitable areas for renewable and low carbon energy sources" (Paragraph 20)
- If renewable energy targets are not being achieved a prompt and effective response is required

November 2008 saw the publication of the *Planning and Energy Act 2008*, which enables local planning authorities to set requirements for energy use and energy efficiency in local plans. Specifically, this enables local authorities to 'legally' include policies in their LDF requiring:

- A proportion of energy used in development to come from renewable and low carbon sources in the locality of the development;
- Energy efficiency standards that exceed the requirements of building regulations

The 2008 launch of the Government's consultation on a *UK Renewable Energy Strategy* and its proposed £4 million programme to help spread existing best practice on climate change mitigation among local authorities also adds emphasis to the responsibility of local authorities to reduce carbon emissions from buildings within their area. Key points emerging from the consultation include:

- The likely requirement that around 32% of UK electricity will need to be sourced from renewables by 2020 in order to meet the European Union 2009 Directive
- The emergence of a Heat and Energy Saving Strategy from the UK Government (see below)
- The expectation that regional and local planners should now actively plan for, and support, renewable energy generation including allocating and safeguarding sites
- The fact that applicants for renewable energy should no longer be questioned about the energy need of their project
- The comparison of renewable energy targets with those for housing – local planning authorities should have specific targets and ensure that there are enough sites/areas to secure their achievement

[2] http://www.communities.gov.uk/publications/planningandbuilding/ppsclimatechange

- The need for renewable energy “growth points” to be identified

More recently, the *UK Heat and Energy Saving Strategy: DECC/CLG Consultation 2009* highlights the following:

- An increased emphasis on delivering increased energy efficiency in existing dwellings
- Stronger incentives to move towards a low carbon future
- A new focus on district heating
- Encouragement of combined heat and power (CHP)

The Code for Sustainable Homes was launched in 2006 alongside the Government’s announcement for all new homes to be zero carbon by 2016, with the Code intended to be one of the main delivery tools for this target. The scheme sets a series of standards ranging from levels 1 to 6 for environmental sustainability across nine categories including energy, water, waste and materials. Local authorities are being encouraged by the Government to adopt the Code through the housing allocations of their Local Development Frameworks and through Supplementary Planning Guidance. Currently English Partnerships and all schemes funded through the Housing Corporation’s National Affordable Housing Programme up to 2011 must be compliance with the Code level three.

An equivalent scheme for rating the environmental performance of non-residential buildings is BREEAM, although the Government has plans to introduce a Code for Sustainable Buildings in the near future.

3.2 Regional policy

The draft South West Regional Spatial Strategy (RSS) submitted to Government in April 2006 has since undergone a consultation exercise and examination in public. Following the publication of an independent panel report, the Secretary of State for Local Government issued in early summer 2008 a list of proposed changes to the draft RSS. This is currently out for consultation before final issue in summer 2009.

The initial draft RSS contained a number of sustainable energy policies, some of which were modified during the above process. These include:

- Policy RE1 setting regional and local renewable electricity targets for 2010 and 2020 was accepted with minor modifications
- Policy RE2 setting an offshore renewables target and Policy RE3 a renewable heat target for 2010 and 2020, have been approved without modification
- Policy RE5 has been changed from a policy to drive minimum levels of renewable energy content within new developments to minimum levels of low carbon energy sources.
- Policy G, which looked to go further than future building regulations in respect of carbon reduction, set progressively higher carbon reduction targets for new developments in stages up to 2016 and beyond. This policy has effectively been dismissed and no longer sets higher energy standards for new buildings in the south west.

These proposed changes will clearly have a major effect on the extent to which local authorities in the South West can influence carbon reduction targets in new developments. In particular, on dismissing Policy G, the Secretary of State for Local Government suggested that local authorities could set their own energy standards for specific sites, but set a very high threshold to ‘‘*demonstrate clearly local circumstances that warrant and allow*” enhanced standards.

The draft RSS also contains statements indicating that local planning authorities should ensure that major new developments take advantage of CHP technology and community heating systems.

3.3 Bristol Core Strategy

In the light of national/regional policy context discussed above, a review was undertaken of relevant policies the Bristol Core Strategy Preferred Options Review Draft (dated 27th January 2009) and key findings are listed below:

- Strategic Objective 10 is the only relevant overarching statement of policy but it appears to be more focused on climate change adaptation than dealing with the causes. It has also been placed near the end of the list of Objectives and detached from Objective 1 dealing with sustainability.
- No other polices in the document include reference to sustainable energy in relation to specific growth areas or topics such as employment land
- There are no targets for CO_2 reduction
- There is no reference to the Severn Barrage studies currently underway, some of which will have implications for Bristol – such as possibly reducing the risk of flooding
- There are no on-site renewables/low carbon energy targets

4 Emerging evidence on low and zero carbon development

4.1 Recent studies

The majority of analysis at the national level for achieving low carbon development has been undertaken in relation to the Government's '*Building a Greener Future*' initiative, as mentioned above, which proposed a series of stepped changes in future building regulations leading to zero carbon dwellings by 2016. As these relate the required proportion of carbon emission reductions to an equivalent level standard of the Code for Sustainable Homes, a considerable amount of work has been carried out on the technical and financial viability of reaching the various levels contained therein. These and other recent publications which relate to the implications for dwellings include:

- *Research to Assess the Costs and Benefits of the Government's Proposals to Reduce the Carbon Footprint of New Housing Development*, Cyril Sweett, Faber Maunsell and Europe Economics (on behalf of the Dept for Communities and Local Government), Sept 2008.
- *Cost Analysis of the Code for Sustainable Homes,* Cyril Sweett and CLG, July 2008.
- *Cracking the Code*, Housing Corporation, April 2008.
- *Energy Efficiency and the Code for Sustainable Homes, Guidance Documents CE 290, CE291 & CE292*, Energy Saving Trust, 2008.
- *Heat and Energy Saving Strategy: a consultation,* DECC/CLG Feb 2009
- *Definition of Zero Carbon Homes and Non-domestic Buildings: Consultation*, Dept of Communities and Local Government, Dec 2008.

This last publication by DCLG is a key document in that it considers the evidence to date and raises a number of uncertainties about the route to zero carbon developments and the approach to regulatory compliance. At time of writing the Government is considering the consultation responses and intends to issue a statement during summer 2009. The analysis undertaken for the consultation clearly indicates that whilst it is technically feasible for energy efficiency and micro-scale generation measures to meet lower carbon targets, there will be a need for macro-scale solutions such as district heating with Combined Heat and Power (CHP) to meet higher targets associated with the expected 2016 Building Regulations and beyond.

In conjunction with this, there is also an ‘industry-wide’ consultation currently being undertaken on the *Code for Sustainable Buildings* being led by the UK Green Building Council, which focuses on the Government’s proposal that all new non-domestic buildings should be zero carbon by 2019. A Government-led public consultation is expected to follow later in 2009.

A key study in the South West on the feasibility of low and zero carbon buildings is: *Supporting and Delivering Zero Carbon Development in the South West,* Faber Maunsell and Peter Capener, Jan 2007[3]. This research was undertaken for a group of South West regional bodies and set out recommendations for a policy requiring zero carbon new developments in the South West Regional Spatial Strategy (RSS).

The report found that zero carbon new development is already technically viable for medium to large residential developments, and could be institutionally and economically feasible by 2011. Zero carbon here refers only to emissions covered by the building regulations. For medium to large non-residential developments, it found that zero carbon (covering regulated and unregulated emissions) is technically viable now and will be economically and institutionally feasible by 2016.

The report’s concluding evidence resulted in a series of targets collectively referred to as Policy G in the draft RSS, which related timescale and the type and scale of development to various levels of carbon reduction targets alongside draft RSS Policy RE5 on onsite renewable energy generation:

Table 1: Policy G from the Draft South West RSS

Residential development:				
	2008-2010	**2011-2015**	**2016 on**	
No. dwellings	>10	>10	10-50	>50
CO_2 reduction compared to Part L 2006	44% of regulated emissions	100% of regulated emissions	100% of regulated emissions	100% of total emissions
Equivalent CFSH standard	Level 4	Level 5	Level 5	Level 6
Onsite generation requirement	20% of regulated emissions			

Non-residential development (>1,000m^2):			
	2008-2010	**2011-2015**	**2016 on**
CO_2 reduction compared to Part L 2006	25% of regulated emissions	34% of regulated emissions	44% of regulated emissions
Onsite generation requirement	20% of regulated emissions		

Following Government review, Policy G was subsequently removed from the draft RSS by the Secretary of State for Local Government.

In relation to the CfSH standards, a joint response to the Secretary of State on Policy G / RE5 by the South West Regional Assembly, South West RDA, Environment Agency (SW) and Natural England stated:

[3] Faber Maunsell and Peter Capener, January 2007, *Supporting and Delivering Zero Carbon Development in the South West.* Available from http://www.southwest-ra.gov.uk/media/SWRA/RSS%20Documents/Technical%20Documents/Technical%20Work/final_policy_report_v11.PDF

"We believe that Level 3 of the Code for Sustainable Homes is technically and economically viable now and should therefore be adopted across the region from 2009 onwards as the minimum standard. We also support the suggestion that Code Level 4 could be applied to major strategic developments (notably the Areas of Search) where this is also shown to be viable."

In addition to the above, a number of site-specific studies have been completed in the South West relating to the development of energy policies and strategies. A selection of these are summarised as follows:

Camborne Pool Redruth Regeneration – Energy Feasibility Study, Element Energy, Jan 2006[4]. This study provided an analysis of sustainable energy options for the Camborne-Pool-Redruth regeneration project and proposed recommendations for action to implement sustainable energy measures throughout the regeneration program.

The report concluded that large-scale CO_2 reductions are possible through the implementation of rational use of energy measures, onsite CHP at large load centres and roll-out of microgeneration technologies (in new buildings but also retrofit where appropriate). The deepest cuts in CO_2 emissions resulting from new developments were found to be achieved with adoption of biomass heating and CHP. CO_2 reductions of around 80% from a baseline of Part L 2005 building regulations are suggested by roll-out of a range of additive measures across the site (additive measures are described as those that can be adopted alongside each other and will have a complementary effect). Each of the measures considered were found to be cost-competitive or near cost-competitive with conventional energy supply.

East of Exeter New Growth Point Energy Strategy: Final Report, Element Energy, 2008[5], provided a strategic analysis of how CO_2 emissions from new developments in the East of Exeter Growth Point to 2020 could be reduced in line with the requirements of national policy in a cost effective way. The study provided recommendations that are applicable beyond Exeter and found that a basic set of building fabric performance improvement measures were a cost effective way of getting houses to Code for Sustainable Homes (CSH) level 3 and would not require the houses to incorporate microgeneration. The effectiveness of district heating was emphasised in its potential to move homes on larger development sites to CSH level 4 and above. The report found that for smaller sites, it would be more expensive to get to the higher CSH levels if there was a need to install microgeneration on a house-by-house basis.

Application of Policy G of the draft Regional Spatial Strategy (see Section 4), which set higher energy standards for new buildings in the south west, was found to have the potential to reduce CO_2 emissions by 30% above the trajectory implied by national building regulations.

Energy and Sustainability Strategy – Truro and Threemilestone Area Action Plan**,** Community Energy Plus, March 2008, provides an overview of the mechanisms that can be used to reduce the impact of the planned urban extension at Truro and Threemilestone in terms of climate change and considers how to ensure the principles of sustainable development are adhered to. It recommends adoption of Policy G and suggests that it would be possible to combine large scale, and building-integrated low carbon generation options to enable the targets to be met more effectively at each level of the CSH.

Sherford New Community Area Action Plan – South Hams District Council, August 2007. This publication is the adopted version of the Sherford AAP and focuses upon the design and implementation of the Sherford new community near Plymouth, in which 5,500 homes are proposed. Under Policy SNC2 on Sustainable Development, it proposes a series of carbon reduction targets for

[4] http://www.csep.co.uk/downloads/cpr_feasibility_study_full_.pdf
[5] http://www.regensw.co.uk/downloads/RegenSW_230.pdf

new dwellings during the four phases of the development. These are 25%, 35%, 50% and 60% respectively when compared to a baseline of Part L 2006 Building Regulations.

The development involves a consortium including The Prince's Foundation for the Built Environment, the Royal Bank of Scotland and the developer Red Tree. Planning permission was obtained in May 2008 and half of all energy used is expected to be sourced from wind turbines in the town's 400 acre park[6].

Plymouth Renewable Energy Strategic Viability Study, Centre for Sustainable Energy and Wardell Armstrong International, March 2007. This study forms part of the evidence base for the Council's Local Development Framework Core Strategy policies on sustainable energy and climate change. It includes a renewable energy resource assessment for the city and outlines how this fits with the implementation of the Council's onsite generation targets for new developments and strategic plans for sustainable development throughout the city.

4.2 The Code for Sustainable Homes

Alongside energy demand and supply issues, there are other elements of building construction and use that will impact carbon emissions and environmental sustainability. As LDF policies on sustainable construction are now making increasing reference to targets for new development in terms of Code for Sustainable Homes levels, it is important to consider energy issues alongside the other areas assessed under the Code. Figure 1 illustrates the nine-category appraisal process used in Code assessments, each category of which is weighted with regard to environmental importance, and Table 2 shows the requirements for % CO_2 reduction and water consumption for each code level.

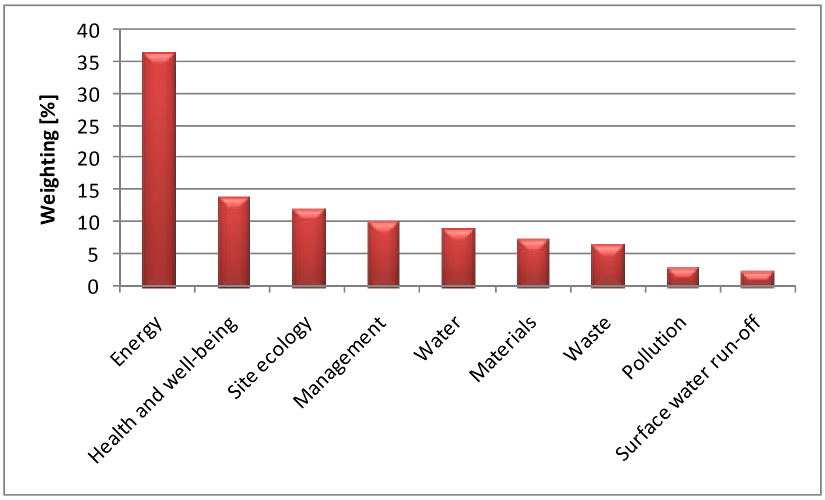


Figure 1: Assessment weightings for the categories of the Code for Sustainable Homes

[6] The Guardian, 2nd May 2008 *Free bikes, no uPVC - green light for prince's ecotown* http://www.guardian.co.uk/environment/2008/may/02/greenbuilding.ethicalliving [Accessed 19 Jan 2009]

Table 3 summarises requirements for the other categories of the Code, which are not so neatly divided into different code levels[7].

Table 2: Code levels for carbon emissions and water consumption		
Code Level	**Minimum % CO_2 reduction (on regulated emissions)**	**Maximum indoor water consumption [litres/person/day]**
1	10	120
2	18	120
3	25	105
4	44	105
5	100	80
6	'Zero carbon home'	80

Table 3: Requirements for other elements of the Code for Sustainable Homes							
Code Level	**Health and Wellbeing**	**Site ecology**	**Management**	**Materials**	**Waste**	**Pollution**	**Surface water run-off**
1	No mandatory elements. Credits available for amount of daylight, sound insulation and outdoor private space	No mandatory elements. Credits available for protection of ecological features and low building footprint	No mandatory elements. Credits available for provision of home user guide, activities related to construction, and consideration of physical security	Mandatory for all levels:: at least 3 of the following 5 key elements achieve a 2008 Green Guide rating of A+ to D: Roof; external walls; internal walls; upper and ground floors; windows*	Mandatory for all levels: adequate external space for household waste & adequate internal space for recyclable waste*	No mandatory elements. Credits available for use of low-pollution insulating materials and low NO_x heating and hot water systems	Mandatory for all levels:: peak rate of runoff & volume of runoff must be no greater than for pre-development site*
2							
3							
4							
5							
6	Complies with principles of *Lifetime Homes*						

* Credits awarded for further specified improvements

Analysis of the costs involved in achieving each level were undertaken in 2008 by DCLG. The analysis made estimates of the additional build costs (2008 prices) associated with each Code level (in relation to costs typical of Part L 2006 Building Regulations). The results for an example house type are shown in Figure 2 below. The analysis assumes that wind power is not available and does not factor in the potential benefits of zero stamp duty on achieving the zero carbon standard.

7 Further technical details of the Code for Sustainable Homes can be found at www.communities.gov.uk/publications/planningandbuilding/codeguide

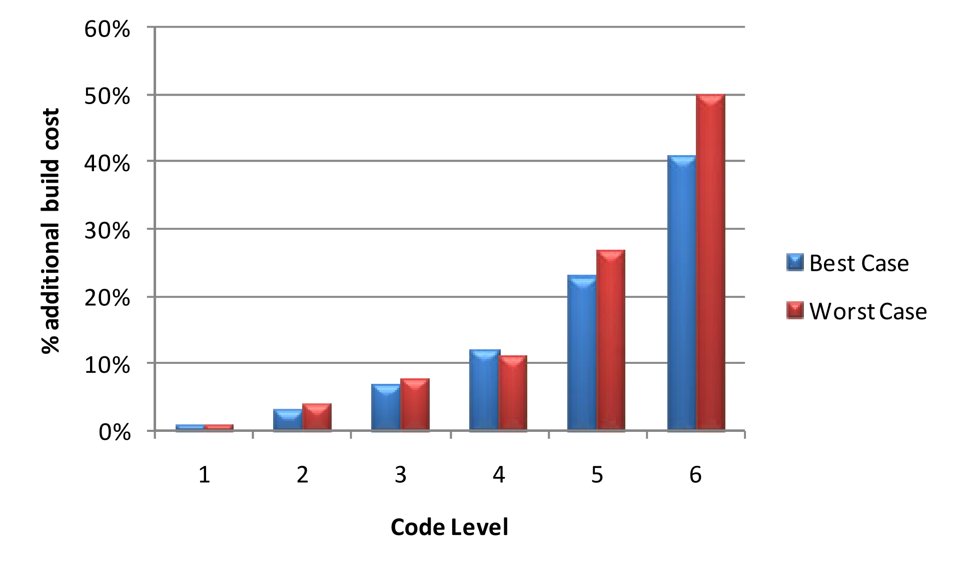


Figure 2: Additional cost over 2006 Building Regulations in meeting levels of the Code for Sustainable Homes for an end-terrace house. [Source: *Cost Analysis of the Code for Sustainable Homes*, DCLG, July 2008]

It is important to note that the requirements under the Code for level 6 include achieving a heat loss parameter of 0.8 W m^2K and zero net CO_2 emissions. The heat loss parameter requirement has the combined effect of increasing capital costs whilst also reducing the home's demand for heat (and therefore the amount of low carbon electricity generated by a CHP system). These requirements are different to those now being proposed by the Government for its 'zero carbon homes' target in 2016 (see Section 6.1).

4.3 CHP and district heating

CHP and district heating has already been shown in the UK and on the Continent to offer the potential for some communities to receive low carbon heat, at comparable or lower costs than conventional heating. The Government is now in the process of setting out a number of possible measures aimed at tackling key barriers to district heating. These include considering changing regulation, enhancing the role of local authorities and improving the supply chain. Forthcoming initiatives mentioned in the Heat and Energy Saving Strategy Consultation include a Summit on Community Energy and Heating with local government leaders to start the process of facilitating the development and expansion of district heating, and the setting up of a Heat Markets Forum, with representatives from the Government, the energy industry and consumers, to assess the various types of arrangements for heat supply.

Several towns and cities in the UK have district heating/CHP systems. These include Southampton, Aberdeen, Nottingham, Tower Hamlets (London), Pimlico (London) and Sheffield (see Figure 3). In most cases these have been in existence for some time – Pimlico, the oldest, was established in 1950 using heat from Battersea Power Station. When the power station was decommissioned it switched to its own gas-fired boilers. The Barkentine Heat and Power Plant in Tower Hamlets, London, has been operational since 2001. The project was developed jointly by EDF Energy and Tower Hamlets Borough Council, and was funded by Defra.

An Energy Recovery Facility in Sheffield's city centre uses 225,000 tonnes of waste to produce up to 60 MW of thermal energy or 19 MW of electrical energy. There are 45km of pipeline delivering heat through two networks to 140 different buildings including: universities, health facilities, shops, offices and leisure facilities. Over 2800 dwellings have benefited, where in a typical year around 120,000 MWh of heat is delivered, saving over 21,000 tonnes of CO_2 a year. All the buildings highlighted in colour below are connected to the district heating network.

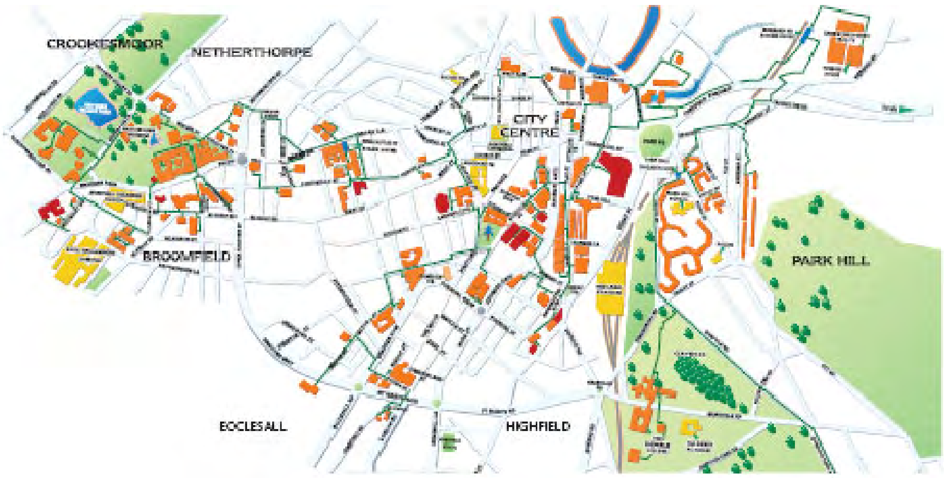


Figure 3: Veolia Environmental Services' Energy Recovery Facility in Sheffield (Source: Heat and Energy Saving Strategy Consultation Document)

Southampton's district heating system uses a combination of geothermal energy and CHP. Initial feasibility research started at the beginning of the 1980s by the Department of Energy was taken up by the city council and eventually construction of the district heating system started in 1987. The scheme currently provides 30,000MWh of heat, 4,000MWh of electricity and 1,200MWh of cooling annually[8]. Southampton now specifies in its Core Strategy that where there is an opportunity to do so, new development will be required to connect to existing CHP schemes. This means that new development within reach of the existing scheme can be required to connect to the existing scheme:

'*Where specific opportunities exist, development will be required to connect to existing Combined Heat and Power (CHP) systems or make equivalent CO_2 savings through other onsite renewable or low-carbon energy measures.* '(Policy CS 20, Core Strategy Proposed Submission December 2008[9])

Sheffield's district heating scheme is based around an energy from waste plant. This was initially established in the 1970s and a new larger facility was recently built. The plant has a throughput capacity of 225,000 tonnes of MSW and generates 110,000 MWh of electricity and 95,000 MWh of thermal energy annually. The district energy network supplies more than 140 buildings in the city.

Sheffield's Core Strategy's policy encouraging connection to district heating is as follows:

'*Where appropriate, developments will be encouraged to connect to the City Centre District Heating Scheme. Shared energy schemes within large developments or between neighbouring developments, new or existing, will also be encouraged*.' (Policy C65, Core Strategy Adopted March 2009[10])

[8] Energy-Cities programme, *Geothermal District Heating Scheme, Southampton, United Kingdom*, http://www.energie-cites.org/db/southampton_140_en.pdf
[9] www.southampton.gov.uk/Images/Proposed%20Submission%20Core%20Strategy_tcm46-218444.pdf
[10] www.sheffield.gov.uk/planning-and-city-development/planning-documents/sdf/core-strategy/adopted-core-strategy

Currently planned initiatives include the London Borough of Barking, which is one of London's Action Energy Areas. Action Energy Areas were designated as a mechanism to implement elements of London's Energy Strategy. Substantial regeneration is planned in Barking's town centre over the next 15 years. Barking has set out an implementation strategy which aims to reduce carbon emissions from new developments by a third, compared to building regulations. The town centre redevelopment includes a district heating network, using heat from Barking Power Station[11].

The Barking Town Centre Energy Action Area provides useful insights into possible approaches to helping establish decentralized renewable and low carbon energy infrastructure at a local level. An initial options appraisal as part of a pilot Energy Action Area project identified the potential to use waste heat from Barking and Dagenham Power station to supply heat to homes and other buildings in the Town Centre.

It was recognised that it would not be possible to utilize these sources of waste heat immediately and a detailed implementation plan was developed incorporating a two phase approach. The first is to develop smaller local community heating networks and then connecting these into a larger community heating network for Barking Town centre.

Barking's planning policy encouraging connection to community heating is therefore particularly interesting and relevant because it is requiring developments to prepare for a community heating system which is not yet operational:

'*The Council will expect all major developments that fall within the Barking town centre energy action area, Barking Riverside and South Dagenham to be compatible with the community heating network (i.e. by installing communal heating systems (including heating meters) to set specifications). Solar hot water systems and heat pumps will not be appropriate in Barking Town Centre Energy Action Area, Barking Riverside or South Dagenham as in these areas space heating and hot water will be provided by the community heating network.*' (Policy BR2, Borough Wide Development Policies Pre-Submission Report November 2008[12])

4.4 The London approach

The London Plan (Consolidated with Alterations since 2004) issued in February 2008 contains a number of polices related to climate change and sustainable energy. Key among these are:

- Policy 4A.1: Tackling climate change – which sets out an energy hierarchy for developers to adhere to when submitting planning applications.
- Policy 4A.5: Provision of heating and cooling networks
- Policy 4A.6: Decentralised energy: heating, cooling and power – which sets out a hierarchy for heating and cooling, including CHP/CCHP (combined heat and power; combined cooling, heat and power)
- Policy 4A.7: Renewable energy – requiring developments to achieve a reduction in CO_2 emissions of 20% from on-site renewable energy generation

[11] A Guide to the Barking Town Centre Energy Action Area, November 2006, London Borough of Barking and Dagenham, http://www.barking-dagenham.gov.uk/6-living/envir-protect/envir-sustainability/pdf/energy-action-area-may-07.pdf

[12] www.barking-dagenham.gov.uk/8-leisure-envir/planning/local-dev-framework/pdf/proposals/borough-wide-pre-sub.pdf

Figure 4 below illustrates the energy hierarchy and the calculation of emission reductions.

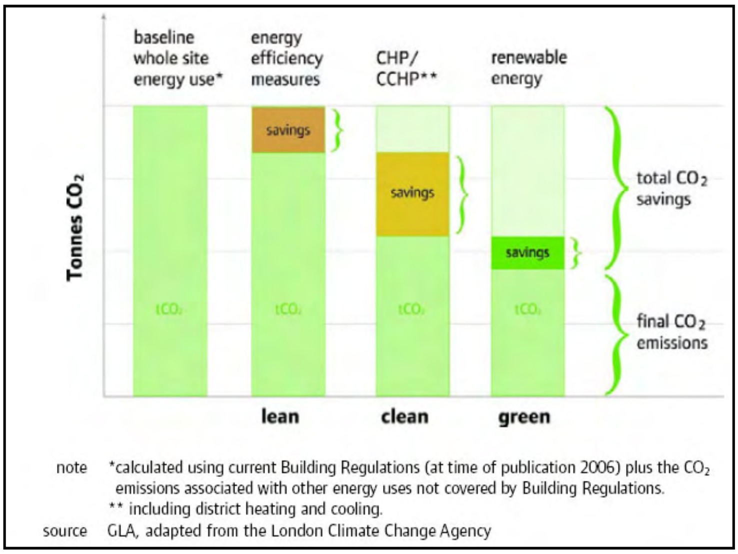


Figure 4: Calculation of energy/CO_2 savings (from The London Plan – Consolidated with Alterations since 2004, Feb 2008)

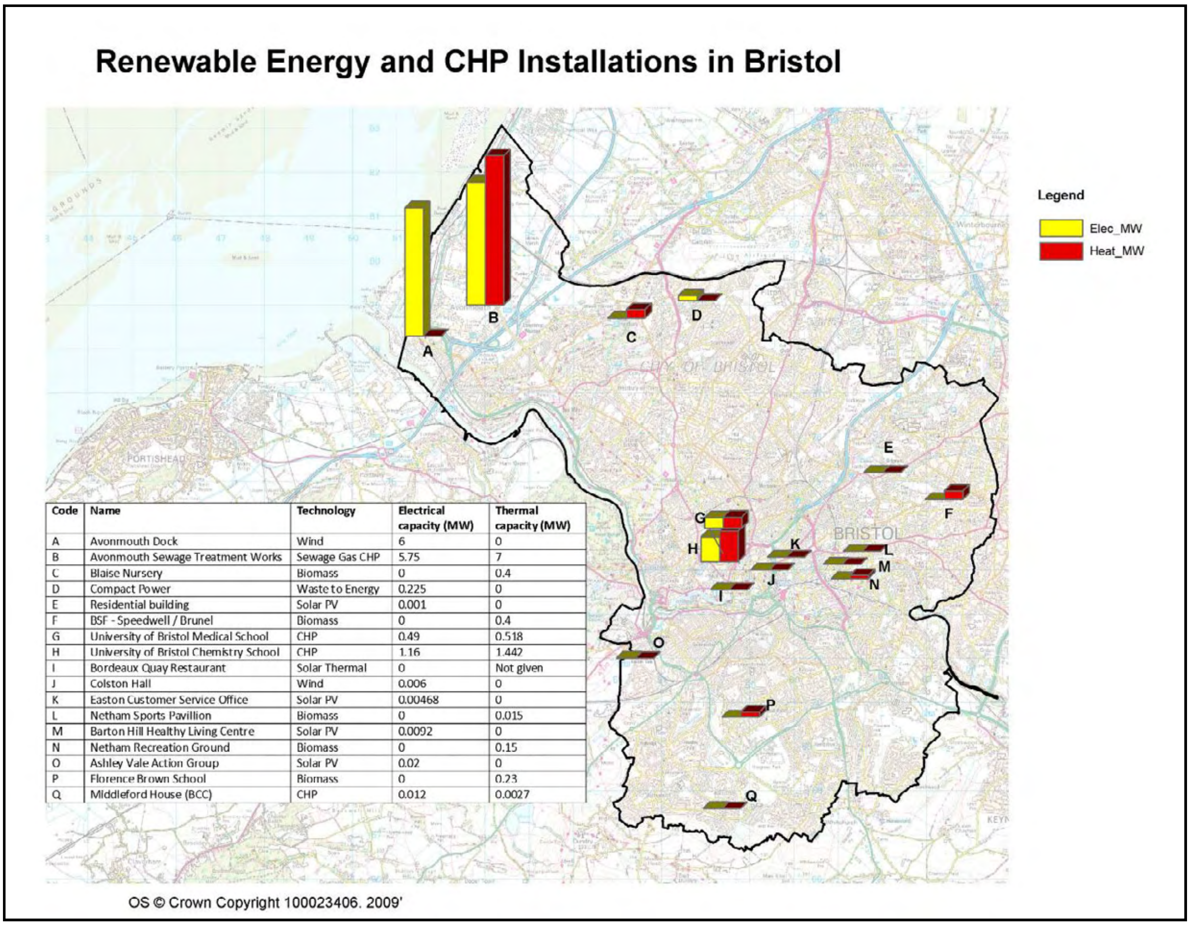
5 Resource assessment for Bristol

5.1 Existing low carbon and renewable energy generation capacity

Bristol currently hosts around 13.7MW of renewable or low carbon electricity generation capacity, of which 7.4MW is CHP powered by sewage gas or mains gas. In terms of renewable or low carbon heat, the figure totals 10.2MW overall, of which 9MW is sourced from CHP. Figure 5 lists the individual generation plants making up these totals and illustrates their spatial distribution. The bulk of this data was obtained from Regen SW's Annual Survey of Renewable Electricity and Heat Projects in the South West.

The amount of energy generated by these installations and the resulting CO_2 savings depends highly on the operating hours of plant – especially CHP installations, and on how much generated heat is actually used to offset fossil fuels such as mains gas. However, assuming that 50% of this heat is utilised, estimates indicate that around 50,000 tonnes of CO_2 savings result each year from these installations. This figure represents around 2.2% of Bristol's total emissions[13].

[13] 2,305,000 tonnesCO_2/year - calculated from BERR Small Area Statistics 2007 and Defra Local Authority Statistics 2006.



Code	Name	Technology	Electrical capacity (MW)	Thermal capacity (MW)
A	Avonmouth Dock	Wind	6	0
B	Avonmouth Sewage Treatment Works	Sewage Gas CHP	5.75	7
C	Blaise Nursery	Biomass	0	0.4
D	Compact Power	Waste to Energy	0.225	0
E	Residential building	Solar PV	0.001	0
F	BSF - Speedwell / Brunel	Biomass	0	0.4
G	University of Bristol Medical School	CHP	0.49	0.518
H	University of Bristol Chemistry School	CHP	1.16	1.442
I	Bordeaux Quay Restaurant	Solar Thermal	0	Not given
J	Colston Hall	Wind	0.006	0
K	Easton Customer Service Office	Solar PV	0.00468	0
L	Netham Sports Pavillion	Biomass	0	0.015
M	Barton Hill Healthy Living Centre	Solar PV	0.0092	0
N	Netham Recreation Ground	Biomass	0	0.15
O	Ashley Vale Action Group	Solar PV	0.02	0
P	Florence Brown School	Biomass	0	0.23
Q	Middleford House (BCC)	CHP	0.012	0.0027

Figure 5. Existing renewable energy and CHP installations in Bristol

Bristol will need to draw on a range of renewable and low carbon energy resources to meet the challenging targets expected from 2010 onwards. The extent to which these can be evaluated within the scope of the current study varies according to the type of resource, the technology employed and the energy end-use.

Certain resources are easier to quantify in that their potential can be independently expressed in terms of stand-alone (i.e. non-building integrated) technology capacities, although in practice their application will be linked to developments. These include wind, wood fuel and municipal, industrial and commercial solid waste. Wood fuel in particular will be a key resource in meeting the higher targets contained in the scenarios modelled below due to the importance of biomass CHP and community heating systems at this level. Solar and heat pump technologies are specifically building-related and so are directly influenced by development policies.

A summary of the main low or zero carbon energy resources or technologies are listed in Table 4:

Table 4: Summary of low or zero carbon energy resources	
Resource/technology	**Potential in Bristol**
Wind	See below
Biomass	
Municipal Solid Waste	
Solar	
Heat pumps	
Agricultural waste	Very little potential due to urban environment
Sewage gas	Most of resource already being exploited in Avonmouth
Landfill gas	No landfill sites in Bristol
Hydro power	Very little potential – only tidal resource from Rivers Avon and Frome
Off-shore wind and marine renewables	Lies outside planning jurisdiction of Bristol City Council
Hydrogen fuel cells	Emerging technology; CO_2 savings dependent on hydrogen production technique

5.2 Wind

Areas of land that could potentially be appropriate for wind turbine development were identified by applying a range of constraints across Bristol. Three scales of generic turbine were considered in the assessment of potential: large scale (~2MW), medium scale (~300kW), and small scale (~15kW). The constraints applied were as follows:

Table 5: Wind power constraints – based on industry standards relating to buffer zones around buildings, roads, etc, and viable wind speeds			
	Turbine Size		
Criteria	**Large**	**Medium**	**Small**
Minimum distance from existing homes and SHLAA sites	400m	400m	120m
Minimum distance from other buildings	120m	60m	20m
Minimum distance from roads and rail	120m	60m	20m
Wind speed	≥6m/s at 80m above ground level	≥6m/s at 44m above ground level	≥5.5m/s at 15m above ground level
Suitability for other scales of turbine	Priority	Takes priority over 15kW but not 2MW	Only areas which are not suitable for 300kW or 2MW

The above constraints were modelled for Bristol: Figure 6 below shows the resulting map.

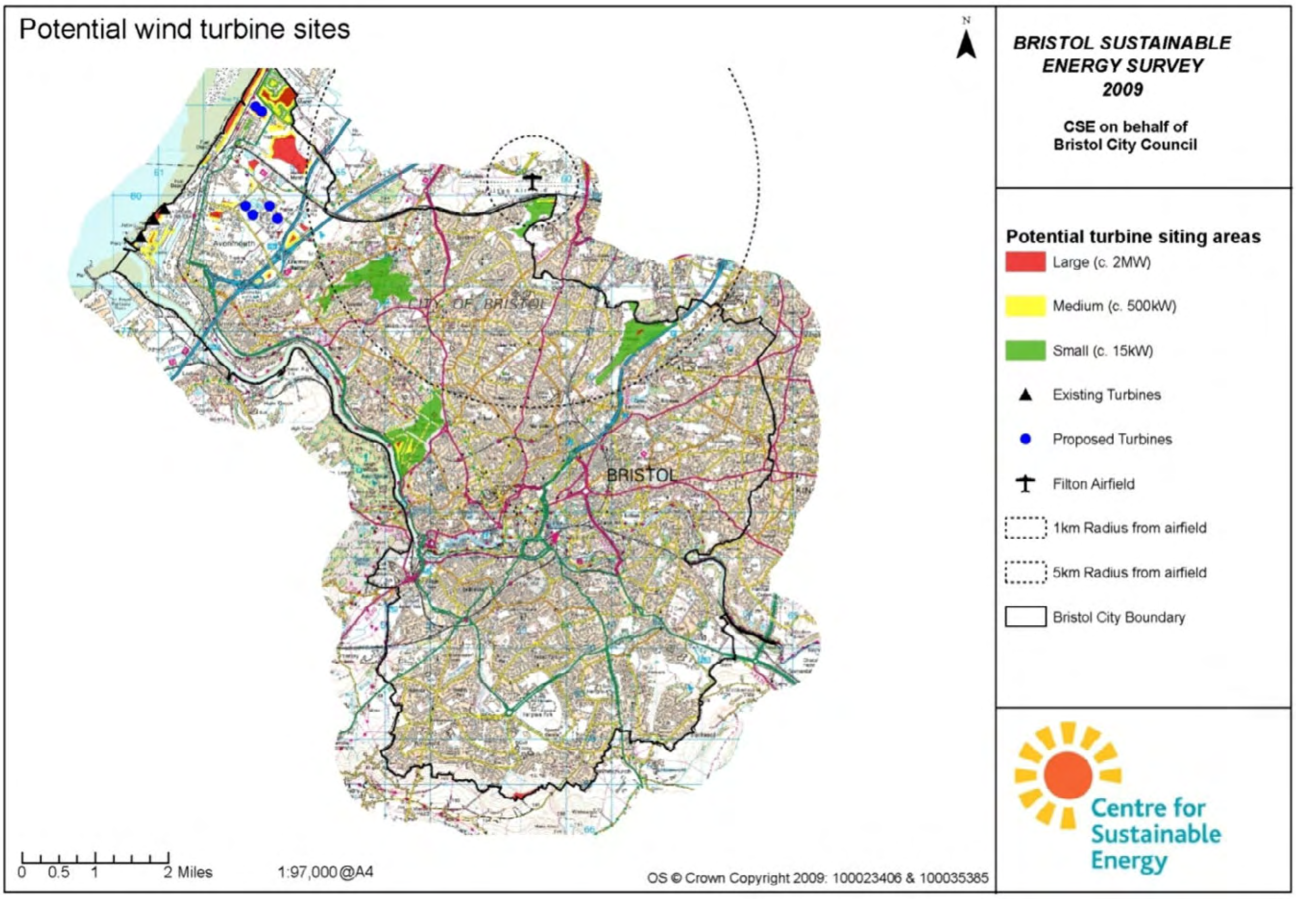


Figure 6. Unconstrained sites for wind turbines

Annual average wind speeds were taken from the NOABL wind speed database and adjusted to typical hub heights of the turbine scales modelled using an industry standard algorithm. Note that this calculation does not account for the reduction in windspeed that would be caused by proximity to buildings. Table 6 below quantifies unconstrained areas according to their suitability to accommodate the scale of turbine modelled.

Table 6: Land area in Bristol unconstrained by buffer zone and wind speed criteria

	Scale of Turbine		
	Large	Medium	Small
Number of land parcels	31	33	56
Total unconstrained area (ha)	95	204	342

Figure 6 indicates that for large and medium scale wind power, the areas of potential are very limited and are mostly confined to the Avonmouth area. It should be noted that the buffer zone does not differentiate between occupied or unoccupied or buildings, e.g. barns and industrial/ commercial premises where the background noise levels may be high and the buffer zones could be reduced, making development of urban brownfield/ industrial sites a possibility. The land areas shown could therefore be higher in practice, especially for large scale wind on industrial sites such as Avonmouth. Evaluating the total capacity for large/medium scale wind at Avonmouth would require a more detailed local assessment of the area and its buildings. The resource here is already being exploited by three 2MW turbines installed in 2007, with planning approval gained for two more large scale turbines.

Opportunities for small scale turbines are more widespread across the city, with a total technical potential approaching 5MW (assuming 15kW machines spaced at one per hectare). **However, over two thirds of the unconstrained area consists of common land such as the Downs, Blaise Castle and Stoke Park, where planning issues may impose further significant constraints.**

There will also be further constraints on all scales of wind power in the vicinity of Filton Airfield in South Gloucestershire due to limitations imposed by aviation activities. Site-by-site analysis would be needed to evaluate the extent of these, but to illustrate the areas which may be affected; radii of 1km (small scale) and 5km (large scale) are indicated on the map.

Table 7 illustrates likely energy yields from turbines, assuming an example scenario for deployment at various scales.

Table 7: Example energy yields for different scales of turbine deployment

Scenario	Approx. energy output (MWh/yr]	Equivalent no. of houses supplied
8 x 2MW turbines (Avonmouth)	37,600	9,400
4 x 300kW turbines (Avonmouth)	788	197
30 x 15kW turbines (citywide)	600	150
Total	**38,988**	**9,747**

Alongside the constraints explored above, there are a number of other issues that need to be addressed at a site specific level when considering wind power development:

- Practical access to sites for abnormal loads, e.g. turbine blades
- Effect of slope and aspect of site topography on wind speeds
- Landowner agreement
- Potential ecological, ornithological and archaeological impacts
- Detailed noise impact assessments (the dwelling buffers used above are a crude approximation of acceptable noise limits)
- Landscape and visual impact of installations, including cumulative impact and shadow flicker
- Impact on listed buildings and conservation areas
- Line of sight for telecommunications links
- The capacity of the local grid infrastructure to accept new generation capacity

Micro-scale wind (most commonly roof-mounted turbines less than 5KW) was not specifically considered in the above analysis. As with all turbines, performance is highly dependent on sites with suitable wind regimes and it has been shown that urban rooftops generally suffer from extremely turbulent wind profiles and low annual average wind speeds[14] making this technology less viable for the majority of sites in Bristol. Whilst some sites (such as tower blocks or very exposed buildings) may offer limited potential, these are not thought to warrant further detailed consideration within this study.

[14] See http://www.warwickwindtrials.org.uk/resources/Warwick+Wind+Trials+Final+Report+.pdf

5.3 Biomass (woodfuel)

Biomass woodfuel considered here includes green wood residues (such as arboricultural or forest residues), recycled untreated wood (including pellets) and energy crops (miscanthus or short rotation coppice (SRC). In practice much of this resource for use in Bristol will be sourced from outside of the city, so the scope of the resource assessment therefore includes areas beyond the city boundaries. The amount of energy that can be produced per oven dried tonne (odt) of woodfuel depends on the type and size of the powerplant. In general, the larger the plant, the higher its efficiency and the less fuel per MW of installed capacity required. To illustrate the size of the resource, an annual figure of 8,000 odt per MW_e (MW electrical) for CHP plant is used in the following assessments, which assumes around twice this capacity ($2MW_{th}$) will also be produced as usable heat. For heat-only biomass plants, annual requirements are considerably less due to greatly reduced load factors[15] e.g. ~700 odt per MW.

Although biomass is effectively a zero carbon resource, there are potential impacts of the combustion of biomass on air quality, mainly through the production of particulates. The challenging targets expected for Bristol's overall emissions reduction strategy are likely to require large amounts of biomass for use in plants at a variety of scales. As parts of Bristol have been declared as Air Quality Management Areas, the cumulative effects of biomass combustion will need to be considered. Larger scale plants are likely to produce fewer emissions than small plant due to the difficulties of fitting additional pollution abatement equipment on the latter. Emissions will therefore be more manageable on the larger scale plants required for a citywide heat network in Bristol (as discussed in Section 7). Heat networks also allow plant to be located some distance from heat delivery points.

5.3.1 Green wood residues

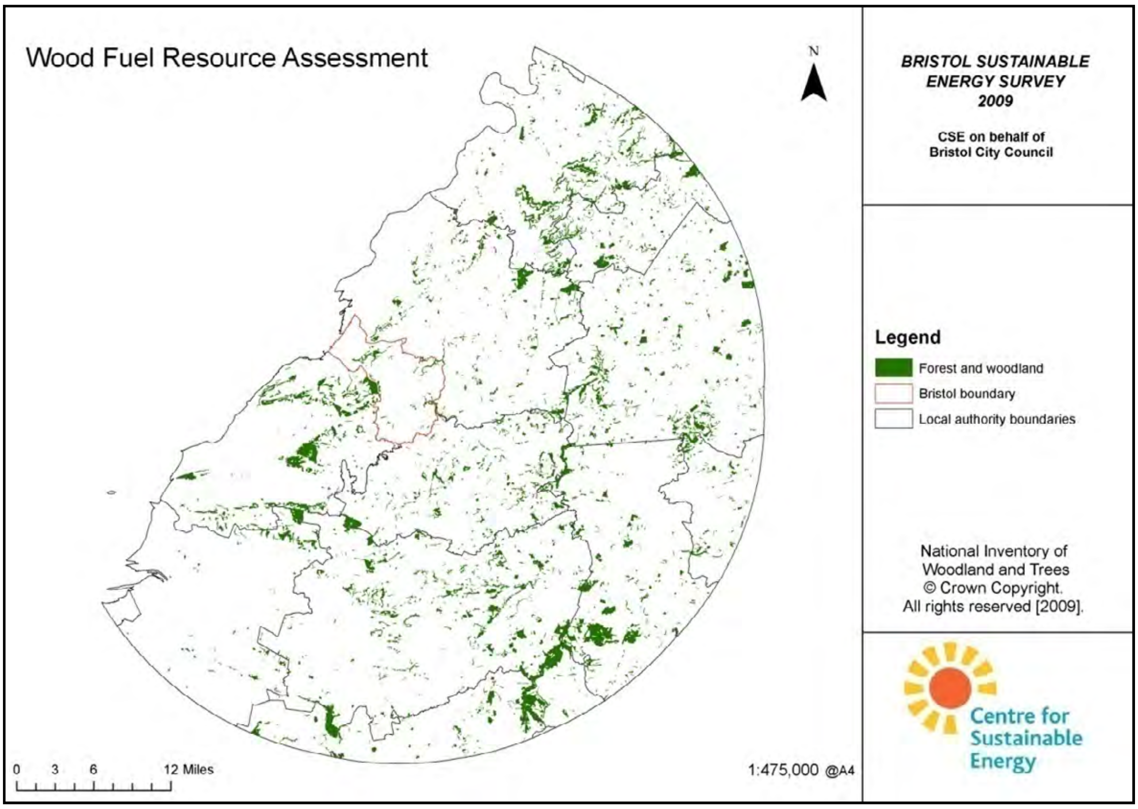


Figure 7: Forest and woodland sites within 40km radius of Bristol

[15] That is, the heat is used for a much smaller proportion of the time than the electrical power.

Green wood residues are mostly sourced from arboricultural residues i.e. tree trimmings carried out on street trees, park trees and smaller woodland areas across the city; and forest residues i.e. those generated from the management of woodlands. The resource is normally produced as woodfuel in the form of wood chip or logs.

Areas of forest and woodland within Bristol and out to a 40km radius of the Bristol boundary are shown in Figure 7, using data from the Forestry Commission's National Inventory of Woodland and Trees, although the dataset used did not cover parts of the Forest of Dean and some Welsh local authorities. The 40km criterion is often broadly applied as the economic 'catchment' area of woodfuel in relation to transportation.

The total area of forest and woodland within the area shown is 27,983 hectares, of which around 320 hectares occurs in Bristol (mainly around the Ashton Court, Blaise castle and Kings Weston estates. Assuming that normal woodland management activities will result in a sustainable yield of 2 odt per hectare annually for woodfuel, the resource amounts to nearly 56,000 odt per year. This corresponds to a CHP generation capacity of around $7MW_e$. Within Bristol, around 640 odt per year could be expected from woodlands, with woodchip from tree surgery activities in Bristol's parks and streets, and potentially from domestic garden waste will increase this figure. By way of illustration, 2,000 odt could potentially support around 2-3MW of heat-only plant. A significant proportion of Bristol's existing woodfuel resource is already supplying a number of biomass boilers throughout the city via an established woodchip supply chain.

5.3.2 Recycled untreated wood

Recycled untreated wood may also be available in significant quantities, although the resource is difficult to quantify as large quantities of treated and untreated wood waste end up mixed together in the waste stream. Different regulations regarding emissions control apply where treated or contaminated wood residues are used as a fuel, which require more expensive clean-up equipment only generally used in very large scale plant.

Sources of untreated wood residue include joinery and furniture workshops, waste management contractors and packaging/pallets. Residues, including sawdust, can potentially be converted into pellets, which can then be burnt in pellet boilers, suitable for use in individual households, or smaller scale non-residential applications such as schools. Wood pellets are produced at a small number of sites across the country and can potentially be delivered in bulk, although costs are significantly higher than for woodchip.

In a survey undertaken for the Bristol Biomass Study (CSE, 2003) around 270 odt per year of untreated wood residues were identified from 10 joinery/sawmill firms in Bristol, which corresponds to around 0.4 MW of heat-only generation capacity.

5.3.3 Energy crops

The production of energy crops may also contribute to Bristol's resource. The two main energy crops most often considered are miscanthus and SRC willow, both of which can be grown on agricultural land grades 1, 2 or 3. Similarly to green wood residues, a 40km catchment area is assumed in evaluating this resource (excluding parts of the Forest of Dean and some Welsh local authorities) as Bristol's own potential resource is very limited, although a small SRC plantation exists on land owned by the University of Bristol at Fenswood Farm and feasibility studies have been undertaken on Council-owned farms in Avonmouth. A further constraint applied was the exclusion of areas protected under the following designations:

- Ramsar sites

- Sites of Special Scientific Interest
- Special Areas of Conservation
- Special Protection Areas
- National Nature Reserves

Although no formal constraints exist within these areas, they were considered as having less potential for energy crops. The resulting land area potentially available for planting i.e. agricultural land grades 1,2 or 3 outside of protected areas is shown in Figure 8. The total area calculates to be 329,769 hectares.

Miscanthus plantations can typically yield 16–18 odt per hectare per year, which is almost twice that of SRC (8-10 odt per hectare per year), but is less suitable in more exposed areas. Figure 8 indicates that such areas (in this case taken as those with an annual average wind speed above 7 metres per second at 10 metres above ground level) are minimal for the area considered, so in evaluating the resource miscanthus would tend to be the crop of choice due to its higher yield. Assuming 5% of the total area identified was planted with miscanthus, the annual yield would be around 264,000–297,000 odt, which could potentially support around 33–37 MW_e of CHP plant.

Other issues that may limit the exploitation of this resource include potential conflicts between other agricultural land use e.g. food production or biofuels, the acceptability of generating plant, crop monocultures, planning and permitting, transportation issues and the question of alternative markets for Miscanthus and SRC. Additionally, energy crop plantations need time to establish and long term supply contracts with local farmers would need to be agreed.

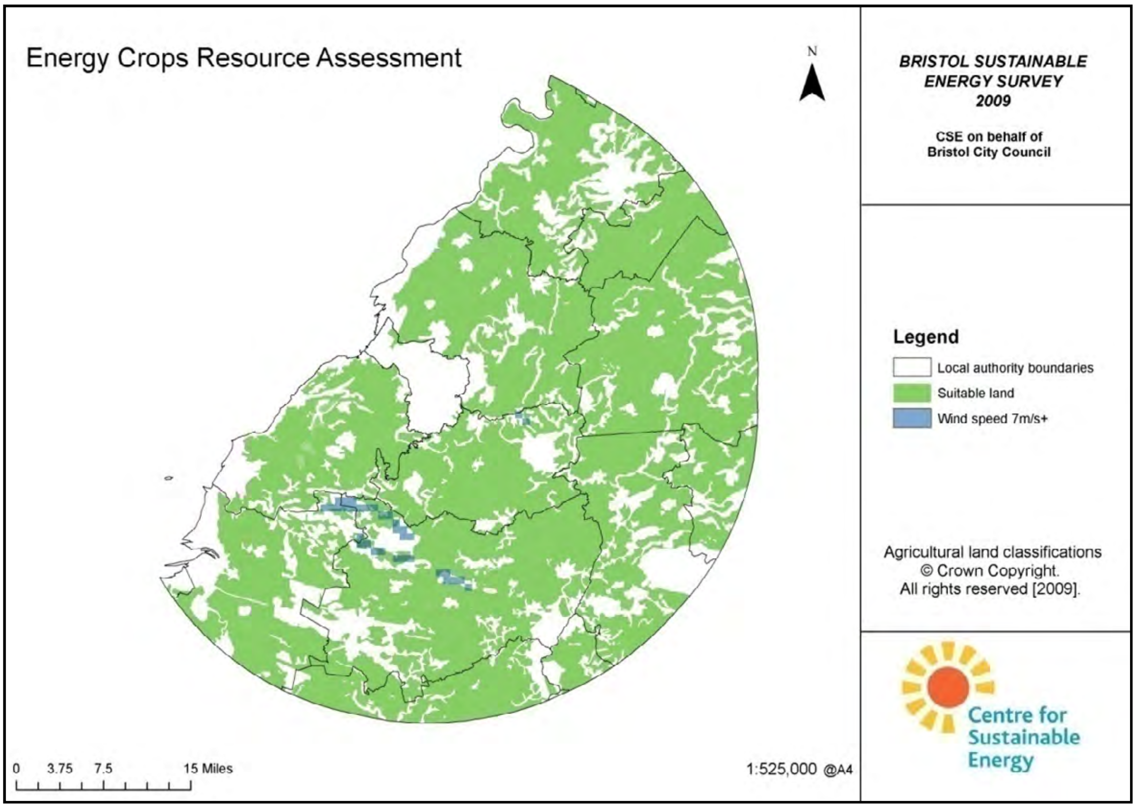


Figure 8. Land with agricultural grades of 1,2 or 3 within 40km radius of Bristol

5.4 Waste

Energy recovery from waste (EfW) provides a double environmental benefit - firstly, the diversion of waste from landfill and, secondly, the recovery of energy, displacing fossil fuel alternatives and reducing CO_2 emissions. At present only electricity generated from wastes undergoing one of the advanced conversion technologies such as gasification or pyrolysis is eligible for Renewables Obligation Certificates, and is therefore classed as 'renewable'.

Bristol's waste is subject to the West of England Waste Management and Planning Partnership's *Joint Residual Municipal Waste Management Strategy* (May 2008). There are currently no energy recovery from waste facilities within the West of England although, as set out in Table 8 there is an annual target for 775,000 tonnes of waste to be managed through recovery facilities by 2020.

Table 8: Indicative annual waste management capacity targets for the West of England in 2020 ('000 tonnes)
(Source: draft Regional Spatial Strategy, Joint Residual Municipal Waste Management Strategy, Jacobs 2006 and South West Regional Waste Strategy)

	Non-Inert	Inert
Recycling/composting	735	220
Recovery	775	N/A
Disposal (Landfill)	265	380

A preferred options consultation document for the Joint Waste Core Strategy Development Plan Document was published in January 2009. This indicated that the preferred option for future waste recovery facilities (probably incorporating Energy from Waste) consists of the five plants shown in Table 9:

Table 9: Options for future waste recovery facilities in the West of England

Location	Capacity (tonnes per year)	Potential sites
North West Bristol	390,000	Avonmouth Crooks Marsh, Hallen
Inner, East or South Bristol	60,000	Hartcliffe Way St Phillips Marsh Fishponds
Weston-super-Mare	100,000	Weston-super-Mare
Keynsham	150,000	Broadmead, Keynsham
Yate	100,000	tbd

The degree of biodegradability of these waste streams varies; for example around 68% of municipal solid waste is typically biodegradable (Defra figures). This type of waste has a lower calorific value than wood and in estimating potential plant size, a figure of 10,000 tonnes per year is assumed for each MW_e of electrical generation capacity. The actual proportion of waste that will actively be used for energy recovery is not known, but assuming a total of 450,000 tonnes per year (from Table 9) is processed in Bristol, the plant capacity would then be 45 MW_e plus potentially at least twice this figure in heat generation capacity.

An alternative option to EfW plant is to process waste streams into Refuse Derived Fuel (RDF). In this process, non-combustibles, hazardous, and valuable recyclable materials are normally removed before a shredding and/or steam pressurised treatment converts the material to the RDF product, which usually consists of a mix of unrecyclable waste plastics and biodegradable waste. This fuel can then be transported for use elsewhere e.g. to fuel CHP/CCHP plants.

5.5 Solar

The solar technologies, photovoltaics (PV) and solar water heating, are inextricably linked to buildings in the vast majority of applications in that they require roof space for unshaded access to sunlight. The technical resource is therefore vast and is dependent on south-facing unshaded roof areas. Although relatively expensive, solar PV is often used by developers as it is simple to install, can form part of a building's structure (often offsetting costs of conventional materials) and is currently the most accessible alternative to wind power in generating zero carbon electricity. Solar water heating is also straightforward to install but is much cheaper and typically requires less roof space. However solar hot water saves considerably less carbon than solar photovoltaics per square meter installed.

The extent to which these solar technologies are exploited on new development will therefore depend on the preferred mix of technologies a developer will select in meeting a particular emissions target – usually based on the least cost option. High capital costs severely limit their application on existing development and rate of uptake tends to be linked to grant availability.

5.6 Heat pumps

Heat pumps extract heat from the ground, air or bodies of water so in an urban environment the medium of ground and air are of most relevance. This technology is used for heating or cooling buildings and take up rates are mostly driven by new development and the likely technology mix chosen by developers in meeting emissions targets.

Physical constraints include the availability of space around buildings for ground loop installations comprising either boreholes or trenches. Installations on existing buildings are very limited as the technology works best in highly insulated buildings with low temperature heat distribution systems. Although an efficient technology, heat pumps have high capital costs and are powered by electricity which will impact running costs and emissions (where grid electricity is used). Emission savings will vary depending on type of building and the proportion of total heat demand supplied.

As heat pump installations will tend to be limited to new development it is difficult to quantify Bristol's resource for the above reasons. The resource will be linked to new development heat demand and assumptions would need to be made on their proportional contribution. The analysis in Section 8 assumes a least-cost approach to the choice of technologies and therefore heat pumps are excluded due to their relatively high capital cost.

5.7 Summary

Table 10 and Table 11 summarise the above analysis and presents the estimated capacities, energy yields and emissions from each resource or technology:

Table 10: Summary of resource assessment – electricity generation (excluding potential from new development)					
Resource/technology	**Technical potential [MW]**	**Annual electricity yield [MWh]**	**Emissions reduction potential [tonnes CO_2 per year][16]**	**Emissions savings as % of Bristol's 2006/7 total emissions**	**Notes**
Large scale wind	22	57,816	31,047	1.3%	Based on existing installations and those proposed by Bristol City Council and Wessex Water
Medium scale wind	(5.3)	(13,928)	(7,480)	(0.3%)	Assumes 200m spacing between turbines
Small scale wind	(1.6)	(4,205)	(2,258)	(0.1%)	Assumes 100m spacing between turbines
Sewage gas	5.75	47,851	25,696	1.1%	Based on existing plant in Avonmouth
Solar PV	74	58,341	31,329	1.4%	Assumes 25% of Bristol's rooftops are suitable for a 2kW system
Waste	45	374,490	201,101	8.7%	Assuming CHP
Total excluding waste	***102***	***164,008***	***88,072***	***3.8%***	
Total including waste	**147**	**538,498**	**289,173**	**12.5%**	

Table 11: Summary of resource assessment – heat generation (excluding potential from new development)					
Resource/technology	**Technical potential [MW]**	**Annual heat yield [MWh]**	**Emissions reduction potential [tonnes CO_2 per year]**	**Emissions savings as % of Bristol's 2006/7 total emissions**	**Notes**
Biomass (green wood residues)	2.5	3,942	729	0.03%	Estimate from woodland and arboricultural residues (in Bristol only)
Biomass (energy crops)	0.5	788	146	0.01%	Based on potential at Fenswood Farm
Sewage gas	7	61,320	11,344	0.5%	Based on existing plant in Avonmouth
Solar Water Heating	74	45,376	8,395	0.4%	Assumes 25% of Bristol's rooftops are suitable for a 2kW system
Waste	90	788,400	145,854	3.6%	Assuming from CHP into District Heating Network
Total excluding waste	***84***	***111,426***	***20,614***	0.9%	
Total including waste	**174**	**899,826**	**166,468**	7.2%	

[16] Carbon emission factors applied are 0.537 and 0.185kgCO_2/kWh respectively for electricity and gas [from Carbon Trust CTL018]

Notes:

- The three scales of wind power resource are stated independently of each other, i.e. they cannot be added together. The totals in the above tables include the total for large scale wind only.
- The same will also be partly true for the solar resource as in many cases PV and solar water heating will not be combined on one roof. Therefore the carbon savings for solar PV and solar water heating cannot be added together, as this would be double-counting.
- If the biomass (green wood residues) resource within a 40km radius from Bristol was included as a resource for CHP plant, an additional 22,688 tonnes CO_2 per year could potentially be saved

Figure 9 below shows the technical CO_2 savings from heat and power from each resource, in order of the proportional reduction in Bristol's citywide emissions. This illustrates the substantial potential contribution from energy recovery from waste.

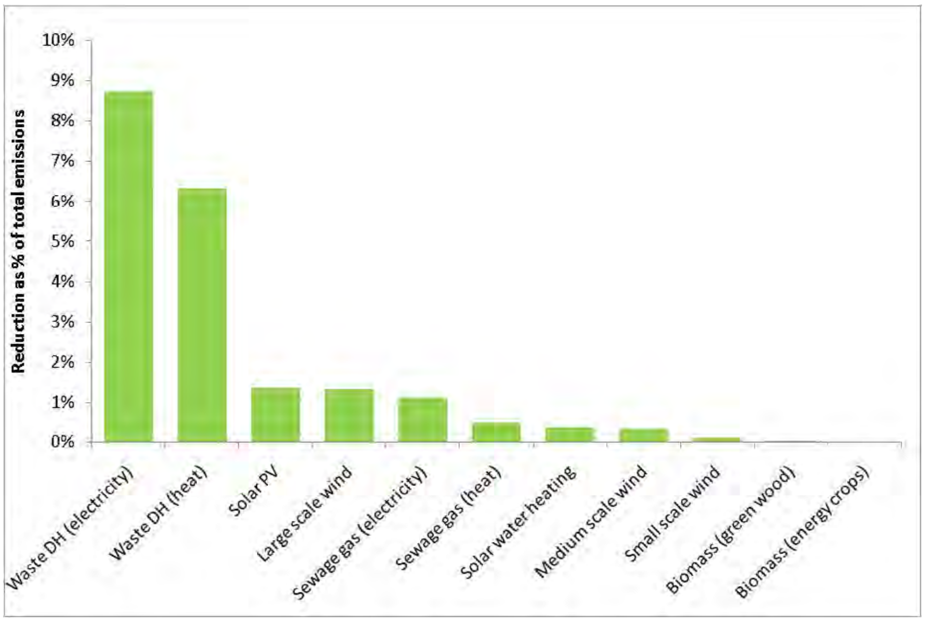


Figure 9: Summary of resources ranked by potential savings compared to citywide emissions

6 Planning policy scenarios

Two main policy scenarios were developed at the project start and subsequently tested against a model developed by CSE to examine the implications for new residential development for the period up to 2026. It is considerably more difficult to model non-residential development in the same way due to the range of building types and the lack of economic data on additional building costs for different levels of carbon reduction. Furthermore, data obtained from the Council on future non-residential development pertains to applications that have already been through the planning process, further reducing the value of the exercise.

The residential scenarios are described below:

6.1 Scenario 1 (baseline)

This scenario effectively assumes the Council imposes the minimum standards for new developments as currently expected through future changes to Building Regulations. The scenario is informed by the current Government consultation on the Definition of Zero Carbon Homes and Buildings as described in Section 4.1, which indicates that developers will be able to achieve the 2016 'zero carbon' target for homes through a hierarchy of measures, with an appropriate trajectory towards this aim up to 2016.

The proposed hierarchy for 2016 and beyond includes a minimum standard of energy efficiency and 'carbon compliance' measures, plus a shopping list of 'allowable measures' (see Section 9) which makes provision for a range of off-site carbon saving solutions. Carbon compliance is the minimum level of CO_2 reduction, compared to Part L 2006 regulations, that is required to be achieved on-site and/or through direct connection of low and zero carbon heat (not necessarily on-site).

The scenario includes a range of carbon reduction targets over three phases as follows:

Table 12: Scenario 1 – based on potential Building Regulation changes up to 2016

	Phase 1 (2010-2012)	Phase 2 (2013-2015)	Phase 3 (2016-2026)
CO_2 reduction compared to Part L 2006 (through energy efficiency and carbon compliance measures)	25% of regulated[17] emissions	44% of regulated emissions	100% of regulated emissions
Equivalent level of the Code for Sustainable Homes	Level 3	Level 4	Level 5

The target of 100% of regulated emissions for Phase 3 is one of several explored in the Government consultation and remains the subject of some debate. The target refers to the minimum level of energy efficiency and carbon compliance measures required for a development, with any residual carbon emissions being offset through the allowable measures mentioned above. In this way, the Government intends to achieve the 'zero carbon' target for all new dwellings built from 2016. The figure of 100% of regulated emissions is thought to be the upper limit of the energy efficiency and carbon compliance level currently proposed by Government.

6.2 Scenario 2

This scenario is based on 'Policy G' in the draft South West RSS as shown in Section 4.1, which related timescale and the type and scale of development to various levels of carbon reduction targets alongside draft RSS Policy RE5 on onsite renewable energy generation. Policy G was subsequently removed from the draft RSS by the Secretary of State for Local Government but is considered to be an appropriate set of targets on which to base a more challenging scenario than that expected from Building Regulations.

[17] Regulated emissions only include those associated with space heating, ventilation, hot water and fixed lighting. Total emissions include regulated emissions plus those associated with cooking and other appliances.

Table 13: Scenario 2 – based on Policy G from the Draft South West RSS			
	Phase 1 (2010-2012)	**Phase 2 (2013-2015)**	**Phase 3 (2016-2026)**
CO_2 reduction compared to Part L 2006 (through energy efficiency and carbon compliance measures)	44% of regulated emissions	100% of regulated emissions	100% of total emissions
Equivalent level of the Code for Sustainable Homes	Level 4	Level 5	Level 6

6.3 Onsite generation policy

Alongside the above scenarios, a 'Merton-style' policy of requiring a minimum amount of onsite renewable or low carbon generation was tested. As mentioned in Section 4, the draft RSS Policy RE5 has been changed from a policy to drive minimum levels of renewable energy content within new developments to minimum levels of decentralised and renewable or low-carbon sources. Local authorities are able to set their own targets at an appropriate level, with the draft RSS suggesting an interim target of 10% to be met by renewable or low carbon sources.

There are three issues that often need clarification when referring to these types of policies:

1. Whether the required reduction is applied to the predicted **energy consumption** of the site or its **CO_2 emissions**. It is now generally accepted that the latter method is more effective in reducing emissions due to subtleties around the differing carbon content of gas and electricity. This report therefore assumes (and recommends) that any percentage reduction target through onsite generation is applied to a development's CO_2 emissions.
2. Whether the required reduction is applied to the **regulated** or **total** CO_2 emissions of a site. For example, a 10% reduction in total CO_2 emissions equates to a reduction in regulated CO_2 emissions of around 15-20%. This report will generally refer to total emissions unless stated otherwise.
3. At which point the policy is applied in relation to any hierarchical approach to CO_2 reduction. For example, in the case where the required energy efficiency standard is above that of current Building Regulations, applying the percentage reduction to the residual emissions after all energy efficiency measures have been applied will require less generation capacity than if it were applied to baseline Building Regulation emissions. This can act as an incentive for developers to maximise energy efficiency, as it will decrease the amount of more costly renewable energy measures required.

   In keeping with the energy hierarchy discussed in Annex B, this report therefore assumes that the required reduction is applied sequentially after energy efficiency i.e. first reduce emissions through a mandatory energy efficiency target; secondly, further reduce emissions using onsite low carbon energy generation, and finally incorporate renewables by applying the onsite renewable energy target to the residual emissions after energy efficiency and low-carbon measures.

It should be noted that additional onsite generation policy requirements of this type would effectively be made redundant for most development if in the longer term Building Regulation requirements increase as expected towards the 2016 target. This is because onsite or near-site renewable or low carbon energy generation (incorporated as part of Building Regulation carbon compliance measures) will be necessary to achieve these higher overall CO_2 reduction targets, and will serve the same purpose as a specific onsite target.

Such a policy will therefore be of most importance in the short term where, for example, during Scenario 1/ Phase 1 (the period up to 2012), the 25% CO_2 reduction target could be achieved through energy efficiency alone and so an on-site generation requirement will serve to further reduce emissions.

7 Energy demand and emissions from buildings

To investigate the measures that may be appropriate in reducing CO_2 emissions from buildings, it is important to establish energy demands – both for existing and new buildings over the period of study. Electricity and heat demands and their spatial distribution will influence the choice of technologies and hence the viability of reaching specific emission reduction targets.

Heat density maps, for example, are a useful way to evaluate the scale, magnitude and density of heat demand for specific groups of buildings or larger areas. They can be used to assess the impact of applying certain threshold criteria for district heating systems and for prioritising areas of high heat demand density that hold most potential for district heating.

7.1 Heat demand from existing buildings

In urban areas, as the resource assessment in Section 5 confirms, there are relatively limited opportunities for large scale standalone renewable energy installations. Section 5 also shows that there is potential for integrating solar PV and/or water heating on existing buildings, which could deliver an additional 1.4% reduction on Bristol's 2006/7 emissions. Exploiting the total potential for standalone and building integrated renewables would therefore save approximately 447,200 tCO_2/year or almost 20% of Bristol's emissions in 2006/7 (if energy from waste is excluded, this figure falls to 100,300 tCO_2/year or almost 5% of Bristol's 2006/7 emissions).

There is therefore going to be a significant gap between the carbon saving that can be achieved through renewable energy within the city boundary, and the long term emissions reductions that are required. To address this in terms of emissions from buildings, two key local approaches must be exploited. The first is demand reduction through a combination of increased energy efficiency and behaviour change, and the second is the utilisation of low and zero carbon sources of heat.

Here we focus on the latter. Carbon savings from behaviour change and energy efficiency measures in existing buildings will certainly contribute a very significant proportion of carbon reductions achieved in Bristol. However the focus of this project is on the potential for sustainable energy supply, alongside building standards for new development.

District heating – the large scale distribution of hot water for space and water heating in buildings - is probably the most important sustainable energy supply technology for urban areas. Several factors underpin the importance of large scale heat distribution networks to achieving carbon reductions in urban areas such as Bristol. These include:

- Allowing the use of larger scale, higher efficiency, lower unit cost, and lower carbon heat sources
- Fuel flexibility: while hot water is the energy carrier, the heat itself can be derived from a wide range of fuel, plant and conversion process types, including traditional gas boilers, biomass

boilers, gas or biomass CHP systems, and importantly, waste heat from existing processes such as power generation and waste incineration

- Significant carbon reductions from heat use in existing buildings, which represented around a third of Bristol's CO_2 emissions in 2006/7[18].
- Long lifetime (decades) and low maintenance costs.

As a result of these advantages, district heating in urban areas has a key role to play in facilitating a shift from the current predominant use of gas and electricity for space heating, towards lower carbon heat sources and CHP, in both new and importantly, existing buildings.

A number of factors influence the viability of district heating networks. Among the most important of these is heat demand density – i.e. units of heat demand per square metre over a year. Heat density maps are therefore used to evaluate the location and scale of opportunities for district heating.

Another important factor is the potential for connecting new development to existing district heating networks, or for establishing new district heating networks at new development sites. An initial assessment of the areas of highest potential for district heating can therefore be carried out by mapping density of existing heat demand alongside the expected locations of large scale new developments.

To achieve this for Bristol, spatial data on energy consumption from existing development in Bristol was obtained from BERR local authority consumption statistics which provide electricity and gas consumption data at Middle Layer Super Output Area (MLSOA) level. Heat demand was then calculated from this data and reprocessed in a GIS model. The resulting spatial distribution of heat demand is presented in Figures 10, 11, 12 and 13 below. These show heat demand across the city on both a 25m grid and contour map basis. Table 14 below shows total building-related electricity and gas consumption split between domestic and industrial/commercial users.

[18] Calculated from BERR Small Area Statistics 2007 and Defra Local Authority Statistics 2006

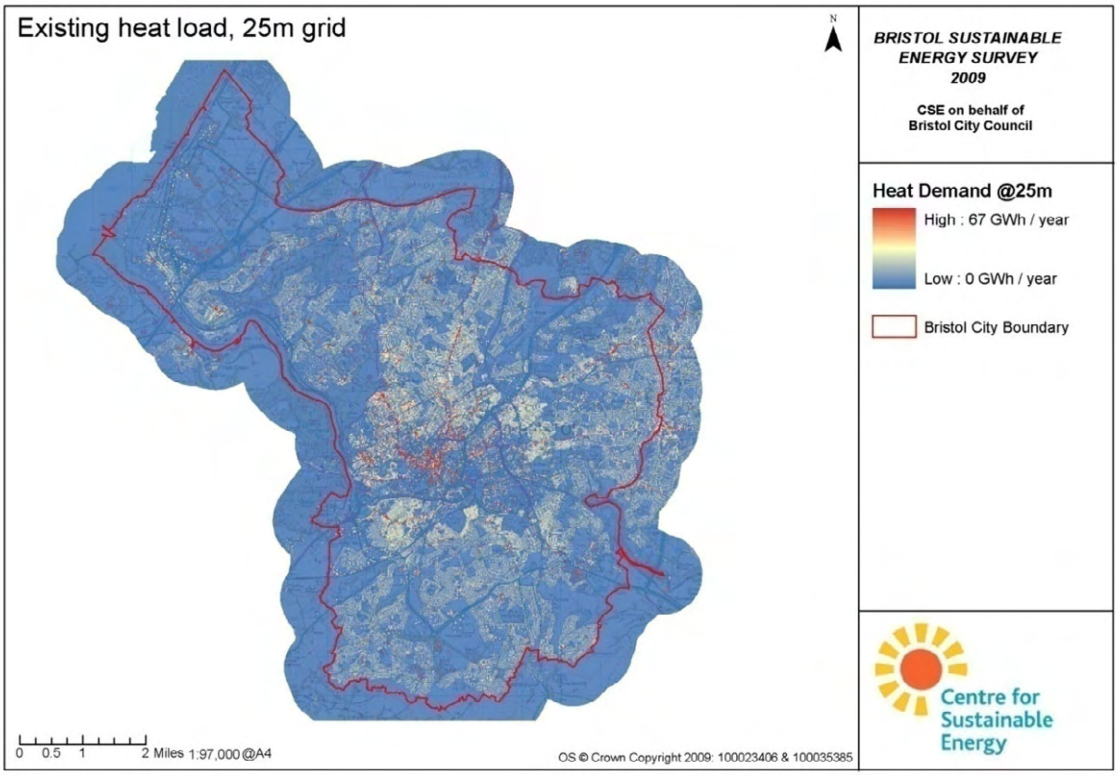


Figure 10: Heat demand from existing buildings in Bristol (25m grid map)

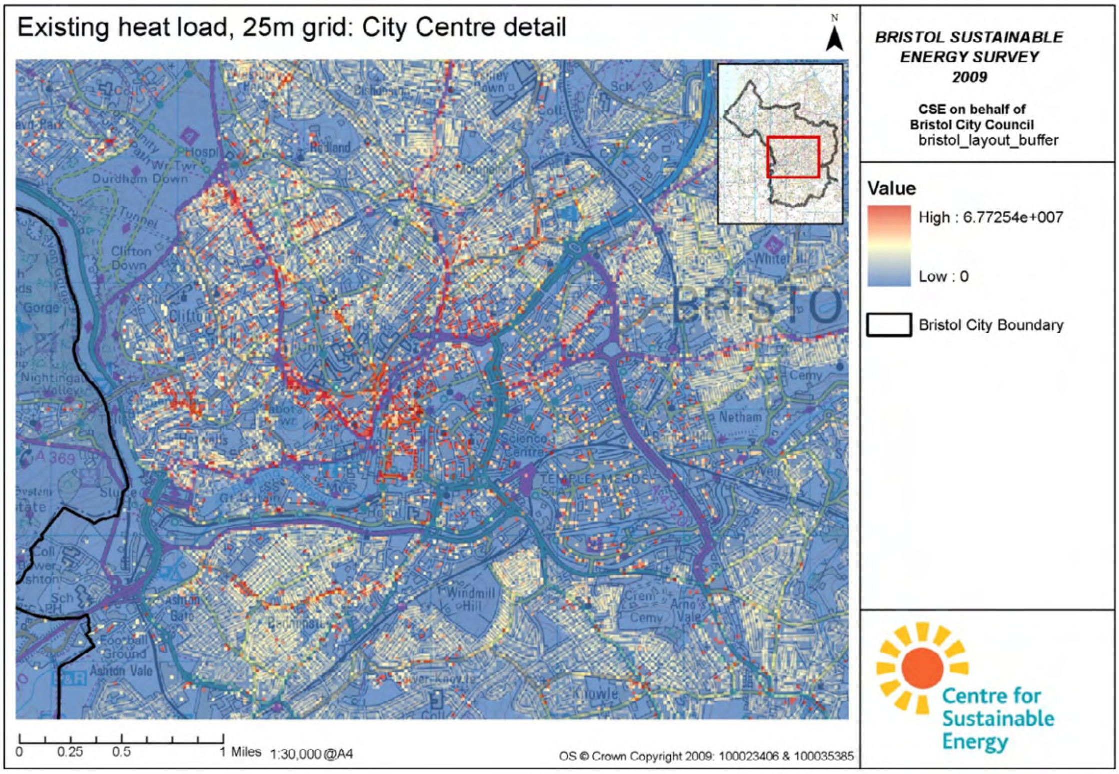


Figure 11: Heat demand from existing buildings in Bristol City Centre (25m grid map)

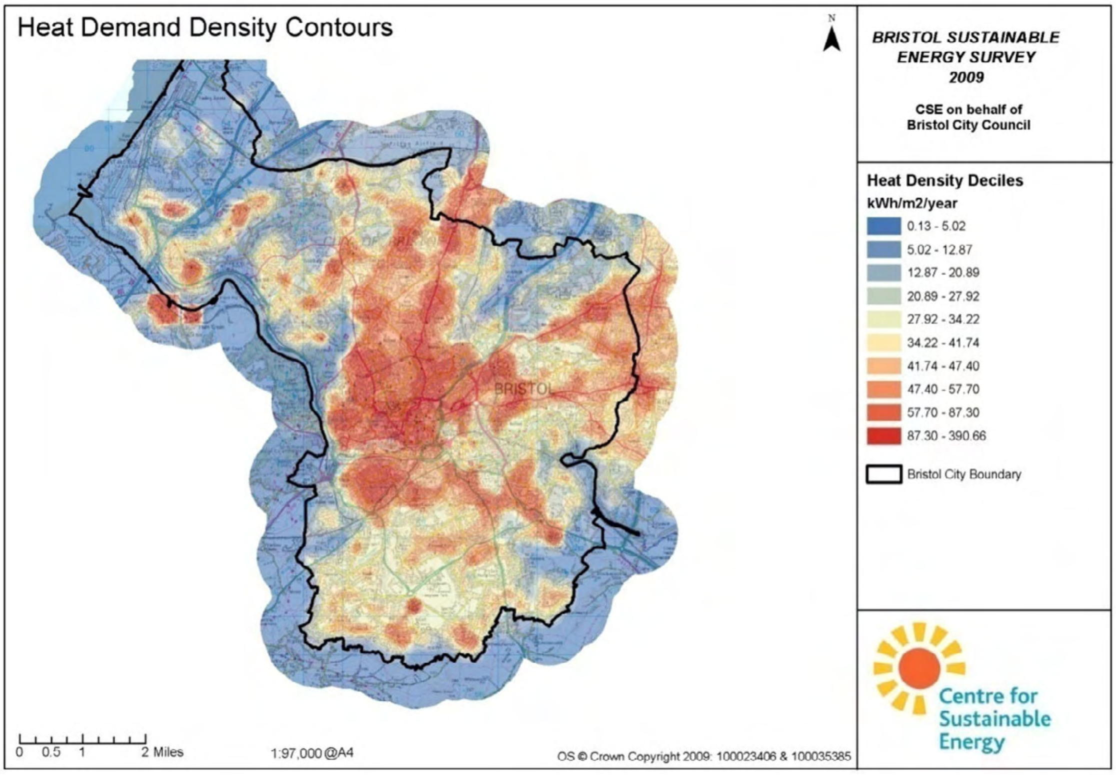


Figure 12: Heat demand from existing buildings in Bristol (demand density contours)

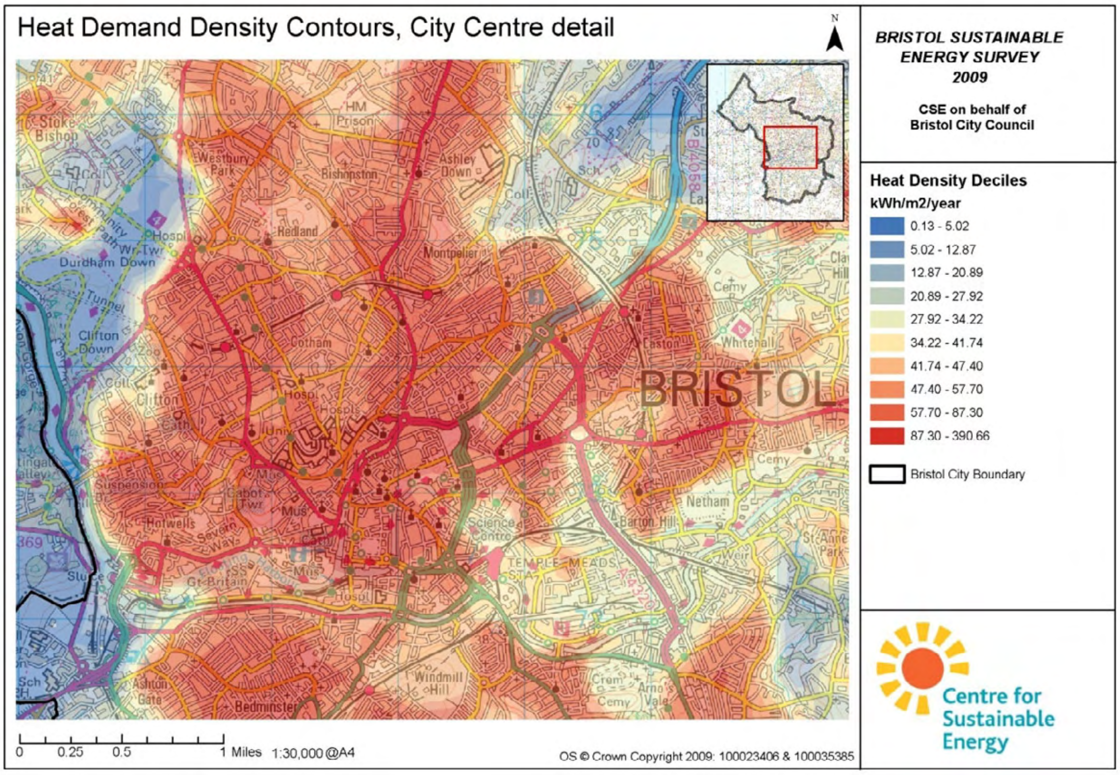


Figure 13: Heat demand from existing buildings in Bristol City Centre (demand density contours)

Table 14: Energy consumption statistics for Bristol (Source: 2005 data from Energy Trends 2007)				
Sector	**Electricity [MWh]**	**Gas [MWh]**	**Total [MWh]**	**CO_2 emissions [t/yr]**
Domestic heat	159,772	2,677,698	2,837,470	581,172
Domestic power	603,571	0	603,571	324,117
Total domestic	***763,343***	***2,677,698***		***905,289***
Industrial / commercial heat	0	1,209,404	1,209,404	223,740
Industrial / commercial power	1,328,152		1,328,152	713,217
Industrial/commercial total	**1,328,152**	**1,209,404**		**936,957**
Total	**2,091,495**	**3,887,102**		**1,842,246**

The figure for gas consumption in the domestic sector is likely to decrease slightly over the next decade due to energy efficiency initiatives, although other changes in factors such as comfort levels and electricity consumption may reduce or reverse the effect on overall CO_2 emissions.

7.2 Heat and power demand in new development

7.2.1 Residential

In predicting emissions from new development, the effect of any proposed CO_2 reduction targets on both heat and power demands needs to be considered. More specifically, the proportional reduction that energy efficiency measures are likely to contribute in meeting the targets in comparison to that from low or zero carbon energy generation is of particular interest as it is the former that will influence energy demands.

For the purpose of estimating projected energy demands, baseline heat and power demands for a range of housing types were first identified using those typical of Part L 2006 Building Regulations. One level of energy efficiency 'backstop' was then assumed across the three phases up to 2026. This level is approximately equivalent to that associated with Level 3 of the CFSH, i.e. an achievement of 25% reduction in CO_2 over the Part L 2006 Target Emission Rate (i.e. 25% of regulated emissions). As indicated in EST Guide CE290, this level of reduction is readily achievable using energy efficiency measures without the need for on/offsite generation.

Minimum standards of energy efficiency to be set by future Building Regulations have not yet been agreed. However, in DCLG's *Definition of Zero Carbon Homes and Non-domestic Buildings* consultation, the Government have indicated that an energy efficiency backstop for dwellings somewhere between 25-44% reduction on regulated emissions is achievable by 2016, with an appropriate trajectory towards this level in 2010 and 2013. It is also worth noting that current Government regulations mean that all new houses being built for local councils and housing associations must now meet a minimum Level 3 standard of the CFSH.

The above assumptions were applied to Bristol's Strategic Housing Land Availability Assessment (SHLAA) data set in order to model CO_2 reduction opportunities up to 2026. The data set used comprises 2,688 sites containing a total of 33,963 dwellings. Each site comes allocated with a specific density (dwellings per hectare) depending on its location. A specific mix of housing types was assumed for each of the five density bands considered (see Table 15) and a linear build-out schedule was assumed from 2010 to 2026 for each site across phases 1-3.

Table 15: Assumed mix of dwelling types for Bristol density bands					
	Density	Dwelling type mix			
Density band	[dph]	flat	terrace	semi	detached
Suburban	65	40%	44%	12%	4%
Suburban priority	85	50%	37%	10%	3%
Inner	100	55%	33%	9%	3%
Inner priority	120	70%	22%	6%	2%
Central	200	90%	7%	2%	1%

Energy demands and resulting emissions accounting for reductions due to the energy efficiency backstop were then calculated. The spatial distribution of the sites and their modelled heat demands is shown in Figure 14 below. Table 16 shows modelled energy consumption and CO_2 emissions from the SHLAA sites. The sites with 'completion' or 'commitment' status are considered separately as these will fall under current or previous regulations i.e. their initial build will not be subject to future planning policy or Building Regulations.

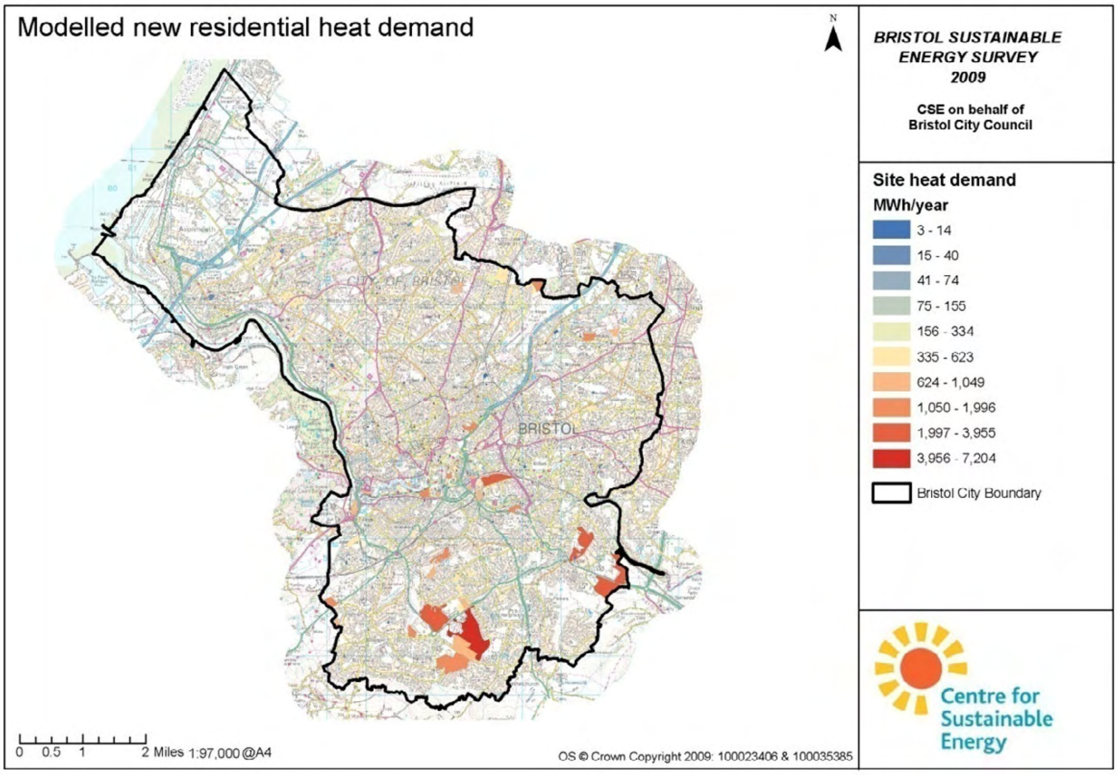


Figure 14. Spatial distribution of Bristol SHLAA sites and modelled heat demands

Figure 15 and Figure 16 illustrate the relative CO_2 emissions per dwelling type from heat and power consumption and the corresponding emissions following application of a 25% reduction on TER (Target Emissions Rate, i.e. concerning regulated emissions only), through typical energy efficiency measures. This illustrates the fact that the large majority of savings will be achieved through building fabric measures to reduce heat loss. Figure 17 shows the reduction in total CO_2 emissions for the 20 largest SHLAA sites following application of a 25% reduction on regulated emissions through energy efficiency.

Table 16: Modelled energy consumption and CO_2 emissions before renewables for Bristol SHLAA sites

SHLAA category	No of Sites	Electricity demand [MWh]	Heat demand [MWh]	CO_2 emissions[19] [t/yr]
Sites with 'completion' or 'commitment' status	2,541	40,176	61,431	32,939
Sites with 'SHLAA' or 'Urban Extension' status	147	38,343	57,654	31,256
Total	**2,688**	**78,519**	**119,085**	**64,195**

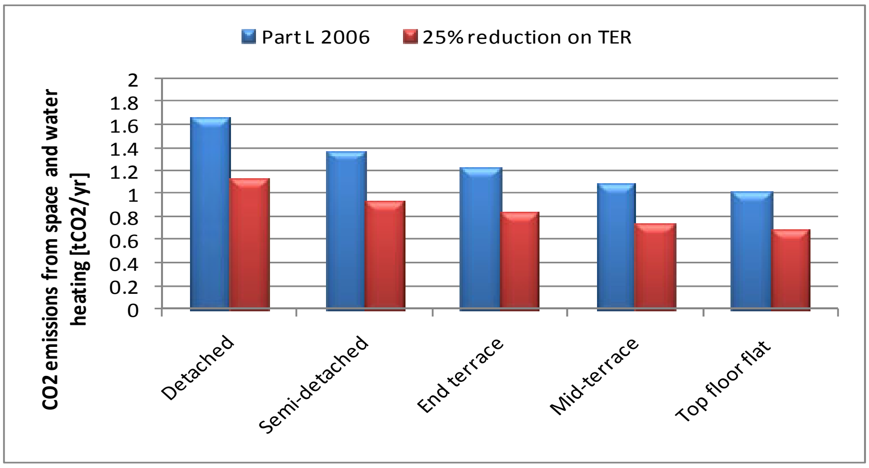


Figure 15. Part L 2006 CO_2 emissions per dwelling type from heating showing corresponding emissions following application of a 25% reduction on TER through energy efficiency.

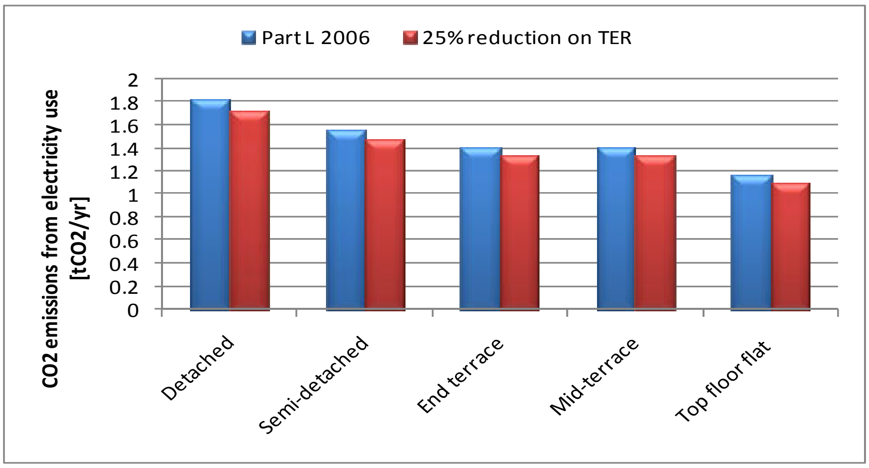


Figure 16. Part L 2006 CO_2 emissions per dwelling type from electricity showing corresponding emissions following application of a 25% reduction on TER through energy efficiency.

[19] Assumes gas boiler efficiency of 90%

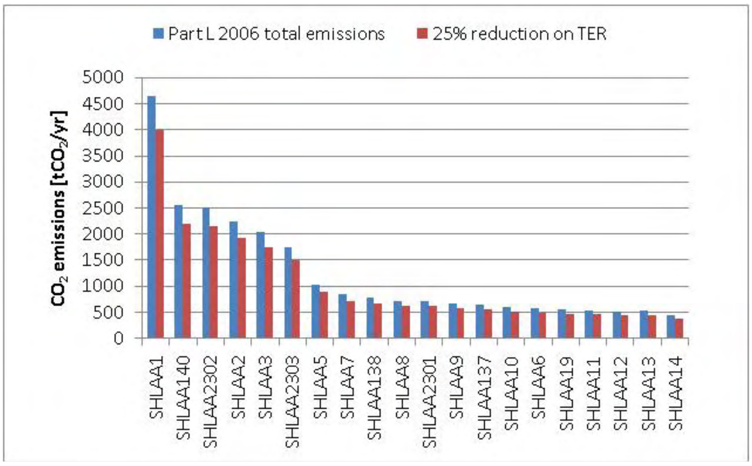


Figure 17. Part L 2006 total CO_2 emissions for the 20 largest SHLAA sites showing corresponding emissions following application of a 25% reduction on TER through energy efficiency.

7.2.2 Non-residential

The planned trajectory of carbon reductions under Building Regulations for new non-domestic buildings up to the zero carbon target in 2019 is currently unknown, although the Government has suggested that phased reductions may be introduced in a similar way to dwellings. Minimum standards of energy efficiency during this period and hence heat and power demands are therefore more difficult to estimate than for future residential development.

DCLG's *Definition of Zero Carbon Homes and Non-domestic Buildings* consultation contains average CO_2 emission rates for a range of non-domestic building types which meet Part L 2006 Building Regulations. By applying the same CO_2 conversion factors used in modelling these figures i.e. those used in the Standard Building Energy Model (SBEM), average energy consumption equivalents can be found.

Using limited spatial data for Bristol's future non-residential development, these demands have been mapped for new, additional floor space only, i.e. where building type is known. Although floor space is also known for developments involving refurbishments or re-builds, it is not known which building types or mixes apply, so demands are very difficult to estimate. Figure 18 maps new non-residential heat demand and Table 17 quantifies the estimated demands and emissions.

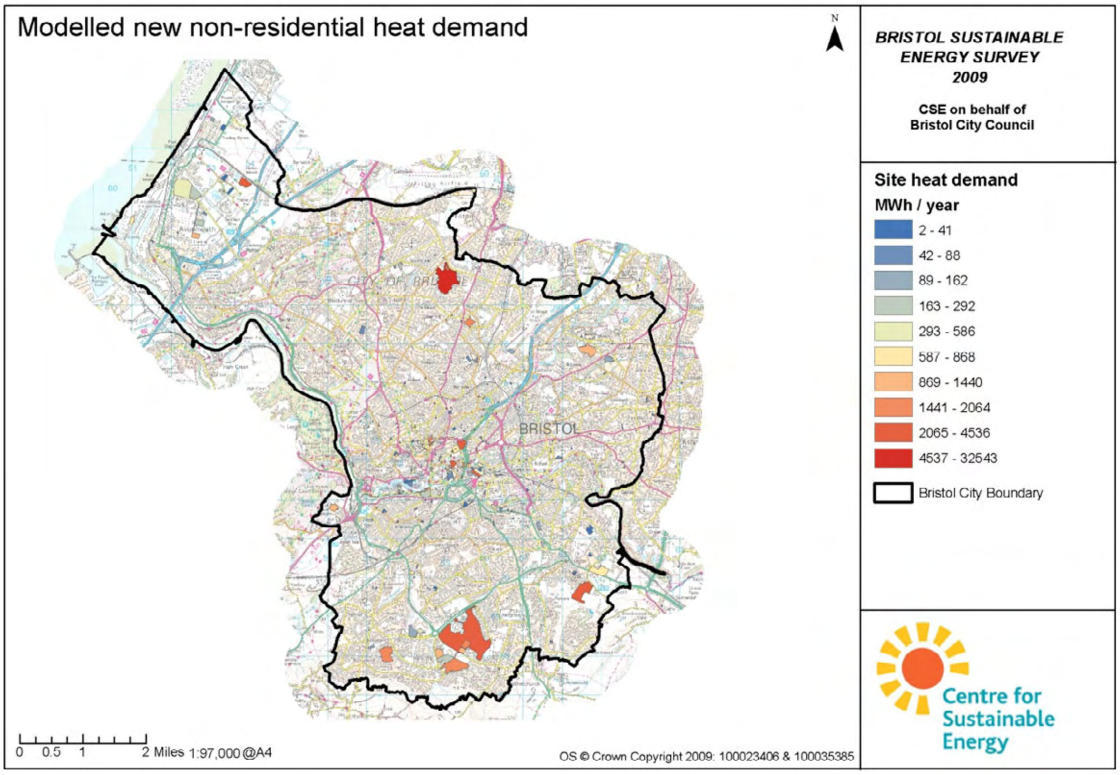


Figure 18. Spatial distribution of Bristol Non-Resi Pipeline sites with modelled heat demands

Table 17: Energy consumption and CO_2 emissions for Bristol non-residential 'pipeline' sites (figures apply to new additional floor space only)

No of Sites[20]	Total new floor space [m^2]	Electricity demand [MWh]	Heat demand [MWh]	CO_2 emissions [t/yr]
219	1,176,583	163,249	103,403	**106,794**

7.3 Identification of Heat Priority Areas

As discussed in Section 7.1, an initial assessment of those areas with highest potential for district heating can be made on the basis of (1) existing heat demand density, and (2) the expected locations of new development. Figures 19 – 22 below illustrate this process.

First, the top 30% highest heat demand areas of Bristol were identified from the heat demand density contour map (Figure 19).

Next new development locations are overlaid on the map (Figure 20).

Finally a Shape Hull is generated to encapsulate these two previous layers, resulting in a layer which represents those areas of Bristol with the highest potential for district heating (Figure 22).

[20] Of the 261 sites in the Bristol Development Database, 42 had insufficient data to model energy demand

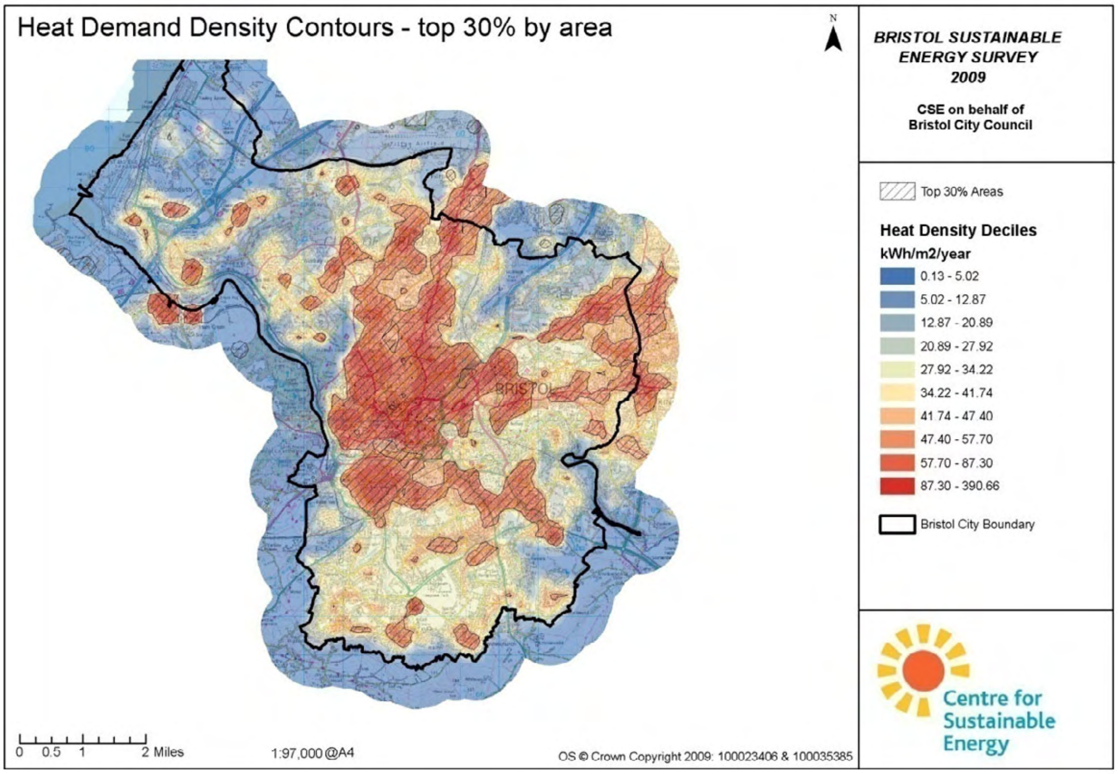


Figure 19: Top 30% of Bristol areas by heat demand density

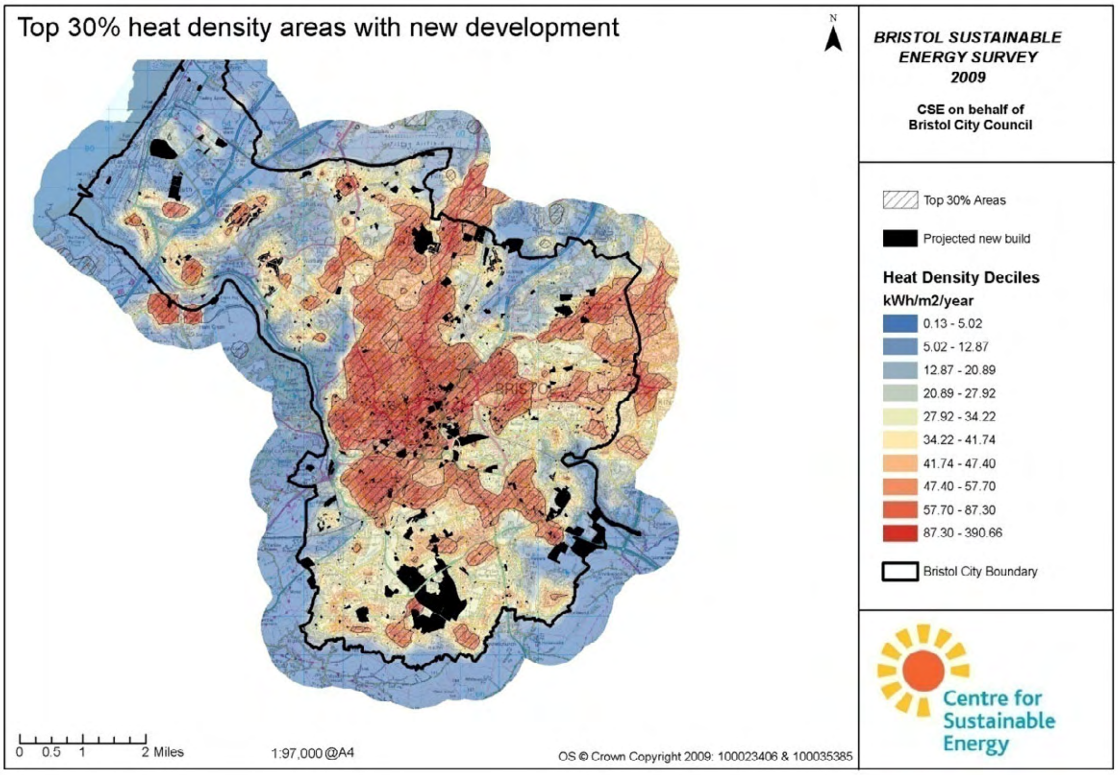


Figure 20: Top 30% of Bristol areas by heat demand density with new development

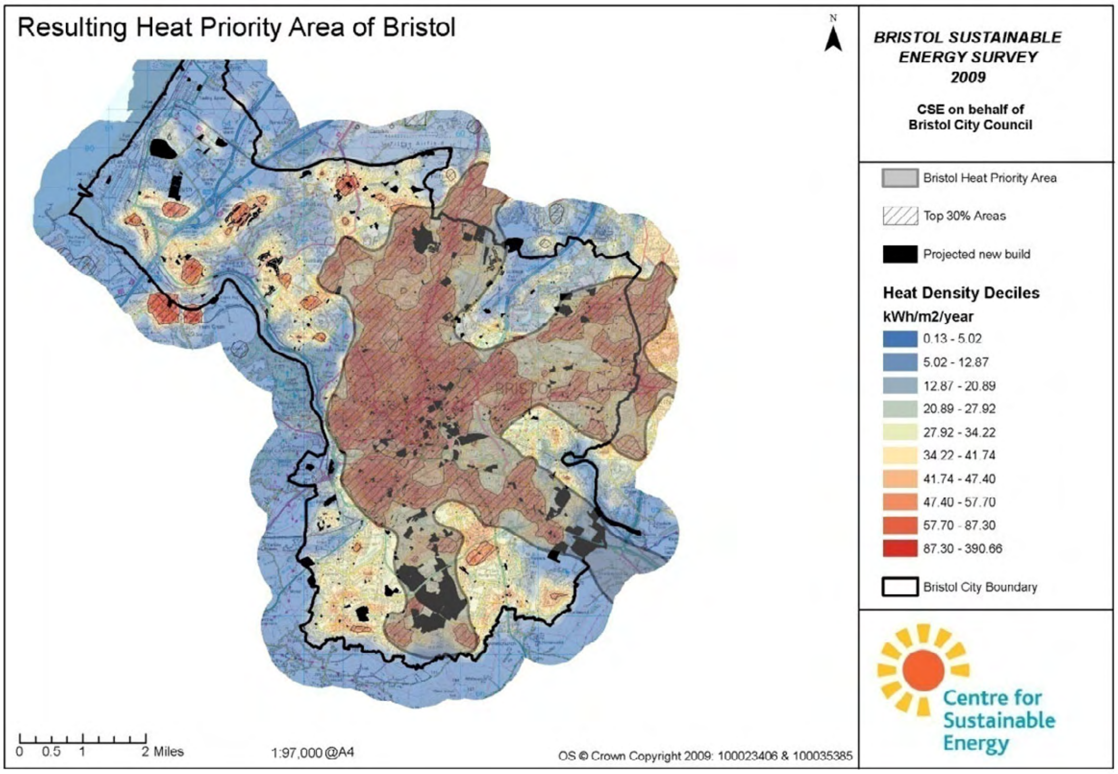


Figure 21: As per Figure 20, with Heat Priority Areas

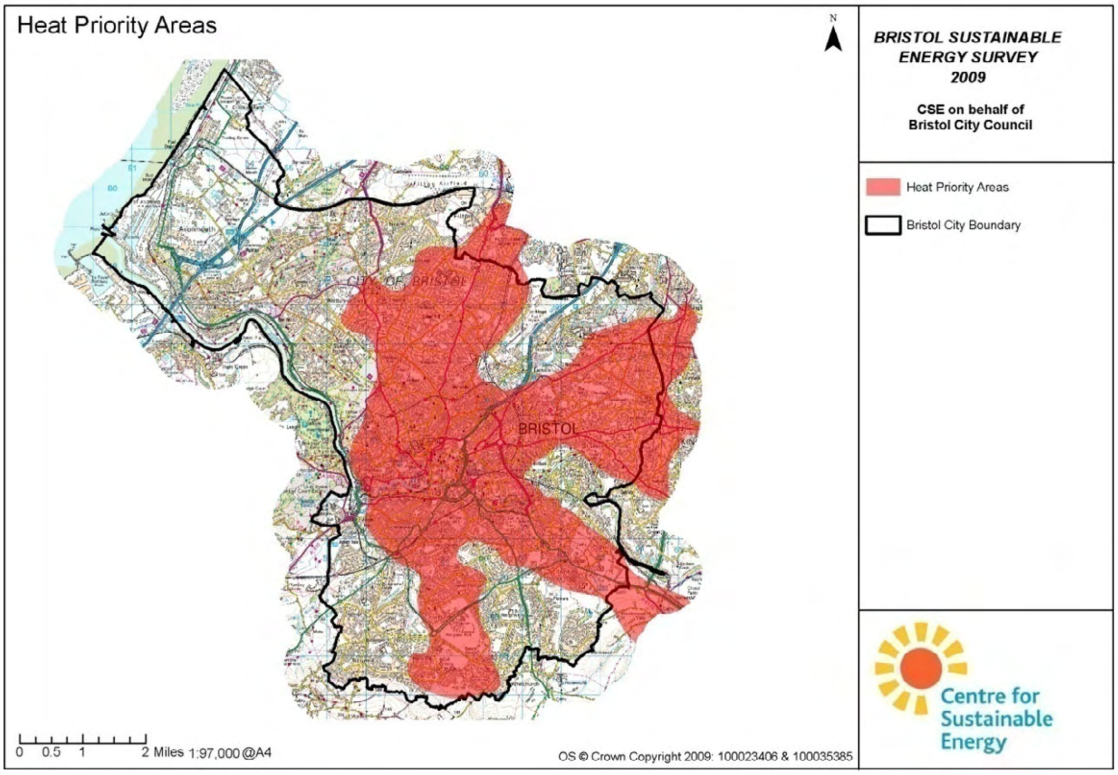


Figure 22: Heat Priority Areas on 50k:1 OS Raster Map

The above Heat Priority Area captures 70% of total heat demand in 45% of the city area. It excludes Avonmouth, which is known to contain a number of industrial heat loads; while these have the potential to be connected to a local heat distribution network, the geography of Bristol suggests that these loads would be unlikely to form part of a citywide network. Nevertheless significant carbon savings are available through the supply of low/zero carbon heating to these loads, and this is currently being investigated by the BETS team.

Table 18 and Table 19 indicate the area split between Heat Priority Areas and non-Heat Priority Areas and the corresponding heat demands. The optimum approaches for heat supply are also shown for each category.

Table 18: Heat demands within Bristol showing Heat Priority Areas

	Area (km^2)	Heat demand (GWh/year)	% of Area	% of Heat demand
Bristol City area	112	4,024	100%	100%
Area within Heat Priority Area	50	2,836	45%	70%
Area outside Heat Priority Area	62	1,188	55%	30%

Table 19: Heat supply options

Heat demand	Optimum approaches for heat supply
2,836 GWh annual heat demand in the Heat Priority Area of Bristol	– District Heating Networks – Combined Heat and Power plants – Sustainable biomass fuel sources
1,188 GWh annual heat demand outside the Heat Priority Area of Bristol	– Site community heating – Biomass boilers – Solar hot water – Micro-CHP – Air/Ground source heat pumps

8 Policy scenario outcomes

8.1 Residential

The DCLG's consultation on the *Definition of Zero Carbon Homes and Non-domestic Buildings* includes lists of low carbon technology mixes and costing data tested against a range of targets for a range of housing development scenarios. For each target of interest, the least-cost technology mix was identified (see Annex A) and applied to the Bristol SHLAA data using a database model. The generation technologies therefore selected included photovoltaics (PV), biomass community heating (BCH) and biomass CHP. Solar water heating, heat pumps and gas-fired CHP were also included in the DCLG study, but are not considered here as they do not occur within the 'least-cost' technology mixes for the targets considered.

Although these have currently been modelled as the least cost options for specific housing development types, it should be noted that future changes in costs and technological advances may well dictate different optimum mixes with regard to technical and economic viability. Developers, therefore, may select different technologies from those modelled here.

The model outputs are designed to assess the likely technology mix, associated costs and emission reductions resulting from the application of both scenarios described in Section 6. Figures 23-28 below present the main findings, as modelled for the 147 sites with 'SHLAA' or 'Urban Extension' status. These sites are all larger scale i.e. over 10 dwellings.

Note – the 'Multiphase' x-axis category refers to the situation where the modelled scenario occurs throughout Phase 1, 2 and 3, i.e. for each site, a linear build out rate is assumed between 2010 and 2026, meaning targets are progressively increased. The 'Phase 1', 'Phase 2' and 'Phase 3' category results show the effect of building all sites during one particular phase i.e. a single phase target applies to all sites.

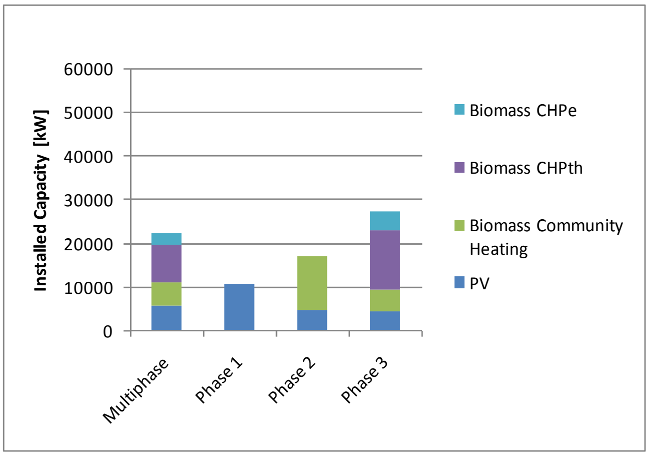


Figure 23: Scenario 1 – installed capacities

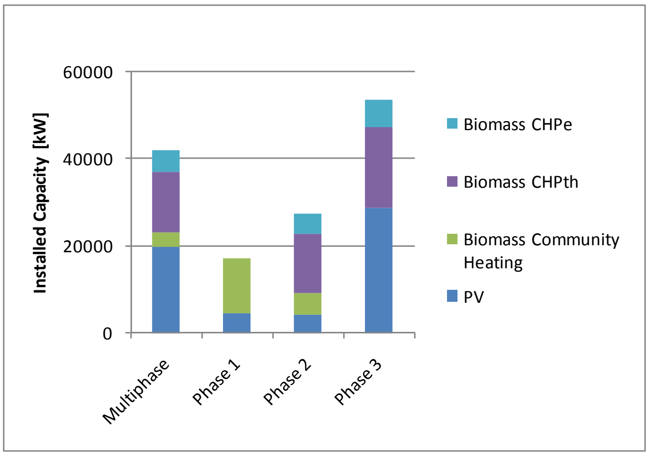


Figure 24: Scenario 2 – installed capacities

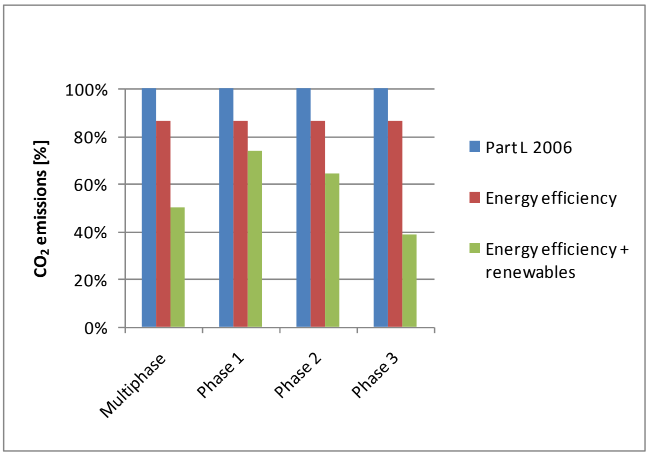


Figure 25: Scenario 1 – total CO_2 emissions

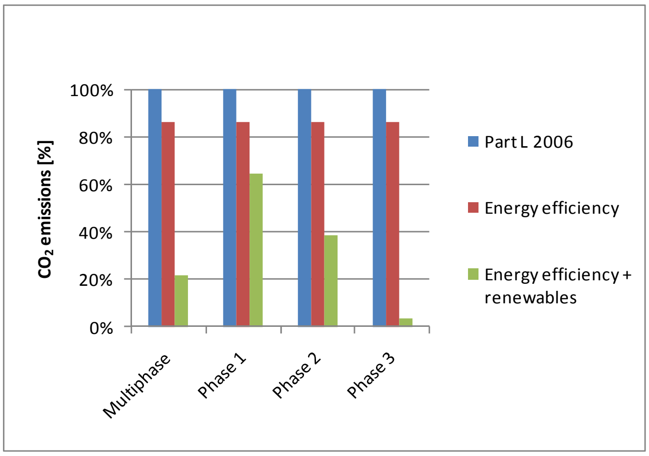


Figure 26: Scenario 2 – total CO_2 emissions

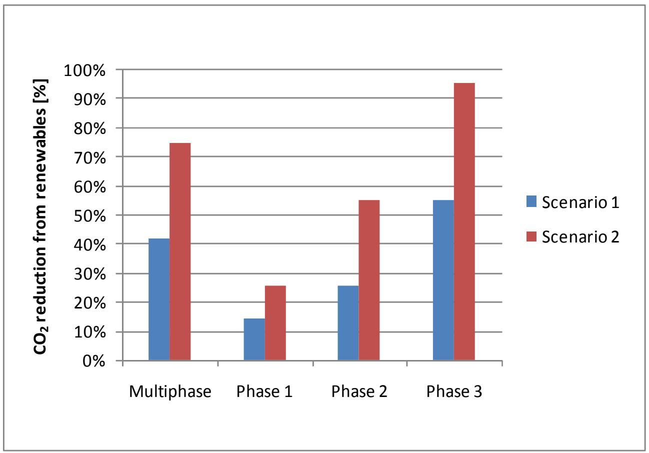


Figure 27: Proportion of CO_2 reduction from renewables

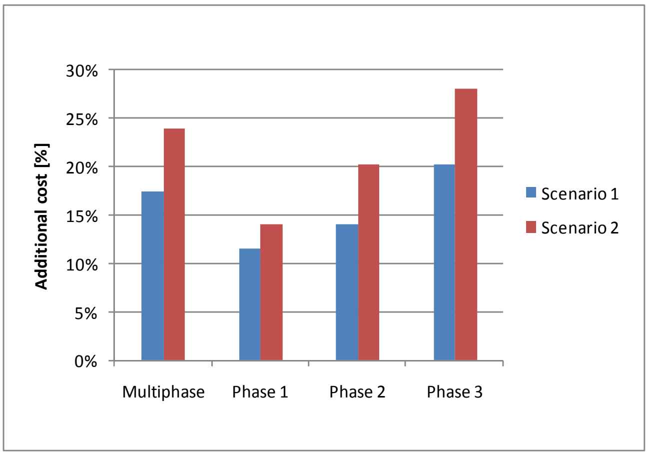


Figure 28: Additional costs over base build costs

Table 20: Summary of on-site generation capacities as modelled on SHLAA sites

	Generation capacity [MW]	
Generation technology	**Scenario 1 (multiphase)**	**Scenario 2 (multiphase)**
Solar PV	5.6	19.7
Biomass CHP (electricity)	2.8	4.7
Biomass CHP (heat)	8.4	14.1
Biomass heating	5.4	3.3

Figures 23 and 24 show the modelled take-up of generation technologies for Scenarios 1 and 2 (as applied after energy efficiency measures). The figures are also shown in Table 20 above. The results for individual phases indicate that PV alone is predominantly used to meet the lower targets, with biomass required alongside PV for the higher targets.

Figures 25 and 26 show the reductions from total Part L 2006 CO_2 emissions after energy efficiency measures[21], and both energy efficiency measures and renewables (49.9% reduction with Scenario 1 and 78.3% reduction with Scenario 2 for multiphases).

Figure 27 indicates the effective proportion of emissions reduction from on-site generation resulting from the scenarios. It can be seen that a value of around 14.5% of total emissions is achieved for Scenario 1, Phase 1. Figure 28 indicates the additional costs over base build associated with the emissions reduction measures considered. This is discussed further in Section 8.3 below.

8.2 Non-residential

Due to the wide range of non-residential building types and uses that exist, technical and economic data relating to the application of renewable and low carbon measures is much less documented than for residential development and cannot be modelled in the same way, although a Government consultation in late 2009 will begin to examine these issues in more detail.

Until further research is undertaken in this area it is suggested that standards for non-residential buildings are expressed in terms of BREEAM targets. Again, there is very limited information on the additional costs associated with each BREEAM standard. BRE Information Paper 4/05[22] from 2005

[21] A 25% reduction in regulated emissions (i.e. from energy efficiency) approximately equates to a 15% reduction in total emissions
[22] *Costing Sustainability: How much does it cost to achieve BREEAM and EcoHomes rating?* BRE and Cyril Sweett, 2005

suggests that the 'Excellent' standard could be achieved for a naturally ventilated or air conditioned office for around 7% increase on capital build cost.

Table 21 and Table 22 show estimated technology capacities for new non-residential development for Scenarios 1 and 2 (S1 and S2). In this case, the proportional capacities and in relation to heat and electricity demands from the residential analysis were applied.

Table 21: Estimated capacities for new non-residential development assuming Part L 2006 standards

Technology	MultiS1 [MW]	MultiS2 [MW]
PV	24	84
BCH	10	6
BCHP thermal	15	26
BCHPkW electrical	12	20

Table 22: Estimated capacities for new non-residential development assuming 25% emissions reduction over Part L 2006 standards

Technology	MultiS1 [MW]	MultiS2 [MW]
PV	18	63
BCH	7.5	4.5
BCHP thermal	11.25	19.5
BCHPkW electrical	9	15

8.3 Financial implications of policies

Scenario 1 models the trajectory of Building Regulation changes expected up to 2016 and beyond, with the selected on-site measures/carbon compliance target for 2016 being at the higher end of the range currently being considered by Government (100% reduction on regulated emissions). These changes will impose additional build costs on new developments, which will need to incorporate a range of low or zero carbon energy measures to meet the targets. Research commissioned by the Government has indicated that the average construction cost premium for delivering zero carbon homes entirely within the development site could be between 17 – 24% over current build costs by 2016, but would decrease from this peak as the costs of key technologies fall.[23]

The analysis for the current study as applied to new residential development (SHLAA sites) proposed in Bristol reveals a slightly lower range of additional costs for Scenario 1. Figure 29 shows the relationship between both parameters. These are also shown for both Scenarios along with corresponding CO_2 reductions in Table 21 below. It can be seen that between Scenarios 1 and 2, an additional 7% cost may result in a further 28% of emissions reduction - this translates into an extra 10,000 tonnes CO_2 saved per year.

[23] *Research to Assess the Costs and Benefits of the Government's Proposals to Reduce the Carbon Footprint of New Housing Development*; DCLG Sept 2008

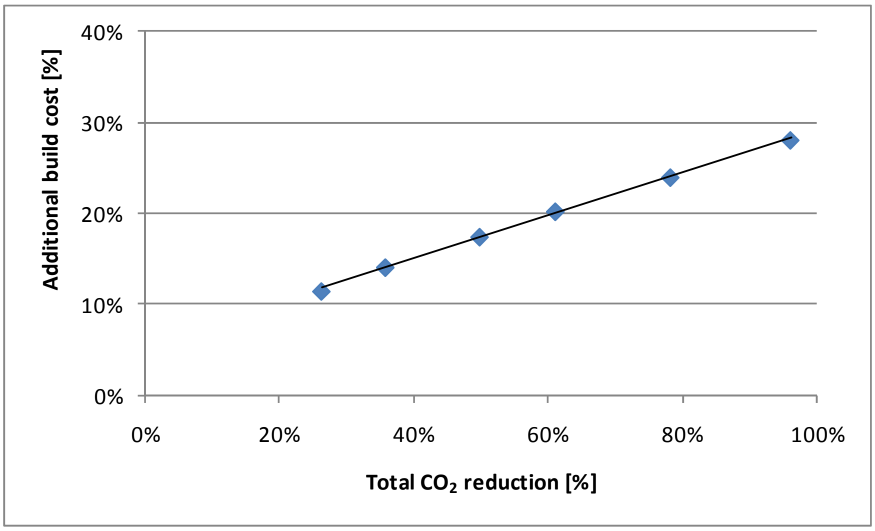


Figure 29: Relationship of % cost increase with emissions reduction (across all phases and both Scenarios)

Table 23: Increase in additional build cost and resulting total CO2 reduction over Part L 2006				
	Range of % additional build costs	**Average across phases**	**% CO_2 reductions over Part L 2006**	**Average across phases**
Scenario 1	11% – 20%	17%	26% – 61%	50%
Scenario 2	14% – 28%	24%	36% – 96%	78%

Due to economies of scale, the financial burden of CO_2 reduction targets on developers will tend to be greater for smaller sites. For this reason many on-site generation policies, including that proposed in the draft RSS, have applied a threshold of development to which the policy applies e.g. larger than 10 dwellings and 1,000 m^2 of non-residential floorspace.

However, policy in London is moving away from these thresholds towards policy which applies to development of all scales. The 2008 Consolidated London Plan Policy 4A.7 which requires 20% CO_2 reduction from renewables just refers to “developments” and does not include any scale thresholds, but there is a feasibility ‘opt-out’ clause. As the PPS22 paragraph 8 tests of viability and undue burden are still relevant, a suitable degree of flexibility is therefore required where scale thresholds are not specifically stated. Viability thresholds at small scale have also been considered as part of the evidence base for the South West RSS[24]. The conclusions from this study are complex and their applicability to Bristol will require further consideration.

Figures 30 to 33 examine the relationship between the development density (given in dwellings per hectare) and the scale parameters (Table 24) used in the study modelling, and how this affects costs and emission savings. The trends of decreasing costs with increasing density and scale are evident in both Scenarios. This suggests that CO_2 targets for large City Centre developments are likely to be more economically viable than developments elsewhere.

[24] See http://www.southwest-ra.gov.uk/media/SWRA/RSS%20Documents/Technical%20Documents/Technical%20Work/extra_modelling_final_report_v4.pdf

Table 24: Scale factors	
Scale factor	No. of site dwellings
1	1-9
2	10-200
3	201+

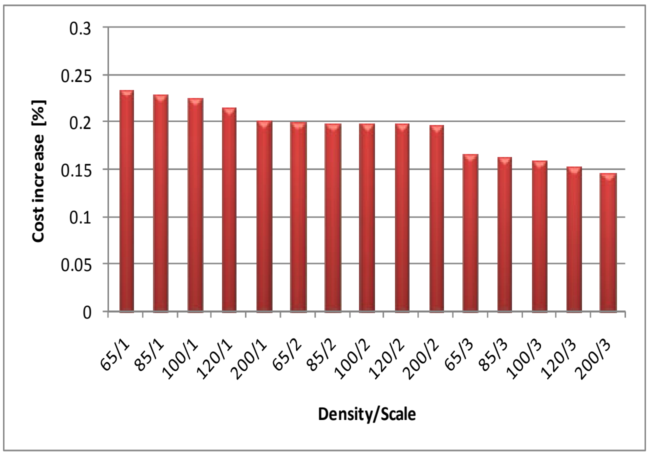


Figure 30: % cost increase with scale and density (Scenario 1)

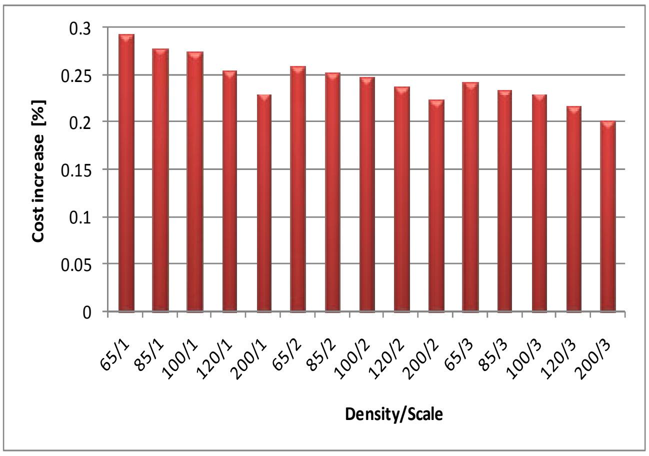


Figure 31: % cost increase with scale and density (Scenario 2)

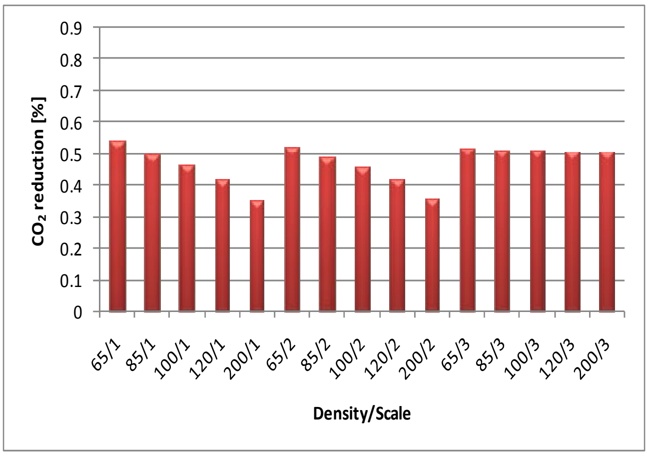


Figure 32: % CO_2 reduction with scale and density (Scenario 1)

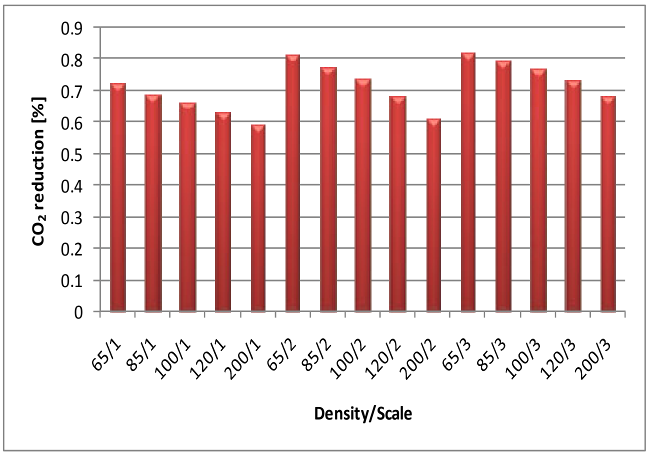


Figure 33: % CO_2 reduction with scale and density (Scenario 2)

9 Delivery mechanisms

There are a number of institutional or financial mechanisms that can assist in the successful delivery of the measures discussed in this report. Although some of these have yet to be fully proven in practice, they should be considered alongside any proposed carbon reduction targets when assessing viability issues.

9.1 Allowable solutions

From 2016 the Government's proposed 'allowable solutions' will enable developers to meet a zero carbon emissions reduction target where 'carbon compliance' measures alone have fallen short of the mark. These allowable solutions include a range of measures that can be undertaken in the locality or potentially further afield, such as exports of heat or direct investments in offsite renewable electricity. The Government's *Definition of Zero Carbon Homes and Non-domestic Buildings* consultation proposes the following list of allowable solutions:

- carbon compliance beyond the minimum standard (towards or all the way up to mitigating 100 per cent of regulated emissions plus emissions from cooking and appliances)
- a credit for any energy efficient appliances or advanced forms of building control system installed by the house builder that reduce the anticipated energy demand from appliances or reduce regulated emissions below the level assumed by SAP
- where, as a result of the development, low carbon or renewable heat (or cooling) is exported from the development itself, or from an installation that is connected to the development, to existing properties that were previously heated (or cooled) by fossil fuels, then credit will be given for the resulting carbon savings
- a credit for S106 Planning Obligations paid by the developer towards local LZC energy infrastructure
- retrofitting works undertaken by the developer to transform the energy efficiency of existing buildings in the vicinity of the development
- any investment by the developer in LZC energy infrastructure (limited to the UK and UK waters) where the benefits of ownership of that investment are passed to the purchaser of the home
- where offsite renewable electricity is connected to the development by a direct physical connection (and without prejudice to any regulatory restrictions on private wire), a credit for any carbon savings relative to grid electricity; and
- any other measures that Government might in future announce as being eligible.

A case can therefore be made for additional guidance possibly within a Development Control DPD to describe in more detail the steps that must be taken before the conclusion is reached that the required target cannot be met through carbon compliance measures alone, and to set out more fully what other solutions will be considered.

When examining these 'off-site' opportunities, the Council should consider the relative benefits of such measures in terms of proven carbon savings and any potential overlap with other policies and initiatives which may result in the measure going ahead anyway by other means. Local authority monitoring and enforcement of these measures may be difficult to undertake and should be given careful consideration.

9.2 Energy Service Companies (ESCos)

The ESCo (Energy Service Company) model is based around an energy service provider installing low carbon energy generation or energy saving equipment and charging consumers for the use of their service over a defined contract period. Companies would own and maintain the technology in exchange for consumers signing up to a service contract.

There are many options for who could provide energy services or elements of such, including energy suppliers, third parties working with energy suppliers or bodies which have a permanent connection or relationship to properties such as Distribution Network Operators, gas distributors and water companies. Additionally, the Local Government Act 2000 enables local authorities to set up ESCos either on their own or in partnership with a private company, as Woking, Birmingham, Aberdeen and

Southampton have done. Further information is available from the Energy Saving Trust's Directory of Energy Services[25] which contains a range of guidance and case studies.

The London Energy Partnership's publication, *Making ESCos Work: Guidance and Advice on Setting Up and Delivering an ESCo* (Feb 2007)[26] found that in the UK there are a variety of models being used for the delivery of energy projects by public authorities. This is due to differences in each authority's attitude to risk and the degree to which they want to involve the private sector in the project, but it is also due to the lack of a well developed standard model for ESCo contracting in the UK.

This lack of standardisation and funding in the UK for ESCo projects has meant that some have been set up through Private Finance Initiatives. Many projects are financially marginal and one of the significant issues has been persuading the private sector to accept sufficient financial and other risk in projects. For example, in the case of heat and power networks, the report found that the private sector is less willing to build a network to distribute heat and power than is it to build and operate the plant itself. This has led to difficulties in some projects due to a funding gap in relation to construction of the network. Developers are more likely to be willing to have district heating networks serving their sites when an ESCo will take some or all of the upfront financial risk for the project

However, with some of the measures proposed in the Government's Heat and Energy Saving Strategy Consultation Document, there are potentially ways in which risks could be reduced and incentives provided to encourage an increased level of activity regarding ESCos and their successful implementation. For example, by packaging different Government subsidies, including CERT and the RHI, Energy Performance Contracting (EPC) arrangements are more likely to be viable for ESCo bodies.

Heat sales would, or course, be subject to regulatory controls which should include quality and continuity of service (including protections for consumers during supply outages), the basis for setting prices in the long term, metering and billing and dispute resolution.

9.3 Renewable Heat Incentive (RHI)

As mentioned in the Heat and Energy Saving Strategy Consultation, the Government's Renewable Energy Strategy consultation (2008) set out two possible support mechanisms for renewable heat: a Renewable Heat Incentive (RHI), which would give a guaranteed payment for renewable heat generated; and a Renewable Heat Obligation, similar to the Renewables Obligation for renewable electricity. Most respondents to the RES consultation made it clear that the priority is to provide effective, practical support for renewable heat as soon as possible and supported the Government's emerging thinking to support an RHI. The Government has since announced that it will retain and extend the RO for electricity, and has taken powers to introduce the RHI currently planned for April 2011.

The incentive will apply to eligible renewable heat generators at all scales across Great Britain, whether it is in households, communities or at industrial scale, and is expected to broadly take the form of that indicated in the Renewable Energy Strategy consultation (Box 4.2, p119).

Although details of how the RHI may be implemented have yet to be decided, it is likely to consider market based options that allow for innovation rather than forcing a particular type of payment. As explained in the Heat and Energy Saving Strategy Consultation:

[25] http://www.energysavingtrust.org.uk/business/Business/Local-Authorities/Your-Sustainable-Energy-Strategy/Energy-Services-Packages
[26] http://www.london.gov.uk/mayor/environment/energy/partnership-steering-group/docs/making-escos-work.pdf

> *"it may be more effective and administratively simpler for RHI support to be provided as an up-front lump sum in certain circumstances, e.g. for particular technologies or below particular cost or output thresholds, rather than as a stream of income over a period of time. Arrangements to deliver payments in this way could be included in the design of the scheme. Alternatively, third parties such as financial institutions could deliver up-front payments or discounts on the cost of renewable heat technologies, in return for receiving the RHI payments when the renewable heating system is up and running."*

9.4 Feed-in Tariff

The Energy Act 2008 provides powers to establish feed-in tariffs giving the option of providing support to small-scale low carbon electricity generation up to 5MWe. The aim is that generators will receive a guaranteed payment for generating low carbon electricity. Such tariffs could potentially make a significant difference to the up-front cost and financial viability of investing in distributed electricity generation, both onsite and at community scale. The FIT is currently due to be introduced in April 2010.

9.5 Community Infrastructure Levy

The Community Infrastructure Levy (CIL)[27] will be a new non-mandatory charge which local authorities in England and Wales will be able to apply to most types of new development in their area. The proceeds of the levy can be spent on local and sub-regional infrastructure to support the development of the area, which could potentially include district heating. CIL charges will be based on simple formulae which relate the size of the charge to the size and character of the development paying it. The Government are currently consulting on whether the CIL could be used as an allowable solution in meeting emissions reduction targets.

9.6 Banding of the Renewables Obligation

The current financial incentive to produce renewable electricity comes from the Renewables Obligation, where electricity suppliers must obtain a specified and increasing proportion of their electricity from renewable sources. The Government has confirmed that the Renewables Obligation will continue up to 2037, providing long-term certainty about this source of revenue for renewable generators.

Legislation to introduce banding to the Renewables Obligation Certificate system (ROC) has been introduced as part of the Renewables Obligation Order 2009, which will revise the terms of the ROC and the Renewables Obligation (RO), setting new targets for electricity suppliers. The banding of ROCs will see different levels of support on offer for different technologies, with less-developed technologies eligible to sell more ROCs per MWh of power generated. For example, from April 2009, CHP plants fuelled by biomass will receive two Renewable Obligation Certificates (ROCs) for each megawatt hour of electricity, compared to 1.5 ROCs for biomass power-only plants

9.7 Land values

The extent to which additional build cost for developers can be factored into the price paid for the land can be a vital issue affecting viability. The higher the proportion of extra build cost that can be compensated within the initial land value, the less burden placed on developers, and the less risk of additional costs being passed on to the building end-user.

A study making up part of the evidence base behind the South West RSS suggests that:

> "*the impact of extra build costs of up to 15% for city infill and market town developments may potentially be accommodated by a reduction in land value of*

[27] http://www.communities.gov.uk/publications/planningandbuilding/communityinfrastructurelevy

> *10-15%. Discussion with stakeholders suggested that this would be a reasonable limit for reduced land value. For large urban extensions, an additional build cost of 10% would require the same 10-15% reduction in land value. However, the figures for a market town development in Cornwall suggest that an extra build cost of 5% might be a more appropriate limit to what could be absorbed by land value in that location."*[28]

The study also flags the importance of ensuring that the pressure on land values does not significantly impact on the quantity of land being brought forward for development, potentially jeopardizing the ability to meet wider housing targets.

10 Potential benefits of policy scenarios

The main beneficial environmental impact of the policy scenarios is the displacement of fossil fuels, which leads to a reduction in CO_2 emissions. The modelled scenarios applied to future residential development indicate that Scenario 1 would result in an overall emissions reduction of nearly 20,000 tonnes per year by 2026 compared to Part L 2006 standards. Savings for Scenario 2 for the equivalent period are estimated to be around 29,000 tonnes per year. However, when taken as net emissions i.e. factoring in the additional emissions resulting from new development, the change on Bristol's total citywide emissions is small – around 0.1% increase for Scenario 2 compared with a 0.5% increase for Scenario 1. This highlights the importance of exploiting Bristol's sustainable resources in other areas alongside new development, such as CHP and district heating for all development in Heat Priority Areas, where potential savings on citywide emissions are in the order of 45%.

The local economic benefits resulting from implementation of the policies will potentially include revenue and employment from building and operating large energy plant, supplying and installing micro-renewables and supplying and installing energy efficiency measures. Although a significant proportion of the materials and equipment is likely to be sourced remotely, a local skills base of installers and operators (in the case of larger scale plant) could easily be established.

Implementation of the policies will also benefit other industries through direct and indirect multiplier effects. The economic benefits of these, however, are difficult to quantify due to the range of industry types potentially involved. Biomass, for example, may involve supply chains involving the forestry sector, waste contractors, joineries, etc in relation to fuel supply. The uncertainty of the multiplier effects, such as the increased expenditure in the local area of people involved with the project, also adds to the complexity.

One of the main social benefits resulting from a decentralised low carbon energy supply is the reduction in energy costs for building occupants and owners. The risk of fuel poverty will diminish if households are supplied with cheaper locally-generated renewable heat or electricity, and community-use buildings can potentially lower their running costs, which may free up resources to benefit the users in other ways.

The availability of a secure, cheap source of energy sourced from innovative low carbon technologies may also act as an incentive to businesses interested in locating to or investing in the area, which will also boost the local economy. This is particularly relevant to the Bristol Environmental Technologies and Services (BETS) project, which was set up in 2006 to support the growth of a vibrant Environmental Technologies and Services sector in the Bristol City Region. In this way, clusters of these types of businesses could be located alongside sustainable energy installations to support further development of the industry.

[28] *Supporting and delivering zero carbon development in the South West*, Faber Maunsell and Peter Capener, Jan 2007

11 Conclusions

11.1 Policy review

The review of sustainable energy planning at national policy level (Section 3) revealed that there are now a number of requirements imposed on local authorities to take increased action through the local planning system, and provide greater opportunities to make best use of local resources to maximise sustainable energy implementation.

The Government is committed to a set of challenging sustainable energy policies including a significant tightening of Building Regulations over time. There is increasing evidence to suggest that forward thinking policies at the local level are now being successfully implemented in response to these proposals, although it is still too early to gauge the full implications of what these policies will mean in practice. Nevertheless, Bristol now has an opportunity to build on this evidence and identify where it can formulate policies that go beyond prevailing Building Regulation standards.

Alongside overall standards for carbon reduction, an on-site generation policy in conjunction with an appropriate energy supply hierarchy should set a logical approach for developers to adopt in low carbon design. An on-site generation policy will strongly encourage developers to firstly reduce demand by maximising energy efficiency in order to reduce the proportional contribution from generally more costly renewable technologies, but will also serve to stimulate the local skills market and supply chains for the renewable energy sector.

11.2 Resource assessment

Table 25 below summarises Bristol's local potential sustainable energy resources, which include wind, biomass, waste, sewage gas and solar technologies. Also shown are figures for existing sustainable generation plant. It can be seen that fully exploiting local resources – including energy recovery from all municipal solid waste (MSW) - a reduction of around 20% of Bristol's total CO_2 emissions in 2006/7 could potentially be achieved. However if MSW is excluded, the total falls considerably, to around 4%. These figures represent the maximum that could theoretically be achieved. In addition some or all of the waste resource should be considered to as an input to district heating, which would also require significant non-local fuel inputs.

Although resources from outside Bristol, such as biomass and natural gas for CHP, would be expected to add to the overall resource, this analysis highlights scale of the challenge presented by the Government's national target of an 80% emissions reduction over 1990 levels. The significant shortfall will have to be addressed by measures including absolute demand reduction through behaviour change, increased energy efficiency in existing buildings, low carbon transport measures, and decarbonising the national grid.

Table 25: Summary of resource assessment*

	Capacity [MW]	Carbon saving [tonnes CO_2/yr]	% of citywide CO_2 emissions (2006 figures)
Local sustainable electricity resource excluding waste	102	88,072	3.8
Electricity from waste: CHP	45	201,101	8.7
Local sustainable heat resource *excluding* waste	84	20,614	0.9
Heat from waste: assuming CHP into DH network	90	145,854	3.6
Existing installations (incl. in above figures above)	*(23.9)*	*(49,787)*	*(2.2)*
Biomass heat via DH (non-local resource)	1,080	524,660	17
Biomass electricity: CHP into DH network (non-local resource)	360	507,644	16

*There is some overlap between the electricity and heat resource for solar technology, and so the total resource is lower than the sum of the electricity resource plus the heat resource. The total here excludes 74MW of solar water heating and includes 74MW of solar PV. Also note that waste would be an input to district heating, hence their carbon savings should not be added together.

The resource assessment presented in this report provides a citywide view of the local potential for sustainable energy supply in Bristol. This assessment is a desk-based study based on second hand data: the project team collected no new local data during the study. The advantage of this is that the whole city can be studied using a consistent methodology, in one project. The disadvantage is that for a given location, data from a citywide assessment is likely to be less accurate than that collected locally for a site-specific resource assessment.

One example of this is that the assessment may underestimate commercial heat demand in Avonmouth, due to a lack of detailed information regarding specific building use types (calculation of total heat demand is not affected by this issue). Another is that the wind resource assessment relies on the NOABL windspeed dataset for the UK, which is known to overestimate windspeeds, particularly in urban areas.

In both these cases, detailed local data may be available – for example Bristol City Council holds locally measured windspeed data for the Avonmouth area, and the BETS team is collecting building-specific heat demand data for the same area.

11.3 Potential for sustainable energy supply on new development

Table 26 summarises the heat and electricity sustainable generation capacities and resulting emission savings for Scenarios 1 and 2 as modelled on the proposed new residential development for Bristol (147 sites with SHLAA or Urban Extension status, totalling 16,250 dwellings). The resulting savings relative to Bristol's overall emissions are small, which serves to illustrate the dominance of existing development in terms of emission sources.

Table 26: Carbon impacts of new residential development

	Generation capacity [MW]		Gross emissions, Part L 2006 standards	Scenario emissions from new development before adding renewables	Emissions savings from renewables [tonnes CO_2/yr]	Net emissions from new development	Net scenario increase in emissions, as proportion of 2006/7 [%]	Net increase @Part L 2006 Standards
	Electricity	Heat						
Scenario 1 (multiphase)	12.1	13.9	36,248	31,256	13,083.38	18,172.68	0.8%	1.6%
Scenario 2 (multiphase)	25.4	17.4			23,388.08	7,867.67	0.35%	

The capacities indicated are made up of various combinations of biomass heat/CHP with district heating, and solar PV, as these technologies have been shown to be the least cost options for the targets modelled in both Scenarios. The analysis indicates that, again on a least-cost basis, photovoltaics will be dominant in meeting the lower targets proposed for earlier phases, but that biomass heating and CHP/CCHP will dominate for the higher targets in later phases. However, early establishment of Heat Priority Areas will encourage the latter technologies to be deployed from the outset, with lower resulting carbon emissions.

11.4 Heat Priority Areas and district heating

An analysis of existing heat loads in Bristol alongside those expected from new development has led to the identification of Heat Priority Areas, in which conditions are likely to favour larger scale, more economic and effective forms of sustainable energy generation such as CHP with district heating (and/or cooling).

The combined Heat Priority Area identified for Bristol captures around 70% of total heat demand in 45% of the city area, as shown in Table 27. If this heat demand were supplied from biomass fuel, offsetting natural gas, the resulting emission savings would be the equivalent of almost 25% of Bristol's citywide emissions.

Table 27: Heat demands within Bristol showing Heat Priority Areas

	% of area	Heat demand (GWh/year)	% of total heat demand	Potential emission savings if demand met using bioheat or gas CHP (tonnes CO_2/yr)	% of citywide emissions
Bristol City area	100	4,024	100	–	–
Area within Heat Priority Area	45	2,836	70	524,660	23
Area outside Heat Priority Area	55	1,188	30	–	–

Additional carbon savings would be achieved if the heat was produced in biomass CHP plant(s) – assuming the use of steam turbine technology, around 1,000 GWh of zero carbon electricity would be generated along with the heat. This could save around 500,000 tonnes of CO_2 by offsetting electricity supplied from the national grid – equivalent to a further 22% reduction in Bristol's citywide emissions. However, the above would require a very large supply of biomass fuel – equivalent to over 700,000 tonnes per year, which would clearly have to be procured from non-local sources.

This highlights the importance of exploiting Bristol's sustainable resources in other areas alongside new development, such as CHP and district heating for all development in Heat Priority Areas, where the maximum theoretical reduction on citywide emissions is in the order of 45%, assuming the use of biomass CHP (see Figure 34 below). Bristol's significant waste resource could provide a major contribution towards this figure but should also be considered alongside the woodfuel resource in the local area and gas-fired CHP, which can also offer significant savings compared to other fossil fuels.

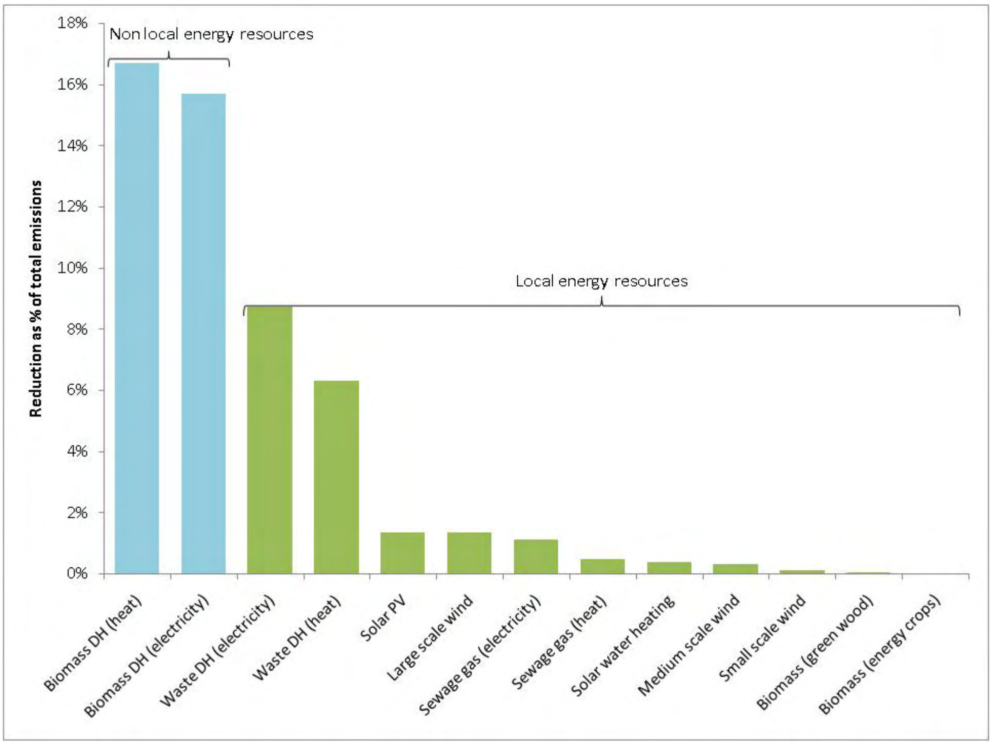


Figure 34: Summary of resources ranked by potential savings compared to citywide emissions (including biomass CHP with district heating)

Although not in the main Heat Priority Area, Avonmouth's good transport links and industrial landscape may also make this area appropriate for the development of other large scale low or zero carbon generation plant such as CHP/CCHP, especially if a sufficient local demand for heating and/or cooling is identified. Avonmouth is already known as having potential for large scale wind power (in addition to the existing turbines) and the resource assessment has recognised this. The availability in Avonmouth and other areas of a secure, cheap source of energy sourced from innovative low carbon technologies could potentially attract clusters of businesses from the environmental technologies and services sector to support further development of the industry, which is one of the aims of the Bristol Environmental Technologies and Services (BETS) project.

11.5 Viability of targets for new development

Targets proposed through future Building Regulation changes will impose additional build costs on new developments, which will need to incorporate a range of low or zero carbon energy measures to meet the targets. The analysis undertaken on new residential development (SHLAA sites) proposed in Bristol suggests additional costs, for Scenarios 1 and 2, of 17% and 24% respectively. It was also suggested that the additional 7% cost between these Scenarios may result in a further 28% of emissions reduction - this translates into an extra 10,000 tonnes CO_2 saved per year.

Additional costs associated with the Code for Sustainable Homes are well-documented in theory, although have yet to be fully tested in practice. There is a significant step-change in cost in achieving Code level 6 over level 5, although it is likely that the definition of Code level 6 will change following the Government's consultation on zero carbon homes and buildings. Additional costs resulting from BREEAM standards on non-residential development are much less defined.

A range of existing and emerging institutional and financial mechanisms can assist in the successful delivery of carbon reduction targets. Management and operation of district heating systems will need tailored arrangements such as the formation of an Energy Service Company (ESCo). Although no standard 'model' currently exists for ESCos, there are increasing numbers now being established for a variety of applications.

An essential element of forthcoming national policy is very likely to consist of a set of ‘allowable solutions’ which are currently being proposed by the Government to be implemented alongside the 2016 zero carbon homes target, to be offered to developers where zero carbon development cannot be achieved solely through on-site measures or by directly connected heat. In these cases residual emissions may be addressed through a range of off-site measures. Opportunities therefore exist for Bristol to introduce locally tailored allowable solutions in advance of Building Regulations, which could include off-site contributions for local district heating infrastructure.

12 Recommendations

12.1 Policy recommendations

The following recommendations are made regarding the development of Bristol’s LDF Core Strategy policies on sustainable energy:

Overarching statement on climate change

To justify and contextualise the development specific policies, an overarching statement should be considered at the outset focused on climate change, CO_2 reduction targets and renewable and low carbon energy targets. An overall greenhouse gas reduction target of 80% by 2050 is recommended, in line with the latest UK policy. Citywide targets for renewable and low carbon energy technologies and how they may relate to an appropriate trajectory of CO_2 reduction towards the 2050 target should be the subject of further study and consultation. These should be informed by the results of the renewable energy resource assessment presented in this report.

Site sustainable energy policies

A low carbon energy policy for new residential developments should be included, which sets increasing standards for CO2 reduction in stepped phases up to 2026. The two scenarios tested in this report will offer a range of CO2 savings and the Council’s perception of ‘undue burden’ on developers of the additional cost of low carbon measures will largely dictate which scenarios to take forward.

The evidence presented in this report suggests that for an additional 7% increase in development cost between the two Scenarios, there would be a further 28% reduction in emissions from new development, and for this reason the authors recommend that Scenario 2 should be given preference over Scenario 1. However, implementation of either option must involve a degree of flexibility by including an appropriate viability clause to permit a range of ‘allowable solutions’ to be available to developers where targets can be shown to be unfeasible. In line with Government guidelines, targets should be set using the Code for Sustainable Homes rather than any other criteria, although it should be clear whether the requirement refers to the CO_2 emission standards in the Code, or to the whole scope of the Code.

Similar stepped targets should be set for non-residential development, but in terms of BREEAM standards. These targets should be equally challenging, but should be subject to review once the outcomes from the Government’s consultation on the Code for Sustainable Buildings are known.

Experience from London strongly suggests that policies should include: (1) an explicit energy hierarchy; (2) a requirement for a Site Energy Strategy/Sustainability Statement to accompany development proposals; (3) an on-site renewable energy target; (4) a heating and cooling hierarchy, and (5) explicit clauses to address feasibility and viability issues.

Consistent with the above recommendation, an on-site renewables policy for new developments should be included. The findings of this study suggest that an on-site renewables policy requiring

20% CO_2 emissions applied to total residual emissions after the inclusion of energy efficiency, CHP and communal heating measures is appropriate.

Further consideration should be given to material to be included within Development Control DPDs, such as detailed criteria-based policies, additional details on the required structure and content of Site Energy Strategies submitted as part of a Sustainability Statement accompanying planning applications, and details on any ‘allowable solutions’ offered to developers. These should include increased flexibility to encourage the development of district heating in the Heat Priority Areas.
All targets and standards should be revised and updated periodically as national policy, sustainability best practice and low and zero carbon technologies develop.

Sustainable energy projects
There is a case for a policy setting out a vision for sustainable energy and including key specific projects – heat networks, larger scale renewables, new build applications and retro-fitting. To support this, site and area specific proposals for sustainable energy should be added to the proposed policies and supporting text. These should include reference to identification of ‘Heat Priority Areas’ as described in this report, where district heating using CHP/CCHP as part of a citywide network is likely to offer opportunities to set higher standards in an earlier phases and so should be encouraged/required.

Sustainable design and construction
Although the focus of this study concerns sustainable energy, the broader scope of environmental benefits resulting from sustainable design and construction also needs to be considered. Areas such as water use, the life cycle of materials, biodiversity, waste recycling and sustainable drainage systems are covered within the Code for Sustainable Homes and BREEAM, so unless otherwise specified, the use of these standards to express CO2 emissions targets will also imply certain standards for other aspects of sustainable design and construction.

It is recommended that a policy on sustainable design and construction is expressed using these standards alongside a general checklist to highlight the main areas of focus. The viability of Code level 6 should be reviewed following the Government’s consultation on the definition of zero carbon homes.

12.2 General recommendations

Energy strategy priorities
Bristol City Council should focus its energy strategy on developing the key resources of waste and biomass (woodfuel) to supply larger scale heat or CHP/CCHP plants serving what should ultimately be a citywide district heat network in the city’s Heat Priority Areas. These resources, and to a lesser extent gas-fired CHP, have the potential to play a key role in meeting the challenging targets up to and beyond 2016, and could be instrumental in achieving substantial citywide emissions reduction targets in line with those recommended above. As an urban area, Bristol’s woodfuel resource is constrained and it should therefore build on existing experience in sourcing woodfuel and encourage the development of local fuel supply chains from outside the city.

Bristol City Council as delivery partner

The strategic position within the community held by Bristol City Council provides an opportunity to facilitate multi-sector partnerships – especially for large scale mixed-use developments, where renewable energy infrastructure may be shared, or where Energy Service Companies (ESCos) may be involved to potentially reduce the additional capital cost burden.

Bristol City Council forms part of the West of England group of local authorities and hence should consider working alongside North Somerset Council, South Gloucestershire Council and Bath and North East Somerset Council in regard of opportunities for sustainable energy. This is already occurring with waste management through the identification of sites incorporating energy recovery from waste but could also include assessing the opportunities for biomass supply chains and sustainable energy supply strategies for cross-boundary urban extensions

Avonmouth

Due to its predominantly industrial land use and excellent transport connections, the Avonmouth area holds significant potential for large scale low or zero carbon energy generation such as wind and biomass plant. A more detailed local study on building energy use in the area and local heat and power demands is suggested to evaluate the potential for CHP/CCHP plant possibly powered by biomass. It is unlikely that connection to City Centre heat loads would be economic in the short term, although this could emerge in the longer term as a citywide heat network develops. Avonmouth's wind power resource should continue to be developed as far as possible.

District Heating

A strategic planning study on a citywide heat distribution network should be undertaken as soon as possible. The initial phase of a network is likely to be kick-started by a major new development with opportunities for a CHP/CCHP plant site – such as the proposed redevelopment of Southmead Hospital - and should also involve the provision of heat to nearby existing development, most likely within the Heat Priority Area. The study should also assess operational and delivery issues and the potential for ESCo partnerships, learning lessons from recent experience and current practice in London, where the London Development Agency is setting an ambitious agenda for the development of 'Energy Masterplans' for all London boroughs.

Annex A– Extract of modelling results from *Definition of Zero Carbon Homes and Buildings: Consultation* (DCLG, Dec 2008)

The following table has been compiled from Annex E of the above document, which presents a series of technology combinations modelled by Cyril Sweett/Faber Maunsell to achieve a range of carbon reduction targets on homes. Shown here are four dwelling types modelled within an 'urban regeneration' scenario, which assumes a development of 750 dwellings with an overall average density of 160 dwellings per hectare. The combinations shown below represent the least-cost combinations modelled in achieving each target reduction, apart from the 'Zero C' target (100% reduction on total emissions) where the modelled combination which achieved the highest CO_2 savings has been selected.

	Target CO2 reduction (% 2006 TER)	Carbon reduction (vs Part L 2006)	Residual CO2 - elec (tpa)	Residual CO2 - other (tpa)	total residual CO2 (tpa)	Capital cost premium	Base build cost (2006)
Urban Regeneration - flat							
PV + BPEE	25%	27%	0.81	1.15	1.96	£3,392	£73,611
Biomass heating 80% + BPEE	44%	68%	0.84	0.55	1.38	£4,938	£73,611
Biomass heating 80% + PV + BPEE	70%	81%	0.66	0.55	1.21	£6,592	£73,611
Biomass CHP 80% + BPEE	100%	118%	0.02	0.68	0.7	£7,916	£73,611
Biomass CHP 80% + PV + BPEE	Zero C	152%	-0.46	0.68	0.22	£12,566	£73,611
Urban Regeneration - mid-terrace							
PV + BPEE	25%	26%	1.02	1.23	2.25	£4,977	£65,825
Biomass heating 80% + BPEE	44%	67%	1.04	0.59	1.62	£6,264	£65,825
Biomass heating 80% + PV + BPEE	70%	79%	0.86	0.59	1.44	£8,330	£65,825
Biomass CHP 80% + BPEE	100%	116%	0.16	0.73	0.88	£9,471	£65,825
Biomass CHP 80% + PV + BPEE	Zero C	173%	-0.73	0.73	0	£18,499	£65,825
Urban Regeneration - end-terrace							
PV + BPEE	25%	26%	1.04	1.34	2.38	£5,063	£71,816
Biomass heating 80% + BPEE	44%	68%	1.04	0.63	1.66	£6,993	£71,816
Biomass heating 80% + PV + BPEE	70%	79%	0.86	0.63	1.49	£9,043	£71,816
Biomass CHP 80% + BPEE	100%	117%	0.05	0.78	0.83	£10,695	£71,816
Biomass CHP 80% + PV + BPEE	Zero C	166%	-0.78	0.78	0	£19,231	£71,816
Urban Regeneration - detached							
PV + BPEE	25%	25%	1.28	1.77	3.04	£5,964	£94,255
Biomass heating 80% + BPEE	44%	68%	1.24	0.79	2.03	£9,065	£94,255
Biomass heating 80% + PV + BPEE	70%	76%	1.06	0.79	1.85	£11,069	£94,255
Biomass CHP 80% + BPEE	100%	118%	-0.13	1	0.87	£14,205	£94,255
Biomass CHP 80% + PV + BPEE	Zero C	155%	-1	1	0	£23,131	£94,255

PV = photovoltaics

BPEE = Best Practice Energy Efficiency

Biomass heating 80% = 80% of heat load supplied by biomass heating plant

Biomass CHP 80% = 80% of heat load supplied by biomass heating plant

Annex B – Key elements for effective energy planning policy

Summarised below are five key elements which should be combined to provide an effective approach to energy planning policy development. It is strongly suggested that these elements be combined in the policy text itself, as opposed to relying on the supporting text, or supplementary planning documents etc. This is because experience has indicated that all five elements are important, and they need to be applied coherently as a whole. Placing some of the material in supporting text/documents, and some in the policy text itself means that they will not be given equal weight by either developers, development control officers, or planning inspectors, and this will weaken their overall effect.

1. Explicit Energy Hierarchy

An Energy Hierarchy is a simple conceptual tool which can be used as an organising and justifying principle in energy policy development, including in the context of planning policy. The hierarchy states the priority order to be adopted when matching energy demand with supply:

1. apply energy efficiency measures to reduce demand as far as possible
2. meet the reduced demand with as much renewable energy as is practical,
3. meet any residual demand using the lowest carbon non-renewable energy sources

Following this hierarchy ensures that the lowest-carbon outcomes are achieved in a given context. It is of course important to note that in real-world situations (such as planning negotiations), the cost and practicality of measures in these three categories will have a significant bearing on the outcome.

2. Requirement for a Site Energy Strategy

Requiring a description of the energy and carbon impacts of proposed development and how they have been minimised forces developers to consider in detail the energy performance of their proposals. Importantly, it also makes this consideration a formal part of the planning application itself. The analysis needed for a Site Energy Strategy which may be part of, or separate to a 'Sustainability Statement' is also a pre-requisite for following the energy hierarchy described above, and for calculating the capacity of renewable energy required to meet an on-site renewables target.

(1) The Site Energy Strategy should set out a calculation of the projected heat and power demands in kWh from the proposed development assuming it was built to a baseline standard equivalent to Part L 2006 Building Regulations. It should then explain how these demands have been reduced through the inclusion of specific energy efficiency measures.

(2) Next the Strategy should demonstrate how the carbon intensity of the heat and power supply to the development has been reduced through efficient supply technologies such as communal/district heating, and combined heat and power. The projected residual emissions from the proposed development can now be calculated by subtracting the carbon savings achieved via energy efficiency, CHP and communal heating, from the baseline emissions set out in step (1) above.

(3) Finally, the proposed on-site renewable energy technologies should be described, and the resulting percentage reduction in residual emissions calculated. This value is then assessed against any on-site renewable energy target in effect.

Note that this approach reverses the second and third steps of the Energy Hierarchy. This is because on-site renewable energy targets are assessed against a proposed development's emissions after the inclusion of energy efficiency, CHP and community heating.

3. On-site renewable energy target

On-site renewable energy targets should be expressed as a requirement to reduce site emissions by (at least) a certain proportion, after the inclusion energy efficiency, CHP and communal heating. Setting the target in terms of carbon emissions (rather than energy consumption) avoids the problem of over-valuing heat supply technologies relative to electricity producing renewables.

When structured in this way, on-site renewables targets achieve two distinct ends. Firstly, they incentivise the developer to maximise the emissions reductions achieved through energy efficiency, CHP and communal heating systems. This is because the lower the projected residual site emissions are, the smaller the capacity of renewables required to meet a given target. In this context, increased investment in energy efficiency can reduce overall costs. Secondly, the renewable energy capacity directly reduces site emissions, again contributing to energy policy objectives.

4. Heating and Cooling Hierarchy

There are two important reasons why the heating systems installed in new developments are significant enough to warrant specific attention in planning policy.

Firstly, space and water heating contributes around 40-50% of total carbon emissions from new buildings, and there are significant carbon savings available by using more efficient and/or low carbon heating systems.

Secondly, in urban areas, large scale heat distribution has a key role to play in reducing emissions both from new and existing buildings. New development can facilitate both the creation and extension of heat distribution networks – either through the installation of a new site-wide heat network supplied from on-site heating plant, or by connecting as extensions to existing networks, thereby improving their economics and spatial coverage.

The specific heat source is independent of the need for a heat distribution network, which in and of itself will facilitate emissions reductions through allowing the use of larger scale (and hence more efficient) heat sources. In addition, heat networks have much longer lifetimes than the boiler plants that supply them – hence, over time a heat distribution network could facilitate a move from gas boilers, to combined heat and power, or biomass boilers, etc.

There is therefore an order of preference for heating systems in new developments, which embodies the issues discussed above – i.e. maximising the opportunities for large-scale heat distribution and minimising site emissions from heat consumption. Because emissions from existing buildings far exceed those from new development, it is appropriate to prioritise support for the creation of new/development of existing heat distribution networks. The following hierarchy takes this into account:

1. Connection to existing heat/cooling networks
2. Site wide renewable (C)CHP
3. Site wide gas-fired (C)CHP
4. Site wide renewable community heating/cooling
5. Site wide gas-fired community heating/cooling
6. Individual building renewable heating

Note that this hierarchy excludes electrical heating altogether. There are three very good reasons for doing this: (1) electrical heating is the most carbon intense way to heat space or water; (2) electrical heating is the most expensive way to heat space or water; and (3) it is extremely expensive to connect electrically heated buildings to a district heating network, because the entire heating system would need to be replaced with a ‘wet’ system. Because of this, no new buildings should be allowed to use electrical heating systems.

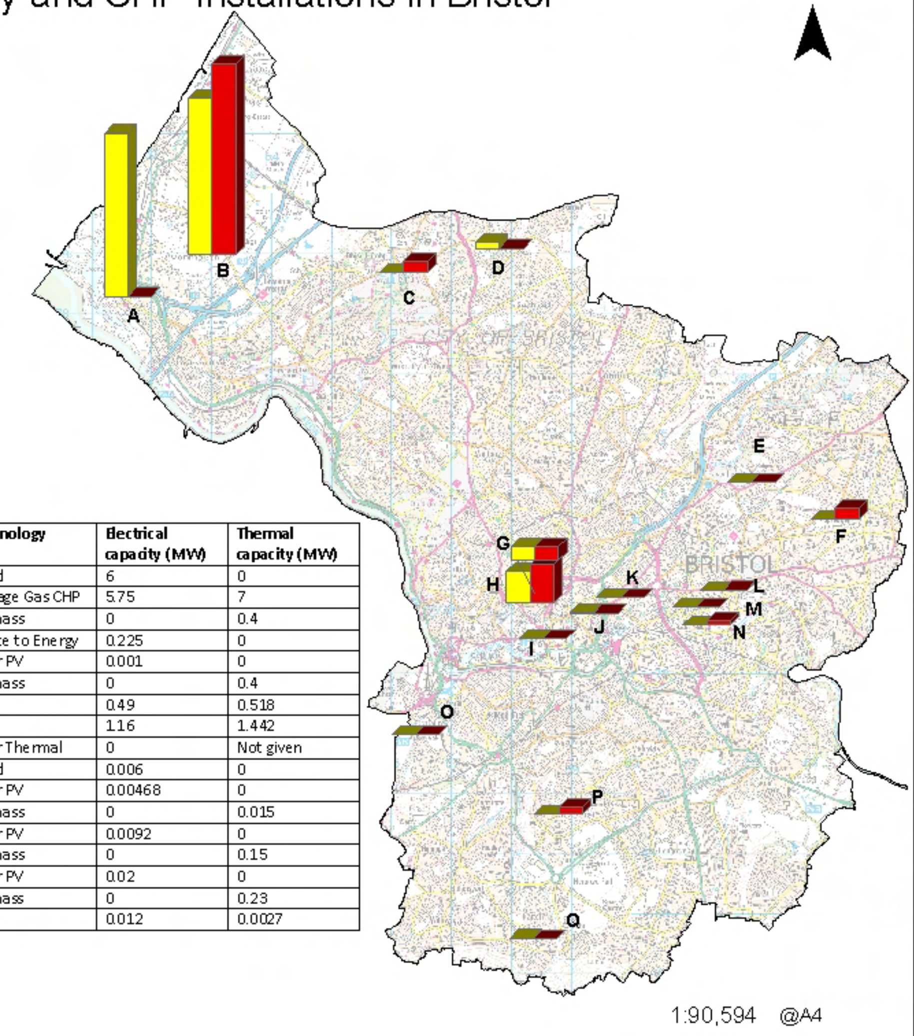
5. Feasibility

Planning decisions balance wide range of policy objectives, and even within the energy field, all targets won’t be achievable on all developments. It is essential that energy planning policies recognise this, by including the words ‘where feasible’ (or equivalent) within the policy text.

This compromise is required, because to neglect it is to implicitly state the opposite – clearly a policy containing or implying that targets should be met where it is unfeasible will not survive scrutiny. That said it is important to ensure that any compromise regarding the targets is on the planning authority’s terms. Where alternative options are set out in cases where targets cannot be met, they should be accompanied by a commitment to prepare SPD on how any such ‘allowable solutions’ will be decided upon.

Annex C – Full page maps

Renewable Energy and CHP Installations in Bristol



Code	Name	Technology	Electrical capacity (MW)	Thermal capacity (MW)
A	Avonmouth Dock	Wind	6	0
B	Avonmouth Sewage Treatment Works	Sewage Gas CHP	5.75	7
C	Blaise Nursery	Biomass	0	0.4
D	Compact Power	Waste to Energy	0.225	0
E	Residential building	Solar PV	0.001	0
F	BSF - Speedwell / Brunel	Biomass	0	0.4
G	University of Bristol Medical School	CHP	0.49	0.518
H	University of Bristol Chemistry School	CHP	1.16	1.442
I	Bordeaux Quay Restaurant	Solar Thermal	0	Not given
J	Colston Hall	Wind	0.006	0
K	Easton Customer Service Office	Solar PV	0.00468	0
L	Netham Sports Pavillion	Biomass	0	0.015
M	Barton Hill Healthy Living Centre	Solar PV	0.0092	0
N	Netham Recreation Ground	Biomass	0	0.15
O	Ashley Vale Action Group	Solar PV	0.02	0
P	Florence Brown School	Biomass	0	0.23
Q	Middleford House (BCC)	CHP	0.012	0.0027

BRISTOL SUSTAINABLE ENERGY SURVEY 2009

CSE on behalf of Bristol City Council

Legend

Electricity

Heat

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Centre for Sustainable Energy

Figure 5, Section 5

Existing renewable energy and CHP installations in Bristol

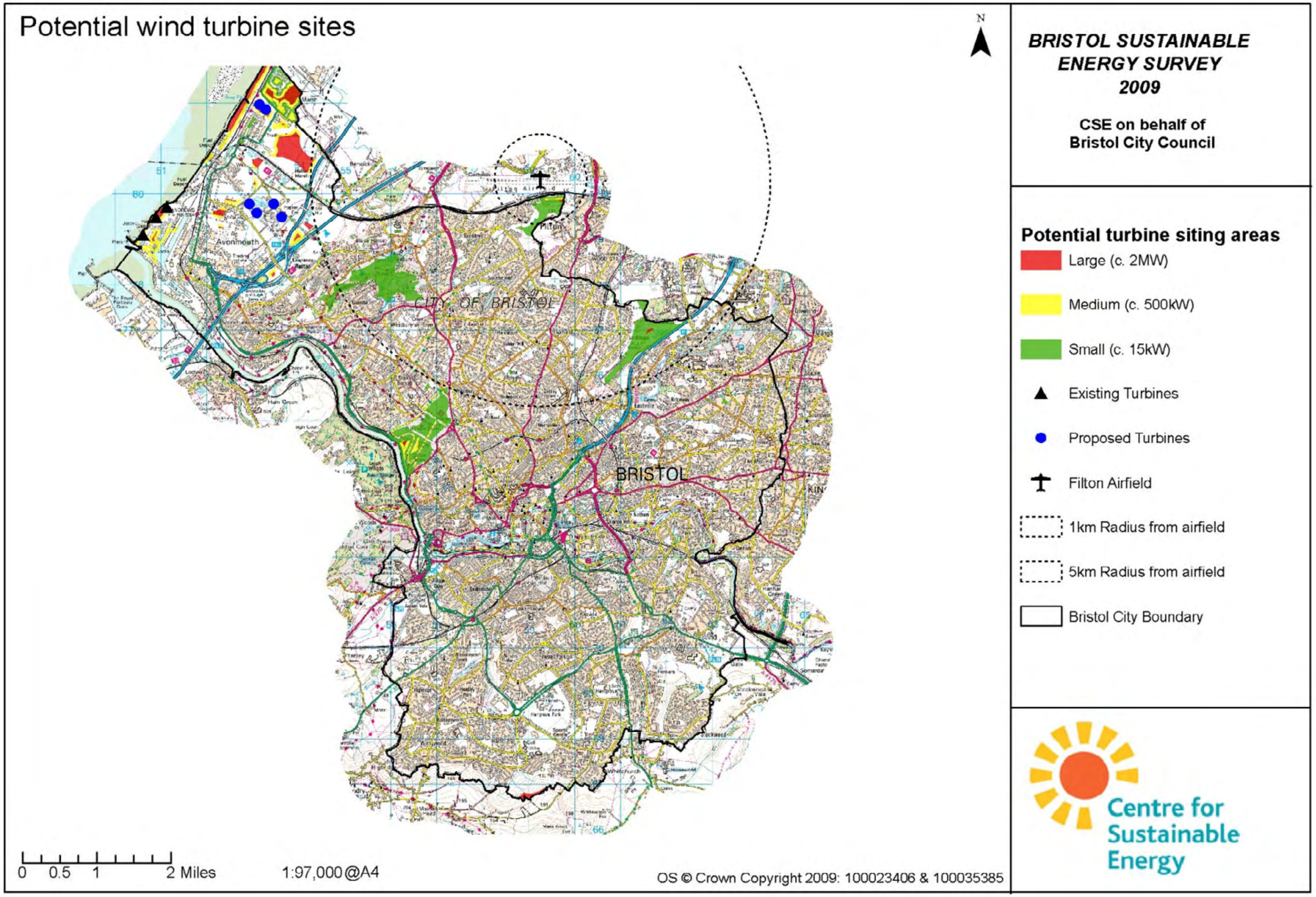

Figure 6
Section 5

Unconstrained sites for wind turbines

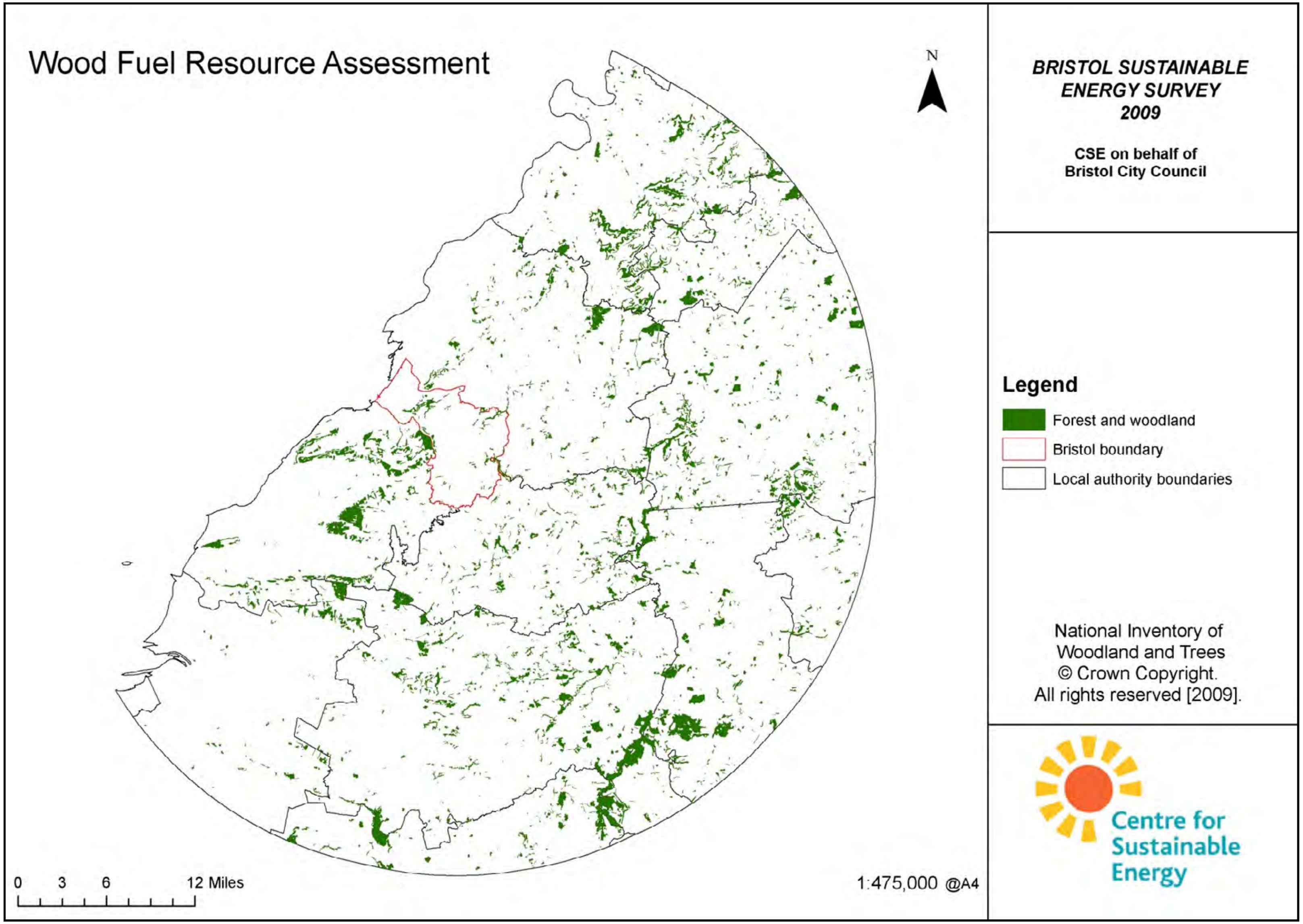

Figure 7
Section 5

Forest and woodland sites within 40km radius of Bristol

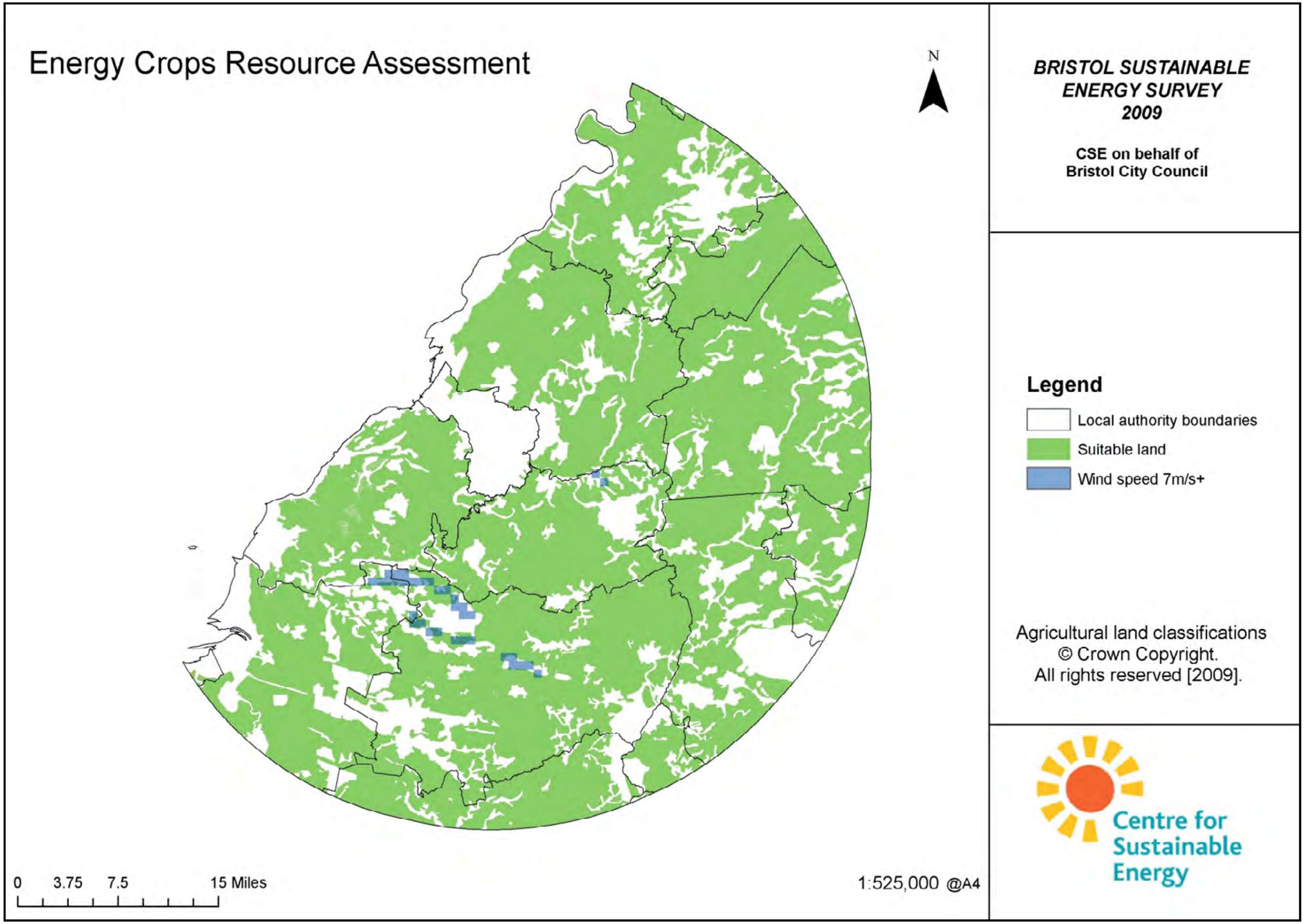

Figure 8
Section 5

Land with agricultural grades of 1,2 or 3 within 40km radius of Bristol

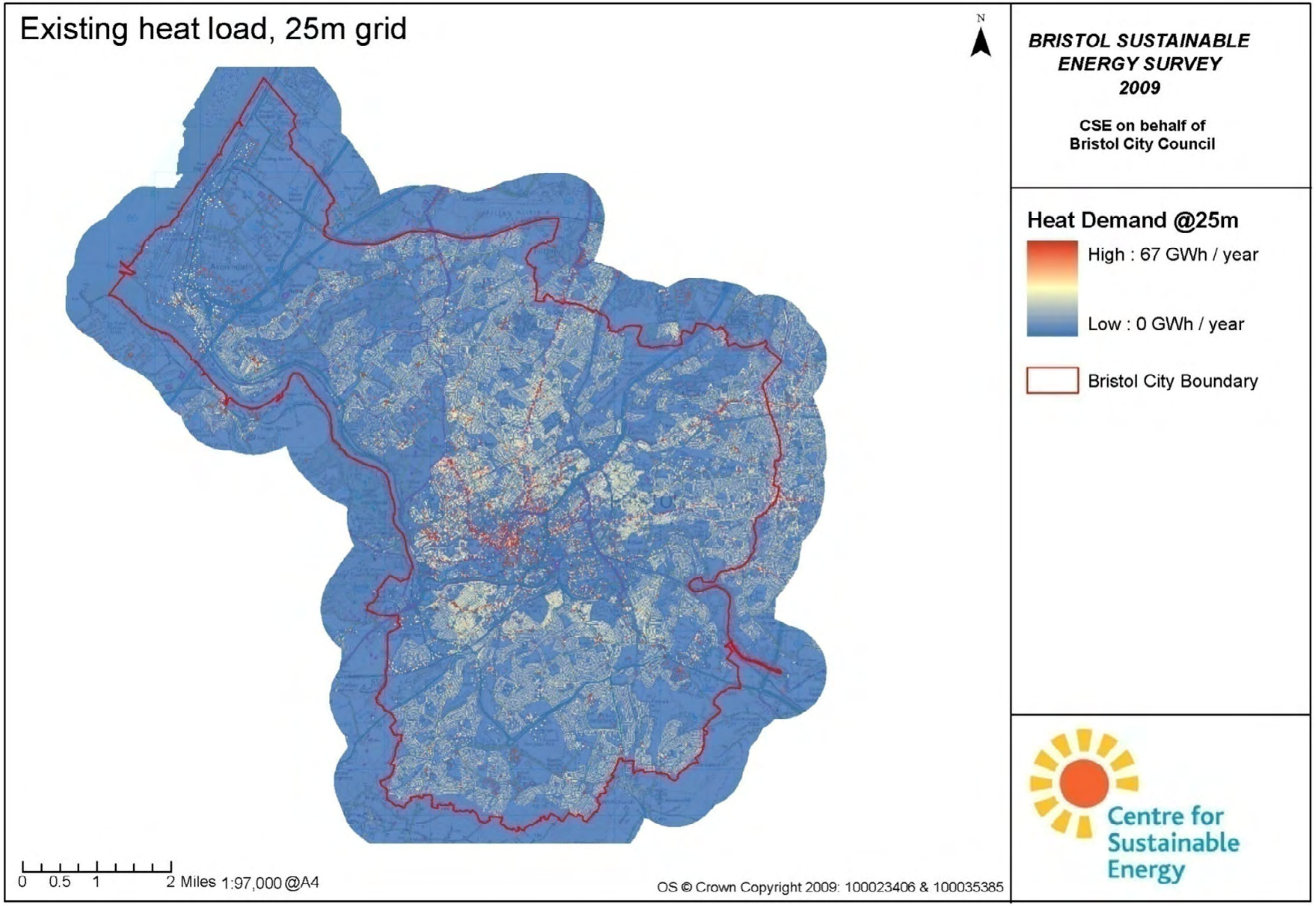

Figure 10
Section 7

Heat demand from existing buildings in Bristol (based on 25m grid)

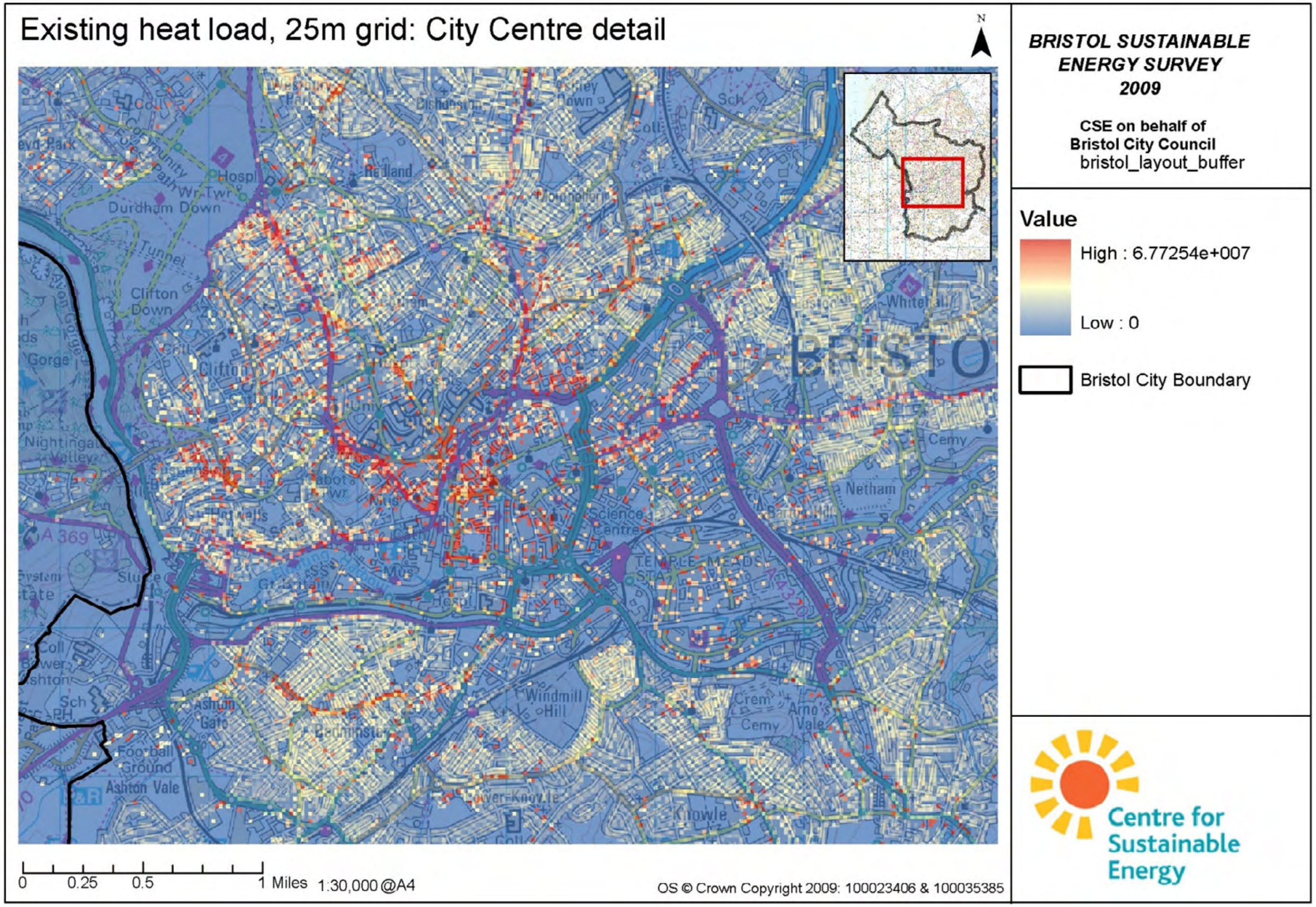

Figure 11
Section 7

Heat demand from existing buildings: City Centre Detail

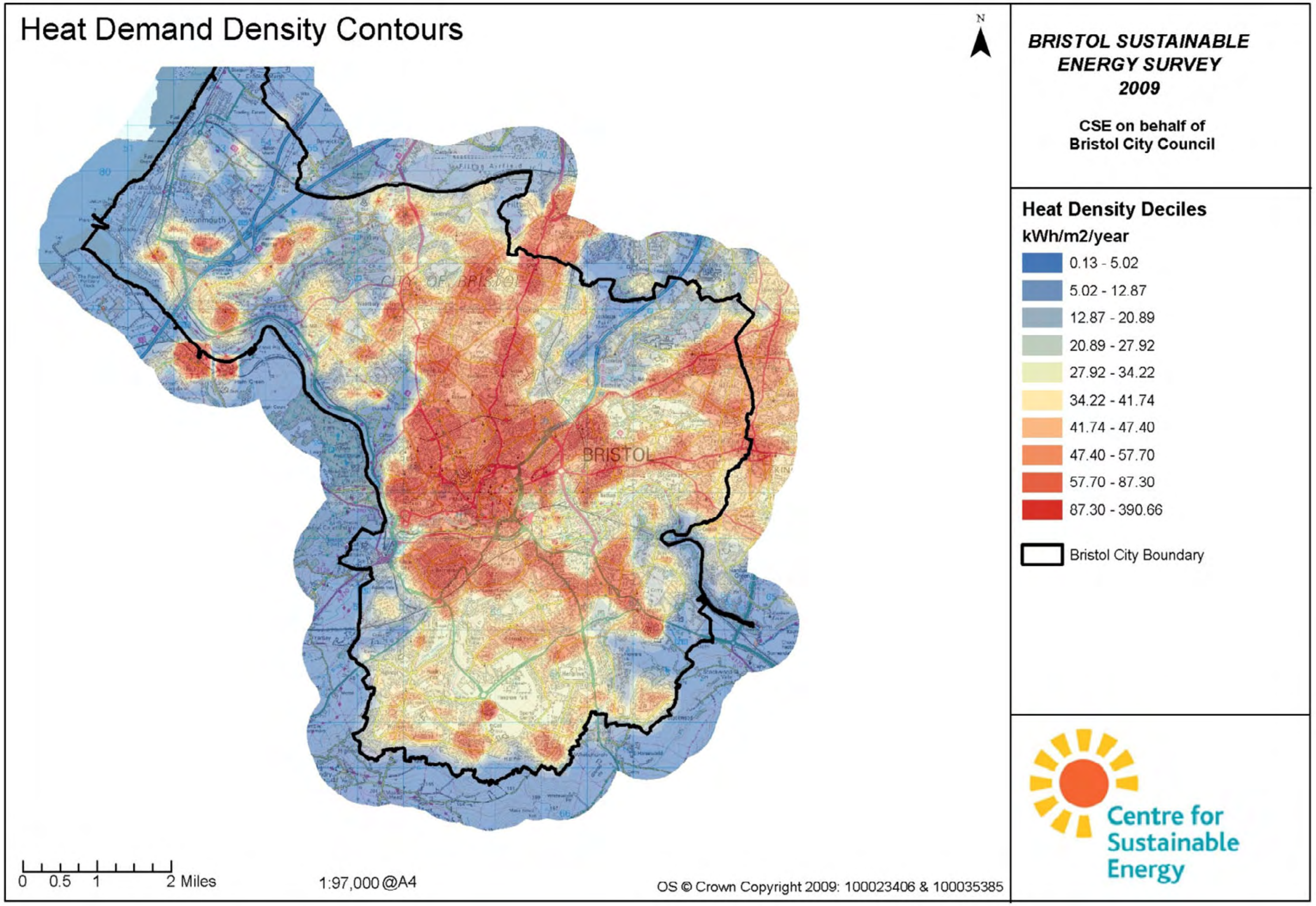

Figure 12
Section 7

Heat density contours for existing demand contours

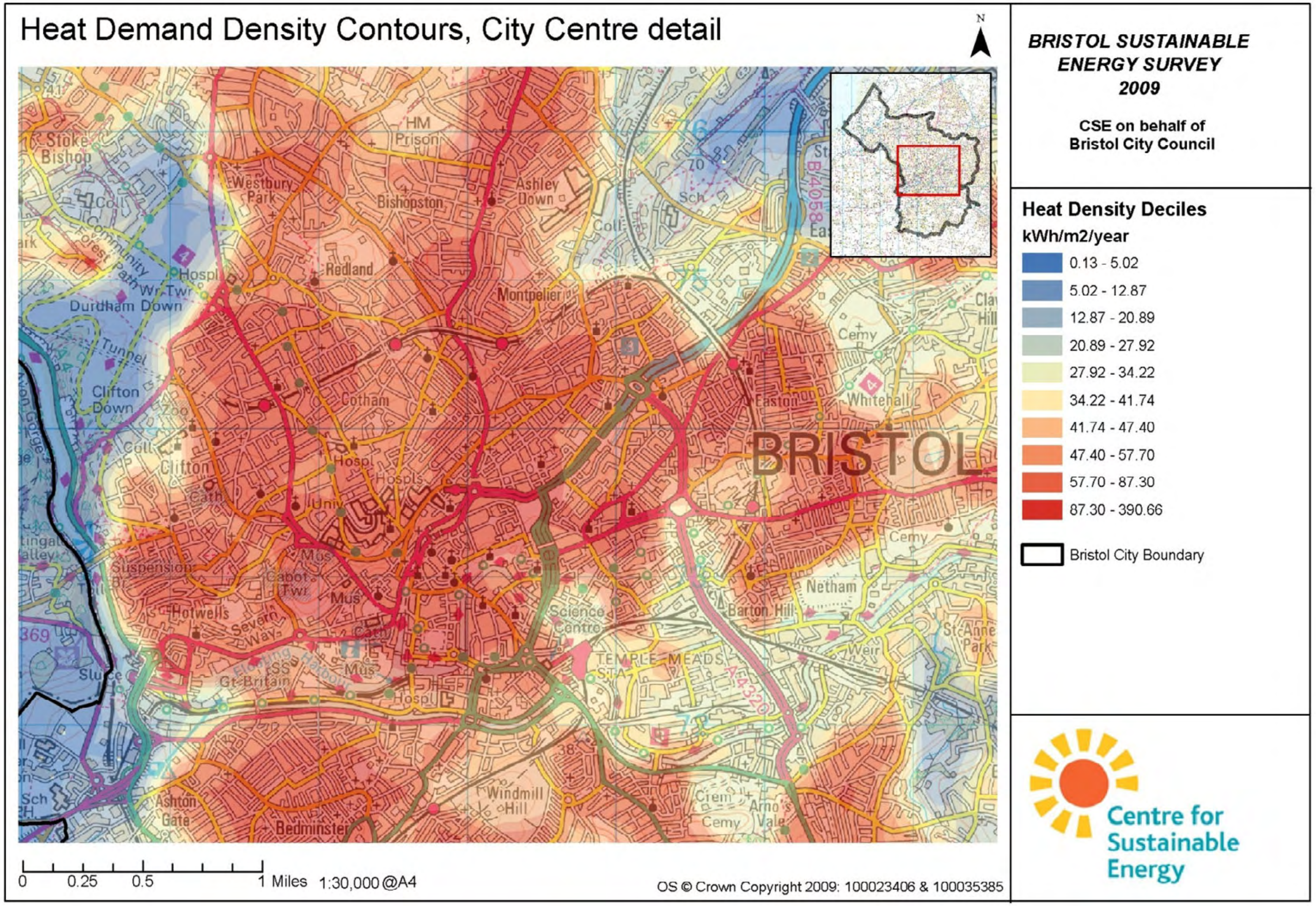

Figure 13
Section 7

Heat density contours for existing demand contours – City Centre detail

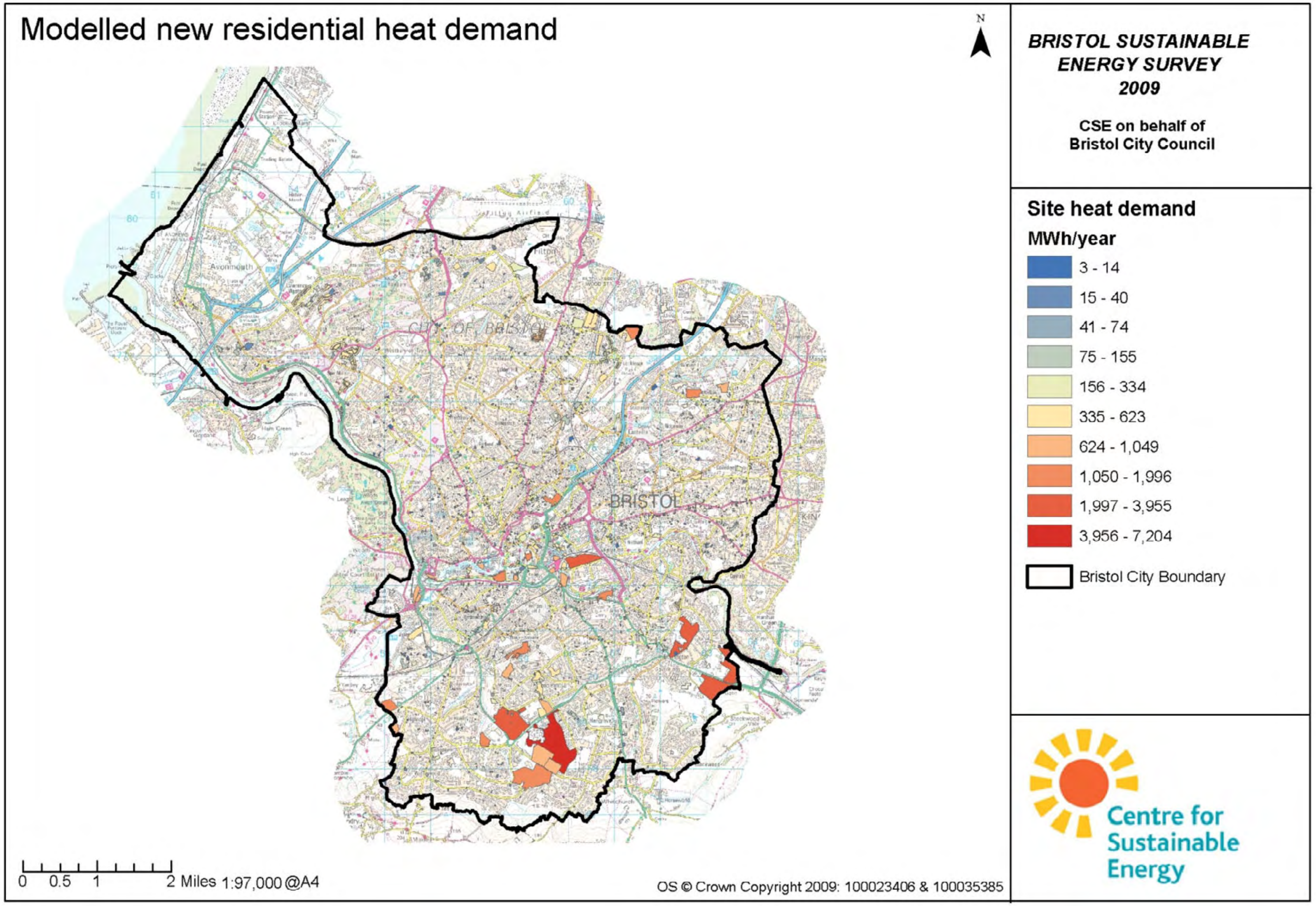

Figure 14
Section 7

Locations of Bristol SHLAA sites with modelled heat demands

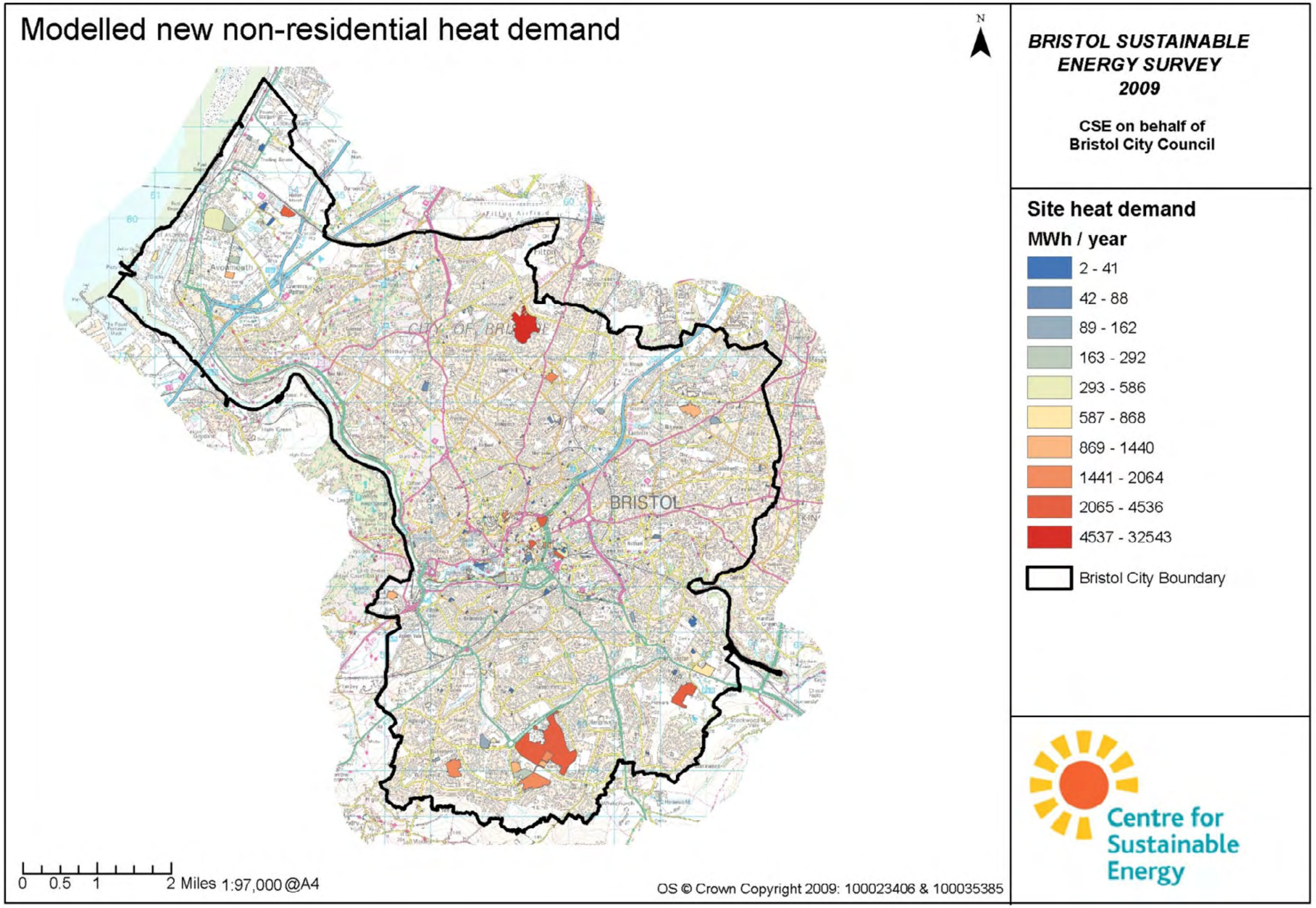

Figure 18
Section 7

Locations of Bristol Non-Resi Pipeline sites with modelled heat demands

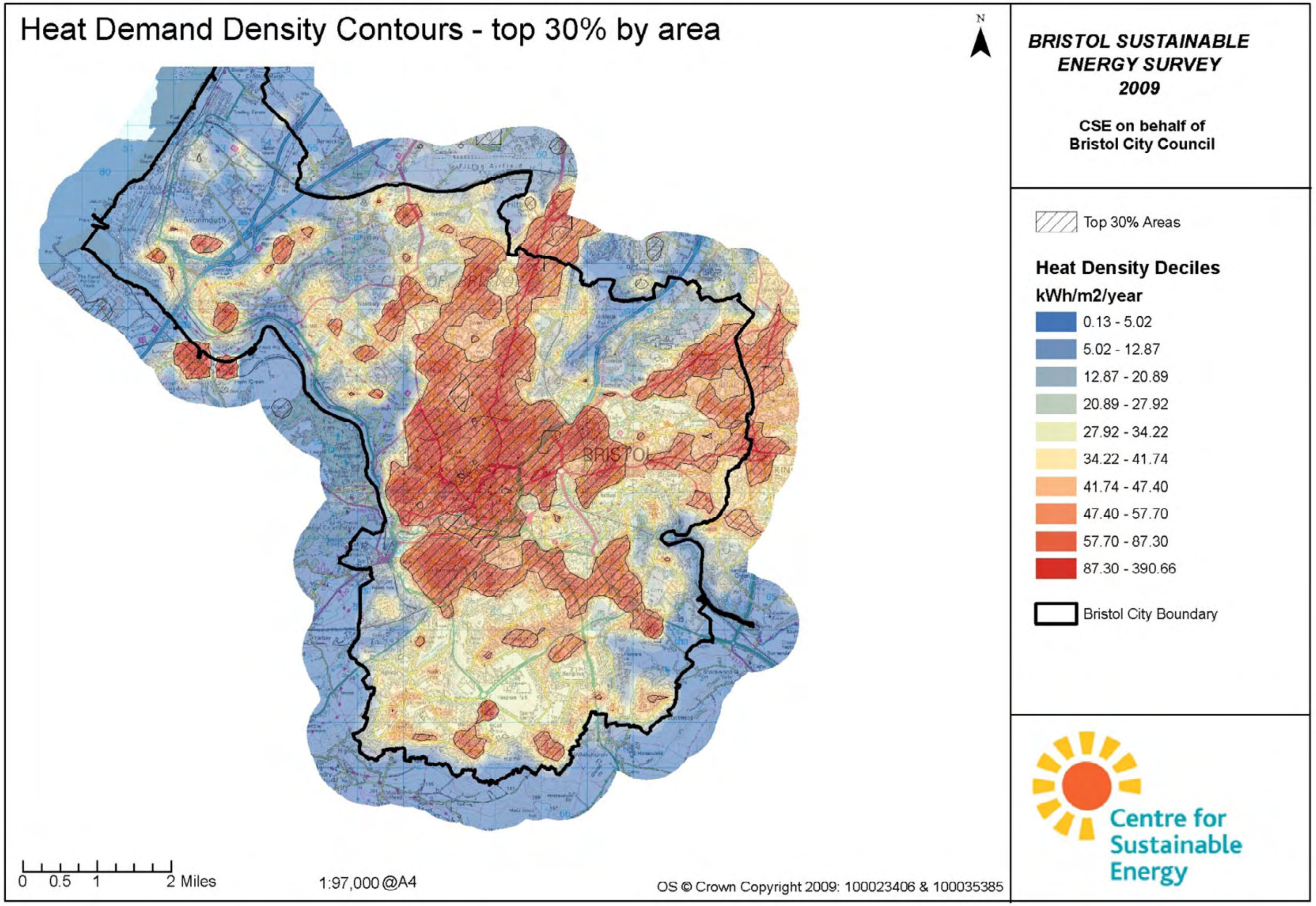

Figure 19
Section 7

Top 30% of Bristol area by heat demand density

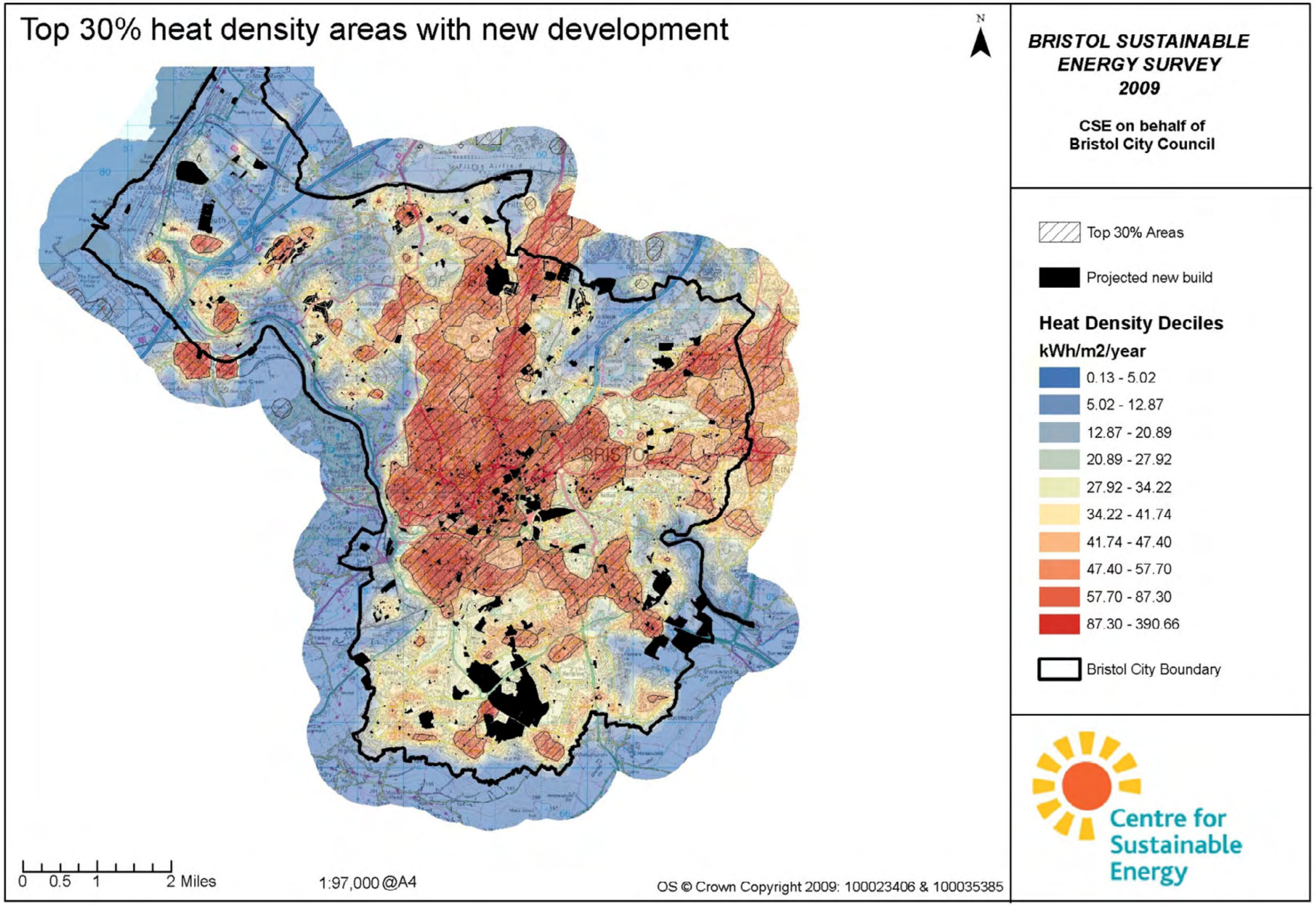

Figure 20
Section 7

Top 30% heat density area, with new development locations

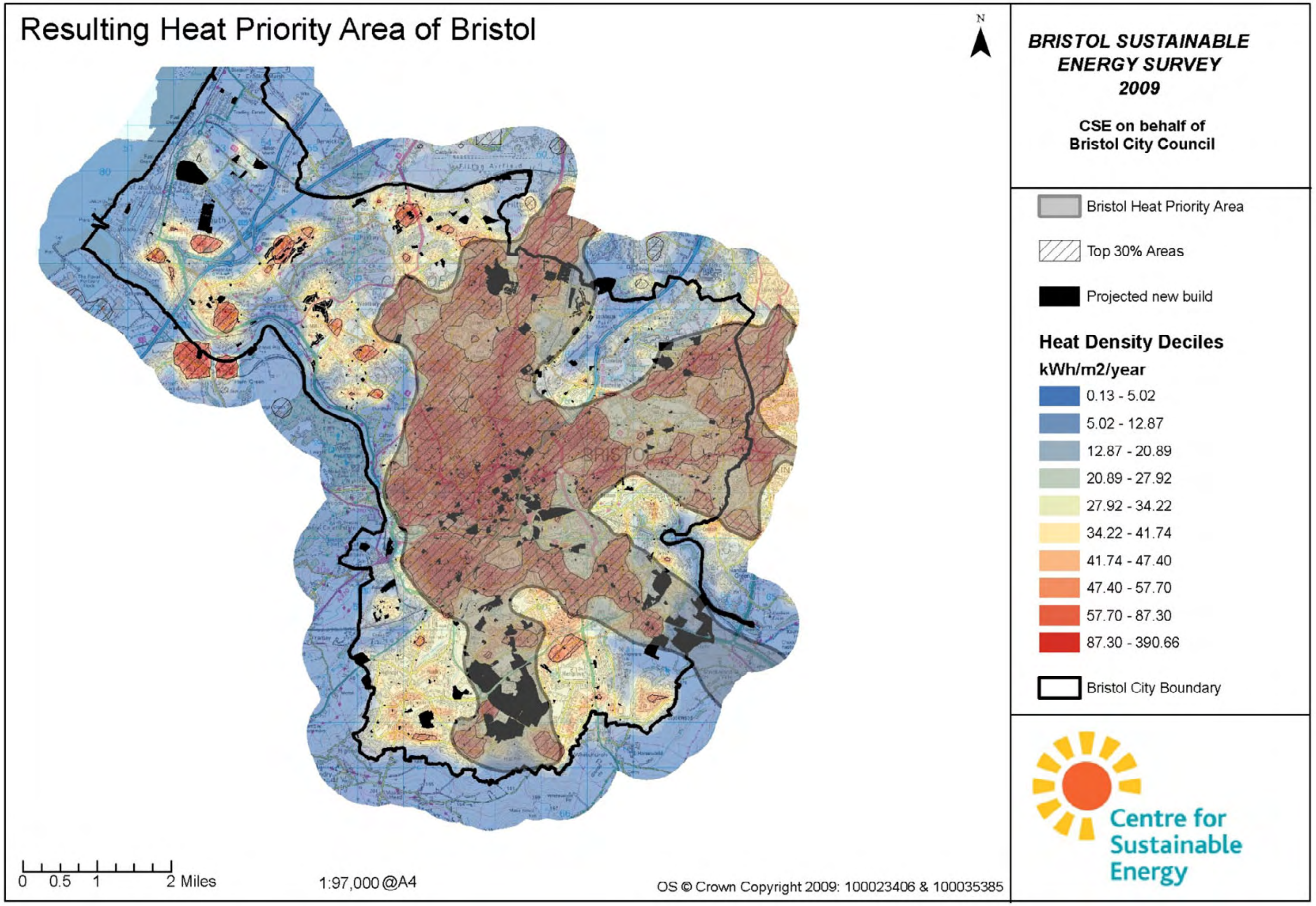

Figure 21
Section 7

Top 30% heat density area, with new development locations and Bristol Heat Priority Areas

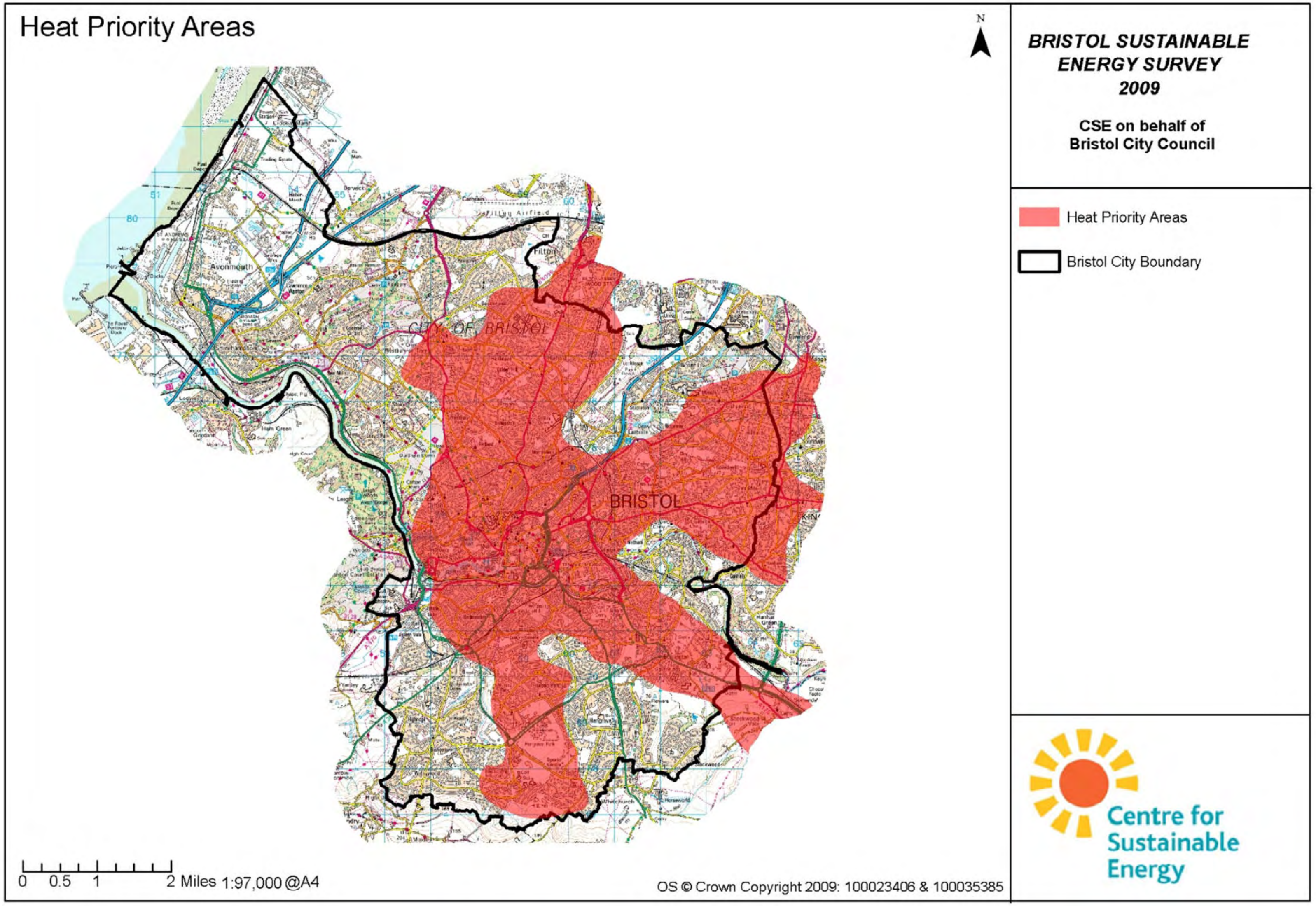

Figure 22
Section 7

Bristol Heat Priority Areas on 50k:1 OS Raster Map