MAYOR OF LONDON

Evidence Base: Climate Change in the Further Alterations to the London Plan

April 2007

ARUP

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Executive Summary

i. This report sets out the evidence regarding the polices in the Further Alterations to the London Plan (FALP) proposed for inclusion to mitigate against and adapt to climate change.

ii. Climate change is a global issue. The Kyoto Treaty, operating at the international scale, has spearheaded a set of frameworks in which trading blocs (such as the EU), national governments, regions and cities have all begun to act. It is in this national and international context that cities and city-regions have to respond to the challenge.

iii. If action is not taken to avoid climate change, London will suffer higher temperatures, endure worse urban heat island effects, changes in the pattern and intensity of rainfall, increased risk to flooding as well as of drought, and adverse health, social, and economic impacts. The risks of climate change to London's built environment and to its citizens are just as great as, if not greater than, the risks on a global scale. Warmer temperatures and the additional overheating caused by the urban heat island effect due to its built form, as well as increased risks of both drought and flooding, will have real consequences for London's economy, viability, and the health and social well-being of its population.

iv. At a national level, the draft Supplement to PPS 1 sets out how planning should contribute to mitigating and adapting to climate change, and PPS 22 provides planning policy on renewable energy. The Further Alterations to the London Plan have reference to these policies in tackling climate change.

The Further Alterations

v. The FALP policies form part of a suite of policies proposed and enacted by the Mayor of London, including his Energy Strategy and Climate Change Action Plan, in order to achieve effective mitigation against and adaptation to climate change.

vi. The FALP policies provide a new three-part energy hierarchy for London, namely **using less energy, supplying energy efficiently, and using renewable energy**, to help effect a reduction in carbon dioxide emissions. The evidence set out in this report fully supports the nature and scope of the FALP policies on climate change.

vii. In order to mitigate against climate change, the FALP policies seek to encourage sustainable design to achieve energy efficiency; to encourage take-up of decentralised power and heat supply; and to require developments to incorporate renewable energy generation.

viii. FALP policies on development design encourage measures to adapt to climate change, as well as responding to the threats of flooding and drought through the incorporation of sustainable urban drainage systems and minimising water usage.

National Planning Policy

ix. The FALP is in concordance with national planning policy, specifically the draft Supplement to PPS 1 and PPS 22 on Renewable Energy, as shown by the table below:

PPS policy requirement	London Plan/FALP content
Reducing the need to travel and promoting development in areas of high public transport accessibility	Existing London Plan high level policy and specific policies on transport, density, mixed use, town centres, employment, central activities zone
Promoting efficient energy supply and contributions from decentralised, renewable and low carbon energy in new developments	FALP policies on ▪ The energy hierarchy in the Mayor's Energy Strategy (minimisation of energy use, then efficient supply, followed by renewable energy) (4A.8) ▪ Decentralised energy through – o connection to existing CCHP/CHP networks, o renewable-powered site-wide CCHP/CHP, o gas-fired CCHP/CHP or hydrogen with renewables; o renewable-powered communal heating/cooling; and last o gas-fired communal heating/cooling (4a.5i) ▪ Hydrogen power should be supported and encouraged (4A.5ii).
Integrating into new and existing development more efficient energy supply and contributions from renewable and low-carbon energy sources	FALP policies on ▪ An energy demand & CO_2 emissions assessment as part of the sustainable design and construction statement (4A.2i) ▪ Waste, landfill, the energy used and transport impacts in managing waste should be minimised, and recycling, composting, and re-use should be maximized (4A.1). ▪ Construction, excavation and demolition recycling or re-use should reach 95% by 2020 (4A.1).
Identifying opportunities for carbon capture and storage	FALP policies on ▪ The production of energy from waste where recycling is unfeasible (4A.1). ▪ Renewable hydrogen produced from waste (4A.1)
Avoiding development in areas susceptible to the effects of climate change	FALP policies on ▪ Adaptation to climate change, particularly by addressing the urban heat island effect, overheating, summer solar gain, and reduction in flood risk (4A.5iii). ▪ Heat resiliency and resistance to overheating to be demonstrated by developers (4A.5iv). ▪ Identification of flood risk areas (4A.5v) ▪ Development next to flood defences should be set back (4A.5vi). ▪ Developments should incorporate sustainable drainage, in line with a drainage hierarchy (4A.5vii). ▪ Maximisation of drainage source control management (4A.5vii) ▪ Major developments should abstract and use rising groundwater (4A5.viii)
Setting regional targets for renewable energy in line with the national targets in PPS 22 for 10% electricity from renewable sources by 2010 and aspirations for 20% by 2010	FALP policies on ▪ Renewable energy is required through a 20% reduction in CO_2 emissions, to be achieved by onsite renewable energy generation (4A.7). ▪ Identification of sites for zero carbon development and locations for wind turbines, one large wind power scheme should be encouraged, and new street appliances should be powered by renewables (4A.7).
Setting regional trajectories for the expected carbon performance of new residential and commercial development to be measured over time	FALP policies on ▪ Overall 60% CO_2 reduction by 2050, 15% by 2010, 20% by 2015, 25% by 2020 and 30% by 2025 (4A.2ii)

Mitigation

x. In order to mitigate against climate change, the FALP policies seek a significant reduction in carbon dioxide emissions from new development. The key ways to achieve this goal are through using less energy and using renewable energy.

xi. Increased energy efficiency in the design of buildings, combined with the education, skills, and building management measures necessary to maximise the benefits of energy-efficient design, are the primary step necessary to reduce the energy intensitivity of development.

xii. Centralised energy supply wastes a significant proportion of the heat created from fuel, is currently highly dependent on carbon sources; and is inefficient due to production and transmission losses. Decentralised energy is more highly efficient in its generation of power and distribution of heat and therefore is key to achieving gains in the overall efficiency of energy generation and use.

xiii. Renewable energy supplies significantly reduce the impacts of energy generation. Decentralised energy generation is also highly suited to renewable fuels, such as biomass, biogas, and hydrogen, and is likely to encourage co-operation between developers. Other renewable technologies such as wind and solar power also have a significant role to play.

xiv. The impacts of the FALP include adapting and normalising new technology; using new locational criteria for developments; reinforcing policy on transport access, density and mixed use; considering masterplanning and detailed design in the face of climate change; and developing the skills and capacity necessary for delivery. Behavioural changes are also needed to reduce energy consumption.

Adaptation

xv. Besides seeking to encourage development to mitigate against the effects of climate change, the FALP policies also recognise that development has to adapt to the inevitable impacts which we are now experiencing. Policies have been proposed that seek to minimise overheating, including the urban heat island effect, and flood risk.

xvi. Sustainable design and construction methods will also prove invaluable not only in helping buildings mitigate against climate change by requiring less energy, but also in coping with the effects of climate change. Masterplanning and building design measures will be essential to helping new development adapt to climate change by minimising solar gain and overheating.

xvii. The policies relating to water supply and drainage are supported by ample evidence which shows the gravity of the flooding risks, as well of the increased possibility of drought, faced by London as the climate changes. The implementation of sustainable urban drainage measures to handle runoff is crucial both to preventing new development from contributing to these risks as well as ensuring the survivability of the built environment in case of flooding, while imposing standards for residential water usage will decrease the effects of droughts.

Costs and Benefits

xviii. The Stern Report sets out that the costs of stabilising the climate are significant but manageable; delay would be dangerous and much more costly. Policy can be a key driver of demand, and meeting the additional costs of policy towards higher energy efficiency may not be overly onerous. A range of climate change technology is feasible for use in London, and implementation of the FALP policies will contribute towards meeting the Mayor's carbon reduction targets, preventing the additional emission of 240 million tonnes of carbon dioxide by 2050 and potentially preventing billions of pounds in environmental damage.

xix. Existing costs include a significant element of innovation costs and will fall in the longer term, shortening the payback period for any climate change investment. The current cost of renewable energy varies considerably by technology; an important feature of the policy is that it allows flexibility as to the choice of renewable technologies specified by developers.

Conclusion

xx. The policies in the Further Alterations to the London Plan are part of a suite of policies that reflect the risks posed by climate change to London's built environment. These policies, taken together, can make a significant contribution towards mitigating against and adapting to climate change. FALP policies on climate change are consistent with the draft Supplement to PPS 1 and other national planning policy, as well as with the statutory obligation on the Mayor of London to tackle climate change, as set out by the GLA Bill 2007. While mitigating against and adapting to climate change will not be achieved without incurring cost, delay in doing so would be dangerous and more costly.

Policy Recommendations

xxi. As a consequence of undertaking this study, we have identified a number of issues that could be supported by policy as soon as an opportunity arises. These are enumerated in detail in the Conclusion (Chapter 12), and are:

- **District-wide infrastructure for energy and/or heat**;
- **Contributions to a renewable energy fund**;
- **Off-site renewable generation**; and
- **Capacity and skills**.

xxii. Discussions with stakeholders have also highlighted a number of misinterpretations of the FALP policy. As a result, if there is scope for **minor amendments to the draft policies** through the Public Examination process, we would recommend the following:

- Further clarity to Policy 4A.15;
- Revisions to the text of Paragraph 4.23ii, possibly moving certain text to become supporting text to Policy 4A.5ii;
- Increased clarity in explaining the benchmarks against which additional energy efficiency and renewable energy targets in FALP Policy 4A.7 will be measured;
- Explanation of the way in which the policy seeking 20% carbon reduction through renewable energy works;
- Increased cross-referencing to other policies in the London Plan and the Climate Change Action Plan; and
- A new policy ensuring borough DPDs and SPDs consider heat and cooling networks.

Preface

This report was commissioned from Arup by the Greater London Authority in 2006. The aim was to assemble the evidence base that had been used in preparing new policy to mitigate against and adapt to climate change in the Further Alterations to the London Plan.

The study was led by Christopher Tunnell and Eli Konvitz, and Richard Neville-Carlé carried out much of the analysis and report drafting. This core team was supported by a range of other Arup staff who contributed at various stages, including Chris Twinn, Chris Trott, Jake Hacker, Mikka Styles, Vicky Evans, and Miriam Leathes. This work would not have been possible without the help and co-operation of officials at the Greater London Authority and the wide range of stakeholders who attended workshops and provided additional evidence.

The work was also guided by an independent advisory group, whose guidance and technical inputs are gratefully acknowledged. The members of the advisory group were:

Alex Bax	Mayor's Office, Greater London Authority
Honor Chapman CBE	
Jamie Dean	Design for London
Bill Harris	Environment Agency
Nick Jones	BRE
Ged Lawrenson	London Borough of Merton
Charles MacDonald	The Carbon Trust
Neil Pennell	Land Securities
Stephen Robinson	GVA Grimley
Prof. Yvonne Rydin	Bartlett School of Planning
Peter Thompson	Energy Saving Trust
Karl Whiteman	Berkeley Homes

The findings of this study do not necessarily reflect the views of the advisory group, the stakeholders consulted, or the Greater London Authority.

Part I: Introduction and Context

1 Introduction

1.1 The Further Alterations to the London Plan and this Study

This report sets out the evidence regarding the polices proposed for inclusion in the London Plan that would mitigate against and adapt to climate change.

The London Plan, published by the Mayor and the Greater London Authority (GLA) was originally published in February 2004. Following the Early Alterations, published in December 2006, the draft Further Alterations to the London Plan (FALP) were published for consultation in September 2006 and have been submitted for Public Examination in Summer 2007. They are intended to guide the spatial future of London to 2026.

The Further Alterations were drafted with regard to the wide-ranging evidence on climate change and the policy options to address the issue, as suggested by national policy and the work of the Mayor. Climate change is a rapidly developing policy area, and consequently this study, commenced in late 2006, draws together both the earlier evidence on which these policies were based and subsequent material, including the Government's draft Supplement to Planning Policy Statement (PPS) 1. Although evidence for all aspects of policy is provided, especially in the early chapters, we have adopted a pragmatic approach in which emphasis is placed on the issues that have raised most comment during stakeholder workshops and in the consultation responses to the revised policy. This includes the renewable energy targets which the GLA has introduced in line with PPS 22.

This study is based upon a literature review, four stakeholder workshops and case study investigations. A detailed account of the method adopted is contained in Appendix 1. Appendix 2 contains a list of consultees, and Appendix 3 a list of case studies. Within the report, specific sources are identified.

1.2 The Role of Policy

As the true effects of forecasted climate change may not be felt for decades, it is unlikely that purely market mechanisms would react until after it is too late to take effective action. It is because of this that the Stern Review of the Economics of Climate Change (HM Treasury 2006) projected that the cumulative costs of taking action today are so much lower than the costs of dealing with it in the future. It therefore falls to governments to implement policy in order to achieve a reduction in greenhouse gas emissions as well as of anticipating changes in the climate that may occur. Policy must act as the key driver in mitigating and adapting to climate change.

The primacy of policy in driving interventions to mitigate and adapt to climate change is now well established. The Kyoto Treaty, operating at the international scale, has spearheaded a set of frameworks in which trading blocs (such as the EU), national governments, regions and cities have all begun to act. It is therefore in the context of national and international obligations that cities and city-regions will have to frame their own policies in order formulate detailed responses to climate change at the local level.

1.3 National Requirements

The emphasis of the proposed FALP policy is on mitigating against and adapting to the effects of climate change, and on the use of the tools available in the planning system to address climate change. Mitigation against climate change refers to the minimisation of greenhouse gas emissions, of which carbon dioxide is the most significant; adaptation to climate change refers to measures which allow the built environment to cope with climate change as it takes place. The proposals regarding these two issues reflect the requirements of national planning policy statements and the judgement of the Mayor, based on evidence, as to how climate change should be addressed through planning and the range of other tools at his disposal.

The draft Supplement to PPS 1 ("Planning Policy Statement: Planning and Climate Change", published for consultation in December 2006) sets out how spatial planning should contribute to mitigating and adapting to climate change by:

- Helping to meet the UK's emissions targets, by influencing energy use and emissions;
- Delivering the Government's zero carbon development;
- Creating an environment which encourages innovation and opportunities for the private sector to invest in renewable and low-carbon technologies and supporting infrastructure; and by
- Giving local communities opportunities to take action on climate change.

In terms of the role of the Regional Spatial Strategy and the London Plan, the PPS outlines the following responsibilities:

- Consideration of how the region contributes to climate change;
- Provision of a framework for integrating policies regarding land with other policies and influencing the nature of places and how they operate;
- Ensuring that the spatial strategy corresponds with national and regional targets for cutting carbon emissions;
- Consideration of the region's susceptibility to climate change, in particular implications for built development, infrastructure and services and biodiversity; and
- Identifying and addressing cross-regional concerns.

In terms of policy content, this means:

- Reducing the need to travel and promoting development in areas of high public transport accessibility;
- Promoting efficient energy supply and contributions from decentralised, renewable and low carbon energy in new developments;
- Integrating into new and existing development more efficient energy supply and contributions from renewable and low-carbon energy sources;
- Identifying opportunities for carbon capture and storage;
- Avoiding development in areas susceptible to the effects of climate change;
- Setting regional targets for renewable energy in line with national targets for 10% electricity from renewable sources by 2010 and aspirations for 20% by 2010; and
- Setting regional trajectories for the expected carbon performance of new residential and commercial development to be measured over time.

At a national level, PPS 22 provides advice on the development of renewable energy, an important step within the context of a national target to achieve a 60% reduction in carbon dioxide (CO_2) emissions by 2050. PPS 22 indicates a requirement for the generation of 10% of electricity needs from renewable sources by 2010, with an aspiration to double that figure to 20% by 2020.

1.4 The Mayor's Proposed Policy

Some aspects of the requirements of PPSs are already covered by the existing London Plan, notably in relation to transport. The Mayor's policy proposals in the FALP concentrate on climate change mitigation and adaptation. Mitigation is to be achieved through reductions in CO_2 emissions from energy, while adaptation is to be achieved through sustainable design of developments.

The FALP policies are related to the Mayor's Energy Strategy and his Climate Change Action Plan. The former is due to be reviewed because its status will change when the GLA is given new powers and duties contained in the Bill currently before Parliament. The FALP makes a preliminary change to the Strategy in providing a new three-part hierarchy for energy in London, namely **using less energy, supplying energy efficiently, and using renewable energy.** These are reproduced in paragraph 4.19 of the FALP.

This hierarchy is a fundamental plank of the way in which the FALP climate change policies will operate and incentivises behaviour in each stage to reduce the potential burdens of compliance in subsequent stages. Developers are to set out their response to the strategy in the energy statements accompanying planning applications; these are dealt with below.

The first limb of the strategy encourages developers to build at a standard higher than Part L of the Building Regulations 2006, to seek to avoid energy-hungry features such as air conditioning, and to add energy saving features such as low-energy light bulbs, plant, and machinery. By reducing energy consumption and the size of the carbon footprint of the proposed development, developers are therefore less burdened in the second limb, which seeks efficient energy supply to buildings, and the size of generation and distribution plant is cut, with consequent reductions in carbon emissions. The final stage of this hierarchy builds upon the first two in order that the requirement for renewable installation is similarly reduced and may in any event be incorporated into the energy supply.

It may help to explain the functioning of these principles through a worked example. The London South Bank University "Review of the impact of the energy policies in the London Plan on planning applications referred to the Mayor" found that savings of 25% in the energy budgets of buildings were possible by exceeding the requirements of Part L of the Building Regulations 2006. Thus, in the first limb of the Mayor's Energy Strategy, this would imply that the energy statement for a development might be able to claim CO_2 savings of up to the same percentage, i.e. 25%. In the second limb of the Strategy, it is widely accepted that the installation of Combined Heat and Power or Combined Cooling, Heat and Power (CHP/CCHP, dealt with in detail in Section 9.2 of this report) can reduce fossil fuel consumption, and hence carbon emissions, by, say, 33%. Thus, in a case where a saving of 25% had already been achieved, a further carbon reduction of 33% from the revised lower energy consumption figure could be secured. This means that the proportion of energy required for generation by renewable sources in the third limb of the Strategy would then fall again in absolute terms. Though the absolute impact would vary on a case by case basis, in simple terms, and using the assumptions above, this is set out in Table 1.1 below, which compares a putative development that complies with the policies versus one which does not:

Table 1.1: Effect of Mayor's energy hierarchy on FALP requirements

	Compliant	Non-compliant
Base case	1	1
Energy efficiency reduction (25%)	0.75	1
Energy supply reduction (CHP = 33%)	0.50	1
20% renewable requirement	0.1	0.2

In detail, the Mayor's proposals include:

- The adoption of overall minimum targets for carbon reduction in line with PPS 22 (Policy 4A.2ii);
- Reduction in energy use in new buildings, which are to minimise energy demand through design (Policy 4A.2i);
- A requirement for developers for energy assessments as part of a sustainable design and construction statement (Policy 4A.8 and Policy 4A.2i);

- A requirement for decentralised energy for heating, cooling and power to minimise carbon dioxide emissions, including an order of preference for: connection to existing CHP/CCHP networks, site-wide CHP/CCHP powered by renewable energy, gas-fired CHP/CCHP or hydrogen fuel cells, both accompanied by renewables, communal heating and cooling powered by renewable energy, gas fired communal heating and cooling (Policy 4A.5i);
- A target for 20% reduction in carbon dioxide emissions by renewable energy onsite in new development (Policy 4A.7);
- Encouragement for more use of hydrogen power (Policy 4A.5ii);
- A requirement to promote and support the most effective adaptation to climate change including minimising heat island effects, minimising solar gain and reducing flood risk (Policy 4A.5iii);
- Encouragement for development that avoids overheating (Policy 4A5i.v);
- Guidance that Boroughs should identify areas at risk from flooding in reviewing their Development Plan Documents (Policy 4A.5vi);
- Guidance to seek the local management and of surface water (Policy 4A.5vii);
- Support for the Water Action Framework (Policy 4A.11);
- Imposition of a water use target for residential development (paragraph 4.25ii); and
- Promoting sustainable construction to reduce emissions from demolition and construction wastes (Policy 4A.2).

In relation to these policies, and in addition to the point made above concerning the energy hierarchy, it is worth noting the following in relation to the renewables target in Policy 4A.7:

- The target of 20% carbon reduction through renewable energy takes as its starting point the base carbon emissions once other measures to minimise energy use and carbon emissions have been taken into account.
- The target of 20% carbon reduction through renewable energy in policy in new development does not compare directly with the targets in PPS 22 because the FALP policies apply only to new development, while PPS 22 is concerned with the entire built environment, new and existing. Moreover, additional measures are required even to meet the minimum standards in the PPS.

1.5 Relationship of Evidence to Proposed London Plan Policy

The evidence on climate change is wide-ranging, but marked by a growing consensus of the need for policy action to mitigate and adapt to the resulting change. There are, of course, multiple means of addressing climate change at international, national, regional and local levels, however, the issues under consideration in this case are the proposed alterations to the London Plan. It is therefore suggested that the relationship of evidence to this policy is determined by overall evidence-based robustness and coherence, which in turn reflects a number of other considerations:

- The **consistency and coherence** of the entire scope of climate policy initiatives at a range of scales. This includes the relationship of the proposed policy in the London Plan to the broad range of options open to the Mayor to address climate change in the unique circumstances of London; the relationship of the Mayor's interventions to other policy initiatives; and the requirement for conformity with national Planning Policy Statements.

- The **effectiveness of the policy proposals** in terms of the balance of costs and benefits of the proposals in comparison with other strategies that might be adopted; and
- The extent of **long-term policy effectiveness and impacts** in driving the scale of change in practices and behaviours sufficient for sustainable mitigation and adaptation.

The first of these requirements is set out in the Mayor's Climate Change Action Plan ("Action Today to Protect Tomorrow: The Mayor's Climate Change Action Plan", GLA, February 2007, referred to hereafter as the Climate Change Action Plan). It is worth noting that the context for addressing climate change in London differs from that in many other areas of the UK. Some conditions in London which are very favourable to addressing climate change; these include high density development the, potential for very high levels of public transport use; the existence of the some the highest property values in the world (against which costs may be judged); and high rates of new development (meaning that measures targeting new development will have a significant effect upon the entirety of the built environment). At the same time, however, London does not offer great scope for interventions such as large-scale wind power. There are also challenges in meeting objectives for the inclusion of natural ventilation in buildings because of the high density already referred to, traffic noise, the urban heat island effect, and occupier expectations.

The second requirement for effectiveness in terms of costs and benefits refers especially to the balance of cost faced in terms of the competitiveness of the London economy and the extent of carbon reduction associated with the strategy. Many of the technologies likely to be required over the longer term are also at an early stage, and costs reflect innovation costs. Over the medium term, there is scope to realise economies of scale and effect; these are often referred to as the 'product life cycle'.

The third requirement concerns the need to secure change that is sustainable over the long terms in the London context. In general terms interventions such as those requiring higher insulation standards will play a significant role in the short to medium term, but ultimately there are limits to what can be achieved.

PPS 1 makes clear that many issues such as insulation standards are a matter for Building Control and the Building Regulations, and thus are not adequate as a basis for a comprehensive planning policy approach. This is reflected both in the proposed plan changes and in current and emerging PPSs in terms of emphasis of these policies on decentralised renewable energy production. PPS 22 further stresses the role of renewable energy.

1.6 Structure of This Report

The remainder of this report is structured as follows:

Part I covers the introduction and general context. In addition to this introduction, it includes:

- Chapter 2, which provides a summary of the basic information on climate change in terms of global causes and effects of climate change; and
- Chapter 3, which provides similar information for London.

Part II addresses issues of strategy and policy coherence.

- Chapter 4 sets out the Mayor's overall strategy and policies towards climate change;
- Chapter 5 examines the consistency of the proposed policy with national policy;
- Chapter 6 examines the costs and benefits of the proposed policy in terms of cost to business and benefits in terms of carbon reduction; and

- Chapter 7 explores the evidence with regard to other issues of development planning and design.

Part III then turns to a number of specific policy topics and the relevant evidence, specifically:

- Chapter 8 addresses energy use in general;
- Chapter 9 is concerned with energy distribution;
- Chapter 10 deals with renewable energy; and
- Chapter 11 addresses evidence for proposals in relation to water.

Part IV contains the final chapter, Chapter 12, which summarises the findings of the evidence base and makes recommendations.

Appendices cover the study methodology, lists of consultees and case studies, detail the wider policy context, and illustrate the specific issue of water-saving technologies.

2 Context: Global Climate Change

2.1 Introduction

Chapter 2 introduces the context of climate change on a global basis and is addressed to readers not already familiar with the scientific evidence and the arguments explaining the causes of climate change. Readers who are aware of this body of knowledge may wish to continue directly to Chapter 3, which addresses the specific case of London.

2.2 Causes of Climate Change

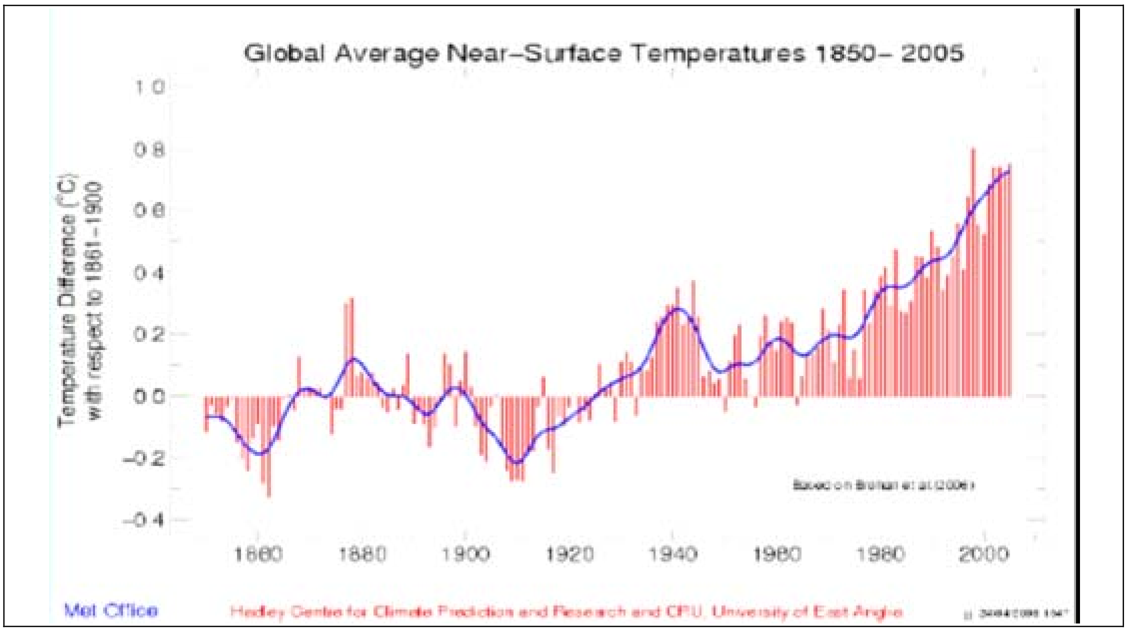
An overwhelming body of scientific evidence now clearly indicates that the Earth's climate is rapidly changing, mainly as a result of increases in greenhouse gases caused by human activities. "Climate Change 2007: The Physical Science Basis", also known as the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), published in February 2007, conclusively demonstrates that the debate over the science of climate has moved on from whether or not it is happening to what action must be taken.

The so-called 'greenhouse effect' is caused by various gases, such as water vapour, carbon dioxide, methane, nitrous oxide and ozone, which act like a blanket and trap heat near the surface. This effect keeps surface temperatures approximately 30°C higher than they would be were the major greenhouse gases not present. The release of additional greenhouse gases from changes in land use, burning fossil fuels and various industrial processes all add to the blanket, making it more efficient at trapping the sun's energy and leading to rising global average temperatures.

The IPCC report confirms that atmospheric concentrations of the major greenhouse gases, carbon dioxide, methane and nitrous oxide have all increased significantly since pre-industrial times because of human activities. For example, carbon dioxide concentrations have risen by just over one third, from 280 parts per million (ppm) in around 1750 to 379ppm in 2005. Including other major greenhouse gases, the total warming effect is equivalent to that of around 430ppm of carbon dioxide; this is expressed by the notation 'CO_2e'. This concentration is far higher than the natural range of 180-300ppm over at least the last 650,000 years, as determined from ice cores.

Global mean temperatures have risen by 0.74°C over the past century, with 0.4°C of this warming occurring since the 1970s. Figure 2.1 illustrates the change in global average near-surface temperatures from 1850 to 2005. In the UK, average annual central England temperatures are currently higher than at any time since records began in 1659. Eleven of the last twelve years (1995 -2006) rank among the 12 warmest years in the instrumental record of global surface temperature (kept since 1850). The IPCC concludes that most of the increase in global temperatures since the mid-20th century is very likely due to the human-induced accumulation of greenhouse gases in the atmosphere. Furthermore, it is estimated that we are already committed to additional global warming of 0.6°C by 2100 as a result of recent emissions.

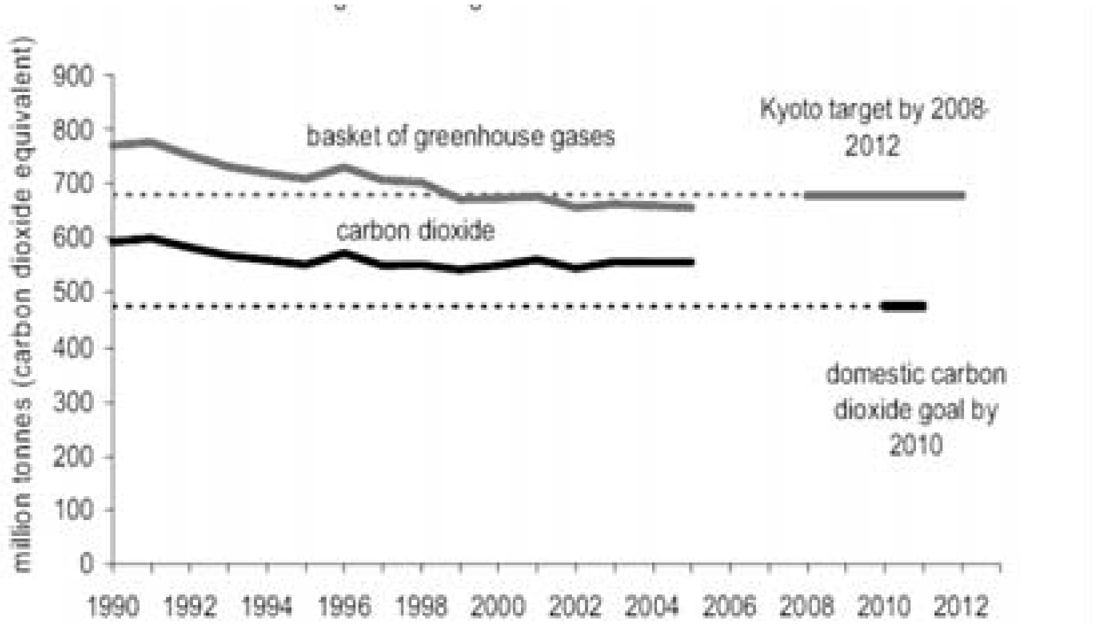
Figure 2.1: Change in global average near-surface temperature 1850 to 2005



Brohan et al. "Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850", Journal of Geophysical Research 111, 2006

In 1990, the UK's emissions of the six major greenhouse gases covered by the Kyoto Protocol were about 209 million tonnes of carbon (MtC). Action in the UK is said to be already driving a significant reduction in emissions, with annual emissions falling by about 14.6% between 1990 and 2004 ("Synthesis of Climate Change Policy Evaluations", Defra, April 2006). Carbon dioxide emissions were 161.5 MtC in 1990 and fell by about 5.6% between 1990 and 2004. Figure 2.2 illustrates emissions of carbon dioxide and the basket of all six greenhouse gases included in the Kyoto Protocol target, over the period 1990 to 2005.

Figure 2.2: UK emissions of greenhouse gases 1994-2005

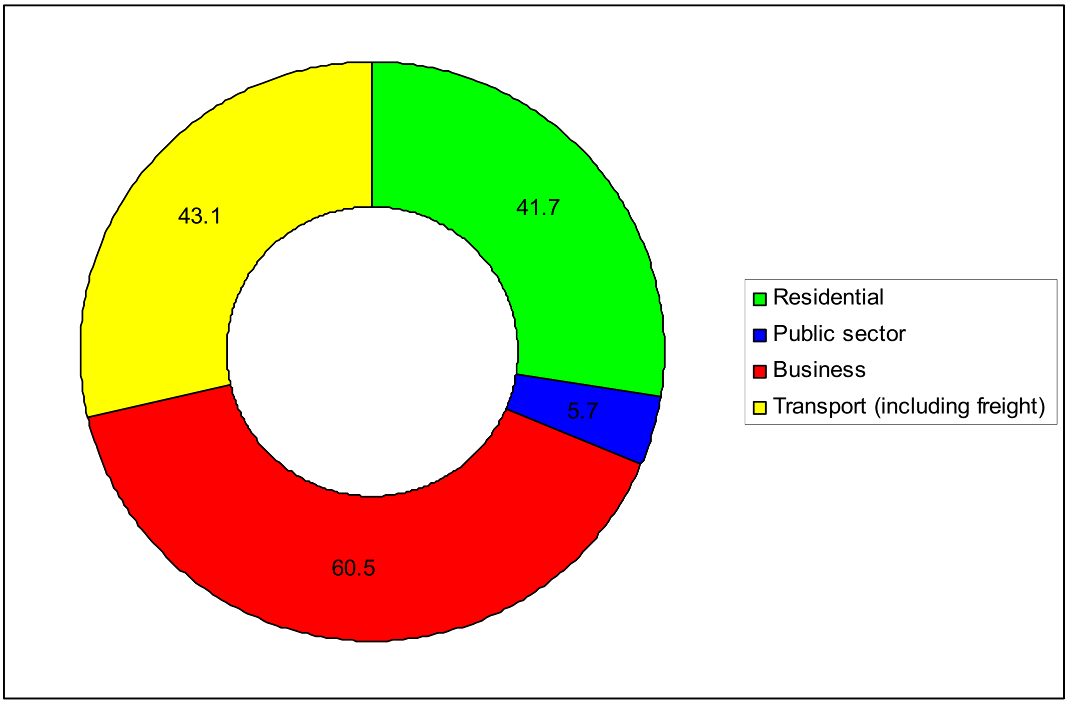


"UK Greenhouse Gas Inventory 1990 to 2005", Defra, 2006

The actual source of carbon emissions varies, as illustrated by Figure 2.3, where the business sector is clearly responsible for a large share of carbon dioxide, and therefore, carbon emissions. However, it is important to consider the role of other greenhouse gases, such as methane and nitrous oxide, when exploring climate change. For example, methane is the second most important greenhouse gas in the UK after carbon dioxide. It contributed 12% of the UK's total emissions of greenhouse gases in 1990, or 25.1 MtC. The major sources of methane are landfill waste, agriculture, natural gas distribution and coal mining. Encouragingly, annual emissions fell by about 50% below 1990 levels to 12.5 MtC in 2004.

"The Energy Challenge" (DTI, 2006) provides projected sectoral long-term trends for carbon emissions to 2050. It suggests that without any further government action and intervention, the residential and service sectors will increase their carbon emissions by 21.9% and 15% respectively, between 2000 and 2050. Interestingly, the industrial sector will increase emissions by only 2.8% and transport will decrease by 1.5%. In this case, carbon emissions from transport are projected to reach a peak around 2015 and fall thereafter. This is on the basis of projections that growth in demand for transport is moderated, fuel efficiency in transport continues to improve, and lower-carbon fuels, especially biofuels, increase their market share.

Figure 2.3: Carbon dioxide emissions by end user in the UK, 2004 (MtC)



"The Energy Challenge", DTI, 2006

2.3 Effects of Climate Change

The Stern Review on the Economics of Climate Change, published by Government in 2006, states that without intervention greenhouse gas levels will reach no less than 550ppm CO_2e by the middle of this century. The Review infers that this level alone would commit the world to a warming of at least around 2°C above pre-industrial levels in the long term, with some recent studies suggesting up to a 20% probability that the warming could be greater than 5°C. Stern comments that a "climatic change of this magnitude would be far outside the experience of human civilisation and comparable to the difference between temperatures during the last ice age and today." In its Fourth Assessment Report, the IPCC estimates that without intervention, greenhouse gas levels will rise to 600-1550 ppm CO_2e by 2100, depending on future emissions. Within a low-emissions scenario, temperatures are projected to rise by 1.7°C, with a likely range of 1.1 to 2.9°C by 2090-2099 (on a base of 1980-1999 temperatures). For a high-emissions scenario, this increases to 4.0°C, with a likely range of 2.4 to 6.4°C.

The effects of climate change will not be felt evenly across the globe. For the UK, climate change means hotter, drier summers (more heat waves), milder and wetter winters, higher sea levels, and an increased flood risk to coastal areas. Across the globe, there will be more intense heat waves, droughts and more flooding. There may be severe problems for regions where people are particularly vulnerable to changes in the weather. The social, environmental and economic costs of climate change could be huge, as indicated in the Stern Review, which concluded that urgent action was needed to avoid serious economic effects from climate change. For some of the poorest countries there is a real risk of being pushed into a downwards spiral of increasing vulnerability and poverty. Resource cost estimates suggested that an upper bound for the expected annual cost of emissions reductions consistent with a trajectory leading to stabilisation at 550ppm CO_2e was likely to be around 1% of GDP by 2050. On this basis, the review suggested that the balance of probability was that doing something to mitigate against and adopt to climate change was cheaper and better then doing nothing.

In terms of rising sea levels, warming of the climate system has been detected in changes of surface and atmospheric temperatures, temperatures in the upper several hundred metres of the ocean and in contributions to sea level rise (IPCC 2007). Studies have established anthropogenic contributions to all of these changes. The observed pattern of tropospheric warming and stratospheric cooling is deemed 'very likely' due to the combined influences of greenhouse gas increases and stratospheric ozone depletion. Projected sea level rises will lead to large increases in the number of people whose homes are flooded. According to Warren et al ("Understanding the Regional Impacts of Climate Change", Tyndall Centre for Climate Change Research Working Paper 90, 2006), between 7–70 million and 20–300 million additional people will experience flooding each year as a result of 3 to 4°C of warming, causing 20–80cm of sea level rise (low and high population growth assumptions respectively). At higher levels of warming and increased rates of sea level rise, the risks will become increasingly serious. Figure 2.4 provides a synthesis of the possible global effects of climate change.

As global temperatures rise above 2-3°C, so the risk of abrupt and large-scale damage will increase, and the costs associated with climate change – across the three dimensions of mortality, ecosystems and income – are likely to rise more steeply. Indeed, no region would be left untouched by changes of this magnitude, though developing countries would be affected especially adversely. This applies particularly to the poorest people within the large populations of both sub-Saharan Africa and South Asia. It is estimated that up to 145-220million additional people could fall below the $2-a-day poverty line by 2100 in South Asia and Sub-Saharan Africa, and that every year an additional 165,000-250,000 children could die compared with a world uninfluenced by climate change. Average global temperature increases of only 1-2°C above pre-industrial levels could commit 15-40% of species to extinction and cause 40-60million more people in Africa to be exposed to malaria.

Modelling work undertaken by the Stern Review suggests that the risks and costs of climate change over the next two centuries could be equivalent to an average reduction in global per capita consumption of at least 5% over the long term. The estimated damages would be much higher if non-market impacts, the possibility of greater climate sensitivity, and distributional issues were taken into account.

Figure 2.4: Highlights of possible climate impacts discussed in the Stern Review

Temp rise (°C)	Water	Food	Health	Land	Environment	Abrupt and Large-Scale Impacts
1°C	Small glaciers in the Andes disappear complete, threatening water supplies for 50 million people	Modest increases in cereal yields in temperate regions	At least 300,000 people each year die from climate-related diseases (predominantly diarrhoea, malaria and malnutrition) Reduction in winter normally in higher latitudes (Northern Europe, USA)	Permafrost thawing damages buildings and roads in parts of Canada and Russia	At least 10% of land species facing extinction (according to one estimate) 80% bleaching of coral reefs, including Great Barrier Reef	Atlantic Thermonaline Circulation starts to weaken
2°C	Potentially 20-30% decrease in water availability in some vulnerable regions, e.g. Southern Africa and Mediterranean	Sharp declines in crop yield in tropical regions (5-10% in Africa)	40 - 60 million more people exposed to malaria in Africa	Up to 10 million more people affected by coastal flooding each year	15-40% of species facing extinction (according to one estimate) High risk of extinction of Arctic species, including polar bear and caribou	Potential for Greenland ice sheet to begin melting irreversibly, accelerating sea level rise and committing world to an eventual 7m sea level rise Risking risk of abrupt changes to atmospheric circulations, e.g. the monsoon Rising risk of collapse of West Antartic Ice Sheet Rising risk of collapse of Atlantic Thermonaline Circulation
3°C	In Southern Europe serious droughts occur once every 10 years 1 - 4 billion more people suffer water shortages, while 1 - 5 billion gain water which may increase flood risk	150 - 550 additional millions at risk of hunger (if carbon fertilisation weak) Agricultural yields in higher latitudes likely to peak	1 - 3 million more people die from malnutrition (if carbon fertilisation weak)	1 - 170 million more people affected by coastal flooding each year	20 - 50% of species facing extinction (according to one estimate, including 25-60% mammals, 30-40% birds and 15-70% butterflies in South Africa Onset of Amazon forest collapse (some models only)	
4°C	Potentially 30 - 50% decrease in water availability in Southern Africa and Mediterranean	Agricultural yields decline by 15-35% in Africa and entire regions out of production (e.g. parts of Australia)	Up to 60 million more people exposed to malaria in Africa	7 - 300 million more people affected by coastal flooding each year	Loss of around half Artic tundra Around half of all the world's nature reserves cannot fulfil objectives	

Temp rise (°C)	Water	Food	Health	Land	Environment	Abrupt and Large-Scale Impacts
5°C	Possible disappearance of large glaciers in Himalayas affecting one-quarter of China's population and hundreds of millions in India	Continued increase in ocean acidity seriously disrupting marine ecosystems and possibly fish stocks		Sea level rise threatens small islands, low-lying coastal areas (Florida) and major world allies such as New York, London and Tokyo		
More than 5°C	The latest science suggests that the Earth's average temperature will rise by even more than 5 or 6°C if emissions continue to grow and positive feedbacks amplify the warming effect of greenhouse cases (e.g. release of carbon dioxide from soils or methane from permafrost). This level of global temperature rise would be equivalent to the amount of warming that occurred between the last age and today – and is likely to lead to major disruption and large-scale movement of population. Such 'socially contingent' effects could be catastrophic, but are currently very hard to capture with current models as temperatures would be so far outside human experience.					
Note: This table shows illustrative impacts at different degrees of warming. Some of the uncertainty is captured in the ranges shown, but there will be additional uncertainties about the exact size of impacts. Temperatures represent increases relative to pre-industrial levels. At each temperature the impacts are expressed for a 1°C band around the central temperature, e.g. 1°C represents the range 0.5 - 1.5°C etc. Numbers of people affected at different temperatures assume population and GDP scenarios for the 2080s from the Intergovernmental Panel on Climate Change (IPCC). Figures generally assume adaptation at the level of an individual or firm, but not economy-wide adaptations due to policy intervention.						

"The Stern Review of the Economics of Climate Change", HM Treasury, 2006

2.4 Global Measures to Mitigate Climate Change

As the UK is currently responsible for 2% of global GHG emissions, it is clearly unable to address the global problem of climate change on its own. The UK's responsibility for a small proportion of current emissions demonstrates the importance of achieving concerted international agreement to tackle climate change. The major developed economies are responsible, collectively, for approximately three quarters of the increase in GHG concentrations above pre-industrial levels. Climate change is a therefore a global problem which demands a global solution; hence there exists a range of international frameworks to tackle the problem, and support and encouragement of these frameworks is required in order to really make an impact.

The overarching goal of the United Nations Framework Convention on Climate Change (UNFCCC) is to stabilise global greenhouse gas (GHG) concentrations at a level that avoid dangerous climate change. The Kyoto Protocol, which was negotiated in 1997 and brought into force in 2005, has now been ratified by over 160 countries. It strengthens the existing UNFCCC framework by committing developed countries to individual, legally binding targets that limit or reduce their emissions. Based on the principle of 'common but differentiated responsibilities', Kyoto sets out that the richest countries – historically responsible for the majority of global GHG emissions – take on targets to prevent, reduce and control atmospheric concentrations of these harmful gases. The framework also allows abatement projects in developing countries to enable technology transfer and sustainable low carbon growth on the basis that where the emission abatement occurs is irrelevant environmentally. The Stern Review considers the various dimensions of global action that will be required to reduce the risks of climate change, both for mitigation (including through carbon prices and markets, interventions to support low-carbon investment and technology diffusion, cooperation on technology development and deployment, and action to reverse deforestation) as well as for adaptation.

2.5 Conclusions

Climate change is a real and present danger. It is caused by temperature rises as a result of the release of large quantities of greenhouse gases into the atmosphere. Scenarios for temperature change and the associated rises in sea levels as a result of polar ice cap melting show the devastating effects of climate change, on a global scale, if sufficient action to reduce the emissions of greenhouse gases is not taken. The costs of action now are far less than the costs of remedying inaction later, and global agreements both emerging and already in place are setting frameworks in which nations can and must act in order to avoid catastrophic climate change.

3 Climate Change in London

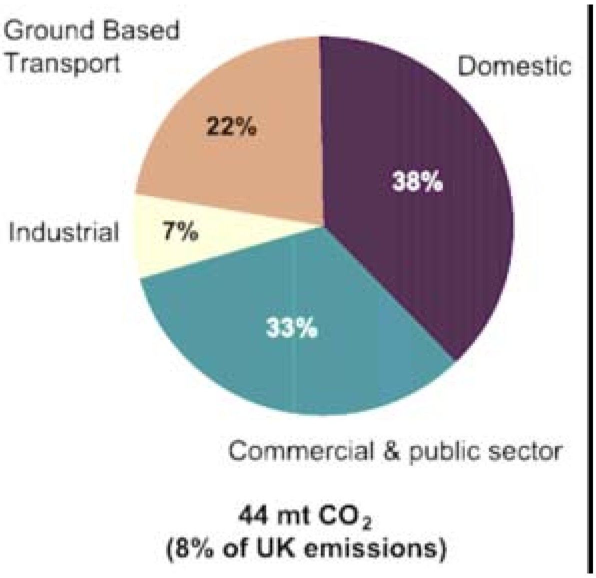
3.1 Introduction

This chapter, building upon the background and explanation of the causes of climate change on a global basis in Chapter 2, provides facts and figures on the situation as it applies to London. It explains the risk to London of inaction in mitigating the causes of climate change as well as the scale of the issues involved if London is to implement national policy to mitigate against and adapt to climate change.

3.2 London's Emissions

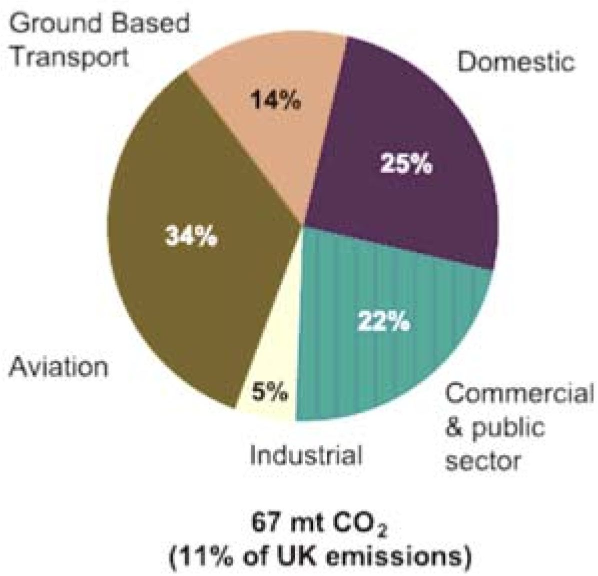
The United Kingdom is the world's eighth largest emitter of carbon dioxide. London is responsible for 8% of these emissions, consuming as much energy as Portugal or Greece, producing 44 million tonnes of CO_2 each year. These figures exclude emissions from aviation, which are not part of CO_2 reductions obligated under the Kyoto Protocol and are not routinely included in the UK government's assessment of emissions. However, London has a key role as an international air hub, and 34% of its total carbon footprint can be attributed to aviation. As aircraft emissions occur at altitude, they have twice the impact of ground-based emissions. With air travel predicted to rise and demand in London to increase dramatically, the Mayor has decided to include aviation within his Climate Change Action Plan (which is dealt with in detail later in this report).

Figure 3.1: 2006 Carbon dioxide emissions from London (excluding aviation)



"Action Today to Protect Tomorrow", GLA, 2007

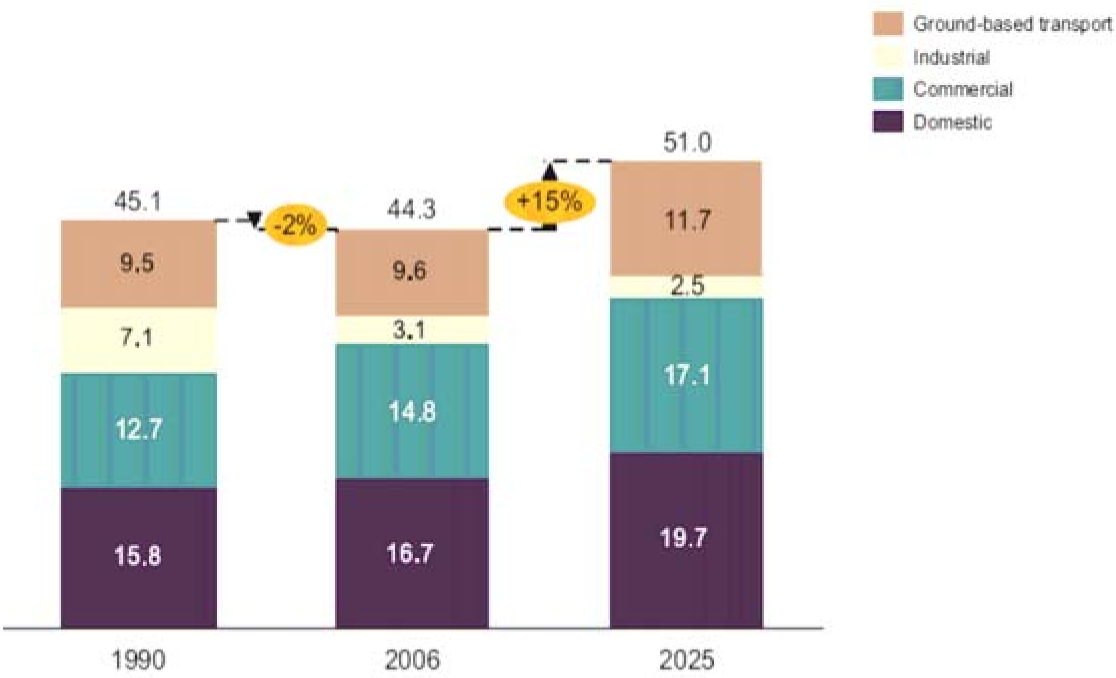
Figure 3.2: 2006 Carbon dioxide emissions from London (including aviation)



"Action Today to Protect Tomorrow", GLA, 2007

Excluding aviation, existing homes are the largest source of carbon dioxide at nearly 40% of London's emissions, of which three quarters is from heating. In considering London's forecast economic and population growth, emissions are projected to increase by 15%to 51 million tones by 2025 (assuming a 'business as usual' approach). Emissions from all sectors are projected to increase by 15 to 30%, with the exception of the industrial sector, which is forecast to decline (see Figure 3.3):

Figure 3.3: 2025 Projected London CO_2 emissions (MtC, BAU scenario, excl. aviation)

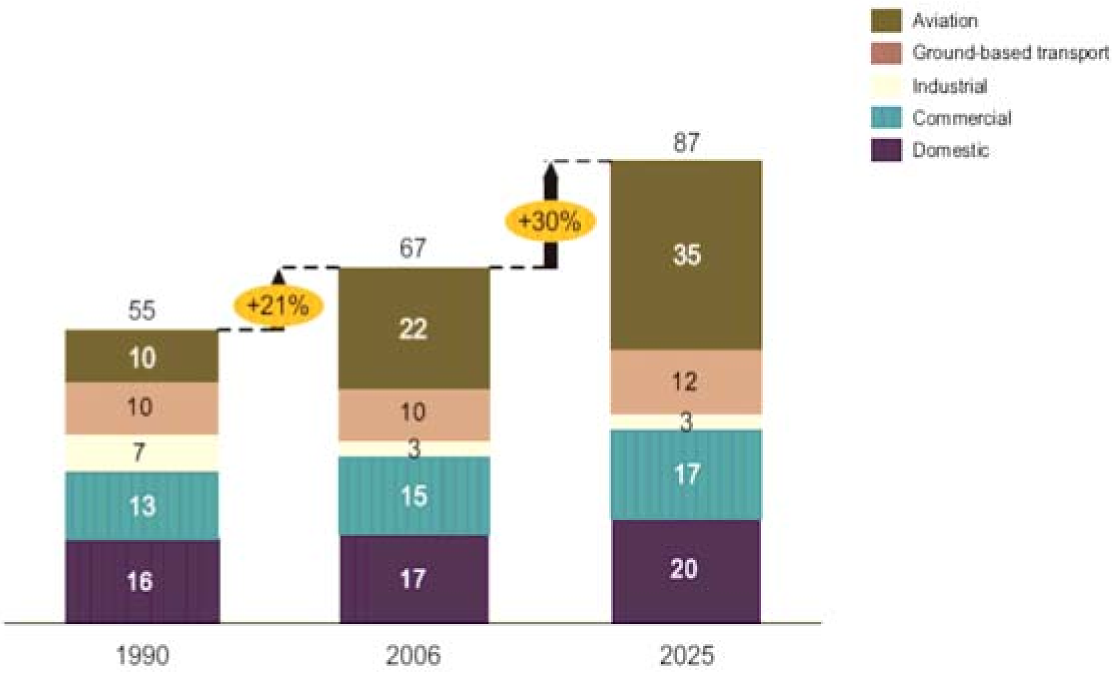


"Action Today to Protect Tomorrow", GLA, 2007

London's overall emissions have actually decreased slightly since 1990, despite a rise in population and jobs between 1991 and 2004. This can be attributed to the movements of industrial activity to elsewhere in the UK or abroad. Interestingly, (ground based) transport emissions have remained stable, despite a 9% increase in distance kilometres travelled.

However, if aviation emissions attributable to London airports are included, overall CO_2 emissions will have increased by 21% between 1990 and 2006, and are forecast to grow by 30% over the next 20 years (see Figure 3.4).

Figure 3.4: 2025 Projected London CO_2 emissions (MtC, BAU scenario, incl. aviation)



"Action Today to Protect Tomorrow", GLA, 2007

3.3 Localised Effects

3.3.1 Temperature

By 2050, it is estimated that London's temperatures will undergo an:

- Increase in winter ambient air temperatures of 1.0 to 2.0°C, and an
- Increase in summer ambient air temperatures of 2.0 to 3.5°C.

Analysis of daily climate change data for Heathrow suggests that the number of days with a maximum temperature of at least 25°C is likely to double by the 2020s, and to increase by between 3 and 5 times by the 2050s. Days with temperatures exceeding 30°C will also become more common, as will extreme temperatures such as those experienced during the heatwave of August 2003 ("Climate Change and London's Transport Systems", GLA, 2005).

3.3.2 Urban Heat Island

The Urban Heat Island (UHI) describes the increased temperature of urban air compared to its rural surroundings. The urban heat island is caused by the storage of solar energy in the urban fabric during the day and the release of this energy into the atmosphere at night. The process of urbanisation and development alters the balance between the energy from the sun used for raising the air temperature (heating process) and that used for evaporation (cooling process), because the cooling effect of vegetated surfaces is replaced by impervious engineered surfaces.

Climate change over the next few decades and beyond is likely to have a major impact on the climate of London, and will therefore affect both the frequency of occurrence and magnitude of extreme UHI events. London can expect intensification of the urban heat island effect beyond the current 6°C potential differential between the city centre and the surrounding countryside.

Using climate change scenarios from UKCIP02, projections of temperature changes within London's UHI can be generated for a low (best case) and high (worst case) emissions scenario. The actual influence of climate change on the UHI can be summarized as:

- Increased maximum and minimum daily average temperatures, with the change in the minima being slightly smaller than the maxima, resulting in a slightly increased diurnal temperature range;
- Small decreases in wind speeds (<10%);
- Moderate changes in solar irradiance (of up to 20%). These changes are due to a reduction in cloud cover – i.e. more sunny days rather than an increase in peak solar irradiance;
- Decreases in relative humidity in all seasons, particularly in summer (up to 15% decrease). Although relative humidity (which changes according to temperature) is projected to decrease, specific humidity (absolute air moisture content) is projected to increase; and a
- Moderate increase in winter precipitation (rainfall) (up to 26% increase) and a more marked decrease in summer precipitation (up to 54% decrease).

3.3.3 Precipitation

Over the last century there has been an 11% increase in winter precipitation and a 10% decrease in summer precipitation. By the 2050s, London is expected to experience:

- Increase in winter precipitation by up to 20%, and a
- Decrease in summer precipitation by 20 to 40%.

Intense rainfall events in both summer and winter are likely to become more common and more severe.

3.3.4 Flooding

London occupies an estuarine location on the banks of the river Thames and has always been at risk from both fluvial and tidal flooding. Both are predicted to worsen as a result of climate change. Already, a combination of thermal expansion and melting of land-based ice due to rising temperatures has caused annual average global sea level rises of 1-2mm/yr over the twentieth century (Church et al 2001, quoted in Lowe & Gregory "The Effects of Climate Change on Storm Surges Around the UK"; Philosophical Transactions of the Royal Society A 363, 2005), with associated rising tide levels within the Thames Estuary ("Living with the tide: Effective flood defence", Environment Agency, 2006). Modeling under various climate change scenarios has revealed that average UK sea levels may rise between 10 and 60cm over the next 100 years. Vertical land shifts in the South East of England are expected to exacerbate the problem, contributing to estimates of sea level rise in the Thames Estuary of between 26 and 86cm by 2080 ("Flooding in London: A London Assembly Scrutiny Report", London Assembly, 2002; "Climate Change Scenarios for the United Kingdom: The UKCIP02 Briefing Report", UKCIP, 2002). As a result, research conducted by the Office of Science and Technology has predicted that the frequency of coastal flooding could increase by between 4 and 10 times ("Foresight Future Flooding Report", 2003). A combination of greater storminess and sea level rise is also expected to contribute to more frequent and greater extreme sea levels and storm surges, caused by a combination of high tides, onshore winds and meteorological depressions in the North Sea (Environment Agency in "Flooding in London"). Research conducted by Lowe and Gregory in 2005 into UK storm surge levels has revealed that the height of a 1/50 year storm surge is expected to increase by up to 0.7m off the South Coast, whilst model simulations run by Lavery and Donovan ("Flood Risk management in the Thames Estuary – looking ahead 100 years", Philosophical Transactions of the Royal Society A 363, 2005) show that extreme sea levels could occur 10 to 20 times more frequently by the 2080s, contributing to more frequent and severe coastal defence overtopping and subsequent flooding.

The effects of climate change on precipitation patterns have been studied extensively, revealing that the frequency, volume and intensity of winter precipitation is likely to increase, with an associated increase in fluvial flood risk. Indeed, observations and climate models show that the frequency and intensity of rainfall has already increased over the 20th century, whilst recent climate simulations predict that winters could become between 10-20% wetter by the 2050s and up to 35% wetter by the 2080s, with heavy winter rainfall occurring twice as frequently and the number of storms crossing the UK rising from 5 to 8 by the 2080s. In terms of London, heavier and more frequent winter precipitation is expected to increase both the frequency and magnitude of flood events: the Thames 100 year return flow is, for example, predicted to rise by 13% by the 2020s (See Evans & Hall, “A New Climate for Flood Planning”, 2004; “London’s Warming: Summary Report”, GLA, 2002; Frei & Schar, “Detection probability of trends in rare events”, Journal of Climate 14, 2001; Karl & Knight, “Secular trends of precipitation amount frequency and intensity in the United States”, Bulletin of the American Meteorological Society 79, 1998; Osborn et al, “Observed trends in the daily intensity of United Kingdom precipitation”, International Journal of Climatology 20, 2000; Jones & Reid, “Assessing future changes in extreme precipitation over Britain using regional climate model integrations”, International Journal of Climatology 21:11, 2001; LCCP 2002a; “Climate Change Scenarios for the United Kingdom”, UKCIP02, 2002).

The risk and severity of flooding is also exacerbated in an urban environment, due to the culverting and canalisation of river courses, poor drain maintenance, reduction of active flood plains and storage areas, removal of natural vegetation, soil compaction and increase in impermeable surfaces, all of which contribute to rising surface run off levels (see Table 3.1) and a heightened risk of flooding (Woods-Ballard et al, “The SUDS Manual”, 2007; “Flooding in London: A London Assembly Scrutiny Report”, London Assembly, 2002; “London Under Threat? Flooding Risk in the Thames Gateway”, London Assembly, 2005).

Table 3.1: The effects of urbanisation on surface runoff rates

	Evapo-Transpiration	Surface Runoff	Shallow Infiltration	Deep infiltration
Natural Ground Cover	40%	10%	25%	25%
10-20% impervious surface	38%	20%	21%	21%
35-50% impervious surface	35%	30%	20%	15%
75-100% impervious surface	30%	55%	10%	5%

“How Urbanization Affects the Water Cycle”, NEMO California Partnership

Greater and more frequent high run off levels in the urban environment will also contribute to a rising risk of surface and sewer flooding, whereby the finite capacity of existing drains and sewers is increasingly overwhelmed by greater surface run off volumes). Indeed, surveys of drain and sewer capacity in London have revealed that existing capacity is already failing to meet growing levels of run-off: Current urban drain systems are only designed to cope with high frequency, low severity storms which might occur with a 5% annual probability with no more than a 20% increase over base flow rates. As the return period for more severe events such as 1in 50 year rainfalls, surface and sewer flooding is therefore expected to become more frequent (for more on these issues, see “Learning to Live With Rivers”, The Institution of Civil Engineers, 2001; Association of British Insurers in “Flooding in London”; “London Under Threat?”).

Not only is there concern over the ability of London’s drainage network to accommodate increased surface run off; the current design standard of London’s network of coastal and fluvial flood defences may also fail to cope with rising flood levels in the coming years. Whilst the Thames Barrier currently maintains tidal flood risk at 0.05%, this is expected to fall to 0.1% by 2030 and to 1.5% by 2100. Whilst this standard of protection is still higher than many other parts of the UK, within the context of a doubling of tidal flood risk by 2030, the economic and social implications of this level of risk within London's context are unacceptable. Elsewhere in London, current river defences already do not offer satisfactory protection: In places the standard of defence provided protects only for floods of 1 in 70 years, which is below the minimum Environment Agency standard of protection against floods which occur only once in 100 years, whilst elsewhere defences have been noted as being in poor or very poor condition. As well as increasing the risk of severe flooding, the current standard of London's defences may also have economic implications for the pace of development within the capital, where poorly-defended new and existing development is unable to secure adequate insurance against flood risk ("Flood Resilient Homes", Association of British Insurers, 2007; "Flooding in London".

3.3.5 Drought

Although an increase in winter precipitation in predicted, rising summer temperatures are expected to be accompanied by a decrease in summer rainfall, surface runoff and soil moisture (Arnell1999 & Hulme et al, 2002, in "London's Warming: Technical Report", GLA, 2002), the balance of which is expected to result in a decrease in annual precipitation totals (see Table 3.2). In terms of water resource planning, changing precipitation patterns are likely to increase aquifer recharge and yield in the winter months, whilst direct abstractions in the summer months will become less reliable. Year-to-year variability in rainfall is also expected to increase, with implications for forward planning and drought management ("Water Resources for the Future: A Strategy for England and Wales", Environment Agency, 2001).

Table 3.2: UKCIP02 Water resource scenarios to 2080

Variable	Predicted change to 2080	
	Low emissions	High emissions
Winter precipitation	10-20% increase	15-35% increase
Summer precipitation	35% decrease	50% or greater decrease
Temperature	2ºC (0.1-0.3ºC / decade)	3.5ºC (0.3-0.5ºC / decade)
Summer soil moisture content	20% decrease	40% or greater increase

"Climate Change Scenarios for the United Kingdom", UKCIP02, 2002

Not only is climate change expected to directly impact on water resources, but rising summer temperatures are also expected to increase domestic water consumption through increased personal washing and garden watering. Demand is also predicted to rise as a result of decreasing household size, increasing population, and increasing commercial requirements.

3.3.6 Health

London is particularly vulnerable to high temperatures – homes, workplaces, public buildings, the public realm and transport infrastructure are not designed for high temperatures. Hot weather places additional stress on the body, raising health risks for the vulnerable and increasing discomfort for everyone.

The compound effects of high urban temperatures and poor air quality, characteristic of London, have an impact on public health. Amongst other effects, exposure to ozone and smog irritates and causes inflammation of airways and can also increase a person's susceptibility to respiratory conditions; it also aggravates pre-existing conditions such as asthma. A 2001 Department of Health report ("Health Effects of Climate Change in the UK") warns that climate change over the next 50 years could potentially cause many deaths and illnesses for people in Britain and outlines that this could overwhelm local NHS resources and cost local authorities billions of pounds. The main effects of climate change outlined in the report, UK-wide, are:

- Heat-related deaths are likely to increase to around 2,800 cases per year. It has been estimated that the heat waves in 1976 and 1995 were associated with a 15% increase in mortality in Greater London, especially among the sick and elderly. ("London's Warming", GLA, 2002);
- Cases of food poisoning are likely to rise by as much as 10,000 per year;
- The effects of ozone damage are likely to increase, leading to several thousand extra deaths annually, and a similar rise in hospital admissions; and
- Cases of skin cancer are likely to rise by 5,000 cases per year, and cataracts by 2,000 cases per year; however,
- Cold-related winter deaths are likely to decline significantly, by perhaps 20,000 cases per year;

The risk of major disasters caused by severe gales and flooding is further likely to rise significantly.

3.3.7 Socio-economic Impact of Climate Change in London

The social and economic impact of climate change on London is discussed and estimated within "London's Warming" (GLA, 2002). From this study, the following key conclusions can be made about the scale of impact on London's economy:

- The increased flood risk to areas of London vulnerable to river and drainage flooding from higher rainfall intensities is a significant threat to many economic assets, including property, communication and transport infrastructure and people;
- The indirect costs of a perceived increased flood risk arise from relocation of business and commercial activities to other (global) cities and/or a relocation of highly skilled parts of the labour force. These costs are thought by stakeholders to be as significant as the direct costs. A response to this threat appears to lie in improved flood prevention schemes;
- The London insurance industry is vulnerable to claims made against damages caused by wind storms and flood events that might require reductions in capitalisation. Any major selling of assets (stocks, property etc.) would have a significant effect on credit availability in the financial capital markets, with negative repercussions for activity in the wider economy. An event that results in insured losses over £1 billion in the UK or globally, (of which the 1987 windstorm was one), may trigger such economic impacts;
- The link between the insurance and financial markets identified above ensures that the financial service sector will also be impacted indirectly by climate change related extreme weather events. The size of this impact will be determined by the extent that the insurance sector has been able to pass on risk to other financial instruments. It is believed ("Climate Change 2001: Impacts, Adaptation and Vulnerability", IPCC, 2001) that the policy of portfolio diversification which large financial institutions have will ensure that this risk is reduced and the impact mitigated;
- The financial services sector is starting to take account of the opportunities provided by the regulation associated with a carbon constrained future, including work in the implementation of revised accounting guidelines, and consultancy in energy related business strategy;
- The economic costs of disruption to London transport systems. Historical analogues of a single weather-related disruption on only one stretch of the rail network suggest costs of broadly £2 million;
- The net balance of change in energy demand as a consequence of climate change in London is unclear. The supply infrastructure network is vulnerable to windstorms and

clay shrinkage. There will be economic impacts of disruption to the power supply for extended periods;

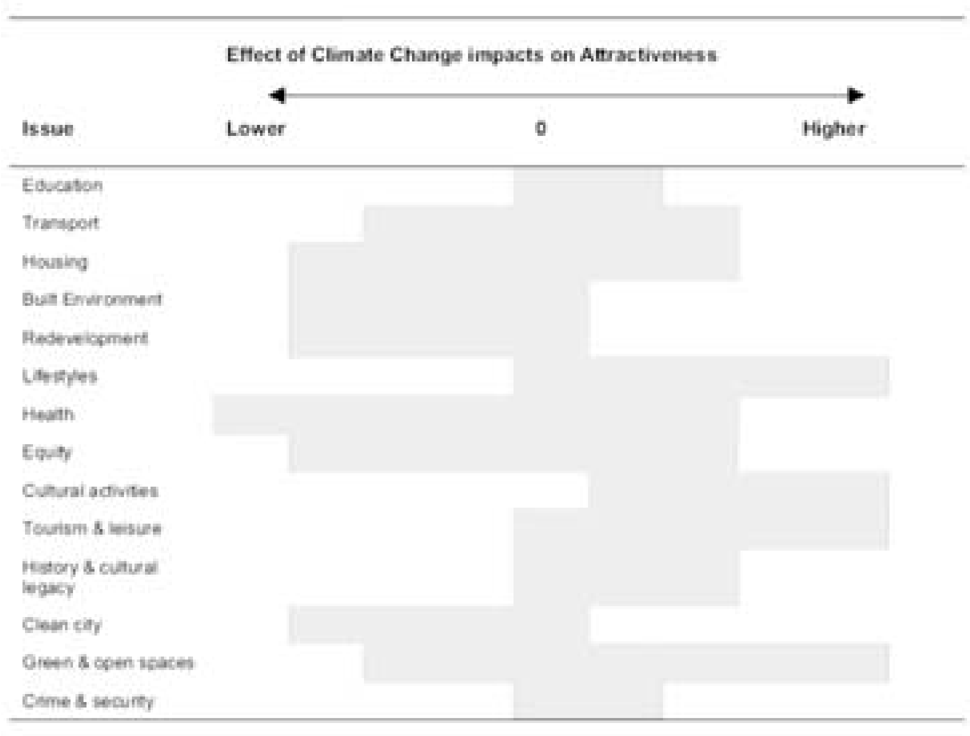
- Manufacturing is subject to disruption of raw materials (e.g. foodstuffs) that are supplied from parts of the world adversely impacted by climate change. Consumer prices may then be expected to rise. The same mechanism may result in opportunities for recycling environmental businesses, where the price of virgin raw materials (e.g. rubber, wood pulp) increases and makes recycled substitute products more competitive;
- The net economic impact of climate change on tourism and leisure is uncertain. Revenues may increase as London (and the UK) becomes a more attractive destination in summer relative to those in Southern Europe and elsewhere that are likely to suffer from adverse climate change impacts such as the increased threat of forest fires. However, more trips may be taken from London to escape e.g. uncomfortable heat island impacts;
- Flood risks, transport disruption, and heat island effects are climate change impacts that might result in the relocation of workers, or changes in commuting patterns. These impacts might impact on the supply of labour to London's public administration, and other economic sectors or the relocation of employers; and
- Increased general awareness of potential and actual climate change impacts in London is likely to focus policy makers' minds on the need to reduce carbon emissions and adapt to such impacts locally and globally in the future.

In terms of the social cost of climate change to London, climate change will have both direct and indirect impacts. In terms of defining a 'social' impact, the GLA's "London Warming" report provides the following classification, and then attempts to quantify the impacts on London's 'attractiveness':

> The overall health and well-being, social and economic equity, public safety, public health and infrastructure, civil cultural and political society (including political institutions), and who bears the costs and reaps the benefits in a future London.

Figure 3.5 below (in which 'lower' indicates London becomes less attractive from the perspective of that sector under climate change) shows that, on balance, the social impacts of climate change upon London are perhaps somewhat more negative than positive. There are, however, some potentially significant benefits for a number of sectors such as tourism and leisure. The study also identified some fairly small benefits for a number of additional sectors including transport, housing, historical and cultural legacy, jobs, health and so on. The larger negative climate change impacts for housing, redevelopment, built environment, health, clean city, cost of living and open and green spaces are all highly uncertain, in part because the scale and precise character of the impact depends on the adjustment and adaptation responses. Most of the larger negatives are attributable to potentially increased flooding, greater incidence of summer heatwaves, exacerbation of existing air pollution problems and increased pressures upon open and green spaces.

Figure 3.5: The effect upon London's 'attractiveness' of climate change impacts by system and sector



"London's Warming: Technical Report", GLA, 2002

The impacts on London will also spill over in important ways and come to affect the South East and East of England regions (as well as further afield), especially for recreational and leisure purposes. Yet, the pressures from climate change upon the coastline and other beauty spots in the South East are considerable.

3.4 Conclusions

The risks of climate change to London's built environment and to its citizens are just as great as, if not greater than, the risks on a global scale. London's situation on the River Thames means that, if climate change mitigation and adaptation are not dealt with, then the effects of flooding from rising sea levels, as well as the additional overheating caused by the urban heat island effect due to its built form, will have real consequences for London's economy and viability.

Part II: Strategy and Policy

4 The Mayor's Strategy Towards Climate Change

4.1 Introduction

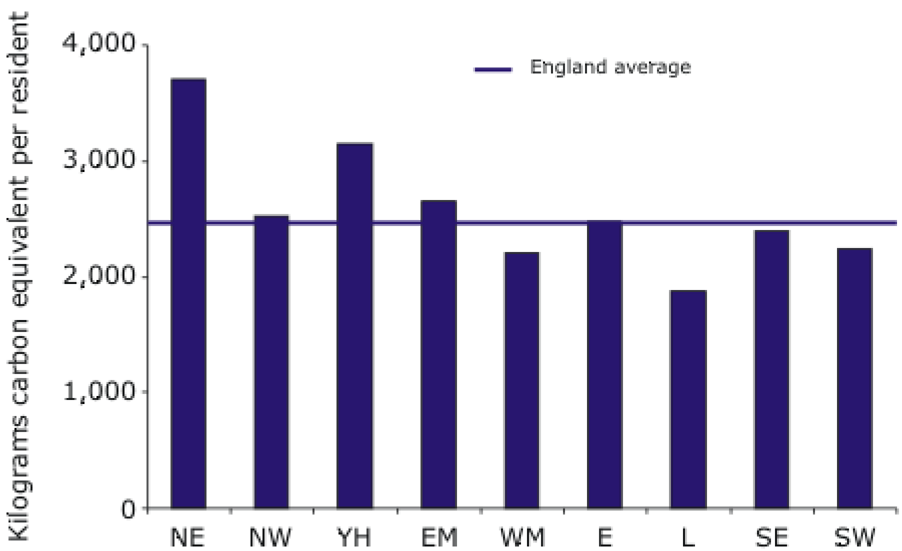
This chapter sets the FALP policies in the wider London policy context. It is necessary to understand these relationships in order to understand the stance taken by the Mayor as well as to understand the ways in which all Mayoral policies seek to work together to achieve the necessary carbon emissions reductions. Familiarity with the Mayor's Climate Change Action Plan is essential to understanding the FALP proposals in their wider London context.

4.2 London's Role

It is particularly important that London make a significant contribution to climate change mitigation and adaptation. London is the locus of government and of the English economy; it is the largest and most populous city in the nation, developing more and more quickly than elsewhere; it has the most extensive transport network and the highest sustained population density; and it is the focus of high levels of investment. London is also a city of increasing importance on the world stage, and projections suggest ("UK Economic Outlook March 2007", PriceWaterhouseCoopers, 2007) that it will rise from having the 7th largest GDP in the world in 2005 to having the 4th largest – eclipsing Chicago and Paris and behind only Tokyo, New York, and Los Angeles. Just as the Government is setting an internationally-visible example in dealing with climate change, so too can London act as an exemplar global city.

London already has the lowest CO_2 emissions per head of any English region, as shown by Figure 4.1:

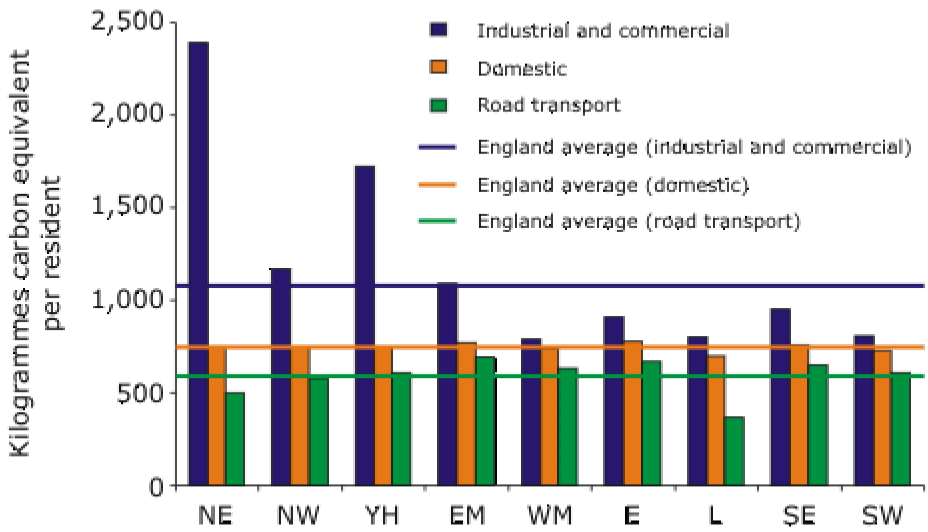
Figure 4.1: Total carbon dioxide emissions per head, 2003



http://www.sustainable-development.gov.uk/regional/summaries/01.htm

This is undoubtedly due to both London's low reliance on industry as well as to its high density and public-transport usage, which lead to lower-than-average emissions from transport, as evidenced by Figure 4.2:

Figure 4.2: Carbon dioxide emissions by end user, per head, 2003



http://www.sustainable-development.gov.uk/regional/summaries/02.htm

London's inherent advantages of mass and density mean that the building blocks for sustainable development are already extant, with the effect that the scope for incorporating climate change mitigation and adaptation measures, such as CHP/CCHP powered by renewable energy or district heating in developments, may be greater for implementation on a large scale than in other cities.

4.2.1 Achieving a 60% Carbon Reduction

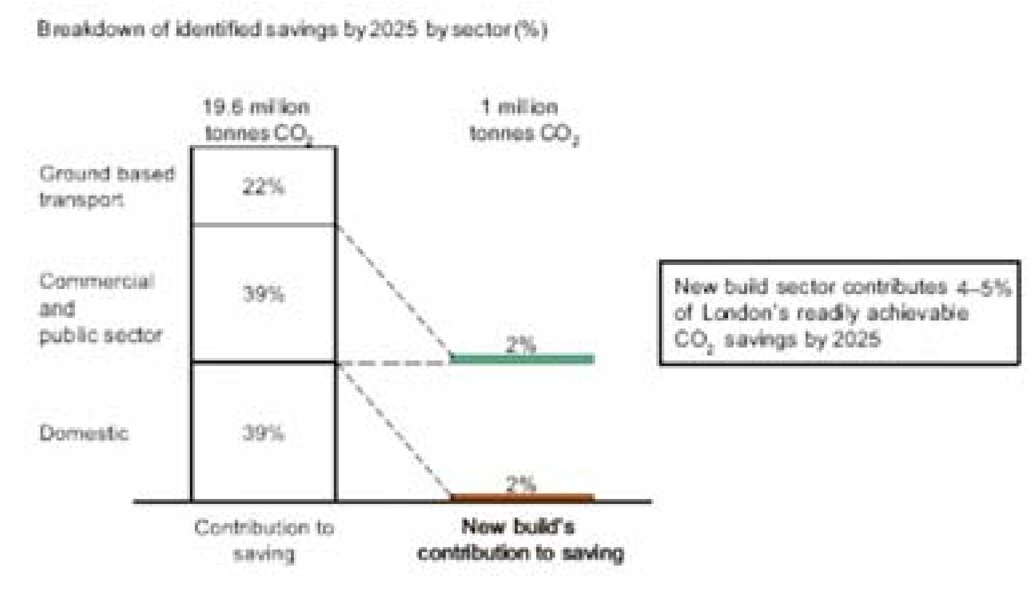
The national target of a 60% reduction in carbon dioxide emissions by 2050 – or, indeed, by 2025, as specified by the Mayor's Climate Change Action Plan – is a significant challenge. All sectors of the economy will have to contribute materially to this, and the target will only be met with the help of changes to energy supply and use at the national level.

The measures that must be taken fall into a number of sectors. Existing development, both commercial, retail, and domestic, will have to change. In order for the 3.1 million dwellings and the 110 million square metres of commercial floor-space to contribute materially to the carbon savings target, progressive retrofit of existing buildings for improved thermal insulation and new appliances to make them more energy-efficient will have to be coupled with behavioural change by occupants to produce effective energy savings. Companies and organisations will need to examine their operations and identify ways to achieve operational savings. Transport will contribute through shifts in mode from private cars to public transport, but will only make a significant contribution when coupled with effective incentives to move to low-carbon technologies and more efficient vehicles. Electricity from the National Grid will need to be increasingly generated from renewable or low-carbon sources.

4.2.2 The Role of New Development

In the context of the large-scale measures for delivering carbon reductions described above, the reduction in carbon emissions that can be delivered by new development as well as by local distributed energy and heat is the fraction of the picture where planning policy is necessary. Chapter 3 of the FALP quotes the GLA Housing Requirements Study as estimating a need for 353,500 homes over ten years, or 35,400 new homes a year, in order to meet the net housing growth figures as well as the existing backlog; the plan, after the Early Alterations, contains a target of 30,500 dwellings per annum. The further development of 16.4m m² of new office space is also expected. As suggested by Figure 4.3, each is expected to contribute 4-5% of London's CO_2 reductions by 2025:

Figure 4.3: New build sector's contribution to CO_2 savings by 2025



"Action Today to Protect Tomorrow", GLA, 2007

The Climate Change Action Plan sets out the requirement for new development in order to reach the target of 60% reduction in carbon emissions (on a 1990 base): While under the business-as-usual scenario new stock could add 5.1 Mt/year of carbon dioxide to the atmosphere, a 60% reduction would require emission of 1.8 Mt/year less than in 1990 by 2025 (CCAP, 85).

4.2.3 Mayor's Powers for Development Management

Beyond his role in publishing the London Plan, The Mayor of London also has certain powers for development management. It is a requirement of the Greater London Authority Act 1999 that the 32 boroughs and the City of London consult him on strategic planning applications. As a result of the 2006 GLA Bill, the Mayor may determine strategic planning applications, in addition to directing changes to borough programmes for their local development plans and having a stronger voice in the determination of whether draft local development plans are in conformity with the London Plan. Approximately 1% of the planning applications received every year in London falls into the category of 'strategic development' and thus under the potential purview of the Mayor. The London Plan and the requirement that borough development plans be in conformity with the London Plan therefore remain the key drivers for executing the Mayor's planning policy in London.

4.2.4 Other Regional Initiatives and Mayoral Powers

The London Development Agency is the GLA agency responsible for economic development and growth. It produces the Mayor's Economic Development Strategy as well as being home to the London Climate Change Agency and Design for London. The London Climate Change Agency has been tasked with reducing carbon emissions in the capital. The London Energy Supply Company (ESCO) was formed by the LCCA, working with EDF; the LCCA also provides support for CHP and renewable energy generation. The LDA implements the Green Homes and Green Organisations Programmes and is also the leader, through its investment programme, in bringing forward sites for low- and zero-carbon development such as that proposed at Gallion's Park. The LDA further funds London Environment Support Services as well as Enhance, which provides business support for London's green enterprises that reduce waste or work with recycled materials, as well as organisations such as London Remade, which provides recycling services.

The London Energy Partnership is responsible for, amongst others, the Mayor's Energy Action Areas, four of which have already been created and which will demonstrate the carbon emissions reductions possible on brownfield redevelopment. The London Hydrogen Partnership aims to promote the uptake of hydrogen across the economy, in the better-known transport field as well as for stationary power generation using, for example, hydrogen produced from waste.

4.3 Climate Change Action Plan

The London Plan is one of a host of statutory and advisory documents prepared by the Mayor and the GLA family of bodies, all of which will complement each other in delivering a comprehensive approach to mitigating and adapting to climate change.

The GLA Bill of 2006 specifies that the GLA has a specific duty to mitigate and adapt to climate change, as well as directing the Mayor to publish a statutory Climate Change and Energy Strategy for London, as well as a Climate Change Adaptation Strategy. The Mayor's Climate Change Action Plan is a precursor to these documents and sets out the issues for London as well as the measures London will take in mitigating climate change. It suggests potential carbon dioxide trajectories by which London could achieve the target of a 20% reduction in carbon emissions by 2016 and of 60% by 2025. The Climate Change Action Plan introduces a Green Homes Programme, which will include subsidies for loft and cavity wall insulation as well as programmes to improve the efficiency of social housing and to provide marketing, advice, and skills. It also introduces a Green Organisations Programme and addresses energy supply, aviation, and ground transport.

The purpose of the Mayor's Climate Change Action Plan is to "set out an aggressive agenda for London to play its part in averting catastrophic climate change by ambitiously cutting our own carbon dioxide emissions. The Mayor supports the broad view that this should be achieved through a process of 'contraction and convergence' - with the largest industrialised nations that have caused climate change required to significantly reduce their emissions, while newly developing nations are permitted to increase emissions up to a point where emissions converge and stabilise at a level which avoids catastrophic climate change."

Once carbon emission levels have stabilised at a safe level, his view is that "the world needs to operate on the basis of 'carbon democracy'; that is, that the world agrees a maximum level of global emissions and every individual is entitled to emit an equal proportion of carbon emissions within that."

The Mayor supports the growing scientific consensus is that stabilising atmospheric CO_2 concentrations at 450 parts per million (ppm) is required to avoid catastrophic climate change. Current levels are around 380ppm - up from levels of 280ppm maintained for most of human history prior to the industrial revolution. This implies a target of stabilising London and the UK's emissions at 60% below 1990 levels by 2025 and compares to the existing UK government aspiration of a 60% reduction from 2000 levels by 2050. This plan adopts these targets and prioritises actions across all sectors to achieve them.

An absolute priority for the Mayor is to work with national government to introduce a comprehensive system of carbon pricing. Such a system will catalyse further technological development and commercialisation, and indeed creates opportunities for London to host carbon-trading markets, invest in green funds, and research, develop and finance new zero and low-carbon technologies.

The Action Plan focuses on what can be achieved over the next 10 years, but in the context of the types of changes that will be needed by 2025 and beyond.

The Mayor's proposal is that by 2025, annual CO_2 savings of 19.6 million tonnes compared to business as usual are achievable through actions set out in the Action Plan. Additional action will be necessary at a national and European level to save the further 13.4 million tonnes needed each year to constrain London's total carbon dioxide emissions to 600 million tonnes between now and 2025.

The contribution from new build domestic and commercial buildings will be a small component of the overall changes necessary. New build commercial and public buildings are expected to contribute 5% of the CO_2 savings from the commercial/public building sector, and new build domestic buildings are likewise expected to contribute 5% of the domestic sector's CO_2 savings. Each of these sectors comprises 39% of the total savings (ground-based transport is the remaining 22%), thus each will contribute just 1.95% of the necessary savings and, taken as a whole, new build will represent 3.9% of the annual carbon reductions target for London by 2025. London renews itself and grows at approximately 1% per year, and thus can be expected to have changed by perhaps 15% between 2007 and 2025; a savings of 3.9% over the business-as-usual scenario in the context of projected growth of almost four times that figure does not appear to be an overly onerous target.

4.3.1 The Measures in the Action Plan

Within London, a number of initiatives will be used to achieve the requisite carbon emissions savings of 19.6 million tonnes. These are set out below and comprise measures for green homes, green commercial buildings, new build and development, and energy. Other measures on transport and aviation included in the Action Plan are not covered here.

- First, the Mayor's **Green Homes Programme** will include:
  - A London-wide offer to homeowners of heavily subsidised (and free to those on benefits) loft and cavity wall insulation;
  - A major marketing campaign to increase awareness about what actions Londoners can take to cut their emissions and reduce their energy bills;
  - A new one-stop-shop advice and referral service, available to all Londoners, on implementing energy savings measures and installing micro-renewables;
  - A pilot Green Homes 'concierge service', providing bespoke energy audits and project management of installation of energy efficiency improvements, micro-renewables and water conservation measures for the able-to-pay sector;
  - A programme of improving the energy-efficiency of London's social housing stock; and
  - Identifying skills gaps in the sustainable energy industry and developing training (in collaboration with the relevant industry bodies) to improve the skills required to install and service energy saving and micro-renewable products and systems.
- Second, the Mayor's **Green Organisations Programme** will include:
  - Better Buildings Partnership: working with and incentivising commercial landlords to upgrade their buildings, particularly during routine refurbishments;
  - Green Organisations Badging Scheme, working with tenants (both private and public sector organisations) to reduce emissions through staff behavioural changes and improved building operations; and
  - Lobbying: Both the Better Buildings Partnership and the Green Organisations Badging Scheme will be supported by a lobbying campaign focusing on key barriers to the uptake of energy savings and clean energy.
- Third, and one focus of the FALP provisions, a programme for **new build and development** will include:
  - Revisions to the London Plan requirements for new developments. The draft Further Alterations to the London Plan issued by the Mayor require new

developments to prioritise the use of decentralised energy supply, most importantly by connecting to combined cooling heat and power (CCHP) networks;

  - Further emphasis on energy efficiency through the Mayor's planning role;
  - A greater focus on energy efficiency at borough level;
  - Showing by doing: individual developments and new housing powers. The Mayor will model exemplary energy-efficiency standards both through individual developments in which the London Development Agency (LDA) is involved, and for all new affordable homes;

- Fourth, and also relevant, the Mayor's strategy on energy supply will include:
  - Dramatically increasing the rollout of combined cooling heat and power energy supply. The main source of carbon reductions from decentralised energy will come from the combined generation of heat and power locally (CCHP);
  - Rapidly developing and delivering mechanisms to produce energy from waste (without incineration);
  - Promoting the uptake of on-site renewable energy in London. Small and medium-scale renewable energy generation will be promoted through the revised London Plan standards, the Green Homes and Green Organisations Programmes, and through the Mayoral group's own installations;
  - Pursuing large-scale renewable power generation in London;
  - Making the case for a greatly accelerated programme of investment in renewable energy in the UK; and
  - Supporting carbon sequestration.

4.4 Conclusions

The FALP policies form part of a suite of policies proposed and enacted by the Mayor of London in order to achieve effective mitigation against and adaptation to climate change. As such, the measures proposed by the Mayor form part of the overall evidence base and justification for the FALP proposals.

5 FALP Consistency with National Policy

5.1 Introduction

For the London Plan to be regarded as sound or robust as a document to deliver sustainable development in London, it must conform to all national planning policy. This section considers the relationship of the FALP to PPSs and other national policy.

The FALP will make explicit changes to the Plan in respect of climate change, and thus two planning policy statements come to the fore; these are the draft Supplement to PPS 1: Climate Change and PPS 22 – Renewable Energy. However, it should be borne in mind that it is not only these policy documents with which the Plan should be in conformity, and that other parts of the Plan (which may not need alteration) are contributing to the objectives of these policy documents. Though the national policy on climate change was issued after the drafting of the FALP on the same matter, we believe that the London Plan with the FALP will conform to the requirements of the draft Supplement to the PPS. The FALP were drafted in the light of PPS 22 – Renewable Energy and, after the adoption of the FALP, the London Plan will conform to its requirements.

5.2 The Threat to London and the Role of Planning

It has been demonstrated both by the Stern Report as well as through scenarios illustrating the effects of inaction in London should planning policy not engage with climate change mitigation (see Chapter 6) that the costs of deferring action are high.

Applying this principle to London, so that it can achieve the Mayor's high level objectives set out in the introduction to the London Plan, it becomes clear that London needs a planning regime that understands and responds to the threats from climate change. The Mayor's objectives are:

- To accommodate London's growth within its boundaries without encroaching on open spaces;
- To make London a better city for people to live in;
- To make London a more prosperous city with strong and diverse economic growth;
- To promote social inclusion and tackle deprivation and discrimination;
- To improve London's accessibility; and
- To make London a more attractive, well-designed and green city.

Climate change directly threatens each of these objectives. The heat island effect, generally higher temperatures, higher winds, flooding, and greater and more intense rainfall will make living and working conditions in the centre of the metropolis more difficult, discourage investment and lead to greater, rather than lesser, inequalities between social groups.

While international and national policy, such as fiscal incentives and changes in energy supply, will have a significant impact, planning policy can also be shaped so that it continues to meet the Mayor's highest level objectives despite the challenge of climate change. The tests of energy efficiency under building control will not by themselves secure the changes in energy performance needed, and the building control process engages late in the genesis of development. A role for planning in tackling climate change will therefore complement the Mayor's use of his other powers to counter climate change, particularly in respect of energy, transport, regeneration and housing.

London Plan policy can build on the national planning policy outlined in the draft Planning Policy Statement on the subject, and guide Boroughs in the detail which their local development frameworks will need to include. In London, the Boroughs and the City of London would need to transfer the high level objectives set out in the London Plan into their local policy. Among the key things that boroughs would seek to add to their local development frameworks are:

- Policies for addressing climate change, both to mitigate against it and adapt to it;
- Trajectories for greenhouse gas emission;
- Identification of sites for zero carbon development, and
- Monitoring regimes to assess the timeliness and effectiveness of delivery.

In adopting policies to conform with the FALP, authorities will need to balance the policy objectives of securing mitigation against and adaptation to climate change with a number of long-standing restraint policies. These include heritage, conservation, green belt, biodiversity, wildlife and habitats. Arguably, balancing these restraint policies against the novel issues of climate change will be no different from, or more difficult than, resolving the tensions between such policies as growth, economic development and regeneration.

5.3 Draft Supplement to PPS 1: Climate Change

The draft Supplement to PPS 1: Climate Change sets a series of requirements for climate change policy in the preparation of regional spatial strategies and the London Plan. They fall into three parts: preparatory work, policies, and monitoring and advice.

5.3.1 Preparatory Work

The preparatory work required by the draft PPS is:

- Consideration of how the region contributes to climate change;
- Provision of a framework for integrating policies regarding land with other policies and influencing the nature of places and how they operate;
- Ensuring that the spatial strategy corresponds with national and regional targets for cutting carbon emissions;
- Consideration of the region’s susceptibility to climate change, in particular implications for built development, infrastructure and services and biodiversity; and
- Identifying and addressing cross-regional concerns.
- In preparing the FALP, these requirements have been met by work undertaken by a range of bodies sponsored or funded by the Greater London Authority. They include the Mayor’s Climate Change Action Plan, the Mayor’s Energy Strategy, London Carbon Scenarios report, and the work of the London Climate Change Agency.

5.3.2 Policies

The matrix below considers the central policy requirements that the draft Supplement to PPS 1, along with PPS 22, set for the preparation of RSS and the London Plan:

PPS policy requirement	London Plan/FALP content
Reducing the need to travel and promoting development in areas of high public transport accessibility	Existing London Plan high level policy and specific policies on transport, density, mixed use, town centres, employment, central activities zone
Promoting efficient energy supply and contributions from decentralised, renewable and low carbon energy in new developments	FALP policies on ▪ The energy hierarchy in the Mayor's Energy Strategy (minimisation of energy use, then efficient supply, followed by renewable energy) (4A.8) ▪ Decentralised energy through – o connection to existing CCHP/CHP networks, o renewable-powered site-wide CCHP/CHP, o gas-fired CCHP/CHP or hydrogen with renewables; o renewable-powered communal heating/cooling; and last o gas-fired communal heating/cooling (4a.5i) ▪ Hydrogen power should be supported and encouraged (4A.5ii).
Integrating into new and existing development more efficient energy supply and contributions from renewable and low-carbon energy sources	FALP policies on ▪ An energy demand & CO_2 emissions assessment as part of the sustainable design and construction statement (4A.2i) ▪ Waste, landfill, the energy used and transport impacts in managing waste should be minimised, and recycling, composting, and re-use should be maximized (4A.1). ▪ Construction, excavation and demolition recycling or re-use should reach 95% by 2020 (4A.1).
Identifying opportunities for carbon capture and storage	FALP policies on ▪ The production of energy from waste where recycling is unfeasible (4A.1). ▪ Renewable hydrogen produced from waste (4A.1)
Avoiding development in areas susceptible to the effects of climate change	FALP policies on ▪ Adaptation to climate change, particularly by addressing the urban heat island effect, overheating, summer solar gain, and reduction in flood risk (4A.5iii). ▪ Heat resiliency and resistance to overheating to be demonstrated by developers (4A.5iv). ▪ Identification of flood risk areas (4A.5v) ▪ Development next to flood defences should be set back (4A.5vi). ▪ Developments should incorporate sustainable drainage, in line with a drainage hierarchy (4A.5vii). ▪ Maximisation of drainage source control management (4A.5vii) ▪ Major developments should abstract and use rising groundwater (4A5.viii)
Setting regional targets for renewable energy in line with the national targets in PPS 22 for 10% electricity from renewable sources by 2010 and aspirations for 20% by 2010	FALP policies on ▪ Renewable energy is required through a 20% reduction in CO_2 emissions, to be achieved by onsite renewable energy generation (4A.7). ▪ Identification of sites for zero carbon development and locations for wind turbines, one large wind power scheme should be encouraged, and new street appliances should be powered by renewables (4A.7).
Setting regional trajectories for the expected carbon performance of new residential and commercial development to be measured over time	FALP policies on ▪ Overall 60% CO_2 reduction by 2050, 15% by 2010, 20% by 2015, 25% by 2020 and 30% by 2025 (4A.2ii)

5.3.3 Monitoring and Advice

The monitoring and advice required by the draft PPS is:

- To ensure that the impact of a RSS or the London Plan on climate change should be a key part of its sustainability appraisal;
- To ensure that the carbon reduction trajectories are part of framework for development management;
- To consider convening a broadly based advisory body; and
- To have in place a mechanism for assembling and coordinating data collection on climate change.

The FALP satisfies these requirements. Climate change has been a part of the sustainability appraisal of the FALP. (It should be noted that the requirement post-dates the original production of the London Plan). The trajectories will cascade down to the Boroughs LDDs and hence their development management functions. The London Climate Change Agency and London Hydrogen Partnership are in place to act as advisory bodies. Policies 4A.5vii, 4A.11, and 4A.1 envisage further collaborative work between agencies with interests in managing and monitoring climate change in London.

The London Plan with the adopted FALP also needs to conform with PPS 22 – Renewable Energy. This planning policy document notes the Government targets to generate 10% of UK electricity from renewable energy sources by 2010 and to double that figure to 20% by 2020. It specifies that a RSS or the London Plan "should include the target for renewable energy capacity in the region, derived from assessments of the region's renewable energy resource potential, and taking into account the regional environmental, economic and social impacts (either positive or negative) that may result from exploitation of that resource potential." The targets should be for 2010 and by 2020 with progress towards them monitored by regional planning bodies. The PPS says that targets should be reviewed regularly and revised upwards (if they are met) subject to the region's renewable energy resource potential and the capacity of the environment in the region for further renewable energy developments.

If there is a question of whether the carbon reduction targets in the FALP correspond with the national and regional targets for carbon reduction, it is important to understand the relationship between the impact of planning (on new development) and the effect of other retrofitting and behavioural change. Any target for planning will almost certainly have to push the contribution that new development can make to carbon reductions to the limit of economic and technical feasibility. Without that drive, there can be no compensation for the smaller contributions to reductions that can be achieved through the existing building stock. Furthermore, if after careful consideration it is decided that it is economically and technically feasible to drive higher reductions in carbon emissions (for instance, because of the over the odds performance that London might achieve because of its density for the character of its development), the international nature of the climate change problem would suggest that the most that can be achieved is for the good of everyone and it would be a narrow view to try to restrict to a lowest common denominator of improved performance.

5.4 Conclusions

This chapter has explained relevant national planning policy and demonstrated the concordance of the FALP proposals on climate change with that national policy. As shown by the matrix in Section 5.3.2, many of the FALP policy proposals are required by national planning policy. This forms a base upon which the remainder of the evidence lies and points to the consistency and coherence of the policy proposals.

6 Costs and Benefits of FALP Policy

6.1 Introduction

This chapter reviews the evidence on costs of different means of addressing climate change in London.

Case study material as well as existing literature and evidence have contributed to this section. Because the technologies are still relatively new, and many existing developments are demonstration projects and not of general applicability, any cost information needs to be treated with caution. We conclude, however, that the cost impacts of doing nothing to mitigate against or adapt to climate change far exceed the benefits of action, and that any additional costs incurred in development will be absorbed in the long term into the price of land will reduce the apparent payback periods of the investment.

6.2 Context

6.2.1 Balance of Costs and Benefits

It is important for decision-makers to assess and understand fully the cost implications of policy as it is drafted. In looking at costs and benefits, it is often important to consider not only the expenditure and gains derived when the development is undertaken, but to look into the longer term to consider the implications throughout the expected life of the development. This is particularly true of policy such as that to address the effects of climate change, where it is only action on a global scale that can reverse the predicted impacts of greenhouse gas emissions. Indeed, the benefits that are directly attributable to an individual development may not be all those derived during its lifetime, when climate change-friendly policy is implemented elsewhere (such as reduced dependence on carbon-rich power sources at the National Grid level).

As is demonstrated in the rest of this chapter, the cost burden of the climate change policies in the FALP is balanced by costs foregone in the impacts of climate change. A cost/benefit assessment, such as is undertaken in relation to new regulation by central government, consists of an equation valuing the additional burden on the one hand, and the benefits on the other. For instance, the partial regulatory impact assessment (RIA) of the draft Supplement to PPS 1: Climate Change notes the following costs:

- Marginal additional costs for planning authorities to undertake the necessary activities, as stipulated in the PPS, and
- Marginal additional development costs for developers, including additional design and planning costs and the costs of implementing on-site and/or off-site renewable and low-carbon energy technologies and storage.

Against this the partial RIA notes that the benefits of the policy are:

- Greater clarity within the planning regime with respect to carbon and climate change issues;
- Reduced costs associated with climate change, both in the UK and internationally, due to the adoption of renewable technologies, and carbon capture and low-carbon energy;
- Reduced environmental damage costs associated with non-carbon atmospheric emissions due to the reduced consumption of fossil fuels;
- Increased ability of developments to cope with higher temperatures without the need for expensive solutions such as air conditioning;
- Reduced health impacts associated with rising temperatures; and
- Stimulation of the markets for renewable and low-carbon energy technologies.

These are not yet fully costed, but will be should the policy become part of the PPS suite.

6.2.2 Balance Between Capital Costs and Running Costs

A key feature of the analysis in the partial RIA is that there are climate change benefits that can be valued from compliance with the proposed new policy. They are long term, and thus, unlike the one-off capital investment foreseen, are necessary to obtain planning permission. Besides the benefits set out above in Section 6.2.1, we should also add the value of reduced running costs. Taken together, these benefits can significantly reduce the apparent payback period for compliance with the policy.

Taking the energy hierarchy, we would argue that through compliance with or exceeding Part L of the Building Regulations 2006, energy consumption falls, and hence energy bills are reduced. Through the use of district energy and heat schemes, costs can also be cut, and the installation of certain renewables (chiefly wind and solar power) have almost zero running costs. So, as shown in the case studies (detailed in Appendix A3), the reduction in the need for external power is an important component of the overall viability of climate change policy.

6.2.3 Impact on Land Values

When we consulted stakeholders, we asked where any burden of climate change planning policy would fall. There was a frequently-stated view that, because development is delivered in the open market, and consumes one non-renewable good – namely land – the impact of policy intervention would ultimately be reflected in land values. If the intervention reduced developers' profit, the value would fall; if it improved it, land prices would increase.

The theory was that, by adding a burden of cost to development, the value would transfer into land values, causing a reduction as the policy is normalised. Furthermore, the certainty brought about by the recent draft Supplement to PPS 1 and the FALP to make climate change measures a standard part of development would speed that normalisation and stabilisation of land values.

We have heard anecdotal evidence that, in the residential market around London, the homeowner has been prepared to accept the burden of any added cost imposed by climate change solutions. That added cost is said not to have been an impediment to rapid sales. However, it appears that the developments in question were in the upper part of the housing market. It remains to be seen how much of the residential market would accept the cost in this way, particularly at the lower end.

6.2.4 Falling Costs Over Plan Life

Although some parts of the world have already embraced the need for climate change measures, in general, we are still at an early stage in the development and implementation of climate change friendly technology. It is inevitable therefore that the cost of the new technology currently includes a significant element of innovation costs. This is because the supply chains are not yet mature or established, and there are few competitors in the market place leaving a few suppliers to charge higher prices.

The Stern Review observes that historical experience of both fossil-fuel and low-carbon technologies shows that as scale increases, costs tend to fall. Economists have fitted 'learning curves' to costs data to estimate the size of this effect. This recognizes the fact that new technology is initially much more expensive than the established alternative, but as its scale increases, the costs fall, and in the medium to long term becomes cheaper. A number of factors explain this, including the effects of learning and economies of scale, but prediction of the rate of reduction in costs carries risk. Step-change improvements in a technology might accelerate progress, while constraints such as the availability of land or materials could result in increasing marginal costs.

The factors in the learning curve of new technology, sometimes referred to as the product cycle, are set out in Table 6.1:

Table 6.1: Product cycle production and distribution characteristics

Production and Distribution Characteristics	*Stage in the Product Cycle*		
	Early	**Growth**	**Maturity**
Technology	1. Short production runs 2. Rapidly changing techniques 3. Dependence on specialist suppliers	1. Mass production methods gradually introduced 2. Variations in technique still frequent	1. Long runs and stable technology 2. Few innovations of importance
Capital intensity	Low	High because of high rate of obsolescence	High because of large quantity of specialised equipment
Critical labour requirements	Scientific and engineering	Management	Semi-skilled and unskilled labour
Industry structure	1. Entry is 'know-how' determined 2. Numerous firms providing	1. Growing number of firms 2. Many casualties and mergers 3. Growing vertical integration	1. Financial resources critical for entry 2. Number of firms declining
Competition	Based on technology	Cost considerations creeping in	Mostly cost
Prices	High	Falling	Low Competition is fierce

(Adapted from "Hirsch, Location of Industry and International Competitiveness", Oxford, 1967)

Policy can be a key driver of demand: Once demand increases, or can be predicted to increase, new entrants will be attracted to the market with the aim of absorbing the greater demand. This drives out the higher pricing of the small number of current market players and introduces the opportunity for further innovation through competition or specialisation among suppliers. In the long term, the greater volume of activity will produce considerable economies of scale. These factors all point towards a long-term fall in the price of climate change technology, and similar changes in technology in the past have triggered equivalent price reductions in related areas of development, for instance in the price of double glazing for all types of building. The issue of cost changes over time is dealt with in more specificity later in this chapter.

An immediate objective is therefore getting the strategic policy framework in place to get development at the right scale to achieve economies of scale (particularly out of CCHP). This can in part be achieved by planning policy, but it needs to be coupled to other fiscal and incentive interventions and to education and awareness campaigns.

6.3 'Demonstration Project' Effect

We have identified only a relatively small number of projects that have reached their full implementation in our search for data on the costs and benefits of climate change policy and technology. Every one of these appears to be a demonstration project which has an element of subsidy to a greater or lesser degree. Each is backed by a sponsor or sponsors with a range of motives that make them committed to the demonstration of the technology that helps avoid of climate change. In such cases, the subsidy manifests itself in the form of:

- Over-the-odds (but fully met) costs;

- Grants (available through a number of trial but not permanent schemes);
- The promotion of a particular product for commercial reasons; or
- A combination of all of these.

We have concluded that the subsidy (real or implied) distorts the economics of each of them. It is difficult to gauge the extent of the subsidy, although it might be very considerable. Most new products or processes undergo what is often known as a 'product cycle effect', detailed below and related to issues of production and distribution characteristics including technology, capital intensity, labour requirements, industry structure, competition, and pricing strategy.

6.4 Cost of Inaction

The Stern Review concludes that the costs of stabilising the climate are significant but manageable; delay would be dangerous and much more costly. The risks of the worst impacts of climate change can be substantially reduced if greenhouse gas levels in the atmosphere can be stabilised between 450 and 550ppm CO_2e. The current level is 430ppm CO_2 today, and it is rising at more than 2ppm each year. Stabilisation in this range would require emissions to be at least 25% below current levels by 2050, and perhaps much more.

Ultimately, it is estimated that stabilisation – at whatever level – requires that annual emissions be brought down to more than 80% below current levels. Each tonne of CO_2 that is emitted causes damages worth at least $85 (at £1 = $2, this is the equivalent of approximately £43), but emissions can be cut at a cost of less than $25 (£13) a tonne. Stern estimates that if no action is taken, the overall costs and risks of climate change (from all land uses, new and existing) will be equivalent to losing at least 5% of global GDP each year. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more. In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year.

The Mayor's Climate Change Action Plan estimates that if new development continues at the rate envisioned in the London Plan and to existing standards, buildings will contribute an additional 5.1 MtC each year by 2025. Our calculations suggest that this represents cumulative additional emissions of nearly 51 MtC between now and 2025, and of over 240 MtC by 2050. This figure means environmental damage from new buildings alone, as valued in the Stern Report (above) and using its discount rate of 1%, could amount to $248 billion (£124 billion) by 2050.

6.5 Cost to Development

6.5.1 Renewable Technology Appropriateness

Only certain renewable technologies are appropriate, at the time of writing, for powering development on a large scale in London. Photovoltaic and solar heat are appropriate for meeting a portion of building energy requirements but are not currently efficient enough on a per-square-metre basis to meet the needs of taller buildings or in buildings housing multiple dwellings, as well as competing with possibilities for green or living roofs. The issues involved in urban wind speeds (see Section 10.10.1) mean that, while there is a place for, at most, a handful of large wind turbines in London, wind power cannot be usefully installed in each development. Hydrogen fuel cells are not yet available in sufficient numbers or at a low price, and zero-carbon hydrolysis of water to produce hydrogen is a further issue. As regards renewable energy, this leaves biomass heating and biomass CHP as the most significant technologies for achieving on-site renewable energy provision.

6.5.2 Costs of Energy Efficiency

In following the climate change policy advocated in the FALP, developers will first meet a higher standard of energy efficiency and hence reduce energy use in buildings. The benchmark for all buildings is compliance with the requirements of Part L of the Building Regulations 2006, which deal with the energy efficiency of new buildings and adaptations to existing ones.

When they were introduced, the government published an RIA. It suggested that the new regulations offered value for money through a cost/benefit analysis of the potential implementation of the higher standards. The national costs of implementing Part L 2006 requirements were £1,192 million. Of course, the RIA went on to show the monetary value of the benefits of the introduction of the new regulations, which amounted to £1.531 million over the expected lifetime of the measures. The regulations were hence found to be value for money, had a relatively short payback period, and delivered a profit ratio of around 1.3 The RIA stated that “Builders will be able to assemble design packages that will cost a little more to build but even in the worst cases the prospective savings will yield a profit margin over the life of the buildings”.

Compliance with Part L of the Building Regulations is mandatory. We believe that a similar analysis of the costs and benefits of exceeding the requirements of the Building Regulations – through such measures as enhanced insulation and air-tightness – would find a similar favourable result. Furthermore, the installation of other energy-efficient devices, including low energy light bulbs and high performance white goods, are also expected to have a suitably short payback period because of their lower running costs. This makes the policy of driving energy efficiency as the first step in the concept of a development one that is appealing as a strategy, and is incentivised by the subsequent stages of that strategy, namely finding low carbon heating and cooling and then installing renewables

6.5.3 Meeting the Requirements of the Code for Sustainable Homes

Recent research has looked at how significant might be the cost of reaching higher standards. The research combined both higher energy efficiency standards with the installation of renewable technology.

Research by Cyril Sweett published in February 2007 (“A Cost Review of the Code for Sustainable Homes”) found that the average additional cost of achieving Level 3 of the new Code for Sustainable Homes would be around 3% more than the previous standard of EcoHomes ‘Very Good’. The costs would range for different house types and technologies from an additional 0.4% to an additional 6.2%. This appears to suggest that the housebuilding sector can tackle climate change effectively without significant extra cost.

The benefits of achieving Level 3 of the new Code were predicted to produce a 25% reduction in carbon dioxide emissions per home, and water-usage savings of 21 litres per person per day over an average home built to EcoHomes ‘Very Good’.

The report looked at four approaches to achieving Level 3 of the Code for Sustainable Homes, applied across six different house types:

- Four traditional house types built using conventional construction methods (detached house; end terrace/semi-detached house; low rise apartment ; medium/high rise apartment); and
- Two homes built using modern construction techniques; an end of terrace house and a mid terrace house incorporating a centralised CHP system.

The four design solutions were:

- Initial energy efficiency measures, followed by use of solar thermal technology, and then by photovoltaics and biomass systems;

- Initial energy efficiency measures, initially followed by use of small-scale wind turbines and then by biomass systems;
- Development with shared energy services, such as combined heat and power (CHP). For this scenario, costs per unit are averaged for different infrastructure options for a theoretical 200 unit development; and
- Achievement of Code Level 3 without recourse to renewable energies, through the use of a whole-house mechanical ventilation system with heat recovery, and by assuming the use of proprietary construction details.

The report found that the Code would be most expensive to achieve in traditionally-built detached and terraced houses. Apartments and two house types using modern methods of construction were the cheapest.

Further analysis of results showed that costs were likely to be lowest where it was possible to use wind energy or site-wide combined heat and power (CHP) technologies. The report concluded that a planning requirement to use renewable energy would have a major impact on the strategy for meeting the Code's energy standards.

6.5.4 Costs of Renewable Energy Installation

In practice, build costs are only a proportion of final costs, and high land values in London mean that build costs can be 30% or less of the total development value. Thus, while a renewable energy measure could add 6% to build costs, that 6% may form only 1% or 2% of the total value of the development.

The most recent study of the cost implications of renewable energy installation in London were set out in London Carbon Scenarios to 2026, published by the London Energy Partnership in November 2006. The document looked at five scenarios for a carbon emission reduction of 60% by 2050. Each scenario was led by a predominant implementation strategy, namely large CHP, building and micro CHP, renewables, insulation and energy efficiency and, lastly, hybrid. The overall results of the work are shown in Table 6.2:

Table 6.2: Summary of the results of the LEP Carbon Scenarios

Scenario	Heat GWh/y	Power GWh/y	CO_2 saving ktpa	Capital Cost £M	NPV £M
Large CHP	30,296	23,587	10,442	8,392	1,192
Building and micro CHP	58,478	22,799	10,285	7,455	-531
Renewables	21,852	13,380	10,414	14,591	-4,237
Insulation and energy efficiency	38,177	14,526	10,362	10,797	-1,429
Hybrid	29,843	18,184	10,344	8,427	678

"London Carbon Scenarios to 2026", London Energy Partnership, November 2006

Because it is most like the likely implementation of the FALP, we have chosen the hybrid scenario for further explanation. For each type of technology, the work included assessing the contributions to:

- Heat and power;
- CO_2 savings;
- Capital cost;

- Payback period;
- Net Present Value; and
- Rate of return.

The results appear to be encouraging for the full implementation of the policies of the FALP. The report concluded that "CHP technologies in general give good results, apart from fuel cell micro CHP. Cavity wall and loft insulation have good economic performances, but solid wall insulation, double glazing and some renewables show highly negative NPVs".

The outcome of the hybrid scenario is set out in Table 6.3 below:

Table 6.3: Summary of results for hybrid scenario

Systems		Installed capacity by 2026	Heat GWh/y	Power GWh/y	CO_2 savings ktpa	Capital cost £M	Simple payback yrs	NPV £M	IRR %
Biomass CHP	MW_e	500	6,023	3,285	3,326	2,263	8.8	508	8.5
Large Gas CCGT CHP	MW_e	1,500	10,293	9,855	3,845	3,319	8.3	914	9.8
Gas CHP – building	MW_e	500	3,756	3,942	1,238	466	10.9	99	9.5
PV – domestic	MW_p	100	0	96	55	288	53.6	-159	n/a
PV – large	MW_p	100	0	96	55	230	52.7	-127	n/a
Wind – large	MW_e	50	0	110	62	44	5.0	49	24.8
Wind – domestic	MW_e	50	0	55	31	79	23.4	-19	-2.2
Solar – thermal	Dwellings	100,000	152	0	37	331	72.6	-215	n/a
Biomass boilers – large	MW_{th}	250	1,533	0	372	50	n/a	-97	n/a
Biomass boilers – domestic	Dwellings	25,000	372	0	90	117	113.2	-87	n/a
GSHP	Dwellings	5,000	66	0	4	19	n/a	-22	n/a
Micro CHP – stirling	MW_e	100	3,504	526	299	192	7.8	45	10.5
Micro CHP – fuel cell	MW_e	50	219	219	83	178	65.1	-106	n/a
Cavity wall insulation	Dwellings	1,000,000	825	0	200	80	2.7	128	56.4
Loft insulation	Dwellings	1,500,000	247	0	60	40	4.5	27	24.4
Double glazing	Dwellings	800,000	155	0	38	225	41.6	-131	n/a

Systems		Installed capacity by 2026	Heat GWh/y	Power GWh/y	CO_2 savings ktpa	Capital cost £M	Simple payback yrs	NPV £M	IRR %
Solid wall insulation	Dwellings	1,000,000	619	0	150	300	13.5	-80	n/a
Heat from powers stations	MW_e	250	2,081	0	399	208	8.4	-49	n/a
Totals			**29,843**	**18,184**	**10,344**	**8,427**		**678**	

"London Carbon Scenarios to 2026", London Energy Partnership, November 2006

An earlier study of the costs implementing renewable energy was undertaken by Faber Maunsell and the London Energy Partnership, resulting in the "London Renewables Report" of September 2004. This was a more comprehensive toolkit for planners, developers and consultants on renewable energy. It sets out in detail the technical, performance and likely planning issues over various types of renewable energy supply. An important element of the toolkit is a series of worked examples of the implications of implementation, and including the cost impacts.

The methodology followed in the worked examples was to look at a range of different types of building project and to assess the impacts of installing renewable energy technology in them. The types of building project included various types of retail, office, industrial, warehouse, hotel, leisure, education and residential development, but not all development types could be found to demonstrate each of the renewables tested. The costs of implementation were considered in a London context.

While we have to treat any interpretation of the figures in the report with caution, drawing on this work we can see that, in 2004, there was a range of benefits for a given increase in costs, and that the range was quite wide. Table 6.4 gives an analysis of the main findings:

Table 6.4: Costs of renewable energy in buildings

Typical Building Types	Base build cost (£/m2/ gifa)	Estimated annual carbon emissions (kgC/m2)	Ground Source heat pumps		Ground Cooling		Biomass heating		Biomass CHP		Solar water heating	
			Cost inc (%)	**Carbon saving (%)**	**Cost inc (%)**	**Carbon saving (%)**	**Cost inc (%)**	**Carbon saving (%)**	**Cost inc (%)**	**Carbon saving (%)**	**Cost inc (%)**	**Carbon saving (%)**
Centre retail block	850.00	37.73	4.40	10.80	4.30	6.20	-	-	-	-	0.20	0.40
Small retail unit	750.00	21.62	1.10	11.40	-	-	-	-	-	-	-	-
Centre prestige office	1800.00	33.07	1.40	6.80	2.20	6.70	-	-	-	-	-	-
Suburb Standard Office	1400.00	19.96	1.80	10.20	2.00	7.40	0.80	13.10	-	-	0.20	0.90
Infill Nat Vent office	1200.00	8.06	1.80	20.60	-	-	0.80	26.50	-	-	0.20	1.80
Suburb Industry	550.00	16.80	9.60	23.00	-	-	4.50	29.50	6.50	56.40	0.50	1.00
Suburb Warehouse	400.00	10.63	9.70	26.70	-	-	-	-	-	-	-	-
Centre hotel	2200.00	26.55	2.40	16.00	1.10	4.00	-	-	1.60	39.50	0.70	5.10
Suburb Care home	1200.00	10.95	2.40	20.60	-	-	1.10	26.40	-	-	0.20	1.50
Suburb Med Density Hsg	1100.00	9.04	3.00	14.60	-	-	2.60	49.70	-	-	1.30	12.00
Infill Med Density Hsg	1400.00	9.04	2.30	14.60	-	-	2.10	49.70	-	-	1.00	12.00
Centre Res Tower	1600.00	8.62	-	-	-	-	1.60	47.20	1.10	42.10	0.90	12.50
Suburb school	1200.00	9.60	3.50	27.20	-	-	1.30	34.90	-	-	0.20	1.80
Suburb sports centre	2100.00	36.69	5.80	20.60	-	-	2.20	26.50	3.20	50.80	1.80	15.00

"London Renewables Report", Faber Maunsell / London Energy Partnership, September 2004

The current cost of renewable energy varies considerably by technology. In all cases, the actual value depends on the form of the development and how heat is used. Opportunities also differ between individual developments. Currently, the evidence shows that biomass systems are to be preferred on cost grounds because they offer a considerably higher reduction in carbon emissions for a relatively small percentage increase in cost. Given the more effective use of primary energy in CHP schemes, it lends further weight to a preference for this to be installed in new development. More specific findings are as follows:

- For ground source heat pumps, for a 1-9% cost increase, it is possible to make a carbon emissions saving of between 7% and 27%;
- For ground cooling, a cost increase of between 1% and 4% can lead to a carbon saving of between 4% and 7%;
- For biomass heating, a cost increase of between 1% and 5% can create carbon savings of between 13% and 50%;
- For biomass CHP, a cost increase of between 1% and 7% can lead to a carbon saving of between 40% and 56%; and
- For solar water heating, increased costs ranging from less than 1% and 2% can generate carbon savings of up to 15%.
- Accurate data is not available for photovoltaics, but at the current time it is generally assumed to be higher than most other technologies.

We note that this information is drawn from a 2004 report and, as explained later in this chapter, we expect the cost of renewable technology to fall over time. We therefore assume that the Faber Maunsell figures are pessimistic long-term estimates of the additional costs of renewable energy supply.

According to the Cogen Europe UK Micro-CHP Fact Sheet (available online at http://www.cogen.org/Downloadables/Publications/FactSheet_MicroCHP_UK.pdf), as of March 2005 there were four micro-CHP products on sale in Britain. It gives two examples of micro-CHP units; in the first, installed in a 3-bedroom semi-detached house, the additional capital cost is £500, and the payback period is 3.3 years. In the second, a larger, £12,000 unit is installed in a sheltered housing development. In this case 5 tonnes of CO_2 are saved each year, and payback is achieved in 14 years.

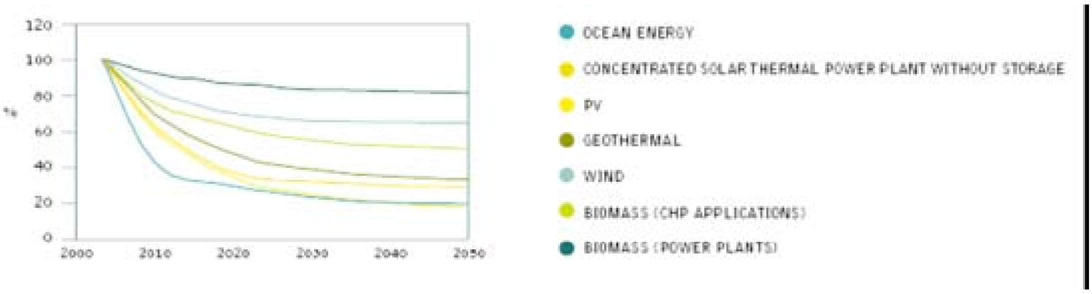
In relation to consideration of costs, a number of implementation factors are relevant:

- Case study evidence suggests that the practical realities of installing renewables technology must be considered alongside costs. For example, several large office developments have chosen to adopt PVs rather than biomass due to practical considerations.
- An important feature of the policy is that it allows flexibility as to the choice of renewable technologies specified. Case study evidence, together with the London South Bank University research, suggests that while it is possible to meet renewables targets, there will also be cases where it is not for good reasons. In light of this, evidence from the case studies also suggests that the Mayor has accepted this situation. The important point is that developers fully assess the opportunities and that solutions can be justified as the best possible to meet targets.
- Besides the costs of investing in climate change technology, account must be taken of the benefits of reduced CO_2 emissions, which can be thoroughly costed.

6.5.5 Forecast Cost Changes

The European Renewable Energy Council (EREC) and Climate & Energy Unit Greenpeace International "Energy [R]evolution" report (January 2007) projects forward the future development of investment costs for renewable energy as derived from 'learning factors' or 'progress ratios' – these reflect the rate that costs fall as the output rate from a specific technology doubles (a ratio of .75 means that costs will fall by 25% each time the installed base doubles):

Figure 6.1: Capital costs for renewable energy over time



"Energy [R]evolution", Greenpeace / EREC, 2007

The Cyril Sweett work on the costs of building to Level 3 of the Code for Sustainable Homes further suggests potentially higher cost savings (as well as concluding that the average cost of achieving Level 3 of the Code on top of the BRE Eco-Homes 'Very Good' standard is 3%). Drawing upon other sources, Cyril Sweett found that that costs are reduced to 92% of the previous quantum each time capacity doubles for community heating, heat pumps, and solar hot water, and that cost reduces to 82% of the previous quantum each time installed capacity of micro CHP, fuel cell CHP, PV or LED lighting doubles.

Table 4A.1i of the FALP sets out the targets for installed Renewable Energy capacity to 2020 in London. Assuming that in 2010, 50 biomass-fuelled CHP plants are installed, and that in 2020, this number has trebled to 150, it can be assumed that the cost of the technology in 2020 will have dropped to 78% of the cost in 2010; this appears to corroborate the line taken by the costs for biomass CHP in the "Energy [R]evolution" graph in Figure 6.1. If take-up is even across the EU as opposed to simply the UK, costs fall further, as in Table 6.5:

Table 6.5: Capital costs of renewable generation over time given EU take-up

	Heat Pump	Community Heating	Solar HW	Energy efficient fridge	LED lighting	New insulation material for housing	Biomass	B1 Wind	Stirling dCHP	PV	Fuel cell dCHP
Current cost	8000	4000	3250	50	20	10000	3000	20000	2000	12600	5000
2050 capital cost UK 40% House	7360	3680	2328	18	5	2634	613	2749	185	642	255
2050 capital cost EU 40% House	5731	2866	1813	14	3	2051	338	1516	102	354	140

Hinnells, M., "The cost of a 60% cut in CO_2 emissions from homes: What do experience curves tell us?", paper given at BIEE Conference, Oxford, 2005

Taken together, these reports corroborate each other; they suggest that the investment costs of biomass generation for CHP applications can be predicted to drop to approximately 60% of the current costs by 2025. This means that the time required for payback of the capital costs of installed capacity will fall as well as that the continued savings produced by lower electricity costs per kWh are extended.

Cost scenarios are very sensitive to energy prices as supplied by the National Grid. If the cost of supplied energy doubles, the payback time to offset the capital cost of installing renewable electricity generation can be halved, as shown by Table 6.6 below:

Table 6.6: Simple payback periods for renewable energy

	Heat Pump	Community Heating	Solar HW	Energy efficient fridge	LED lighting	New insulation material for housing	Biomass	B1 Wind	Stirling dCHP	PV	Fuel cell dCHP
Current cost effectiveness (years)	13	15	37	2	6	53	15	29	21	126	30
Cost effectiveness in 2050 (UK 40% House today's energy prices)	12	14	26	1	2	14	3	4	2	6	2
Cost effectiveness in 2050 (UK 40% House double energy prices)	7	8	16	0.4	1	9	2	2	1	3	1
Cost effectiveness in 2050 (EU 40% House double energy prices)	5	6	13	0.3	1	7	1	1	1	2	1

Hinnells, M., "The cost of a 60% cut in CO_2 emissions from homes: What do experience curves tell us?", paper given at BIEE Conference, Oxford, 2005

Normalisation is another factor which will have a catalytic effect on the movement of prices for climate change mitigation technology. As the installed base of technology becomes larger and as the development community becomes more familiar and comfortable with specific measures, costs will both come down and be incorporated as a matter of course into developments or, ultimately, into land costs.

6.6 Conclusions

Besides the costs of investing in climate change technology, account must be taken of the benefits of reduced CO_2 emissions, which can be thoroughly costed. If we follow the policy in the FALP, reduced energy use through design and behaviour can contribute to a cost/benefit circle. This chapter has demonstrated the very significant costs of inaction and set out the benefits that can be achieved through following the FALP policies today at cost relatively lower than that of inaction. It is widely agreed that the extra burden of cost that is imposed by the FALP will eventually find its way into reduced land values. In the meantime, the upper end of the residential market appears willing to absorb some climate change costs. Economic modelling has shown that a range of climate change technology is feasible for use in London and has a positive net present value. As innovation costs fall, the payback periods for investment in climate change technology get shorter.

7 Policy, Planning, and Design

7.1 Introduction

Many factors are critical to the success of planning policy. This chapter therefore considers some of the evidence of options, issues, and challenges with which developments seeking to deliver climate change mitigation and adaptation should engage. These include the administrative deliverability of policies and the balance of costs of benefits associated with them for both public authorities and the development sector. Issues covered here include development management and development design, skills and resourcing in planning authorities, and other aspects affecting stakeholders in the planning process.

7.2 Addressing Scepticism That Targets Can be Met

Although the technology for meeting targets is not yet available in a mature market and may seem relatively expensive, it certainly exists. It has been shown to be capable of installation and also to work, but yet stakeholders have been somewhat sceptical that targets set for carbon emissions can be met. This is probably a natural reaction to the challenge of 'the new', but also suggests that minimum compliance with rules and regulations is foremost in the minds of most developers and others involved in the development business.

High-level policy is therefore important to drive a change in attitudes, and planning can play its part in this. If a range of policies are successful in driving change and innovation, we could see a repeat of the example of the legislation that drove and continues to deliver a reduction in vehicle exhaust emissions. Despite initial resistance, emissions targets produced significant and creative developments in automotive engineering, and today car makers are vying to produce the cleanest vehicles. Policy needs to drive an equivalent and equally effective change in relation to carbon emissions.

7.3 Appropriate Role of Technology

All the stakeholders with whom we have spoken have recognised the significant, indeed key, role of technology in delivering solutions to policy for climate change. This is likely to be because of the fast rate of change that is going on in the hardware and other kit available to tackle climate change, and the way that innovation continues apace. For instance, work on the wider and more affordable development of hydrogen fuel cell power units and, separately, on the harnessing of up and down wave motion to drive a continuous electricity generator turbine are innovating processes that are widely known in climate change technology.

7.4 Planning for New Technologies and Lifestyles

As has happened in the past, planning needs to take account of and be prepared to accommodate 'the new'. It would not, of course be 'planning' if it could not (or did not want to) foresee (but not necessarily to predict) future change. Sometimes such change will be a challenge to the existing order and will, at first sight, seem to run contrary to established policy and received wisdom.

In relation to climate change, it is necessary to draft planning policies that will accept future technology change, even though we cannot say what those changes might be. The over-riding need is therefore for a balance to be struck between over-prescriptive and over-generalised policies. The requirement is for a regime with flexibility to deliver in a range of as yet unknown circumstances, but with sufficient robustness to ensure that the spirit of the policies is carried forward in very new development.

7.5 Normalisation

Planning has a key role in assisting in the normalisation of measures for climate change mitigation and adaptation. By this we mean the making such mitigation and adaptation more normal, typically by conforming to some rule. This process has begun to take place in relation to the regulation imposed in building control. Planning can add to it at a different and potentially important part of the design process. As we have already noted, the location of development and its disposition on the site may be as significant as the performance of the structure as controlled through the building regulations.

7.6 Education and Awareness

All the stakeholders with whom we have engaged in the project have told us that raising the public profile of the impacts of climate change and the means with which we can mitigate it and adapt to it are very important policy activities to assist in achieving greenhouse gas reduction targets. In the first instance there is a pressing need to overcome the minimum compliance attitude brought about by some interpreters of legislation and policy. Unless developers and occupiers are seized by the wider need to contribute to the reduction in CO_2 emissions – as some high profile household names have already done – London will only make incremental steps towards the targets rather than bigger strides.

Aside from the professional participants in planning, a wider education and awareness programme is needed to encourage retrofit of climate change technology on and in buildings not subject to the planning process.

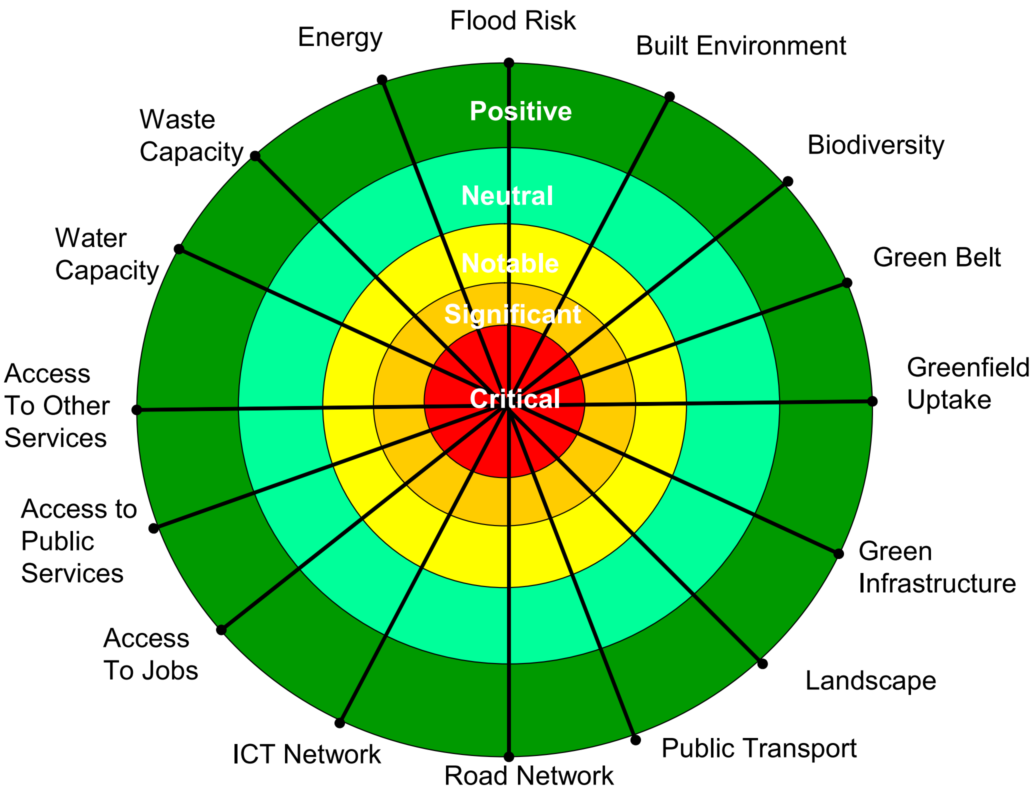
7.7 Development Location

Our discussions with stakeholders have concluded that, to ensure the most beneficial climate change impacts, it is crucial that planning take a strategic view about the most suitable form and location of development, including that which is intended to be 'zero carbon'. That strategic view links together a number of planning policy areas (described below) in a virtuous circle of co-ordinated high level policy actions. Furthermore stakeholders agree that such locational issues need to be tackled at a strategic level, because it is that level that addresses the scale of development that brings the biggest mitigation effects or the most successful adaptation solutions. This implies that there should be a hierarchy of planning policy that feeds down to the sub-region or borough level to find sites of the right size and distribution across the metropolis to make the contribution needed to addressing climate change.

In London, the impacts of rising sea levels are particularly difficult to address in planning terms. If London is to continue as a thriving city in its current situation, the location of development will have to continue in areas threatened with potential inundation due to sea level changes. A substantial proportion of the city is currently adequately protected from the effects of rising sea level by the Thames Barrier, which will continue to be effective during the life of the London Plan. However, much of the area of London is liable to be lost in the most severe predictions beyond the life of the Plan, and further consideration will need to be given to how it might be protected.

Identifying in a rigorous manner the right location for development, where climate change impacts are minimised, will possibly require the creation of new modelling and site selection techniques. These would have to be based on the policy criteria set out below, but might also consider other planning policy aspects such as the application of restraint policies, including green belt, heritage, and nature conservation. Models for selecting sustainable locations are emerging; these take into account general planning issues and policies as well as specific indicators relating to climate change. The factors included in one such model are illustrated by the graphic in Figure 7.1 below:

Figure 7.1: Arup model for sustainable development location



7.8 Transport Access

For more than a decade, transport policy has encouraged the location of development in places that are consonant with the requirements of climate change mitigation and adaptation. PPG13 – Transport, and its successor, PPS 13, have both stated that there is a need to reduce dependence on the private car because of the consumption of fossil fuel, the air quality impacts, and the relative inefficiency of travel by motor car.

Despite this policy thrust, transport remains a significant contributor to climate change. Policy therefore needs to use all means to reduce the negative impacts of transport and use of transport in the most effective and efficient way. In fact, this is very much in line with existing policy of encouraging development where transport accessibility is high, and the development of public transport systems to open up new areas suitable for development.

Existing policies in the London Plan on transport chime with climate change objectives. Chapter 2 says:

> Spatial policies cannot be considered in isolation from their links to existing and proposed transport accessibility and capacity. London benefits from a well developed public transport network, which includes the Underground, National Rail services and an extensive bus network, which provide a high level of transport accessibility.…The central area is particularly well served and town centres also have good levels of public transport accessibility. The current network is well used and in some places it operates at or close to capacity. A programme of public transport improvements has been developed to address current problems of movement and support the expected growth.
>
> The transport policies…seek to assist in achieving spatial development priorities by integrating development with existing and

future public transport infrastructure and services as well as exploiting existing areas of good public transport accessibility. Future public transport improvements include those that support the development of East London, growth in Central London, Opportunity Areas and Areas for Intensification and better access to town centres and Areas for Regeneration.

Chapter 3 includes these policies:

Policy 3C.1 Integrating transport and development

The Mayor will work with TfL, the Strategic Rail Authority, the government, boroughs and other partners to ensure the integration of transport and development by:

Encouraging patterns and forms of development that reduce the need to travel especially by car

Seeking to improve public transport capacity and accessibility where it is needed, for areas of greatest demand and areas designated for development and regeneration, including the Thames Gateway, Central Activities Zone, Opportunity Areas, Areas for Intensification and town centres

In general, supporting high trip generating development only at locations with both high levels of public transport accessibility and capacity, sufficient to meet the transport requirements of the development. Parking provision should reflect levels of public transport accessibility.

Policy 3C.2 Matching development to transport capacity

The Mayor will and boroughs should consider proposals for development in terms of existing transport capacity, both at a corridor and local level. Where existing transport capacity is not sufficient to allow for travel generated by proposed developments, and no firm plans exist for a sufficient increase in capacity to cater for this, boroughs should ensure that development proposals are appropriately phased until it is known these requirements can be met. Developments with significant transport implications should include a Transport Assessment and Travel Plan as part of planning applications.

Policy 3C.3 Sustainable transport in London

The Mayor will and strategic partners should support:

- High levels of growth in the Thames Gateway by substantial new and improved transport infrastructure. Opportunity Areas and Areas for Intensification, particularly in east London, should be supported by improved public transport.
- Access improvements to and within town centres and their residential hinterlands by public transport – including by improved bus services, walking and cycling – and between town centres by improved bus services, more frequent rail services and, where appropriate, new tram and bus transit schemes.
- Improved, sustainable transport between suburban centres, particularly by enhanced bus services, walking and cycling and by greater integration between bus, rail and underground services.

- Enhanced bus services, pedestrian facilities and local means of transport to improve accessibility to jobs for the residents of deprived areas.

The need is to complement the thrust and direction of these policies with new ones related to similarly-aligned climate change objectives.

7.9 Density/Mixed Use

Like existing policy on transport, meeting climate change objectives will not significantly change policy in the London Plan towards density and mixed use in new developments. This is because it ties with the thrust of earlier policy to encourage suitably high density development of mixed uses. By ensuring that density is appropriately high, there will be a reduction in the unnecessary use of carbon fuels, and the right mix of uses to ensure that journeys are cut to minimum. Chapter 4 of the London Plan says:

> *Policy 4B.1 Design principles for a compact city*
>
> The Mayor will, and boroughs should, seek to ensure that developments:
>
> - maximise the potential of sites
> - create or enhance the public realm
> - provide or enhance a mix of uses
> - are accessible, usable and permeable for all users
> - are sustainable, durable and adaptable
> - are safe for occupants and passers-by
> - respect local context, character and communities
> - are practical and legible
> - are attractive to look at and, where appropriate, inspire, excite and delight
> - respect the natural environment
> - respect London's built heritage.
>
> These principles should be used in assessing planning applications and in drawing up area planning frameworks and UDP policies. Urban design statements showing how they have been incorporated should be submitted with proposals to illustrate their design impacts.
>
> *Policy 4B.3 Maximising the potential of sites*
>
> The Mayor will, and boroughs should, ensure that development proposals achieve the highest possible intensity of use compatible with local context, the design principles in Policy 4B.1 and with public transport capacity. Boroughs should develop residential and commercial density policies in their UDPs in line with this policy and adopt the residential density ranges set out in Table 4B.1. The Mayor will refuse permission for strategic referrals that, taking into account context and potential transport capacity, under-use the potential of the site.

These policies on density and mixed use need to be complemented with a revised climate change emphasis (Chapter 4 of the London Plan contained an older, but now out-of-date, version of climate change policies for London).

7.10 Scale

The final major factor which must be taken into account in identifying sites is the threshold for cost-effective implementation of appropriate climate change measures. This arises out of a number of factors including the fact that CCHP in particular has heavy infrastructure costs, the realistic size of distributed heat networks (before losses become too great to make them efficient), and that biomass and gasification will only become viable at a certain scale of activity. The full climate change and economic benefits of climate change focussed development can only realistically be recouped (in economic and carbon reduction terms) through an adequate scale of development.

Our discussions with stakeholders have suggested that a development including 1,000 homes is the starting point for independent electricity generation. Such a development might also include industrial and commercial uses, and indeed such a mixed use scheme might use the balance of power and heat from a CCHP scheme more evenly. The implication is that locational policy will need to recognise that the scale at which development is contemplated may be considerably larger than is common, perhaps at a scale that was more common when new towns were being contemplated.

This issue has already been recognised. Examples of current planning for zero carbon include Stratford City and the Thames Gateway, which are among the largest developments being undertaken in the UK.

7.11 Masterplanning

Having identified sites for development in line with climate change principles at strategic level, there is a second stage need to take a masterplanning approach to deliver full effects of mitigation and adaptation at the local level. Stakeholders agree that this is a necessary step in relation to many of the ‘softer’ elements of building design and layout. In broad terms, the actions fall into two categories:

7.11.1 Urban Design

The first design issue is identifying and implementing a suitable masterplan layout that separates and shows which of the uses will depend on which climate change measures. There was broad agreement among the stakeholders we consulted that the most significant of the measures to be considered at this stage was the opportunity for naturally ventilated buildings. Where adequate master planning could take place, a combination of the street layout and use of car free areas could reduce sound and poor air quality that could otherwise be an impediment to the use of natural ventilation. Among the key features for this concept were keeping the car at margins of sites, using buildings where uses dependent on air-conditioning were located as barriers to sound and poor air quality, and creating pedestrian areas in the middle. In the same way as we concluded that the scale of development needed for effective CHP had to reach a particular threshold (see above), there is a similar conclusion in relation to masterplanning that some climate change policies can only be effectively implemented at a considerable scale – perhaps larger than encountered. It points back to a strategic approach to the location of zero carbon sites. We further note that the prospect of including CHP in a development or a group of developments, and of securing the resultant heat and energy benefits, will encourage collaborative working in masterplanning.

7.11.2 Environmental Management

On top of the control of air and noise for natural ventilation, there is a second range of factors to be taken into account to achieve a successful climate change–friendly development. Their aim is to reduce energy needs by ensuring that temperatures do not rise unnecessarily during the day and add to the heat island effect in London. Avoidance of this negates an increase in the need for cooling, and hence a higher energy demand. Significant tools to achieve this are green grids, a sensitive and effective disposition of open space, and the use of green roofs. These features also help to address increased run-off during rainfall and can delay or avoid the need for increased sewer capacity.

A secondary need in managing the environment is taking into account the impacts of any combustion plant located in or near a development. The issues to have regard to are:

- Prevailing wind;
- Noise and air quality;
- Servicing needs, including the delivery of fuel (if not piped or reliant on CHP located on another site); and
- The location of combustion plant on nearby sites (if it is the CHP plant).

7.12 Development Layout, Building Design and Form

A range of adaptation measures might be used to reduce the impacts of climate change on buildings. To the extent that it is possible, they need to be incorporated into planning policies to them in such a way as to contribute to the targets for reduce carbon and greenhouse gas emissions. The main features for which provision needs to be made are:

Issue	Principle	Design impacts
Orientation	Sun and wind	Managing solar gain Permitting effective natural ventilation
Solar Capture/Avoidance	Balance of natural warming in winter (to avoid dependence on fuel for heating) and overheating in summer	Use of blinds/louvres/grilles to adjust conditions Natural angle of sun (in winter aids greater warming during short days, in summer higher angle makes direct heating less) Shadowing to avoid summer insolation or to make most of it in winter
Cooling	Day and Night cooling	Heat pumps Natural ventilation (but note need for compliance with security needs)
Ventilation	Avoidance of a/c unless needed by specific occupiers	Design for natural ventilation Assist ventilation with natural turbines (not forced air)
Floor Plan Depth	Reducing floor plates	Ensure adequate light in all usable parts of building Facilitate natural ventilation
Facades	Controlling heat - avoid loss in winter and gain in summer	Thick walls, greater mass and smaller apertures Avoid current fashion for floor to ceiling glass on sunny sides without thinking of the consequences of same
Insulation and Materials	Controlling heat - avoid loss in winter and gain in summer	Compliance with or exceeding Building Regulations Providing air-tightness (but not at expense of opening windows) Roof space and wall insulation Green roofs
Recycled or managed forest construction materials	Avoiding use of embedded carbon in building materials	Recycled/low carbon materials Renewable sources of wood

Drainage	Reducing water usage and coping with higher rainfall	Use of grey/ground water and rainwater harvesting SUDS Minimising run off Porous surfaces (plus capture of potential pollutants/contaminants)

As part of the forthcoming London Office Policy Review 2007 commissioned by the GLA, research is being undertaken to assess the implementation of climate change mitigation and adaptation measures within the commercial office sector. This work will explore this issue with a view to identifying the levers that might encourage more widespread demand for climate change measures and a more positive perception of them throughout the development industry.

7.13 Behavioural Adaptation

A point made by many of the stakeholders with whom we have spoken during the course of this study is that there is no point in having renewable or low carbon technology installed in new or old buildings if the technology is not used or is not used properly. It follows that there a further stream of education and awareness activity needs to address occupier behaviour. Among other things, it could be used to instill a need for lower energy consumption, which in turn should accelerate the change over to more energy efficient practices, such as low energy light bulbs, and reduced internal heat temperatures. These practices may also feed in a virtuous circle back to domestic activity.

The sorts of behaviour that need to be addressed are:

- Misunderstanding of mitigation and adaptation equipment;
- Mismanagement of systems (including leaving heating and lighting on during unused periods of property occupation, excessive water use etc);
- Failure to deal with summer overheating – with short term mitigation through the use of air-conditioning or portable fans; and
- Provision of time heaters in buildings with adequate (but not properly used) low-carbon heating systems.

All these actions could, perversely, end up increasing carbon output, rather than reducing it, even though the property occupied appears to meet the climate change policy.

A further area that needs to be addressed in certain commercial sectors is the image of the company and conformity to high-carbon behaviour because it is the peer group norm. Part of this may lie at the door of influencers of style, such as architects and interior designers. Key among the issues that need to be tackled are:

- Desires for offices of particular design styles and technical specification (including glass fronted buildings and high levels of air conditioning);
- Sales and marketing techniques relying on high energy-consumption environments (such as bright lighting);
- Attitudes to energy prices in balance sheets, which are generally small components of the overall costs of many commercial enterprises, and thus represent little incentive to economy;
- Expectations of the short term costs that might come from climate change friendliness; and
- Willingness to pay more for eco-homes.

7.14 Skills

7.14.1 Local Authority

Despite the way in which regulation and guidance can ameliorate the potential effects of additional policy in plan making and development management, our work with stakeholders has identified that the resource implications is still a considerable worry for local planning authorities.

Until the companion guide and other tools are completed, authorities are unsure how they will be able to meet the challenge of the new policy drive. This is because they perceive the creation of a new specialism involved in planning.

The immediate consequence appears to be a need for additional staff in planning departments or funds to pay consultants. Supervising consultants may be difficult for authorities without a comprehensive and developed understanding of the policy, which at this stage is only present in a handful of London authorities. In any event, consultants may feel a conflict of interest between their work for applicants and that for authorities and not necessarily be willing to undertake the work.

Additional resource is on offer to local planning authorities through the housing and planning delivery grant – and there is emphasis on the production of local development documents, as well as development management performance, in the distribution of that resource. However, the climate change work needs to be prioritised and skills developed on a steeply rising learning curve. We note that graduates from planning courses are now emerging who are aware of the range of climate change issues.

Without an increase in the skills generally available to authorities, we note that stakeholders take the view that authorities are already fully committed by the requirements of Local Development Schemes to the work they are doing on Local Development Document production, and improvements in development management performance. Many authorities fear that until they are up to speed on the subject they will be overwhelmed with climate change policy related analysis, or have the wool pulled over their eyes by unscrupulous applicants, or both.

7.14.2 Wider Building Experts

Besides the capacity in local authorities, and while again it is not strictly a matter for planning policy, there is a demand for a wider RTPI-qualified capacity to advise applicants on the measures needed in their proposals s before they are the subject of planning applications. Our work with stakeholders has also identified a need for a wider qualified capacity to advise building owners/occupiers more generally on solutions to climate change issues. It was suggested that this might come from the RICS, to complement work already done by those qualified on the Building Regulations. We also understand that there are suitable modules and courses which would fill this current vacuum.

At a more practical level, and still outside planning policy, is a need for skills among day-to-day maintenance workers and operatives about the use and repair of climate change technology. Unless installed machinery can be run efficiently and effectively, and kept working when it breaks down or needs adjustment, planning policies will not be delivered satisfactorily.

7.15 Supply Chain Risk

Earlier in this chapter we noted the immaturity of present state of the market in climate change technology and skill. In short, the present market in hardware is characterised by the fact that many suppliers are from mainland Europe where demand and supply have been stimulated by tighter regulation on climate change matters that has yet to reach the UK. This shows that a market can develop successfully if nurtured by appropriate regulation and incentives.

However, in the UK, stakeholders currently feel that this early stage of the market is a risk. Because of the immaturity of supply they are trying to assess how great a risk it is and finding it difficult to reach a conclusion. For instance, they ask themselves whether they can put their trust in the supply of biomass (at its current market price) when none of the economies of scale have played in. They ask 'what if, having installed biomass boilers, the market collapses and we have no guaranteed supplier for them?'.

Currently the high level of innovation costs (as already mentioned) in overall prices for climate change technology and fuel, are slowing down uptake of the products. This is tending to slow down the process of driving out innovation costs and is hence acting as a brake on the market. This is rather a chicken-and-egg situation which regulation and incentive measures need to drive out. Without such regulation, potential users of climate change products are clear that the long term cost will fall, but they are not clear when this will happen, how quickly, or by how much.

One risk operates almost in the reverse way. As is always the case, an intervention, once made, is hard to end (if its withdrawal can be decided at all) without potentially distorting and disrupting effects. There are a number of grants and subsidies in place that help to understate the full cost of implementation of climate change measures. While they are stimulating the market and helping it grow, they cannot be expected to last for ever; indeed, they will not last for ever, because Budget 2007 said that many of them were due for review in the future. Stakeholders are therefore not sure the degree to which current cost plans can be carried forward.

7.16 Conclusions

This chapter has reviewed evidence ranging across planning and designing for sustainability, including addressing mitigation against and adaptation to climate change. These issues are central to delivery of wider strategies for tackling climate change and should be borne in mind particularly as the energy-specific provisions of the FALP policies are considered.

8 Energy

8.1 Introduction

Energy is at the heart of climate change mitigation. This is because it is the means of energy generation which forms the basis of much greenhouse gas emission, and thus of climate change.

The FALP policies in Chapter 4A revolve around the generation and supply of electricity and heat. In essence, the focus of the Mayor's policy is on promoting sources of energy which are carbon-friendly and on the generation of electricity locally. The FALP policies say that:

- The Mayor's Energy Strategy is to be supported;
- An energy demand & CO_2 emissions assessment will be required as part of the sustainable design and construction statement;
- The energy hierarchy is to be followed as the primary concern: First, the minimisation of energy use, then efficient supply, followed by renewable energy;
- Decentralised energy is to be included where possible, first through connection to existing CCHP/CHP networks, second by renewable-powered site-wide CCHP/CHP, third by gas-fired CCHP/CHP or hydrogen with renewables, fourth by renewable-powered communal heating/cooling, and last by gas-fired communal heating/cooling;
- Renewable energy is required through a 20% reduction in CO_2 emissions, to be achieved by onsite renewable energy generation;
- In addition to the 20% renewables requirement, sites for zero carbon development and locations for wind turbines should be identified, one large wind power scheme should be encouraged, and new street appliances should be powered by renewables;
- Hydrogen heat and power should be supported and encouraged;
- Adaptation to climate change will be promoted, particularly by addressing the urban heat island effect, overheating, summer solar gain, and reduction in flood risk; and
- Heat resiliency and resistance to overheating should be demonstrated by developers.

To explain the justification of these FALP policies, Chapters 9 and 10 deal with the role of energy in the built environment and the means by which it is generated, and the method of distribution adopted. The key issue for Chapter 9 is the balance between delivery over the National Grid and generating energy locally; for Chapter 10, it is the adoption of renewable energy.

8.2 Energy Use in Buildings

The FALP addresses energy generation simply because buildings and developments, which are a subject of planning policy, are major users of energy. As Chapter 3 has suggested, the built environment accounts for over half of all London's carbon emissions, and these arise primarily through energy use for heating, cooling, and electric power.

In "The Urban Environment" (March 2007), the Royal Commission on Environmental Pollution summarised the key features of energy use in buildings (and hence the notional carbon footprint of the buildings) and the issues that need to be addressed to reduce carbon emissions. It said:

> Buildings are responsible for more than 45% of total UK carbon dioxide (CO_2) emissions, with 27% of the total emitted from domestic dwellings. To help reduce CO_2 emissions from housing and contribute to the UK goal of a 60% reduction in CO_2 emissions by 2050, both

new and existing homes must become much more energy efficient. The current uptake of energy efficiency measures is not sufficient to offset rising demand for energy from households.

Research shows that a 60% reduction in CO_2 emissions from housing would be technically possible through a combination of major improvements to the building fabric (for example, cavity wall and roof insulation, draught proofing windows, and insulation of floors and solid walls throughout the housing stock), substantial increases in the energy efficiency of lights and appliances, and the installation of low and zero carbon technologies (LZCs) to provide renewable energy to buildings. The combination of measures will be important, but any one of these interventions on its own will not be sufficient.

Non-residential buildings account for approximately 20% of CO_2 emissions in the UK. Energy efficiency measures are therefore vital for non-residential as well as residential buildings. These can be achieved through physical and practical design changes that improve the way people work as well as producing environmental and cost savings, for example, by:

- Maximising the use and quality of daylight to enhance the working environment and thus reduce the use of artificial light;
- Minimising the need for air conditioning;
- Optimising passive aspects of the construction materials commonly used in buildings. ‘Heat’ or ‘cool’ can be stored in the structure, moderating temperature swings during the day and reducing the heating or cooling loads on boilers or air conditioning; and
- Adopting designs for easy reconfiguration during medium-term occupancy and for future occupants.

Given its prevalence, the environmental impact of air conditioning in commercial premises is an important issue. Air conditioning provision is rising and, if current trends continue, it is estimated that 40% of commercial floorspace will be air conditioned by 2020, compared with 10% in 1994. This could be tackled through good building design, which can help to keep indoor temperatures more comfortable through a variety of techniques, including passive cooling and the provision of good ventilation and appropriate use of solar shading and active facades. Recent surveys suggest that occupants prefer naturally ventilated buildings. For example, US research has shown that occupants of naturally ventilated buildings are comfortable over a much wider range of temperatures compared to occupants of air-conditioned buildings, primarily because the higher degree of personal control shifts expectations and preferences.

The introduction of the wide range of technologies available to deliver more environmentally sustainable buildings needs to be accelerated through a package of policy measures. These would include comprehensive and freely-available information about building energy performance; increasingly stringent standards for commercial, industrial and domestic buildings (new and refurbished), as well as effective enforcement to ensure implementation; and financial incentives to make energy saving more financially attractive. In our view, lower energy use in buildings is much more likely to be achieved and maintained when technological improvements are complemented and reinforced by greater awareness of energy use and behavioural change.

This illustrates that the potential contribution of the built environment to mitigating climate change is significant.

8.3 Current Energy Generation

To provide a baseline by which to understand the state of power generation and consumption in the UK, we give first a précis of usage by sector for electricity and gas:

Electricity

Table 8.1 below shows the million tonnes of oil equivalent used in electricity generation in Britain in 2005 (calculated on an energy supplied basis), and the percentage of total use this represents. Coal, oil and natural gas are all carbon-based and amount to 71.8% of generation capacity.

Table 8.1: Fuel sources for UK electricity generation

Fuel	Usage, Mt oil equivalent	Percentage
Coal	32.617	37.4
Oil (1)	1.329	1.5
Natural Gas (2)	28.705	32.9
Nuclear	18.372	21.1
Hydro	0.426	0.5
Other (3)	5.669	6.5
Total	87.12	100

"Digest of UK Energy Statistics", DTI, 2006

(1) Includes oil used in gas turbine and diesel plant or for lighting up coal fired boilers, Orimulsion, and refinery gas

(2) Includes colliery methane

(3) Main fuels included are coke oven gas, blast furnace gas, waste products from chemical processes, refuse derived fuels and other renewable sources including wind

Gas

Table 8.2 below shows the gigawatt hours of natural gas and colliery methane consumption by sector in 2005, and the percentage of total consumption:

Table 8.2: UK gas consumption by sector

Sector	Consumption, GWh	Percentage
Domestic	381,879	35.2
Industrial	159,399	14.7
Electricity generators	333,834	30.7
Other energy industries	103,896	9.6
Services (1)	106,653	9.8
Total	1,085,661	100

"Digest of UK Energy Statistics", DTI, 2006

(1) Public administration, commercial, agriculture and miscellaneous

These tables demonstrate that the primary sources of energy used in the UK as of the time of writing are from non-renewable fuels. Meaningful reductions in carbon emissions will not be achieved unless there is a significant switch away from these energy sources.

9 Energy Distribution

9.1 Introduction

As indicated in Chapter 8, the Mayor's policy seeks the use of decentralised area-wide and local power generation and heat distribution. This is reflected in the Mayor's heating and cooling hierarchy (FALP Policy 4A.5i), which says that

> The Mayor will expect all major developments to demonstrate that the proposed heating and cooling systems have been selected in accordance with the following order of preference:
>
> - Connection to existing CCHP/CHP distribution networks;
> - Site-wide CCHP/CHP powered by renewable energy;
> - Gas-fired CCHP/CHP or hydrogen fuel cells, both accompanied by renewables;
> - Communal heating and cooling powered by renewable energy;
> - Gas fired communal heating and cooling.

The evidence case for this rests upon the inefficiencies involved in supply through the National Grid and the feasibility of CHP and CCHP. These inefficiencies are, of course, of concern because they imply unnecessary carbon generation. There is general acknowledgement that local generation offers scope for solutions resulting in lower carbon emissions.

Accordingly, this chapter reviews the evidence on these issues. It is structured in two parts as follows:

- Efficiency of CHP/CCHP; and
- Inefficiency of centralised power generation and distribution.

9.2 CHP and CCHP

Combined Heat and Power (CHP) is the simultaneous generation of usable heat and power (usually electricity) in a single process to produce higher energy efficiencies. CHP uses a variety of fuels and technologies across a wide range of sites, and scheme sizes. The basic elements of a CHP plant comprise one or more prime movers (a reciprocating engine, gas turbine, or steam turbine) driving electrical generators, or other machinery, where the steam or hot water generated is utilized for either industrial processes, or in community heating and space heating. CHP is usually much smaller than electricity-only plant, and attached to a site that consumes the majority, if not all, of the heat and power produced. Due to its high efficiency, it is considered that it can make a "substantial contribution" to the Climate Change Programme (Watson et al, "Renewable Energy and Combined Heat and Power Resources in the UK", Tyndall Centre for Climate Change Research Working Paper 22, 2002; Digest of UK Energy Statistics 2006, DTI, 2006).

CHP exploits primary energy carriers (i.e. fuels) more efficiently than the traditional multi-phase processes and technologies of power generation. As a result, CHP's overall fuel efficiency is around 70-90% of the input fuel – much better than most power stations which are only up to around 40-50% efficient (Energy White Paper 2003). Almost all energy sources (i.e. natural gas, heating oil, coal, waste, biomass) can be utilised in CHP. (For illustrative purposes, elsewhere in this report, we have assumed that a 33% reduction in carbon emissions is possible through adopting CHP.)

An analysis of the benefits of CHP conducted by Belgian consultants Delta Energy and Environment showed that CHP saves between 17% and 26% energy consumption when compared to high-efficiency CCGT (combined cycle gas turbines) and new boilers, saving between 0.25 and 0.4 million tonnes of carbon per 1000 MWe of CHP installed per year; and, when compared to the average fossil fuel-fired UK electricity system, saves between 27% and 40% of energy consumption, saving between 0.72 and 1.03 million tonnes of carbon per 1000 MWe of installed CHP annually ("Time to Take a Fresh Look at CHP", Delta Energy and Environment, October 2005).

Combined Cooling, Heating and Power (CCHP) provides cooling to buildings through using waste heat with absorption chillers. This replaces electricity-driven air-conditioning systems and could be of more widespread use in circumstances of rising temperatures.

"The UK Potential for Community Heating with Combined Heat and Power" (BRE, 2003, for the Carbon Trust) says that:

> The realisable potential for community heating in the UK has been assessed. …[Three] discount rates that have been used correspond to:
>
> - A minimum public sector investment level of 6%;
> - A full private sector finance scheme at 12%; and
> - A private/public partnership at 9%.

Table 9.1 below summarises this:

Table 9.1: Summary of the UK potential for CHP/CCHP at various discount rates

CH/CHP potential	Units	6%	9%	12%
Total net CH/CHP Potential for UK	MW_e	18,263	2,289	787
Number of postcode sectors	-	2016	450	341
Total heat sold	GWhp.a.	114,281	19,380	11,467
Total capital cost	£m	26,506	2,746	1,323
Total NPV of all sectors	£m	2,943	405	258
Total customer savings on heating bills	£m p.a.	4,097	435	219
Carbon emissions saving (fossil fuel basket excluding nuclear and renewables)	MtCp.a.	10.51	1.67	0.93
Carbon emissions saving (average grid mix basis)	MtCp.a.	4.34	0.68	0.38

Table 9.2 below shows a breakdown of UK potential by postcode area for major cities. Again, the total potential is shown for three different discount rates. Note that these postcodes do not necessarily correspond to local authority boundaries.

Table 9.2: Breakdown of UK potential between major cities

Location	CH/CHP potential MW_e		
	6%	9%	12%
London postcodes	2,448	460	206
Birmingham postcodes	815	123	33
Manchester postcodes	466	72	37
Sheffield postcodes	356	73	32
Southampton postcodes	204	49	20
Leicester postcodes	393	48	17
Liverpool postcodes	171	46	25
Leeds postcodes	251	40	16
Bristol postcodes	272	38	12

Location	CH/CHP potential MW_e		
	6%	9%	12%
Newcastle postcodes	441	29	18
Cardiff postcodes	194	42	6
Glasgow postcodes	222	29	11
Edinburgh postcodes	134	18	7
Belfast postcodes	234	31	12
Other UK cities	11,851	1,343	477
Sub-total	18,453	2,441	929
Less existing CHP capacity	190	152	142
TOTAL	**18,263**	**2,289**	**787**

The 2007 RCEP report "The Urban Environment" summarizes several of the issues and options regarding CHP:

> Given the urgency of delivering a major reduction in carbon dioxide emissions, a strategic approach to planning for energy in new and existing urban areas is essential. On the supply side, a low carbon, urban energy strategy should mandate greater use of renewables and Combined Heat and Power (CHP). On the demand side, reduction of energy use and greater conservation must be encouraged.
>
> CHP requires relatively large, fixed investments, with significant financing implications. Net densities of 100 people per hectare (or about 40-50 dwellings per hectare) are the minimum densities for CHP district heating, making its use more viable in high density urban areas than in low density suburban or rural areas. Another problem is that, in recent decades, major power stations have been located outside urban areas, making it uneconomic to pipe their waste heat into cities. However, the need to replace a substantial quantity of power generation capacity by 2020 and for substantial urban new build and regeneration, provides major opportunities for large-scale gas-burning CHP programmes in urban areas. Although there are potential air quality issues inherent in repatriating power generation to urban areas, there would be off-setting benefits arising as a result of the removal of individual combustion-based heating systems from the areas benefiting from CHP.
>
> CHP systems can also meet a demand for cooling through using waste heat with absorption chillers. This will be particularly important as an alternative to the rising use of electric air conditioning systems. With climate change predicted to increase average temperatures and the heat island effect within cities, it is essential that energy efficiency is considered in terms of both heating and cooling.

With regard to industrial and commercial applications, there is further evidence for the potential of CHP, as shown by the Combined Heat and Power Association's "Response to the Consultation Paper on the Government's Energy Review 2006" (2006):

> The potential for further growth in CHP capacity in the UK industrial and commercial sectors is substantial. The last detailed analysis from Government highlighted that up to a further 17,000 MW of CHP capacity is achievable across these sectors. This study identified over 500 UK businesses where, on the basis of their heat and power requirements, the installation of CHP would be suitable. Additionally,

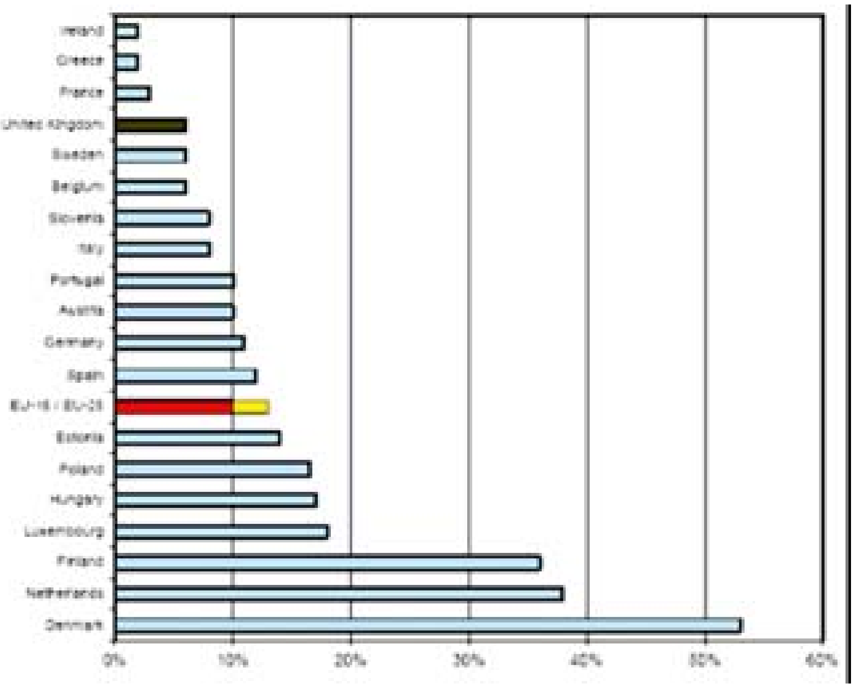
> less than 200 out of the 1000 sites within the UK NAP have CHP installed: many of these have the potential to install CHP. It has also been identified that, based on the current heat loads at the 10 largest existing industrial sites in the UK, in excess of 10 GWe of new CHP could be established given the right Government framework. In addition new LNG terminals being constructed around the UK also offer significant potential.
>
> The Association's analysis indicates that the level of penetration of CHP engines in typical building applications, where CHP is most appropriate (typically leisure centres, hotels, hospitals, universities), remains very low. It is across these sectors that the Carbon Trust's recent input in the Government's Energy Efficiency Innovation Review identified the very significant efficiency and carbon savings which could be made. Many of these sites would be ideal for the installation of micro and small scale CHP (<100kWe) plants.

In London, the Mayor plans to make CHP district heating a practical reality through decentralizing energy generation. Decentralised energy entails local generation of a significant proportion of the energy consumed in homes, offices, shops and public buildings. Currently, it relies largely on the use of existing, technically proven solutions based on conventional energy sources, with some small-scale renewable energy generation. The installation of CHP plants and community heating networks capable of distributing heat from different fuel sources would offer flexibility in meeting heat demand in the coming decades.

In the report informing the Mayor's decision, two scenarios are presented, assuming the growth estimates set out in the London Plan. Both show the clear potential to meet a significant amount of London's heating and electricity needs by 2025 by decentralised means. Scenario one conservatively estimates that adoption of a low level decentralised energy generation strategy can reduce CO_2 emissions in London by 28% by 2025 (from 2005 levels), while providing London with 30% of its heat demand. Scenario two indicates that if a high decentralised energy strategy is adopted, CO_2 emissions would drop by 36% below 2005 levels, providing 50% of heat demand.

Some urban areas already have implemented wide-scale decentralised energy generation. In the Netherlands 40% of electricity is created using decentralised systems; in Finland, 98% of Helsinki is heated by community networks ("Powering London into the 21st Century", PBPower for the Mayor of London and Greenpeace, 2006). This confirms the feasibility and scope for implementation of decentralised energy generation. Indeed, UK take-up of cogenerated electricity is very low when examined in context with the rest of Europe:

Figure 9.1: Share of cogenerated electricity across Europe



COGEN Europe 2005 in Combined Heat and Power Association “Response to the Consultation Paper on the Government’s Energy Review 2006”, 2006

The PBPower “Powering London” report concludes that by 2025, carbon emissions from London could be reduced by at least 27.6% using a range of existing distributed energy technologies, primarily from gas-fired CHP and central heating systems.

9.3 Grid Generation and Carbon

By comparison with local energy, centralised generation features a number of inefficiencies that make it an unattractive basis for policy.

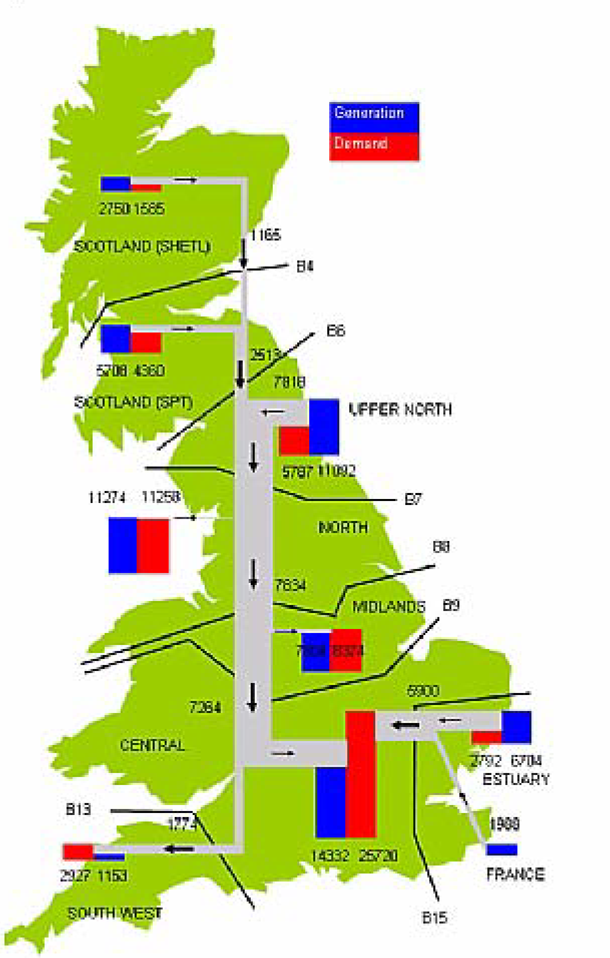
The characteristic of centralised generation (with the exception of certain types of large-scale renewable energy generation, such as that using wind or tidal power) is the way in which it fails to make use of the heat from the primary combustion plant. The broad estimate is that only 40% of the heat generated in the combustion process in grid power stations is used in the generation of electricity. This figure can easily be seen online at http://www.aepuk.com/faq_pdf/dukes_2005_5.10.xls.

The wastage occurs because the energy taken to drive the alternator turbines reduces the pressure and heat of the steam so that it is not capable of reuse until it is fully exhausted. This means it cannot be distributed to lower steam pressure and heat content uses (such as district heating) because of the location of the plant. This gives rise to the characteristic distant view of vapour pouring from cooling towers in UK power stations that embody older technology. While newer technology in power stations recycles some of the power and heat in the vapour, it is a less than perfect use of all heat derived from the primary fuel in the boilers. In addition, much of the large-scale UK power generation has been sited not near the location of power demand but close to traditional primary sources such as coalfields.

As a result, comparison of DTI Digest of UK Energy Statistics 2006 data on the efficiency of major power plants to CHP (using gross calorific values) shows that while combined cycle gas turbine stations were achieving thermal efficiency factors of 48.2% (with coal-fired stations reaching only 35.9%), CHP was reaching overall efficiencies of 68.3%. This is twenty percent higher than the efficiency achieved by CCGT generation and over thirty percent higher than coal-fired stations.

A further inefficiency is in the transmission of electricity through the grid. Losses in power amount to approximately 2-3% of demand ("National Grid: Seven Year GB Statement 2006", National Grid, 2006), and further losses exist in the distribution system. As a result, the average grid loss in the UK has been measured at approximately 7.5% in 2003 (DTI Digest of UK Energy Statistics 2006) and, separately, at 8.7% ("Time to Take a Fresh Look at CHP", Delta Energy and Environment, October 2005). When taken with the amount of carbon fuel wasted in generation, the inefficiency is considerable. Finally, as Figure 9.2 shows, there is a high degree of reliance on the grid to transfer energy from the north of the UK to the south to meet peak demand.

Figure 9.2: UK power flow pattern 2006-07



National Grid

It can also be argued that the National Grid is unsuitable for carrying renewable energy because there is a need for base load and for supplementary plant during peak periods to meet known and predictable increases in demand. The exception is perhaps that biomass, for example, can be used in combustion in a manner identical to that of fossil fuels. Furthermore, the supply of electricity from hydro-generation can also be controlled.

9.3.1 Local Energy Generation

Because of its configuration, local energy generation (such as CHP) enables the use of both electric power and the 'waste' heat, that is, low pressure, low temperature steam. This raises the efficiency of the combustion energy over straightforward generation plant. It also saves some of the power lost in distribution because of the shorter distance that energy needs to travel 'down the wires'. A further efficiency increase can be achieved by using the heat that would be surplus during the summer months as a means of cooling (against a background of rising temperatures).

These efficiencies – and hence a carbon reduction – accrue regardless of the fuel that is burnt. The greatest carbon reduction arises from renewable sources, and such plant could become ‘zero carbon’ in terms of their running.

However, it should be noted that CHP and CCHP require ‘wet’ systems and separate local infrastructure to distribute the steam/heat. The infrastructure can be extensive and costly and needs careful planning to ensure that the pipework (which may be duplicated if it is heating and cooling) is in ground, provided in the buildings, and the demand for it and associated economic case are correctly assessed. In some cases, where a development precedes others, a developer or planning authority may need to second-guess the likelihood of nearby schemes being implemented that would either supply energy or use it. Nonetheless, it will cost less to fit pipework to new development than to retrofit it to existing buildings, and thus it can be argued that new development as well as generation plants should be designed to ease later connection, thus avoiding the increased costs of retrofit.

In addition to the case where a CHP proposal is part of a development that is an ‘early adopter’ and needs subsequent development to absorb its energy output, there is a long-term risk of energy wastage. Because heat will not be used in the summer, unless CCHP is installed, there can be no guarantee that all the energy produced in a plant will be used. So CHP and CCHP may be best suited to true mixed-use developments where residential, commercial and office uses are better balancing the overall demand for electricity and heat/cooling throughout 24 hours. CHP can also be added on a modular basis and its output can be ‘ramped’ up and down to supply the required load. Mixed developments are best for CHP applications in most instances; although there can be an element of heat wastage from CHP over the year, the plant must still comply with the Government’s Good Quality standard if it wishes to benefit from Climate Change Levy exemption and other fiscal measures.

In Appendix 4.4.16 we record the qualifying criteria for the establishment of a successful energy supply company (ESCO) as part of a CHP scheme. These suggest a scale of activity that needs to be reached before this option becomes attractive. Even then, there are governance and management costs to meet. But this remains an attractive policy option to encourage for the benefits that it can produce in reduced carbon emissions.

At this stage of the development of the market, the over-riding need is for policy to drive capacity. Present energy supply at the local level is understating the overall long term capacity because the industry is at the neophyte stage of the supply.

9.4 Conclusions

This chapter has demonstrated the issues surrounding the distribution of power over the National Grid and heat wastage in energy generation; it sets out the potential for CHP/CCHP and for decentralised energy generation. The next chapter continues by considering the role of renewable energy generation in delivering carbon reductions.

10 Renewable Energy

10.1 Introduction

Renewable energy is potentially one of the lowest-carbon options for generating heat and power. The benefits of local renewable energy generation are also potentially multiple if they use low-carbon generation methods. In some cases (generally excepting e.g. wind and tidal power, which do not create waste heat, as well as some types of centralised renewable generation which do create waste heat), renewable energy generation displaces highly carbon-intensive electricity use through the ability to use waste heat as a substitute for both heating and cooling by electricity.

Many technologies have emerged and continue to develop, but are not necessarily yet in widespread use. This chapter reviews the available evidence in relation to the FALP policies on renewable energy as drafted and considers their contribution to carbon reductions. Accordingly, the chapter covers the following:

- The Mayor's policy proposals in the published FALP;
- Carbon emissions from renewable energy;
- Options for renewable energy in London; and
- The long-term strategy for implementing low-carbon energy generation in London.

10.2 Mayor's Policy Proposals

The Mayor's proposed policy is predicated upon decentralised or local renewable energy. The energy hierarchy is to be followed as the primary concern: First comes the minimisation of energy use, then efficient supply, followed by the use of renewable energy sources.

Decentralised energy is to be included where possible. This is to be done first through connection to existing CCHP/CHP networks, second by renewable-powered site-wide CCHP/CHP, third by gas-fired CCHP/CHP or hydrogen with renewables, fourth by renewable-powered communal heating/cooling, and last by gas-fired communal heating/cooling.

As outlined in Chapter 8 above, one of the primary policy tools is for a 20% reduction in carbon emissions, to be achieved through the use of on-site renewable energy. It is important to note that this 20% reduction is to be achieved only after other measures to reduce energy demand and to supply energy efficiently through decentralised means have been implemented. The burden upon developers thus falls as the savings achieved by the first two measures rise.

Adoption of the Mayor's target represents a fairly specific requirement in a context in which technology and practice are both still emerging. In essence, it is a pragmatic response to a context in which such technologies are unlikely to develop without a policy requirement and driver. It also responds directly to Government policy in PPS 22, which sets a target for renewable energy generation and which rises to 20% of all energy by 2020. In addition, various Government statements have stressed the role of decentralised renewable energy generation, including the statement from the Minister for Housing and Planning set out below. Ministerial statements carry substantive weight, just below that of published Government policy such as a PPS, and the need for the London Plan to thus conform to this statement should be clear:

On Thursday 8 June 2006, the Minister for Housing and Planning (Yvette Cooper) said in Parliament:

On 9 February my hon. Friend the Minister for Energy informed the Standing Committee of the Climate Change and Sustainable Energy Bill that I would undertake an urgent review of local plans to determine whether there is a problem with emerging plans that do not fully incorporate PPS 22 guidance. That review has now been completed.

The review has shown that in emerging new style regional spatial strategies and local development frameworks there has been a strong take-up of the policy in PPS 22 on the use of on-site renewables in new developments. For those authorities preparing new plans where an appropriate stage in plan making has been reached, 26 out of 29 surveyed have devised policies to secure on-site renewables in new developments. The majority of them have set a requirement for 10 per cent. on-site renewables, where it is viable. Many of those at an earlier stage of developing their local development frameworks have not yet included PPS 22 policies, although they still have time to do so. We strongly encourage them to do so. For those areas still completing old style plans, such as unitary development plans, policies on on-site renewables are less likely to have been included.

It is essential that all planning authorities follow this example and take account fully of the positive approach to renewables set out in PPS 22 at the earliest opportunity in their plan-making. In particular the Government expect all planning authorities to include policies in their development plans that require a percentage of the energy in new developments to come from on-site renewables, where it is viable. Such policies have a vital role to play in reducing emissions, through the use of carbon-neutral energy sources. Local authorities who are now updating their plans through new local development frameworks should take the opportunity to update their policies in this area. The Government's forthcoming draft planning policy statement on climate change will be an opportunity to consider further how the planning process more generally can help combat climate change by extending the contribution of renewables from both on-site and off-site sources.

A more detailed breakdown of plans that were examined for this review of PPS 22 policies has been published today on the DCLG website at: http://www.communities.gov.uk/index.asp?id=1500549 and is available in the Libraries of both Houses. I have instructed my officials to write to all chief planning officers enclosing a copy of this ministerial statement and to draw attention to the importance that the Government attach to such measures in tackling climate change.

The FALP policies must therefore as a matter of course be consistent with these requirements.

The decision to adopt a 20% on-site renewable generation target was also a reflection of the experience of the energy statements coming forward with new development proposals as discussed in Section 10.3. This suggests that developers are already meeting the requirement to incorporate renewable energy to achieve carbon dioxide emissions reductions. Based upon 47 statements received in 2005, it became clear that developers in London were already proposing to meet the 10% ‘Merton Rule’ requirement, and thus the adoption of a 10% target would not represent any improvement upon current good practice, and new policy would have no additional ‘bite’. This in turn reflects the more ambitious stance taken by national policy including the draft Supplement to PPS 1, as well as by other objectives, such as those for zero-carbon development by 2016. As London wishes to set an example and to achieve exemplary carbon emissions performance, it became clear that a higher standard would have to be sought. Nevertheless, most of the schemes for which the submitted energy statements apply are still at the implementation stage, and evidence of their performance in operation is not yet available.

10.3 London Experience

In 2006, London South Bank University (LSBU) gathered information on the planning applications to the GLA, developed a database, and entered and analysed the data.

The data obtained was found to be sparse, patchy and of variable quality, but improving. Given this, the conclusions were judged not entirely robust, although the data set was thought to be substantial enough to come to some conclusions. It has been possible to fill some of the gaps and to reach a more consistent data set and findings by making a number of assumptions.

LSBU concluded that while the Mayor's energy policies and the planning process relating to his powers were then still relatively new, the data indicated that although the policy was still developing, there had been considerable success. The first year following the publication of the London Plan in February 2004 was spent trying to get applicants to submit coherent energy statements with sensible data, rather than submitting ad hoc correspondence. There was a reluctance to recommend refusal of planning applications on radical policies that had only just been introduced, allowing time for the policies to 'bed down'. However, even from the limited data available, it was clear that a significant step-change in the understanding and activities of the GLA and the development community was taking place. Around the middle of 2005, all the trends turned upwards, indicating that applicants and the GLA began to get to grips with the policies, process, and the provision of more dedicated technical support. It was deduced that developers were better able to respond (technically) to the requirements, and that the lead time of the planning process started to take effect (i.e. developers were now understanding the needs of the new regime and the time it takes for referable schemes to reach the Mayor). More energy statements were thus being submitted, data quality was improving rapidly, and reductions in process time were being achieved. The study authors concluded that their report should therefore be viewed as a snapshot in this evolving process.

In general, the LSBU study concluded that the Mayor's policies had been highly successful in reducing energy consumption and CO_2 emissions. There appeared to be a strong upward trend in cumulative CO_2 savings, indicating that the Mayor's policies have had a significant effect, with annual overall savings of around 210,000 tonnes CO_2 since the introduction of the London Plan in 2004. This figure, based on data analysed from 46 energy statements and extrapolated for 186 known developments over this time, represents around a 28% saving of CO_2. The renewable energy savings could, however, have been doubled had the full potential impact of the policies been administered and policed more rigorously. In mitigation, the study suggested that the introduction of new policies, and the systems related to them, inevitably took time to develop and reach successful implementation. Nonetheless, the analysis demonstrated that savings were increasing and that both developers' teams and the GLA themselves have climbed a major learning curve and were becoming more aware of how to make, and administer, planning submissions.

Many of the graphs indicate a step-change or tipping-point in the implementation of the Mayor's policies around mid-2005. The study concluded that this tipping-point was closely related to new staff joining the GLA, resulting in greater activity and an improved understanding of the processes involved.

Table 10.1: Approximate CO_2 savings in tonnes/year projected to January 2007 from actual data and extrapolated for 186 developments.

	From available data			Extrapolated for 186 developments		
	Linear	mid-range	max	linear	mid-range	max
EE	60,000	68,000	75,000	243,000	275,000	303,000
RE	8,000	13,000	18,000	47,000	75,000	105,000
Total	68,000	85,000	93,000	290,000	350,000	408,000

LSBU data

Table 10.1 above provides a summary of the general trends in CO_2 savings from energy efficiency, renewable energy savings, and total CO_2 savings. The left-hand columns show the likely savings projected for 2007 based on the 46 sites where data was available. The right hand columns show the likely savings projected for 2007 based on all of the 186 submissions made to date.

Table 10.2 below shows the adoption of renewable energy technology by developer. These may be for multiple or single developments, and may not be indicative of technology spread on individual developments. The table shows that a number of developers are adopting a range of technologies, while some are limited to a single technology. The latter probably represents single development submissions.

Table 10.2: Adoption of renewable energy by developer

Developer	Biomass	GCC	GSHP	PV	SHW	Wind
Acton High School				✓		✓
Acton Housing Association					✓	
AIB Worthy Trust				✓		
Aitch Group and Toynbee Housing Association	✓					
Arch Diocese of Southwark			✓		✓	
Archdiocese of Westminster	✓					
Arsenal Football Club					✓	
Audi UK			✓			
Ballymore Homes, Domaine Developments Ltd			✓			
Barratt Homes	✓				✓	
Belgrave Land Ltd					✓	
Boxwood Leisure Ltd				✓	✓	
Capital & Counties and Prudential			✓			
City Assets Limited		✓		✓		
Co-operative Insurance Society (CIS)		✓		✓	✓	
Co-operative Insurance Society Ltd		✓		✓	✓	
Copland Community School & Technology Centre Foundation				✓	✓	
Department for Education & Skills				✓		
Dewent Valley London Ltd		✓		✓	✓	
Ealing Council			✓	✓	✓	✓
Elite realm Ltd					✓	
Enfield Council					✓	
Genesis Housing Group & Mosaic Housing Group	✓		✓			
Heron Tower Property Unit Trust				✓		
Howard Holdings Plc	✓					
Ilex properties & Great Portland Estates					✓	
Imperial College				✓	✓	
Kier Property Developments			✓			
Land Securities			✓			
Linden Homes					✓	
London & Quadrant Housing Trust				✓		
London Urban development Ltd				✓	✓	

Developer	Biomass	GCC	GSHP	PV	SHW	Wind
Mile End Park Partnership				✓		
Norwich Union Life and Pensions Ltd.				✓		
Requira Ltd				✓		
Secondsite Prop. Holdings/Castlemore Securities	✓					
Shendle Ltd			✓			
South Hampstead Synagogue			✓			
St. Mary Magdalene Academy Trust, London Diocese	✓					
Stephen Lawrence Trust					✓	
Terrace Hill Ltd			✓		✓	
The TreeHouse Trust		✓				
Tiffany Assets Ltd & East Thames Housing Ass.					✓	
York and Beckett GP Limited			✓	✓	✓	
ZedHomes & Julian Seabrook	✓			✓		✓

LSBU data

In view of the success of the Mayor's policies, we would make the following conclusions and recommendations:

- The analysis of energy efficiency savings shows that 25% of developments have energy efficiency savings in excess of 20 kg CO_2/m^2. This could provide a clear but challenging target for energy efficiency savings;
- Very significant reductions in CO_2 emissions have been achieved due to energy efficiency savings. Energy efficiency measures are contributing, on average, 25% of the energy budget for those developments where data is available (45,867 tonnes of CO_2 over 46 developments);
- Lighting with lighting control improvements and enhanced insulation are the most popular energy efficiency measures, whereas there are few examples of daylighting measures. It is clear that the GLA's efforts to promote CHP and community heating are paying off, as there has been a significant rise in the numbers of installations and the associated savings since the middle of 2005; and
- The analysis of renewable energy (RE) savings shows that, on average, developments can show 9.3% savings. In practice, over one third of developments reach or exceed the 10% target. Analysis of RE savings in terms of kg CO_2/m^2 shows that 35% of developments achieve 5 kg CO_2/m^2 or higher. It is reasonable to assume this coincides with those projects meeting the 10% target, and could be the basis of RE targets in future. Although this average is slightly less than the 10% set out in the Mayor's policy, it is still a major achievement. In addition, the average percentage continues to rise as the Mayor's policies bed down with greater awareness of the planning submission system. Ground Source Heat Pumps (GSHP), Photovoltaics (PV) and Solar Hot Water (SHW) are the most popular renewable technologies in terms of numbers, whereas there are few examples of wind generators.

The application process has evolved rapidly since the introduction of the Mayor's policies and is still developing. Based on a very small number of sites where start and finish CO_2 data is available, it became apparent that the GLA Planning Decisions Unit and Energy Team have added to the savings achieved, as incoming savings averaged 3.6%, and the final approved figure was 9%.

The radical nature of the Mayor's policies and the speed with which they have been introduced has meant that applicants and the GLA have been climbing a steep learning curve. Early submissions were incoherent and lacked clear data, whilst the technical support for, and knowledge of, planning officers was limited. It is apparent from the limited data available that many applications did not reach the 10% target. However, there has been a steady rise in the number of energy statements, the data these include, and the savings from both energy efficiency and renewables.

This shows that applicants and the GLA are coming to terms with the process, resulting in greater energy and CO_2 savings. Emerging data confirms that developers are now more readily achieving the 10% target and shows that schemes being submitted for planning approval in London are expecting to achieve reductions in carbon emissions exceeding 10% on a regular basis. Table 10.3 below lists planning applications before March 2006 which expected to exceed 10% on-site renewable energy generation:

Table 10.3: Major developments incorporating renewables over 10% to March 2006

GLA Case Name	% CO_2 savings	Renewable technology used
Phase III, former Bell Green Gas Works	11	Biomass boiler
Biro House, TXU Site and Arches, Stanley Road, South Harrow	19	Biomass CHP
Lucozade Annexe Site, Brentford	17	Ground Source Heat Pump
14-26 Stratford High Street	14	Biomass
One New Change	12	Ground Source Heat Pump
Railway embankment & land west of Adelaide Road	21	Ground Source Heat Pump

GLA data

An updated London South Bank University study which reflects this data is expected to be published in summer 2007.

Stakeholder responses at our workshops have drawn attention to many of the challenges involved in implementing both the 10% and 20% on-site renewable obligation standards. At the time of writing, most stakeholders and other experts agreed that in London the most viable option for local renewable energy generation is likely to involve biomass, with the possibility of gas-based renewable supply in the future (e.g. gas from waste). The questions raised largely reflect a number of factors. These include:

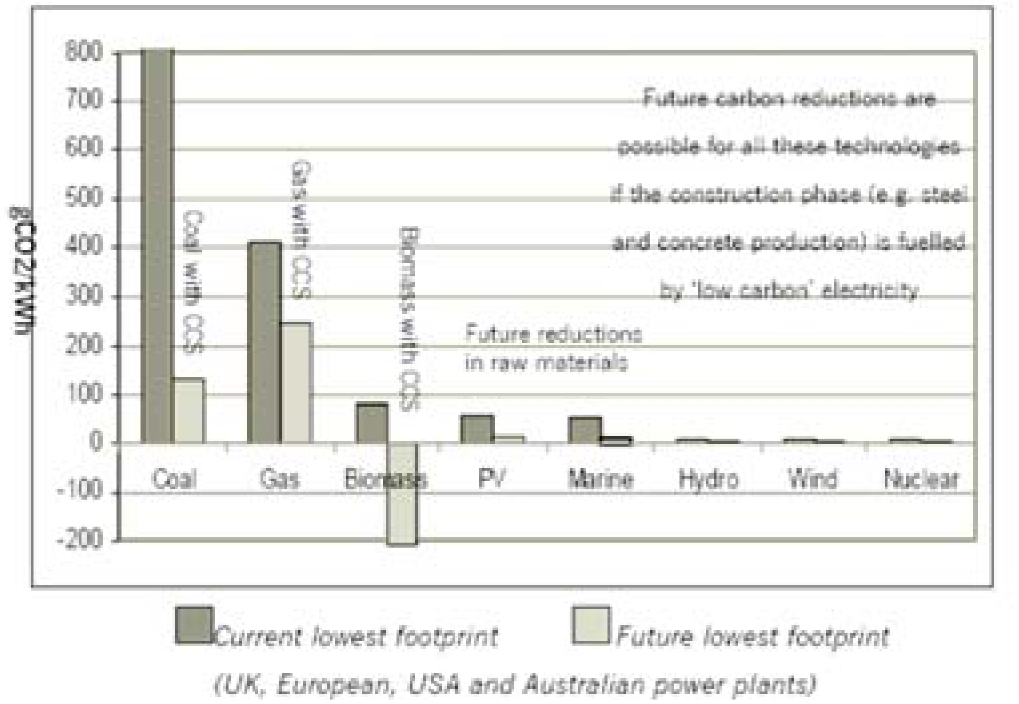
- Questions about the carbon output of biomass;
- Uncertainty regarding market development for biomass supply;
- Concerns for the physical transport and distribution of biomass; and
- Concerns regarding air quality and residual ash when biomass is burnt or gasified.

In addition, as biomass may not be the best long-term solution, there have been questions as to the best transition state and how to accommodate the possibility for change. In particular, it has been suggested that the important short-term issue is to establish systems within buildings that are capable of being retro-fitted to local renewable energy supply and generation in order to build up the market that would allow the creation of a wider support infrastructure. The particular objective here is to avoid the use of electricity for cooling and heating and to promote the use of 'wet' systems that are amenable to CHP and CCHP. These are the questions examined in relation to evidence through the rest of this chapter. However, whatever approach is adopted, there is a need for policy to have 'bite' and to force change if Government and Mayoral targets are to be achieved.

10.4 Carbon Emissions and Renewable Energy

It is now accepted that renewable energy, possibly along with nuclear generation, is potentially the most carbon-neutral means of generating electricity, as demonstrated by the graph below (Figure 10.1) which illustrates a dominant overall view of the carbon outputs per kilowatt-hour generated for different generation technologies:

Figure 10.1: Carbon footprints for methods of electricity generation



"Carbon Footprint of Electricity Generation", Parliamentary Office of Science and Technology, Postnote 268, October 2006

It should be noted that carbon emissions from nuclear generation are a highly contentious issue. An April 2007 study released by the German environment ministry (available at (http://www.bmu.de/files/pdfs/allgemein/application/pdf/hintergrund_atomco2.pdf) concludes that fossil-fuel-based cogeneration of heat and power emits less carbon dioxide than nuclear-based alternatives providing the same service. The study was done by think-tank Öko-Institut, which calculated life-cycle emissions for cogeneration of heat and electricity in high-efficiency gas-fired power plants. It compared these to the carbon emissions from nuclear power generation, including uranium mining, and from the separate heating requirements of consumers not connected to cogeneration plants. Because nuclear-powered households normally use oil or gas for heating, the study suggests, their overall emissions come to 772 grams of carbon dioxide per kilowatt-hour (g/kWh). Emissions from heat-and-power plants are slightly lower, at 747g/kWh. The study also compares the carbon emissions of nuclear generation alone (31-61g/kWh) with emissions from different renewable technologies such as wind (23g/kWh), hydropower (39g/kWh) and photovoltaics (89g/kWh).

An important issue is capacity. The EREC / Greenpeace "Energy [R]evolution" report of 2007 describes the capacity of renewable sources in energy supply. It concludes:

> ….Renewable energy is not a dream for the future – it is real, mature and can be deployed on a large scale. Decades of technological progress have seen renewable energy technologies such as wind

> turbines, solar photovoltaic panels, biomass power plants and solar thermal collectors move steadily into the mainstream.
>
> The global market for renewable energy is growing dramatically; in 2006 its turnover was US$38 billion, 26% more than the previous year. The time window for making the shift from fossil fuels to renewable energy is still relatively short.
>
> Within the next decade many of the existing power plants in the OECD countries will come to the end of their technical lifetime and will need to be replaced. But a decision taken to construct a coal power plant today will result in the production of CO_2 emissions lasting until 2050. So whatever plans are made by power utilities over the next few years will define the energy supply of the next generation. We strongly believe that this should be the 'solar generation'.
>
> ….The future of renewable energy development will strongly depend on political choices by both individual governments and the international community. By choosing renewable energy and energy efficiency, developing countries can virtually stabilise their CO_2 emissions, whilst at the same time increasing energy consumption through economic growth. OECD countries will have to reduce their emissions by up to 80%.

Among the features of the report's scenario is the ending of nuclear electricity generation. But the report takes a wider view about population growth, increases in GDP and the decline in innovation costs in the technology needed to deliver the bigger share of renewable energy.

10.5 Options for Renewable Energy in London

According to the Mayor's Energy Strategy (GLA, February 2004), London's renewable energy targets aim to generate at least:

- 665GWh of electricity, and
- 280GWh of heat, from up to 40,000 renewable energy schemes by 2010.

This would generate enough power for the equivalent of more than 100,000 homes, and would heat more than 10,000 homes.

To meet this target, the Strategy suggests that London should aim to install at least:

- 7,000 domestic photovoltaic installations, converting daylight into electricity;
- 250 photovoltaic applications on commercial and public buildings;
- Six large wind turbines;
- 500 small wind generators associated with public or private sector buildings;
- 25,000 domestic solar water heating schemes;
- 2,000 solar water heating schemes associated with swimming pools; and
- More anaerobic digestion plants with energy recovery and biomass-fuelled combined heat and power plants.

It is proposed by the Mayor that these capacities should then be at least tripled by 2020.

In order to help implement this policy and meet these targets, the FALP seeks to require major developments to show how the development would generate a proportion of the site's energy needs from renewable sources, where feasible.

In practical terms, renewable energy in London is likely to include biomass, gasification, hydrogen, wind, solar, wave, and tidal power. Each option is considered below in context of its relevance and issues in implementation.

10.6 Biomass

Biomass refers to refers to the use of organic matter for fuel. This generally means plant matter grown specifically for use as biofuel, but can also include degradable waste which can be burnt. Because of the timescale necessary for the creation of coal and petroleum, these substances are excluded from the definition. Much biomass today as burnt in buildings is supplied as wood pellets or chips, however, biofuels may include bioethanol, biodiesel and biogas.

More generally, biomass is most commonly grown from plants, especially grasses and forestry products. Production of biomass is a growing industry. Biomass forms part of a 'carbon cycle' in which plants absorb carbon from the atmosphere through photosynthesis and that carbon is released back into the atmosphere when the biomass is burnt. Because this takes place within a matter of months or several years, the process is considered low-carbon (this is why burning coal or petroleum is definitely not included in the definition of biomass despite its biological origins). In addition, certain other products e.g. involving the felling of older trees should also be excluded from the definition of biomass, as the carbon cycle is very long in these cases. It should be noted that although biomass is a renewable fuel, its use can still contribute to global warming as a result of the transportation of the biomass itself and cases where it is not renewed.

The London Energy Partnership (LEP) has already assembled and reviewed the evidence for biomass supply in London, and this is reported in its November 2006 "Feasibility Study into the Potential for Non-building Integrated Wind and Biomass Plants in London: Final Biomass Report".

This study found that biomass CHP could displace 15% of London's conventional energy needs for buildings, excluding transport, and reduce CO_2 emissions by just over 5 million tonnes per year. However this would involve using all available biomass whatever its current fate. Assuming that all biomass that is currently not recycled or already used for energy recovery is used, the potential would be to displace around 10% of conventional sources, saving around 3.5 million tonnes per year of CO_2. All of these figures assume that CHP is utilised. If instead, electricity only systems were used, these would provide only 5% (all biomass) and 3% (residual biomass) respectively.

The LEP suggests that biomass is one of the renewable technologies closest to commercial viability for the urban environment, particularly where waste sources can be utilised, and with the advantage that it is relatively flexible with the ability to transform it into a solid, liquid or gas and, in contrast to wind and solar, the ability to store it and use when required.

The following biomass streams were identified within London by the LEP report: Sewage; paper/card; putrescibles; used bio-oils; straw; wood; and short rotation coppice willow. The LEP suggests that it is the biological part of the waste stream which holds the largest potential for biomass power generation. Together the energy content of these streams are equivalent to some 14% of London's total energy demand (including transport). Clearly, to utilise all of this resource for energy generation would go against the whole thrust of both UK and London waste policy; and so they conclude that it is the residual elements of these waste streams that should be made available for energy generation.

Issues identified by LEP in relation to the use of biomass include supply, use, pyrolysis, and transport and distribution. Biomass could become suitable for widespread use and represent an appropriate way forward for London to implement renewable energy on a wide scale, because the scope to introduce the other technologies discussed below is generally low in comparison to the scope for biomass-fired local generation.

Potential biomass sources in London, as identified by the LEP report, include:

- **Waste:** Waste incorporates many different elements. The worst performing area in terms of recycling is municipal waste with 73% going to landfill. 81% of construction waste on the other hand is recycled. Most of London's municipal waste is taken by road, rail, or barge to landfill sites outside of London in the surrounding counties. The LEP suggests that transfer stations could be converted to energy facilities in the future, as practices move away from collection and transfer for disposal at landfill to local recovery facilities. Shanks' Frog Island Waste Management Facility in Rainham, East London, incorporates a Mechanical Biological Treatment Facility (Bio-MRF) designed by EcoDeco that processes 180,000 tonnes of waste which ordinarily would be sent to landfill. The Bio-MRF processes household rubbish, 50% of which will be turned into solid recoverable fuel and metals, stones and glass that will be reused by industry.

- **Paper/Card:** This constitutes the largest single resource of biomass energy in London. However, following the waste hierarchy would suggest that this resource should not primarily be utilised for energy production. Some of this material, where it forms the residual element of the waste stream, will become available as solid recovered fuel; this will then form part of the available resource.

- **Putrescibles:** Putrescible waste is solid waste that contains organic matter capable of being decomposed by micro-organisms. It represents a significant resource in London, whether from commercial or household sources (kitchen and garden waste). An increasing amount of this waste is being composted but very little is being used for energy generation. It has a much lower calorific value, but as a wet section of the resource stream it is most suited to anaerobic digestion technology.

- **Refuse Derived Fuel (RDF) & Solid Recovered Fuel (SRF):** Mechanical Biological Treatment (MBT) facilities produce a dry residue called RDF or SRF, which can be used as a fuel source. SRF has a higher calorific value than mixed municipal waste. Where this material is treated by gasification or pyrolysis or in CHP plant, the electricity generated from the biomass proportion (estimated to be 62%) will qualify for Renewables Obligation Certificates.

- **Oils and Fats:** Vegetable oils or animal fats can either be burnt as they are or converted into biodiesel. The calorific value of vegetable oil is similar to that of conventional diesel. London Remade and the London Community Recycling Network estimated that 37,000 tonnes of used cooking oil, mainly vegetable- or nut-based, is available in London, of which only 15,000 tonnes is actually collected. A further 53,000 tonnes of animal fats is estimated to be available.

- **Sewage:** The UK Biomass Taskforce estimates that there is around 1.8TWh of energy available from sewage in the UK using combined heat and power (CHP) technology. This would constitute 0.2% of total UK heat and power demand. Currently there is 100% utilisation of sewage sludge in London – no sewage is landfilled or disposed of at sea. Much of the resource (32%) is burnt at the two sewage sludge incinerators at Beckton and Crossness. At Mogden in Hounslow and Beddington in Sutton, anaerobic digestion is still used to process sewage and, according to the Mayor's Energy and Municipal Waste Strategies, there is potential to expand this at those sites. These state that altogether the potential exists to deal with a further 600,000 tonnes of biodegradable materials at these sites.

- **Agricultural Residues:** There is approximately 97km² of arable farmland within Greater London, which is 5.6% of London's land area and already produces some materials that could be used for energy production, namely straw and vegetable/cereal residues. According to the Biomass Task Force, straw is a major potential resource for biomass, able to deliver around 1.3% of total UK heat and power demand if used in

CHP plant. 3,000,000 tonnes of straw is available, mainly in East Anglia, for energy production.

- **Energy Crops:** A large area of land is required to produce significant quantities of fuel, which is in competition with growing food. One answer to this is that set aside land should be used to grow fuel. These crops also require a long-term commitment; farmers will need to feel it is a secure choice before changing their crops. Energy crop choices include willow and poplar, miscanthus and oil bearing crops.
- **Woodfuel:** Wood is present in all three of the main waste stream classifications: municipal, commercial/industrial and construction/demolition. It is also the main constituent of arboricultural waste from tree surgery operations in London. A recent study conducted by Bioregional and the London Tree Officers Association gives a total of 127,000 tonnes per year. The potential for woodfuel from forestry operations around London from the Future Energy Solutions 2002 study puts the forestry operations potential at 2,195 oven dried tonnes per year within London (from 6,700 ha of woodland), and at 63,441 oven dried tonnes per year around London (40km radius). It is worth noting that an assessment was made by BioRegional of the wood fuel potentially available in London in 2005, identifying a minimum of 500,000 tonnes a year after allowing for existing uses.

According to the LEP report, a range of possible biomass materials is available to London, and the size of the resource is dependent on how far afield they should be sourced. The report concludes that, of the biomass energy sources identified above, the most concentrated, cheap and easily available resource will be SRF produced by MBT treatment facilities.

The report also states that more sewage could be used for energy generation in London, although the relative carbon benefit of diverting this from use as a fertiliser is unclear. Agricultural residues are surprisingly large in London and the counties around London have the highest density of straw production in the UK.

The use of biomass as a fuel provides significant potential to reduce London's carbon burden arising from conventional fossil fuel electricity and heat. There are, however, associated carbon impacts in terms of the production, processing and transportation of biomass. If strategically developed with sustainably sourced biomass, and if the material is produced locally and/or transported by rail or water, these impacts should be minimal when compared to the carbon reductions achieved through renewable heat and power generation. Assuming the worst case mode and an average transportation distance of 40km, the transport carbon emissions represent less than 1% of the savings from the operation of the generating plant.

The LEP report states that biomass CHP "provides one of the most attractive methods of providing low or zero carbon developments in London". It goes on to say that all of the pilot Energy Action Areas have considered the use of biomass CHP as one of the ways of meeting carbon reduction targets, but have yet to commit to it until they have a guaranteed supply.

Other reports that examine the wider context of biomass supply provide corroboration of this evidence. The Tyndall Centre (Watson et al, "Renewable Energy and Combined Heat and Power Resources in the UK", Tyndall Centre for Climate Change Research Working Paper 22, 2002) succinctly explains the issues regarding biomass supply:

> Energy crops are plants grown specifically for use as a fuel. As a natural carbon-based source of energy they resemble in many ways fossil fuels. Their main environmental advantage, however, is that energy crops are carbon-neutral because carbon is removed from the atmosphere when plants are re-grown. Energy crops are expected to

make a substantial contribution to a renewables target. Under the new Renewables Obligation, schemes using energy crops will be eligible for capital grants.

Perennial crops are currently preferred, such as varieties of deciduous trees, or grasses, such as Miscanthus. The most advanced energy crop for northern European conditions is coppiced willow, grown on a rotation of 2 to 4 years (Short Rotation Coppice, or SRC). Of the grasses, those of tropical origin use sunlight more efficiently, and produce higher yields than native plants and are significantly drier. They are, however, less well adapted to the climate in the UK and experience of producing these crops on a commercial scale is still limited. Current thinking is that their range will be restricted to the more temperate climates of the south of England.

Agricultural and forestry wastes fall into two main groups – dry combustible wastes (e.g. forestry residues, straw and chicken litter) and wet wastes (e.g. farm slurries). The first group can be converted to electricity and/or heat by combustion to produce heat and/or power. Technologies as well as economic and environmental issues are similar to those described in the section on energy crops. The second group is best used to produce methane-rich biogas through the process of anaerobic digestion.

Straw is available from cereal and other crops such as oilseeds. It is produced seasonally and is localised, with highest production centred in East Anglia. As straw is a low-density material, transport and storage can be a significant part of the fuel cost. This has led to the adoption of large high-density bales. Straw is a relatively low heating value fuel, with an energy content of around 18GJ/dry tonne. Only one project in the UK has been granted a contract under the NFFO to generate electricity from straw. This is a 31MW plant in Cambridgeshire, which uses around 200,000 tonnes/year of straw. An increasing number of UK farms have straw-fired boilers to help meet their on-site heat requirements.

Wood for fuel, in commercial quantities, can be produced as a by-product of forestry management and occurs in sawmills. The residual material from these operations is a clean fuel that can be converted to useful energy. Wood has a relatively low calorific value of around 19GJ/dry tonne. When harvested, wood has a moisture content in the order of 55% by weight. Contracts to generate electricity from forestry residues have been allocated under the NFFO. Outside of the NFFO, electricity generation from wood fuel is restricted in the UK to locations where sawmill or paper-making residues are co-fired with fossil fuels in existing plant.

Poultry litter is the bedding material from broiler houses. It usually comprises material such as wood shavings, shredded paper or straw, mixed with droppings. As received, the material has a calorific value slightly lower than that for wood at 9-15GJ/tonne. It has a high variable moisture content of between 20% and 50%. The technology has been proven in recent years, and several UK plants are in operation. The technology used is based on a conventional steam cycle. Transport and storage of the fuel needs to be carefully

> controlled so that odour does not escape into the surrounding environment.
>
> Wet agricultural wastes (farm slurries) are derived from three major sources: cattle, pigs and poultry. Farm slurries can be turned into fuel through anaerobic digestion. Typically, 40-60% of the organic matter present is converted to biogas; the remainder consists of a stabilized residue with some value as a soil conditioner. The technology is now well developed and a range of digesters are commercially available.

The Report to Government of the Biomass Task Force, chaired by Sir Ben Gill (2005) said:

> While published estimates of feedstock volumes can vary greatly depending on assumptions made, what is clear is that significant amounts of biomass materials are available within the UK. The total, from the data we have assembled, shows 20 million tonnes of material which could be used for energy. Wastes – both municipal solid wastes (MSW) and animal wastes – offer the greatest immediate sources of energy, with 2.5 million tonnes of MSW already being used for energy generation and a 400% increase in available tonnage anticipated by 2010. However, the development of Refuse Derived Fuel (RDF) from MSW, although offering improved handling characteristics, higher calorific values and a more consistent burn than MSW, has had restricted market penetration to date due to the need to burn it in Waste Incineration Directive-compliant plants. Also, there could be a significant contribution from forestry, wood waste and crops with what we consider to be conservative estimates totalling nearly 5 million tonnes.
>
> Around 3 million tonnes of wet animal slurries and manures are generated annually in the UK; if 50% of these farm wastes were processed in anaerobic digesters, they would potentially contribute up to 1.1 TWh per annum of electricity, resulting in carbon savings of over 0.13 MtC per year. Co-firing has raised the profile of both forestry and energy crops as sources of biomass and, although much of the co-firing capacity currently uses imported materials, the hectarage of energy crops is increasing annually, with current combined plantings for short rotation coppice and miscanthus of around 2,500 hectares (equivalent to yields of around 25,000 tonnes per annum).
>
> Our vision statement assumes that around 1 million hectares of land may be available for non-food uses in general. This could mean around 8 million tonnes of energy crop. The development of biofuels in the UK is likely to lead to competition for feedstocks although some biofuels, or their feedstocks, will be imported.

In response, the Government welcomed the report and proposed a range of measures, of which the most significant were:

- A new five year capital grant scheme for biomass boilers, with funding of £10 - £15 million over the first two years and a second round of the Bio-energy Infrastructure Scheme, with funding at or close to the level proposed in the Gill Report;
- Agreement in principle to support for energy crops under the new Rural Development Programme for England to be introduced in 2007, closely integrated with bioenergy market development; and

- Announcement of the Forestry Commission's new Biomass Energy Centre as a major new hub for bioenergy advice and best practice for industry and the public.

In line with the London Energy Partnership report, we conclude that if all biomass that is currently not recycled or already used for energy recovery is used in combined heat and power (CHP) plant, the potential would be to displace around 10% of all conventional energy sources, saving around 3.5 million tonnes of CO_2 a year. This would constitute a total of approximately 540-660 MWe of installed biomass generating capacity and generate around 3.6-4.3 TWh of electricity and 7.2-8TWh of heat. Despite this optimistic conclusion, it is acknowledged that uptake of this capacity in completed and operational schemes is currently low, even at a national scale. The strongest evidence at this stage is for planned developments to incorporate these techniques and technologies, of which there are several.

10.7 Gasification and Pyrolysis of Biomass

Biomass need not simply be burnt; other options exist, such as pyrolysis and gasification. These are thermal processes using high temperatures to break down any waste containing carbon. The pyrolysis process degrades waste to produce char (or ash), pyrolysis oil and synthetic gas (called syngas). The gasification process then breaks down the hydrocarbons left into a syngas using a controlled amount of oxygen.

Gasification and pyrolysis typically rely on carbon-based waste such as paper, petroleum based wastes like plastics, and organic materials such as food scraps.

Gasification involves using a small amount of oxygen whereas pyrolysis uses none. Both produce a synthetic gas (called syngas) made up mainly of carbon monoxide and hydrogen (85%), with smaller amounts of carbon dioxide and methane. Syngas has a calorific value, so it can be used as a fuel to generate electricity or steam, or used as a basic chemical in the petrochemical and refining industries. Other by-products include liquids (mainly water used for washing the gas clean) and solid residues – ash, or char.

Most gasification and pyrolysis processes have four stages:

- Pre-treating the waste, which usually involves sterilizing it and separating out some of the recyclables, especially glass, grit and metal (which have no calorific value); then
- Heating the remaining waste, mainly organic pulp, to produce gas, oils and char (ash); then
- 'Scrubbing' (cleaning) the gas to remove some of the particulates, hydrocarbons and soluble matter; then
- Using the scrubbed gas to generate electricity and, in some cases, heat (through combined heat and power – CHP).

Research into these developing techniques is underway. PyNe, The Biomass Pyrolysis Network, is a global network of active researchers and developers of fast pyrolysis, and has been established to discuss and exchange information on scientific and technological developments on pyrolysis and related technologies for the production of liquid fuels, electricity and chemicals.

Fifty municipal buses in Pamplona, Spain began to use biodiesel in February 2007. This is first experience where 100% unmixed biodiesel is used in public transport in Spain on a large scale. For the daily work of 50 buses the City needs 1.5 million litres per year of this fuel. As a result of this measure the emission of 3,500 tonnes of CO_2 has been avoided.

10.8 Hydrogen

Hydrogen power, a renewable energy, has the longer-term potential to replace fossil fuels. This potential has been recognised for well over 100 years, but it requires energy to extract hydrogen from water, or any other source. Depending on how it is produced, hydrogen fuel can be an easily-stored, clean, green source of power. At present, most hydrogen is made from the reforming of fossil fuel gas, but it can be made electrolytically, by splitting water molecules into its constituent parts of oxygen and hydrogen. If the electricity that is used comes from a renewable energy source, then hydrogen could then become a green energy alternative to power everything from laptops to submarines. Hydrogen power can also be produced from hydrocarbons, like oil and gas, but these have downsides in their by-products.

Fuel cell technology, which allows hydrogen gas to bond back with atmospheric oxygen to create electricity and fresh water, is the key to hydrogen exploitation. Although many different systems have been successfully designed, economies of scale require mass production before any can hit the high street. A wide range of research areas are active across the world.

Pollution-free hydrogen cell technology is predicted to be the next wave in emissions-control after the hybrid electric motor, currently used in the automotive industry. Research into hydrogen power has been pumped with funding in the US in particular. DaimlerChrysler, Ford and GM have spent about $2bn on fuel cell cars, trucks and buses. The first products came out in 2003, and many UK cities have deployed hydrogen buses.

Hydrogen storage and distribution technologies are under development. Other projects use hydrogen in different ways:

BP and Scottish & Southern Energy have engaged in a project to build a hydrogen power plant in Peterhead. The facility will generate hydrogen from natural gas, and capture the produced CO_2 for permanent underground storage in a depleted oil and gas reservoir in the North Sea. The scheme will store over 5,000 tonnes of CO_2 per day, equivalent to taking half a million cars off our roads, and at the same time generate enough clean electricity to power a third of Scotland's homes.

An experimental hydrogen-powered building has been designed by the Arup Building Engineering team in Sheffield for a small business incubator project which will house a fuel cell research group. The carbon-neutral development is funded by Objective 1 and the Carbon Trust, and will be used as a test bed to experiment in the use of fuel cells in buildings. Wind turbines will provide power to an electrolyser to produce hydrogen. This hydrogen is then fed into a fuel cell that converts the gas into electricity and heat. The project is a test-bed for this leading-edge technology, including the provision of an on-site mini-grid scheme. The project is currently at design stage and is expected to be completed by 2009.

Nuclear-hydrogen power uses the energy generated by nuclear reactors to produce hydrogen and this is then available to power engineering and industry. Supporters argue that the development of nuclear-hydrogen power will contribute to global energy security and decrease the demand for fuels which affect climate change.

Undoubtedly, evidence suggests that hydrogen is an attractive option for meeting specific energy needs and may offer some potential over the longer term. This finding supports the Mayor's general support for this emerging source.

10.9 Energy from Waste

Recovering energy from waste is an important means of mitigating the effects of climate change as it plays a "vital role in helping the UK to meet its international obligations to reduce the emission of greenhouse gases, in particular carbon dioxide, by replacing fossil fuels as a source of energy" ("Energy from Waste Position Paper", SITA, 2004). Table 10.4 illustrates the GHG emissions savings that can be achieved when producing energy from waste, compared with current waste management practices of municipal solid waste (MSW):

Table 10.4: Comparison of 'business as usual' and energy from MSW GHG emissions scenarios

	Total GHG emissions (1000 tonnes CO_2 equivalents)					
Scenario	**2005**	**2010**	**2015**	**2020**	**2030**	**2040**
Business as usual	-1016	-751	-494	-272	-72	248
Energy from waste	-2714	-4700	-7068	-7988	-8310	-8474

"Impact of energy from waste and recycling policy on UK greenhouse gas emissions", Defra, 2006

Energy from waste (EfW) currently accounts for 23% of all renewable energy in the UK ("Energy from Waste Position Paper", SITA, 2004). It can be produced through a variety of means, summarised below:

- Combustion, the conversion of heat energy into steam and electricity, achieved using moving grates, rotary kilns and fluidised bed combustors. Fluidised bed combustors are particularly advantageous as they are extremely versatile, being able to handle large volumes of different types of waste. Atmospheric fluid beds have already achieved commercial status, whilst pressurised beds are still in their earlier phases. Such combustion technology has already been successful implemented, for example, in Madrid, where a revolving fluid bed takes in 10% of the city's waste, converting it to energy for electric power (Yassin et al, "Energy recovery from thermal processing of waste: A review", Engineering Sustainability 158 (2), 2005).
- Gasification, the thermal conversion of organic matter into a gaseous product via partial oxidisation, which is particularly well-suited to district heating/electricity, institutional heating, and combined heat and power. Fluidised beds (for larger schemes, >25-50MWe) and fixed beds (for smaller schemes, <5MWe) are the main forms of technology currently, both of which have become commercial. Gasification technologies have been successfully implemented in Tokyo and Berlin with waste treatment facilities capable of handling 225,000 and 100,000 tonnes per year respectively (Yassin et al, 2005).
- Pyrolysis, the thermal conversion of organic matter in the absence of oxygen to produce a liquid fuel, solid char and combustible gas. Like gasification, fluidised beds are the preferred technology. However, it has yet to go beyond pilot and demonstration projects and is relatively expensive when compared to more traditional energy sources. Its further commercial development is also dependent on the establishment of a reliable biofuels market (Yassin et al, 2005).

Whilst these technologies are becoming increasingly commercially viable, they still face a number of barriers to wider implementation, the most significant being cost, as well as the current state of technology, take up in the energy sector by those with vested interests in other forms of energy, public opposition (NIMBYism) and regulatory barriers (Yassin et al, 2005). However, its potential for greater implementation is borne out by the significant role it already plays in other European countries (Table 10.5). In Sweden and Denmark for example, 40% of community and domestic energy demands come from district heating schemes linked to EfW/CHP plants ("Energy from Waste Position Paper", SITA, 2004).

Table 10.5: Waste management in selected European countries

Country	% waste recycled	% waste used to generate energy	% waste landfilled
Austria	44	18	32
Denmark	30	58	12
France	14	27	58
Germany	21	36	43
Netherlands	37	41	22
Sweden	32	35	33
Switzerland	39	47	14
UK	15	9	78

"Energy from Waste Position Paper", SITA, 2004

Whilst the generation of electricity from waste is considered to be more expensive than a 'business as usual' waste management scenario, once the cost and benefits of reducing GHG emissions are taken into account, producing energy from waste becomes the cheapest option (Table 10.6). Furthermore, the costs illustrated in Table 10.5 are based upon present day costs for energy from waste technologies, whose increased uptake and implementation will substantially lower costs in the future:

Table 10.6: Comparison of total value costs of MSW waste management options (£m)

Timeframe	Present value of costs		Present value of costs plus costs/benefits of GHG emissions	
	Business as usual	Energy from waste	Business as usual	Energy from waste
Up to 2010	156,68.9	168,21.2	154,01.8	151,05.7
Up to 2020	369,84.2	434,38.2	378,65.3	364,23.3
Over lifetime	699,17.4	860,52.3	718,64.3	697,61.6

"Impact of energy from waste and recycling policy on UK greenhouse gas emissions", Defra, 2006

10.9.1 Hydrogen from Waste

One of the most significant prospects offered by waste in reducing GHG emissions is the opportunity to generate hydrogen from waste. Sung writes that "as a sustainable energy supply with minimal or zero use of hydrocarbons, hydrogen is a promising alternative to fossil fuel. The combustion product of hydrogen is a non-pollutant, water. In addition, hydrogen can be directly used to produce electricity through fuel cells without any combustion" ("Biohydrogen Production from Renewable Organic Wastes", Iowa Energy Center, 2006). Indeed, in London, "the potential for the production of hydrogen from waste is considerable. There is an aggregate potential for 141 tonnes of hydrogen per day in 2020" ("The potential for hydrogen production from waste in London", London Hydrogen Partnership, 2006).

One of the greatest benefits of producing hydrogen from waste is that waste is a renewable source. The majority of hydrogen currently produced requires traditional energy sources, rendering it not truly sustainable. In America, for example, only 5% of hydrogen currently produced is generated from a renewable source such as waste (Geiger, "Automotive Hydrogen Infrastructure – on the way to the hydrogen economy", 2003). Hydrogen can be produced from waste in a number of ways. Gasification (see earlier) produces syngas – a mixture of hydrogen, carbon monoxide and carbon dioxide, which can be converted into H_2 by cleaning, reforming and water-gas shifting. Anaerobic digestion involves the breakdown of organic matter with microbial organisms in the absence of oxygen to produce biogas, which can be easily cleaned to produce bio-methane, from which hydrogen can be made.

There are, however, a number of drawbacks associated with current hydrogen technologies. The exact cost of producing hydrogen by either gasification or anaerobic digestion has yet to be established. Gasification is further disadvantaged by the requirement for facilities producing hydrogen to be located close to demand. The planning period of 4-5 years required for such facilities could also hinder their development, as hydrogen demand cannot necessarily be guaranteed so far in advance. Its further development will therefore depend upon establishing a more robust supply chain, from production to distribution and storage (Geiger, 2003). Despite such issues, there has been considerable international commitment to hydrogen, which will encourage the pace of its development through both greater commercial market opportunities and growing technological expertise. Japan for example aims to have 50,000 hydrogen fuel cell vehicles on the road by 2010, whilst Germany aims to have a 15% hydrogen fuel penetration by 2020 ("London Hydrogen Action Plan", GLA, 2002). Such international interest is evidence of hydrogen's potential to reduce GHG emissions; the replacement of London's diesel buses with hydrogen is for example estimated to reduce their GHG emissions by as much as 50-75%. Furthermore, "regardless of all the problems which might seem unconquerable today, hydrogen is expected to become one or even the leading energy source within the next 20-30 years" (Geiger, 2003).

10.10 Wind Power

In 2006, the global wind energy sector grew by 30%, pushing the global total of installed wind energy capacity to finally break the 40 GW mark.

This growth, however, has not been equal across the world. Europe, and in particular Germany, has the largest share of today's wind market- about 75%. Germany's contribution to this global total is 15 GW, almost 40% of the planet's installed wind power capacity. Spain is placed second globally with over 6 GW of capacity installed, that is, more or less the same as North and South America combined. India still has three times more installed wind energy than the UK.

Economies of scale are encouraging the development of larger and larger turbines. Turbines rated as 4.5 MW can now be bought off-the-shelf, while components suitable for future turbines of 7.5 MW are now been developed and tested. This growth in turbine size is encouraging and enabling both the re-powering of existing wind farm sites and the proposal of large new off-shore farms which would have been considered uneconomic with the small turbines available ten years ago.

The LEP report on wind and biomass referred to above made calculations of the potential for non-building integrated wind energy capacity in the Greater London area. This, the report says, is predicted to be 50.34MW, generating 144.5GWh of electricity annually, able to supply approximately 116,015 households and saving 147,015 tonnes of CO_2 each year. This represents a 22.73% contribution towards the Mayor's target for electricity from renewable schemes by 2010.

10.10.1 Wind Turbine Location Issues

The total resource for wind energy is determined by the availability of land or sea area for the siting of wind turbines combined with wind speeds.

A minimum annual mean wind speed (AMWS) of 7.0 m/s is currently thought to be necessary for commercial viability. Hardly any UK land has an AMWS of more than 10 m/s. Because mean wind speeds increase with the elevation of the land, the most suitable areas tend to be on hills. About 33% of UK land area (around 100,000 km^2) has an annual mean wind speed equal to, or higher than, 7.0 m/s. However, only a proportion of this land could be used due to physical constraints (roads, lakes, unsuitable structure of sea bed etc.). The British Wind Energy Association estimates that the UK has 65,252 km^2 of land area suitable for wind generation.

The total resource for both onshore and offshore wind is far larger than the total UK electricity demand. However, it would be impractical to exploit it. As a result of various restrictions, the disparity between the physical and the practicable resource is very large for both onshore and offshore wind. All estimates are very sensitive to a variety of assumptions, for example about siting, height of turbine towers, the severity of various physical constraints, public concern over visual intrusion, and network restrictions.

Large turbines work well in high wind speeds and relatively smooth airflows: the technology matches the conditions where they are sited. The remoteness of these locations has allowed ever-larger turbines to be built, generating significant amounts of electricity. Urban areas can, however, be very different. Some sites – parks, riverbanks and edge-of-town areas – may have relatively high wind speeds and low turbulence; in these places, large turbines may work well. However, elsewhere in urban areas, buildings and other features tend to cause turbulence, and average wind speeds tend to be lower. The challenge to urban wind turbine design is to harness these mixed wind conditions effectively. As a result, it is unlikely that wind power can be used to deliver the major electricity generation that London requires. The availability of appropriate sites for wind generation is the critical issue.

The LEP study into the siting of wind turbines concluded that there are 25 locations suitable for wind energy in London. These comprise seven areas within London and ten within the M25 Corridor with the potential for medium- to large-scale wind, and eight with potential for small- to medium-scale wind development. The general conclusion is that, while wind power may make a contribution to London's overall energy needs and the needs in specific opportunity areas, wind is not likely to be of general applicability in relation to the FALP policy concerning decentralised, renewable energy.

10.11 Solar Design and Power

The use of passive solar design is possibly the simplest form of solar energy. Many buildings today are designed to utilise the energy of the sun as efficiently as possible. The location and orientation of the building are all key factors in optimising passive solar design.

Passive solar design can be best applied in new buildings, where the orientation of the building, the size and position of the glazed areas, the density of buildings within an area, and materials used for the remainder of the structure are designed to maximise free solar gains. Designing a property to maximise free solar gain need not add to the price of construction.

Studies on houses in Milton Keynes have shown that low-cost passive solar design features and draughtproofing and insulating measures reduced heating bills by 40%. Operational savings paid back the capital costs in two years (see http://www.nef.org.uk/greenenergy/index.htm).

Solar energy can also be captured by solar panels. Two main types of solar panels exist, using complete different technologies to harness energy from the sun:

- Solar Water Heating collectors absorb the energy from the sun and transfer it to heat water; and

- Photovoltaic, or solar electric panels transform solar radiation directly into electricity.

For maximum efficiency, solar panels should be mounted on a south facing roof at a 30° angle from the horizontal and away from any shadows from trees, surrounding buildings or chimneys.

10.11.1 Solar Water Heating

Solar water heating systems are the most popular form of solar energy used in the UK. The panels are connected directly to the hot water system of the building. They can provide over half of an average household's hot water requirements over the year.

Two types of solar water heating collector exist. Flat Plate Collectors in their simplest form are made from a sheet of metal painted black which absorbs the suns energy. Water is fed through pipes attached to the metal sheet and picks up the heat in the metal. For the UK climate the pipe work contains non-toxic anti-freeze. The pipes are often made of copper for better conduction. The metal sheet is embedded in an insulated box and covered with glass or clear plastic on the front. It is usually installed on the roof.

The evacuated tube system is a series of glass heat tubes grouped together. The tubes are highly insulated, due to a vacuum inside the glass.

The cost of installing a solar hot water system ranges from approximately £500-£1500 for a DIY system to £2000-£5000 for a commercially-installed system. These prices, however, are dependent on the size of the system. A typical installation in the UK has a panel of 3 m^2 to 4 m^2 with a storage tank of 150- 200 L (2 m^2 for evacuated tubes). However, the optimum size will depend on actual hot water use. This can be calculated using software to simulate system performance throughout the year. Undoubtedly, solar water heating is a viable option and may be used as part of the means for meeting FALP policy targets.

10.11.2 Solar Electric Generation

Photovoltaic (PV) or solar electric generation offers the ability to generate electricity in a clean, quiet and renewable way. Applications for solar electric power are numerous. PV cells are used in simple applications, e.g. calculators and watches, as well as for domestic and larger applications. Large PV systems can be integrated into buildings to generate electricity for export to the National Grid.

PV applications are already quite commonplace. Domestic burglar alarm systems are now fitted with PV panels to charge the battery for the system. In Milton Keynes, parking meters are powered by solar panels. Many leisure uses have PV panels for back up electricity, including TV, lighting in caravans, and nautical instruments.

While the daylight needed is free, the cost of equipment can take many years before receiving any payback. However, in remote areas where grid connection is expensive, PV can be the most cost effective power source.

In general, for large-scale applications, PV generation is still very high in capital cost and, when considered in terms of the density to which much of London is built, is only able to generate small proportions of the total energy need. This suggests that it may form part of a suite of measures. Larger-scale applications are still at a highly embryonic stage.

10.12 Tidal Power

Tidal power generation is achieved by capturing the energy contained in moving water mass due to tides. Two types of tidal energy can be extracted; kinetic energy of currents between ebbing and surging tides can be harnessed, as can the potential energy from the difference in height (or ‘head’) between high and low tides. The former method – generating energy from tidal currents – is considered much more feasible than building ocean-based dams or barrages, and many coastal sites worldwide are being examined for their suitability to produce tidal (current) energy.

Tidal power is classified as a renewable energy source, because tides are caused by the orbital mechanics of the solar system and are hence inexhaustible within a human timeframe. Tidal power has great potential for future power and electricity generation because of the total amount of energy contained in this rotation. Tidal power is furthermore highly predictable; tidal mills have been used for nearly 1,000 years, mainly for grinding grain.

The efficiency of tidal power generation largely depends on the amplitude of the tidal swell. As with wind power, selection of location is critical for a tidal power generator.

Seaflow is a twin-bladed Marine Current Turbine rotor connected to an electrical generator mounted on a steel mono-pile drilled into the seabed. The blades turn in the tidal stream (as wind turbines are driven by wind), and the greater density of water means that although the blades are smaller and turn more slowly, they still deliver a significant amount of power.

Stingray uses a hydroplane, similar to an aircraft wing but in water, to collect energy from the tide. This is attached to a mechanical arm which changes the position of the hydrofoil each cycle, and is also connected to a pump which pressurises oil. This oil passes through a hydraulic turbine which drives a generator to produce electricity. Stingray is a seabed mounted machine, designed for use in water up to a depth of 100m.

10.13 Conclusions

This chapter has demonstrated the potential value of renewable energy as a low-carbon energy source. The evidence supports the technical potential for a 20% target for carbon reduction through renewable on-site generation, which may be achieved in London particularly through biomass or solar sources as well as from wind power on certain larger sites.

While the FALP policy can be supported by the evidence, it is unclear that this is the only means to achieve long-term carbon reductions in energy supply. The important issue, however, is that any achievement of growth in low-carbon generation requires significant policy support, as the market is insufficiently strong to generate supply on the necessary scale to meet Government targets. This means that the proposed FALP policies are appropriate in this sense, particularly because it is difficult to identify any alternative and robust method of achieving the policy objectives. We suggest, however, that there may be scope to accept alternative methods in the future that can achieve similar outcomes. These might include area- or district-wide power and heat generation. An equally strong, but more flexible, policy would allow similar objectives to be met. Policy could, for example, seek 20% reductions to carbon emissions through renewable energy of any kind where the renewable energy source can be explicitly identified and is not transmitted through the National Grid.

11 Water

11.1 Introduction

The probability of high increases in the incidence of flooding as well as of drought and the attendant issues of drainage and management of surface water is crucial to successfully adapting to climate change, as is the challenge of meeting future water supply issues. As regards water supply, drainage, and flooding, the provisions of the Further Alterations to the London Plan related to climate change can be summarised thus:

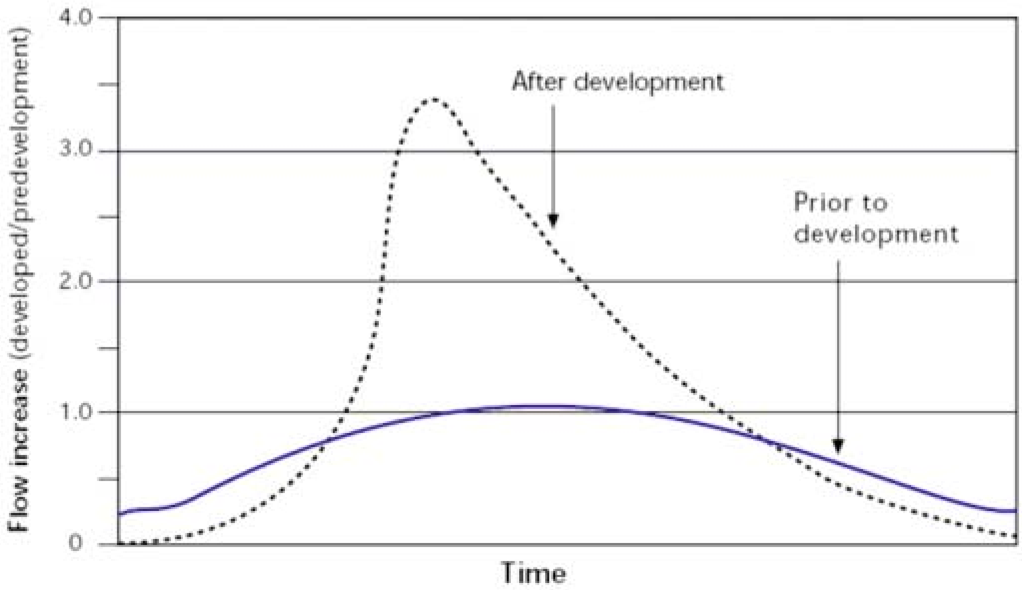
- Boroughs should identify areas at risk of flooding.
- Development next to flood defences should be set back.
- Developments should incorporate sustainable drainage, managing surface water run-off as close to source as possible, in line with the drainage hierarchy.
- Drainage capacity should follow only after source control management has been maximised.
- Major developments where rising groundwater could be an issue should try to abstract and use it.
- Residential development is to adhere to a 40m³/bed/year water use target.
- Water quality will be protected by ensuring adequate sewerage capacity is available for developments, refusing proposals that will lead to a reduction in water quality, and using sustainable drainage systems.
- The Mayor will work with Thames Water and others to improve water supply and sewerage infrastructure.

11.2 Flooding

It is widely acknowledged that “inappropriate new developments can reduce floodwater storage areas and increase surface run off” (“London Under Threat? Flooding Risk in the Thames Gateway”, London Assembly, 2005). With intense rainfall events predicted to increase as a result of climate change (see Sections 2.3 and 3.3), it is therefore increasingly important that new developments are neither located where they will obstruct the optimal operation of flood defences, nor within active flood plain areas. Land Drainage Byelaws require that new developments must maintain a Land Drainage Consent Zone of 16m from the most landward part of the defence, in order that it can be repaired, replaced and maintained satisfactorily (“Thames Region Land Drainage Byelaws”, Environment Agency, 1981). Elsewhere on the flood plain, national planning policy guidance contained within PPS25 requires that new development should be directed away from the floodplain to areas of lowest flood risk, in order both to protect it *from* flooding and reduce its contribution *to* flooding.

Not only does inappropriate development within the floodplain contribute to flood risk; urbanisation beyond the flood plain can also increase flood risk, principally by “decreasing the proportion of rainfall that infiltrates into the ground and consequently increasing surface runoff, in terms of both volume and flow rate” (“Learning to Live With Rivers”, The Institution of Civil Engineers, 2001). Increased surface runoff volumes and flow rates are a major factor in the occurrence of ‘flash floods’, whereby the volume of water delivered to a water channel is delivered at such a rate that the channel discharge capacity is quickly overwhelmed (Figure 11.1):

Figure 11.1: The effect of urbanisation on runoff



Environment Agency et al 2003: 8

It is clear therefore that "unless care is taken with their design and location, (new buildings) can worsen flooding. Inappropriate development can increase the risk of flooding downstream and also result in sudden rises in water levels and flow rates" ("Flooding in London: A London Assembly Scrutiny Report", London Assembly, 2002).

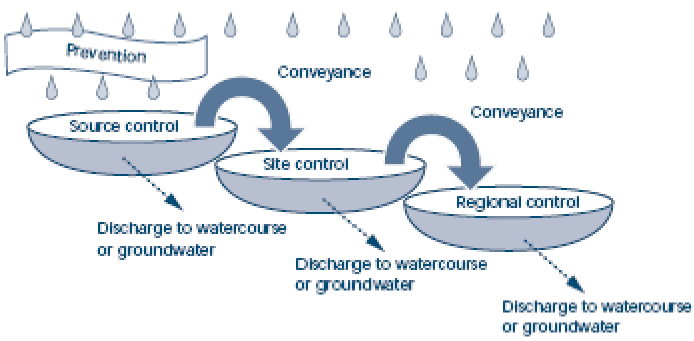
Within the context of heightened flood risk as a result of climate change, it is increasingly important that the effects of urbanisation on flooding are minimised. In terms of identifying the most sustainable solution, the ICE remarks that "water is stored in all parts of the catchment and river system as part of the natural process of conveying rainfall to the sea. Solutions that encourage temporary storage of flood waters are mimicking nature and where practical are to be preferred" ("Learning to Live With Rivers", 2001). In this respect, Sustainable Drainage Systems (SUDS) can help manage surface water runoff which might otherwise cause flooding and pollution by introducing drainage systems that mimic natural processes rather than piped solutions (Ellis et al, "Sustainable Urban Development and Drainage", Municipal Engineer 157, 2004). SUDS is the collective term used to refer to a diverse range of sustainable approaches to surface water drainage management which "can be designed to fit into all developments, from hard surfaced areas to soft landscaped features, as there are many design options available" ("Sustainable Drainage Systems (SUDS)", Environment Agency, 2003).

Although there are 'many design options available', it is widely recognised that "the most sustainable solutions are likely to be those that address the issue of runoff at source…the introduction of storage into the rainfall-runoff relationship can be particularly effective when applied near to the point where the runoff begins" ("Learning to Live With Rivers"). With this principle in mind, the Environment Agency therefore recommends a primary approach by which achieving a reduction in the quantity of runoff generated from a new development is considered first. Reduced runoff totals through SUDS can be achieved in a number of ways, the most beneficial being the collection and storage of rainwater for reuse within a development. Not only does this reduce total runoff, but it also helps to mitigate against potential water resource shortage issues in London (see Section 3.3) (Woods-Ballard et al, "The SUDS Manual", 2007; "Down the Drain: London's water usage and supply", London Assembly, 2005).

Runoff can also be reduced by encouraging infiltration into the ground below. Such techniques are seen as the most desirable solutions as they help to restore the natural hydrological process (Woods-Ballard et al, “The SUDS Manual”, 2007). They are, however, dependent upon the suitability of the ground and soil conditions in the local area. Infiltration can be encouraged through a variety of means. Ellis et al (“Sustainable Urban Development and Drainage”, Municipal Engineer 157, 2004) recommend the use of infiltration trenches and porous or permeable paving for developments less than 3ha: Porous asphalt or blocked surfacing is suitable for mews-streets and cul-de-sacs and other quiet residential side streets, whilst driveways, pavements, pedestrian and cycle ways, courtyards and parking bays/ areas lend themselves to porous paving, block pavoirs and open grasscrete structures, all of which enhance on-site infiltration, therefore reducing total site runoff. Such techniques have also been found to be effective in simplifying construction, for example, by eliminating the risk of puddles and therefore the need for pumping). Sustainable drainage techniques have been successfully implemented in BedZed, a mixed residential and commercial development in Croydon, South London, which employs permeable paving, green roofs and water harvesting (“Sustainable Drainage Systems (SUDS)”, Environment Agency, 2003). Runoff from development can also be reduced through the installation of green roofs and infiltration basins.

Whilst achieving a reduction in the volume of water generated from a development is identified as the main priority, further down the drainage hierarchy (see Figure 11.2), the rate at which residual runoff is delivered to watercourses should also be addressed. This can be achieved most effectively through the incorporation of attenuation/detention ponds or open water features within a development. Although better suited to larger developments (>6 ha) (Ellis et al, “Sustainable Urban Development and Drainage”, Municipal Engineer 157, 2004), as well as providing temporary storage, encouraging further infiltration and consequently delaying the delivery of runoff to a water course, such features can also add recreational value to a development. Surface water generated from Emmerson’s Green housing development north of Bristol passes through a system of ponds and wetlands, which, as well as reducing development runoff, is an important amenity for the local community (“Sustainable Drainage Systems (SUDS)”, Environment Agency, 2003).

Figure 11.2: Surface water management train: Addressing runoff quantity throughout the drainage system



“Sustainable Drainage Systems (SUDS)”, Environment Agency, 2003

Where development, ground and soil conditions do not permit the use of open water features, runoff can be stored for gradual discharge or reuse in sealed tanks and water features. A more detailed summary of all SUDS techniques is contained in Appendix 4.

In terms of cost, the implementation of SUDS has not been found to be any more expensive than traditional drainage solutions (Woods-Ballard et al, “The SUDS Manual”, 2007). Furthermore, the benefits can be seen as extending beyond flood management to the provision of community and environmental amenities. Construction costs associated with SUDS are likely to vary depending on variables such as ground conditions, catchment characteristics and development specifications. Table 11.1, however, provides an indication of anticipated costs for various SUDS solutions:

Table 11.1: Average costs for SUDS implementation

Component	Cost	Unit
Filter drain	£100-140	/m³ stored volume
Infiltration trench	£55-65	/m³ stored volume
Soakaway	£>100	/m³ stored volume
Permeable pavement	£30-40	/m² permeable surface
Infiltration basin	£10-15	/m³ detention volume
Detention basin	£15-20	/m³ detention volume
Wetland	£25-30	/m³ treatment volume
Retention pond	£15-25	/m³ treatment volume
Swale	£10-15	/m² swale area
Filter strip	£2-4	/m² filter area
Maintenance costs		
Filter drain/ infiltration trench	£0.2-1	/m² filter surface area
Swale	£0.10	/m² swale surface area
Filter strip	£0.10	/m² filter surface area
Soakaway	£0.10	/m² treated area
Permeable pavement	£0.5-1	/m³ storage volume
Detention/ infiltration basin	£0.10-0.30	/m² detention basin area
Wetland	£0.10	/m² wetland surface area
Retention pond	£0.50-1.50	/m² retention pond surface area

HR Wallingford in Woods-Ballard et al, "The SUDS Manual", 2007

Where it is unfeasible to install SUDS within a development, water can be discharged direct into a watercourse, although the control of its release through the use of underground storage tanks and permeable conveyance systems such as filter drains and detention ponds (see Appendix 5) which delay its delivery is encouraged ("Sustainable Drainage Systems (SUDS)", Environment Agency, 2003).

The use of SUDS as a substitute for traditional drainage systems is regarded as providing "the maximum possible social and economic resilience against flooding by protecting and working with the environment, in a way which is fair and affordable both now and in the future" (Scottish Executive in Werritty, "Sustainable Flood Management: Oxymoron or New Paradigm?", Area 38 (1), 2006). Indeed, increasing urban drainage capacity and discharging development runoff into surface water drains and combined sewers is seen as a last option for a number of reasons. As outlined in Section 3.3.4, the capacity of London's sewer and drainage network is already nearly at capacity. Furthermore, the significant amount of time required to allow sufficient upgrades – identified as between 10 and 15 years by the Office of Science and Technology ("Foresight Future Flooding Report", 2003) – does not provide a solution to already existing and growing flooding and drainage capacity problems. Indeed, it is not only the time constraints that prohibit the use of pure hard engineering solutions address the problem of urban drainage; it would also be ‘inconceivable’ and ‘prohibitively expensive’ to do so, according to Werritty and the Office of Science and Technology. Research into the use of hard engineering (both for flood defences and urban drainage) to manage flood risk has revealed that it would require an additional £52 billion in investment, compared with £22 billion when used in combination with a number of non-engineering measures (Evans & Hall, “A New Climate for Flood Planning”, 2004).

Besides purposeful flood management such as SUDS, other aspects of urban design can also play an important part in reducing flood risk. The value for example of green spaces within the urban environment is widely recognise – as Alexander remarks, the Office of Science and Technology writes in the 2003 “Foresight Future Flooding Report” that “approaches to the creation of new green corridors and the maintenance of existing undeveloped spaces would provide ‘safety valves’ for the storage and passage of floodwaters when the drainage networks become overloaded”. Not only are pen spaces of value in providing extra flood storage areas, they also allow the natural infiltration of rainfall, thus reducing surface runoff totals and the rate at which water is delivered to the drainage network. In this respect, it is not only London’s strategic open spaces which are of great value, but domestic gardens also. In London, more than a third of green space and two thirds of tree cover are in domestic gardens (GLA in Alexander, “The Environmental Importance of Front Gardens”, Municipal Engineer 159 (4), 2006, which therefore perform a very important strategic role in reducing flood risk within the capital. However, concern has been raised over the increasing number of domestic gardens and public open spaces that have become hard surfaced – in London 12 square miles of front gardens have now been paved where 14% of gardens are now more than ¾ paved (“Gardening Matters: Front Gardens”, Royal Horticultural Society, 2007). The average suburban garden has been found to absorb about 10 litres of rainwater a minute, which, in combination with other gardens contributes to a reduction of thousands of litres (RHS in Alexander, “The Environmental Importance of Front Gardens”, Municipal Engineer 159 (4), 2006). It is therefore important that these valuable resources are retained within existing and future development. Indeed, research in London has shown that the existence of a ‘presentable’ front garden can add up to 6% on a house price, equating to 12% on the average home (Hunt, 2005). Considering the value of green spaces in mitigating flood risk, the use of green roofs should also be encouraged. Research has found that green roofs can reduce surface runoff from light rainfall by 60% (Beattie in Byrd & Block, “Green Roofs Clean Rainwater Runoff”, 2007, available online at http://www.earthsky.org/radioshows/48981/green-roofs-clean-rainwater-runoff).

In terms of exterior and interior building design and construction, flood resilient measures can also be built into developments where there is a risk of flooding. Amongst other things, successful design measures include restricting ground floor uses to flood compatible uses (eg car parks), concrete floors, water proof plaster, raising electrical wiring above possible flood levels, solid not suspended floors, raised ground floor levels and use of water resistant alternatives to traditional internal wall finishes (“Flood Resilient Homes”, Association of British Insurers, 2007).

11.3 Water Resources

Whilst it might seem paradoxical that within the context of rising flood risk water resources are expected to become scarcer, Sections 2.3 and 3.3 make it clear that water resources are very likely to become more unpredictable in the future as a result of climate change. Indeed, recent research has revealed that within the Thames region, the present balance of water supply and demand is already in deficit by 180Ml/d (“London’s Warming: Technical Report”, GLA, 2002). London is therefore already operating under security of supply conditions of a 'large deficit' (over 10%) of water supply against target headroom ("Security of Supply Leakage and Water Efficiency", Ofwat, 2006), which has begun to impact on water use, with a region-wide hosepipe and sprinkler ban being introduced in April 2006. Such conditions have arisen due to a combination of factors. One of the most significant in the London area has been the high leakage figures experienced within the Thames region (Table 11.2), which actually experiences the highest leakage rates in the whole country ("Down the Drain: London's water usage and supply", London Assembly, 2005).

Table 11.2: Leakage in the Thames Region (ML/d)

2001-02	2002-03	2003-04	2004-05	2005-06
865	943	946	915	862

"Security of Supply Leakage and Water Efficiency", Ofwat, 2006

Higher leakage is also occurring within the context of reduced annual average rainfall totals. In 2005, for example, average monthly rainfall was consistently lower than the 1961-1990 average, and in some cases up to 56% lower (Table 11.3).

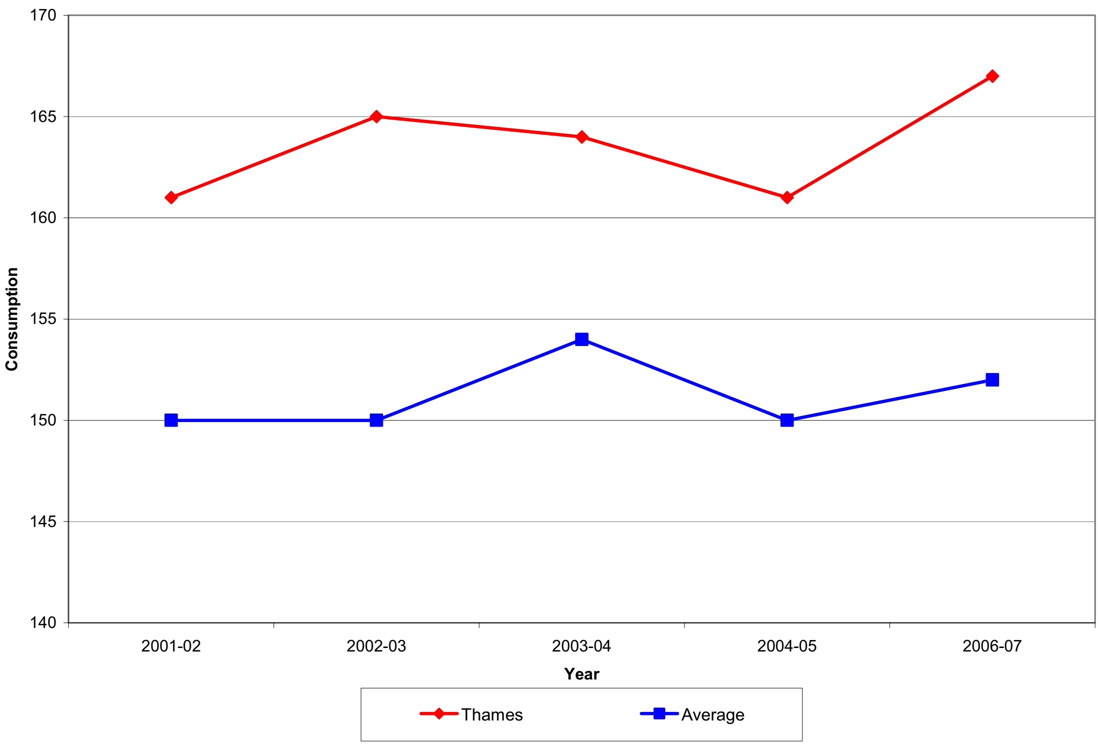
Table 11.3: Monthly rainfall in the Thames, 2005

	J	F	M	A	M	J	J	A	S	O	N	D	2005
2005 (mm)	29	24	47	49	30	39	47	49	50	80	49	56	550
%1961-1990 average	44%	53%	83%	97%	53%	72%	93%	83%	84%	125%	74%	79%	79%

"Hydrological Review of 2005 – Rainfall", Met Office, 2006

Whilst leakage and falling rainfall totals have certainly contributed to current water deficits, average household water consumption within the Thames region is consistently above the national average and is now at its highest estimated level (see Figure 11.3) – a situation which could worsen as the changing climate influences domestic water use patterns.

Figure 11.3: Thames estimate of unmetered household consumption (L/head/d)



"Security of Supply Leakage and Water Efficiency", Ofwat, 2006

Whilst leakage can and is to be addressed (see Table 11.4), it is widely acknowledged that this alone will not solve the problem. Indeed, Thames Water has already failed to meet its target leakage reductions for 2005-06, thus jeopardising its ability to meet future targets.

Table 11.4: Thames Water leakage targets (ML/d)

2005-06	2006-07	2007-08	2008-09	2009-10
830	810	755	715	690

"Security of Supply Leakage and Water Efficiency", Ofwat, 2006

Combined with the growing uncertainty over water resource supplies caused by a warming climate, it is clear that in the future "the region's demand for water will exceed the amount that can be supplied", causing Londoners to "face an unacceptably high risk of water shortages unless there is a change in patterns of water usage" ("Down the Drain: London's water usage and supply", London Assembly, 2005). Whilst major infrastructure projects such as new water treatment plants and reservoirs will help to alleviate the problem, the long time periods required to deliver these projects hinders their ability to address more immediate water resource needs; "although new supplies will go a long way to closing the gap, demand management should play a greater role to minimise the effects of a growing populace" ("Water Matters: Mayor's Draft Water Strategy", GLA, 2007). One of the most effective means of reducing water consumption immediately is therefore through the introduction of water use targets for new development – such targets are seen as easily achievable through a number of mechanisms.

One of the main causes of increasing demand for water has been the growth in domestic appliances; findings from the Environment Agency reveal that household water consumption has risen by 70% over the past 30 years, mainly due to the introduction of water-demanding appliances (2007). However, in this respect there are also large savings to be made – as Suzenet et al write, "per capita urban water use could be significantly reduced and urban water better managed through the use of new water technologies that can contribute to improving water efficiency" ("Sustainable water management for the city: technologies for improving domestic water supply", Built Environment 28 (2). There exists a wide variety of water saving technologies (see Appendix 5), the effects of which on domestic consumption are summarised in Table 11.5 below:

Table 11.5: Current and best practice water use

Household water use	Current median (l/p/d)	Best practice (l/p/d)	Saving (%)
Toilet use	39	27	31
Personal washing	51	37	27
Clothes washing	21	16	24
Total	111	80	28
Total individual use	156	45	20

Environment Agency in "Water Matters: Mayor's Draft Water Strategy", GLA, 2007

The implementation of such measures in new build development is expected to reduce water consumption by 25% (ODPM in "Down the Drain: London's water usage and supply", London Assembly, 2005). Gallions Ecopark, a development of 39 affordable homes, has for example achieved an average water use of 109L per day (current average is 156 L/p/d) through a combination of easily maintainable water saving features, including low-volume baths, water efficient showers, spray taps, flow regulators, mixer taps, low dual flush toilets and water butts ("Water Matters: Mayor's Draft Water Strategy", GLA, 2007).

Fixtures can also be complemented by the installation of water meters within the home, which have been found to reduce consumption by between 5-10% (RSPB in "London Under Threat? Flooding Risk in the Thames Gateway", London Assembly, 2005). However, the implementation of such technologies must be accompanied by changes in water consumption behaviour, for example through educational campaigns promoting greater awareness amongst consumers.

Whilst water saving devices and improved consumer awareness can help to significantly reduce the pressure on mains-supplied water, they are not expected to achieve a sufficient reduction in water resource consumption ("Water Matters: Mayor's Draft Water Strategy", GLA, 2007). One of the most wasteful areas of current water consumption patterns is, however, the inappropriate use of pumped and purified water within the home. Environment Agency statistics reveal that nearly 50% of domestic water consumption does not require purified water (Table 11.6).

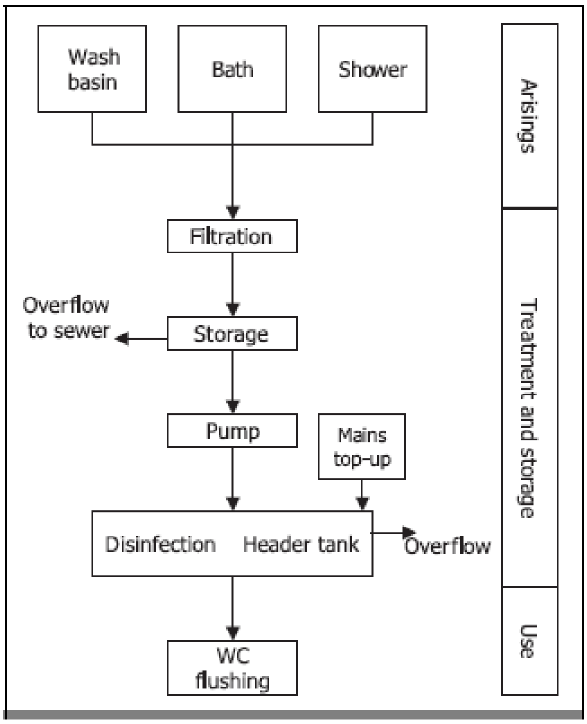
Table 11.6: Breakdown of domestic water consumption
(blue shading denotes where piped water could be replaced)

Household water use	L/person/day	% total use
Toilet use	39	25
Personal Washing	51	33
Drinking water	2	1.9
Clothes washing	22	14
Dish washing	12	7.7
Car washing	1	0.6
Gardening	9	5.8
Miscellaneous	20	12.2
Total	156	100

Environment Agency in ("Water Matters: Mayor's Draft Water Strategy", GLA, 2007

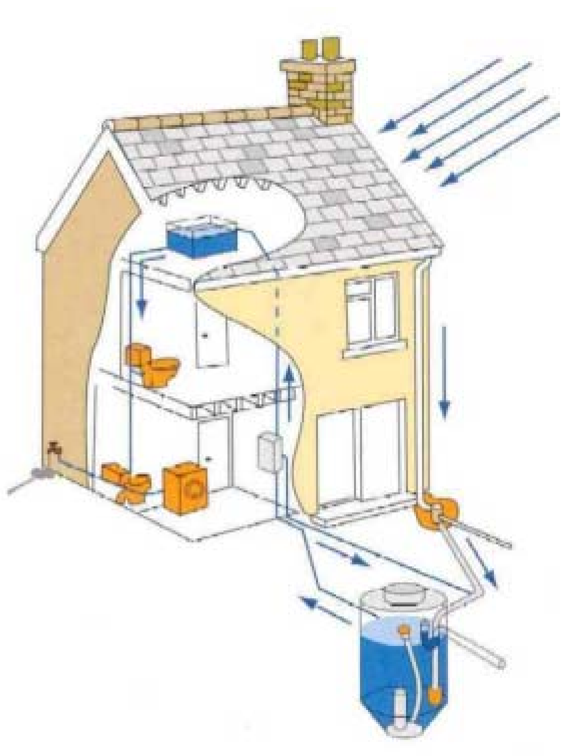
The needs of activities such as toilet flushing and gardening could therefore be met through the use of filtered grey and rain water, which does not have to meet potable water standards (see Table 11.7 below). As Leggett and Schaffer write, "rainwater and grey water use can contribute to the sustainability of water resources in providing an alternative water supply (rainwater) and reducing demand through using water more than once (grey water)" ("Buildings that save water – rainwater and greywater use", Municipal Engineer 151, 2002). Figures 11.4 and 11.5 illustrate typical grey water and rainwater reuse systems.

Figure 11.4: Flow diagram of a typical greywater system



Leggett & Schaffer, "Buildings that save water – rainwater and greywater use", Municipal Engineer 151, 2002

Figure 11.4: Typical rainwater system



"Rainwater Reuse", Environment Agency, 2007

Such schemes are capable of reducing household water use by a further 14% (Environment Agency in "Down the Drain: London's water usage and supply", London Assembly, 2005), whilst analysis undertaken by Thames Water found that grey water systems could successfully replace 97% of the water that would normally be used for toilet flushing (Thames Water in Leggett & Schaffer, "Buildings that save water – rainwater and greywater use", Municipal Engineer 151, 2002).

Table 11.7: Rainwater and grey water sources and end uses

Rainwater		Grey water	
Source	**End use**	**Source**	**End use**
Roof guttering	Toilet flushing	Wash basins	Toilet flushing
	Car washing	Baths	Car washing
	Plant watering	Showers	
	Clothes washing		

"Water Matters: Mayor's Draft Water Strategy", GLA, 2007

In this respect therefore, Sakellari et al ("Modelling Sustainable Urban Water Management Options", Engineering Sustainability 158, 2005) draw our attention to the benefits of 'joined-up' urban water management systems:

> The three main components of the water cycle within an urban setting, namely water supplied to consumers to meet their demand, stormwater and wastewater are often examined as distinct parts of the urban water cycle. As a result, their outputs are dealt with separately.

> Potential disadvantages of this practice are excessive water and energy consumption, as well as financial costs, owing to the high quality standards which need to be met by the water service provider, sometimes irrespective of the end use of the water. The use of integrated management of urban water becomes even more important when examined under the prism of sustainability…Introduction of more sustainable practices in an urban development necessitates investment in new technologies employed to improve existing infrastructure or provide new infrastructure with the ability to cope with the combination of urban water flows and exploit their interactions.

Whilst the reuse of grey water has met with some public opposition, particularly with regards to their perceptions of health and hygiene (Hill et al, "Assessment of water savings from single house domestic greywater recycling systems", 2006), there are clearly obvious advantages associated with the installation of dual systems. First, and most important, combined systems can achieve up to 90% domestic water efficiency (Sakellari et al, "Modelling Sustainable Urban Water Management Options", Engineering Sustainability 158, 2005). Second, although there are significant capital costs (typically ranging between £750 and £2500 extra) associated with the installation of combined water systems and the subsequent treatment required in order that such water is fit for reuse, research has found that financial savings from reduced mains water demand can exceed their operating costs, particularly for rainwater systems. Greywater systems have been found to be less reliable whilst taking longer to recover their initial cost, although their cost and reliability is continually improving (Leggett & Shaffer, "Buildings that save water – rainwater and greywater use", Municipal Engineer 151, 2002). Finally, by improving the internal water sufficiency of homes, grey and rain water systems also help to decrease energy consumption, and, therefore total carbon emissions, by reducing the volume of mains water that needs to be pumped long distances from its source. As the Environment Agency remarks, "it is important to take into account the energy use of different schemes. Pumping large volumes of water around uses significant amounts of energy, and therefore contributes to total emissions" ("Water Resources for the Future: A Strategy for England and Wales", 2001).

Whilst reducing the amount of required pumped water helps to reduce the volume of energy consumed, remaining energy consumption involved in the water supply chain can also be reduced through good engineering. The use of frequency converters in a mixed use development in Moscow for example achieved savings in both electricity, water and heat (Illinski, "Frequency converters in water supply systems for energy saving", Energy Engineering 97(5), 2000), whilst energy efficient motors can achieve a 2-8% increase in energy efficiency and variable frequency drives up to 50% ("Variable Frequency Drive", California Energy Commission, 2006, available online at http://www.energy.ca.gov/process/pbs/vfds.pdf).

11.4 Conclusions

The challenges posed by issues of water supply and drainage to climate change adaptation are dealt with by this chapter, which examines both the policies as well as the options for addressing supply and drainage. This is a policy area for which the evidence is clear and the measures necessary to meet the challenges are addressed by the FALP policies and other Mayoral strategies.

Part IV: Conclusions

12 Conclusions

12.1 Introduction

This study has reviewed the evidence for the proposed policy changes in the Further Alterations to the London Plan (FALP) together with more recent evidence that has emerged since publication of the proposed alterations. The work has included a comprehensive literature review, five stakeholder events attended by over one hundred developers, consultants, interest groups, local authorities, and occupiers, as well as case studies. This has provided evidence supporting the Mayor's proposals as set out below.

12.2 Context

Contextual evidence reviewed confirms the serious nature of climate change, the significant costs that it may impose, and the potentially higher costs of inaction:

- There is now an overwhelming body of scientific evidence that the earth's climate is changing, mainly as a result of increases in greenhouse gases caused by human activities. The risks of climate change to London's built environment and to its citizens are significant. London's situation on the River Thames means that, if climate change mitigation and adaptation are not dealt with, then the effects of flooding from rising sea levels, as well as additional overheating will have real consequences for London's economy and its long term competitiveness. **The policies in the FALP and in the overarching Climate Change Action Plan directly reflect this context and form an important part of a suite of policies proposed and enacted by the Mayor of London in order to achieve mitigation against and adaptation to climate change in line with requirements in the GLA Bill 2007;**
- The draft Supplement to PPS1 confirms that spatial planning should contribute to mitigating and adapting to climate change by influencing energy use and delivering and encouraging low and zero carbon development. As detailed further below, **FALP policies on climate change are consistent with PPS1;** and
- The Stern report concludes that while there may be costs of stabilizing climate change, delay in doing so would be dangerous and more costly. **The Mayor's proposals will drive additional action to help avoid these long term costs.**

The primacy of policy in driving interventions to mitigate and adapt to climate change is now well established. The Mayor's proposals reflect the requirements of national policy and evidence of the experience of various measures and policy to date.

12.3 Consistency with National Policy

The work has examined the FALP proposals in light of the relevant national policy. Analysis reveals that much of the FALP policy regarding climate change is now required by national policy (particularly the draft Supplement to PPS 1 and PPS 22), as set out by this matrix:

PPS policy requirement	London Plan/FALP content
Reducing the need to travel and promoting development in areas of high public transport accessibility	Existing London Plan high level policy and specific policies on transport, density, mixed use, town centres, employment, central activities zone
Promoting efficient energy supply and contributions from decentralised, renewable and low carbon energy in new developments	FALP policies on ▪ The energy hierarchy in the Mayor's Energy Strategy (minimisation of energy use, then efficient supply, followed by renewable energy) (4A.8) ▪ Decentralised energy through – o connection to existing CCHP/CHP networks, o renewable-powered site-wide CCHP/CHP, o gas-fired CCHP/CHP or hydrogen with renewables; o renewable-powered communal heating/cooling; and last o gas-fired communal heating/cooling (4a.5i) ▪ Hydrogen power should be supported and encouraged (4A.5ii).
Integrating into new and existing development more efficient energy supply and contributions from renewable and low-carbon energy sources	FALP policies on ▪ An energy demand & CO_2 emissions assessment as part of the sustainable design and construction statement (4A.2i) ▪ Waste, landfill, the energy used and transport impacts in managing waste should be minimised, and recycling, composting, and re-use should be maximized (4A.1). ▪ Construction, excavation and demolition recycling or re-use should reach 95% by 2020 (4A.1).
Identifying opportunities for carbon capture and storage	FALP policies on ▪ The production of energy from waste where recycling is unfeasible (4A.1). ▪ Renewable hydrogen produced from waste (4A.1)
Avoiding development in areas susceptible to the effects of climate change	FALP policies on ▪ Adaptation to climate change, particularly by addressing the urban heat island effect, overheating, summer solar gain, and reduction in flood risk (4A.5iii). ▪ Heat resiliency and resistance to overheating to be demonstrated by developers (4A.5iv). ▪ Identification of flood risk areas (4A.5v) ▪ Development next to flood defences should be set back (4A.5vi). ▪ Developments should incorporate sustainable drainage, in line with a drainage hierarchy (4A.5vii). ▪ Maximisation of drainage source control management (4A.5vii) ▪ Major developments should abstract and use rising groundwater (4A5.viii)
Setting regional targets for renewable energy in line with the national targets in PPS 22 for 10% electricity from renewable sources by 2010 and aspirations for 20% by 2010	FALP policies on ▪ Renewable energy is required through a 20% reduction in CO_2 emissions, to be achieved by onsite renewable energy generation (4A.7). ▪ Identification of sites for zero carbon development and locations for wind turbines, one large wind power scheme should be encouraged, and new street appliances should be powered by renewables (4A.7).
Setting regional trajectories for the expected carbon performance of new residential and commercial development to be measured over time	FALP policies on ▪ Overall 60% CO_2 reduction by 2050, 15% by 2010, 20% by 2015, 25% by 2020 and 30% by 2025 (4A.2ii)

This matrix, which also appears in Section 5.3.2, reveals that **FALP policy proposals are required by national planning policy.**

12.4 FALP Policy and Energy

The most critical element of the Mayor's policy is the **energy hierarchy**, which sets out in the broadest terms how the FALP seeks to address climate change adaptation and mitigation through the built environment. **The first means to address these issues is through improved energy efficiency, the second is by supplying energy efficiently, and the third is through utilizing renewable energy sources wherever possible**. This order is important and mutually-reinforcing. In particular, the more efficient the building, the easier it will be to meet the on-site renewable energy generation targets. The three strands of policy also reflect specific evidence which suggests that they may be feasibly met:

- In relation to **energy efficiency**, evidence suggests that developers in London have demonstrated considerable savings to achieve energy efficiencies in excess of those required through building regulations. In effect, energy efficiency has been an easier win. Accordingly, the Mayors proposed policy including his energy hierarchy prioritises using less energy as the first objective;
- In relation to **supplying energy efficiently**, the evidence points to the inefficiencies involved in supply energy through the National Grid and the competitive feasibility of CHP and CCHP. The efficiencies of the grid are of concern because they imply unnecessary carbon generation. There is general acknowledgement that local generation offers scope for solutions resulting in lower carbon emissions. Accordingly, the Major's proposed policies promote local generation and the use of CHP and CCHP; and,
- In relation to **on- site generation using renewables**, the Mayor is responding directly to statements by the Minister for Planning and in PPS22 that makes it clear that all planning authorities should make policies that require a percentage of the energy in new developments to come from onsite renewables. PPS 22 also requires the share of renewables to increase. In addition, evidence assembled by South Bank University suggests that many developers are now meeting or planning to meet or exceed the 10% renewables target. There is now a clear case to increase this target to ensure that policy continues to be effective in driving further improvements in line with Government targets in PPS22 and those in the London Plan.

12.5 Costs and Benefits of Measures

It is important for decision-makers to assess and understand fully the short- and long-term cost implications of policy. In particular:

- Because the technologies are still relatively new and many existing developments are demonstration projects, there is good reason to believe that **existing costs include a significant element of innovation costs and will fall in the longer term, shortening the payback period for any climate change investment**. This is because the supply chains are not yet mature or established, and there are few competitors in the market place leaving a few suppliers to charge higher prices. Policy can also be a key driver of demand;
- **Meeting the additional costs of policy towards higher energy efficiency may not be overly onerous**. The average additional cost of achieving Level 3 of the new Code for Sustainable Homes would be around 3% more than the previous standard of EcoHomes 'Very Good'. Equivalent values for other commercial buildings are more variable but generally accepted by stakeholders as feasible;

- The Stern Review concludes that the **costs of stabilising the climate are significant but manageable; delay would be dangerous and much more costly**. The risks of the worst impacts of climate change can be substantially reduced if greenhouse gas levels in the atmosphere can be stabilised between 450 and 550ppm CO_2e. The current level is 430ppm CO_2 today, and it is rising at more than 2ppm each year. Stabilisation in this range would require emissions to be at least 25% below current levels by 2050, and perhaps much more; and
- **The current cost of renewable energy varies considerably by technology**. In all cases, the actual value depends on the form of the development and how heat is used. Opportunities also differ between individual developments. Currently, the evidence shows that biomass systems are to be preferred on cost grounds because they offer a considerably higher reduction in carbon emissions for a relatively small percentage increase in cost. Given the more effective use of primary energy in CHP schemes, it lends further weight to a preference for this to be installed in new development. More specific findings are as follows:
  - For ground source heat pumps, for a 1-9% cost increase, it is possible to make a carbon emissions saving of between 7% and 27%;
  - For ground cooling, a cost increase of between 1% and 4% can lead to a carbon saving of between 4% and 7%;
  - For biomass heating, a cost increase of between 1% and 5% can create carbon savings of between 13% and 50%;
  - For biomass CHP, a cost increase of between 1% and 7% can lead to a carbon saving of between 40% and 56%; and
  - For solar water heating, increased costs ranging from less than 1% and 2% can generate carbon savings of up to 15%.
  - Accurate data is not available for photovoltaics, but at the current time it is generally assumed to be higher than most other technologies.

In relation to consideration of costs, a number of implementation factors are relevant:

- Case study evidence suggests that the **practical realities of installing renewables technology must be considered alongside costs**. For example, several large office developments have chosen to adopt PVs rather than biomass due to practical considerations.
- **An important feature of the policy is that it allows flexibility as to the choice of renewable technologies specified**. Case study evidence, together with the London South Bank University research, suggests that while it is possible to meet renewables targets, there will also be cases where it is not for good reasons. In light of this, evidence from the case studies also suggests that the Mayor has accepted this situation. The important point is that developers fully assess the opportunities and that solutions can be justified as the best possible to meet targets.
- Besides the costs of investing in climate change technology, **account must be taken of the benefits of reduced CO_2 emissions**, which can be thoroughly costed.

Based on the FALP, it is assumed that reduced energy use through design and behaviour can contribute to a cost/benefit circle and that the extra burden of cost imposed by the FALP will eventually find its way into reduced land values. Economic modelling has shown that a range of climate change technology is feasible for use in London and has a positive net present value. In addition, as innovation costs fall, the payback periods for investment in climate change technology are likely to become shorter.

12.6 Water

In addition to the considerations regarding energy, the Mayor also makes specific further alterations to address water supply and drainage. The evidence for these makes plain the case for:

- The use of **sustainable urban drainage techniques**, to minimise runoff and flood risk; and for
- **Reductions in water use** in new development, particularly in housing, to maximise water supply in the face of possible future droughts.

Successful adaptation to climate change requires action to cope with drought, flooding, and water shortages; the Mayor's FALP policies seek to implement these measures in order to deliver the requisite adaptation with regards to water and reduce future risks.

12.7 Recommendations

As a consequence of undertaking this study, we have also identified a number of issues that could be supported by policy as soon as an opportunity arises. These are:

- **District-wide infrastructure for energy and/or heat**. A significant number of stakeholders have suggested that collective action may provide a long-term solution to meeting targets for low-carbon and decentralised energy generation and heat distribution. They note, however, the challenges in implementing such systems in the context of individual developments. Accordingly, while the FALP policies provide clear support for such networks, there is a view that scope for policy to facilitate such provision should be further investigated.
- **Contributions to a renewable energy fund**. Related to the first point, stakeholders have suggested that they could be willing to contribute to area-wide strategic funding in order to provide on-site or local renewable energy for developments. This could appear as a final step in the hierarchy the FALP provides for provision of distributed energy (Policy 4A.5i)This would require the creation of new structures and supporting policy as well as probable changes to the regulatory regime. Such a possibility should be investigated in conjunction with the stakeholder community, and particularly with ESCOs.
- **Off-site renewable generation**. Many developers were in favour of finding ways to credit off-site renewable generation to meeting renewables targets, where appropriate. Although this is an interesting point, it is beyond the scope of regional government to influence the wider energy market and policy on energy purchasing is not, strictly speaking, a planning matter. Nevertheless, if a mechanism could be found by which to implement such an approach, it should be considered.
- **Capacity and skills**. Stakeholder workshops highlighted that there are deficiencies in the skills and knowledge of climate change and renewable energy in both local authorities and the consultancy sector. This can be reflected in an overly-cautious and defensive response to addressing the issue, to the technologies used to address it, and comments which run counter to case study evidence. Comments of technical consultants also demonstrate differing opinions about strategy to deliver, which is probably inevitable when considering a complex and emerging issue. The market will resist additional requirements, but part of the issue comes down to a lack of knowledge and experience.

12.8 Further Recommendations

Discussions with stakeholders have also highlighted a number of misinterpretations of the FALP policy. As a result, if there is scope for minor amendments to the draft policies through the Public Examination process, we would recommend the following:

- Policy 4A.15, setting out the Mayor's overall approach to tackling climate change, would benefit from further emphasis to indicate that this policy incorporates the revisions to the Energy Hierarchy from the Energy Strategy. This policy prioritises energy efficiency first, efficient energy supply second, and renewable energy third. This might also be achieved by moving Paragraph 4.19, which is currently explanatory text, into the text of Policy 4A.15.
- Within Paragraph 4.23ii of the FALP, the sentences on fuel cells beginning "The establishment of fuel cells…" and ending with "…fuel cells does not preclude links being made to additional uses" are perhaps best read separately from the rest of the paragraph, as they appear to be misplaced and cover the more specific issue of hydrogen. This would seem more appropriate if moved to become supporting text to Policy 4A.5ii.
- There is confusion as to the benchmarks against which additional energy efficiency and renewable energy targets in FALP Policy 4A.7 will be measured. This is a concern both for developers and for local planning authorities, as it seems that compliance can be demonstrated by any means either group sees fit. To this end, increased clarity in drafting could explain that Part L of the Building Regulations 2006 is the starting point, as this is an increasingly understood minimum statutory benchmark.
- In addition to the point above, it could be made clear that the target of 20% carbon reduction through renewable energy in policy takes as its starting point the base carbon emissions once other measures to minimise energy use and carbon emissions have been taken into account. This could be reinforced through drafting changes regarding the manner in which the policy is expected to operate.
- Increased cross-referencing to other policies in the London Plan (particularly those with regard to housing and transport) and the Climate Change Action Plan (which was not available at the time the FALP were originally drafted) would further explain the internal coherence of the policies and the manner in which they fit together.
- The current proposed heating policy is intended for individual developments, and while it prioritises connection to district networks first and encourages generating energy for neighbouring developments, the development process may be too far advanced to be able to establish an area-wide heat network starting from one development by the time the policy is applied. There is scope for the GLA to encourage boroughs to prioritise decentralised energy in all area-based development plan documents. To address this, a new policy could be added to Chapter 4A of the FALP, to read:

  "Boroughs should ensure that all area-based DPDs and SPDs incorporate a heat, and where applicable, cooling network and identify the potential for these to be supplied by Combined Heat and Power and renewable energy sources, including stand-alone renewables. Boroughs should ensure that all new developments within these areas are designed to connect to the network. The Mayor will and boroughs should work in partnership to ensure the delivery of these networks and to maximise the potential for existing developments to connect to them."

Appendices

A1 Methodology

A1.1 Policy Review and Matrix

This study has been guided by an 'evaluation matrix' which identified and consolidated the issues for evidentiary support. An extensive desk-based study populated the policy axis of the evaluation matrix and the relevant part of the database. Sub-themes included macro- and micro-climatic effects, the impacts of adverse weather phenomena, requirements for new or different design and construction techniques, changes in sea level and the risk of increased flooding, and harm to flora and fauna. The use of the database approach to data entry meant that themes could be manipulated and re-ordered as logically or operationally necessary.

Phase two of the desk study, which populated the evidence axis of the evaluation matrix and accompanying database, concentrated on identifying and understanding the content of the scientific and practical literature and data sources. This drew upon the existing and large body of academic research literature as well as upon other sources, including Government policy documents and knowledge Arup has already assembled in the course of existing work on climate change.

A1.2 Stakeholder Engagement

The second stage of the research was a consultation process with relevant stakeholders about the emerging evidence base.

We worked with the client body steering group from project inception to identify and then communicate with a wide range of relevant stakeholder interests. The stakeholders were drawn from the professions and disciplines engaged in formulating and delivering development proposals and making planning applications, as well as property occupants, statutory consultees, and key figures from the GLA and the London boroughs.

Arup convened four consultation events with key stakeholders. These adopted a sectoral approach to help us to keep the sessions focused on the matters at hand, and were comprised of:

- Public authorities, including London boroughs as planning authorities, London government, and statutory consultees.
- Those making planning applications;
- Those proposing development; and
- Property occupiers.

The GLA later convened a fifth, further workshop.

Working with a professional facilitator and an Arup expert team including authorities on sustainable building engineering, quantity surveying, sustainability appraisal, environmental physics, and policy development, we prepared presentations and discussion topics based upon the completed desk study to guide the workshops.

The discussions held in the workshops were constructive and presented a clear picture of the opportunities and difficulties facing those who will have to implement climate change policies.

A1.3 Case Studies

The third stage of the research combined the findings of the initial desk study and the stakeholder events to identify issues which had not yet been sufficiently dealt with, as well as remaining gaps in the evidence, to identify and scope subsequent case studies with an aim, in particular, to examining issues of implementation and the costs and benefits of measures for climate change mitigation and adaptation. A summary of case studies examined in provided in Appendix 3.

A1.4 Knowledge Transfer

The fourth and final stage of the research includes working with the client body steering group to finalise the study report as well as subsequent communication with the client and the advisory group.

This report compiles and synthesizes the outcomes of the previous stages of the research into a single document setting out the issues and options for policies to mitigate and adapt to climate change, with a particular emphasis on those interventions which can be effected on the London scale. It would have been possible in writing this report to simply present the scientific evidence for climate change and the policies which could arise from the evidence. This approach was rejected in favour of a more complex and synthetic approach. This approach sets out the policy environment in which policies for London will have to be drafted, then sets out the evidence, and finally draws upon the understanding of the policy context as well as the scientific and practical evidence regarding implementation to set out the issues for policy as it moves forward.

A2 Annex 2: List of Consultees

Alan Baxter & Associates

Argent

Bartlett School of Planning

Barton Willmore

BDP

Bennetts Associates

Bevan Brittan

British Property Federation

Buro Happold

CABE

Camden Council

CBRE

Central London Partnership

Colin Buchanan & Partners

CoreNet Global

Countryside Properties

Crest Nicholson

Cushman & Wakefield

Davis Langdon

Demos

Development Securities

Drivers Jonas

ECD Architects

EDF

English Partnerships

Environ

Environment Agency

Ethical Property Foundation

European Land and Property

Eversheds

First Base

Forum for the Future

Gensler

Grosvenor

GVA Grimley

Home Builders Federation

HSBC

Jones Lang Lasalle

King Sturge

Kiran Curtis Associates

Land Securities

London Borough of Barking and Dagenham

London First

London South Bank University

Lunson Mitchenall

Max Fordham

NJL Consulting

Pringle Brandon

PRP Architects

Quintain Estates and Development

Redrow Regeneration

RICS

Royal Borough of Kensington and Chelsea

RPS

Savills

Slough Estates

Southwark Council

St. George

Stanhope

Strutt & Parker

Thames Water

The British Land Company

The Prince's Foundation

Unite Group

United House

University College London

Westfield

White Young Green

A3 Annex 3: Implementation: Case Study Examples

A3.1 Introduction

This section summarises a number of case studies reviewed as part of this work. The objectives in carrying out this case study research were to identify existing developments which incorporate energy-saving measures and renewable energy generation, and particularly to identify where possible the cost implications of these measures.

A3.2 Case Study 1: Red Kite House, Wallingford

This building is a three-storey, naturally-ventilated office for the Environment Agency with an internal floor area of approximately 3,000 square metres. It is one of the most environmentally friendly offices of its kind and opened in June 2005. The building achieved a BREEAM 'Excellent' rating. This rating was achieved without the renewable energy strategies now in place being taken into consideration.

The passive building design is optimised for natural ventilation and nocturnal cooling and incorporates best practice renewable energy features including:

- Photo-voltaic cells to generate electrical power;
- Solar panels to provide hot water;
- Rainwater harvesting; and
- Sustainable car park drainage.

Overall, the building is expected to produce 25% less CO_2 than the Defra benchmark of good practice and will save 40% of an equivalent building's demands on water.

Some of the sustainable design measures include:

- **PV:** 20% of the estimated total electricity demand will be met through photovoltaic cells. These cells clad the south-facing canopy, which is designed to provide shade as well as power.
- **Solar hot water:** Solar thermal panels have been placed on the roof and will satisfy around 40% of the demand for hot water. Both the solar installations were part-funded by the DTI's Major PV Demonstration Programme and are expected to save a combined total of 13.6 tonnes of CO_2 each year.
- **Ventilation:** Wind turbines have been installed on the roof to help draw air through the windows and upper floor of the building. Together with other design features these turbines mean that the office does not require an air-conditioning system.
- **Drainage:** A rainwater harvesting system collects and re-uses rainwater collected from the roof. This will satisfy about 40% of the building's annual demand for water. Overspill is directed into a reed bed. The 94-space car park uses pervious blocks, which allow rainwater to soak through into the ground. A geotextile membrane traps oil and other pollutants.
- **Sustainable transport:** The building has cycle racks, a changing room, three showers and a drying room. Staff agree that there is no excuse not to cycle to work.

A3.2.1 Approximate costs

All costs are quoted in pounds Sterling.

Item	Developer	Tenant	Grant	Total after grant
Base building, including permeable car park	4,100,000	0	0	4,100,000
Canopy that generates solar electrical power from photo-voltaic cells	0	295,000	165,000	130,000
Solar heating panels to provide hot water	0	23,000	9,000	14,000
Rainwater harvesting System	0	35,000	0	35,000
Roof-mounted fans to support natural ventilation	0	10,000	0	10,000
Automated and motorised high-level windows	30,000	86,000	0	116,000
Internal fitting and furnishing	75,000	1,400,000	0	1,475,000
Total cost	**4,205,000**	**1,849,000**	**174,000**	**5,880,000**

A3.2.2 Anticipated environmental benefits and savings

Item	Consumption saved per annum	Tonnes of carbon dioxide saved per annum
Cells that generate solar electrical power	23,000 kwH	12
Solar heating panels	3,100 kwH	1.6
Natural ventilation (as opposed to air conditioning)	7,500 kwH	4
Rainwater-harvesting system	240,000 litres of water	N/A
Total	**33,600 kwH** **240,000 litres of water**	**17.6**

It was anticipated at the time of building that energy savings from the solar louvres, complemented by the energy efficient design of the building, would meet around 20% of the building's annual demand for electricity. No figures are shown above for financial savings or payback periods. Using current utility costs, the annual financial savings are relatively small and the payback periods are long (up to 80 years in the case of the photo-voltaic cells. However, it has been argued that the current utility costs – especially for energy – do not include the full environmental costs, and that they would increase significantly if they did. This would have a considerable impact on the financial savings and payback period. The building demonstrates that, for very small increases in the construction costs, important contributions can be made to reducing carbon emissions.

A3.3 Case Study 2: Abbeyfields, Faversham

Abbeyfields, Swale Housing Association's new sheltered housing scheme in Faversham, Kent, has a mini combined heat and power unit (mini CHP).

The 12 kWe CHP unit is incorporated into the centralised heating system as lead boiler, with condensing boilers providing back-up heat. The system consists of a gas-fired engine to generate electricity. Heat produced in the process is reclaimed and fed into the heating and hot water system. The electricity is sold to residents, with any additional electricity requirement met by the national grid. The reduced energy costs mean that Swale Housing

Association will be able to sell electricity to the 39 residents at 20% less than the local electricity suppliers.

The system, which was installed with a grant of 10% (£2500) EDF and a 75% interest-free loan, produces 60,000 kWh electricity and 137,500 kWh heat per annum. It contributes an annual CO_2 reduction of 12,000 kg.

A3.4 Case Study 3: Adelaide Wharf

Adelaide Wharf is a mixed-use development of 147 dwellings, 73 of which will be sold on the open market and 74 of which will be affordable housing or reserved for Key Workers. Thirty per cent of the development will be three- or four-bedroom family homes, and it also includes 700 m² of affordable workspace for a community regeneration initiative.

Developer First Base anticipates that Adelaide Wharf will achieve EcoHomes Excellent and Lifetime Homes accreditations. It will do so through the use of rainwater recycling, 'green' living roofs growing sedum plants, which act as a good insulator as well as attracting birds and insects, a wildflower meadow along the canal and high thermal efficiency.

A3.5 Case Study 4: Greenwich Millennium Village

Greenwich Millennium Village is a Countryside Properties development of 3,000 homes, 4,500 m² of commercial space, and social and community facilities including a school, health centre, workshops, restaurants, and 50 acres of open space. It has been developed to be a model for sustainable construction, using recycled and locally-produced materials as well as some off-site prefabrication. Every phase completed thus far (the development is due for completion in 2012) has achieved the BREEAM ‘Excellent’ rating.

The development optimises solar gain through measures such as building layout and location of glazing; reduction of hot water use; low-energy lighting; education of residents; and standards for windows and thermal insulation that exceed Building Regulations.

In addition to sustainable construction methods and the use of design to maximise solar gain benefits, gas-powered CHP plant has been used to generated heat and electricity. The development aims to achieve an 80% reduction in primary energy construction over its lifetime compared to similar projects without the sustainability measures incorporated at Greenwich Millennium Village, as well as a 50% reduction in embodied energy, a 50% reduction in construction waste, a 30% savings in water use, and a 30% savings in construction costs.

Most of the sustainability goals and targets in the original project proposal were either dramatically modified or completely omitted after winning the competition. The 10% energy reduction target was not met, zero carbon dioxide emission target was revised to a 35% carbon dioxide reduction, 35% water use reduction was lowered to 15% reduction in the first year and ultimately 30% reduction in five years, waste reduction goals were left out of the legal agreement, and standardized off-site construction was changed to brick and concrete on-site construction (Kyung-Bae Kim, 2005).

Conflicts between architects and developers over costs of sustainable innovations resulted in compromises on sustainable, social, and construction aspects of the project, and resignation of the original project architect. Academic research on the project has been hampered by the developer’s policy prohibiting employees from discussing the project or revealing project documents (Kyung-Bae Kim, 2005).

A3.6 Case Study 5: Herman Miller, Chippenham

American furniture maker Herman Miller’s new £10 million offices at Chippenham, designed by Gensler, were completed in February 2006. The building was awarded both American

LEED 'Gold' and BREEAM 'Excellent' ratings. The Merton Rule website suggests that the project was completed "for the same cost as a basic developer speculative solution".

In order to achieve these accolades, the offices incorporate recycled products and locally-sourced materials, high standards for air sealing and insulation, a high-albedo roof (that is, one that reflects and does not absorb solar energy), and natural ventilation in conjunction with floor plate design that struck a balance between size and the ability to support natural cooling. The design uses stone walls on the southern side, a roof that overhangs the building on the east side, and brises-soleils on the south and west elevations to minimise unwanted solar gain, along with exposed concrete eaves that release heat overnight. Other measures keep water use low through in-building technology such as meters for leak detection and waterless urinals as well as permeable paving to the exterior.

A3.7 Case Study 6: St Matthews Estate, Brixton

In Brixton, the St. Matthews Estate in Brixton is a block of 28 social housing flats. At roof level, 31 m² of solar PV arrays were installed and are estimated to produce approximately 3109 kWh of energy every year (the equivalent energy need of two standard houses or more highly efficient flats – the latter close to the 20% target) and to save 1,336.87 kg of CO_2 on an annual basis as a result. Thermal tubes provide hot water heating, assisted in the winter by a biomass (wood pellet) boiler. As a result of specifying a highly-airtight building and insulation in excess of Building Regulations, a 'zero heating standard' in which all space heating comes from solar energy and the heat from household appliances was implemented. Projected heating bills are only £75 per annum per residential unit.

A3.8 Case Study 7: Kings Cross Central

Kings Cross Central has set an initial target of reducing carbon emissions by up to 25% below those specified in the Building Regulations through a combination of energy efficiency, use of renewables, and increased supply efficiency. The developers acknowledge that implementation of certain carbon saving technologies must be done as part of a district-wide infrastructure. The available and emerging technologies are passive cooling using night ventilation or groundwater; active cooling and heating using ground-source heat pumps; community heating infrastructure serving the site; and large-scale combined heat and power. Because of the scale of the development, the developers will consider each of these technologies in relation to specific developments. Feasibility studies will be carried out as the building forms, mix of uses, and likely energy demand profiles begin to become available during the detailed design of the first major phase. These studies will consider issues wider than the completely technical, including occupier acceptability, long-term operating business plans, availability and range of alternative suppliers, supply reliability for end users, and whole-life carbon-saving potential. As development of KXC progresses, consideration will be given to the full range of active renewable energy systems, and an initial review of options indicates that:

- Solar electric photovoltaics offer considerable future potential but currently carry a cost premium. Recent experience suggests to the developers that the same funding can achieve considerably greater carbon reduction through investment in energy saving. Future-proofing buildings will be explored to ensure that buildings can, as far as practicable, later accept PV as it becomes viable. Early wins may include off-grid PV-powered street lighting.
- Solar hot water collectors are likely to be viable for certain buildings but are expected to contribute only a small proportion of overall development energy use;
- Wind-generated electricity is expected to become a viable possibility;
- Biomass, which is acknowledged as a rapidly-developing field; and

- The use of electricity supplied on a green tariff. Proposals for the major development of wind power in the Thames Estuary are seen as relevant in this context.

Overall, on the basis of previous similar studies, it is anticipated that there is potential for generating some 15% of the KXC energy needs from renewables. A proportion could be generated on site, but because of the high-density form and the extent of the heritage buldings that the majority of the renewables would be generated off-site.

A3.9 Case Study 8: Broadgate Tower

The Broadgate Tower is a skyscraper currently under construction in London's main financial district, the City of London. Adjacent to the tower is a smaller building at 201 Bishopsgate, which also forms part of the development.

Built at an estimated cost of £240 million, the tower will have 35 floors, and the neighbouring 201 Bishopsgate is attached via a new public plaza. The development as a whole marks the next major phase of construction in the Broadgate estate that began in the 1980s to provide desperately needed high-spec office space for the City of London.

The Broadgate Tower has been designed by Skidmore, Owings & Merrill and developed by British Land. It utilises air-rights in the form of sitting on a large construction raft that has been built over the entrance to Liverpool Street Station. One notable feature will be the first double-decker lifts to be used in the United Kingdom.

As the tower lies over major train lines heading into Liverpool Street, groundwork took longer than would normally be expected for a tower of this size. However, the steel core has the advantage of a quicker finish than a concrete core, and the two buildings will be rising throughout 2007 in time for scheduled completion in 2008. When complete, it will be the 7th highest building in London (3rd tallest in the City of London) and the first skyscraper to be built in London in over 3 years.

According to the Hackney planning committee report of 9 January 2006, the proposed building would achieve a BREEAM ‘Very Good’ rating. In addition, the applicant proposes the use of renewable such as PV and ground source cooling to provide approximately 3% of the energy requirements of the building. Although this falls short of the current 10% target for renewable energy provision, the committee judged that the applicant had provided adequate justification for the proposed level of renewable energy provision. The proposal was one of 5 pilot projects across London where the Council has worked with the London Energy Partnership to assess energy needs. A dedicated recyclable waste storage room is proposed at basement levels and there is a green travel plan.

A3.10 Case Study 9: Bishops Square, Spitalfields

Developers Hammerson’s Bishops Square in Spitalfields utilises PV to replace louvres that were included in the original design, to provide the added benefit of shading to the plant deck area. The offices are let to law firm Allen and Overy, who will benefit from a considerable reduction in their energy bills as a result of the PV installation.

Bishops Square generates 54,000 kWh a year (enough electricity for 18 average three-bedroom houses) and saves over 23 tonnes of CO_2 emissions.

A3.11 Case Study 10: CIS Solar Tower, Manchester

The CIS wished to re-clad part of its headquarters in Manchester in line with its ethical business aims when the service core, which is covered in 14 million one-centimetre-square grey tesserae, began to fail a mere six months after the building was completed. This had become a significant health and safety issue, and hence had to be addressed. The solution proposed, ventilated PV rain cladding, is the largest commercial solar facade in Europe. It will also be one of the largest solar power systems in the UK, demonstrating that solar technology is a practical cladding application and provides an extremely cost effective alternative to conventional cladding materials. This £5.5m project, the largest ever in the UK, was supported by an £885,000 grant from the Northwest Regional Development Agency (NWDA) and a £175,000 grant from the Department of Trade & Industry.

The power output of 183,000 kWh a year is the equivalent of 61 average three-bedroom houses and saves over 79 tonnes of CO_2 annually.

A3.12 Case Study 11: Croydon Centrale Shopping Centre

Croydon Centrale is a shopping centre development located on North End in the heart of Croydon. The new Centre is located on the site which included a former department store and a Bingo hall located below a multi-storey car park, built in mid-1960. It now incorporates the adjacent Drummond Centre, now also named Centrale, to form one shopping centre with the internal public mall, bridging over Drummond Road. The new centre provides 40,000 m². of shopping area on four floors with 1000 car parking spaces on three floors. The philosophy adopted for the design and construction was dictated by the need to relocate a bingo hall and provide it with uninterrupted operation The centre was opened to the public in April 2004 with the major occupier, House of Fraser, commencing trading in October 2004.

The integration of solar photovoltaics and a wind turbine into the plant deck on the top floor of the Croydon Centrale shopping centre was a retrofit solution. The PV and wind turbine are located above the car park and are visible to the public. The PV modules cover a total area of 28.6m² and are capable of producing a total power of 3.52 kW, and approximately 1,765 kWh of energy each year. A wind turbine was also installed and consists of a single 3.5m diameter, 3-bladed rotor mounted on a 6.5m mast. The peak output of this turbine is 2.5 kilowatts.

A3.13 Case Study 12: Manchester College of Arts and Technology

Manchester College of Arts and Technology (MANCAT) has incorporated pioneering design and building innovation in its North Manchester Sixth Form Centre in the Harpurhey area of the city. The new building is a redevelopment of a brownfield site, which used to house the public baths. In a major project the original Grade 2 listed Victorian building has been retained and restored, whilst a futuristic extension has been added, to create a sixth form college, library and exhibition hall incorporating the latest building integrated solar technology. Inspired by the installation at the CIS Tower, the new building is clad in an array of solar PV modules, providing an extremely cost effective alternative to conventional cladding materials. The new library also incorporates solar thermal technologies. The PV cladding at MANCAT was part funded by the Department of Trade and Industry.

This installation is forecasted to produce 43,738 kWh of electricity a year, saving over 19 tonnes of CO_2 and enough total electricity for 14 average three-bedroom houses each year.

A3.14 Case Study 13: Willow Lane, Mitcham

The new business park development in Mitcham, South London, is considered the first implementation of the Merton Rule. Willow Lane was a 4,500 m² speculative commercial development comprising 10 units of varying sizes for storage and distribution, light fabrication, offices, and light manufacturing uses.

Planning permission was granted in August 2004. It was the first time a developer had responded to a prescriptive renewable energy policy. Careful consideration needed to be given to the implementation of this policy, as this component of the application ensured that the Willow Lane development was unique.

At Willow Lane, a speculative development, it was not possible to establish a baseline energy/carbon footprint because the end users were unknown, and hence how much energy might be needed. As such it ruled out water-heating renewable technologies, ground source heat exchange systems and CHP. Furthermore no water boilers or full lighting systems were installed during building so that full flexibility for the occupiers' needs could be met.

LB Merton and the developer agreed that the theoretical original carbon footprint was 108,200 kg of CO_2 emissions per annum. Therefore (in theory) LBM expected the developer to cut that carbon footprint by 10% (10,820 kg of CO_2) through the use of renewable energy equipment. If however, the predicted CO_2 emissions were reduced through the use of energy saving measures in the design of the building, then the CO_2 reduction required fell proportionately.

The renewable energy infrastructure is:

- 10x 1.5m diameter wind turbines, and
- 5kWs of PV solar panels, which cover about 50 m². The PVs cost approximately £70,000 to install.

The energy saving measures are:

- Water saving infrastructure, and
- Passive stack ventilation.

It was not known at the time of development how many, and which, of the 10 units would install water boilers. If some don't, the wind turbines and PVs would generate more than the policy expectation of 10%. If all the units are heated then the proposal would deliver a CO_2 reduction of 6.2% – the 10% could only be achieved if the final occupant were to install energy-efficient (condensing) boilers instead of conventional ones and energy-efficient lighting systems. Merton required the developer to provide a cash fund as part of a Section 106 agreement, to cover any final occupiers' additional costs of upgrading from conventional to condensing boilers, and from conventional to energy efficient lighting systems.

If condensing boilers were ultimately fitted in all units, the overall CO_2 reduction would be 17.6% of which 7.5% would come from on-site renewable energy equipment. The realistic maximum achievable is a total CO_2 reduction of 21%, of which 13% would come from renewable energy, and hence provides an opportunity to possibly exceed the 10% renewable energy target.

A3.15 Case Study 14: London City Hall

The starting point of Foster and Partners' City Hall, according to project architect Ken Shuttleworth, "was to reduce the energy load of the building by 75%".

City Hall cost £40 million and is leased to the GLA at an initial rent of £34.50 per ft² in 2004. In setting an example for low-energy design within the framework of a commercial marketplace, the challenge was to demonstrate that low energy design does not have to cost more.

Measures to achieve this target include a maximum solar heat gain per linear metre of façade, achieved through high-performance solar control glass, insulated panels and openable vents with occupant-controlled blinds in the external cavity, as well as through an intelligent presence-sensitive lighting system and through the inclusion of passive chilled beams, which provide the main cooling system in conjunction with an underfloor ventilation system. This system uses aquifer water supplied by pumps in boreholes. After use for cooling, this borehole water is stored for flushing WCs and irrigation before any surplus is discharged to the Thames. The building design relies on borehole water abstraction for all cooling demands, thereby meeting low-energy targets while contributing to reducing water table levels.

The payback for photovoltaics would extend well beyond 10 years, so they were not considered cost-effective when the building was constructed. The sun shading around the top floor was expected, however, to accommodate PV panels in the future. In 2005, GLA facilities management received a £270,000 grant from the DTI to go ahead with a £500,000 PV scheme to convert light energy into electricity using 81 kW of PV panels on the curved roof.

It was expected that the sustainable design and construction measures would contribute to a 75% reduction in energy consumption compared to a typical commercial high-specification office building, and City Hall was granted a BREEAM ‘Excellent’ rating and complies with 2006 Part L of the Building Regulations (which had yet to come into force when the building was designed).

In practice, however, City Hall has not met its target reductions in energy use, achieving a usage of 376 kWh/m² of floor area rather than the target set at the design stage of 250 kWh/m². This may be because the building now houses more people than it was originally intended to (650 rather than the 426 anticipated). Nevertheless, City Hall uses 34% less energy than a comparable ‘standard’ office building. The discrepancy in City Hall as well as in several other high-profile green buildings that have performed better in theory than in practice has been ascribed to building management, which critics say has yet to come to grips with how to run low-energy buildings.

A4 Policy Context and Other Measures for Tackling Climate Change

A4.1 Introduction

This section of the Appendices presents the wider policy context at all levels for mitigating against and adapting to climate change as well as a host of other associated measures. It is included to give the reader a general overview of the scale and the necessity of the wide scope of measures required globally for effective intervention.

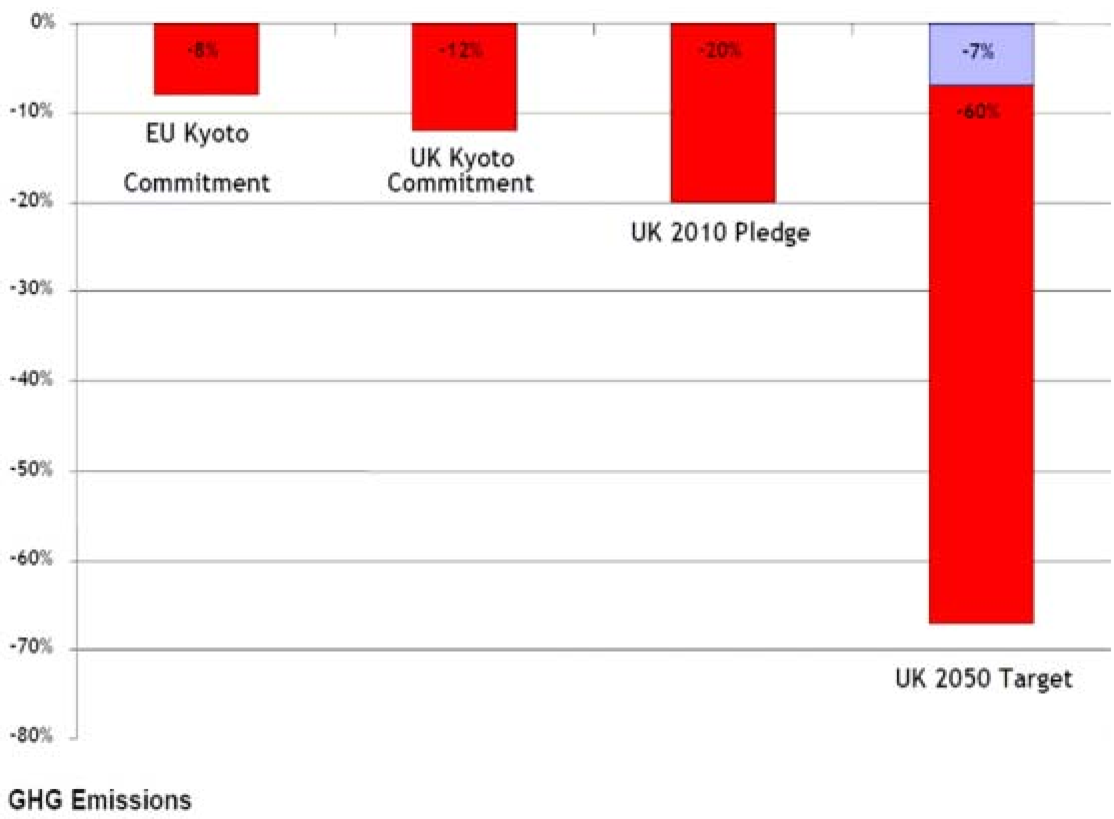
A4.2 International Treaty Obligations

A4.2.1 Kyoto

The Kyoto Protocol to the UNFCCC is the main international mechanism for tackling climate change. It represents a legal agreement made by the majority of industrialised countries to cut greenhouse gas emissions by a collective 5% from 1990 levels by 2012. As part of the EU's commitment to cut emissions by 8%, the UK has pledged a total emissions reduction of 12.5%.

Figure A4.1 below summarises the overall targets to which the UK currently aspires. As the 2050 target is based on emission levels in 2000 rather than 1990, the overall target is actually 7% higher once set against 1990 levels – a 7% reduction was achieved between 1990 and 2000.

Figure A4.1: UK emission reduction targets and aspirations against 1990 baseline



"London Carbon Scenarios to 2026", London Energy Partnership, November 2006

A4.3 European Policy

A4.3.1 EU Climate Change Policy

Within the European context, the European Union Emissions Trading Scheme (EU ETS) is a key plank of EU climate and energy policy. Support for market-orientated mitigation measures such as this scheme is outlined within the Stern Review and within the Better Regulation Commission's report "Regulating to Mitigate Climate Change: a Response to the Stern Review!" (2006). This suggests that in order to control the extent of green-house gas emissions, there must be an effective international market in permissions to emit carbon with the total volume each year consistent with the pre-agreed path, such as the EU ETS. It suggests that such a market would therefore enable emission reductions to take place wherever in the world this can be done most cheaply. It further suggests that this would also allow the 'social cost of carbon' to be set in market conditions over time, and the resulting carbon price could then be allowed to feed through the supply chain to the final user.

At the Spring European Council on 8/9 March 2007, EU Heads of Government agreed an ambitious, independent binding target to reduce Europe's greenhouse gas emissions by at least 20% by 2020 (compared to 1990 levels) and to increase this commitment to a 30% reduction as part of an international agreement. They also decided to increase the use of renewable energy sources so that they make up 20% of EU energy consumption by 2020, with differentiated overall targets for Member States; to ensure that a minimum of 10% of EU transport petrol and diesel consumption comes from bio-fuels by 2020; to promote energy efficiency by reducing overall EU energy consumption by 20% by 2020; and to stimulate the use of new technology on clean coal power stations, with the aim of bringing environmentally safe carbon capture and sequestration (CCS) to deployment with new fossil-fuel power plants, if possible by 2020.

A4.3.2 Energy Performance of Buildings Directive

Directive 2022/91/EC came into force in January 2003, its main intention being to substantially increase investments in energy efficiency measures within buildings, both domestic and non-domestic. The directive is expected to reduce carbon dioxide emissions by 45 million tonnes by 2010 through the implementation of a number of requirements to measure energy use in buildings, including:

- Agreed measurements of relative energy performance;
- Regular inspections and re-evaluations;
- Requiring higher standards for upgrading larger buildings; and
- Improving standards for new buildings.

The Directive was implemented into UK law in January 2006, its adoption requiring the introduction of a number of new measures, including amendments to Building Regulations and the introduction of a thorough certification scheme.

A4.3.3 European Spatial Development Perspective

Adopted in May 1999, the European Spatial Development Perspective (ESDP) provides a shared vision for Europe as a whole – namely "a more balanced and multi-centric system of cities and a new urban-rural relationship, the parity of access to infrastructure and knowledge and the prudent management and development of the natural and cultural heritage". Whilst it is not a legally binding document, its three fundamental goals of economic and social cohesion, sustainable development and competitiveness provide a strategic context for greater partnership working both between member states and sectoral policies. With regards to climate change, the ESDP states that "spatial development policy can make an important contribution to climate protection through energy-saving from traffic-reducing settlement structures and locations, as well as making contributions through the increased use of CO_2 neutral, renewable energy sources".

A4.3.4 Habitats Directive

The Habitats Directive aims to put in place a common framework for the protection of wild plants, animals and habitats of community interest through an ecological network of protected 'special areas of conservation', designated by Member States and collectively known as 'Natura 2000'. The Directive requires Member States to:

- Manage features of the landscape which are essential for the migration, dispersal and genetic exchange of wild species;
- Establish systems of strict protection for those animal and plant species which are particularly threatened and study the desirability of reintroducing those species in their territory; and
- Prohibit the use of non-selective methods of taking, capturing or killing certain animal and plant species.

A4.3.5 Birds Directive

The Directive and its amending acts provide long term protection for all bird species, their nest and habitats naturally found living in the wild within European territory. Member States must maintain or restore these species by:

- Creating Special Protection Areas;
- Maintaining habitats;
- Restoring destroyed biotopes; and
- Creating biotopes.

A4.4 National Policy

Non-Planning Policy

Planning is, of course, only one of many policy levers available to drive a reduction in green house gas emissions and better adaptation to the effects of the consequential climate change. A range of other policies is available to achieve reductions in emissions. These include tax, voluntary agreements, traditional regulations, awareness raising and trading schemes. Each instrument has a role to play in reducing emissions and has different characteristics. Tax, for example, can be increased on specific activities to reflect the cost of emissions and, where relevant, other negative impacts which they produce and therefore discourage the emissions. This gives certainty that the costs of emissions (and in some cases other negative impacts) are being taken into account, but does not guarantee a fixed level of emissions.

Because the impacts of greenhouse gas emission are felt regardless of where the gases themselves are emitted, an international approach to their reduction is highly attractive. Co-ordinated international response also has the appeal of ensuring equitable consideration for all sources of greenhouse gases, and of preserving the competitive position of each participant in the agreement.

The synergy between policy levers is crucial; legislators and regulators must ensure that the policies pull with, and not against, each other. Some policy questions transcend all others and include international agreements and decisions on national energy supply (including the degree of reliance on nuclear energy). This part of the report considers those that are most likely to influence the way planning policy can drive change in this field.

A4.4.1 Carbon Emissions Targets/Trajectories

In 2000, the Royal Commission on Environmental Pollution pressed the Government to respond to the challenge of climate change ("Energy - The Changing Climate", June 2000). It said:

> The goal of reducing the UK's annual carbon dioxide emissions by 20% from their 1990 level by 2010 is a major step in the right direction. It should become a firm target and the government should produce a climate change programme that will ensure it is achieved. The UK should continue to play a forceful leading role in international negotiations to combat climate change, both in its own right and through the European Union. The government should press for further reductions in the greenhouse gas emissions of developed nations after 2012, and controls on the emissions of developing nations. The government should press for a future global climate agreement based on the contraction and convergence approach, combined with international trading in emission permits. Together, these offer the best long-term prospect of securing equity, economy and international consensus. While UK carbon dioxide emissions are falling at the moment, they are expected to begin rising again. All but one of the nuclear power stations, the main source of carbon-free energy at present, are expected to close by 2025. The government should set out, within the next five years, a programme for energy demand reductions and development of alternative energy sources that will prevent this from causing an increase in UK emissions. The government should now adopt a strategy which puts the UK on a path to reducing carbon dioxide emissions by some 60% from current levels by about 2050. This would be in line with a global agreement based on contraction and convergence which set an upper limit for the carbon dioxide concentration in the atmosphere of some 550 ppmv and a convergence date of 2050.

The Government responded by setting targets, and, in its most recent version, the UK Climate Change Programme (Defra, 2006) says:

> We have also set ourselves a more challenging domestic target to reduce carbon dioxide emissions by 20% below 1990 levels by 2010. Although we have made significant progress, higher than anticipated levels of economic growth and the recent rise in global energy prices, which has altered the relative prices of coal and gas, have led to increases in our carbon dioxide emissions in recent years. As a result, achieving our domestic target has become more challenging since our last Climate Change Programme in 2000. We have therefore used this Review to assess both the impact of existing policies and the potential contribution of new policy options.
>
> This new Climate Change Programme will take us close to our domestic target, and ensure that the UK can make the real progress by 2020 towards the long-term goal to reduce carbon dioxide emissions by some 60% by about 2050 that we committed to in the 2003 Energy White Paper. The package of existing and new policy measures in the Programme are projected to reduce carbon dioxide emissions to 15-18% below 1990 levels – the new measures saving 12 million tonnes of carbon by 2010. This is very good progress. Our overall emissions of greenhouse gas emissions are now projected to be 23-25% below 1990 levels in 2010 – around double our Kyoto target.

> This Programme is not the final word. The projections and policies set out in this Programme will change over time. There is more that government will do both to influence emissions directly and to encourage action by others. The 2010 carbon target is still within reach. Further contributions could be made by the Energy Review, the ODPM review of buildings and other government policy processes over the coming years.

A4.4.2 Climate Change Bill (Draft)

The draft Climate Change Bill is the first of its kind in any country. The Bill provides a legal framework to manage future emissions. It provides a clear, credible and long term framework that will provide greater clarity and confidence for businesses and individuals to plan and invest in delivering the changes needed to move to a low carbon economy. It aims to demonstrate leadership through example – vital in helping to secure future international agreements. The final Bill to Parliament is due in autumn this year, and the target date for Royal Assent is spring 2008.

In summary the Bill:

- Makes legally-binding and challenging carbon dioxide reductions targets for 2020 and 2050, putting into statute the UK's targets to reduce carbon dioxide emissions through domestic and international action by 60% by 2050 and 26-32% by 2020, against a 1990 baseline;
- Introduces a system of 'carbon budgeting' capping emissions over five-year periods – with three budgets set ahead to help businesses plan and invest with increased confidence;
- Creates a new independent body to advise on the setting of carbon budgets and to report on progress;
- Contains enabling powers to make future policies to control emissions quicker and easier to introduce; and
- Introduces a new system for Government to report to Parliament on climate change adaptation policies.

A Committee on Climate Change will be set up as an independent statutory body to advise the Government on the pathway to the 2050 target and to advise specifically on: the level of carbon budgets; reduction effort needed by sectors of the economy covered by trading schemes, and other sectors; and on the optimum balance between domestic action and international trading in carbon allowances.

Taken together, these measures create a coherent framework that will ensure we achieve reductions in emissions whilst maintaining a strong and growing economy and high levels of social welfare.

A4.4.3 Code for Sustainable Homes

In December 2006, the government launched the Code for Sustainable Homes, a new national standard for sustainable design and construction of new homes.

By integrating elements of this voluntary Code into new homes and obtaining assessments against the Code, developers will be able to obtain a 'star rating' for any new home which will demonstrate its environmental performance. It will provide valuable information to home buyers, and offer builders a tool with which to differentiate themselves in sustainability terms.

The Code is intended as a single national standard to guide industry in the design and construction of sustainable homes. It is a means of driving continuous improvement, greater innovation and exemplary achievement in sustainable home building.

In the short term, Code compliance is voluntary, but home builders are encouraged to follow Code principles set out in this publication, because the Government is considering making assessment under Code standards mandatory in the future.

The design categories included in the Code are:

- Energy/CO_2;
- Pollution;
- Water;
- Health and well-being;
- Materials;
- Management;
- Surface water run-off;
- Ecology; and
- Waste.

The Code uses a star rating system to communicate the overall sustainability performance of a home. It runs from one to six stars depending on the extent to which the development has achieved Code standards. One star is the entry level (above the level of the Building Regulations) and six stars is the highest level, reflecting exemplar development in sustainability terms.

Assessment procedures will be transparent and technically rigorous, whilst at the same time straightforward and beneficial to all parties. BRE will accredit assessors for the new Code. Code assessors will conduct initial design stage assessments, recommend a sustainability rating, and issue an interim Code certificate. They will perform a post-completion check to verify the rating before a final Code certificate of compliance is issued.

The RCEP commented:

> Since April 2006, all new publicly-funded residential developments have been required to meet the level in the Code for Sustainable Homes that corresponds to EcoHomes 'very good' or above. It will be important to put in place mechanisms to ensure that performance does not fall short of aspiration. For non-residential developments, it would seem that very considerable improvements are required . For example, in 2003/04 only 3 out of 137 new public sector non-residential buildings were delivered to a BREEAM 'Excellent' standard compared with the target level of 100%.

Full technical guidance on how to comply with the Code is promised by the government in April 2007. The Town and Country Planning Association's March 2007 response to the Government's "Building a Greener Future" and the draft Supplement to PPS 1 consultation papers suggested that the savings from the Code's energy efficiency measures were that moving to 3 stars saves £50 per annum, and to level 4 saves £100. In terms of the costs to developers, moving to 3 stars added 2-3% to the cost of an average dwelling (about £2000 per dwelling), and to 4 stars added 4-7%. This was predicated on the basis of existing technology, but there was an expectation that more stringent regulation would force innovation on a greater scale, so reducing costs.

A4.4.4 Fiscal Policy

Fiscal policy is generally regarded by governments as the most potent influence over behaviour. As already noted, any action needs an international foundation if the UK is not to put itself at a competitive and hence economic disadvantage. Such foundations would be highly likely to take a considerable time to agree because they would need to rest on cooperation between governments to undertake a scrutiny of the broad range of greenhouse gas sources. In deciding on the taxation regime that might follow, it would be essential to ensure that each sector contributing to climate change was targeted 'fairly' in the whole range of sources.

In the 2007 Budget, the Chancellor of the Exchequer set out a full programme of fiscal incentives to mitigate against and adapt to climate change. It responded to the Stern Review on the Economics of Climate Change and set out the next stage in the Government's strategy for tackling climate change both domestically and globally, including:

- A competition to develop the UK's first full-scale demonstration of carbon capture and storage, the result of which will be announced next year;
- An increase in fuel duty rates of 2 pence per litre (ppl) from 1 October 2007, and increases in the next two years of 2ppl and 1.84ppl respectively;
- Car vehicle excise duty rates for the next three years, including rates for the most polluting cars rising to £400 and rates for clean cars in band B falling to £35;
- A review to examine the vehicle and fuel technologies which over the next 25 years could help 'decarbonise' road transport;
- A package of measures to support biofuels including extending the 20 pence per litre biofuels duty differential to 2009-10;
- A rise in climate change levy rates from 1 April 2008 in line with current inflation;
- An exemption from stamp duty from 1 October 2007 for all new zero-carbon homes costing up to £500,000, with zero-carbon homes costing in excess of £500,000 receiving a reduction in their stamp duty bill of £15,000;
- An intention that, by the end of the next decade, all householders will have been offered help to introduce energy efficient measures with the aim that, where practicably possible, all homes will have achieved their cost-effective energy efficiency potential;
- Increasing funds available through the Low Carbon Buildings Programme to a total of over £18 million to help meet the demand from households for microgeneration technologies; and
- A £800 million international window for the Environmental Transformation Fund to finance overseas development projects that deliver both poverty reduction and environmental benefits in developing countries.

The Budget also reported on the Government's strategy for tackling other environmental challenges, including:

- An increase from 1 April 2008 in the standard rate of the landfill tax by £8 a tonne per year, until at least 2010-11, and an increase in the lower rate of the landfill tax from £2 per tonne to £2.50 per tonne from 1 April 2008; and
- An increase in the aggregates levy rate to £1.95 per tonne from 1 April 2008.

A4.4.5 Climate Change Levy

The Government intends that all sectors must play their part in reducing greenhouse gas emissions. A key element is the Climate Change Levy announced as long ago as 1999 and which effectively replaced the Fossil Fuel Levy.

The primary law on Climate Change Levy is contained in the Finance Act 2000. The Levy is structured to achieve a balance between environmental objectives and administration. Account has been taken of the organisation of the energy industries, including minimising the compliance costs to business, and the need to administer specific reliefs and exemptions.

To ensure that domestic energy consumption is not caught by the Levy and to keep compliance costs to a minimum, the Levy is imposed at the time of supply to industrial and commercial consumers rather than at the time of consumption by end-users. This means that suppliers of taxable commodities are required to register and to pay the Levy due. The Levy is a single-stage tax charged only on taxable supplies to end-users within its scope.

The Levy is chargeable on the industrial and commercial supply of taxable commodities for lighting, heating and power by consumers in the following sectors of business:

- Industry;
- Commerce;
- Agriculture;
- Public administration; and
- Other services.

The levy does not apply to taxable commodities used by domestic consumers, or by charities for non-business use.

The Levy is charged on certain supplies of a taxable commodity as defined in the legislation. Taxable commodities are as follows:

- Electricity;
- Natural gas as supplied by a gas utility;
- Petroleum and hydrocarbon gas in a liquid state;
- Coal and lignite;
- Coke, and semi-coke of coal or lignite; and
- Petroleum coke.

The following examples are not taxable commodities for levy purposes:

- Oil;
- Road fuel gas;
- Heat;
- Steam;
- Low value solid fuel (for example coal tailings and sweepings) with an open market value of not more than £15.00 per tonne; and
- Waste as defined in statute.

More up-to-date information is not readily available, but according to the Parliamentary record (Hansard Col 884W 1 May 2002), "Climate change levy receipts for [England in] the year 2001–02 were £551 million."

The rate of the Levy was increased in line with inflation in the 2007 Budget.

A4.4.6 Ofgem Policy

Ofgem (the Office of Gas and Electricity Markets) has specific responsibilities in respect of energy efficiency and carbon reduction in energy supply. Ofgem's first priority is consumer protection, in particular promoting competition and regulating the higher companies which run the gas pipes and the electricity wires.

But it also helps the gas and electricity markets and industry achieve environmental improvements as efficiently as possible. Ofgem encourage development of market mechanisms to value and reduce carbon. It also promotes energy efficiency: More efficient use of energy not only helps reduce emissions but also helps lower energy costs, which is important to promote competition and tackle fuel poverty.

Ofgem has responsibility for implementing the Government's Renewables Obligation, which came into effect in April 2002. The Obligation sets a target for electricity suppliers to source at least part of their electricity from renewable generation. The target started at 3% in 2002-2003 and reaches 10.4% in 2010-2011; the target for 2003-2004 is 4.3%. Renewable generators can apply to Ofgem for accreditation to prove that their generation comes from eligible renewable sources, and these generators are issued with Renewables Obligation Certificates (ROCs) for their qualifying output. Each ROC represents one MegaWatt hour of renewable electricity generated. ROCs can be sold by the renewables generator either with, or separately from, the electricity generated.

A4.4.7 Carbon Trading/ETS

The UK Emissions Trading Scheme was the world's first economy-wide greenhouse gas emissions trading scheme. It was launched in March 2002, and ran until December 2006, with final reconciliation in March 2007. It is administered by Defra.

Thirty-three direct participants have voluntarily taken on emission reduction targets to reduce their emissions against 1998-2000 levels. They have committed to reducing their emissions by 3.96m tonnes CO_2e by the end of the Scheme. Over the lifetime of the scheme (2002-2006), this equates to 11.88m tonnes of CO_2e emissions releases avoided.

The scheme was also open to 6,000 other companies with Climate Change Agreements. These negotiated agreements between business and Government set energy-related targets. Companies meeting their targets receive an 80% discount from the Climate Change Levy, the tax on the business use of energy. These companies could use the scheme either to buy allowances to meet their targets, or to sell any over-achievement of these targets. Anyone can open an account on the registry to buy and sell allowances.

The 2005 results showed that the scheme had brought about emissions reductions of over 7million tonnes CO_2e since 2002.

The EU Emissions Trading Scheme is a pan-European policy to tackle emissions of carbon dioxide and other greenhouse gases and combat the serious threat of climate change. The UK's interest in it is maintained by Defra and features of it were influenced by the experience the UK government had gained when establishing the UK ETS.

The scheme began on 1 January 2005. The first phase runs from 2005-2007, and the second phase will run from 2008-2012 to coincide with the first Kyoto Commitment Period. Further subsequent five-year periods are expected.

The scheme works on a 'Cap and Trade' basis. EU Member State governments are required to set an emission cap for all installations covered by the Scheme and draw up a National Allocation Plan. Each installation is allocated allowances for a particular commitment period. The number of allowances allocated to each installation for any given period (the number of tradable allowances each installation will receive) are set down in the National Allocation Plan.

A4.4.8 Carbon Offsets

A carbon offset is a means of reducing the net carbon emissions of individuals or organisations indirectly, through proxies who reduce their emissions and/or increase their absorption of greenhouse gases. Such projects will prevent / have already prevented or removed an equivalent amount of carbon dioxide elsewhere in the World. As CO_2 emissions are distributed across the world, it does not matter where the reduction is made because the positive effect on the environment will be the same. A wide variety of offset actions are available, of which tree planting is the most common, but also including renewable energy and energy conservation.

Due to their indirect nature, many types of offset are difficult to verify. Through the emissions trading schemes, some offsets are fully traceable and properly regulated. Some providers obtain certification that their offsets are accurately measured, to distance themselves from potentially fraudulent competitors. However, accounting systems differ on what constitutes a valid offset for voluntary reduction systems and for mandatory reduction systems. Formal standards for quantification of offsets are not in place; differences of opinion between emitters, regulators, environmentalists, and project developers have yet to be resolved. This tends to undermine the worthiness of such offsets.

Accounting of offsets may address the following basic areas:

- Baseline – What emissions would occur in the absence of a proposed project?
- Additionality – Would the project occur anyway, without the investment raised by selling carbon offset credits?
- Redundancy – Are the reductions already required by some other law or regulation?
- Permanence – Are the claimed benefits truly long term, for instance, once a planted forest reaches maturity, it absorbs carbon dioxide more slowly.
- Leakage – Does implementing the project cause higher emissions outside the project boundary or create added emissions in its delivery?

A4.4.9 Renewables Obligation

The Renewables Obligation is the Government's main mechanism for supporting renewable energy. Introduced in April 2002, it provides a substantial market incentive for all eligible forms of renewable energy.

The Renewables Obligation requires licensed electricity suppliers to source a specific and annually increasing percentage of the electricity they supply from renewable sources. The current target is 6.7% for 2006/07 rising to 15.4% by 2015/16.

It is expected that the Obligation, together with exemption from the Climate Change Levy for electricity from renewables, will provide support to industry of up to £1billion per year by 2010.

At the end of 2005, generation from renewable sources eligible under the Obligation stood at 4%. This rises to 4.2% if non-eligible sources are included.

Eligible renewable energy sources are listed in the following table:

Source	Eligiblility
Landfill gas	Yes
Sewage gas	Yes
Hydro exceeding 20 MegaWatts declared net capacity (dnc)	Only stations commissioned after 1 April 2002
Hydro of 20 MegaWatts or less dnc	Yes
Onshore wind	Yes
Offshore wind	Yes
Co-firing of Biomass	Any biomass can be co-fired until 31 March 2009 with no minimum percentage of energy crops
	25% of co-fired biomass must be energy crops from 1 April 2009 t 31 March 2010
	50% of co-fired biomass must be energy crops from 1 April 2010 until 31 March 2011
	75% of co-fired biomass must be energy crops from 1 April 2011 until 31 March 2016

Source	Eligiblility
	Co-firing ceases to be eligible for Renewable Obligation Certificates (ROCs) after 31 March 2016.
Other biomass	Yes
Geothermal power	Yes
Tidal and tidal stream power	Yes
Wave power	Yes
Photovoltaics	Yes
Energy crops	Yes

The eligibility of energy from waste is summarised below:

	Mixed waste	Waste that is purely biomass	Energy crops, agricultural waste and forestry material
Incineration	Ineligible	Eligible*	Eligible*
Pyrolysis, gasification and anaerobic digestion	Only non-fossil-derived energy is eligible	Eligible*	Eligible
Co-firing	Ineligible	Eligible until 31 March 2016 (25% energy crops from 1 April 2009; 50% energy crops from 1 April 2010; 75% energy crops from 1 April 2011)	Eligible until 31 March 2016

* Subject to a maximum fossil-derived energy content of 2% to allow for accidental contamination.

Only stations first commissioned or re-equipped on or after 1 January 1990 (except micro-hydro and co-firing stations) are eligible. All stations must be located within the UK, its territorial waters or the Continental Shelf. The Obligation is administered by Ofgem.

A4.4.10 UK Energy Performance Commitment

The Government has consulted on measures to reduce carbon emissions in large non-energy intensive organisations by 1.2 million tonnes of carbon per year by 2020. Consultation began on 8 November 2006 and closed at the end of January 2007.

The consultation identified options for achieving these emissions savings:

- The Energy Performance Commitment (EPC) proposal – a mandatory cap and trade proposal; and
- A system of voluntary benchmarking and reporting.

Under the EPC, participants would be required to purchase allowances corresponding to their emissions from energy use (either at the auction or from each other) and then surrender them to a coordinator. Government would cap total energy use emissions by deciding on the number of allowances issued for auction.

Analysis of the responses to the consultation is awaited.

A4.4.11 Building Regulations

Building Regulations set standards for the design and construction of buildings to ensure the safety and health for people in or about those buildings. They also include requirements to ensure that fuel and power is conserved and facilities are provided for people, including those with disabilities, to access and move around inside buildings. The Building Act 1984 is the enabling Act under which the Building Regulations have been made. The function of building control is performed by local authorities or an 'approved building inspector'.

Part L of the Regulations, which deals with energy issues, was introduced in January 2006. It targets energy efficiency and the government claims it will improve the energy standards of new homes by 40% compared with pre-2002 levels. The means by which this is achieved are:

- Prescribing an annual CO_2 rate for a completed building, calculated by a prescribed method, and compared with a notional building;
- Specifying building fabric, services performance, solar shading and other measures to limit the risk of summer overheating;
- Setting standards for fabric insulation and airtightness; and
- Ensuring information on energy efficiency for occupiers.

There are different standards for dwellings and non-residential property as well as for new and existing buildings. As national standards, the Regulations set performance that is deemed reasonable, measurable and achievable throughout the UK.

Building control – the testing of the application of the Building Regulations – gives an opportunity to scrutinise the notional performance of the buildings that make up a development when they are in their fully-fledged design. However, some key configuration issues are decided earlier in the regulatory process, which is why using planning policy and the planning system to tackle climate change is vital.

However, aspects of the Building Regulations across the UK remain less stringent than those in a number of other European countries, and a DCLG Minister has called for UK buildings to be built to higher Scandinavian standards. There are also major concerns regarding compliance with and enforcement of the Part L 2006 requirements of the Building Regulations.

The Building Regulations also fall short of best available practice. Other standards include the Ecohomes ratings developed by the Building Research Establishment (BRE), and those standards set by Passive House, the Beddington Zero-Energy Development project (BedZED), the Energy Efficiency Partnership for Homes, and the Association for Environment Conscious Building (AECB). These require, among other things, a thick layer of insulation in the building fabric (including high-performance windows and doors), as well as attention to airtightness. As a result, the BedZED and Hockerton Housing Project housing schemes achieve zero net space heating demand with current technology. Energy consumption is very low by conventional standards due to careful design to maximise useful solar gain, combined with an envelope of insulation about 300 mm thick in the walls, roofs and floors.

There is, however, little incentive at present for housing developers to go beyond the Building Regulations, and some developers, with a tried, tested and profitable product, resist proposals for the tightening of standards. While the Code for Sustainable Homes is voluntary, as already mentioned, it is envisaged that over time the Building Regulations will be tightened to reflect the standards of the Code. In turn, the Code's standards will become increasingly stringent, progressively ratcheting up the mandatory standards. While this is an improvement, the opportunity was not taken to extend this Code to all buildings (that is, not just new homes).

A4.4.12 EU Energy Performance of Buildings Directive

The EU Energy Performance of Buildings Directive (EPBD) is an important driver of better environmental performance of buildings. It requires new and existing homes, public sector buildings and commercial properties to display an energy rating when property changes hands. The EPBD requires Member States to review their Building Regulations every five years, and the Statutory Instruments for implementing the EPBD's requirements in respect of Building Regulations for non-domestic buildings emerged as this report was being prepared. Further, the government has introduced a range of initiatives to increase greatly the information available to householders about the energy use of buildings:

- Energy Performance Certificates provide buyers and sellers with A-G ratings reflecting the energy efficiency of their homes, and it is mandatory to include them in Home

Information Packs, from June 2007; the certificates will provide a universal objective basis for possible fiscal or other financial incentives (such as ‘green mortgages’) to improve homes;

- Home Condition Reports provide more detailed information about the physical condition of the property and, therefore, what measures may be available to make it more energy efficient; these are to be included in the Home Information Packs on a voluntary basis;
- More informative billing from 2007, as electricity suppliers will provide bills to householders in an easily-comprehensible form showing the quantity and sources of their electricity and associated carbon emissions; and
- ‘Smart’ metering. Trials are underway for gas and electricity meters which give real-time information about consumption, allowing differential charging according to the time of use. Electricity meters with an ‘import-export’ capability will allow households which generate some of their own electricity to export surplus to the grid and be paid for it, while interactive meters would be able to turn equipment off and on according to whether electricity is more or less expensive.

A4.4.13 Standard assessment procedure for energy rating of dwellings (SAP)
SAP is the Government's recommended system for energy rating of dwellings. The latest version was introduced in 2005. A manual describes the procedure for assessing the energy performance of dwellings, and standard software packages are now also available for performing SAP assessments. The energy performance indicators for dwellings are:

- Energy consumption per unit of floor area;
- An energy cost rating (the SAP rating);
- An Environmental Impact rating (based on CO_2 emissions); and
- A Dwelling CO_2 Emission Rate.

The SAP rating is based on the energy costs associated with space heating, water heating, ventilation and lighting, less cost savings from energy generation technologies. It is adjusted for floor area so that it is essentially independent of dwelling size for a given built form. The SAP rating is expressed on a scale of 1 to 100; the higher the number, the lower are the running costs.

The Environmental Impact rating is based on the annual CO_2 emissions associated with space heating, water heating, ventilation and lighting, less the emissions saved by energy generation technologies. It is adjusted for floor area so that it is essentially independent of dwelling size for a given built form.

The Environmental Impact rating is expressed on a scale of 1 to 100. The rating rises to reflect rising standards.

The Dwelling CO_2 Emission Rate is a similar indicator to the Environmental Impact rating, which is used for the purposes of compliance with building regulations. It is equal to the annual CO_2 emissions per unit floor area for space heating, water heating, ventilation and lighting, less the emissions saved by energy generation technologies, expressed in $kg/m^2/year$.

The method of calculating the energy performance and the ratings is set out in a worksheet, accompanied by a series of tables. The methodology is compliant with the EU Energy Performance of Buildings Directive.

A4.4.14 Measuring/predicting energy use in buildings
There is a range of techniques for measuring and predicting energy use in buildings. Most of these techniques come from the US.

eQUEST is a freeware building energy-use analysis tool and was designed to allow detailed comparative analysis of building designs and technologies by applying sophisticated building energy use simulation techniques but without requiring extensive experience in the 'art' of building performance modelling. This is accomplished by combining schematic and design development building creation wizards, an energy efficiency measure (EEM) wizard and a graphical results display module with a complete building energy use simulation program. Earlier versions of the eQUEST tool were approved by the California Energy Commission (DOE2.com web site).

Despite the multitude of benefits of a CHP installation, relatively few tools exist for estimating the displaced emissions, or for predicting how CHP affects constrained transmission systems or distributed emissions implications. CHP systems offer huge improvements in system efficiency over traditional electricity generation. However, the difficulty in analyzing the emissions displaced by both the heat and power outputs of these CHP systems has hampered the development of effective policies (ACEEE Industry Program Research, January 2007).

A4.4.15 Energy White Paper

The extant energy white paper dates from 2003. The government had proposed to publish a new energy white paper in March 2007. It was to contain proposals for further development of nuclear power – which can be argued to be zero carbon.

However, the pressure group Greenpeace made a legal challenge to the adequacy of the consultation process that had been undertaken to precede the policy statement. Greenpeace were successful in the courts and, in late February 2007, the government postponed the white paper.

Alistair Darling, the trade and industry secretary, told Parliament he would not appeal the ruling. The white paper was postponed until May 2007, and a decision on whether to build a new generation of nuclear power stations was put back from July 2007 until the autumn. Mr Darling said in late February 2007 that "We continue to believe, subject of course to consultation, there is a case for having new nuclear power stations as one of the options companies should consider because of their potentially significant contribution to security of supply and reducing carbon emissions. Last week's court judgment does not undermine this view."

A4.4.16 Energy Supply Companies (ESCOs)

The Utilities Act 2000 enables electricity to be generated, distributed or supplied by persons authorised to do so by a licence or exemption. The licensed electricity market is the conventional, large scale, centralised power generation market. The exemption electricity market is the local distributed generation market using CHP and/or renewable energy, including private wire networks. Energy Supply Companies or ESCOs are authorised to generate, distribute and supply electricity under The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001. The maximum supply limit is 5 MW, of which no more than 2.5 MW may be to domestic customers. Heat is an unregulated market. The purpose of the ESCO is to provide local energy services, rather than energy per se, and roughly speaking the maximum size of distribution by an ESCO would be to 2,500 homes.

An ESCO should be able to finance the most sustainable energy development using the financial contributions that the developer/sub-developers and/or owners/occupiers would otherwise have spent on conventional energy electricity and gas grids, connections, boilers and other primary energy plant, metering, etc. A detailed feasibility study is undertaken to determine the appropriate costs and suitable investments.

An ESCO can take the form of a public/private partnership. Any local authority can work with private sector partners in establishing an ESCO. The council will typically take less than 20% of the share capital, with the rest owned by an energy supplier or finance house.

It can be the most favourable vehicle to invest in local energy schemes. Unlike a local council operating under public sector borrowing constraints, an ESCO has the capacity to borrow money to make the initial investments in CHP and/or energy efficiency measures beyond the resources of individuals or even of communities. There will usually be significant economies of scale involved in acting on behalf of a large number of residents in the same area. An ESCO can also be the repository of technical and professional expertise and resources that can work with local community organisations to realise energy schemes

Maintenance of the primary energy plant undertaken by the ESCO is more competitive than boiler maintenance contracts. An energy services or ESCO contract is normally index-linked, so that the benefit that the customer starts out with is maintained throughout the length of the energy services contract (typically 20 to 25 years). The cost differential between ESCO and grid energy supplies should be maintained whatever happens to electricity and gas prices.

For non-residential customers, the energy services contract with an ESCO is usually individual and bespoke, similar to the deregulated energy market, except that issues such as the avoided costs of primary energy plant, operation, and maintenance are taken into account. For residential customers the energy services contract with an ESCO is different, in that a common domestic tariff is normally used to demonstrate that the electricity and heat prices are more competitive than the local regional electricity and gas supply tariff prices.

Our discussions with stakeholders have highlighted that the economics of establishing an ESCO only become viable at a scale of supply of approximately 1 MegaWatt. The implication of this is that only very large developments (incorporating at the minimum 1,000 dwellings) would be immediate candidates, unless there was also a large non-domestic demand in a mixed-use development, or collaboration with other developers on nearby schemes.

A4.4.17 Selling Off Peak Energy

One of the features of any energy generation and supply business is that it has to be designed to meet peak demand. It means that for relatively long periods through its life, it will not be operating at maximum capacity, and these periods are uneconomical unless an alternative use or market for the energy can be found. Stakeholders have told us in our discussions that there are certain disincentives in the present operation of the energy market for small scale suppliers, so that they are enable or unwilling to sell surplus off peak energy for wider use.

The most significant of these disincentives are:

- Because spare capacity is available at a time when the major energy supply companies are also operating under-capacity, the price offered for unused capacity sold back to the grid is not adequate;
- That although demand for electricity from CHP schemes continues during the summer months, the demand for heat falls off, making the plant less viable and, arguably, not reducing carbon emission as a result (this is where the technical advantage of CCHP comes into play, though it would involve developing a market for summer cooling in a large part of the domestic market); and
- That spare capacity at the household level – for instance, from individual wind turbines or micro CHP schemes – may require the installation of new transformer infrastructure to increase the voltage for distribution to a wider area than the very local one (where demand may be low at the time distribution is possible).

A4.4.18 Retrofit

The installation of retrofitted climate change mitigation and adaptation measures could make a very significant contribution to the tackling of climate change issues. Although by the time long-term targets – like those for 2060 – are being met, the contribution made to carbon emission reductions by development created after 2007 will be significant, there will still be more built form which pre-dates 2007. Even if that were not the case, the government wishes to make short term and substantial cuts in greenhouse gas emissions.

Retrofitting may involve a number of activities including the installation of insulation, new windows, new boilers, solar power sources, microgeneration plant, sustainable drainage, and blinds. It is not always subject to planning control. If there is no change of use, no material development, or if the development is permitted without the need for planning permission, there is no opportunity for the planning system to intervene. In some cases, alterations to buildings are not subject to building control either, though there are specific provisions in Part L of the Building Regulations that deal with existing buildings.

On the one hand, government would wish to encourage retrofitting, on the other there is little regulation of it and it is hard to require it. Householders and occupiers of existing commercial property may see little efficiency or effectiveness in investment in climate change technology given the possible cost or disruption or both of its installation.

A4.4.19 Refurbishment

The Royal Commission on Environmental Pollution has recently considered the value to tackling climate change of large-scale refurbishment of the existing built stock. Such refurbishment would be of the nature and scope that it would require planning permission and, hence, could become subject to planning policies in the London Plan. The RCEP report “The Urban Environment” (2007) concluded there was considerable value from refurbishment. It said:

> Existing buildings can be refurbished and/or improved to meet higher energy efficiency standards, in many cases up to the standard of average new build. There have been some impressive refurbishments of even the least promising housing, for example the Urban Splash projects in Manchester and Birmingham. Resource efficiency and social renewal can occur at a lower financial and environmental cost when buildings are refurbished.
>
> We commissioned a study from the Environmental Change Institute on reducing the environmental impact of housing. It reviewed several recent studies in this area and concluded that although details differed, the technological potential for environmental savings in the housing stock was significant. However, the report also recognised that technological potential is not the only important aspect in reducing, for example, CO_2 emissions. People’s behaviour in buildings will also have a significant impact, in some cases potentially undermining technological savings, in others enhancing it.
>
> As part of this study, the Environmental Change Institute developed three scenarios to assess aspects of the environmental impact of housing stock up to 2050, including CO_2 emissions. Scenario A reflected the continuation of current and near-term trends, technology, policies and practice with changes occurring slowly into the future. Society is assumed to continue along current trends with no restriction on consumption and with any uptake of new energy efficiency technology being slow. Scenario B looked at how the residential sector could achieve the UK’s goal of a 60% reduction in CO_2 emissions by 2050. As well as technical measures, it was assumed in

this scenario that society becomes more carbon and energy aware and makes changes in its behaviour accordingly. Scenario C looked at the options for CO_2 reductions greater than 60%, through increased new build, more energy from renewables, greater uptake of energy efficiency measures and higher rates of demolition of existing housing than in scenarios A and B. However, demolition is controversial for a number of reasons, including its social and heritage impact, and because it produces construction waste. It is possible that by changing the assumptions in the scenarios, a similar level of CO_2 savings might be technically achievable with less demolition. In addition, the scenarios used in this study considered only effects on CO_2 emissions in the housing stock and did not include any broader impacts on society such as the cost of infrastructure associated with new build.

The outcome of the three scenarios in terms of CO_2 emissions is as follows:

- Scenario A achieved an 8% cut in CO_2 emissions by 2050 compared with 1996;
- Scenario B achieved a 56% cut in CO_2 emissions by 2050 compared with 1996;
- Scenario C achieved a 75% cut in CO_2 emissions by 2050 compared with 1996.

The term ‘refurbished’ here covers much more than just the building fabric and represents a ‘whole systems’ approach – it encompasses both energy demand reduction and the installation of low and zero carbon technologies. The total reduction in CO_2 emissions in 2050 is a combination of:

- refurbishment of existing stock;
- demand reduction for lights and appliances in all homes;
- replacement of some old housing with new housing (i.e. demolition and new build);
- a change in householder attitude to energy saving;
- new homes to meet projected demand; and
- the installation and use of low and zero carbon technologies (for example, photovoltaics, CHP).

The process of building new homes or carrying out refurbishment requires energy, for example, to extract raw materials, to process them and to assemble the building. This is known as embodied energy and, for new buildings, accounts for about 10% of a building’s lifetime carbon emissions. However, as the efficiency of buildings increases, the embodied energy will represent a higher proportion of total energy use. Embodied energy in refurbishment works can be one sixth that of new-build works.

[The] 1996 stock average of 15 MegaWatt-hours (MWh) delivered energy per year for space heating (with zero embodied energy), [compares with] an example of a recent development, Gallions Ecopark in Greenwich, with an average of 8 MWh delivered energy per year for space heating and 90 MWh embodied energy. The Gallions Ecopark development was built to the EcoHomes 'excellent' standard – one of the most stringent standards used by the mainstream construction industry – and is used here as an example of current good practice.

There are several key messages. If embodied and operational energy are both taken into account, then the impact of the Gallions Ecopark new-build home is lower than the existing, unrefurbished house after 13 years. After 60 years, the total cumulative energy of the new-build home is significantly less than the total energy consumed in running the existing home. Therefore, the embodied energy in dwellings is no reason not to demolish, but there may be other reasons why demolition is not appropriate, including social, community or heritage reasons. Moreover, demolition and rebuild is only beneficial over refurbishment in energy terms provided that the new homes are built to a high enough standard.

The Environmental Change Institute also found that it would be technically possible to reduce CO_2 emissions from housing by 60%, in line with the UK's goal, if the existing stock was refurbished to roughly the same level as the 'excellent' standard achieved by the Gallions Ecopark development, but that significantly higher standards would have to be met by new buildings. Standards for new build therefore have to be made much more ambitious than at present, and existing housing must be refurbished to at least a maximum average space heating demand of 9 MWh in order to reach the 60% goal. To achieve the CO_2 reductions beyond 60%, as set out in Scenario C, the standard of refurbishment would need to be to 6 MWh. Aiming for Scenario C may be necessary to ensure that a 60% reduction in carbon emissions is achieved in practice, because some investments may not deliver the expected savings, or because of unexpected social trends.

While our focus up to this point has been energy, it is important to understand the impact of refurbishment and new build in terms of waste generation. Construction waste is a significant component of the waste stream in urban areas. Increasing the rate of housing renewal can lead to increased levels of construction and demolition waste. The Environmental Change Institute study suggests that the total amount of waste generated would increase significantly with an accelerated programme of demolition and rebuild and to a lesser extent refurbishment.

In order to minimise the environmental impacts of redevelopment, the reuse of materials needs to be prioritised over recycling materials and using new materials with recycled content. However, much of this waste is hard to reuse and recycle, although there is scope to recycle bricks, wood and piping. The environmental consequences of material use in construction and refurbishment include depletion of natural resources, local and global impacts of extraction and processing activities, and transport effects. Additional factors to consider include the embodied energy of construction, use of material resources, disruption to communities and heritage value.

Since the vast majority of current housing in the UK will be in use for at least the next 50 years, improvements made within the existing stock could yield major environmental savings immediately and in the future. Significant efforts to improve the efficiency with which energy, water and natural resources are used in buildings have a key role to play in meeting the UK's CO_2 reduction targets for 2010 and 2050.

Refurbishment of existing dwellings to a standard significantly beyond current Building Regulations is crucial if CO_2 targets are to be achieved. However, the actors involved in refurbishment are many and varied. Homeowners are key in bringing about change. The rented housing sector, where the landlord receives no direct benefit from any alterations, is a further challenge. There are tax incentives to encourage this and proposals in the Chancellor's 2006 Pre-Budget Report to extend them. An alternative approach has been suggested recently to require landlords to ensure their properties meet a minimum environmental standard before they can be rented out.

Other important actors are the builders who carry out refurbishment work, which are often different from the large companies that typify the mainstream construction industry. Their small scale of operation presents a particular challenge when attempting to bring about change in which each tradesman has a significant role to play in informing and influencing house builders and owners about the various technologies available.

The refurbishment and improvement of existing dwellings, including retrofitting of energy efficiency measures, is hugely challenging. Homeowners are not always aware of the available opportunities to reduce running costs, or how to deliver them, nor do they perceive use of capital for this purpose as a priority over other expenditure. Therefore, the point at which a property is purchased or rented is a key opportunity to demonstrate what needs doing, and we believe that the government should be more ambitious in exploiting the potential for energy saving via the forthcoming provision of easily accessible information for homeowners. The Home Information Pack has the potential to be a useful tool.

Despite there being a strong economic, social and environmental case for refurbishment, there are still challenges to be overcome; for example VAT is currently charged at the full rate on refurbishment, while new buildings are zero rated. We note from the House of Commons Environmental Audit Committee's report that Germany has a plan to increase the energy efficiency of its existing housing to the standards of its current building regulations, which are already more stringent than those in the UK.

A4.4.20 Impact of Future Technology Change

We cannot foretell with accuracy the likely changes in technology that will occur during the period of the Government's long-term climate change targets. There will, however, be two effects that we can describe in general: the reduction of price and the development of new solutions.

Whatever happens, we can expect that the price of existing technology will fall. This will be because of the driving-out of innovation costs in existing delivery mechanisms. As technology which is currently pioneering becomes part of the standard market, the high costs of research and development will be gradually absorbed; meanwhile, more suppliers will enter the market, and competition will drive economies and further marginal innovation to reduce price.

It is difficult to forecast the impact of this process. However, in a recent assessment, it was concluded that "Most of the technologies will be able to reduce their specific investment costs to between 30% and 60% of current levels by 2020, and to between 20% and 50% once they have achieved full development (after 2040)." ("Energy [R]evolution", EREC / Greenpeace, 2007)

In addition, pressure through regulation and public opinion will also drive further innovation creating technological solutions that we cannot predict at this stage. These will begin by bearing innovation costs but, in the longer term, will be subject to the price mechanism described above.

A4.4.21 Security of Energy Supply

An issue that has recurred as a concern in our discussions with stakeholders is about the general need for a secure energy supply. The use of ICT in business is almost universal: few sectors have no reliance on some sort of record keeping or payments system that is computer driven. Dwellings also rely on a arrange of electrically powered equipment for domestic chores and leisure activities, which are regarded as essential in a modern life with long working hours and little rest time. That means that continuous electricity supply is a high priority.

Two particular issues have arisen in our discussions:

- Some commercial interests have electricity supply as a paramount requirement: For instance, some businesses function entirely on ICT equipment, or are dependent on air conditioning for the proper conditions for work or industrial processes. To remain competitive, they need to have guaranteed access to accommodation that does not appear (at least at first sight) low-carbon friendly; and
- At this stage of the development of the market, concern has been expressed over the continuity and sustainability of biomass supplies (of various sorts), and adequate repair and maintenance knowledge to ensure that energy can be maintained – even if is not a paramount need.

A4.5 Planning Policy

National Planning Policy guidance is contained within Planning Policy Guidance Notes (PPG) and Planning Policy Statements (PPS), which are progressively replacing PPGs under the new planning system. Together, they provide a framework to guide regional and local planning policy, and as such provide the context within which Regional Planning Bodies (RPBs) must address climate change.

A4.5.1 Planning Policy Statement 1: Delivering Sustainable Development

At the heart of Planning Policy Statement 1 is a commitment to sustainable development through the planning system, defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

Implicit to the achievement of these goals is mitigation of and adaptation to the effects of climate change. Indeed, PPS1 requires regional planning authorities to "address (on the basis of sound science) the causes and potential impacts of climate change – through policies which reduce energy use, reduce emissions, promote the development of renewable energy resources, and take climate change impacts into account in the location and design of development", the justification of which should be supported by a "common, robust evidence base".

A4.5.2 Draft Planning Policy Statement: Planning and Climate Change (Supplement to PPS1)

The draft Planning Policy Statement on Climate Change states that "climate change is the greatest long-term challenge facing the world today. Addressing climate change is therefore the Government's principal concern for sustainable development". It is therefore recognised that "there is an urgent need for action" within which spatial planning plays a pivotal role. This draft PPS therefore sets out how spatial planning should contribute to mitigating and adapting to climate change, by:

- Helping to meet the UK's emissions targets, by influencing energy use and emissions;
- Delivering the Government's zero carbon development;
- Creating an environment which encourages innovation and opportunities for the private sector to invest in renewable and low-carbon technologies and supporting infrastructure; and by
- Giving local communities opportunities to take action on climate change.

In terms of the role of the Regional Spatial Strategy, the PPS outlines the following responsibilities:

- Consideration of how the region contributes to climate change
- Provision of a framework for integrating policies regarding land with other policies and influencing the nature of places and how they operate;
- Ensuring that the spatial strategy corresponds with national and regional targets for cutting carbon emissions;
- Consideration of the region's susceptibility to climate change, in particular implications for built development, infrastructure and services and biodiversity; and
- Identifying and addressing cross-regional concerns.

In terms of policy content, this means:

- Reducing the need to travel and promoting development in areas of high public transport accessibility;
- Promoting efficient energy supply and contributions from decentralised, renewable and low carbon energy in new developments;
- Integrating into new and existing development more efficient energy supply and contributions from renewable and low-carbon energy sources;
- Identifying opportunities for carbon capture and storage;
- Avoiding development in areas susceptible to the effects of climate change;
- Setting regional targets for renewable energy in line with national targets for 10% electricity from renewable sources by 2010 and aspirations for 20% by 2010; and
- Setting regional trajectories for the expected carbon performance of new residential and commercial development to be measured over time.

A4.5.3 Companion Guide to PPS on Climate Change

To assist planning authorities in their understanding of PPS26, CLG are preparing a companion guide to the policy document. It is due to be completed during the second half of 2007.

In line with the PPS, the companion guide will relate to the regional, local, area and site-specific spatial scales. Its primary audience is regional and local planning officers and the development industry, although there will also be considerable interest from other stakeholders including local communities, interest groups and energy companies.

A main function of it is likely to be to give confidence to planning authorities that they can push for development that will lead to a reduction in carbon emissions, reflecting Ministers' and the Mayor's ambition to incorporate renewable technologies in all new development. It will also demonstrate how climate change policies can be implemented in an integrated way with other Government policy objectives.

The companion guide provides an opportunity to provide good practice advice, based on existing or possible practice within the scope of the PPS. Through positively worded policies, and the demonstration of good practice in both rural and urban settings, the companion guide should offer reassurance to planning officers across England that the implementation of these policies will be achievable and enforceable. However, in so doing, it is likely to encounter the fact that there are numerous demonstration projects of energy efficiency, renewable installations and adaptation, but very few production models. It is likely to be heavily reliant on the Merton rule and these demonstration projects.

Among the issues that the guide is expected to cover are:

- The difference between measures to mitigation climate change (by reducing the output of greenhouse gases) and those that adapt to it (by upgrading the defences of buildings against rain, sun and wind);
- The way to balance support for new development in principle with a need to direct it towards locations which are most sustainable, and positively worded policies that might achieve this;
- The balance between the impacts of climate change policy and existing planning policies for restraint;
- A range of possible targets, including larger-scale renewable energy capacity such as windfarms and biomass (as for PPS 22), smaller on-site provision for particular scales of development, such as CHP, district heating and local distribution, use of water, and the convergence of urban and rural night-time temperatures;
- Clarification of the relationship between planning policy on climate change and the requirements of the Building Regulations and operation of building control;
- A checklist of information needed by decision-makers about the impact of buildings in terms of greenhouse gases, especially if they fall below the EIA threshold;
- The treatment of environmentally-beneficial businesses, such as public transport operators, and energy distribution infrastructure (e.g. LPG and hydrogen);
- The permitted development rights issues that arise in relation to retrofit, and in particular to domestic microgeneration;
- Model approaches to the use of planning obligations in terms of on-site generation, mixed uses, thermal efficiency, etc.;
- The skills needed by participants in the planning process;
- A 'toolkit' for assessing the viability of enhanced sustainability performance for each development (similar to the approach taken by London's Mayor), with the Building Regulations as a minimum standard, and the scope for individually-assessed improvements;
- Indicators to monitor effective implementation of climate change; potentially through Annual Monitoring Reports for RSSs and LDFs, and possibly good practice examples of evaluation/review;

- Design guidance, with examples of current or emerging practice;
- Good practice of the use of 'green' infrastructure, for example to lessen the heat island effect in cities or to provide access corridors for wildlife seeking to migrate to cooler areas over the coming decades; these include water features (to enhance evaporative cooling), greater use of reflective materials, building designs and massing that trap thermal energy and increase reflectivity;
- Advice on the different climate change impacts and effects in different contexts across England: the issues are different for rural and urban areas, areas of high development demand and areas currently in decline;
- The strategic location of population and key facilities in flood risk areas (although much of this is covered by PPS 25) in a proactive rather than a reactive way, and taking a longer term view; and
- An appropriate evidence base, and using this in option generation and preferred option identification in the RSS/ LDF preparation process; methods of scenario modelling and testing, and possible sources of evidence.

A4.5.4 Merton Rule

The Merton Rule, as it has become widely known, is currently the best-known example of how to draft a policy on renewable energy. It was pioneering work which has subsequently been adopted by a number of other authorities.

The initial driver for the policy was work on global environmental issues developed through Local Agenda 21, which led to objectives to reduce energy use and promote the use of renewable energy. The policy was also driven by economic development, because it was seen as a way to reduce energy bills for start-up business premises and to help encourage the development of the renewables industry.

The policy specifying 10% renewable energy in new developments was adopted by the London Borough of Merton's Unitary Development Plan in October 2003. This made Merton the first local authority in the UK to include a policy of this kind.

The relevant part of the policy reads: "all new non-residential developments above a threshold of 1,000 m² will be expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements." Supplementary justification says that where the incorporation of renewable energy equipment would make the development unviable it will not be expected, for instance, if for technical reasons it is not possible to mount solar or wind methods on a roof. Further text explains that the means of generating renewable energy to be photovoltaic energy, solar-powered and geo-thermal water heating, energy crops and biomass, but not energy from domestic or industrial waste.

Merton was instrumental in encouraging the ODPM (now CLG) to incorporate text in Planning Policy Statement 22 to strengthening the council's policy stance. When PPS 22 was published in late 2004, it provided further support to authorities with ambitions to implement a similar policy. It said "Local planning authorities may include policies in local development documents that require a percentage of the energy to be used in new residential, commercial or industrial developments to come from on-site renewable energy developments."

Merton's experience so far with implementation is that the policy has not affected the development industry. Indeed, one developer has made three applications that incorporate renewables. Developers have said that the policy has added 3-4% to the build cost of their schemes. The authority is clear that early discussion with applicants during the design phase helps to ensure that equipment is incorporated effectively and that the cost implications are known and understood. (London Borough of Croydon has had the same experience with its own similar policy).

Compliance with the policy is required as a condition of the planning consent. Until the condition is signed off, the development is not legal.

The basis for the 10% calculation is the energy consumption of the proposed building multiplied by the floorspace of the development. Where speculative commercial/industrial development is intended and the end user is not known, fittings are not included in this energy assessment.

To work out the energy consumption, Merton use Energy Use Benchmarking Guides that have been produced by Building Research Establishment. The guides give the energy consumption per square metre for various building types. Figures for gas and electricity are worked out separately and then combined. Energy consumption is then converted into carbon by multiplying by a factor to give the notional carbon consumption for the building from which the 10% requirement can be determined. The figure is converted into carbon because of the differing quantities of carbon dioxide produced when generating electricity or producing heat from a gas boiler.

Merton meet the applicant where necessary to agree this figure and are prepared to negotiate ways of meeting the target. For example, if energy efficiency measures are to be incorporated as standard into the building (such as energy efficient lighting or increasing its thermal mass), the authority will reduce the carbon footprint of the building, thereby cutting the 10% renewable requirement. In practice, it is usually cheaper to reduce the energy consumption of a building than to provide on-site renewable electricity generating equipment. Thus, a building that exceeds the requirements of Part L of the Building Regulations works in the favour of the developer. Merton recognise that combined heat and power is an efficient way of producing energy, and where developers propose CHP in a scheme, the authority make a compensating reduction in the 10% requirement.

Merton had intended to extend the 10% policy to cover all development in the borough, including residential development. The FALP [and PPS26] now suggest that this would be an acceptable step and that it could be set at a higher percentage rate.

Merton has been heavily involved in promoting the policy through individual presentations across the country. Over 80 local authorities are now following Merton's lead, with many more aiming to do so in their LDFs.

A4.5.5 Planning Policy Statement 9: Biodiversity and Geological Conservation

Planning Policy Statement 9 outlines key planning objectives regarding biodiversity:

- Ensuring that biological and geological diversity are conserved and enhanced as an integral part of social, environmental and economic development;
- Conserving, enhancing and restoring diversity of England’s wildlife and geology by sustaining and improving the quality and extent of natural habitat sites; the physical processes on which they depend; and the populations of naturally occurring species which they support; and
- Enhancing biodiversity and green spaces among developments so that they are used by wildlife and valued by people.

PPS 9 also recognises that “over time the distribution of habitats and species…will be affected by climate change and such change will need to be taken into account”. Not only will a changing climate affect England’s habitats and species, but it is evident that the adoption of certain climate change mitigation and adaptation policies may, in some cases, have implications for the achievement of the above biodiversity objectives.

A4.5.6 Planning Policy Statement 10: Planning for Sustainable Waste Management

Planning Policy Statement 10 aims to "secure the recovery or disposal of waste without endangering human health and without endangering the environment", implicit in which is a reduction of the contribution of waste and its management to the effects of climate change. PPS10 also identifies a number of good practice principles, which are also effective in reducing the impacts of waste production and management on climate change. The 'waste hierarchy' introduces a number of best practice activities, including the reduction of waste at source, reuse and recycling, the generation of energy from waste and the treatment of waste close to source, all of which can contribute positively to combating climate change by reducing the volume of harmful gas emissions associated with waste and its management.

A4.5.7 Planning Policy Statement 11: Regional Spatial Strategies

Planning Policy Statement 11 defines the purpose and scope of a Regional Spatial Strategy (RSS), which should "provide a spatial framework to inform the preparation of LDDs, Local Transport Plans and regional and sub-regional strategies and programmes that have a bearing on land use activities" . Whilst RSSs are required to provide a framework for development over a 15 to 20 year period, PPS11 acknowledges that "there is a need to look beyond the end of this period in certain circumstances, since some relevant forecasting horizons are longer terms, for example, adaptation to climate change". Implicit therefore in this statement is the idea that planning for climate change must begin now, particularly as the policies and practices adopted today will impact in the longer term on a region's ability to adapt to and mitigate the effects of climate change. In terms of drafting policies relating to climate change (and other issues), PPS11 provides some guiding principles. Policies should:

- Contribute to the achievement of sustainable development;
- Be specific to the region, providing spatially specific policies which apply national policy principles within the individual circumstances of the region;
- Provide a clear link between policy objectives and priorities, targets and indicators; and
- Add value to the overall planning process.

In order that RSS can remain up to date and relevant to the issues and challenges faced by regions, PPS11 also acknowledges that periodic revisions may be required, where changing circumstances, emerging new evidence or national policy changes regarding issues such as climate change will necessitate an update in regional policy content and direction.

A4.5.8 PPG 12 Local Development Frameworks

PPS12 replaced Planning Policy Guidance 12 – Development Plans. It sets out the Government's policy on the preparation of local development documents which will comprise the local development framework. Further guidance is contained in a suite of documents:

- Local Development Frameworks – A Guide to Procedures;
- Creating Local Development Frameworks;
- Local Development Frameworks - Monitoring Guidance; and
- Sustainability Appraisal of Regional Spatial Strategies and Local Development Frameworks.

PPS12 says:

> Local development documents must be in general conformity with the regional spatial strategy or, in London, the spatial development strategy. However, where the regional spatial strategy or spatial

> development strategy is being reviewed, account may be taken of the strategy's progression through the statutory procedures. The weight to be attached to the revised strategy depends on the stage it has reached. Where the regional spatial strategy/spatial development strategy has been through an Examination in Public, and the proposed changes have been published, considerable weight may be attached to that strategy because of the strong possibility that it will be published in that form by the Secretary of State.
>
> The test is of general conformity and not conformity. This means that it is only where an inconsistency or omission in a development plan document would cause significant harm to the implementation of the regional spatial strategy/the spatial development strategy, that it should be considered not to be in general conformity. The fact that a development plan document is inconsistent with one or more policies in the regional spatial strategy/the spatial development strategy, either directly or through the omission of a policy or proposal, does not, by itself, mean that the document is not in general conformity. Rather, the test is how significant the inconsistency is from the point of view of delivery of the regional spatial strategy/the spatial development strategy.

Section 344 of the Greater London Authority Act 1999 introduced the general conformity statutory requirement to London. This requires borough councils to seek the Mayor’s written opinion as to whether a revised development plan was in general conformity with the London Plan. If the Mayor’s opinion was that the plan was not in general conformity, the written opinion was to be treated as a duly made objection for consideration by a planning inspector at a UDP inquiry. In practice, London plans must not be adopted unless they are in general conformity with the London Plan. This requirement for general conformity of plans with the London Plan set out in the initial legislation has been transferred to the new development plan system introduced in late 2004.

Issues of non-general conformity are resolved as far as possible through discussions between the Mayor and the borough councils before plans reach the examination stage.

The development management policies set out in each local development document therefore need to reflect the content of the London Plan and, when complied with, implement its objectives. This will, of course, include climate change policies.

A4.5.9 Planning Policy Guidance Note 15: Planning and the Historic Environment

Planning Policy Guidance Note 15 provides planning guidance in relation to the protection of all aspects of the historic environment, described as “a central part of our cultural heritage and our sense of identity…an irreplaceable record which contributes, through formal education and in many other ways, to our understanding of both the present and the past”. PPG15 calls for Local Authorities to give particular consideration to the effects of planning applications and developments on the preservation of the following:

- Listed buildings;
- Conservation areas;
- World Heritage sites;
- Historic Parks and gardens; and
- The setting of all of the above.

As several actions taken to address climate change have physical manifestations in terms of the appearance of a development itself or the surrounding area, special consideration will therefore have to be given to the adoption of climate change policies in areas of historic value.

A4.5.10 Planning Policy Guidance Note 16: Archaeology and Planning

Planning Policy Guidance Note (PPG) 16 describes archaeological remains as “irreplaceable”, providing “the only evidence of the past development of our civilisation”. As such they should be regarded by planning authorities as “finite and non-renewable…highly fragile and vulnerable to damage”. PPG16 therefore calls for appropriate management to ensure that they survive in good condition. As with listed buildings and their settings, the installation of mechanisms to combat or safe proof against climate change may, in some instances, conflict with maintaining the integrity of surface archaeological assets, particularly those of great visual quality. In this respect, PPG16 calls for development plans to “reconcile the need for development with the interests of conservation including archaeology”. In this respect, it acknowledges that “it is not always feasible to save all archaeological remains. The key question is where and how to strike the right balance”. In this respect, PPG16 calls for a presumption in favour of the physical preservation of nationally important remains, although in the cases of archaeological remains of lesser importance, it requires local authorities to weigh the remains’ relative importance with other factors relating to the development.

A4.5.11 Planning Policy Statement 22: Renewable Energy

Planning Policy Statement 22 provides advice on the development of renewable energy within the national context of achieving a national 60% reduction in carbon emissions by 2050, towards which both renewable energy and combined heat and power are recognised as making a ‘vital contribution’. In light of this, PPS 22 recommends that “Regional Spatial Strategies (RSS) should contain policies designed to promote and encourage, rather than restrict, the development of renewable energy resources”. Furthermore, RSS should provide targets for renewable energy capacity within the region, calculated from assessment of the area’s potential as well as taking account of the regional environmental, social and economic impacts that would result from pursuing that potential. With respect to smaller scale projects more appropriate as part of new developments, it is emphasised that they can “provide a limited but valuable contribution to overall outputs of renewable energy and to meeting energy needs both locally and nationally”. With this in mind, planning authorities and developers are encouraged to “consider the opportunity for incorporating renewable energy projects in all new developments.”

PPS 22 also provides further clarity on the potential conflict between installation of carbon saving devices in new developments and their potential impacts on the value of designated sites (see PPS9, PPG15 & PP516). In this respect, it emphasises that planning permission should only be granted where applications will not harm the integrity of designated sites of international and national importance, where there is no alternative or reasons of overriding public interest.

A4.5.12 Planning Policy Statement 23: Planning and Pollution Control

Planning Policy Statement 23 outlines the role that planning should play in mitigating the effects of pollution on the environment, through the location of development causing pollution either indirectly or directly, as well as ensuring that other land uses are not affected by existing or potential sources of pollution. Its approach to limiting and mitigating against air pollution will also have an effect on development’s contribution to climate change, as many of those emissions contributing to poor air pollution also play a role in the greenhouse effect and associated climate change.

With regards to the approach planning takes to pollution control through development plans, Regional Planning Bodies are directed to “adopt a strategic approach to integrate land use planning processes with plans and strategies for the mitigation and removal of pollution, as far as is possible and practicable to do so", the overall aim of pollution control policies being to ensure the sustainable and beneficial use of land.

A4.5.13 Planning Policy Guidance Note 24: Planning and Noise

With regards to noise, Planning Policy Guidance Note 24 outlines the responsibility of the planning system to "minimise the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business". To this end, development plan policies should provide a framework by which noise sensitive developments (housing, hospitals and schools) are located away from existing sources of significant noise, whilst potentially noisy developments are located in areas where noise will not be such an important consideration, or where its effects can be reduced.

A4.5.14 Planning Policy Statement 25: Planning and Flood Risk

Planning Policy Statement 25 provides guidance on how to reduce and mitigate flood risk through the planning system. Direction is provided within the context of an acknowledgement of climate change and its effects on rising flood risk in the coming decades – namely wetter winters and rising sea levels. PPS 25 adopts a risk-based approach to the avoidance of flood risk, whereby flood risk is addressed and its effects minimised through attention to the source, pathway and receptors of flooding. In terms of new development this has a number of implications, including:

- Avoidance of new development in areas of high flood risk;
- Attention to flood pathways, river processes, likely routes and storage locations of floodwater;
- Avoidance of increased run off generation and downstream flood risk from new development;
- Incorporation of Sustainable Urban Drainage Systems (SUDS); and
- Incorporation of flood resilient design and layout.

A4.5.15 Planning White Paper

The Government has announced that it will set out its plans in a forthcoming planning reform White Paper. These will include measures to deliver a substantial reduction in the bureaucracy associated with making planning applications, including a reduction in paperwork. The government agrees with the views in Kate Barker's Review of Land Use Planning (December 2006) that the planning system does not always fully consider the benefits that economic development can bring in terms of increasing employment and prosperity or ensuring transparent, certain and efficient decision making on infrastructure of national economic importance.

The forthcoming White Paper will include measures to ensure that planning takes a positive approach to sustainable economic development by:

- Setting out a new single system of planning for major infrastructure, with clear national policy statements which balance economic, social and environmental objectives, effective public consultation, and decisions taken by an Independent Planning Commission;
- Significantly streamlining national planning policy, including a new framework for positive planning for economic development, with a more explicit role for market signals to inform plans and planning decisions; and
- Substantial improvements to the process for obtaining planning permission for all users, with clearer and simpler processes and quicker handling of appeals cases, backed by a more efficient plan-making process.

A4.5.16 Review of Permitted Development Rights for Microgeneration

The government has recently undertaken two pieces of work to look at the burden of the planning system on minor work.

The review of permitted development rights was a report published by ODPM in September 2003. It had a wide remit and looked at almost all aspects of small scale development that was or might be subject to planning control. However, because it was prepared before the increase in small scale renewable energy, it does not mention renewables at all.

The report of the householder development consents review steering group was published in July 2006. It took a narrower view than the review of permitted development rights and was concerned with the burden on householders arising from the planning system. However, like its predecessor, it makes no specific (or implied) mention of renewables. As this report was in preparation CLG published a Consultation Paper on Permitted Development Rights for Householder Microgeneration. This document reveals the Government's desire to deal with the shortcomings of the existing guidance, but it will only be after the consultation is completed that any easing of rights will be revealed.

A4.5.17 Policies and Factors Concerning Sustainable Design and Construction

Many factors now exist to encourage developers to adopt more sustainable construction practices, and for these to be promoted more effectively through the planning system:

- Sustainable development is at the core of European and UK Government policymaking, including targets on issues such as reducing CO_2 emissions and waste, and increasing social equity;
- "Sustainable development is the core principle underpinning planning" (from the opening paragraph of the recently-updated Planning Policy Statement 1);
- It is a legal requirement that Sustainability Appraisal is undertaken as part of regional and local planning policy development;
- The landfill tax, aggregates levy, climate change levy, stamp duty exemption for deprived areas, have all been introduced to provide economic incentives;
- Development Agencies are tasked with promoting sustainable development and are building requirements into procurement processes, for example requirements to meet EcoHomes or BREEAM rating targets; and
- New legislation, including the Energy Performance of Buildings Directive and Updates to Part L of Building Regulations and the Implementation of the Sustainable and Secure Buildings Act, has increased minimum standards relating to sustainable construction.

Most of these points simply make good business sense, for instance, minimising waste and increasing efficiency. Sustainability is of increasing importance to the efficient, effective and responsible operation of business.

From a developer's perspective, this changing policy framework has created a number of business drivers:

- Obtaining planning permission will increasingly require the adoption of sustainable construction practices;
- Those companies that adopt forward thinking approaches will increase opportunities for developing on sites being brought forward by informed landowners and building clients;
- Growing awareness from shareholders, investors and the public has led to increased public reporting on social and environmental issues, with some developers now producing annual environmental, social or sustainability reports;

- Socially responsible investment has placed pressure on companies to integrate social and environmental considerations into their working practices, and to adopt environmental management systems, creating greater pressure from clients for buildings with reduced running costs and more attractive and healthy working environments for their staff;
- There is growing recognition that creating decent places for people to work and live, with high quality public spaces and amenities creates value and will lead to higher investment returns for developers. Recent research has, for example ,shown higher investment returns for mixed-use development; and
- Pressure groups have become more sophisticated in their approach to promoting sustainable development, by either working more closely with key industry groups or by publicly embarrassing those organisations that fail to take issues seriously.

"Building a Better Quality of Life, A Strategy for More Sustainable Construction", (www.dti.gov.uk/construction/sustain/bql) established key themes for action by the construction industry. These include:

- Design for minimum waste;
- Lean construction & minimisation of waste;
- Minimisation of energy in construction & use;
- The edict 'Do not pollute';
- Preservation & enhancement of biodiversity;
- Conservation of water resources;
- Respect for people and the local environment; and
- Monitoring & reporting (i.e. the use of benchmarks).

The Mayor of London has adopted Policy 4B.6 in the London Plan which sets a framework for sustainable design and construction in development. He has issued Supplementary Planning Guidance that addresses the seven measures in the existing Policy 4B.6 in the London Plan, and to address sustainable construction.

A5 Water Saving Technologies

Device	Description
Rainwater harvesting	Collection and storage of rainwater on site for use as a substitute for mains water, for example in watering gardens or for flushing toilets 
Green roofs	Systems covering a roof with vegetation. Laid over a drainage layer, with other layers providing protection, waterproofing and insulation. Reduce the volume and rate of runoff as well as improving insulation and the lifespan of a building. . 
Infiltration devices	Temporarily store runoff and allow it to percolate into the ground. Can be trenches, basins or soakaways.
Infiltration trenches	An infiltration trench is a shallow, excavated trench that has been backfilled with stone to create an underground reservoir. Stormwater runoff diverted into the trench gradually infiltrates into subsoil. 
Infiltration basin	Shallow surface impoundments where stormwater runoff is stored until it gradually infiltrates through the soil of the basin floor 
Permeable surfaces	Allow runoff to infiltrate through the surface into an underlying storage layer, where water is stored before infiltration, reuse or release to surface water.

		
Filter strips	Wide vegetated areas of gently sloping ground designed to drain water evenly off impermeable areas as well as filtering out silt and other particulates	
Swales	Shallow vegetated channels that conduct and retain water, and may also permit infiltration; the vegetation filters particulate matter.	
Wetlands/ ponds	Areas that may be utilised for surface runoff storage.	
Detention basins	Detention basins are designed to hold back storm runoff for a few hours to allow the settlement of solids. Bypasses may be included to ensure the “first flush” is detained. Detention basins drain via an orifice or similar hydraulic structure into a watercourse or surface water drainage system.	

Bioretention areas	Vegetated areas designed to collect and treat water before discharge via a piped system or infiltration to the ground.	
Pipes and accessories	A series of conduits and their accessories normally laid underground that convey surface water to a suitable location for treatment and/or disposal.	

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Chinese

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Hindi

यदि आप इस दस्तावेज की प्रति अपनी भाषा में चाहते हैं, तो कृपया निम्नलिखित नंबर पर फोन करें अथवा नीचे दिये गये पते पर संपर्क करें

Vietnamese

Nếu bạn muốn có văn bản tài liệu này bằng ngôn ngữ của mình, hãy liên hệ theo số điện thoại hoặc địa chỉ dưới đây.

Bengali

আপনি যদি আপনার ভাষায় এই দলিলের প্রতিলিপি (কপি) চান, তা হলে নীচের ফোন্ নম্বরে বা ঠিকানায় অনুগ্রহ করে যোগাযোগ করুন।

Greek

Αν θέλετε να αποκτήσετε αντίγραφο του παρόντος εγγράφου στη δική σας γλώσσα, παρακαλείστε να επικοινωνήσετε τηλεφωνικά στον αριθμό αυτό ή ταχυδρομικά στην παρακάτω διεύθυνση.

Urdu

اگر آپ اِس دستاویز کی نقل اپنی زبان میں چاھتے ھیں، تو براہ کرم نیچے دئے گئے نمبر پر فون کریں یا دیئے گئے پتے پر رابطہ کریں

Turkish

Bu belgenin kendi dilinizde hazırlanmış bir nüshasını edinmek için, lütfen aşağıdaki telefon numarasını arayınız veya adrese başvurunuz.

Arabic

إذا أردت نسخة من هذه الوثيقة بلغتك، يرجى الاتصال برقم الهاتف أو مراسلة العنوان أدناه

Punjabi

ਜੇ ਤੁਹਾਨੂੰ ਇਸ ਦਸਤਾਵੇਜ਼ ਦੀ ਕਾਪੀ ਤੁਹਾਡੀ ਆਪਣੀ ਭਾਸ਼ਾ ਵਿਚ ਚਾਹੀਦੀ ਹੈ, ਤਾਂ ਹੇਠ ਲਿਖੇ ਨੰਬਰ 'ਤੇ ਫ਼ੋਨ ਕਰੋ ਜਾਂ ਹੇਠ ਲਿਖੇ ਪਤੇ 'ਤੇ ਰਾਬਤਾ ਕਰੋ:

Gujarati

જો તમને આ દસ્તાવેજની નકલ તમારી ભાષામાં જોઈતી હોય તો, કૃપા કરી આપેલ નંબર ઉપર ફોન કરો અથવા નીચેના સરનામે સંપર્ક સાધો.

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