Guildford borough

Environmental sustainability and climate change (2015)

GUILDFORD BOROUGH

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Executive summary

The aim of this document is to identify the environmental sustainability and climate change issues that the Local Plan must or should address. To do this we have looked at the requirements placed on us by national and international legislation and policy, our performance on sustainability, and the current and future needs of the borough.

Current national policy explicitly requires us to:

- help achieve ambitious national targets for carbon emission reductions
- support improvements to energy efficiency in existing and new buildings
- take account of, mitigate and adapt to the impacts of climate change
- support renewable and decentralised energy (including heating/cooling networks) and
- do this without compromising growth.

Per capita carbon emissions in our borough are high compared to the nation as a whole, and this is particularly true of the emissions considered to fall within the scope of local authority influence. This is mainly driven by very high road transport emissions, and higher than average domestic emissions. Renewable energy capacity is lower in our borough than in other areas. We use much more water per person than in other areas though we have a low supply. Our record on domestic waste is satisfactory and our recycling record is good, however there is potential for improvement in both.

Climate projections show that the most significant change we are likely to see is in the distribution of precipitation, with a likely move towards much wetter winters and drier summers. Temperatures are extremely likely to rise, and could rise by a very large amount. Projections also show a likelihood of significant decreases in cloud cover and humidity in summer. Whilst the complex nature of climate science means we cannot have complete confidence in the detail of these projections, we are confident that they tell us the general direction that climate will move.

There is a reasonable chance that we will face significant negative economic, social and environmental impacts, particularly from flooding, water shortage, high temperatures and disease and pest migration. However, there may also be some benefits to agriculture and forestry (in the shorter term only), and for tourism and health.

This document identifies six key themes:

Climate change adaptation

Water shortage

Water shortage is very likely to become a problem in our borough due to an already limited supply, a rising population, changing rainfall patterns reducing water availability and planned reductions in abstraction from the environment. If shortages are severe, it will present a serious risk to the agriculture and forestry sectors, social sustainability and human health. However, as per capita consumption in our borough is presently very high there is scope for reducing our consumption by

making adaptations that ensure we can maintain our standard of living while using less water. Reducing consumption also helps mitigate the problem by reducing pressure on environmental water stocks.

Increasing temperatures
Rises in temperature are unlikely to be trivial, and we could see severe rises. Rises are very likely to be most pronounced in summer and in urban areas. Potentially we could see average summer daily maximums above 30 degrees by the 2080s, which would have a significant effect on health and our built and natural environments. New developments should take this into account and provide adaptive measures.

Flooding
Flooding is already a problem and floods are likely to increase in both frequency and severity. Floods have a very strong economic impact, as well negative social, health and environmental impacts. We need to both avoid flood risk and use adaptations that provide resilience to flooding.

Climate change mitigation

Transport emissions
Our per capita carbon emissions from transport are very high. We own more cars and have high levels of in and out commuting, though commuters resident in our borough are moving to sustainable transport. Our high transport emissions are largely driven by the A3, where traffic volumes are increasing. To play our part in meeting national emissions reduction targets we need to bring our transport emissions down.

Domestic energy efficiency and energy demand
Our domestic emissions per capita are higher than the national average, despite a climate that is warmer and sunnier than other parts of the UK. This is driven by high domestic energy consumption, which in turn may be a result of affluence and larger homes that tend to be detached. However, homes in our borough are also older and few have taken up the energy efficiency improvements offered through national retrofit schemes, which suggests energy efficiency may be both a cause of high domestic emissions, and an opportunity to reduce our emissions. Changes in national policy mean we will not be able to address many technical standards (including fabric efficiency) in new buildings through the Local Plan, but local policy can influence designs to encourage energy efficiency through landform, layout, building orientation, massing and landscaping.

Renewable and low carbon energy
We generate nearly a third less renewable energy per household through small-scale renewable installations than the England average. In order to help meet the national goal of a decentralised and clean energy supply, we need to increase our uptake of domestic renewable energy. There is also a significant opportunity in development of heating/cooling networks, of which our borough currently has low provision. Heating/cooling networks receive particular support in national legislation and are something that can be facilitated through the new Local Plan.

Contents

1. Introduction

The purpose of this document

1.1 This document presents evidence that will inform local plan policies dealing specifically with environmental sustainability and climate change, though it also briefly discusses economic and social sustainability. It identifies:

- the issues we are required to address by international and national policy and law
- the issues we have an obligation to address based on our current performance and
- the issues we ought to address in the best interests of our borough.

This document ends by identifying the key themes for environmental sustainability and climate change in our borough.

1.2 This document assembles evidence that will inform emerging policies in the new Local Plan.

1.3 Under the current planning system, sustainability and climate change must be considered when a planning decision is made. The consideration of sustainability and climate change in the development of the new Local Plan is therefore not limited to this document.

2. Background

2.1 This section explains the key concepts of sustainability, sustainable development and climate change and looks at what they might mean for planning in our borough.

What does sustainable development mean?

2.2 The internationally accepted definition of sustainable development can be found in Resolution 42/187 of the United Nations General Assembly:

"…development that meets the needs of the present without compromising the ability of future generations to meet their own needs. "

The National Planning Policy Framework (NPPF, 2012) puts this more simply:

"… ensuring that better lives for ourselves don't mean worse lives for future generations. "

2.3 The NPPF identifies three dimensions of sustainable development: **economic, social** and **environmental**, and cites the five guiding principles given in the *Securing the Future: delivering UK sustainable development strategy*:

- living within the planet's environmental limits
- ensuring a strong, healthy and just society
- achieving a sustainable economy
- promoting good governance and
- using sound science responsibly.

2.4 The NPPF states that sustainable development means change for the better, positive growth and economic, environmental and social progress. Taking all this together, sustainable development means we must have positive growth that meets current economic, social and environmental needs without compromising the economic, social and environmental needs of future generations. This growth must lead to improvement rather than maintaining the status quo.

Environmental sustainability

2.5 When we talk about sustainability, we are often referring to environmental sustainability. The concept of environmental sustainability is embodied in the guiding principle of 'living within the planet's environmental limits'. This means we need to be careful about how much we consume and what type or resources we use.

2.6 We should prioritise renewable resources like sunlight and biomass (plant material) over finite resources like minerals and fossil fuels. When using renewable resources, we should make sure that demand does not overwhelm the supply by not harvesting materials more quickly than they are naturally replaced. We should re-use and recycle previously used materials wherever possible, especially when they are finite resources that cannot be replaced indefinitely. We can do this by, for example, using demolition waste as construction material and reusing brownfield land.

2.7 When we choose resources and products, we should use the life cycle approach. The life cycle approach means considering the environmental impacts across the whole life of a product. When we choose a car we often think about how much fuel it uses, but we should also think about the hidden impacts. The materials in the car were derived from minerals extracted from the ground. Mining those resources, turning them into useable materials and assembling the car used energy, most of which probably came from fossil fuels. This process carries an environmental cost. We should also think about what happens to those resources at the end of the car's life, about whether they can be used again or have to be disposed of.

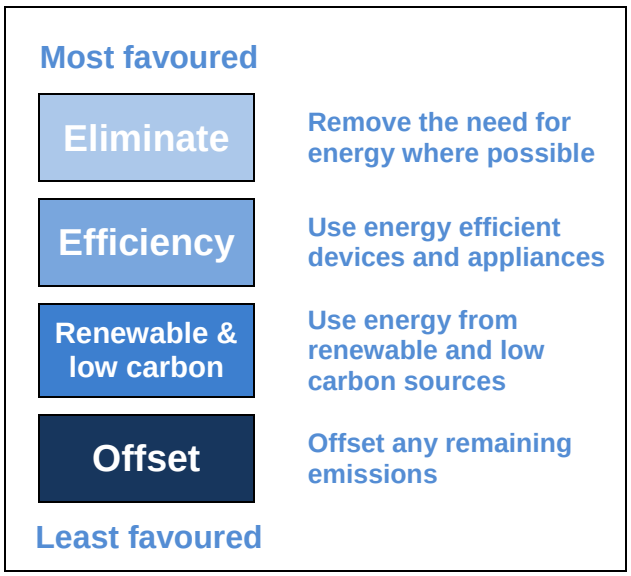


Figure 1 - The energy hierarchy

Figure 2 - The waste hierarchy

2.8 Energy is an important issue. At present most of our transport is powered by oil-based fuels. We power our homes, businesses, and some of our rail network with electricity, but we produce most of our electricity from gas and coal power stations. We import a large percentage of our gas, coal and oil, which is bad for our economy and means our energy supply is not secure. Fossil fuel resources are finite so will inevitably dwindle, become costly to use and eventually run out.

2.9 The energy hierarchy (Figure 1) shows the steps we should take in order to make our energy consumption more sustainable. We can start by eliminating the need for energy wherever possible. For example, by providing spaces to dry washing in new homes, we can eliminate the need for a tumble drier. Where energy use cannot be eliminated, we should make sure we use as little as possible, for example, by choosing low energy appliances. When energy need has been reduced as much as possible we should meet the remaining need from renewable and low carbon energy sources. Finally, any remaining carbon emissions can be offset through actions that either prevent an equivalent amount of carbon being released or remove an equivalent amount of carbon from the atmosphere. Examples of offsetting include funding projects that promote reforestation to take carbon out of the air, or projects that support renewable energy and energy efficiency in other places.

2.10 Waste is an important consideration in the way we consume resources. The waste hierarchy (Figure 2) shows us the most sustainable way to deal with it. We can reduce our waste by simply consuming less, or by consuming products that produce less waste. Where waste is produced, the best way to deal with it is to reuse it rather than recycling as recycling uses energy. Recycling and reusing materials will help us work towards a circular economy where materials stay in the economy indefinitely, rather than being lost as waste.

2.11 Where reuse or recycling is not possible, waste should usually be incinerated for energy as an alternative to fossil fuels. Sending waste to landfill should usually be considered a last resort (though not in every case). Space for landfill is now at a premium, especially in the South East of England.

2.12 The NPPF calls for the planning system to contribute to protecting and enhancing our natural, built and historic environment, which includes; helping to improve biodiversity, using natural resources prudently, minimising waste and pollution, mitigating and adapting to climate change and reducing carbon consumption. The Local Plan can help to:

- ensure that housing is placed near employment sites to reduce the need for travel
- help improve sustainable transport options such as bus, train and cycle
- ensure development uses space efficiently and uses brownfield land wherever possible
- ensure that buildings are designed to be energy efficient and to reduce consumption and waste by the occupants
- encourage renewable energy at small, medium and large scales and
- guide the design of our buildings and towns so that they will be adapted and adaptable for the changing climate so we won't need to change them later on.

Economic sustainability

2.13 Economic sustainability means creating an economy that will continue to be viable and provide benefits far into the future. The NPPF states that such an economy should be strong, responsive and competitive. The Local Plan can:

- ensure that there is balance between the number of homes and the number of places of work
- plan for jobs that match the skills and talents of the workforce and
- plan for the right type and amount of floor space and infrastructure to meet the needs of business.

Social sustainability

2.14 The term 'social sustainability' is often used when talking about urban areas and could mean…

"the continuing ability of a city to function as a long-term viable setting for human interaction, communication and cultural development" (Yiftachel and Hedgcock**,** 1993).

It could also mean…

"creating sustainable, successful places that promote wellbeing, by understanding what people need from the places they live and work" (The Young Foundation).

In summary, we must make sure that our towns and villages, open spaces, town centres, and all the other places we have created will continue to be good places for people to live, work and interact.

2.15 The NPPF expands this by citing the guiding principle of "ensuring a strong, healthy and just society". It also places an obligation on us to help bring about social progress. Therefore, to be socially sustainable we need to make progress towards a stronger, healthier and more just society by making our settlements better places to live, work and interact.

2.16 To achieve this, the NPPF states that the planning system should support strong, vibrant and healthy communities by providing enough housing to meet the needs of present and future generations and by creating a high quality built environment with accessible local services. To facilitate this, the Local Plan can help to:

- design-out crime and other social ills
- design-in equal access to facilities, services, movement and work opportunities
- ensure good quality housing is available for all income groups
- produce high quality environments for all that everyone can take pride in
- ensure our plans are adaptable to changing societal and community needs
- use urban design to improve social networks and build a cohesive and inclusive community and
- ensure the burdens and benefits of growth are shared equally.

2.17 In the UK, social sustainability has historically been addressed largely through national schemes such as the Sustainable Communities Plan and the Urban Renaissance. Under the new planning system created by the NPPF we now need to address this at the local level and this will include deciding what social sustainability means for our borough.

Climate change

2.18 When we refer to the climate, we are often talking about things like the temperature and rainfall patterns that we see over a large area on a yearly basis. This is different from weather, which happens over the short term and on a smaller scale.

2.19 The climate system is powered by energy from the Sun. The Sun's energy is absorbed by the Earth's surface and then redistributed, mainly from the hotter tropics towards the cooler poles, causing circulation patterns in the oceans and atmosphere. These climate patterns, along with other factors, like the shape of the land and areas of water, create our local weather.

Is the climate changing?

2.20 There has always been some change in the Earth's climate because of natural processes. We know that in the past the climate has moved between cold periods (ice ages) and warmer periods. The current period is no exception.

2.21 The atmosphere contains greenhouse gases (GHGs) which allow the atmosphere to capture and store the Sun's energy. The most important GHG is water vapour, followed by carbon dioxide (CO_2). Plants, animals and humans can affect the climate system by increasing or decreasing the amount of GHG in the atmosphere.

2.22 Over millions of years, large quantities of carbon were removed from the atmosphere and locked away in carbon sinks, which include deposits of coal, gas and oil. The idea that human activity may have an impact on the global climate by releasing carbon from sinks into the atmosphere was first suggested in 1896. Over decades of research and debate, scientists have been able to build a clearer picture of how the climate works, how it has changed and the part human activity has played.

2.23 Climate change is caused by a variety of factors including changes in solar activity, aerosols (particles) in the atmosphere and the reflectivity of the planet's surface, and some of the climate change that we have experienced is natural. However, it is now believed that the release of GHGs by human activity is the most important factor in the change that we are currently seeing.

2.24 The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the UN Environmental Programme and the World Meteorological Organisation to assemble and assess the scientific, technical and socio-economic information needed to gain an understanding of climate change. The IPCC has since published four Assessment Reports, with a fifth (AR5) currently being published in stages. The AR5 report *Working Group 1: The Physical Science Basis, Summary for Policymakers* (2014) states the following.

- Each of the last three decades has been successively warmer at the Earth's surface than any other decade since 1850. It is virtually certain that the upper ocean warmed from 1971 to 2010, and it likely warmed between the 1870s and 1971.
- Over the last two decades, the Greenland and Antarctic ice sheets have been shrinking, glaciers have continued to shrink, and Arctic sea ice and spring snow cover in the Northern Hemisphere have continued to decrease. Over the period 1901 to 2010, global mean sea level rose by 0.17 to 0.21 metres, rising faster since the mid-19th century than during the previous two millennia
- Concentrations of carbon dioxide, methane, and nitrous oxide in the atmosphere have increased to levels unprecedented in at least the last 800,000 years. Carbon dioxide concentrations have increased by 40% since pre-industrial times, driven primarily by fossil fuel emissions, and secondarily by land use change.
- It is extremely likely that human influence has been the dominant cause of the warming that we have observed since the mid-20th century.

2.25 There is now a broad scientific consensus that the climate is changing and that emissions from human activity are contributing significantly to this change.

The role of carbon

2.26 Carbon dioxide ($CO_{2)}$ is the greenhouse gas chiefly responsible for the climate change caused by human activity. We add CO_2 to the atmosphere mainly when we burn fossil fuels like oil, gas and coal so we often talk about our carbon emissions, or our carbon footprint. This goes beyond the carbon we emit while driving our cars or heating our homes. It also includes all the embodied carbon in the products we consume. This often comes from the energy used to make or transport those products. For example, the embodied carbon costs in a house include:

- the energy used to mine and process the minerals needed for building materials and components (bricks, insulation, bathroom tiles, doors, windows etc.)
- the energy and resources used in the manufacturing process for those components
- the energy and oil products used to grow, harvest and process the timber used in the frame and
- the energy used to deliver materials and labour and to construct the house.

2.27 When we work to reduce our carbon footprint, we need to take the embodied emissions throughout the whole life of the products we use into account. Often, we can reduce these by sourcing materials locally to reduce transport emissions and by using products that were produced using fewer materials and less energy, and have a longer useful life.

Planning for sustainability and climate change

2.28 Climate change is an important element in sustainability. The developments and infrastructure we bring forward now must be resilient and adaptable to a range of climates so we can avoid costly repairs, retrofitting or rebuilding further down the line. We also need to make sure we understand which groups of people in our borough are most vulnerable to climate change impacts and ensure their needs are met.

2.29 The planning responses to sustainability and climate change often overlap. For example, by moving away from fossil fuels towards renewable energy sources we can both mitigate climate change and make the way we use resources more sustainable over the long term.

2.30 The Local Plan must follow the guidance in the National Planning Policy Framework (see Section 3), which asks us to help deliver sustainable development and address climate change. As a result, all the new Local Plan policies will address these two issues, whether they deal with the location of new homes and offices, flooding, our green spaces and countryside or any other topic. This paper deals specifically with issues relating to climate change mitigation and adaptation and environmental sustainability.

2.31 Climate change **mitigation** refers to our efforts to **prevent the effects of climate change**. We do this mainly by reducing the amount of GHGs we produce, as part of a global effort. We have to do this because we are required to do so by national policy, but also because we have an obligation to help meet national and international goals.

2.32 Climate change **adaptation** refers to our efforts to **adapt to a changing climate**. There is a lag of several decades between the release of greenhouse gas and the effect it has on the

climate. This means that even if the world drastically reduces its GHG emissions today there will still be decades of climate change impacts in the pipeline. Adaptation means changing our behaviour to respond to both the current and projected future impacts of climate change.

2.33 The planning system can ensure that new developments are designed to produce less GHG, and can also encourage and enable retrofit improvements to existing developments to reduce their emissions. It can make sure that new developments are suited to future climate conditions, and encourage and enable existing developments to adapt.

2.34 Increasingly the government has decided to address climate change and GHG emissions directly through legislation and national programmes. Local authorities are no longer obliged to have emissions reductions targets for the areas they cover, there are national programmes in place to encourage renewable energy production and energy efficiency improvements, and changes to building regulations are making new homes and offices increasingly efficient.

2.35 However, national policy and guidance still requires us to address some of these issues through our Local Plan (see section 3), and the impacts of climate change will not be the same across the UK (see section 5) so national adaptation plans may not necessarily be appropriate or adequate for our borough. In terms of sustainability and climate change mitigation, there may be areas where our borough can do particularly well or needs to improve (see section 4). In these instances, it makes good sense for us to act at a local level through Local Plan policy.

3. The policy landscape

3.1 This section looks at the national and international policies, treaties and laws that cover sustainability and climate change and the requirements and obligations they place on us. It also looks at the direction that national policy is taking and asks how much we should assist in achieving national targets where we are not explicitly obliged to do so.

International agreements and treaties

3.2 *The United Nations Framework Convention on Climate Change,* sometimes called the Earth Summit, was signed in 1992. It had the objective of stabilising human greenhouse gas (GHG) emissions at a level that prevents dangerous climate change. The treaty created a framework that allowed binding agreements to be set and a method of monitoring the emissions of individual states. This led to *The Kyoto Protocol* in 2005, which put a binding obligation on the countries that ratified the treaty (including the UK but notably not the USA) to limit or reduce emissions of greenhouse gases between 2008 and 2012. The UK signed up to a second phase after that date. *The Bali Conference* in 2007 brought together over 180 countries to discuss how climate change should be addressed after the Kyoto Protocol ended. The result was the Bali road map, which called for "deep cuts in global emissions".

3.3 *The European Climate Change Programme* was launched in 2000 by the European Commission. It aimed to develop a Europe wide climate change strategy for avoiding dangerous climate change and through *EU Directive 2009/28/EC* set binding targets of a 20 per cent reduction in greenhouse gas emissions and for 20 per cent of EU energy production to be from renewable sources by 2020 (15 per cent for the UK). The ECCP led to the introduction of the European Union greenhouse gas Emission Trading Scheme.

3.4 There are other European directives in place that cover how we sustainably manage other resources, including the Energy Efficiency Directive, the Waste Framework Directive and the Water Framework Directive.

3.5 International agreements and treaties demonstrate a global and European movement to address the problem of climate change through the reduction of greenhouse gas emissions, and in Europe in particular to move towards a sustainable, low impact way of living.

National legislation, policy and guidance

3.6 The *National Planning Policy Framework*, introduced in March 2012, sets out the government's planning policies for England. As well as requiring us to generally make progress towards sustainable development (paras. 6, 7, 14, 151, 152), the NPPF places responsibilities on us to:

- support reductions in greenhouse gas emissions to mitigate climate change, help to meet the national emissions reductions targets, plan for development in locations and ways that reduce GHG emissions (paras. 30, 93, 94, 95, 156)
- support improvements to energy efficiency in existing buildings (para. 95)

- expect new developments to take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption (para. 96)
- take account of the impacts of climate change in areas including flooding, water supply, changes to biodiversity and the landscape (para. 99)
- adapt to the impacts of climate change including flooding, water stress and climate stress in both the urban form, the landscape and biodiversity (paras. 14, 94, 99, 156)
- favour and support a decentralised energy supply favouring renewable/low carbon sources, producing a strategy to promote this (paras. 93, 97)
- favour, approve and support renewable and low carbon energy infrastructure (paras. 98, 156)
- encourage the reuse of existing resources, the prudent use of natural resources and the best use of finite mineral resources (paras. 7, 17, 142) and
- minimise waste (para. 7).

3.7 The National Planning Policy Guidance (NPPG) introduced in March 2014 identifies addressing climate change as a core land use planning principle that should be reflected in Local Plans and states that spatial planning should support the delivery of appropriately sited green energy and influence the emission of greenhouse gases (Climate Change, para. 1). The NPPG notes that every area will have different challenges and opportunities for reducing carbon emissions from new development and identifies information on carbon emissions at local authority level published by DECC as valuable in informing emission reduction options (Climate Change, para. 7).

3.8 The NPPG gives specific examples of climate change mitigation and adaptation actions:

- providing opportunities for renewable and low energy technologies and for decentralised energy and heating
- promoting low carbon design approaches to reduce energy consumption in buildings
- considering future climate risks when allocating development sites
- considering the impact of and promoting design responses to flood risk
- considering availability of water and water infrastructure for the lifetime of the development and design responses to promote water efficiency and protect water quality
- promoting adaptation approaches in design policies for developments and the public realm and
- integrating mitigation and adaptation actions though maximising summer cooling through natural ventilation in buildings and avoiding solar gain, district heating networks that include tri-generation or through the provision of multi-functional green infrastructure.

The impact of climate change needs to be taken into account in a realistic way. In doing so, local planning authorities should consider:

- identifying no or low cost responses to climate risks that also deliver other benefits, such as green infrastructure that improves adaptation, biodiversity and amenity
- building in flexibility to allow future adaptation if it is needed and
- the potential vulnerability of a development to climate change risk over its whole lifetime.

3.9 The *Planning and Compulsory Purchase Act 2004* places a statutory duty for Local Plans to include policies covering development and land use that help mitigate and adapt to climate change. It also requires us to prepare plans that contribute to sustainable development.

3.10 Other national policy and legislation does not always explicitly apply to the new Local Plan but does imply the directions our policies need to take, sometimes fleshing out the requirements that have been placed on us.

3.11 The *National Adaptation Programme (2013)* (NAP) highlights the variability of climate change across the country and the need to manage it locally. It identifies flooding, high temperatures and water efficiency as particular issues for the built environment. The NAP identifies a range of public and private organisations that can help bring about adaptation (not just Local Authorities), but it also references the NPPF and the need for local planning authorities to plan proactively to mitigate and adapt to climate change.

3.12 The *Climate Change Act 2008* put into statute CO_2 emissions reductions targets of 80 per cent by 2050 and at least 26 per cent by 2020 against a 1990 baseline. The 2020 target was amended to 34 per cent in 2009. While there is no specific local emissions reduction target that we need to meet, the NPPF describes the role of planning as helping to secure 'radical reductions' in greenhouse gas emissions (para. 94) and specifically requires us to have regard to the objectives of the 2008 Climate Change Act. These targets are ambitious and mean our own efforts at carbon reduction must also be ambitious.

3.13 The NPPF taken as a whole shows a vision of a sustainable economy where growth is not compromised. While our emissions reduction strategy needs to be ambitious, it must not compromise economic growth. The *Low Carbon Transition Plan 2009* explicitly suggests that growth in the green economy is a way to achieve this. The *Stern Review (2006)* established that emissions could be stabilised without ending growth and emphasised the benefits of early action in this area.

3.14 There is clear support for improvement in construction standards. The current government has continued support for the 2016 Zero Carbon standard for new homes and *Zero-carbon non-domestic buildings: phase 3 final report (2011)* sets out the intention for all new non-domestic buildings to be zero carbon by 2019. This report identifies building shape and form as significant areas for improvements in efficiency and identifies guidance or regulation as the driver.

3.15 The *Planning and Energy Act 2008* enables Local Planning Authorities to set "reasonable requirements" for energy use and efficiency. However, the Deregulation Act 2015 has amended this act to revoke this power. The commencement date for this amendment has not yet been announced, but in a ministerial statement (25 March 2015) the government stated that this will coincide with the introduction of the zero carbon standard into building regulations in 2016.

3.16 The NPPF tells us that if we do set a local standard it must be consistent with the zero carbon buildings policy and use nationally described standards. At time of writing, the Code for Sustainable Homes is the only current nationally described standard for homes. A written

ministerial statement (25 March 2015) states that the government has withdrawn the Code for sustainable homes but that Councils can continue to apply a water efficiency standard. The nationally described standard for commercial buildings, BREEAM, remains in place.

3.17 The government has signalled its intention for technical standards (covering things like fabric efficiency) to become the remit of Building Regulations only, while planning deals with energy efficient design. A written ministerial statement (25 March 2015) states that in August 2015 the government will introduce new national technical standards for homes that includes a standard for water efficiency. This will be in the form of an optional building regulation that can be adopted through a Local Plan, and will be enforced through the Building Regulations process rather than the planning system.

3.18 The NPPF (paras. 95 and 96) supports the use of local policy to improve energy efficiency through design while the NPPG gives 'promoting low carbon design approaches' as an example of how Local Plans can help mitigate climate change. The NPPG lists layout, form, scale, detailing and materials as design considerations.

3.19 Therefore, Local Authorities are not required to set local building standards but may do so as long as they use a nationally recognised standard. There is such a standard in place for commercial buildings, but not for homes. Building regulations standards are set to improve significantly in 2016 for homes, which may remove the need for a standard set through local policy. However, local policy should still seek to improve energy efficiency through design.

3.20 There is strong support in central government for retrofitting existing buildings to make them more energy efficient and the report *How local authorities can reduce emissions and manage climate risk (2012)* identifies this as the largest opportunity for local authorities to help meet emissions reduction targets. The *Low Carbon Transition Plan 2009* envisaged that retrofitting would be key to achieving a low carbon economy. The *Household Energy Management Strategy 2010* sets a national target of reducing energy use in households by 29 per cent by 2020. The current government's ambition in this area is signalled by initiatives like the *Green Deal* and continuing support for the *Energy Company Obligation.* Whilst there is no requirement for us to address the improvement of existing buildings through local policy, it is clear that national policy is pulling in that direction and that it will be key to meeting national targets.

3.21 There is strong support for renewable and decentralised energy and heating in national policy and guidance. The *Energy Act 2008* requires electricity suppliers to produce 11.1 per cent (rising to 15.4 per cent in 2015/16) of their energy from renewable sources. The Act also introduced the feed-in-tariff, which offers a financial incentive for small-scale renewable generation. The *Renewable Energy Roadmap (2011)* set out plans for ensuring the UK meets the target of 15 per cent of energy from renewable sources by 2020, with support for wind and wave power, biomass electricity and heat, ground and air source heat pumps, and low or zero carbon transport. Microgeneration also enjoys strong support, with continuing support for the *Feed-in Tariff* and domestic generation targets in the *Low Carbon Transition plan 2009* (updated in 2011) and support for the introduction of the *Renewable Heat Incentive*. The NPPF requires us to encourage the use of renewable resources (para. 17) which implies an obligation to support the targets described by the legislation above.

Planning guidance for renewable and low carbon energy released in July 2013 confirms that planning should play a role in delivering these technologies.

3.22 *Future Water 2008* sets out the Government's water strategy. It acknowledges the increasing likelihood of both droughts and floods and sets out a vision for sustainable and secure water supplies and an improved and protected water environment in 2030. The strategy highlights the importance of both reducing water demand by managing consumption and protecting and improving water supplies, and identifies building design as a way that can help achieve this. The *National Adaptation Programme (2013)* supports this view and identifies better water efficiency as a point of action for urban design.

4. How sustainable is Guildford borough?

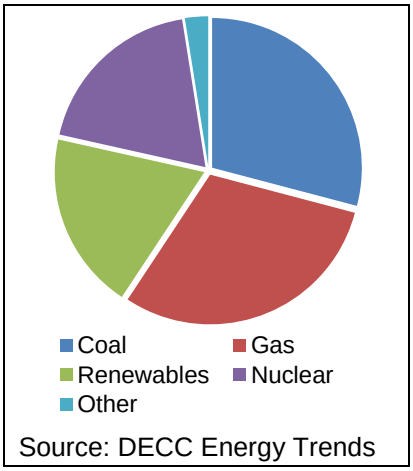
4.1 The NPPF requires us to make sure that the Local Plan is based on adequate, up-to-date and relevant evidence about the characteristics and prospects for the area (para. 158). This section presents a snapshot of our current performance and continuing trends in terms of sustainability in the following areas:

- carbon emissions
- household energy consumption
- small scale renewable energy production
- consumption of water resources and
- waste.

Carbon emissions profile

4.2 We emit CO_2 from a number of sources. This section is concerned with our direct emissions and does not look at the carbon embodied in the products we use (see 2.26). We look at waste in 4.47, which tell us something about consumption patterns and how much embodied carbon we are responsible for.

4.3 In the UK, most of our direct emissions come from transport fuels and electricity production. In 2014, 29.1 per cent of the electricity we generated was produced from coal, 30.2 per cent from gas, 19.2 per cent from renewables and 19 per cent from nuclear, with other fuels making up the remainder (Figure 3). Most of the gas and coal we use is imported, leading to transportation emissions. The Department of Energy and Climate Change (DECC) has stated that replacing coal and petroleum with natural gas can reduce our emissions in the near to mid-term and the government is keen to increase the amount of electricity produced from renewables and domestic shale gas, so we could see the carbon content of our electricity come down. However, much of our shale gas is obtained through fracking, a controversial process, so it is not clear at this stage how much our energy supply will be affected. There is also disagreement about the true carbon content of fracked gas.



Source: DECC Energy Trends

Figure 3 – UK electricity generation by source 2013

4.4 In the past, much of our low carbon energy has been produced by nuclear power stations. The recent retirement of several nuclear reactors has seen nuclear's share of overall production fall from a 1997 peak of 26 per cent, with the gap in production filled by coal and gas as well as renewables. Most of the UK's nuclear power stations are scheduled to retire by 2023, and at present there are plans to build just one new one, so we cannot be sure that the embodied carbon content of our electricity will come down in the short term at least.

Emissions within the scope of influence of local authorities (EWSILA, formerly NI186)

4.5 The Department of Energy and Climate Change (DECC) produces statistics on CO_2 emissions at a local authority, regional and national level. This data is available for total emissions in the borough, but also as a subset that only includes emissions from sources considered to be within the scope of influence of local authorities. This subset was formerly called National Indicator 186 (NI186) and will be referred to here by its new name, Emissions Within the Scope of Influence of Local Authorities (EWSILA).

4.6 The EWSILA dataset excludes emissions generated by:

- motorway traffic
- air travel
- shipping
- installations large enough to be covered by the EU emissions trading scheme
- the offshore industry and
- land use (including land use change and forestry).

In both the total emissions and EWSILA datasets, emissions from railways fall under the industry and commercial sector.

4.7 The EWSILA data series was started in 2005 and at time of writing ran up to 2012, as there is a delay in the release of figures. The data is still being produced but is no longer used as a National Indicator, which means we are not obliged to use it. We have chosen to use EWSILA data because it gives us a picture of where Local Plan policies can be most effective, as opposed to the total emissions dataset which includes sources beyond the influence of the Council. Where we refer to total emissions, we are not referring to EWSILA.

Emissions in our borough

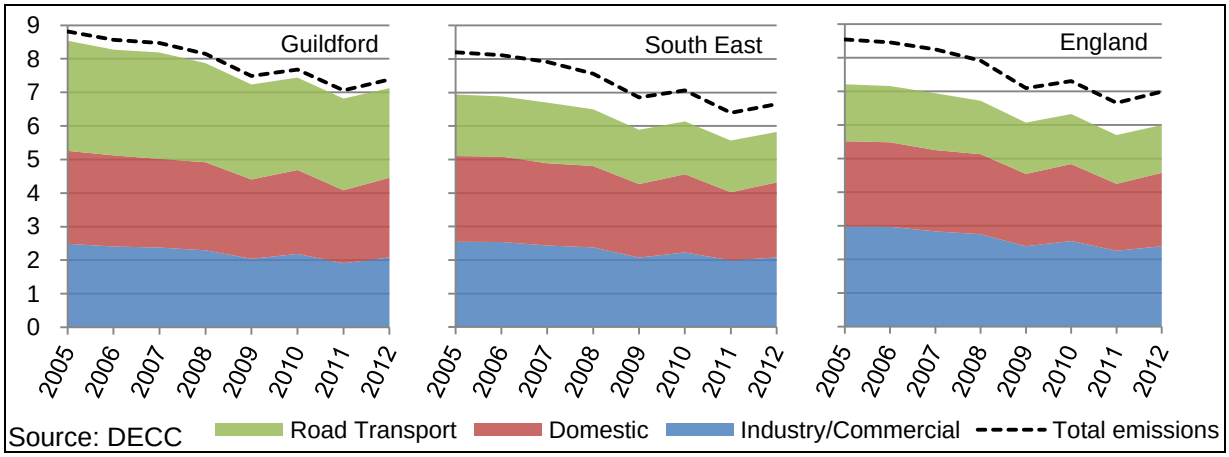


Figure 4 - Total emissions and EWSILA by sector 2005-2012 (tonnes CO_2 per person)

4.8 A larger than usual proportion of total emissions in our borough fall within the scope of local authority influence (Figure 4). The reason for this is discussed later on but it means that

Local Plan policies have greater scope to reduce emissions in our borough than in other places.

4.9 The UK's CO_2 emissions are concentrated around cities and major roads (Figure 5). The highest concentration is in the South East in London and surrounding towns, but there are significant concentrations around Birmingham, Liverpool, Manchester, Leeds and Newcastle. However, emissions are generally high across the South East, largely due to the high population density. Carbon emissions in and near our borough are concentrated around the urban areas of Guildford town, Ash and Tongham, Byfleet and Godalming (Figure 5, inset). Emissions are also high on the routes of the A3 and M25. They are lowest in undeveloped areas like the Ash Ranges. Our emissions are generally high when compared to the UK area as a whole.

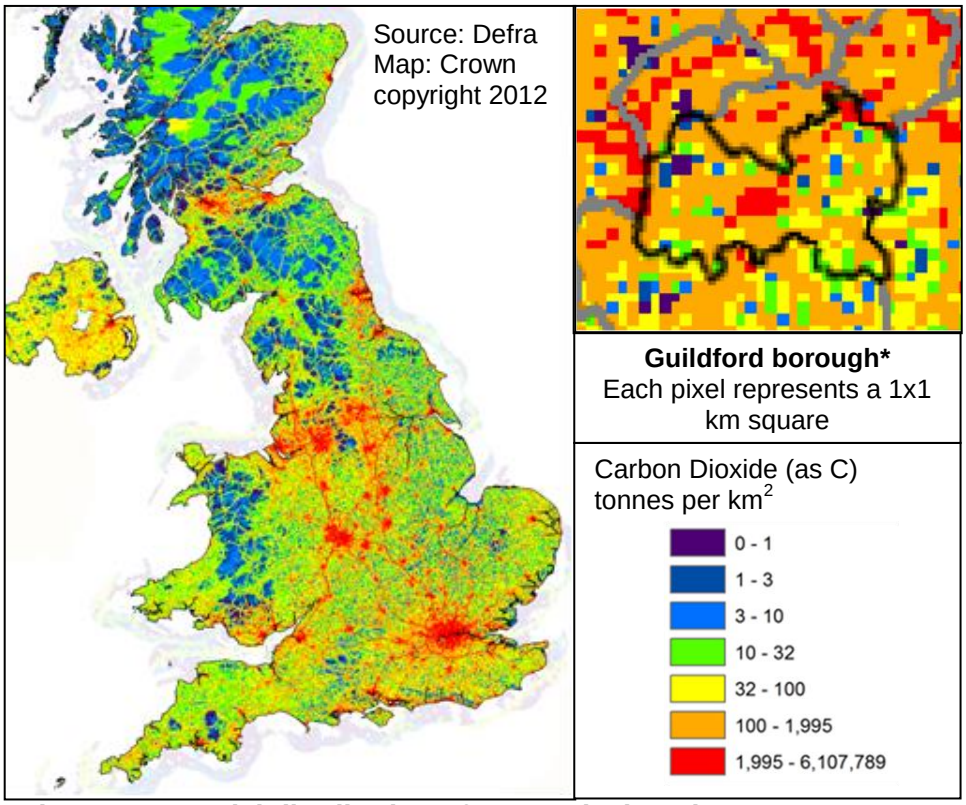


Figure 5 – Spatial distribution of CO_2 emissions in 2011
*Note: Location of 1km grid squares on inset map is approximate.

4.10 Total emissions per person in 2012 in the borough were higher than the South East average and slightly higher than England (Figure 4). EWSILA emissions per person in 2012 in the borough were significantly higher than the England and South East averages. However, if we exclude road transport emissions our EWSILA emissions per person were slightly higher than the South East and slightly lower than England.

4.11 Emissions show a general trend for decline between 2005 and 2012 in all sectors (Figure 4). Dips and troughs are likely to be caused by a combination of economic conditions and periods of mild and cold weather.

4.12 It seems likely that the downward trend in emissions will continue both in our borough and nationally due to the recent rollout of new national initiatives aimed at reducing emissions, such as the Green Deal, the Ultra-Low Emission Vehicle Grant and the Renewable Heat Incentive. However, projections show population and economic growth in the South East increasing in the coming years, which could affect this decline.

4.13 Table 1 shows how much EWSILA CO_2 emissions per person declined from 2005 to 2012. The key points are:

- EWSILA in the borough declined by around 16.5 per cent, largely matching the decline in the South East and England.
- EWSILA from road transport showed a decline slightly higher than the South East and notably higher than England.
- EWSILA emissions from homes show a decrease slightly higher than England and notably higher than the South East.
- The decline in EWSILA emissions from industry and commerce is significantly weaker than the South East and England.

Table 1- Decline in EWSILA CO_2 emissions per person by sector 2005 – 2012

	Guildford borough	South East	England
Road transport	0.61 t (18.7%)	0.33 t (17.9%)	0.27 t (16.1%)
Domestic	0.39 t (14.2%)	0.32 t (12.5%)	0.35 t (13.7%)
Industry/Commercial	0.41 t (16.3%)	0.47 t (18.4%)	0.59 t (19.8%)
All emissions	**1.41 t (16.5%)**	**1.12 t (16%)**	**1.21 t (16.8%)**

Source: DECC

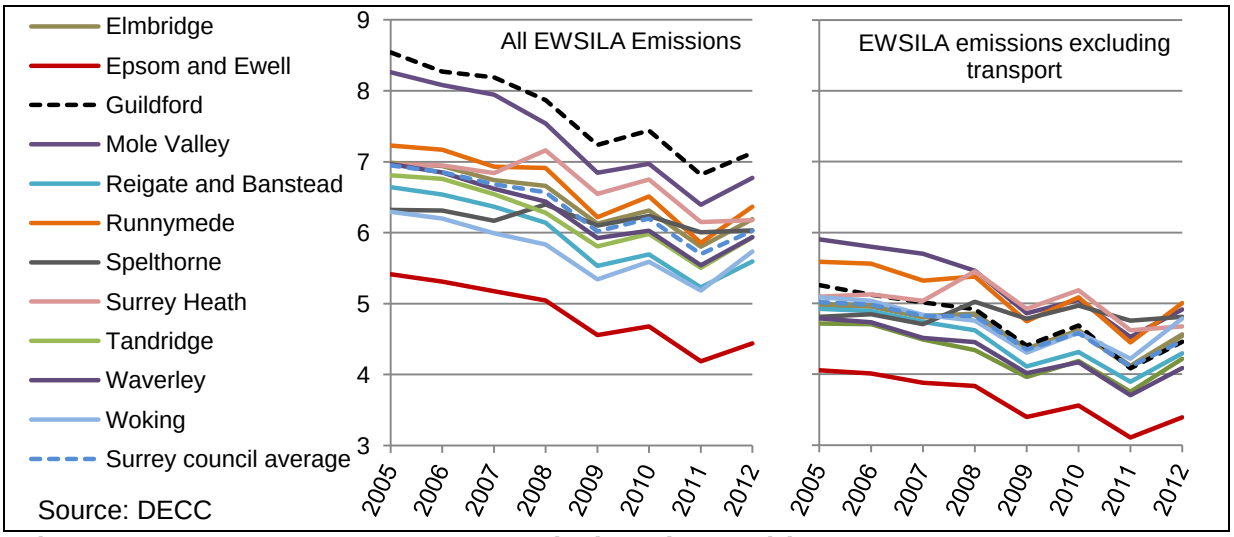


Figure 6 – EWSILA per person CO_2 emissions (tonnes) in Surrey 2005-2011

4.14 Significant factors that affect our emissions are large employment centres close by (including London) which generate commuter traffic, regional public transport infrastructure and weather and climate conditions that affect the need for heating and cooling. It is therefore useful to compare our emissions with those of other local authorities in Surrey as these areas have more in common with us than other parts of the UK.

4.15 Guildford borough had the highest per person CO_2 EWSILA emissions of all Surrey local authorities from 2005 to 2012 (Figure 6). Epsom and Ewell, the local authority with the lowest emissions, produced around a third less. Without road transport emissions, Guildford has an average performance.

4.16 Summary:

- Our total and EWSILA per person emissions are high.
- We emit the most carbon per person out of all Surrey local authorities.
- This is mostly because of very high road transport emissions.
- If we exclude road transport, our emissions per person are similar to the rest of Surrey.
- Our emissions are falling in line with other parts of the UK.

Road transport emissions

4.17 Our very high EWSILA road transport emissions can be partly explained by the lack of motorways in the borough (see 4.6, we only have a very short stretch of the M25). This means nearly all our road emissions are included in the EWSILA figures, unlike in other areas. However, our road transport emissions are also higher than other areas in the total emissions dataset, which includes motorway emissions. In this dataset, our emissions are 13, 35 and 56 per cent higher than Surrey, the South East and England respectively (Figure 7). In fact, our EWSILA road transport emissions are higher than their total emissions.

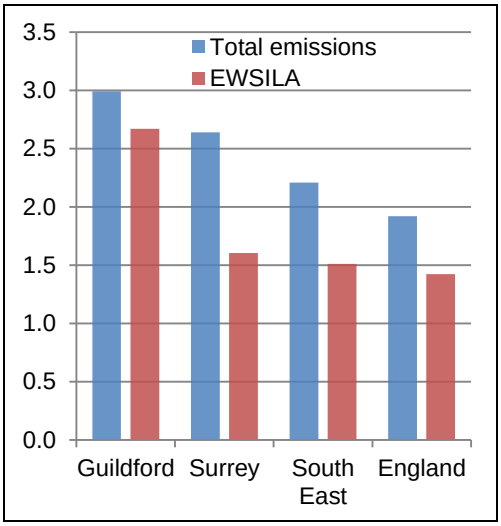


Figure 7 – Total and EWSILA road transport emissions in 2012 (tonnes CO_2 per capita)

4.18 Census data shows that residents in our borough own more vehicles than in other parts of the UK (Figure 8). With the greater affluence in our borough, it seems likely that our residents also own bigger cars that emit more CO_2.

4.19 Commuting levels in our borough are high. Data from the Annual Population Survey 2011 tells us that 46 per cent of residents work outside the borough, (the local authority average is 41.5 per cent), and 50 per cent of workers live outside the borough (local authority average 36 per cent). Both figures increased slightly from 2010. The data does not tell us about commuting distances but does tell us that the majority of our commuters travel to other parts of Surrey.

4.20 Census data from 2001 and 2011 (Figure 9) shows that rail commuting by our borough's residents has increased by 34 per cent while commuting by private car, van and motorcycle has decreased by 4.2 per cent over that decade.

4.21 Figures show that an unusually large percentage of our borough's transport emissions come from A-roads: 75.6 per cent compared to just over 56 per cent in the South East and England. The A3 is a major commuter route, which runs through the whole borough, and these figures identify it as a big contributor to our road transport emissions. Traffic count data from the Department for Transport shows traffic volumes on the A3 increased by up to 24 per cent on some stretches in our borough between 2000 and 2013.

4.22 Traffic levels and car ownership have increased, but our resident commuters have been moving towards more sustainable modes of transport. We must therefore assume that non-commuting traffic and/or people commuting into or through the borough has increased. This means that addressing commuting alone will not solve this problem. With traffic coming in from outside the borough, it also means there may be limited scope for reducing these emissions through the Guildford borough Local Plan.

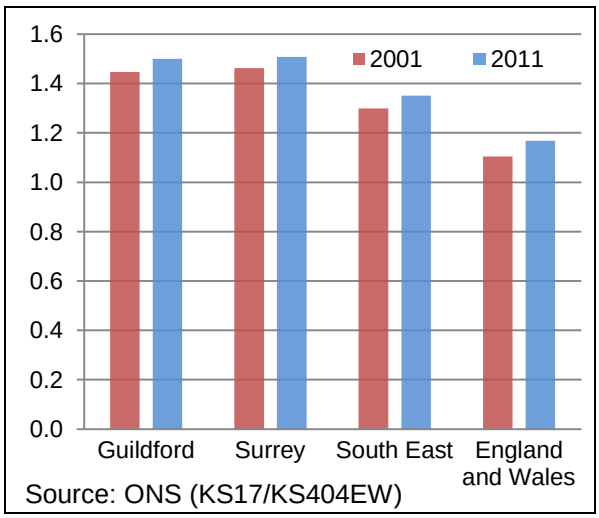


Figure 8 - Cars and vans per household from the 2001 and 2011 census

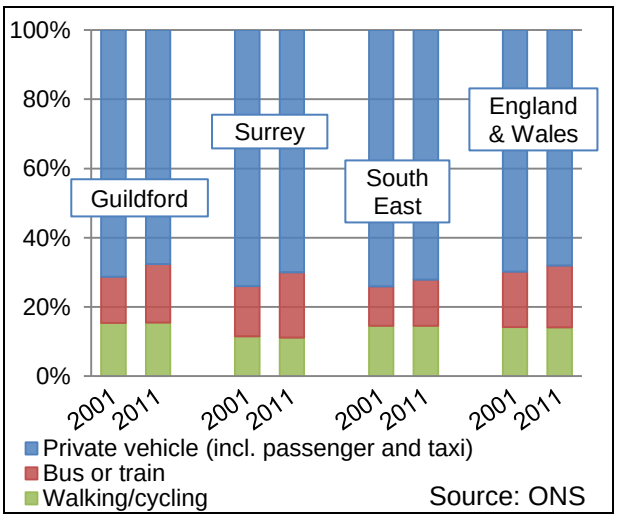


Figure 9 - Travel to work data from the 2001 and 2011 census

4.23 The declines in transport emissions that have already occurred have probably been driven by improvements in vehicle technology. Driver and Vehicle Licensing Agency data shows that cars registered nationally in Q1 2014 produced an average of 25.7 per cent less CO_2 than cars registered in Q1 2005 and the number of registrations for ultra-low emission vehicles (such as those using alternative low carbon fuels like gas and electricity) increased 241 per cent from 1,279 in 2010 to 4,359 in 2013. We expect that emissions from transport will decrease further as vehicle technology continues to improve and becomes more widely available. National policy may be expected to have a strong impact in this regard but Local Plan policies can assist this change.

4.24 Guildford is part of a two-tier local authority structure and transport is generally dealt with by Surrey County Council who are the Local Highway Authority covering the borough. Transport issues are also being addressed at the regional level through the M3 Local Enterprise Partnership. Change in travel behaviour needs to be encouraged at a borough, county and regional level.

4.25 Summary:

- Transport emissions higher than other areas, much of it from A-road traffic.
- More private vehicles than other areas.
- High levels of inward and outward commuting.
- Transport emissions are falling faster than the South East and England. This decline was strong enough to continue during 2010 and 2012 when other emissions rose.
- Traffic levels on the A3 are increasing while commuters are moving to sustainable transport.
- Falls in transport emissions have probably been driven by improvements in vehicle technology.

Industry and commercial emissions

4.26 Our EWSILA emissions per person from the industry and commercial sector (which includes railways) are the same as the South East and around 15 per cent lower than England (Figure 10). These emissions are around 30 per cent lower than England in the total emissions dataset as in many other areas there are large installations whose emissions are excluded from the EWSILA dataset. We do not have any installations big enough to be excluded from EWSILA in our borough.

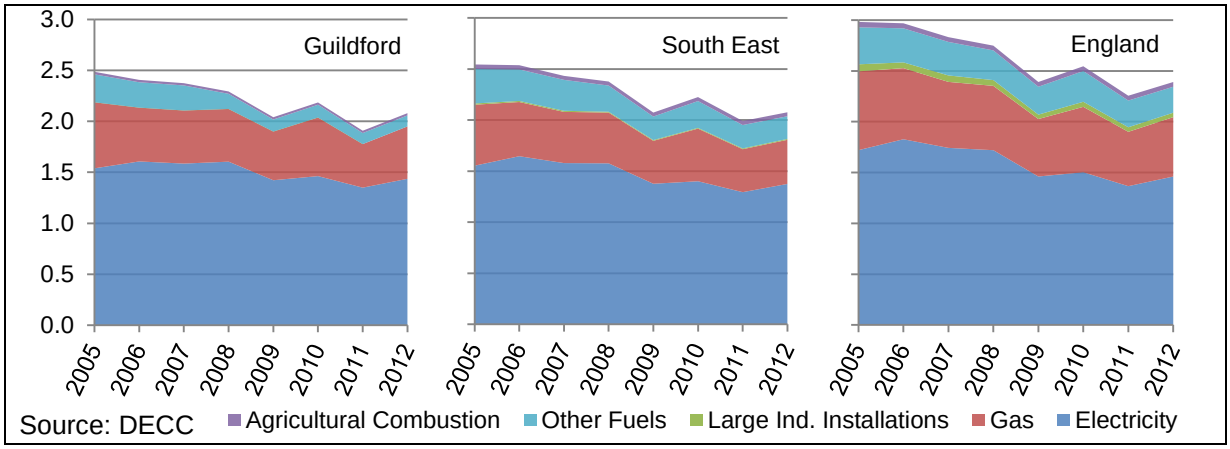


Figure 10 – EWSILA per person CO_2 emissions (tonnes) by energy source in the industry and commercial sector

4.27 Our borough has a much lower proportion of factory floor space at only 17.6 per cent of all industrial and commercial floor space (Neighbourhood Statistics 2005, revalued 2008). In comparison, the South East and England and Wales have 27.8 and 35 per cent respectively. Most of our floor space in this sector is used as offices and retail, which tend to be less energy intensive than industrial uses.

4.28 The mix of energy sources used by the industry and commercial sector is broadly similar to other areas. The main difference is in the use of 'other fuels' (solid fuels, on-site renewables, industrial petroleum and coal) which is lower in our borough (Figure 10). Overall, emissions have shown a strong decline of 23.3 per cent from 2005 to 2012, similar to the South East and England at 21.7 and 24.4 per cent respectively. The decline across Surrey was 17 per cent.

4.29 Summary:

- Our industrial and commercial emissions are lower than other areas.
- Our emissions show a strong decline, but this is vulnerable to economic change.
- Most of our emissions in this sector come from office and retail uses.

Domestic emissions

4.30 Domestic EWSILA emissions are the same as domestic total emissions as all domestic emissions are considered to be within the scope of local authority influence. Domestic emissions per person in our borough are 5.7 per cent and eight per cent higher than the South East and England respectively (Figure 11). However, domestic emissions in our borough have fallen by 14.2 per cent since 2005, a slightly stronger fall than the South East and England at 12.5 and 13.7 per cent respectively.

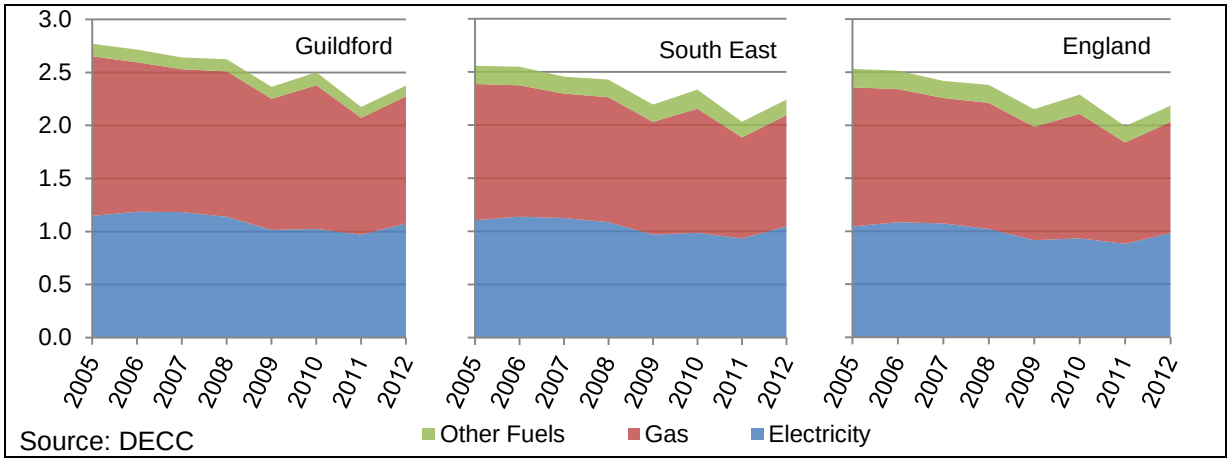


Figure 11 - EWSILA per person CO_2 emissions (tonnes) by energy source in the domestic sector

4.31 A lower proportion of emissions in our borough came from the use of 'other fuels' than in other areas, which probably reflects better access to the gas and electricity grids. Growth in emissions in 2010 and 2012 probably reflects extra heating used during the unusually cold temperatures seen in those years, as well as economic recovery. 2010 and 2012 are the only years in the last 16 years to have an average annual temperature below the 1981-2010 average (Met Office data).

4.31.1 In the UK as a whole since 2000, energy consumption per household has fallen by 16 per cent and energy consumption per person by 14 per cent, reflecting an increase in energy efficiency. The majority of domestic energy is spent on space heating (60 per cent) with the rest spent on water heating (18 per cent), lighting and appliances (19 per cent) and cooking (three per cent).

4.32 Energy consumption in 2013 in our borough was high (Figure 12). In terms of kilowatt-hours, we consumed around three times more gas than electricity. Despite this, the emissions per person from gas and electricity are similar (Figure 11). This is mainly because of the inefficiency of the large fossil fuel power stations used to generate electricity and the relative efficiency of modern domestic gas boilers. Switching our homes from gas to electricity at this time would increase emissions, unless it is accompanied by a large increase low carbon energy generation.

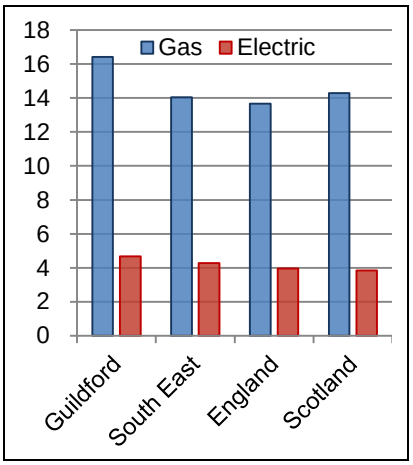


Figure 12 – Average household energy consumption 2013 (thousands kWh)

4.33 Household energy consumption in our borough exceeds even Scotland where cooler and less sunny conditions mean homes require more energy for heating and lighting (Figure 12). Our higher household energy consumption may be a result of the following factors.

- Residents in our borough have higher disposable incomes; national data shows a strong correlation between disposable income and domestic energy consumption. We have fewer households in fuel poverty; 8 per cent compared with 10.4 per cent nationally in 2012. However, fuel poverty across the South East is slightly lower than Guildford, at 7.8 per cent of households.
- We have a slightly higher household occupancy at 2.54 people per house on average, compared to 2.43 and 2.4 in the South East and England and Wales respectively.
- Dwellings in our borough are slightly bigger and therefore harder to heat. Our dwellings average 2.9 bedrooms, compared to 2.8 in the South East and 2.7 in England and Wales.
- We have fewer apartments and significantly fewer terraced houses than the South East and England and Wales. Terraces and apartments are more energy efficient than detached and semi-detached houses.
- A higher proportion of our housing stock was constructed before 1919 and these are likely to have solid walls, which makes homes harder to heat.

(Sources: Private Sector House Condition Survey 2009, DECC, Centre for Sustainable Energy and National Census 2011)

Table 2 – Percentage of homes taking up measures under CERT and EEC (up to 2012)

	Guildford	South East	Great Britain
Cavity wall insulation	10.82%	11.25%	12.28%
Solid wall insulation	<0.01 %*	0.01%	0.12%
Loft insulation	9.22%	11.06%	14.36%

Source: Home Energy Efficiency Database (HEED)
*Only one solid wall insulation measure has been taken up in the borough under these schemes

4.34 Energy Performance Certificate (EPC) data tells us how energy efficient homes are. The current EPC data that we need to compare the homes in our borough with those in other areas is very expensive and has not been purchased for this study. The English House Condition Survey in 2007 found that private sector houses in Guildford were very slightly more efficient than the national average. However, most domestic energy is spent on space heating so our high domestic emissions and energy consumption suggest that our housing

stock may be now be less efficient than the national average. This is supported by Table 2, which shows that the energy company obligation schemes CERT and EEC, which provided funds for people to improve their homes between 2002 and 2012, were taken up in fewer houses in our borough than in other areas.

4.35 Since March 2011, the Council's Sustainable Design and Construction Supplementary Planning Document (SPD) required new dwellings in the borough to be built to the Code for Sustainable Homes level 3 standard. This standard generally leads to fabric efficiencies similar to those produced by the 2010 Building Regulations (the national minimum standard). Building regulations standards were strengthened in 2014 so the fabric efficiency of new dwellings in our borough is governed by Building Regulations.

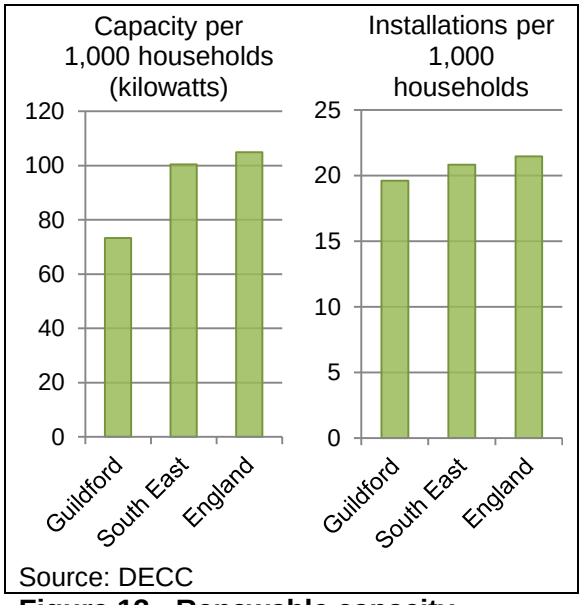
4.36 Summary:

- Our domestic energy consumption and domestic emissions are high.
- This is probably a result of affluence and the type, size and efficiency of the homes in our borough.
- Our emissions show a strong decline, but this is susceptible to weather and economic conditions.

Renewable and low carbon energy profile

4.37 Local planning authorities are responsible for granting planning permissions for renewable and low carbon energy developments under 50 megawatts. The Secretary of State for Energy decides anything above that.

4.38 Figure 13 shows payments made under the Feed-In-Tariff (FIT) for renewable energy. Only installations up to five megawatts capacity are eligible for FIT (though DECC have stated this will increase to 10 megawatts). Five megawatts is a lot of energy so all households and the vast majority of businesses that install renewable technology are eligible. FIT only pays for electricity, so renewable heat installations, like solar thermal panels, are not included in these figures. Around 13 per cent of the renewable energy generated in the UK comes from small FIT eligible installations.



Source: DECC

Figure 13 - Renewable capacity eligible for FIT payments at end of 2014

4.39 The South East and England have six and nine percent more installations per household than our borough, but generate 37 and 43 per cent more energy than we do. This means that installations in our borough tend to be smaller than average.

4.40 FIT eligible renewable installations in our borough are overwhelmingly solar photovoltaic and include very little wind power when compared to England as a whole (Table 3). There are no FIT eligible wind power installations in the rest of Surrey.

Table 3 – Mix of renewables eligible for FIT by capacity at end of 2014

	Guildford	South East	Great Britain
Anaerobic digestion	-	1.39 %	3.4 %
Hydro	0.85 %	0.17 %	0.33 %
Micro CHP	0.24 %	0.03 %	0.02 %
Solar photovoltaic	98.85 %	96.42 %	90.89 %
Wind	0.05 %	1.99 %	5.36 %

Source: DECC

4.41 At present, the Sustainable Design and Construction SPD (2011) requires new homes and commercial buildings over 1,000 square metres to reduce the net carbon emissions of the building by 10 per cent through the use of low and zero carbon technologies, which includes renewable energy generation.

4.42 Summary:

- Small scale renewable energy production is lower than other parts of the UK.
- Our renewable energy production is dominated by solar, more so than in other areas.

Water

4.43 Water consumption statistics are not available for individual local authority areas, but we can compare consumption across water company delivery areas. Figure 14 below shows consumption statistics by water company for June 2011. Ofwat, the water regulator, has not supplied data after this date. The four companies who provide water in Guildford borough (Affinity Central, Thames Water, South East Water and Sutton and East Surrey Water) have the highest average water consumption per person in the UK at 163 to172 litres per day, which is 17 per cent above the water company average. We can assume that this means that water consumption in our borough is particularly high. Data from Ofwat shows that homes with water meters use 12 to 30 per cent less water than un-metered homes.

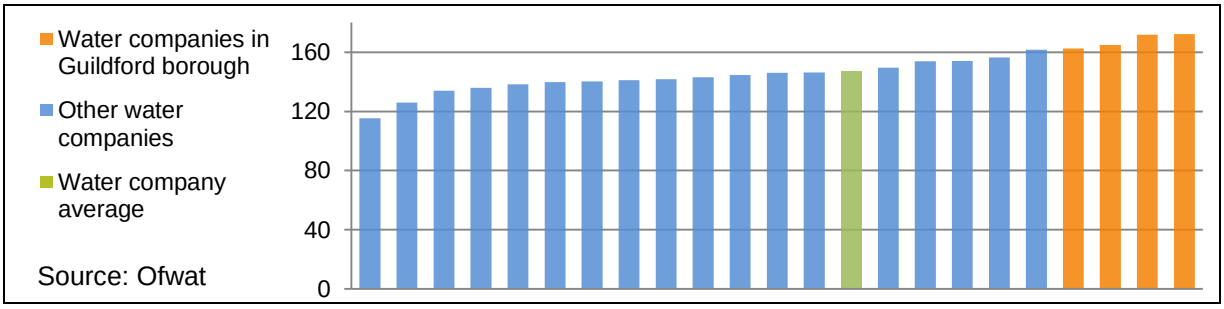


Figure 14 – Average water consumption (litres per person per day) in England and Wales by water company delivery area for June 2011

4.44 The Sustainable Design and Construction SPD requires that new dwellings are designed with a target water usage of 105 litres of water per occupant each day. The current building regulations standard is for 125 litres per person per day.

4.45 Our borough is in an area where water availability is already low, and this is expected to worsen in coming years (see 6.38 onwards).

4.46 Summary:

- Our water consumption is very high compared to England and Wales, while availability is low.

Waste

4.47 The amount of waste we produce is related to the amount we consume. The products we consume carry an embodied carbon cost, so this consumption is an indicator of our carbon footprint.

4.48 Figure 15 shows how much household waste was collected per person in different areas between in the year 2012 to 2013 (annual statistics produced by Defra). Our borough generally produces less household waste per resident than other boroughs in Surrey, around 10 per cent less than the South East and notably less than England. We recycle slightly over 53 per cent of our waste, which is slightly higher than the Surrey average and significantly higher than the South East and England averages. However, the best performing authority in the South East has achieved around 64 per cent.

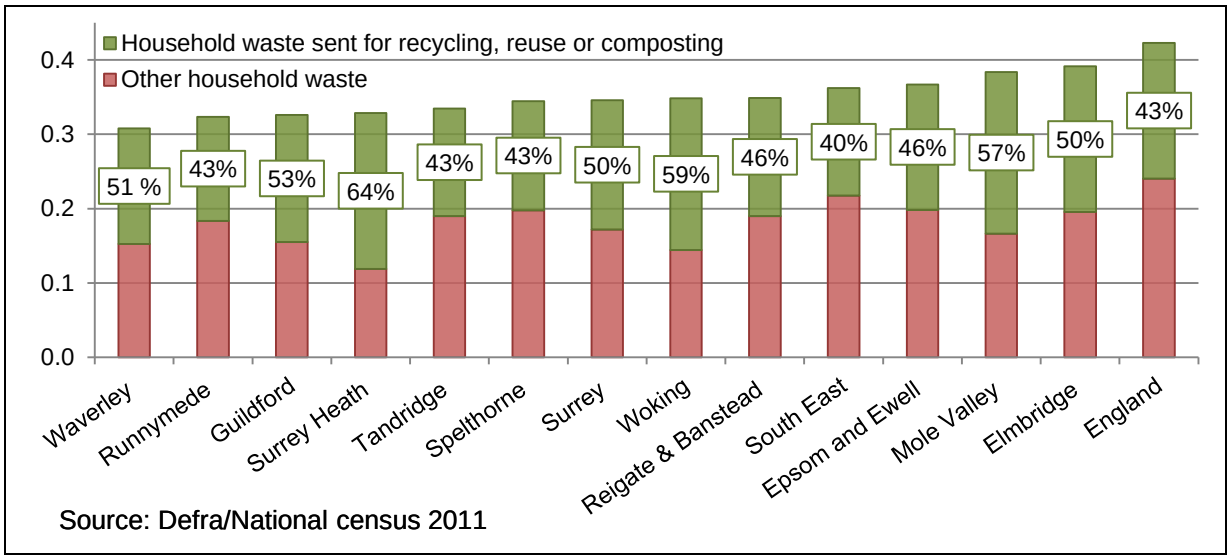


Figure 15 – Local Authority Collected and Household Waste Statistics 2012/13 (tonnes per resident) and the recycling rate

4.49 It is possible to design new homes to make it easier for residents to recycle more and compost their organic waste. We do not presently have any design code for household or community waste management.

4.50 Construction and demolition (C&D) accounts for around a third of the waste produced in the UK. Data is not available showing how much C&D waste is reused or recycled at either local or national level so we cannot be sure how well we perform in this area.

4.51 The Local Plan can influence the way C&D waste is handled, and can encourage the use of sustainable waste management practice, for example by encouraging demolition waste to be reused on site or by encouraging waste minimisation behaviour in the construction materials procurement chain.

4.52 Summary:

- Our household recycling rate is good; higher than Surrey and significantly higher than the South East and England.
- We produce less total household waste than Surrey and around ten per cent less than the South East and significantly less than England.

5. Climate projections

5.1 Climate projections tell us what kind of climate changes our borough could see over the coming century. This section presents a summary of what the climate projections say. More detailed projections, and a discussion of climate projections in general, can be found in Appendix 10. The potential impacts of these changes are discussed in section 6.

5.2 The climate is a very complex system with large amounts of natural variability. Coupled with this we do not know how much greenhouse gas emissions will grow or fall over the coming decades. Climate projections do not therefore attempt to predict the future with certainty, but instead tell us what the evidence says is likely or unlikely to happen under certain emissions scenarios. The summary of climate change projections below covers a range of outcomes and a range of scenarios (see Appendix 1). It is worth noting that current global emission levels put us in the higher emissions scenarios and point to climate change towards the upper end of the range of possible change.

5.3 The projections show average conditions across three different future 30 year periods, and use a historical 30 year period as a baseline:

- baseline – 1961 to 1990
- 2020s period – 2010 to 2039
- 2050s period – 2040 to 2069
- 2080s period – 2070 to 2099

5.4 Our climate is already different to the climate in the baseline period so some of the change described below has already happened. The projections below are taken from UKCP09, the UK climate projections produced by Defra in 2009, and draw on projections for both the South East region and a 25km square area covering the western half of our borough.

5.5 The figures for future temperature, precipitation, humidity and cloud cover given below are not the most likely outcomes. The figures show climate extremes that are 'very unlikely' to be exceeded (less than 10 per cent chance) most of the time. Actual climate change is likely to fall short of these extremes, but we have decided that these outcomes are likely enough that they should be considered. It is also probable that these extremes will be exceeded in years and on days with very unusual weather. The way the climate projections work, how they should be used and why we have chosen to look at this range of outcomes is explained in Appendix1.

Precipitation

5.6 Precipitation means water falling in any form (rain, snow, hail etc.). The total amount of water falling throughout the year is unlikely to see major change (somewhere between a fall of 4.7 per cent and an increase of 11 per cent by 2080), but the distribution of precipitation throughout the year could change significantly, with much wetter winters and much drier summers.

- Winter mean precipitation could rise by up to 20 per cent in the 2020s, by up to 40 per cent in the 2050s and by up to around 65 per cent by the 2080s.
- Summer mean precipitation could fall by up to 31 per cent in the 2020s, by up to 54 per cent in the 2050s and by up to nearly 70 per cent by the 2080s.

5.7 The projections also show the possibility for extremely wet winters and extremely dry summers in exceptional years. Extreme weather events are likely to become more common, especially heavy winter rainfall events, largely before 2040.

Temperature

5.8 Temperatures are expected to rise all throughout the year, but this is likely to be most pronounced in summer. There is potential for very large rises in temperature.

- In summer:
  - mean daily maximum temperatures could increase from a baseline of 20.6°C up to as high as 24.5°C in the 2020s, up to as high as 27.8°C in the 2050s and up to as high as 31.8°C in the 2080s,
  - mean daily minimum temperatures could increase from a baseline of 10.5°C up to as high as 13.5°C in the 2020s, up to as high as 16°C in the 2050s and up to as high as 19.2°C in the 2080s.
- In winter:
  - mean daily maximum temperatures could increase from a baseline of 7°C up to as high as 9.3°C in the 2020s, up to as high as 11°C in the 2050s and up to as high as 13°C in the 2080s,
  - mean daily minimum temperatures could increase from a baseline of 0.9°C up to as high as 3.5°C in the 2020s, up to as high as 5.5°C in the 2050s and up to as high as 7.7°C in the 2080s.

5.9 Heatwaves are likely to become more frequent and more severe. Temperatures during heatwaves could reach 27.5°C in the 2020s, 32.9°C in the 2050s and 39.5°C in the 2080s. The Urban Heat Island (UHI) effect, where temperatures in urban areas become significantly higher than in surrounding countryside areas, is likely to become more pronounced so temperatures in urban areas could exceed the figures given here.

Cloud cover and humidity

5.10 Cloud cover and humidity are likely to decrease in summer, potentially significantly, leading to sunnier summers. Winter is likely to see little change.

- Cloud cover in the summer months could fall from a baseline of 66 per cent cloud cover to as low as 56 per cent in the 2020s, to as low as 50 per cent in the 2050s and to as low as 43 per cent in the 2080s.
- Summer humidity could fall from a baseline of 77 per cent humidity to as low as 70 per cent in the 2020s, to as low as 64 per cent in the 2050s and to as low as 59 per cent in the 2080s.

Conclusion

5.11 The projections demonstrate that there is potential for extreme change in typical temperatures and rainfall patterns, and that extreme weather events also have the potential to become a lot more severe than they have been in the past.

5.12 The projections also demonstrate very clearly that there is a large amount of uncertainty in what the future climate will look like. This uncertainty increases the further forward we look. To illustrate, the climate models tell us that the maximum daily temperature in summer in the 2080s may be as low as 22°C, which is similar to present day Tours, France, or as high as 32°C, which is similar to present day Larnaca in Cyprus.

5.13 We expect that better information will become more available as climate science and the technologies used in modelling improve, and this may mean there will be more certainty in the projections in the future. There will be a chance to review our strategy at a later date, potentially at the next local plan period. However, the potential for extreme change, and the possibility that change may come quickly, as the 2020s projections show, means we will need to make plans for adaptation to begin in this plan period.

5.14 Any plans we make to meet the challenge of climate change will need to be adaptable to deal with both the uncertainty and the range of climate conditions we are likely to experience over the coming decades. Developments we build in this plan period will need to be both resilient to climate change and adaptable to a range of climates so we can avoid costly and resource heavy refurbishment and retrofitting later on.

6. Climate change impacts

6.1 This section identifies and assesses the threats and opportunities that future changes to our climate could bring. We have used three main sources:

- *UK Climate Change Risk Assessment 2012: Government Report* (UKCCRA)
- *A Summary of Climate Change Risks for South East England* (SECCRA)
- *Draft Surrey Local Climate Impact Profile* (SLCLIP)

6.2 The UKCCRA was produced by Defra to identify, compare and prioritise the likely risks and opportunities the UK will encounter because of climate change. The main purpose of the report is to provide evidence that the Government, businesses and local authorities can use when making climate change policy. The report sets out the main priorities for adaptation in the UK.

6.3 The SECCRA was commissioned by Defra and produced by Climate South East (the Climate Change Partnership for the South East region). It was produced to coincide with the UKCCRA in order to highlight the key risks and opportunities specific to the South East region. These two sources draw upon a robust evidence base, set out in the *UK Climate Change Risk Assessment Evidence Report*.

6.4 The SLCLIP was commissioned by the Surrey Climate Change Partnership in 2009. Local Climate Impact Profiles look at past extreme weather events (EWE) and the impact those events have had. Doing this helps us to understand our current vulnerability to weather, and therefore what the impacts from future weather and the associated risks and costs might be. The SLCLIP found that there were 78 separate EWEs in Surrey from 1999 to 2009, 45 of which had a significant impact on the community (Table 4). As part of the London commuter belt, our economy may be particularly vulnerable to EWEs that interrupt travel.

Table 4 - Extreme weather events identified in the Surrey LCLIP 1999-2009

	Flood	Ice & snow	Strong winds	Lightning strikes	Heat-waves	Dry periods (health & fire)	Dry periods (droughts)
Significant	26	11	4	0	2	1	1
Minor	10	5	9	8	0	1	0

Source: Draft Surrey LCLIP

A generally warmer climate

6.5 The South East is the most wooded region of England and has the highest concentration of ancient woodlands in the country, and therefore is particularly susceptible to the risks associated with forest species loss. Agriculture and forestry are sensitive to climate conditions and climate change may have a big impact on productivity and economic viability (SECCRA). New timber species may become available but existing species may become less viable (UKCCRA).

6.6 The impact on forestry is unclear. Warmer conditions and carbon fertilisation may allow the growing range of forests to expand. This could improve the industry and help achieve the

ambition of Surrey County Council to develop the county into a wood hub. However, water shortages may limit growth and trees may be at risk from new diseases such as red band needle blight which affects conifers, a type of tree commonly used in commercial forestry in Surrey.

6.7 Changing conditions will improve conditions for some species but not others and will probably lead to changing patterns of crop use. This may bring the opportunity to exploit new crops but may also mean that current crops lose viability. Warmer and longer growing seasons could increase productivity and which will allow us to grow more "continental" crops such as grapes and sunflowers (SECCRA) as long as water shortage and nutrient availability do not limit growth (UKCCRA).

6.8 The South East is also likely to become more suitable for some types of biomass crops, including switch grass, which is grown as a biomass crop in the Americas. Warmer temperatures and carbon fertilisation may present some opportunities to increase crop yields in the short term, assuming there is enough water (SECCRA). In the longer term, yields may begin to fall again as water and flooding become limiting factors (SECCRA). Agricultural pests could increase due to disruption in predator prey relationships and insects expanding their range (UKCCRA) which could also negatively affect yields.

6.9 There is very high potential for water shortage in our borough (see 6.37 onwards) so the risks to agriculture and horticulture are significant and could destroy the opportunities listed above.

6.10 A warmer climate could also bring direct health benefits and risks. As the environment changes, so will our lifestyles. We may become healthier due to a greater potential for outdoor recreation (see below). However, we may also see an increase in diseases due to an expansion in the range of bacteria and pests brought by a warmer climate.

6.11 Warmer winters will mean reduced health risks from the cold. The death rate typically increases by 16 to 20 per cent in winter in the South East region, and those at risk tend to be the elderly and those in fuel poverty. Warmer winters will reduce winter deaths and bring a reduction in inequality in vulnerability between social groups.

6.12 Our natural environment may also be expected to change. There is likely to be an increased habitat range for some species, for example warm water fish or insects currently found only in the south of the UK. As a rough rule of thumb, most species are able to migrate 200 miles further northwards in the northern hemisphere for every 1 degree C of warming. This may lead to an increase in the number of invasive species as their native competitors are put under environmental stress and the cold winters that often remove cold intolerant species occur less frequently (UKCCRA, POSTnote: Invasive Non-native Species). This could negatively affect biodiversity and severely damage wildlife, habitats and economic interests (UKCCRA, POSTnote). Damage to our Special Protection Areas and SSSIs could be particularly bad as the species and habitats they have been set up to protect are particularly valuable.

6.13 The warming of rivers and lakes may also affect the productivity of our aquatic ecosystems (UKCCRA).

6.14 For businesses, it is expected that there will be opportunities for developing and producing green technologies, and for providing products and services that help adapt to climate change and assist in the transition to a low carbon economy (UKCCRA). Our borough is well placed to take advantage of this with strong technology, research and development and service sectors.

Hotter, sunnier summers with lower humidity

6.15 It is very likely that we will see hotter and sunnier summer months with lower humidity. These conditions will bring challenges and opportunities.

6.16 Hot summers appear to have a positive effect on leisure activities and tourism in the UK, as people tend to use leisure opportunities here rather than travel abroad (*Surrey Climate Change Strategy*). Lower humidity will increase this as it allows us to sweat more freely and makes higher temperatures more comfortable. Potentially this could increase the value of the service sector and boost the economy. An increase in outdoor activities will also bring improved physical health and a corresponding reduction in illness. Increased exposure to sunlight and a corresponding increase in vitamin D levels could help with mental health (UKCCRA). This may be significant in our borough with the increase in summer sunshine and decrease in summer rainfall and humidity.

6.17 However, warmer summers bring direct health risks: seasonal excess deaths start to occur at 25°C (*Heatwave Plan for England*). This temperature could become a typical July daily maximum by the 2050s period and may be common occurrence in summer by the 2020s period. Increased exposure to UVB sunlight could mean that cases of melanoma increase (SECCRA).

6.18 Worsening air quality, including increased ozone levels caused by sunlight reacting with emissions from cars, could also lead to increased deaths and respiratory problems like asthma and allergic reactions (UKCCRA, SECCRA).

6.19 There is a significant threat to workplace productivity due to overheating (*Surrey Climate Change Strategy*, SECCRA), which could possibly triple in some industries by the 2050s (SECCRA). This is likely to increase the demand for mechanical air conditioning, which will mean an increase in our energy consumption and extra costs for business. The extra carbon emissions generated could exceed the savings made from a decrease in winter fuel consumption (SLCLIP). The potential loss of staff hours is particularly important for the health, education and retail sectors, which have large workforces (UKCCRA). Retail is a very important part of our economy so the impact upon this could be large.

6.20 Hotter temperatures also make it harder to undertake outside work (SLCLIP) and increase the risk of dehydration for those that do. While there will be a saving in work lost due to the number of rainy days, potentially the drop in everyday productivity due to the heat could exceed this.

6.21 In the built environment there is potential for heat damage or other disruption to the energy infrastructure (UKCCRA). Increased levels of outdoor activity could place pressure on our green spaces and countryside.

Heatwaves

6.22 The projections show that as well as general increases in temperature, we are likely to see an increase in both the frequency and severity of heatwaves.

6.23 The Met Office regards a heatwave as posing a significant risk to health in the South East where there are two consecutive days with maximum temperatures over 31°C, with the intervening night-time temperature over 16°C. These conditions fall within the outer limit of possible change in July and August in the 2050s period and fall within the range of change projected for the 2080s period. It is fair to say that heatwaves (as we currently know them) may be more common in summer in our borough by the 2050s period and a regular occurrence by the 2080s period.

6.24 Heatwaves can have a hugely negative impact on agriculture, can trigger water shortages, increase the risk of wildfires and damage infrastructure (SLCLIP). In extreme cases, roads can melt due to prolonged hot temperatures and direct sunlight (Heatwave Plan for England). Damage to the transport infrastructure has a knock on effect on health as people stranded in cars may suffer the effect of overheating.

6.25 Other disruptions can also be problematic, such as school closures or speed restrictions on trains due to tracks overheating. Preventative measures are applied to the rail network at 22°C with extreme precautions applied at 36°C. This temperature was reached as a daily maximum in both 2003 and 2006. 22°C could be a common daily maximum temperature from June to August in the 2020s and a common mean temperature in July in the 2050s. 36°C could become an infrequent daily maximum temperature in July and August in the 2080s.

6.26 In the heatwave of 2003, there were several cases of branches or entire trees falling due to the sap inside the trunks expanding. Cedar trees appear to be the most susceptible to this (SLCLIP). There may also have been an increase in crime because of windows left open.

6.27 However, potentially the biggest impact will be on health. The South East has the highest risk of excess deaths, as it is already the warmest part of the UK (SECCRA). The 2003 heatwave led to approximately 2,000 excess deaths in the UK and 15,000 in Northern France. It is worth noting that the daily mean maximum temperature seen in August 2003 falls within the upper end of the range of temperature change in the UKCP09 projections for 2080 which means they could become the summer norm.

6.28 Excess deaths and illnesses occur primarily due to our inability to cool ourselves sufficiently, with dehydration, heatstroke and respiratory illness being particularly important. The minimum temperature may be more important in relation to health impacts as a cool night time temperature allows respite and time for vulnerable peoples' bodies to cool down, but a hot night will not allow this and may lead to increased risks the following day.

6.29 Heatwaves present a health risk to everyone but pose a particularly high risk to vulnerable groups such as the elderly (especially those over 75, living alone, socially isolated, or in a care home), those who suffer from chronic or severe illness, and those with an inability to keep cool, such as Alzheimer's sufferers, the bed bound and young children (SLCLIP). Those in urban areas, the homeless and manual workers working outdoors or in hot environments will also be more at risk (SLCLIP). Poor access to cool environments, like air conditioned rooms or swimming pools, may mean the less wealthy suffer more than the better off. Heatwaves are a significant social sustainability issue.

Wildfires

6.30 The combination of heat, low humidity and dry conditions makes wildfires more likely and there is evidence of a correlation between warmer, drier spring conditions and increased incidents of wildfires (SECCRA).

6.31 Wildfires are identified as hazards by the Department for Communities and Local Government but the impacts of wildfires can be wider ranging than the direct threat to safety. Other impacts include damage to the environment (air pollution, water quality and destruction of habitats), damage to the economy economic (disruption to businesses activity and transport and destruction of crops and infrastructure) and social impacts (health impacts, injuries to firefighters, anti-social behaviour). Wildfires can be very resource demanding in terms of appliances and emergency services personnel and can use water resources in times of water shortage.

6.32 The environments particularly at risk within our borough are the heathlands, which are important bird habitats, and chalk grasslands (Surrey Hills AONB), which are prone to parching in dry periods and are an important tourism and leisure asset. There have been several spates of large heath fires in the past 10 years, with two in 2003 (SLCLIP). Large parts of the borough are covered by the Special Protection Area designation, which means they are habitats of international significance. The designation protects three bird species (Dartford Warbler, Nightjar and Woodlark), all of which nest on or near the ground and are therefore very susceptible to fire.

6.33 Wildfire impacts on humans are generally worse where they occur near dense populations, as would be the case with a wildfire on the Ash Ranges heathland east of Ash Vale. Ash Ranges is also a Special Protection Area.

Warmer winters

6.34 The warming of our winters brings several potential benefits. We can expect a fall in the amount of energy we use for winter heating, which will both reduce our carbon emissions and bring people out of fuel poverty.

6.35 We are also likely to see a fall in cold-related winter deaths and illness (UKCCRA). Winter illness and excess winter deaths typically occur in vulnerable groups including the elderly and those in fuel poverty so this will bring about a significant improvement in social sustainability.

6.36 With reduced snowfall (precipitation will be less likely to fall as snow and less likely to settle if it does), we will see a reduction in disruption caused by snow and a reduction in health risks from ice. Traditional transport infrastructure and waste collection issues may disappear (*Surrey Climate Change Strategy*).

Changing rainfall patterns

6.37 The projections suggest there will probably be little change in the total amount of water received throughout the year. However, there will be an increasing population drawing on those resources. Changing precipitation distribution, with drier summers and much wetter winters, will mean it is harder to capture and store those resources, both in reservoirs or in aquifers and rivers. It is also likely that the consumption pattern of those resources will change as people and businesses draw more water in summer to compensate for the lack of rainfall. This means water shortages will be more frequent and more severe.

Drier summers and drought

6.38 Increasing demand, changing rainfall patterns and a fall in available resources are expected to have a major impact on our water supply. Water shortage is a risk that requires early action (UKCCRA Evidence report).

6.39 According to the Environment Agency, the South East is a region that already experiences serious water stress. This means that there is already demand for a large proportion of the water that is currently available. This is supported by the European Environment Agency which classifies the South East and London among areas in the EU with the least available water per person and under severe water stress. Other areas in this group are southern Spain, southern Italy and most of Belgium.

6.40 This situation is expected to get worse. Thames Water's *Draft Water Management Plan 2015-2040* predicts that the London zone deficit will increase from 35 to 367 megalitres per day. The shift towards drier summers means that there will be a greater risk of water shortages and drought (UKCCRA).

6.41 The South East has a growing population (projected to grow by nine per cent by 2021). The *Thames Water Management Plan* predicts a greater demand for water in the summer from increased bathing and watering of gardens, and from cooling systems in commercial buildings.

6.42 Change in rainfall patterns mean that soil moisture content will be reduced in spring, summer and autumn, with the greatest decrease in autumn (of up to 60 per cent). As a result, agriculture will need extra support from irrigation using public water stocks. Water scarcity is considered a major threat to agriculture in the South East (SECCRA) and there is the potential for crop losses.

6.43 There could also be additional pressure from fracking (hydraulic fracturing), which is a water intensive process. Much of the UK's shale gas and oil reserves can be found in the South East, and the government is keen to exploit these resources. DECC states that fracking is

likely to use large quantities of clean water, though not exceptional when compared with other industrial activities; operating a fracked well for a decade may be equivalent to the amount needed to water a golf course for a month (DECC, 2014).

6.44 The Environment Agency has said that current abstraction levels are placing some environments under threat and are asking water companies to make 'sustainability reductions'. Affinity Water has stated that this reduction will reduce their available groundwater stock by over six per cent in our water resource region. The management plan from South East Water recognises that at present there is an over reliance on groundwater stocks and that supply needs to be shifted to other sources.

6.45 The water resource zones that cover our borough are generally in surplus but water company projections show that surplus dwindling over time. Our water stocks may be exported to areas of deficit, like London so the availability of water here does not mean our resources are secure.

6.46 A decrease in water supply and an increase in demand will lead to water shortages if current consumption patterns continue. In some cases this will be severe enough to lead to limitations on domestic and business water consumption (SLCLIP). This has already happened and recent years have seen the imposition of Drought Orders, which go beyond hosepipe bans and restrict non-essential uses of water such as cleaning cars and watering plants.

6.47 We can expect that as water becomes less readily available the cost to the consumer will increase. This raises a social sustainability issue where the introduction of compulsory water metering in the coming years means wealthy households have greater access to water, especially if water tariffs are not progressive.

6.48 Drier summers will also have environmental impacts. Low water levels and reduced river flows can lead to an increased concentration of pollutants from agriculture, sewage and air pollution, which damages freshwater habitats and other ecosystems (UKCCRA). The drying up of village ponds and rivers can cause water toxicity (SECCRA). A Local Climate Impacts Profile undertaken by Aylesbury Vale showed that this had affected ducks, fish and birds and possibly caused a botulism outbreak in 2006 that severely affected the duck population. Drier soil may lead to a reduction of plant cover and increased erosion (SLCLIP). This can have an impact on biodiversity and lead to soils releasing carbon (UKCCRA).

Wetter winters and flooding

6.49 Higher winter precipitation, with heavier rainfall and an increase in the number of rainy days, will likely have a negative impact on tourism and leisure opportunities as people stay at home to avoid the rain.

6.50 Flooding at present is already the most important extreme weather event (EWE), being the most frequent and most damaging (Table 4). River flooding will probably increase during the winter months due to wetter ground conditions, with soils becoming overloaded, and a significant increase in rainfall swelling the volume of water flowing through our rivers. Major flooding events, which used to occur every 100 years, may increase in frequency to every

10-20 years (LCLIP). Predicted increases in short, intense periods of rainfall will risk the overloading of drainage and sewer systems causing flash flooding (*Surrey Climate Change Strategy*).

6.51 Our energy infrastructure is at significant risk and transport infrastructure can be severely damaged, potentially cutting off villages and closing the M25 (SLCLIP). Urban flooding could force the town centre to close, and cause damage to homes and businesses, as happened twice in Guildford in 2000 (SLCLIP). Further costs may come from the decrease in output caused by disruption in the supply chain, and damage to agriculture and timber production.

6.52 Flooding represents a direct threat to human health through deaths and injuries. There are also further threats from illnesses such as diarrhoea, trauma, depression and shock (UKCCRA).

Winter snowfall

6.53 While precipitation will be more likely to fall as rain due to warmer winters, when snow does fall it is more likely to be heavier due to increased winter precipitation. Recent experiences show what the impact of this might be. In February 2009 in Surrey heavy snow fell very quickly leaving people, schools and businesses little time to prepare. Roads ground to a halt, with many being shut for safety. Hospitals cancelled non-urgent appointments and one person was killed by a skidding car (SLCLIP).

Storms and driving rain

6.54 The UKCP09 projections show that we are likely to see more extreme storm and rain events. The SLCLIP notes that in the past large storms have damaged buildings (roofs removed, windows broken), felled trees, which damaged property and disrupted travel, and killed people. Storms may also have impacts on the environment; heavy rain followed by gales in October 1987 downed an estimated 15 million trees in the UK damaging assets such as the Royal Horticultural Society garden at Wisley, Chanctonbury Ring and Kew Gardens. Heavy rainfall is the most common EWE to occur in Surrey (SLCLIP) and contributed to the widespread damage to trees in 1987.

6.55 An increase in severe winds will also bring about an increase in driving rain. Driving rain is one of the major sources of moisture damage in the envelope of a building (the outer skin) and potentially could lead to the degradation of our building stock.

7. Conclusions

7.1 This section identifies the key sustainability and climate change themes in our borough that can be addressed through the new Local Plan, based on the evidence in this document.

Climate change adaptation

7.2 The projections show that the climate change we face will probably not be trivial, could present a serious risk and needs an immediate response. Summer temperature increases and changing rainfall patterns in particular could have severe impacts across the social, economic and environmental dimensions.

Key theme 1: Water resources

7.3 Our water supply is currently under pressure and this situation will worsen. Consumption is high and projected to increase while supply is projected to fall. The risks from water shortage are severe across the social, economic and environmental dimensions. In order to realise the benefits to agriculture and forestry that climate change could bring, we need to make sure that there is a secure and reliable water supply available.

7.4 Our high consumption suggests that there is plenty of scope for reducing consumption; simply falling in line with average national consumption rates will reduce our household consumption. Reducing our water consumption allows us to reduce the amount of water we take from rivers and groundwater, which in turn mitigates the impacts of reduced summer rainfall on the natural environment. Putting measures in place that allow us to maintain our high standard of living while using less water also helps us to adapt to conditions of lower water availability. Additionally, this will mitigate the negative impacts on social sustainability brought about by increased water metering.

Key theme 2: Rising temperatures

7.5 While high temperature is likely to be a significant risk across our borough, the urban heat island effect means that it could be a particular issue in urban areas. We therefore need to ensure that urban design takes adaptation to hotter conditions into account, so our buildings and settlements can continue to be good places to live and work in. We can expect the retrofitting of existing buildings for greater efficiency to become a common occurrence and it is important that this is done in a way that prevents overheating. High temperatures are likely to be a more significant issue in our borough than elsewhere, so we need to make sure that national adaptation measures are both suitable and adequate for our borough and act locally if they are not. This adaptation should avoid further energy use where possible so that it does not increase the climate change impact.

Key theme 3: Flooding

7.6 The projections show that the potential for flooding could increase dramatically. Some parts of our borough are already prone to flooding and these events can bring very negative social, health, economic and environmental impacts. Responsibility for flood mitigation and adaptation is currently the responsibility of Surrey County Council as the Lead Local Flood

Authority (LLFA), but we have a responsibility to cooperate with this and the Local Plan can be used to manage flood risk. There may also be opportunities to act to adapt by improving resilience to flooding at a borough level.

Climate change mitigation

7.7 Our emissions are falling at a rate in-line with the average for England. However, they are still very high. The NPPF requires us to help bring about 'radical reductions' in emissions needed to meet the targets in the Climate Change Act 2008. Our emissions reductions at the moment are not 'radical' and with our high emissions we are not yet playing our part. We therefore need to improve our emissions reductions efforts.

Key theme 4: Transport emissions

7.8 There is a significant opportunity for emissions reductions in our borough in the road transport sector. Whilst our commuters are moving to sustainable transport, traffic levels are still very high and growing. Some of this is driven by an over reliance on the car by our residents, and some by high levels of commuting into and through the borough. Surrey County Council is the Local Highway Authority and has responsibility for transport planning, but the Local Plan can support any measures that help reduce road transport emissions and look for ways to act at the borough level. We should also be looking at ways that local development can design out the need for motorised trips.

Key theme 5: Home energy efficiency

7.9 There is as an opportunity for emissions reductions in the domestic sector. We have high domestic emissions, driven by high household energy consumption. This happens for a number of reasons, but poor building efficiency is an important factor across the UK, which national policy is aiming to address. Taken together means there is a need, scope and support for retrofitting our housing stock. The new Local Plan should encourage and enable domestic retrofitting to address this.

7.10 We also need to make sure the homes we build now are designed to be energy efficient. At the present time we do not know exactly how the plan for zero carbon homes in 2016 will be implemented so it is difficult to say whether there will be an opportunity or a need for the Local Plan to improve the efficiency of new buildings through local policy. However, we can make sure we support the national move to improve building efficiency, potentially by requiring designs to consider shape, form, landform, layout, orientation, massing and landscaping.

Key theme 6: Renewable and low carbon energy

7.11 Our borough is lagging behind in small-scale renewable energy generation. Installations of these types are permitted development in many cases, so we can't achieve this just by removing barriers in the planning system. Action is needed to stimulate more renewable energy developments. National policy encourages the development of heating/cooling networks and the use of CHP, which have been very successful in other parts of the UK. This is an area where the Local Plan can and should play a pivotal role.

8. Glossary

Abstraction (of water) – Water extracted from aquifers, river or lakes.

Adaptation (to climate change) – The actions we take to ensure that we can live comfortably in changing climate conditions.

Anaerobic digestion – A method of waste management and renewable energy production where biodegradable material is broken down by micro-organisms in an oxygen free environment, creating fuel that can be used to produce energy.

Biomass – Biological material (e.g. plants, wood) that can be used directly as a fuel, or processed into a biofuel like biodiesel, bioethanol or biogas.

Carbon emissions, carbon footprint – Carbon emissions refers to the CO_2 that is released due to human activity, from sources like cars, domestic heating and electricity generation. Carbon footprint also measures carbon emissions, but often takes a more holistic approach by including embodied emissions.

Carbon, carbon dioxide, CO_2 – Carbon is a chemical element. Carbon dioxide (CO_2) is compound that includes carbon, and is a common gas in the atmosphere. Carbon dioxide is a greenhouse gas and enables the atmosphere to trap and store heat.

Baseline (climate) – Many climate projections show how much change is expected based on a baseline. The baseline used in most UK climate projections is the average conditions between 1961 and 1990.

Climate Change Risk Assessment (CCRA) – A CCRA is an evidence-based assessment of the likely impacts of climate change that looks at the costs and likelihoods of individual impacts and sets out the main priorities for adaptation.

Climate projection – A picture of the future that shows what future climate change is possible, and how likely different outcomes are. Climate projections are usually based around a specific emissions scenario.

Code for Sustainable Homes, the Code – An environmental assessment method for rating and certifying the performance of new homes in the categories of Energy and CO_2 Emissions, water, materials, surface water run-off, waste, pollution, health and well-being, management and ecology. Some of the standards are mandatory while others are optional and instead contribute 'credits' towards an overall score.

Combined heat and power (CHP) – An efficient energy generation system that captures waste heat and uses it, for example by providing heat to homes. CHP can use fossil fuels more efficiently, or can be used with renewable fuels to produce zero carbon electricity.

Direct (carbon) emissions – The carbon emissions that we produce directly through our daily activities, for example by burning fuel when driving our cars or heating our homes. This is in contrast to embodied carbon emissions, which are often hidden in the products we consume.

Display Energy Certificate – Needed for commercial buildings, it shows how energy efficient the building is. Similar to the Energy Performance Certificate for homes.

Embodied carbon, embodied emissions – The carbon emissions that we produce indirectly. This could include, for example, the emissions that were produced to make the products we buy or grow the food we eat.

Emissions scenario – Emissions scenarios show possible futures with different emission levels. They vary from low emissions scenarios that assume low global population growth, low consumption patterns and the widespread use of green technology, to high emissions scenarios that assume the opposite. They are often used when making climate projections.

Energy Performance Certificate (EPC) – The EPC shows how energy efficient a home is. All homes are required to have an EPC when they are sold or rented.

Feed-in-tariff (FIT) – A government payment made to people who produce electricity from renewable energy sources.

Finite resources – Non-renewable resources that do not renew themselves, or renew themselves very slowly, so that they run out if we keep using them. This includes fossil fuels and minerals.

Fossil fuels – Fuels formed by natural processes from buried dead organisms, such as coal, oil and natural gas. Fossil fuels contain carbon, which is released into the atmosphere when they are used.

Green Deal – A government scheme that provides loans to people wishing to improve the comfort and efficiency of their homes. Loans are capped at the amount saved on energy bills, so the work should be low or zero cost.

Green economy – The green economy usually refers to the businesses that produce green technology and green services.

Green technology – Technologies that help us live in a more sustainable way, either by reducing the amount of energy and resources we consume, by allowing us to use different more plentiful or renewable resources, or by helping us to adapt to a changing environment.

Greenhouse gas (GHG) – A gas that that absorbs solar radiation and allows the atmosphere to hold more heat. The most important GHGs are water vapour, carbon dioxide, methane and ozone.

Hydro, hydro energy, hydropower – Renewable energy produced from falling or running water, for example by installing a turbine on a river.

Local Climate Impacts Profile (LCLIP) – A study that looks at a local area, such as a county or borough/district, and highlights the current vulnerabilities to extreme weather by studying past

events. It looks at how these events affect local communities, local authority assets, infrastructure and the capacity to deliver services.

Micro CHP – Small scale CHP, providing heat and power to a home or an office building.

Mitigation (of climate change) – The actions we take to try to prevent climate change. This usually means reducing our carbon emissions.

Ofgem – The Office of Gas and Electricity Markets, the government regulator for the electricity and natural gas markets in Great Britain. It promotes competition in the energy market and helps implement government policy regarding energy production and decentralisation.

Ofwat – The Water Services Regulation Authority, the body responsible for the regulation of the privatised water and sewerage industry in England and Wales. It protects the interests of consumers by promoting competition.

Precipitation – Water falling naturally in any form; rain, sleet, snow, hail, etc.

Relative humidity – The amount of water suspended in the air as water vapour. This is relative to air temperature as warmer air can carry more water.

Renewable energy, renewables – Energy that comes from renewable resources. This includes energy from the Sun (solar panels), wind (turbines), water (hydropower, tidal energy, wave energy), biomass (biofuels, anaerobic digestion) and the Earth (geothermal heat).

Renewable Heat Incentive (RHI) – A government payment made to people who produce heat from renewable energy sources. Examples include solar thermal panels where water is heated by the sun, and boilers run on wood fuels.

Renewable resources – Resources which are continually replenished and/or don't run out, for example plants, wind and the sun.

Solar photovoltaic, solar PV – A technology that generates electricity directly from the sun. Solar panels are commonly PV and not solar thermal.

Solar thermal – Technology that uses the sun to heat water.

Ultra Low Emission Vehicle Grant – A government grant given to people who buy very low or zero emission vehicles.

Urban heat island (UHI) effect – The phenomenon where urban areas become significantly warmer than the rural areas that surround them. This is caused by the shape of the urban area and the materials used to construct it, which trap heat, and the human activity within, which generates heat.

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10. Appendix 1: Climate projections in detail

10.1 The NPPF requires us to base the Local Plan on adequate, up-to-date and relevant evidence about the characteristics and prospects of the area, and to use sound science responsibly. This section looks at three climate change projections, discusses how reliable they are and draws conclusions about the direction our climate is likely to move in.

About climate projections

10.2 The Earth's climate is very complex and we are not able to be certain about future climate change. Uncertainty in the climate projections is caused by natural climate variability, an incomplete understanding of natural climate processes and uncertainty over the amount of future greenhouse gas (GHG) emissions.

10.3 Projections are not the same as predictions; projections do not tell us the future. They instead show what the evidence says is likely to happen if a particular future scenario plays out. Climate projections generally look at a range of scenarios, each showing different levels of emissions based on assumptions made about certain global factors including:

- success in the effort to reduce greenhouse gas (GHG) emissions
- economic growth
- population growth and
- changes in lifestyle and technology.

10.4 The projections are probabilistic, which means they give a range of possible outcomes for each scenario, and probability rating for each outcome. This rating tells us how much evidence there is in support of that outcome and how well we understand the phenomenon, which in turn tells us how likely it is to happen.

10.5 Geographical scale is an important factor in climate projections. Running projections for smaller geographical areas means you can get detailed information tailored to that area, but projections for smaller areas are generally less reliable than those for bigger areas. UKCP09 (see 10.11) describes the confidence in some aspects of the continental projections as 'moderate'. There is no confidence level given for the regional or local projections but as these smaller scale projections are a modification of the continental projections we can assume that the confidence is lower than 'moderate'.

10.6 We have looked at climate change projections at three different geographical levels se we can crosscheck the results. The projections we have used are:

- Intergovernmental Panel on Climate Change (IPCC) projections for the world and Europe
- UK Climate Projections 2009 (UKCP09) projections for the South East of England
- UKCP09 projections for an area covering the western part of our borough

10.7 These climate projections show the UK heating up, which follows UK and global trends. However, there are also possible scenarios that show the UK cooling. This is because the

UK benefits from the Gulf Stream (or Meridional Overturning Circulation), an ocean current that takes cold arctic water to the Gulf of Mexico deep down in the Atlantic ocean, and brings warm Caribbean waters to UK shores at the surface. The delivery of warmed waters and air warmed by the sea means the UK is around 15 degrees warmer than it would otherwise be.

10.8 Climate change is expected to weaken this process, and could possibly lead to it changing course to bypass the UK, or even stop completely. If this should happen the UK would experience much cooler climatic conditions than at present. The projections below take changes in the Gulf Stream into account and all the climate models suggest it will weaken but not change significantly during this century, and that the reduction in heat delivered to the UK will be more than compensated for by rising air temperatures. However, we should remember that there is a small possibility of cooling when we think about how we will adapt to climate change.

Intergovernmental Panel on Climate Change (IPCC) projections

10.9 The IPCC projections use a very broad range of emissions scenarios. These include very high emissions scenarios that assume high population growth and rapid development, and low emissions scenarios where population growth and development are slower and green technology is more widely used.

Table 5 - Projected climate change and impacts this century from the IPCC AR4

Global changes	*Probable* sea level rise by somewhere between 18 and 59 centimetres during this century
	Possible rises in global average temperature this century of between 1.1 and 6.4 °C with rises of around 0.2 °C per decade for the next couple of decades
	More frequent warm spells, heatwaves, and heavy rainfall (*confidence level above 90%*)
	An increase in droughts and extreme high tides (*confidence level above 60%*)
European changes	An increase in winter floods in maritime regions and flash floods throughout Europe (v*ery high confidence)*
	Coastal flooding from increased storminess and sea level rise (v*ery high confidence)*
	Warmer drier conditions leading to prolonged droughts and increased fire risk (though mostly in Mediterranean areas) (*very high confidence)*
	Significant warming, especially in winter (v*ery high confidence)*
	An increase in mean annual precipitation in northern Europe and a decrease in southern Europe (*very high confidence)*
	A change in crop suitability, increased productivity in Northern Europe with a longer growing season, expanding forests (*very high confidence)*
	An inland migration of beaches and the loss of up to 20% of coastal wetlands due to sea level rise (*very high confidence)*
	An increase in the intensity and frequency of summer heatwaves throughout Europe (*very likely*)
	Europe's natural (eco)systems and biodiversity will be substantially affected (*very high confidence*) with the great majority of organisms and ecosystems likely to have difficulty in adapting (*high confidence*)
	A magnification of regional differences of Europe's natural resources and assets (*very high confidence*)
	Challenges to many European economic sectors and alteration of the distribution of economic activity, particularly tourism (*high confidence*)
	A change in the seasonality of precipitation and in increase in the frequency of intense precipitation events (*likely*)

10.10 Some of the main projected climate changes and associated impacts from the *Fourth Assessment Report* (AR4) for the world and Europe for this century are summarised in Table 5. The impacts described are generalised but have a high level of confidence. This projection draws on a range of emissions scenarios.

UK Climate Projections 2009 (UKCP09)

10.11 UKCP09 is a project run by the Department for Environment, Food and Rural Affairs (Defra) that provides climate projections for the UK. The UKCP09 projections are recognised as some of the most advanced available.

10.12 The UKCP09 projections draw on a range of climate models, which have been weighted. If a model is good at reproducing past climates then it is likely to be good at indicating the future climate, so it is given greater weight in the outcome.

10.13 The figures that the projections provide are averages over periods of three decades. For example, the period for the 2020s shows average conditions from 2010 to 2039, so a winter daily minimum temperature for 2020 shows an average minimum daily temperature across all the winters for the period 2010 to 2039. All the projections are based on a baseline of climate conditions in the 1980s, which covers the 30-year period from 1961 to 1990.

UKCP09 emissions scenarios

10.14 UKCP09 uses three different global emissions scenarios selected from the IPCC Special Report on Emissions Scenarios (SRES). These scenarios are shown in Table 6. The UKCP09 high and low scenarios span almost the full range of the IPCC scenarios. However, they do not span the most extreme high and low IPCC emission scenarios, which are based on very high global population increases, very high rates of fossil fuel combustion or a strong global effort to reduce emissions. None of the three UKCP09 scenarios consider the effects of action by people and governments to mitigate climate change, but they do look at possible changes in technology and economic growth. Neither UKCP09 nor the IPCC suggest which scenario is most likely.

Table 6 - UKCP09 emissions scenarios

UKCP09	IPCC	Description
Low emissions scenario	B1	Environmentally friendly growth, with rapid change towards a service and information economy, a reduction in material intensity and the introduction of clean, efficient technologies, emphasis on global solutions for economic, social and environmental stability
Medium emissions scenario	A1B	Growth leads to converging global equality, a quick spread of new efficient technologies, a balanced use of fossil fuels and other energy sources
High emissions scenario	A1f1	Same as A1B but with intensive use of fossil fuels
All three scenarios assume a more integrated world with rapid economic growth and a population peaking at 9 billion in 2050 and then declining.		

10.15 *Busting the Carbon Budget* published by Pricewaterhouse Coopers in November 2013 stated that the current rate of decarbonisation puts us on a path consistent with the most extreme scenarios presented by the IPCC and potential warming of around four degrees by 2100. It highlights that the lack of progress makes the goal of limiting global temperature rise to two degrees increasingly unachievable. This position has been supported by statements from the International Energy Agency which suggests that current trends point to a rise of around six degrees, or of four degrees if current pledges by various governments are honoured.

10.16 We do not know whether global emissions will keep rising, or how quickly they will rise or fall in the long term. Recent emissions reductions strategy announcements by some of the largest emitting nations may have an impact on this (notably, China has now surpassed the USA as the biggest investor in renewable energy). A report published by the European Commission in 2013 found that global emissions increased by only 1.1 per cent over 2011 against an average annual increase of 2.9 per cent since 2000, and showed 'remarkable' trends for slowing or reduction in the top three emitters; China, the USA and the EU. The same data showed that the slowdown in emissions increases was not caused by a slowdown in growth, demonstrating a genuine movement towards low carbon energy.

10.17 The IPCC AR4 found that recent population projections have suggested that the global population may not grow as much as expected in the SRES scenarios (and therefore the three scenarios used in UKCP09).

10.18 At this stage, it is impossible to say which emission scenario is most likely so we have looked at the range of outcomes across all three UKCP09 scenarios.

Understanding the data

10.19 UKCP09 projections are very complicated. The projections produce a range of possible change for temperature, rainfall and other climate variables. The climate models are run repeatedly and the number of times a particular value, like a daily maximum temperature in June, comes out is recorded, showing how likely that outcome is.

10.20 The data is presented to us as a cumulative distribution function. This tells us how likely it is that the output from the models will exceed or fall short of a particular value. For example, for summer daily maximum air temperature in the 2050s under the medium emissions scenario, the highest outcome produced by the models is 32.95˚C. However, the models produce temperatures that are lower than this 99.9 per cent of the time so there is a 99.9 per cent chance that temperature will fall short of this. For the temperature of 27˚C, models produce a value that is higher 10 per cent of the time and lower 90 per cent of the time so there is a 10 per cent chancel temperatures will be higher and a 90 per cent chance they will be lower than this figure. For the temperature 24.3˚C, the models produce temperatures that are either higher or lower 50 per cent of the time. This 50 per cent figure is referred to as the central figure.

10.21 Guidance from UKCP09 warns us not to use only the central figures. The range of outcomes we are considering should be based around the amount of risk we are willing to take. Given that developments in the borough will be around for a very long time, and that

damage to human health and the borough's economy is potentially very serious, we will look at the range of outcomes higher in the 10 percent or above probability range. We feel confident in doing this because UKCP09 describes figures below 10 per cent probability as 'very unlikely'.

10.22 We will still consider outcomes in the 'very unlikely' range (less than 10 per cent likely), but only in terms of possible extreme weather events, or the absolute maximums and minimums we might face on some occasions. This decision has been taken under advice from UKCP09.

UKCP09 projections of change for the South East

10.23 Table 7 shows climate projections for the South East. In each box, the lower figure will be exceeded and the higher figure will be fallen short of 90 per cent of the time. Figures outside this range are 'very unlikely'. The figure in blue is the central figure. The projections show change against the 1980s baseline.

Table 7 - UKCP09 projections of change for the South East for three periods

	Low scenario	Med. scenario	High scenario	All scenarios
		2020s		
Winter mean temperature	0.5˚C 1.3˚C 2.1˚C	0.6˚C 1.3˚C 2.2˚C	0.6˚C 1.4˚C 2.2˚C	0.5˚C to 2.2˚C
Summer mean temperature	0.7˚C 1.7˚C 2.8˚C	0.6˚C 1.6˚C 2.7˚C	0.5˚C 1.5˚C 2.7˚C	0.5˚C to 2.8˚C
Summer mean daily max. temperature	0.7˚C 2.2˚C 3.8˚C	0.6˚C 2.1˚C 3.8˚C	0.6˚C 2˚C 3.7˚C	0.5˚C to 3.8˚C
Winter mean precipitation	-4% 7% 19%	-4% 6% 19%	-3% 7% 20%	-3% to 20%
Summer mean precipitation	-24% -7% 13%	-26% -8% 14%	-3% 4% 20%	-26% to 20%
		2050s		
Winter mean temperature	0.9˚C 2˚C 3.1˚C	1.1˚C 2.2˚C 3.4˚C	1.4˚C 2.5˚C 3.8˚C	0.9˚C to 3.8˚C
Summer mean temperature	1.1˚C 2.6˚C 4.3˚C	1.3˚C 2.8˚C 4.6˚C	1.4˚C 3.1˚C 5.2˚C	1.1˚C to 5.2˚C
Summer mean daily max. temperature	1.2˚C 3.5˚C 6.1˚C	1.4˚C 3.7˚C 6.6˚C	1.8˚C 4.3˚C 7.4˚C	1.2˚C to 7.4˚C
Winter mean precipitation	1% 13% 30%	2% 16% 36%	3% 19% 40%	1% to 40%
Summer mean precipitation	-37% -14% 16%	-41% 19% 7%	-43% 19% 9%	-43% to 9%
		2080s		
Winter mean temperature	1.4˚C 2.6˚C 4˚C	1.6˚C 3˚C 4.7˚C	2˚C 3.7˚C 5.7˚C	1.4˚C to 5.7˚C
Summer mean temperature	1.4˚C 3˚C 5.1˚C	2˚C 3.9˚C 6.5˚C	2.6˚C 4.9˚C 8.1˚C	1.4˚C to 8.1˚C
Summer mean daily max. temperature	1.4˚C 4.1˚C 7.4˚C	2.3˚C 5.3˚C 9.2˚C	3˚C 6.7˚C 11.5˚C	1.4˚C to 11.5˚C
Winter mean precipitation	4% 18% 40%	4% 22% 51%	7% 30% 67%	4% to 67%
Summer mean precipitation	-39% -15% 13%	-48% -23% 7%	-57% -29% 5%	-57% to 13%

Source: DEFRA, 2011

10.24 The *UKCP09 Briefing Report* also identifies other impacts likely to be seen in the South East by the 2080s under the medium emissions scenario. Central figures are in brackets:

- an increase in rainfall in the wettest day of winter by seven to 56 per cent (25 per cent)
- a decrease in relative humidity of 0 to 20 per cent (9 per cent) in summer
- a decrease in summer-mean cloud of two to 33 per cent (18 per cent) in parts of southern UK, leading to an increase in downward shortwave radiation
- a decrease in snow of 80 per cent to 95 per cent
- 10 to 67 (32) days warmer than 28˚C each year (the baseline average is two per year)
- seven to 15 (11) dry spells greater than 10 days each year (the baseline average is nine per year) and
- substantially fewer days with frost.

UKCP09 absolute projections for our borough

10.25 The situation in our borough is not the same as the South East as a whole. Met office data shows that the borough typically gets around 10 to 20 per cent less rain than the South East average throughout the year and is generally warmer. This difference is significant so it makes sense for us to look at projections for the borough, even though they are less reliable.

Table 8 - Average weather for the South East and Guildford Borough 1981-2010.

	South East	Guildford borough
Average annual temperature	10.3°C	-
Average January temperature	4.6°C	-
Average minimum January temperature	1.7°C	1.8°C
Average July temperature	17.1°C	-
Average maximum July temperature	22°C	22.9°C
Average summer rainfall	158 mm	144 mm
Average winter rainfall	219 mm	177 mm

Source: Met office climate summary and weather station datasets

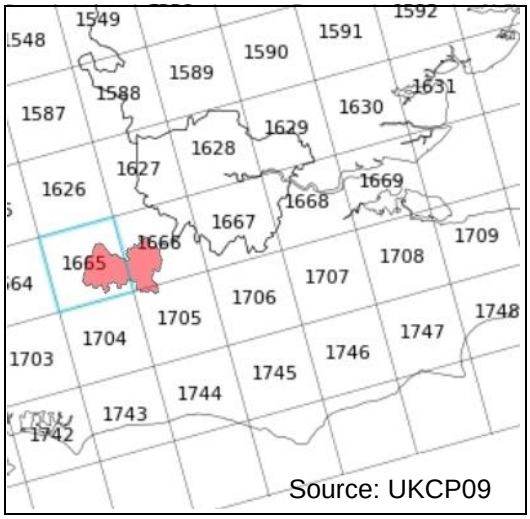

Figure 16 - UKCP09 25km grid squares (Guildford borough in red)

10.26 The projections here are based on 25km grid squares. Our borough spans two grid squares (Figure 16). We have chosen to use the projections for grid square 1665. We have not averaged the data across grid squares 1665 and 1666 as UKCP09 guidance advises not to do this. It is reasonable to assume that as square 1666 has a similar landscape, the projection for grid square 1665 will provide a good picture for the whole borough. 1665 has been chosen over 1666 because it covers two of our urban areas (Guildford and Ash/Tongham) and the larger part of the borough's population.

10.27 The 25km grid square projections give us absolute figures for future climate, rather than percentage change. This is useful because absolute figures are often easier to imagine than amounts of change.

10.28 The absolute projections below span all three emissions scenarios and show three sets of data (Figure 17).

1 - **The baseline** (broken black line) shows average climate conditions for the period 1961 to 1990.

2 - **The likely range of change** (shaded area). Changes are unlikely to exceed of fall short of this range of values. This is explained further in 10.20.

3 - **The limits of possible change** (broken coloured lines) show the absolute maximum or minimum values possible according to the climate models.

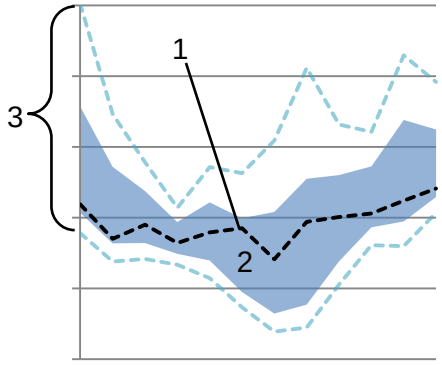

Figure 17 - Key to the UKCP09 climate change projections charts

10.29 The outcomes that fall outside the likely range of change (the coloured shaded area) and inside the outer limits of possible change (the coloured broken line) are considered 'very unlikely' (UKCP09 guidance). The likelihood decreases as you move outwards, decreasing from 10 per cent chance at the edge of the likely range of change to 0.1 per cent chance at the outer limit of possible change.

10.30 We will probably see conditions outside the likely range occasionally, for example during extreme weather events or on the hottest day of summer or wettest day of winter. Figures at these extremes show events with a lower probability but they also reflect unreliability in the climate models. However, we have already seen our weather exceed the most extreme figures for even the 2080s period, as shown by the examples below.

- At the end of 2000, average January daily rainfall far exceeded the seven mm given by the projections as the outer upper limit of change in the 2080s.
- The summer heatwave temperatures in 2003 and 2006 both also exceeded the outer limits of change for the 2020s.

This means the outcomes in the 'very unlikely' range cannot be ignored.

10.31 It is worth noting that conditions in our borough have already changed since the 1961 to 1990 baseline period so we have already seen some of the change shown in the projections below.

10.32 Where seasonal figures are given, seasons cover three months with winter covering December, January and February and summer covering June, July and August.

Precipitation

10.33 Precipitation means water falling in any form (rain, snow, hail etc.). The figures given below are in millimetres of water. We have used percentages to describe the potential change because it can be difficult to visualise volumes of precipitation.

10.34 The projections show that the total amount of annual precipitation in our borough will probably be broadly similar to now, with a change likely to be somewhere between an increase of 11 per cent and a decrease of 4.7 per cent by the 2080s. However, the distribution of precipitation throughout the year could change significantly (Figure 18).

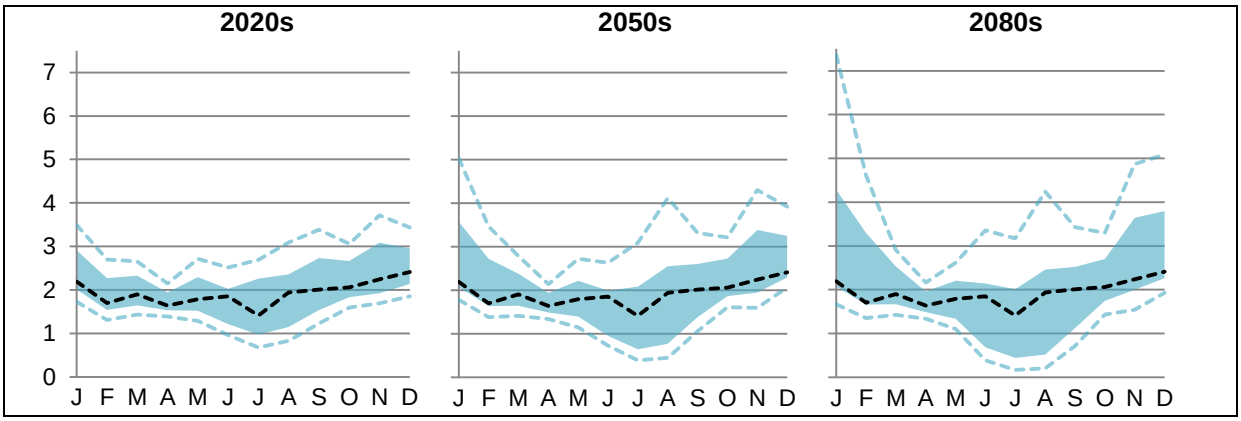

Figure 18 – Projected changes to precipitation patterns (mm per day)

10.35 Winter rainfall could rise or fall but is extremely likely to rise and we could see increases of up to 21, 40 and 63 per cent in the 2020s, 2050s and 2080s. This means up to around 3.5mm per day in the 2080s. This increase could be most pronounced in January and as high as 33, 63 and 96 per cent over the three time periods.

10.36 Summer precipitation could also rise or fall but is more likely to fall. Falls could be up to 31, 54 and 69 per cent in the 2020s, 2050s and 2080s. Summer rainfall has already decreased over the past 45 years (Met Office, 2010). In extreme cases, summer rainfall could fall to a fraction of the baseline.

10.37 The report *Changes in the frequency of extreme rainfall events for selected towns and cities* from the Met Office (2010) states that over the past 45 years winter rainfall has become concentrated in heavy rainfall events. It also states that under the UKCP09 medium emissions scenario this trend is projected to continue, with winter heavy rainfall events becoming more frequent and most of this change to occur between now and 2040. There is uncertainty over summer heavy rainfall events, which are slightly likely to become more frequent but could also become less frequent. South Central England (including Surrey) will see the biggest increase in frequency of heavy rainfall events that currently occur on average every five and 10 years. These changes occur under the all the emissions scenarios but are more pronounced under the high emissions scenario and less so under the low emissions scenario.

10.38 Summary:

- Little change in total annual precipitation

- Big increases in winter precipitation by up to 21 per cent (2020s), 40 per cent (2050s) and 63 per cent (2080s)
- Very big increases in precipitation in January by up to 33 per cent (2020s), 63 per cent (2050s) and 69 per cent (2080s)
- Very likely increase in the frequency and severity of extreme winter snow/rainfall events
- Probable decreases in summer precipitation of up to 31 per cent (2020s), 54 per cent (2050s) and 69 per cent (2080s)
- Possibility of extremely wet winters and extremely dry summers

Temperature

10.39 The 25km climate projections look at the impact that the shape of the land will have on local climate and weather. However, they do not consider the distribution of temperatures within grid squares caused by the Urban Heat Island (UHI) effect. UHI describes the situation where urban areas become significantly hotter than the surrounding rural areas. This is caused by the shape of the urban area, the materials it is made from and the concentration of human activity within it.

10.40 Our buildings and roads are made from materials that tend to absorb and store more heat than natural spaces. The arrangement of high buildings affect the rate at which heat escapes so urban areas cool more slowly at night. The UHI effect is generally more pronounced at night and in summer and can mean that urban areas similar to Guildford or Ash and Tongham are up to five degrees hotter than the surrounding countryside. However, the UHI effect is currently not well understood so it is difficult to know how big the impact will be.

10.41 These climate projections already include the warming effect of urban areas within grid square 1665 (including Guildford, Ash and Tongham, Godalming, Farnham, Aldershot, Farnborough and Camberley) and show us the projected average temperature across the grid square. However, they do not tell us about the distribution of temperature within the grid square, so we can assume that temperatures in urban areas would tend to be higher than the projections show, and that temperatures in rural areas would tend to be lower. This will be especially true in summer and at night.

10.42 The projections suggest that mean daily minimum and maximum temperatures are extremely likely to increase (Figure 19) with mean daily maximum temperatures in summer possibly reaching 24.5, 27.8 and 31.8°C in the 2020s, 2050s and 2080s respectively. These are very significant increases on the baseline temperature of 20.6°C.

10.43 In July, the hottest month, mean daily maximum temperatures could increase to 25.3, 28.5 and 32.5°C in the same periods from a baseline temperature of 21.5. It is worth noting that weather station data from around our borough shows that during the most recent three-decade period, the July mean daily maximum temperature was 22.9 °C.

10.44 Mean daily maximum temperatures in winter show a smaller potential for increase, with maximums up to 9.3, 11 and 13°C in the 2020s, 2050s and 2080s respectively against a baseline of 7°C.

10.45 Mean daily minimum temperatures show slightly smaller potential for increase, with the summer increase the greatest. From a baseline of 0.9°C, winter mean daily minimum temperatures could increase to 3.5, 5.5 and 7.7°C in the 2020s, 2050s, and 2080s.

10.46 Mean daily minimum temperatures in summer could increase from a baseline of 10.5°C to 13.5, 16 and 19.2°C degrees across the same periods. It is likely that this will mean the UHI effect becomes more pronounced as warmer night time temperatures mean urban areas will be less able to cool down in between hot days.

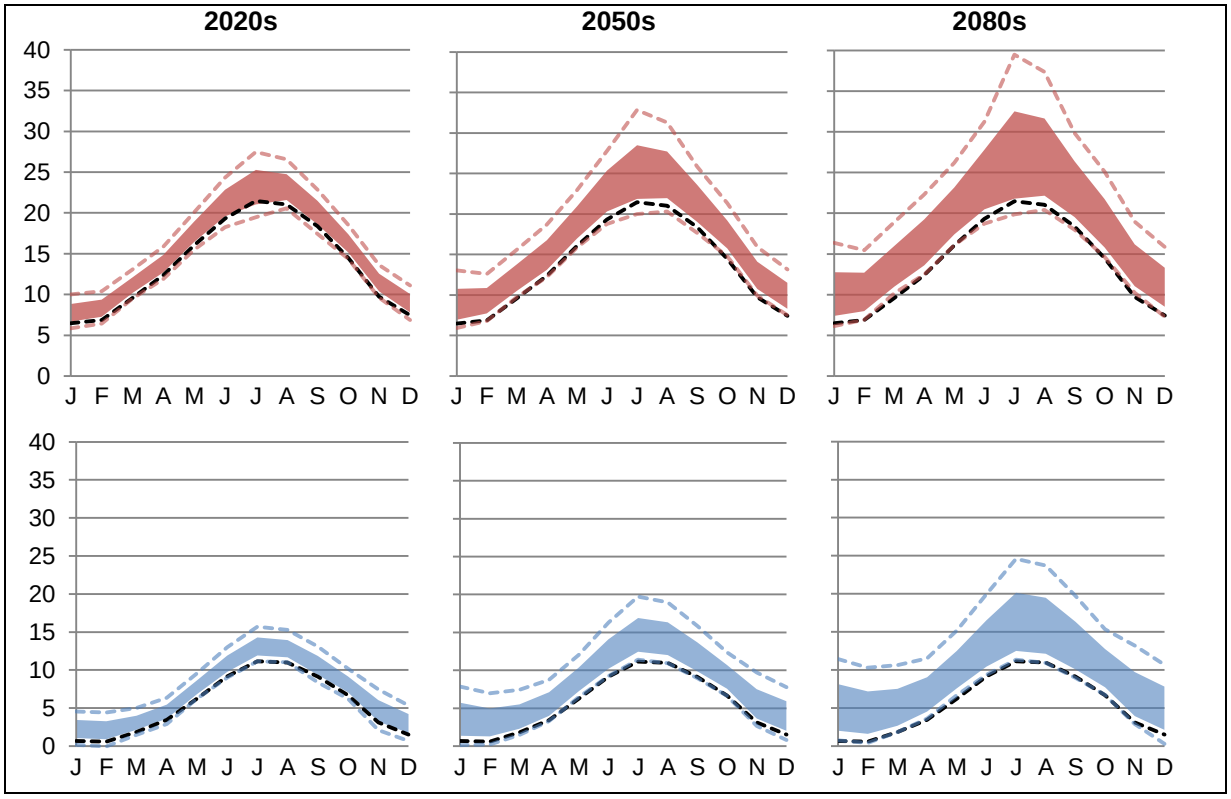

Figure 19- Projected changes to mean daily maximum (top) and mean daily minimum (bottom) air temperatures (°C)

10.47 The potential for heatwaves increases significantly throughout the three periods. The outer limits of possible change show the potential for temperatures to reach 27.5, 32.9 and 39.5°C in the 2020s, 2050s and 2080s respectively.

10.48 Summary:

- Big increases in mean daily maximum temperatures, biggest in summer
  - up to 24.5°C (2020s), 27.8°C (2050s) and 31.8°C (2080s) in summer against a baseline of 20.6°C
  - up to 25.3°C (2020s), 28.5°C (2050s) and 32.5°C (2080s) in July against a baseline of 21.5°C
  - up to 9.3°C (2020s), 11°C (2050s) and 13°C (2080s) in winter against a baseline of 7°C
- Big increases in mean daily minimum temperatures

- up to 13.5°C (2020s), 16°C (2050s) and 19.2°C (2080s) in summer against a baseline of 10.5°C
- up to 3.5°C (2020s), 5.5°C (2050s) and 7.7°C (2080s) in winter against a baseline 0.9°C

- Potential for heatwaves to reach 27.5°C (2020s), 32.9°C (2050s) and 39.5°C (2080s)
- Urban Heat Island effect could become more pronounced

Cloud cover and humidity

10.49 Figure 20 shows projections of cloud cover and air humidity. The figures given are a percentage, with 100 per cent being total cloud cover or totally saturated air. The humidity data refers to relative humidity, which depends upon air temperature as warmer air can transport more water, so humidity will be affected by the temperature change discussed above. Both datasets show little potential for change in the winter months.

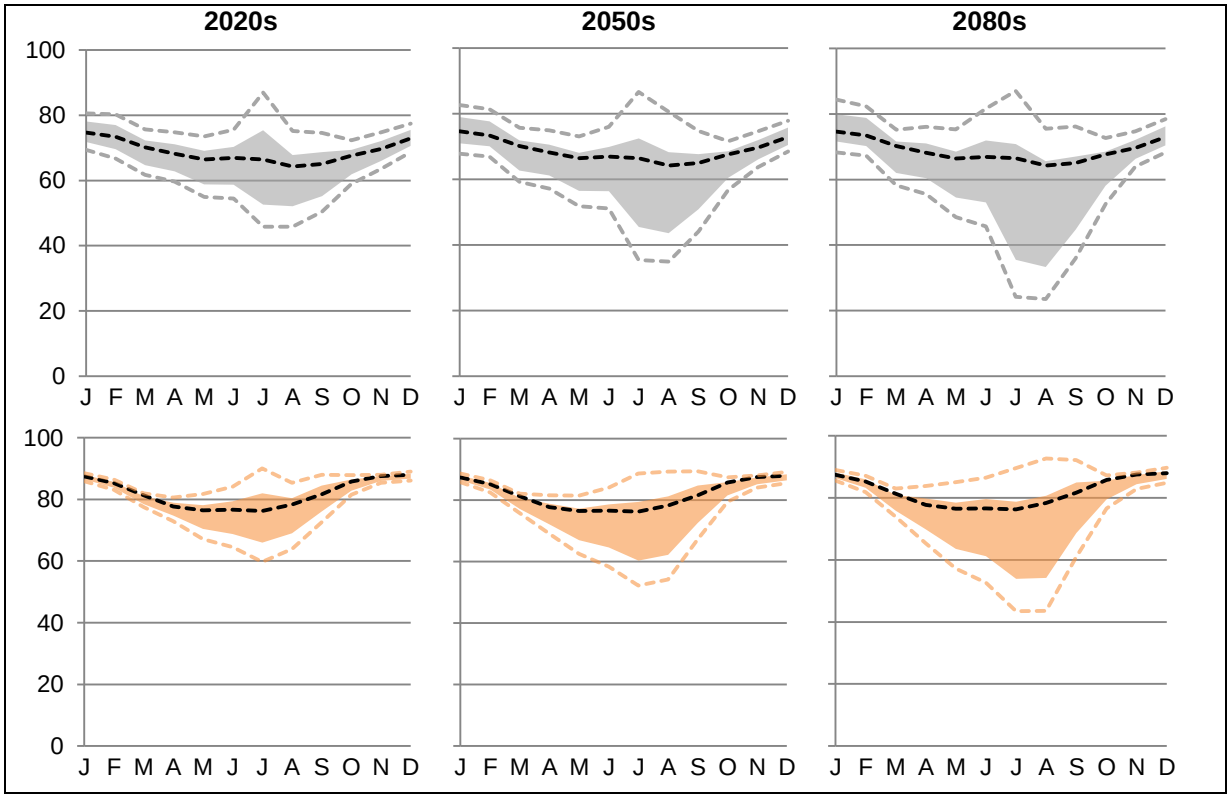

Figure 20 - Projected changes to cloud cover (top) and humidity (bottom) (per cent cloud cover and per cent humidity)

10.50 The projections show that cloud cover could increase or decrease throughout the year but is likely to decrease in the summer months, down to 56, 50 and 43 per cent cloud cover in the 2020s, 2050s and 2080s respectively against a baseline of 66 per cent. Days in the summer are likely to be sunnier, and sunny days are likely to be more frequent.

10.51 This will be most pronounced in August when cloud cover could fall below 52, 44 and 33 per cent on average in the 2020s, 2050s and 2080s, against a baseline of 64 per cent. In extreme cases, the outer limits of change show this could fall as low as 23 per cent by 2080.

10.52 Humidity is also likely to decrease in a similar pattern. Summer humidity could fall from a baseline of 77 per cent to 70, 64 or 59 per cent in the 2020s, 2050s and 2080s respectively. This could be a few per cent lower in July.

10.53 Summary:

- Very little change in the winter months
- Potential for significant reduction in cloud cover in summer, with cloud cover reducing to 56 per cent (2020s), 50 per cent (2050s) and 43 per cent (2080s) against a baseline of 66 per cent
- Potential for significant fall in summer humidity to 70 per cent (2020s), 64 per cent (2050s) and 59 per cent (2080s) against a baseline of 77 per cent

What this means for us

10.54 While confidence in the projections for grid square 1665 is less than 'moderate', they are pointing to largely the same thing as the projections for the South East and for Europe, which have higher confidence levels.

10.55 The projections demonstrate that there is potential for extreme change in typical temperatures and rainfall patterns. Freak weather events also have the potential to become a lot more severe than they have been in the past.

10.56 What the projections also demonstrate very clearly is that there is a large amount of uncertainty in what the future climate will look like. This uncertainty increases the further forward we look. As an example, in the UKCP09 absolute projections for our borough the mean maximum daily temperature in summer in the 2080s may be as low as 22°C, which is similar to present day Tours, France, or as high as 32°C, which is similar to present day Larnaca in Cyprus.

10.57 We expect that better information will become more available as climate science and the technologies used in modelling improve, and this may mean there will be more certainty in the projections in the future. There will be a chance to review our strategy at a later date, potentially at the next local plan period. However, the potential for extreme change, and the possibility that change may come quickly, as the 2020s projections show, means we will need to make plans for adaptation to begin in this plan period.

10.58 Any plans we make to meet the challenge of climate change will need to be adaptable to deal with both the uncertainty and the range of climate conditions we are likely to experience over the coming decades. Developments we build in this plan period will need to be both resilient to climate change and adaptable to a range of climates so we can avoid costly and resource heavy refurbishment and retrofitting later on.