



Climate Change and the Historic Environment



ENGLISH HERITAGE



Climate change is one of the most important and urgent problems facing us today. Without action to reduce greenhouse gas emissions, the direct impacts of a changing climate will have major adverse effects on society, the economy and the environment, including our cultural heritage. The wide-ranging actions required to limit further damaging emissions, combined with the need to adapt historic assets to make them more resilient to a changing climate, will also have significant implications for the historic environment.

English Heritage is the Government's adviser on the historic environment. Our responsibilities include the understanding and conservation of archaeology on land and under water; historic buildings, sites and areas; designed landscapes and the historic aspects of the wider landscape. We also manage an estate of more than 400 historic properties.

This statement, which updates and replaces our 2006 position paper, sets out our current thinking on the implications of climate change for the historic environment. It is intended both for the heritage sector and also for those involved in the wider scientific and technical aspects of climate change; in the development of strategies and plans relating to climate change impacts; or in projects relating to risk assessment, adaptation and mitigation.

Alongside this high-level statement, English Heritage continues to publish more detailed research and guidance relating to climate change and its implications for the historic environment. These publications are listed in this document and are available at the *Historic Environment – Local Management* website: www.helm.org.uk/climatechange and the English Heritage website: www.english-heritage.org.uk

OUR CHANGING CLIMATE

Although the Earth's climate changes continually, and often dramatically, as a result of natural processes, there is now a strong scientific consensus that greenhouse gas emissions resulting from human actions are causing significant additional and very rapid changes to the climate. These changes will have a major adverse impact on the environment, on society and on the economy.

During 2007 the Inter-Governmental Panel on Climate Change (IPCC 2007a to d) published its Fourth Assessment Report. IPCC Working Group I, charged with examining the physical science basis for climate change, concluded that global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. Working Group I also noted that due to an improved understanding of anthropogenic

warming and cooling influences on climate they were very highly confident (90 per cent certain) that the globally averaged net effect of human activities since 1750 has been one of warming.

Among the climate changes noted by Working Group I were:

- Eleven of the 12 years between 1995 and 2006 rank among the 12 warmest years in the instrumental record of global surface temperature, available since 1850. The linear warming trend over the last 50 years is nearly twice that for the last 100 years, with average global surface temperature rising by 0.74°C between 1906 and 2005.
- Widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights, and heat waves have become more frequent.

The historic environment is vulnerable to changes in the climate

01 Storm damage at Ashridge Estate, Hertfordshire after the January 1990 storm.

© NTPL/Rob Judges

02 Clavell Tower, Kimmeridge Bay, Dorset during work to relocate it further from the eroding cliff edge.

© The Landmark Trust

03 An extensive fire at Fylingdales Moor in 2003, following a very dry summer; caused damage to important archaeological sites.
© English Heritage

- Expansion of sea water as a result of warming together with melting of glaciers and the ice caps mean that global average sea level rose at an average rate of 1.8mm per year between 1961 and 2003. The rate was faster over 1993 to 2003, at about 3.1mm per year; with the total 20th-century rise estimated to be between 0.12 and 0.22m.
- Since the 1970s, higher temperatures and decreased precipitation have led to more intense and longer droughts over wider areas, particularly in the tropics and subtropics.
- The frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour.
- Although there is no clear trend in the annual numbers of tropical cyclones, there is observational evidence for an increase of intense tropical cyclone activity in the North Atlantic since about 1970, correlating with increases of tropical sea surface temperatures.

Drawing on these observations and recent climate modelling at the international level, IPCC Working Group I suggests that for the next two decades a warming of about 0.2°C per decade is projected for a range of differing greenhouse gas-emission scenarios, with further emissions at or above current rates causing additional warming. As a result, best estimates suggest that by the end of the 21st century temperatures could rise by between 1.8 and 4°C or, if all uncertainties are taken into account, between 1.1 and 6.4°C. The working group believes this projected warming may increase the frequency of heat waves and heavy precipitation events and may also increase the intensity of storm events, although the number of these events may decrease.

Working Group I also predicts an average rise in sea levels globally of between 0.18 and 0.59m relative to 1980 to 1999 levels by the end of the century.



It should be noted, however, that in reaching this conclusion IPCC chose not to include the full effects of ice sheet flow, given the considerable uncertainty about this process, so these figures may be an underestimate.

In October 2006, Sir Nicholas Stern, Head of the Government Economic Service and former World Bank Chief Economist, published his independent review on the economics of climate change (Stern 2007). The review concluded that there is still time to avoid the worst impacts of climate change, if concerted action is taken now. It estimated that the impact of unmitigated climate change will be equivalent to a permanent loss in world consumption per head of at least 5 per cent and, if a wider range of risks and impacts is taken into account, potentially as much as 20 per cent of global GDP each year. In contrast, the costs of stabilising the climate were considered to be significant but manageable. Action to reduce greenhouse gas emissions in order to avoid the worst impacts of climate change was calculated as costing around 1 per cent of global GDP each year.

The Stern report also highlights the effects of uncertainty on the way in which climate change impacts on society, the environment and the economy and how these impacts should be assessed. Uncertainty about the occurrence and impact of large-scale climate change events implies that measures to adapt to and mitigate the impacts of climate change should adopt a precautionary approach. Stern also makes recommendations about the appropriate approach to international co-operation in taking forward action on climate change.

CLIMATE CHANGE IN THE UK

The latest assessment of the climate of the United Kingdom and recent trends by the UK Climate Impacts Programme (UKCIP) agrees with the IPCC Fourth Assessment Report that warming of the global climate system is unequivocal and that man-made greenhouse gas emissions have caused most of the observed temperature rise since the mid 20th-century (Jenkins *et al* 2007). In addition it concludes that:

- Central England temperature has risen by about a degree Celsius since the 1970s, with 2006 being the warmest on record.

- Annual mean precipitation over England and Wales has not changed significantly since records began in 1766. Seasonal rainfall is highly variable, but appears to have decreased in summer and increased in winter, although with little change in the latter over the last 50 years.
- All regions of the UK have experienced an increase over the past 45 years in the contribution to winter rainfall from heavy precipitation events; in summer all regions except north-east England and northern Scotland show decreases.
- There has been considerable variability in the North Atlantic Oscillation, but with no significant trend over the past few decades.
- Severe windstorms around the UK have become more frequent in the past few decades, though not above the level seen in the 1920s.
- Sea-surface temperatures around the UK coast have risen over the past three decades by about 0.7°C.
- Sea level around the UK rose by about 1mm per year in the 20th century, corrected for land movement. The rate for the 1990s and 2000s has been higher than this.

In 2002, in order to assist long-term planning for future climate change, a series of scenarios for climate change in the UK was published by the UK Climate Impacts Programme (UKCIP) on behalf of Defra (Hulme *et al* 2002). These scenarios suggest that:

- Average annual temperatures across the UK may rise by between 2°C and 3.5°C by the 2080s, depending on the future scale of global emissions of greenhouse gases; in general, there will be greater warming in the South-East, where temperatures may rise by up to 5°C in summer by the 2080s; high summer temperatures will become more frequent and cold winters increasingly rare.
- Winters may become wetter and summers may become drier across the UK, with the biggest relative changes in the South and East; summer precipitation may decrease by 50 per cent by the 2080s in the South-East, while heavy winter precipitation will become more frequent.

Any increase in flooding and soil erosion will put historic settlements and archaeological sites at risk and threaten the integrity and economic contribution of our heritage.

04 Flooding at Tewkesbury, Gloucestershire, in July 2007.
© Reuters/Stephen Hird. RTR1553K

05 Flooding in the historic centre of York in 2000. © English Heritage

06 Severe gully erosion, Flitwick, Bedfordshire, in the autumn of 2000, one of the wettest on record.
© Cranfield University

- Relative sea level will continue to rise around most of England, in line with global changes but with local variations due to land movement; in south-east England, sea level may rise between 260mm and 860mm by the 2080s.

During the course of 2008 UKCIP will issue a new set of climate change scenarios for the UK. These updated scenarios are likely to provide a better basis for predictions of the possible impacts of climate change on the historic environment than previous scenario exercises and should also help users of such predictive exercises to understand the ranges of uncertainty associated with them (UKCIP08).

THE FRAMEWORK FOR ACTION

Under the Kyoto Protocol, the UK is pledged to reduce total greenhouse gas emissions by 12.5 per cent below 1990 levels by 2008–12. The UK Government has also set a domestic goal of reducing carbon dioxide emissions by 20 per cent below 1990 levels by 2010, with a longer term aim of cutting carbon dioxide emissions by 60 per cent by about 2050, towards which real progress will be made by 2020. The UK is one of the few countries likely to meet and exceed targets for greenhouse gas emissions reductions under the protocol and is now working towards the establishment of a successor international framework for the period from 2012 onwards.

In 2007, the European Union Heads of Government agreed a binding target to reduce Europe's greenhouse gas emissions below 1990 levels by at least 20 per cent by 2020 and to increase this commitment to a 30 per cent reduction as part of a wider international agreement. They also committed to increasing the use of renewable energy sources so that they make up 20 per cent of EU energy consumption by 2020; ensuring that a minimum of 10 per cent of EU transport petrol and diesel consumption comes from bio-fuels by 2020; and reducing overall EU energy consumption by 20 per cent by 2020 through energy efficiency measures.



A changing coastline threatens historic buildings and sites. Responses need to be planned as early as possible.

07 Coastal defence work adjacent to a Martello tower threatened by erosion at Slaughden, Suffolk. © English Heritage

08 The English Heritage-funded Rapid Coastal Zone Assessment

survey programme allows risks to historic assets to be assessed at national and local levels. © English Heritage

09 Erosion of Second World War defences at Ringborough, near Aldbrough East Yorkshire, demonstrates the rapid pace of coastal change © English Heritage

The Government's overarching Climate Change Strategic Framework for the UK (Defra 2007a) sets out the broad direction of travel on future policy. Key areas for action identified by the framework are incentives for energy-efficient and low-carbon investment delivered through emissions trading, taxation, and regulation; driving the transformation of new low-carbon technologies, in particular through Government procurement and subsidy; and promoting significant modifications to personal behaviour on issues relating to a changing climate.

The revised UK Climate Change Programme (HM Government 2006) is designed to deliver progress towards international and domestic commitments on greenhouse gas emissions, with progress reported annually to Parliament. The first progress report was published in July 2007 (Defra 2007b). Among key developments as part of the programme are:

- the establishment of The Office of Climate Change (www.occ.gov.uk) in October 2006 in order to co-ordinate climate change policy across Government
- the independent review of the economics of climate change, by Sir Nicholas Stern (see above)
- a Climate Change Bill (2007), which is intended to put in place a legally binding framework to enable the UK to meet and, if possible, exceed these international obligations. Through a combination of domestic and international action, the proposed Act will require the UK to reduce its contribution to carbon dioxide emissions by between 26 and 32 per cent below 1990 levels by 2020 and by 60 per cent by 2050. In order to achieve these reductions, the Act will establish five-year carbon budgets, based on recommendations by an independent Committee on Climate Change, and will require independent annual reporting of progress to Parliament



- the Energy White Paper Meeting the Energy Challenge (DTI 2007), which sets out the strategy for reducing emissions of greenhouse gases arising from energy production and consumption while ensuring security of supply. The package of policies in the White Paper could save between 84 and 121 million tonnes of carbon dioxide by 2020
- an adaptation policy framework, which identifies priority areas for adaptation and defines the roles and responsibilities of Government Departments in delivering action
- a raft of initiatives launched in 2007 aimed at the energy efficiency of the built environment, particularly the housing sector. These are designed to implement the duty placed on the Secretary of State by the Housing Act 2004 to take reasonable steps to improve residential energy efficiency by at least 20 per cent by 2010 from a year 2000 baseline. The most recent measures include the Code for Sustainable Homes (www.planningportal.gov.uk), which sets new national voluntary standards, including ones on energy efficiency for the sustainable design and construction of new homes; the Zero Carbon Homes initiative, which proposes a progressive tightening of energy-efficiency standards in the Building Regulations, rising to a zero carbon target in 2016; proposed changes to Permitted Development Rights for micro-generation to make it easier for householders to install micro-generation technologies; and a new Supplement to *Planning Policy Statement 1: Delivering Sustainable Development* (ODPM 2005), setting out how participants in the planning process should work towards reducing carbon emissions in the location, siting and design of new development.

Local authorities already have a series of targets to improve the energy efficiency of the housing stock. The Home Energy Conservation Act (1995) requires them to improve the energy efficiency of residential accommodation in their area, with Government recommending a target of a 30 per cent improvement by 2011. The local government performance framework requires councils to use the Standard Assessment Procedure (SAP) to report on the average energy efficiency rating of the local authority-owned housing stock and the 2006 Local Government White Paper proposed they should report on the percentage annual reduction achieved in CO₂ emissions in both the local authority estate and across the community.

CLIMATE CHANGE AND THE HISTORIC ENVIRONMENT

Many historic buildings, sites and landscapes have already experienced and survived significant climatic changes in the past and may demonstrate considerable resilience in the face of future climate change. However, many more historic assets are potentially at risk from the direct impacts of future climate change. Without action to adapt to a changing climate and limit further changes it is likely that these will be irreparably damaged and the cultural, social and economic benefits they provide will also be lost. Equally, the significance and integrity of important historic assets can be threatened by poorly designed adaptation and mitigation responses. The non-renewable character of historic features and the potential for their damage and loss should, therefore, always be taken into account when adaptation and mitigation responses are being planned and executed.

Some implications of the direct and indirect impacts of climate change on historic assets are considered further below. Detailed English Heritage guidance is also available on a number of these topics (see Key Sources).

Direct impacts

Direct impacts of climate change on the historic environment may include:

- rising sea levels and a possible increase in storminess that endangers historic landscapes, structures, buildings and archaeology in the coastal zone
- increased extremes of wetting and drying that heighten the risk of ground subsidence and accelerated decay of stonework and thus pose a threat to many historic buildings
- more frequent intense rainfall that causes increased erosion of archaeological sites and damaging flooding in historic settlements, the latter making historic buildings difficult to insure
- changes in hydrology that put buried archaeological remains, including well-preserved wetland archaeology, at risk
- changes in vegetation patterns that threaten the visibility and integrity of archaeological remains and historic landscapes

10



The implications of renewable energy projects for historic buildings, sites and landscapes and their settings should be evaluated at an early stage in project planning.

10 Prehistoric standing stone and wind turbines on St Breock Down, Cornwall. © *English Heritage*

11 *Miscanthus* planting near Sutton Church, Cambridgeshire. © *English Heritage*

Well-designed adaptation and mitigation measures can often be accommodated in historic buildings without loss of their special interest

12 Photo-voltaic array installed on the roof of St James's, Piccadilly, London, a Grade I-listed 17th-century church. © *Simon Dawson, St James's Church Piccadilly*

13 Historic Gibson Mill, Hardcastle Crag, West Yorkshire, provides a model of sustainable development with its power generated on site, using renewable sources including water power. © *National Trust*

11



- a warming climate that makes some historically authentic tree plantings difficult to conserve
- changes in the distribution of pests that threatens the integrity of historic buildings, collections and designed landscapes
- possible increases in the frequency or geographical range of extreme weather that could pose an increased risk of damage to some historic landscapes and buildings.

12



Impacts from adaptive responses

Some adaptive responses to climate change may themselves have an impact on the historic environment, for example:

- 'Hard' coastal defence is seen as untenable on much of the undeveloped coast and has led to a new emphasis on selective managed realignment and 'soft' defences (such as salt marsh), posing a possible risk to archaeology, buildings and landscapes.
- New flood defences, particularly in historic towns, can cause major archaeological damage along historic waterfronts and may impair the character of historic quaysides and waterside buildings and gardens.
- The design integrity of some historic buildings and landscapes could be damaged by the need to provide new and more effective rainwater disposal or storage systems or flood protection features.
- Alteration of agricultural and forestry practices, resulting from changes in crop, stock or species viability, could pose a risk to buried archaeological sites, traditional farm buildings and historic landscapes.

13



ENERGY EFFICIENCY AND HISTORIC BUILDINGS

Existing homes are likely to account for two-thirds of the total housing stock by 2050, with a quarter of these homes employing traditional construction methods. Because some 46 per cent of carbon dioxide emissions in the UK is attributed to the energy requirements of buildings, with approximately half of this total from dwellings (BERR 2007, CLG 2007a), upgrading the energy efficiency of traditional buildings has a fundamentally important role to play in meeting targets for reducing emissions.

It is, however, incorrect to assume that the older a building is the less energy efficient it is. Many historic buildings perform well in terms of energy efficiency (eg Yates 2006). The thick walls and small windows of many vernacular buildings provide them with a high thermal mass that keeps them warmer in winter and cooler in summer; while terraces can be more energy-efficient than some detached houses because of their smaller surface area. In a hotter climate, the natural ventilation, high ceilings and generous proportions of many historic buildings may also make energy-intensive air conditioning less necessary than in more recent structures.

Policy makers planning for climate change are faced with a lack of reliable data about the behaviour of historic buildings. Most assessments of energy use are based on theoretical models and produce results that conflict with actual measurements of the behaviour of historic structures. English Heritage is concerned that poorly founded assumptions that modern buildings inevitably out-perform older ones could result in proposals to demolish housing stock to make way for new-build. It must always be remembered that any historic building represents a significant past investment of energy and materials. Demolition and replacement means not only losing all of the resources embodied in the original buildings, but also the investment of yet more energy for demolition, the creation and delivery of new construction materials, the building process itself, and the disposal of the resulting waste. In 2000 the manufacture and transport of building materials accounted for more than 10 per cent of UK carbon dioxide emissions (English Heritage 2007e) and the report, *Resource Productivity*, noted that 'Over 90 per cent of non-energy minerals extracted in Great Britain are used to supply the construction industry with materials ... yet each year some 70 million tonnes of construction and demolition materials and soil end up as waste' (PIU 2000), accounting for 24 per cent of the total waste in the UK.

Any sustainability appraisal of historic building stock should be informed by a wide range of factors including:

- the cultural and social significance of the existing stock
- the whole-life energy costs of new stock, its lifespan and durability
- the residual-life energy costs of the existing stock, allowing for strategies to increase its thermal efficiency
- the sustainability of new stock in terms of both energy and materials
- the effect of the generous green spaces associated with many historic buildings, in mitigating some climate change effects.

It is important to make every reasonable alteration to the existing building stock that can mitigate climate change. Often the energy efficiency of historic buildings can be increased in ways sympathetic to their historic character (eg through draught-proofing, improved insulation or bringing internal shutters back into use). Changing to a condensing flue gas boiler and introducing secondary glazing can also significantly improve thermal performance (English Heritage 2004a). A less wasteful approach to heating could be adopted in many publicly accessible historic buildings than is currently the case. The use of humidistat controls in these buildings, rather than thermostats, may not only reduce the demand for energy but also mitigate the adverse effects on historic fabric of fluctuating temperatures and humidity. It should also be recognised that historic building materials are often more durable than modern replacements and more cost-effective in energy terms. Traditional softwood window frames can have an almost indefinite life if properly maintained, whereas many PVCu windows may not last long enough to repay their installation costs from energy savings.

Alterations to historic buildings should always be considered carefully to ensure that they do not cause buildings that were previously functioning well to fail. When we make changes to a building, we need to be absolutely certain they are the right ones to make in terms of climate change, the longevity of the building and the health and comfort of the occupants.

Our advice to householders on improving the energy efficiency of historic properties will become available during the course of 2008 at the *Climate Change and your Home* website at: www.english-heritage.org.uk/climatechangeandyourhome

The impact of policies to mitigate future climate change

Developments designed to generate renewable energy – like any other infrastructure developments – can have a wide variety of impacts, both positive and negative, that vary from the insignificant to the unacceptable. The benefits delivered by these new technologies can also vary considerably, particularly when considered on a whole-life basis. It is always important, therefore, to evaluate these benefits and impacts on a case-by-case basis. Among typical issues that will need to be considered are:

- The construction of new renewable energy infrastructure, including hydro-electric and tidal plants and onshore and offshore wind farms, may have direct impacts on archaeological remains.
- Wind farms need to be carefully sited to avoid compromising significant landscapes, or the visual setting of important sites or buildings where the integrity of that setting is an important part of their significance.
- The introduction of new biomass crops may pose a risk to buried archaeology through deeper disturbance and lowered water tables, or it may radically change the appearance of historically significant landscapes. The impact of other initiatives, such as the re-use of existing coppiced woodland, may be entirely positive.
- Some types of micro-generation equipment, such as mini wind turbines, or micro combined heat and power plants, are unlikely to present problems if sensitively located on historic buildings; others may be more visually intrusive and difficult to accommodate. Consideration should be given to minimising physical impacts on the historic fabric of buildings and ensuring reversibility wherever practicable.
- Poorly designed or inappropriate energy-saving measures could seriously detract from the historic character and fabric of buildings and landscapes, whereas well-designed measures can make considerable savings with little or no damage. Proposals to replace historic buildings with new stock that is ostensibly more energy-efficient (for example, Boardman *et al* 2005) could result in serious losses of historic character and diversity.

THE CONTRIBUTION OF THE HISTORIC ENVIRONMENT TO UNDERSTANDING, MITIGATION AND ADAPTATION

The past has witnessed significant climatic change and today's historic sites, buildings and landscapes provide an unparalleled source of information on these long-term fluctuations, on human responses to them and on past approaches to living in a low-energy economy. It is important this evidence is not neglected as we consider how to adapt in the future.

The evidence of past climate change preserved in the archaeological and environmental record extends back for thousands of years – much further than the observational evidence of the modern era that provides much of the basis for current climate change projections. This long-term perspective, together with the detailed geographical and temporal resolution provided by archaeological investigation, offers considerable potential to refine climate-change models in the future. Similar considerations apply to maritime and marine archaeological deposits, which can greatly enhance understanding of coastal processes. Wetlands, including peat deposits, are an important repository of this information on past environmental change. Wetlands are, however, extremely vulnerable to climatic change and deteriorating peatlands are now recognised as an important source of greenhouse gas emissions, releasing as much carbon dioxide into the atmosphere annually in the UK as the entire terrestrial transport system. The active conservation of peat deposits can, therefore, not only protect their high archaeological potential and safeguard the evidence they contain about past climate change, but also reduce damaging carbon emissions.

For many people in England today, the historic environment provides the setting for their day-to-day life. Many of us make our homes in older buildings, whether iconic half-timbered thatched houses or the more ubiquitous 19th-century terraces. This historic building stock has met with, adapted to and survived changes in both climate and society. Its survival is a mark of its fitness-for-purpose: buildings that cannot cope with storm and flood, or with changes of use, are for the most part quickly lost or replaced.

The 20th century saw a revolution in materials and techniques of building. Solid wall construction in brick and stone was replaced by reinforced concrete, concrete block, and curtain-wall architecture.

The entire approach to how a building excluded rainwater – its central purpose – also changed, from dense permeable materials that buffered changes in humidity by exchanging moisture with the ambient air, to thin waterproof membranes, layered to intercept water. Glass, once the most expensive of materials, began to be used in sheets, even forming the greater part of the external building walls. The ramifications of this revolution have still to be completely understood – not least, the implications for energy efficiency and climate change mitigation.

This building stock, in all its breadth and range, provides a wealth of data about how we might approach design and planning for a low-carbon economy. We do know that traditional construction techniques and materials were developed in, and designed for, a world where energy was expensive. Until the Industrial Revolution made transport cheap, materials and labour were locally sourced wherever possible, and the buildings were designed to require the minimum of special care and maintenance. The result was not necessarily 'best practice', but it is perhaps no surprise that traditionally constructed buildings come out well whenever studies measure actual energy use in buildings.

Historic towns, too, evolved in a low-energy economy. Traditional mixed-use neighbourhoods, built to a high density and providing their essential services within walking distance, offer a good model of sustainable development that requires less traffic movement and fewer building services than their modern counterparts. The provision of parks, open spaces and trees and the development of private gardens and allotments in historic towns also have much to offer for sustainable communities. This inherited pattern of green space is highly valued as part of the amenity and character of an area and, with the hotter and drier summers and extended seasons predicted for the future, it is likely we will see a greater demand for green spaces as people spend more time outdoors. However, in some cities this range of green spaces and features like mature trees are disappearing due to infill housing development. Consideration needs to be given to the sustainability of this approach, as research is beginning to show the potential importance of these features for tempering hotter summer temperatures, heavy rainfall and poor air quality, as well as helping to conserve wildlife (CLG 2007b and McEvoy *et al* 2006). Modelling work has shown, for example, that a 10 per cent loss of green cover in Manchester could result in an 8.2°C increase in ground temperatures by the 2080s.

Historic settlement patterns may also provide alternative models for living in the countryside. Current spatial planning policy for rural areas favours development and service provision in nucleated settlements. However, for many centuries, more dispersed settlement patterns were the norm for large areas of England. These historic patterns of dispersed settlement with their live-work dwelling places and the capability for producing energy locally from watermills, windmills and surrounding woodland, may provide an alternative model for sustainable rural development (CRC 2007).

ENGLISH HERITAGE POLICY ON RESPONDING TO CLIMATE CHANGE

Without action to mitigate and respond to its impacts, climate change will cause severe disruption to society and inflict serious impacts on the environment, including the historic environment. It will damage or destroy many historic assets and may significantly impair the ability of future generations to understand and enjoy their cultural heritage.

English Heritage therefore recognises the urgent need to reduce greenhouse gas emissions by decreasing fossil fuel use, increasing energy efficiency and exploiting low carbon technologies and renewable energy sources. We also recognise the need for today's built environment to be adapted to become more resilient to unavoidable climate change over the next 20 to 40 years. Nevertheless, we also recognise that some policies for adaptation and mitigation may have a damaging effect on historic buildings, sites and landscapes. These impacts can diminish the public's quality of life and be detrimental to the important social and economic contribution our cultural heritage makes to society. These impacts should always be taken into account when policy is being formulated and English Heritage is committed to working with others to avoid or minimise any adverse impacts, while delivering the necessary changes.

We will continue to develop our policy in line with the best available scientific opinion, in particular the advice of the IPCC, and we will continue to advise the government and others on the implications of climate change on the historic environment with the aim of reducing the risks it may pose to historic assets.

RESPONDING TO CLIMATE CHANGE: ACTION BY ENGLISH HERITAGE

English Heritage has been responding to the challenges posed by climate change for more than a decade:

1997

- We publish *After the Storms* (English Heritage 1997) looking at the longer term impact of the 1987 great storm.

1998

- We commission the first in a series of rapid coastal archaeological surveys in order to allow us to respond to government policy on coastal defence in the face of climate change.

2000

- We publish guidance on protecting historic churches from lightning (English Heritage 2000), augmented in 2003 with guidance on protecting historic buildings from electrical surges (English Heritage 2003b).

2002

- We commission a scoping study on the implications of climate change for the historic environment by University College London. Published in 2005, this served to illustrate possible approaches to future research (Cassar 2005).
- With a wide range of partners we co-fund the UK Climate Impacts Programme (UKCIP) to undertake a study of the potential impacts of climate change on UK gardens, garden plants and the garden industry (Bisgrove and Hadley 2002).

2003

- We publish guidance on the coastal defence policy for the historic environment (English Heritage 2003a), augmented in 2006 with more detailed guidance on shoreline management planning (English Heritage 2006b).

2004

- We arrange for the Carbon Trust to undertake a number of assessments of our energy use.
- We publish advice on dealing with flooding and historic buildings (English Heritage 2004b).

2005

- We publish the first in a continuing series of guidance notes on renewable energy technologies, sustainability and heritage. This now includes wind energy (English Heritage 2005a), biomass crops

(English Heritage 2006a), micro-generation technologies (English Heritage 2007a, 2007b, 2008a, 2008b) and water management (English Heritage 2008c).

2006

- We publish an initial policy statement *Climate Change and the Historic Environment*, which this document now supersedes.
- We commission a study of the implications of climate change on World Heritage Sites, as part of the UK Government contribution to the UNESCO Experts' meeting on climate change (World Heritage Centre 2007).

2007

- We publish guidance for home owners on energy conservation in traditional buildings (English Heritage 2007c 2007d) and interim guidance on understanding SAP ratings for historic and traditional homes (English Heritage 2007e), building on our technical advice on compliance with building regulations (English Heritage 2004a).
- With the Engineering and Physical Sciences Research Council (EPSRC) and UKCIP, we co-sponsor the publication of the *Engineering Historic Futures* report by University College London, which focuses on responses to flood damaged historic buildings (Cassar and Hawkings 2007).

2008

- We launch a website, *Climate Change and Your Home*, to provide the general public with information about how traditionally constructed buildings are likely to respond to climate change and how any necessary adaptations, including energy saving measures, might be made.
- We launch a research project, *Hearth and Home*, to measure the energy use and embodied energy of a group of Victorian terraced homes and to lead to enhanced advice on the cost-effectiveness of various energy-saving measures.
- We host *Inventing the Future: Buildings in a Changing Climate*, a summit for invited representatives from government, industry and academia to look at buildings in a changing climate.

The historic environment has an important part to play in climate change adaptation and mitigation.

14 The Royal Borough of Kensington and Chelsea and City of Westminster's 'Flagship Home' project reduced carbon dioxide emissions from a mid-Victorian terraced house at 36 Beaufort Gardens by 63 per cent (www.rbkc.gov.uk/flagshiphome). © English Heritage

15 Historic open spaces in urban areas will play an important role in ameliorating the effects of a hotter climate. Visitors overlooking London from Kenwood House gardens. © English Heritage Photo Library

In particular we will:

- continue to undertake strategic studies to identify historic assets at risk from climate change and related processes, both in our own ownership and in the ownership of others
- work with others to ensure that significant historic sites that are at risk as a direct result of climate change are protected or, where that is not feasible, prioritised and considered for recording
- keep under review, and update as required, our advice on topics such as the energy efficiency of historic buildings, responding to flood damage and insuring historic buildings
- provide best practice guidance on the historic environment aspects of renewable energy generation
- ensure that appropriate emergency response procedures are in place, proportionate to the risk, to mitigate the impact of extreme weather on the historic environment

We also aim to learn and disseminate the lessons the past can provide on living in a low-carbon economy and in a changing environment. In particular, working in partnership with others, we will:

- encourage improved understanding of past climate change and human adaptation to it
- assist those delivering climate change policy to take appropriate account of this evidence
- seek the protection of historic sites that preserve a record of past climatic change and which may be of benefit to future climate change research.



We will continue to reduce the damaging greenhouse emissions arising from our own activities and drive towards greater efficiency in the consumption of energy and materials arising from all our corporate activities, including our commercial activities. We will also continue to review the management of our own estate in terms of climate change and will:

- increasingly use the historic buildings, sites and landscapes of our historic estate to provide opportunities to trial best practice in terms of adaptation to and mitigation of climate change and to demonstrate these to public and technical audiences
- investigate low carbon and alternative energy systems that can be used in historic buildings to reduce carbon emissions
- ensure that buildings occupied or used by English Heritage are maintained and operated to optimise their environmental performance
- ensure that any new buildings constructed on our estate achieve 'excellent' energy performance ratings.

We will seek to exchange expertise on the implications of climate change with others, within or beyond the UK, with an interest in managing the historic environment, and we will particularly:

- support moves by the UK Government to raise international awareness of the threats of climate change to cultural heritage
- work with those managing major historic estates, extensive historic landscapes and World Heritage Sites to develop thinking on approaches to adaptation and mitigation measures sympathetic to historic buildings, sites and landscapes.

We are also committed to building consideration of climate change into all relevant aspects of our planning and decision making, and will keep its implications for the exercise of our statutory duties under continual review.

DEALING WITH UNCERTAINTY

The Stern Review concluded that while the science of climate change is reliable and the broad direction of change is clear, we do not know precisely when and where particular impacts will occur (Stern 2007). This presents a significant challenge for those involved in day-to-day decision making or long-term planning.

Historic assets are a fragile and non-renewable resource, the significance of which can be reduced or lost as a result of poorly conceived changes. Decisions on how, when or whether to make adaptive changes to historic assets in order to enhance their resilience to climate change should be based on a good understanding of the pressures they are likely to face. It is important therefore that decision makers understand the uncertainties inherent in current climate change predictions and the timescales over which changes are likely to occur. The Hadley Centre of the Met Office (Jenkins and Lowe 2003) notes that predictions of climate change, such as those used for the UKCIP02 scenarios, involve uncertainty arising from unknown future greenhouse gas emission rates, imperfect understanding of climate science and modelling, and natural variability. It recommends that each of these should be taken into account, especially when planning major infrastructure or regulatory changes.

UKCIP advocate a risk-based approach to decision making on climate change adaptation (Willows and Connell 2003) and recommend that, wherever possible, decision makers identify and adopt 'no regret' and 'low regret' options. These are adaptation measures considered to be worthwhile now (in that they would yield immediate economic and environmental benefits which exceed their cost) and which continue to be worthwhile irrespective of the nature of future climate change. A simple 'no regret' option for historic buildings is, for example, to improve basic maintenance measures in order to minimise risks from storm damage. It should always be recognised that poorly informed decisions about adaptation can lead to badly specified measures that not only diminish the significance of historic assets but also reduce their flexibility to respond to future climate change. It must also be recognised, however, that a 'no regret' approach does not equate to 'no action', which risks failure to make necessary adaptations.

Updated climate change scenarios for the UK will be issued by UKCIP in 2008 (UKCIP08). These will allow uncertainty in the modelling process to be better defined and outputs will be described in probabilistic terms, better suited to risk-based decision-making for adaptation. When these scenarios become available, English Heritage will use them as the basis for new research into the implications of climate change for the historic environment in the medium to long term and, with our partners in the heritage sector, we will also work towards improving adaptation strategies for historic assets in the context of our emerging *Conservation Principles* (English Heritage forthcoming 2008d). In the interim, recognising that the implications of climate change are real but still uncertain, we will adopt a 'no regrets' or 'low regrets' approach to our regulatory and grant-aid activities, basing our decisions on the best available information. We will also promote research designed to support and improve our decision-making in the context of climate change.

RESEARCH

The uncertainties inherent in future climate projections, the complex effects any changes will have on the historic environment and the need to find ways to reduce the carbon footprint of traditional buildings, all mean that research will play a fundamental role in shaping the heritage sector's response to climate change. Responsibility for identifying the impacts of change and for considering the contribution our heritage can make to climate change mitigation rests with a network of organisations involved in research, going far beyond the heritage sector: English Heritage will, therefore, seek to work with a wide range of partners, initiating some research and adding value to the research of others.

The English Heritage Research Strategy for 2005–2010 (English Heritage 2005b) identified the management of change as an important theme for our future research. In implementing it we will focus our own climate change-related research (and encourage others to similarly focus theirs) on:

- climate change related processes that are **immediate** (such as the impacts caused by current mitigation and adaptation measures) or with the **highest probability** of occurrence (such as responses to sea-level rise, flooding and water shortages)

- topic areas which ensure that the **historic environment can make a significant contribution to Government targets for climate-change mitigation and adaptation** (such as research on understanding and improving the energy efficiency of historic buildings; the efficiency and cost-effectiveness of differing options for mitigation and adaptation; and the impact of fiscal incentives and investment in reducing the carbon footprint of the built environment)
- learning relevant **lessons from the past** (including better understanding of climate change mechanisms drawn from the record of long-term environmental change and sustainable approaches to living drawn from past low-carbon societies)
- initiatives to **improve our ability to monitor the impacts of climate change on the historic environment**
- initiatives to improve our ability to **predict changes to the historic environment arising from climate change** (such as modelling based on the forthcoming UKCIP08 scenarios)
- tools to support **decision-making for the long term** (such as the suitability of tree species for planting in historic landscapes or the appropriateness of investment in particular coastal defence schemes, both of which need to consider the implications of up to 100 years of climate change)
- strategies for the **future management of our estate** in a changing climate.

Our research priorities will continue to evolve, informed by dialogue within the environmental, heritage, architecture and construction sectors and by improvements in our understanding of climate processes and the mitigation and adaptation measures required to respond to change.

REFERENCES AND KEY SOURCES

- BERR 2007: *Draft Strategy for Sustainable Construction: A Consultation Paper*. London: Department for Business, Enterprise and Regulatory Reform
- Biggrove, R and Hadley, P 2002: *Gardening in the Global Greenhouse: The Impacts of Climate Change on Gardens in the UK*. Technical Report. Oxford: UKCIP
- Boardman, B, Darby, S, Killip, G, Hinnells, M, Jardine, C N, Palmer, J and Sinden, G 2005: *40% House*. Oxford: University of Oxford, Environmental Change Institute
- Broadmeadow, M and Ray, D 2005: *Climate Change and British Woodlands: Information Note*, FCIN069, June 2005. Edinburgh: Forest Research/Forestry Commission
- Cassar, M 2005: *Climate Change and the Historic Environment*. London: University College London, Centre for Sustainable Heritage
- Cassar, M and Hawkings, C (eds) 2007: *Engineering Historic Futures: Stakeholders Dissemination and Scientific Research Report*. London: University College London, Centre for Sustainable Heritage
- Colette A (ed) 2007: *Case Studies on Climate Change and World Heritage*. Paris: UNESCO World Heritage Centre
- CLG 2007a: *English House Condition Survey 2005*. London: Communities and Local Government
- CLG 2007b: *Climate Change and Urban Green Spaces*. London: Neighbourhoods, Cities and Regions Analysis Division, Communities and Local Government
- CRC 2007: *Planning for Sustainable Rural Communities: A New Agenda?*, CRC 45. Cheltenham: Commission for Rural Communities.
- DTI 2007: *Meeting the Energy Challenge: A White Paper on Energy May 2007*. London: The Stationery Office
- Defra 2007a: *Climate Change Strategic Framework*. London: Department for Environment, Food and Rural Affairs
- Defra 2007b: *UK Climate Change Programme: Annual Report to Parliament, July 2007*. London: Department for Environment, Food and Rural Affairs
- English Heritage 1997: *After the Storms*. London: English Heritage (Product Code XH20065)
- English Heritage 2000: *Lightning Protection for Churches: A Guide to Design and Installation*. London: English Heritage and Ecclesiastical Insurance Group (Product Code XH20087)
- English Heritage 2003a: *Coastal Defence and the Historic Environment: English Heritage Guidance*. London: English Heritage (Product Code 50756)
- English Heritage 2003b: *Surge Protection Equipment: A Guide to Selection and Installation in Historic Buildings*. London: English Heritage and Ecclesiastical Insurance Group (Product Code 50498)
- English Heritage 2004a: *Building Regulations and Historic Buildings*. London: English Heritage (Product Code 50900)
- English Heritage 2004b: *Flooding and Historic Buildings: Technical Advice Note*. London: English Heritage (Product Code 50776)
- English Heritage 2005a: *Wind Energy and the Historic Environment*. London: English Heritage (Product Code 51099)
- English Heritage 2005b: *Discovering the Past: Shaping the Future, Research Strategy 2005–2010*. London: English Heritage (Product Code 51136)
- English Heritage 2006a: *Biomass Energy and the Historic Environment*. London: English Heritage (Product Code 51100)
- English Heritage 2006b: *Shoreline Management Plan Review and the Historic Environment: English Heritage Guidance*. London: English Heritage (Product Code 51238)
- English Heritage 2007a: *Micro Wind Generation and Traditional Buildings*. London: English Heritage (Product Code 51366)
- English Heritage 2007b: *Small Scale Solar Electric (Photovoltaics) and Traditional Buildings*. London: English Heritage (Product Code 51370)
- English Heritage 2007c: *Energy Conservation in Traditional Buildings*. London: English Heritage (Product Code 51367)
- English Heritage 2007d: *Cutting Down on Carbon: Improving the Energy Efficiency of Historic Buildings*. Summary of Government Historic Estates Unit Annual Seminar; Building Research Establishment, Garston, 9 October 2007 (www.helm.org.uk/climatechange)
- English Heritage 2007e: *Understanding SAP Ratings for Historic and Traditional Homes: English Heritage Interim Guidance*. London: English Heritage
- English Heritage forthcoming 2008a: *Micro-generation in the Historic Environment*. London: English Heritage (Product Code 51391)
- English Heritage forthcoming 2008b: *Ground and Air Source Heat Pumps and Traditional Buildings*. London: English Heritage (www.english-heritage.org.uk)
- English Heritage forthcoming 2008c: *Rainwater and Greywater Use and Traditional Buildings*. London: English Heritage
- English Heritage forthcoming 2008d: *Conservation Principles: Policies and Guidance for the Sustainable Management of the Historic Environment*. London: English Heritage (Product Code 51393)
- HM Government 2006: *Climate Change: The UK Programme 2006*. London: The Stationery Office
- Hulme, M, Jenkins, G J, Lu, X, Turpenny, J R, Mitchell, T D, Jones, R G, Lowe, J, Murphy, J M, Hassell, D, Boorman, P, McDonald, R and Hill, S 2002: *UKCIP02 Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report*. Norwich: Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia
- IPPC 2007a: *Climate Change 2007 – The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC*. Cambridge: Cambridge University Press
- IPPC 2007b: *Climate Change 2007 – Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC*. Cambridge: Cambridge University Press
- IPPC 2007c: *Climate Change 2007 – Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the IPCC*. Cambridge: Cambridge University Press
- IPCC 2007d: *Intergovernmental Panel on Climate Change: Fourth Assessment Report, Climate Change 2007: Synthesis Report (Longer Report)* (<http://www.ipcc.ch>)
- Jenkins, G and Lowe, J 2003: *Handling Uncertainties in the UKCIP02 Scenarios of Climate Change*. Hadley Centre technical note 44. Exeter: Hadley Centre, Met Office
- Jenkins, G J, Perry, M C, and Prior, M J 2007: *The Climate of the United Kingdom and Recent Trends*. Exeter: Hadley Centre, Met Office
- McEvoy, D, Lindley, S and Handley, J 2006: 'Adaptation and mitigation in urban areas: synergies and conflicts', *Proceedings of the Institution of Civil Engineers, Municipal Engineer*, **159**, 185–191.
- ODPM 2005: *Planning Policy Statement 1: Delivering Sustainable Development*. London: Office of the Deputy Prime Minister
- PIU 2000: *Resource Productivity: Making More with Less*. London: Performance and Innovation Unit
- RIBA 2007a: *Climate Change Briefing*. London: Royal Institute of British Architects and Commission for Architecture and the Built Environment
- RIBA 2007b: *Low Carbon Design Tools*. London: Royal Institute of British Architects and Commission for Architecture and the Built Environment.
- Stern, N 2007: *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press
- UKCIP08: UK Climate Impacts Programme Scenarios Gateway: UKCIP 08 (www.ukcip08.org.uk/scenarios/ukcip08)
- Willows, R I and Connell, R K (eds) 2003: *Climate Adaptation: Risk, Uncertainty and Decision-making*. UKCIP Technical Report. Oxford: UKCIP
- World Heritage Centre 2007: *Climate Change and World Heritage*. World Heritage Reports No. 22. Paris: UNESCO
- Yates, T. 2006: *Sustainable Refurbishment of Victorian Housing – Guidance, Assessment Method and Case Studies*. Watford: Buildings Research Establishment Trust

This leaflet supersedes an earlier version of *Climate Change and the Historic Environment* published in January 2006. For further copies, please contact English Heritage Customer Services Department on 0870 333 1181 or email: customers@english-heritage.org.uk. Most of the the English Heritage publications listed above can be obtained free of charge from the same address or downloaded from www.helm.org.uk/climatechange or www.english-heritage.org.uk. Published by English Heritage January 2008, Product Code: 51392.