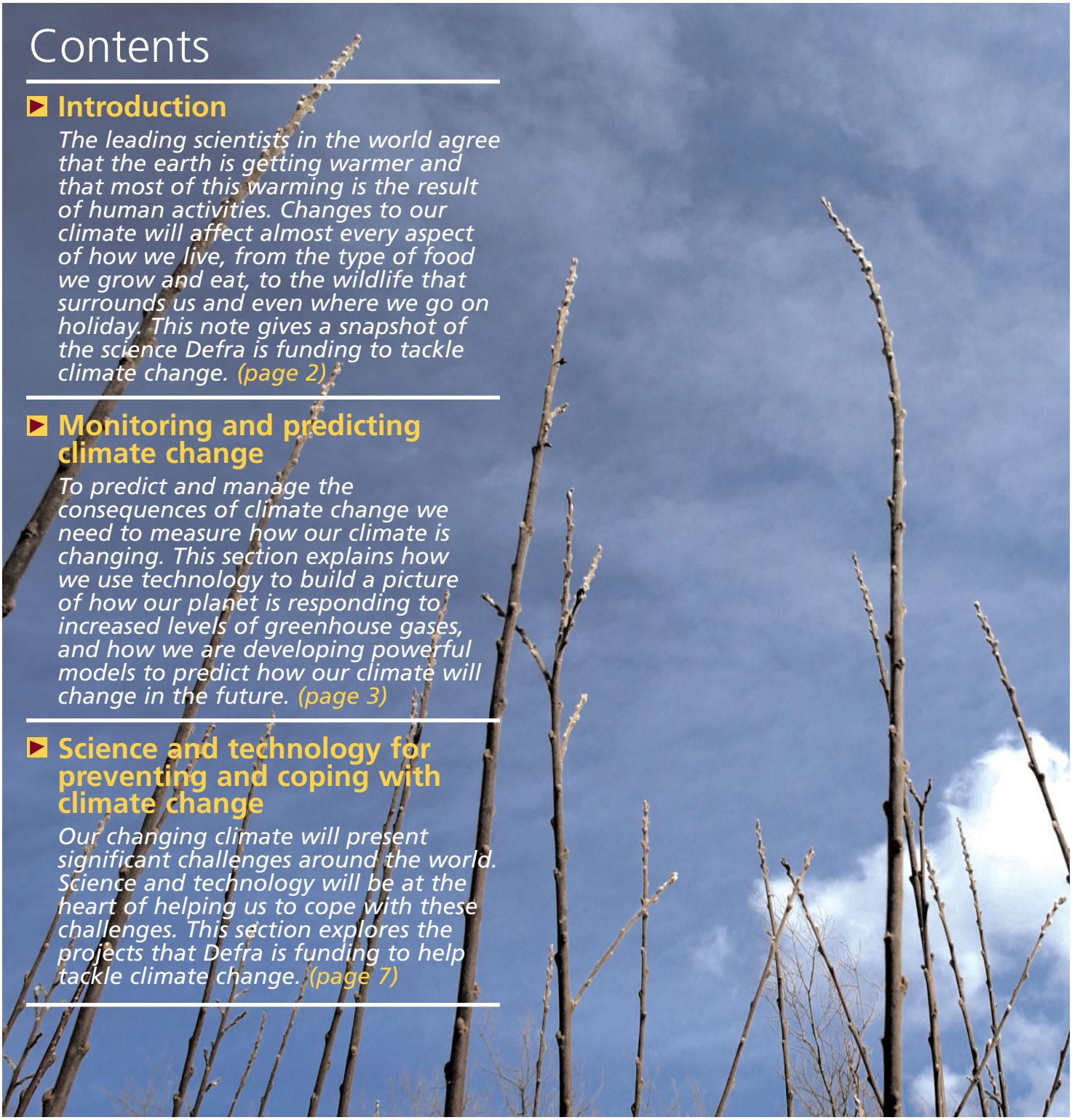
How is Defra

Tackling Climate Change?

Defra Science Notes 2



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Department for Environment Food and Rural Affairs

Understanding climate change

The leading scientists in the world agree that the earth is getting warmer and that most of this warming is the result of human activities. The average global temperature has risen 0.7 degrees Celsius (°C) over the last 100 years.

Gases such as carbon dioxide (CO_2), methane (CH_4) and water vapour occur naturally in the atmosphere. They allow the sun's rays to pass through and warm the earth by trapping some of the heat that is radiated from the earth's surface. Without this natural 'greenhouse' effect, the earth would be 30°C cooler than it is. Human activities, such as burning fossil fuels (coal, natural gas, and oil), agriculture and deforestation, are creating additional greenhouse gases which build up in the atmosphere. So temperatures around the world have risen and will continue to rise.

The Intergovernmental Panel on Climate Change (IPCC) predicts that by 2100 the average global temperature will increase by between 1.4°C and 5.8°C above 1990 temperatures. Even if we stopped producing more greenhouse gases today, the climate would continue to change for another 30–40 years as it adjusts slowly to the increased gases of recent decades. Changes to our climate will affect almost every aspect of how we live – from the type of food we grow and eat, to the places we live, to the wildlife that surrounds us and even where we go on holiday. It is the greatest environmental challenge facing the world today.

The enhanced Greenhouse effect

Some greenhouse gases exist naturally in the atmosphere, such as water vapour, carbon dioxide (CO_2), ozone (O_3), methane (CH_4) and nitrous oxide (N_2O). They act as a 'blanket' around the earth keeping it warm. Without it the earth would be 30°C colder. This is known as a natural greenhouse effect.

The temperature of the earth depends on the energy coming in from the sun and the balance between heat trapped by the 'blanket' and the heat lost into space; if this balance is altered the global temperature begins to change. The effect that changing concentration of greenhouse gases has on this process is known as 'radiative forcing'. As the concentration of long-lived greenhouse gases increases, it enhances the natural greenhouse effect, making the surface temperature warmer. Concentrations of CO_2, CH_4, and N_2O have contributed the most to this effect with amounts rising by about 30%, 150% and 16% respectively since the middle of the 18th century.

Observed changes worldwide

- The global sea level rose by between 10 and 20 cm during the 20th century.
- The ten hottest years on record have all occurred since the beginning of the 1990's.
- The area of snow cover across the globe has declined by about 10% since the 1960s.
- The overall volume of glaciers in Switzerland decreased by two-thirds during the 20th century.

Observed changes in the UK

- Average annual temperatures in central England have risen by almost 1°C over the last 100 years.
- The highest temperature recorded in the UK is 38.5°C, which was recorded on 10 August 2003 at Brogdale near Faversham (Kent)
- 20 out of 65 bird species laid their eggs on average eight days earlier in 1995 compared to 1971.

This leaflet looks at the science Defra funds to monitor and predict climate change, as well as the science that will help us develop polices to cope with and reduce further changes.

Monitoring climate change and Greenhouse gases

Our climate is a complex system with a multitude of subtly interrelated global, regional and local factors. To predict our climate in the future, we need to understand the things that affect our climate today.

Sea levels

Sea levels will rise as a result of global warming as ice sheets melt and warmer water expands. The JASON II satellite programme measures changes in sea level.

It sends microwave pulses to the ocean surface and measures the length of time the pulses take to bounce off the sea surface and back to the satellite. The lower the sea level, the further the distance to the satellite and the longer the pulse will take. Over time scientists build up a picture of how sea levels are changing as a result of global warming, developing more accurate models to predict future changes.

Ocean acidification

Oceans act as a sponge by taking up CO_2 from the atmosphere. Oceans have helped buffer the effects of climate change as the oceans have absorbed as much as half of the atmospheric emissions of CO_2 released as a result of human activity.

However, the high levels of CO_2 released over the past 50 years have led to a situation where the previously stable pH of the oceans is changing. This process, known as Ocean acidification could have a damaging effect on the plants and animals living in the sea. Unless significant reductions in atmospheric CO_2 are made, this process could disrupt marine food chains and influence oceans in ways that are not yet fully understood or predicted. Defra has commissioned Plymouth Marine Laboratory to oversee an international research programme investigating how animals might respond to different acidity levels in their habitats. This research will help us to understand the effects of different CO_2 levels on different ecosystems and food chains.

Sea Surface Temperature

The sea surface temperature is one of the factors affecting the climate and so it's important to keep track of it. Advanced Along Track Scanning Radiometer (AATSR) is an instrument, co funded by the Australian Government and Natural Environment Research Council, on board the European Space Agency's environmental satellite that can measure the temperature of the sea-surface to an accuracy of 0.3C.


Used with permission from the Hadley Centre

It has thermal infrared channels that measure the heat coming off the earth's surface, allowing scientists to monitor long-term trends in the climate system and improve future predictions. Annual sea-surface temperatures around the UK coastline have increased by about 0.5C for the period 1871 to 2000.

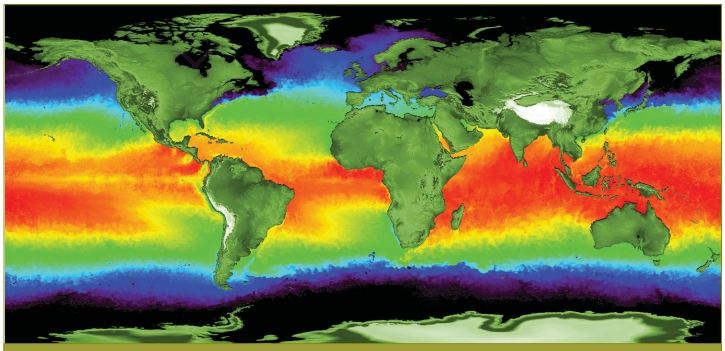
The spread of microscopic ocean life is also an indicator of changing sea temperatures. The Continuous Plankton Recorder (CPR) survey has been monitoring near-surface plankton in the North Atlantic and North Sea for the past 70 years, making it one of the longest running marine monitoring programmes in the world. Staff at the Sir Alistair Hardy Foundation for Ocean Science recently noted that warm water plankton in the North Sea are migrating northwards while cold-water plankton are moving even further north, as seawater temperature rises due to global warming. Plankton are at the start of almost all food chains in the marine environment, so movement is likely is to impact on the animals that feed upon them such as fish. Importantly they act as a 'biological pump', using the CO_2 from the atmosphere as their food source for growth. Without this process, the concentration of CO_2 in the atmosphere would be much higher.

Ocean currents

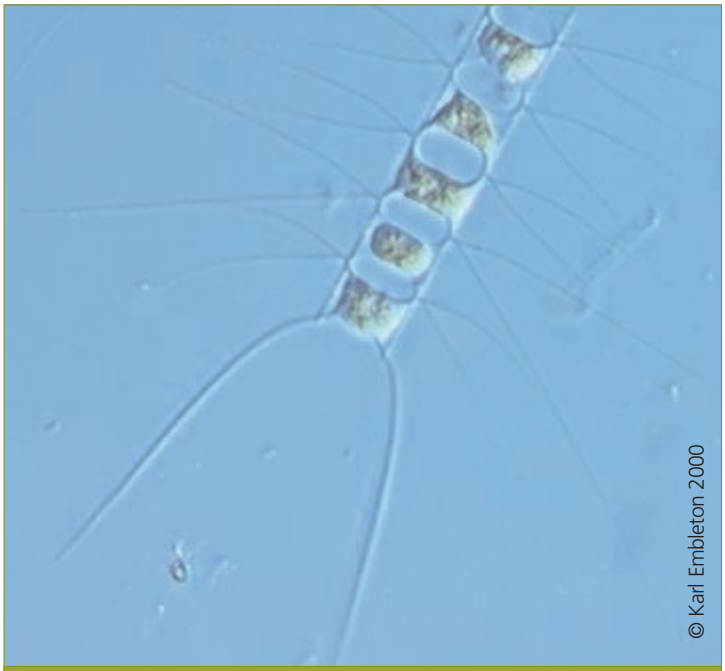
The ocean carries large amounts of heat around the world. If the movements of the ocean changed, so too would the temperature on the land.

More than 3000 robotic 'smart buoys' floating in the seas around the world are helping scientists to understand ocean currents and monitor changes that might alter our climate. This fleet of floats spends most of its time 2km underwater, but rises to the surface once every 10 days to measure the temperature and salt content of the sea, sending the information back to land via a satellite. Many countries have contributed buoys, including 194 from the UK, as part of the Argo project. The information is freely available.

Current Worldwide distribution of Argo floats. (UK floats shown in red)



Averaged sea surface temperature taken by AATSR for March 2004



Plankton like *Cheatocerous decipiens* species above have started to move further north as seawater temperature has risen due to global warming.

Measuring Greenhouse gases

As part of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, Defra funds the annual UK Greenhouse Gas Inventory. The inventory estimates the levels of 6 greenhouse gases in our atmosphere from all sectors of the economy, including energy production, transport, industrial processes, waste, and agriculture.

As it would be extremely difficult to measure the concentrations of the 6 gases in the atmosphere directly and frequently, the inventory uses national statistics. For example, transport emissions are based on the statistics for the amount of fuel sold, multiplied by a factor that estimates how the fuel will be burned. This factor is an estimate of the mix of old and new, light and heavy vehicles being driven in the UK. These methods are based on internationally agreed guidance from the IPCC, which UK scientists have helped to develop.

To help check the accuracy of these estimates, Defra supports the Mace Head Atmospheric Research Station on the West coast of Ireland to monitor greenhouse gas concentrations in the air as part of a world network.

The inventory helps scientists to monitor and predict how the climate is changing globally as well as to develop ways of reducing greenhouse gas production.

Measuring land temperatures

The temperature on land has been measured and recorded by instruments and satellites for over a century around the world. Many of these records are related to weather forecasting and analysed by the Hadley Centre (Met Office) to produce a global picture of temperatures both at the earth's surface and in the upper atmosphere. The records are checked and corrected for known changes in the way that they are measured, and changes in local situations such as growth in urban areas. This information shows that the world is getting warmer and that average global temperature has risen by 0.7 C in the last century.

The UK Greenhouse Gas Inventory

The inventory comprises of six greenhouse gases:

- Carbon Dioxide makes up 86% of the UK's greenhouse gas emissions. It is released naturally from inside the earth through volcanic eruptions, by respiration, evaporation of the oceans, and through man-made actions such as the burning of carbon compounds such as coal, oil and natural gas.
- Methane, forms around 6% of emissions. It is produced through chemical and biological reactions that don't use oxygen, such as animal digestion.
- Nitrous Oxide is also responsible for around 6% of emissions and is produced by biological processes in the soil and oceans as well as industrial combustion, vehicle exhausts and chemical fertilizers.
- The halocarbons; hydroflurocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6), which in total make up just under 2% of the emissions can be found in aerosol propellants, refrigerator coolants and air conditioners.

Predicting climate change

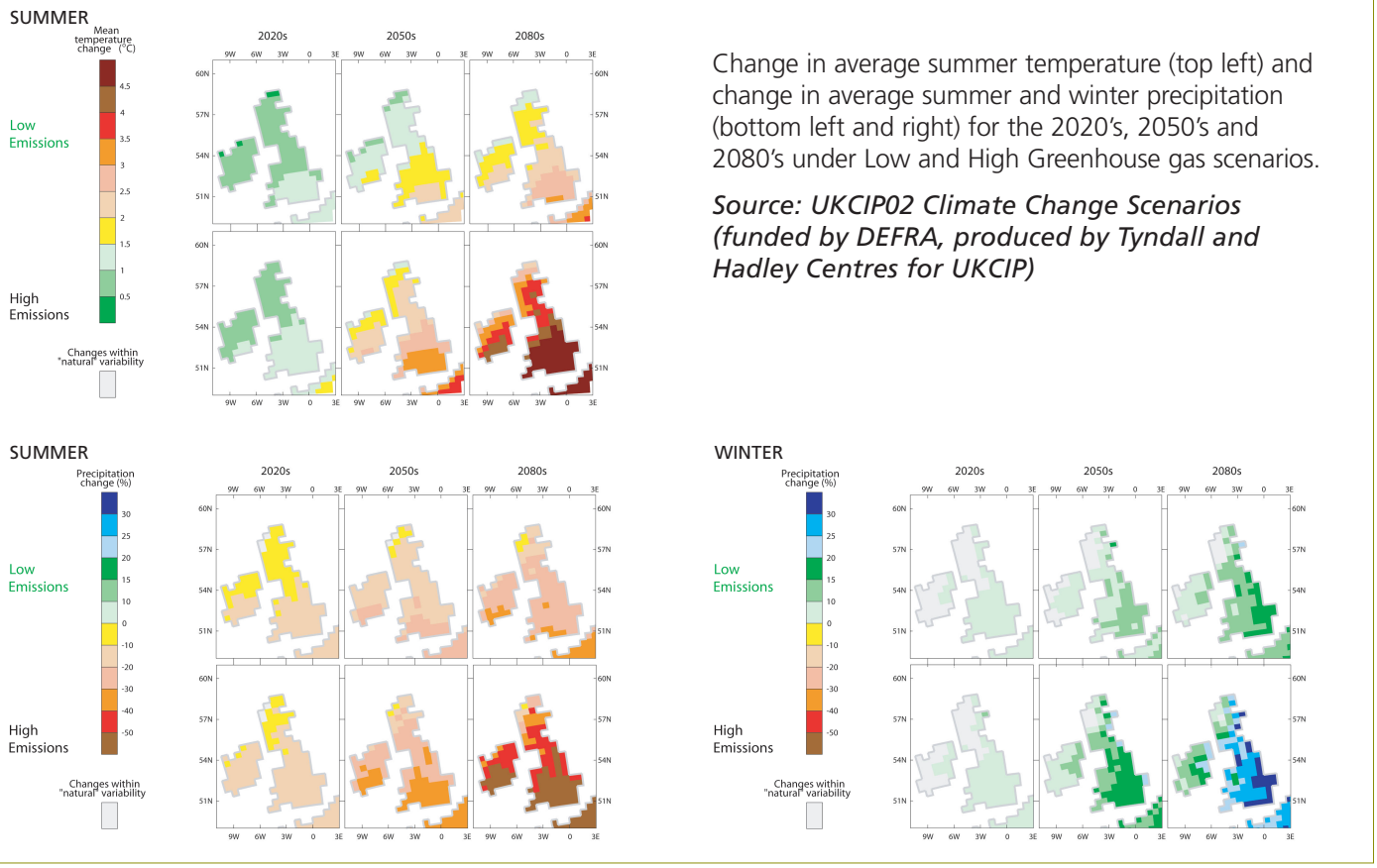
Scientists at the Defra funded Hadley Centre for Climate Prediction and Research at the Met Office use much of this information about our current climate to make predictions about future climate, both on a local and global scale.

Predicting climate change involves billions of mathematical calculations. At the Hadley Centre, scientists have access to two of the fastest supercomputers in Europe that contain 45 computer networks each with a peak performance of around 64 thousand million calculations per second. These supercomputers allow the scientists to develop 3-D models of the climate that can simulate conditions and processes in the environment. This enables them to make projections of our climate centuries into the future on a quick timescale.

Using one of these complex climate models to simulate the general trend in twentieth century temperatures, scientists at the Hadley centre have also run experiments to find out whether recent temperature rises could be the result of natural changes – cloudiness or the earth orbiting closer to the sun for instance, as some people have suggested. Their experiments showed that the increase in global temperatures could not have been caused by natural changes alone and that recent warming isn't a blip.

Greenhouse gases from human actions are clearly causing long-term changes to our climate.

The latest climate models from the Hadley Centre have helped the UK Climate Impacts Programme (UKCIP) to develop scenarios that show how our climate might change with different levels of greenhouse gases in the atmosphere. These climate change scenarios show that we should expect hotter, drier summers and milder but wetter winters, with extreme weather events such as storms becoming more common. Sea levels around the UK will continue to rise with the south-east likely to experience greater changes than the north-west. By the 2050s, summer temperatures in south-east England could be similar to present-day Bordeaux.



Change in average summer temperature (top left) and change in average summer and winter precipitation (bottom left and right) for the 2020's, 2050's and 2080's under Low and High Greenhouse gas scenarios.

Source: UKCIP02 Climate Change Scenarios (funded by DEFRA, produced by Tyndall and Hadley Centres for UKCIP)

Science and technology for reducing emissions

To prevent our climate changing dramatically, we will have to reduce the amount of greenhouse gases we produce considerably – both by reducing the amount of energy we use and by using carbon neutral fuels such as renewables, which don't contribute to increasing CO_2 concentrations

Defra is supporting a range of science to develop new ways of generating and transporting energy, including:

- **Biomass**, which generates electricity by burning woody plants such as Willow or the tall grass *Miscanthus*, or waste products such as slurry or food wastes. Biomass energy helps stop levels of CO_2 rising in the atmosphere because any CO_2 produced when the crops are burned is balanced out by the CO_2 taken in by the crops, to make food when they are growing.
- **Combined heat and power (CHP)** is a fuel-efficient technology that uses the waste heat energy produced as a by-product of electricity generation, as a source of energy for heating or hot water systems. Defra, through the Carbon Trust, is supporting a trial to assess the viability of micro CHP which is small enough to be used in residences to generate heat and electricity.

Breaking the links

As society has become wealthier we have used more energy and produced more CO_2. The way we produce and consume goods is having a severe impact on our environment – 80% of products' impact on the environment is determined by product design. Defra has a programme of research which will analyse the amount of energy, water and waste produced across the lifetime of a product in order to promote more thought in the design process of a product. Another challenge of breaking the link between consumption and environmental damage is to steer consumers towards more sustainable choices. Defra is currently developing a programme of research which will help to develop better products and services. This will reduce the environmental impacts from the use of energy and other resources and build on people's growing awareness of social and environmental concerns, helping to promote more sustainable patterns of consumption.

Linked to this, Defra has been studying how food transport impacts on the environment, in order to inform development of a Food Industry Sustainability Strategy ('FISS'). The ways in which food gets from farm gate to plate has changed dramatically over the past 50 years. This has involved a huge increase in the distance food travels - 'food miles'. Since 1974, the annual amount of food moved in the UK by lorries has doubled with CO_2 emissions from food transport increasing 12% between 1992 and 2002. But it isn't simply a matter of how far the food has travelled – the research has found that the method of transportation, location and even the timing of the travel can vary the environmental impact, raising some important issues for the food industry and shoppers. Other major consequences of food transport include its impact on road congestion adding impetus to plans under the 'FISS' to monitor and reduce environmental and social impacts.

Fact: developments in technology, and good policy intervention have resulted in the energy efficiency of fridges and freezers being improved by more than 50% over the last eight years.

Coping with climate change

Even if we manage to keep the levels of greenhouse gases in the atmosphere as they are today, the climate will still continue to change for another 30-40 years as it adjusts slowly to the increased levels of greenhouse gases from recent decades.

Science and technological solutions will be at the heart of helping us to cope with the impacts of climate change. The changing climate will have an impact on our businesses and lifestyles. Heavier rainfall during the winter, coupled with rising sea levels will increase the risk of flooding. Drier summers are likely to bring greater problems of subsidence. We will need intelligent sustainable design for buildings and infrastructure to minimise the risk of damage to properties, power, and telecom distribution networks, railway tracks, bridges, and road surfaces in the future.

UK Climate Impacts Programme (UKCIP)

Defra funds UKCIP to help organisations assess how they might be affected by climate change, so that they can prepare for its impacts. Alongside the climate change scenarios, UKCIP has developed guidance on how to understand and respond to the threats, opportunities, uncertainties and risks that climate change will bring.

The changing climate will bring both threats and opportunities for businesses, not only in sectors like construction, health, water, tourism, that will experience direct physical impacts. There are also likely to be significant implications for utility companies and the financial sector, such as insurance services. Decisions made by the private sector will be crucial in the UK's response to climate change. The UKCIP works with a wide range of organisations in both public and private sector. A recent initiative is 'A Changing Climate for Business' which involved businesses in the agriculture, building design and construction, motor manufacturing, and financial services industries identifying some of the incentives and barriers for taking account of climate change. It resulted in a new framework through which organisations can examine the impacts of climate change across their business and help find possible ways of coping.

A changing climate for the regions

Defra's Climate Change Impacts and Adaptation 'Cross-regional Research Programme' is supporting several projects to provide detailed information relevant to regional decision-makers. One of these projects is exploring potential adaptation responses to climate change for new developments in housing growth areas such as the Thames Gateway. The research is identifying master-planning, building and infrastructure design options that could 'climate proof' developments, to provide guidance for regional authorities across the UK.

The way our coastlines change might alter with a changing climate also, as sea levels rise, wave patterns and storm events change. We will probably need to rethink how we protect and manage different stretches of shore. Defra's Futurecoast project has been looking nationally at the different conditions that climate change will bring in terms of how our coastlines might evolve and the results provide a source of reference and toolkit to help coastal managers decide the most appropriate ways of managing shorelines in the future.

Higher temperatures will also lead to greater demand for water, putting pressure on the existing supplies. However, the way we coped with water shortages during the drought of 1976 will provide valuable clues to developing future water management. Another project in Defra's Cross-regional Research Programme is reviewing the effectiveness of the strategies used in 1976 and those in use in the East of England, to develop practical guidance on how to manage water under a changed climate.

The warm weather might bring new opportunities, as well as challenges, for the tourist industry. A new project jointly funded by Defra, the Northwest Development Agency and the Environment Agency, is using the UKCIP climate change scenarios, combined with information on how weather influences tourism and recreation, to predict how the visitor economy in England's north west will be affected by climate change. The project is looking at how new opportunities for tourism, leisure and recreation can be developed. For example, more educational facilities such as visitor centres might be required and sustainable transport options will be needed to avoid increasing congestion and greenhouse gas emissions.

A changing climate for agriculture and biodiversity

Virtually every natural resource from soil to air will be affected by climate change. Reduced rainfall and increase in CO_2 levels will also have mixed impacts on crop production. Plants use CO_2 as a food source that gets converted into sugar, so an increase in CO_2 might increase crop yields for certain plants. But the higher temperatures associated with increased levels of CO_2 could have the effect of reducing the crop yields for species that are already being grown at ideal temperatures. Since 1987 Defra has been studying how increased CO_2 affects crops by growing plants in environments that closely mirror their natural habitat while controlling the level of CO_2 in the atmosphere over time. Other effects of climate change in the UK might include new opportunities such as vineyards and commercial production of sunflowers.

Wild plants and animals are strongly affected by the climate and changes in this system will cause some species to thrive and others to decline and possibly even disappear from the UK - such as natterjack toad and the mountain ringlet butterfly. Defra is contributing to a range of research projects aimed at improving our understanding of these impacts. For example, the MONARCH project led by English Nature uses a computer model to predict the impact of climate change on the potential distribution of selected wild plants and animals in land, freshwater, and coastal environments throughout Britain and Ireland. By using MONARCH's computer model it's possible to see how certain species including the dwarf willow, great crested newt or large heath butterfly are vulnerable to the effects of climate change such as changes in temperature and rainfall. This information can enable us to develop more effective conservation policies.

Species like the mountain ringlet butterfly might disappear altogether from the UK if our climate continues to change

What is Defra doing to reduce emissions?

The UK Government believes in the importance of taking domestic action to cut greenhouse gas emissions. Since Kyoto summit in 1997, the UK has been pressing ahead and introducing innovative policies that will have a significant impact.

Action taken in the UK has significantly reduced greenhouse gas emissions and we are on track to meet our Kyoto Protocol target of reducing emissions by 12.5 % by 2008 – 2012.

The UK Climate Change Programme, published in 2000, was focused on a package of policies and measures to help achieve our Kyoto target and move towards our domestic goal to reduce CO_2 emissions by 20% below 1990 levels by 2010.

The UK has also set a long-term goal to reduce CO_2 emissions by some 60% by about 2050, with real progress by 2020, which was set out in the Energy White Paper.

The Climate Change Programme is currently being reviewed and the Government intends to publish the revised programme before the end of 2005. The review is looking at how existing policies to reduce greenhouse gas and CO_2 emissions are performing and the range of policies and measures that might be put in place in the future to achieve our 2010 goal and to put us on a path towards 'real progress' by 2020. The programme will also cover our strategic approach to adaptation to climate change.

Defra has the Government lead on tackling climate change, but many of the policies in the Climate Change Programme are implemented by other Government departments and the devolved administrations.

Defra is also taking the lead in implementing the Government's commitment to offset CO_2 emissions from official air travel in central Government. To pilot this approach, Defra will offset all CO_2 emissions arising from hosting the G8 presidency by investing in an Africa based project, and will further extend this approach to cover emissions from the EU presidency.

Climate change is one of the priorities for the UK's Presidency of the G8 in 2005. The Government wants to build a global consensus about the need to take action to substantially reduce greenhouse gases; work out how to speed up science and technological advances to tackle climate change; and take forward a dialogue with countries that have growing energy needs. We are also committed to making further progress through other forums, particularly during our Presidency of the EU, and in the UNFCCC.

Action on all levels – locally, nationally and internationally – is needed to help reduce emissions.

Links for further information

The Department for Environment, Food and Rural Affairs. More information about Defra can be found on the website.
www.defra.gov.uk/science

The Hadley Centre for Climate Prediction and Research provides a focus in the UK for the scientific issues associated with climate change.
www.metoffice.com/research/hadleycentre/index.html

The Tyndall Centre brings together scientists, economists, engineers and social scientists to develop sustainable responses for climate change through research and dialogue.
www.tyndall.ac.uk

Argo Project
International collaboration that uses underwater buoys to measure ocean currents.
www.argo.ucsd.edu/index.html

The Intergovernmental Panel on Climate Change, world organisation that assesses scientific, technical and socio-economic information relevant for the understanding of climate change.
www.ipcc.ch

Review of the UK Climate Change Programme – the review of the UK Climate Change Programme is looking at how existing policies are performing and the range of policies that might be put in place in the future.
www.defra.gov.uk/environment/climatechange/ccprog-review

United Nations Framework Convention on Climate Change – international treaty signed over a decade ago by most countries to begin to consider what can be done to reduce global warming and to cope with the inevitable temperature increases.
www.unfccc.org

The Carbon Trust helps businesses and the public sector to cut carbon emissions.
www.thecarbontrust.co.uk

The Energy Saving Trust, one of the UK's leading organisations tasked with sustainable energy solutions in the home and on the road.
www.est.org.uk

UK Climate Impacts Programme helps organisations assess how they might be affected by climate change, so they can prepare for its impact.
www.ukcip.org.uk

Carbon Offsetting
Individuals can offset their carbon emissions with several companies including Climate Care.
www.co2.org and Future Forests *www.futureforests.com*

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