Climate Change Strategy for Leicestershire

ENABLE
Environmental Action for a Better Leicestershire

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Acknowledgements

This report was prepared for ENABLE by ENTEC UK Ltd

For more information about ENABLE – the county's environmental partnership, or to join ENABLE please contact Leicestershire County Council on 0116 265 7242 or e-mail: enable@leics.gov.uk

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Executive Summary

Our climate is already changing. Global average temperature rose by 0.6°C in the 20th century. Some of this rise was due to natural variation but scientists believe that most of the warming over the past 50 years is likely to have been caused by human activity.

We only have to cast our minds back to August 2003 to gain an insight into what the future climate could be in the next 50-80 years. The record for the highest temperature in the UK was broken on 10th August 2003 at 38.5°C at Brogdale near Faversham in Kent. The summer was also very dry. However, August 2004 was very wet with many areas receiving double their average August rainfall. This resulted in flooding and accompanying disruption from Cornwall to Scotland. The future climate could be hotter, wetter and more variable.

It is likely that we will have to learn to live with some level of climate change but, by reducing our emissions of gases that contribute to climate change, we can reduce the extent of change and its impact.

This report presents a summary of the evidence for climate change and gives information on the uncertainties surrounding climate change. It presents information from climate models that present a range of scenarios for future climate in Leicestershire. A comparison is made between the hot August of 2003 and its impacts with the wet August of 2004, to illustrate possible future climate variability. Leicestershire has recently experienced some disruption from flooding following heavy summer rainfall and the potential impacts on key sectors and service providers in Leicestershire are also discussed.

Estimates are presented of emissions in Leicestershire of the gases that are contributing to climate change: 43% are from road transport, 35% from commercial and domestic combustion processes and 18% from industrial combustion processes. The report presents the estimates of emissions by source and sector and presents a draft mitigation and adaptation strategy. Finally, in order to help the development of local strategies and policies, the report presents a list of national and regional and local policies that could be affected by or could affect climate change. A further list of climate change guidance documents for a range of issues is also included.

Glossary

CO_2	Carbon dioxide
CET	Central England Temperatures
Defra	Department for Environment Food and Rural Affairs
DTi	Department of Trade and Industry
EA	Environment Agency
EEC	European Economic Community
GHG	Greenhouse gas
HSE	Health and Safety Executive
IPCC	Intergovernmental Panel on Climate Change
kT CO_2	Kilo tonnes of carbon dioxide or 1,000 tonnes of carbon dioxide
LTO	Landing and takeoff cycle
Mt CO_2	Mega tonnes of carbon dioxide or 1,000,000 tonnes of carbon dioxide
NAEI	National Atmospheric Emissions Inventory
NAO	North Atlantic Oscillation
NGT	National Grid Transco
ODPM	Office of the Deputy Prime Minister
Ofgem	The Office of Gas and Electricity Markets
TUC	Trades Union Congress
UKCIP	United Kingdom Climate Impacts Programme
WMO	World Meteorological Office

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Foreword

By the ENABLE Chairman, Councillor Ernie White

Climate Change poses one of the greatest environmental threats of the 21st Century. Scenarios for the UK published recently by the Met Office and UKCIP (UK Climate Impact Programme) show that annual UK temperatures could rise by between 2 and 4.5˚C depending on future greenhouse gas emissions.

The Climate Change Strategy is a comprehensive review of current thinking on Climate Change. The report was commissioned by ENABLE, Environmental Action for a Better Leicestershire as a priority action within the Leicestershire Community Strategy, with a deadline to be completed by 2005.

This document is a very good introduction to Climate Change looking at the global and local effects and combines a mitigation and adaptation strategy. The mitigation section investigates how greenhouse gas emissions can be reduced whilst the adaptation section looks at how the adverse impacts of climate change can be managed, focussing on extreme weather conditions such as flooding, high levels of rainfall and high summer temperatures.

The Leicestershire Climate Change Strategy is one of the few strategies of this kind to contain an adaptation section as this is a very new area of thinking. In the recent past, documents have concentrated on reducing greenhouse gases rather than lessening the impact of climate change. I hope Leicestershire can lead the way in this area and that other organisations can learn from our experiences.

Introduction

This report presents a climate change mitigation and adaptation strategy for Leicestershire County Council. The document looks at the broad issue of climate change; with some illustrative recent high profile weather events as examples of what may happen; then evaluates the main activities in Leicestershire that contribute to climate change and the key sectors that are likely to be most sensitive to it. It also provides a list of most relevant national, regional and local policies.

The document includes proposals for combating climate change and mitigation measures that can be made by the public, business, industry and other organisations. Examples of how Leicestershire can adapt to climate change are also included as well as recommendations for indicators of change.

2. Climate change context

This chapter presents the evidence for past climate change and the output from models of future climate.

2.1 Our climate is already changing

Global temperature has risen by about 0.6°C over the last 100 years and 1998 was the single warmest year in the 142-year global instrumental record[1]. 2002 was one of the warmest years in Britain since records began in 1659 and it is likely to have been the fourth warmest year on record[2]. An example of unseasonably high temperatures that may support these trends occurred on 26 January 2003 when Aboyne, Aberdeenshire saw temperatures rise to 18.3°C, equalling the warmest January day on record. Soon after this Scotland was hit by gale force winds and snow[3]. The storms across the country in October 2002 resulted in widespread damage to infrastructure leaving about two million homes without power. The electricity companies have recently agreed to pay compensation worth £1.8 million to their customers[4]. These incidents are not in themselves proof of climate change, although these types of observations serve to illustrate the type of climate that we may experience in the future. Hot summer days with temperatures exceeding 25°C, like the hot summer of 1995, have become more common. The hot spell during the summer of 2003 saw temperature records broken, notably 10 August 2003: the hottest day ever recorded in the Britain[5]. Figure 2.1 shows the observed temperature changes compared to a long term average.

UK winters have also been getting wetter, with more frequent heavy downpours. Recent evidence seems to support these observations; for example, late 2002 and early 2003 saw a series of floods across the southern half of the country. The Thames Barrier; normally closed a handful of times in a year; was closed 14 times between 15 December 2002 and 15 January 2003. This was due in part to October, November and December being very wet months; the fourth wettest autumn in the Thames region since 1882. Prolonged high river flows in the previous winter had also contributed to increased use. It is estimated that over 1,000 Environment Agency (EA) staff were involved in responding to the floods and that 1,200 properties were affected. Interestingly, the report reviewing the floods highlighted the issue of flooding from several sources including rising groundwater[6].

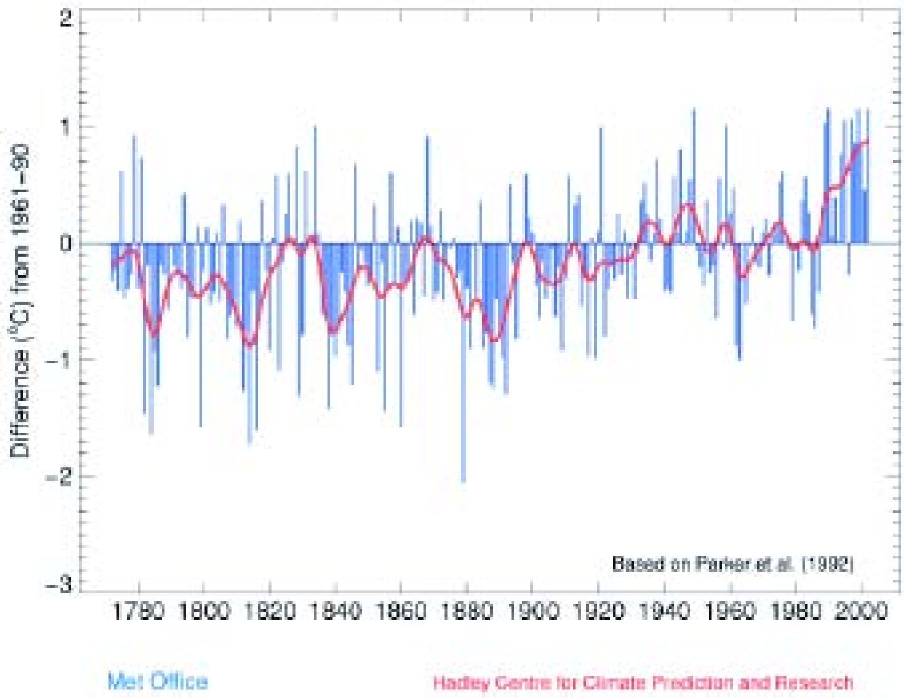
The average rate of sea level rise around the UK coastline during the last century, allowing for natural land movements, has been about 1mm per year.

Climate changes occur naturally but the Inter-Governmental Panel on Climate Change (IPCC) feels that "…most of the warming observed over the last 50 years is likely to have been due to increasing concentrations of greenhouse gases." Climate models have been simulated to show observed trends: only when human induced and natural change are combined does the model show close correlation with the climate record.

The following figure shows a steady rise during the 20th century but with a marked increase at the end of the century. Central England Temperature (CET) is representative of a roughly triangular area of the United Kingdom enclosed by Bristol, Manchester and London. The monthly series began in 1659, and to date is the longest available instrumental record of temperature in the world. Since 1974 the data have been adjusted by 1-2 tenths°C to allow for urban warming.

1. Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report, Hulme et al April 2002. ISBN 0 902170 60 0
2. UK Meteorological Office press release, December 2002
3. UK Meteorological Office press release, January 2003
4. ofgem press release, September 2003
5. UK Meteorological Office press releases, August 2003
6. Review of the New Year Floods 2003, 19th March 2003 Environment Agency Board paper. Available at: www.environment-agency.gov.uk/commondata/105385/ea_03_11_new_year_floods.pdf

Figure 2.1: Central England temperature anomalies 1772 to 2002



2.2 What further changes could there be?

In order to understand how our climate may change in the future, large scale computer models are run using different levels of emissions of the gases that trap heat in the earth's atmosphere. The main gas that does this is carbon dioxide but there are five other types of gas that also contribute to the overall global warming effect. These gases together are known as greenhouse gases (GHG).

The different levels of GHG emissions used in the predictions are based on a range of socio-economic scenarios including different rates of economic and population growth, consumption patterns, technological development and approaches to regulation of emissions. Table 2.1 illustrates the link between the different emissions scenarios, concentrations of carbon dioxide in the atmosphere and potential temperature rise. In 2002, the UK Climate Impacts Programme (UKCIP) produced scenarios of climate change based on outputs from the Meteorological Office's Hadley Centre's climate models.

Table 2.1: Increase in atmospheric CO2 concentrations, temperature rise for the 2080s period (2071-2100 average) and their relationship to emissions scenarios

UKCIP02 climate change scenario	Atmospheric concentration of CO_2 Parts per million	Increase in global temperature, °C
Low Emissions	525	2.0
Medium-Low Emissions	562	2.3
Medium-High Emissions	715	3.3
High Emissions	810	3.9

The UKCIP scenarios are related to the scenarios used by the Inter-Governmental Panel on Climate Change (IPCC). Pre-industrial carbon dioxide concentrations were about 280 ppm and in 2001 were 370 ppm.

The key results from the UKCIP02 scientific report[1] are given in Table 2.2 overleaf.

Table 2.2: Summary of results presented in the UKCIP02 scientific report

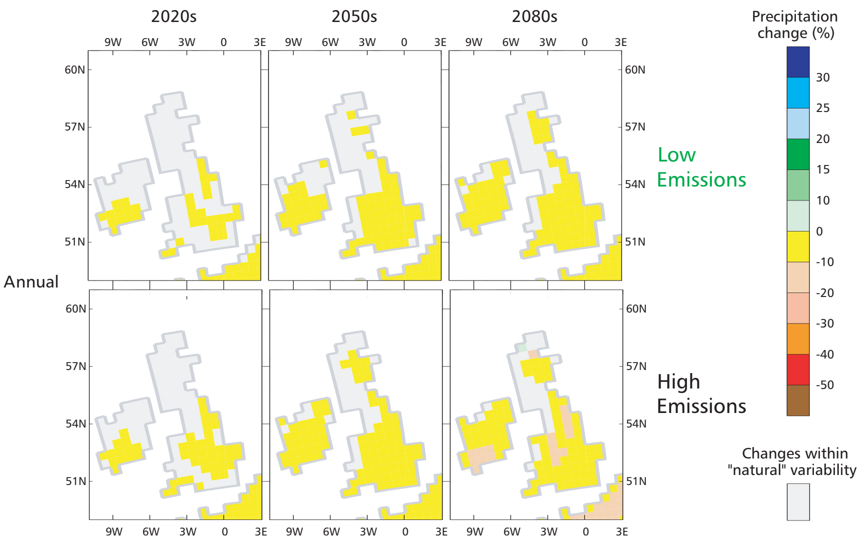
The UK climate will become warmer by between 1 to 2 °C by the 2050's and by up to 3.5 °C by the 2080's, with parts of the south-east warming by as much as 5 °C in summer
Higher summer temperatures will become more frequent and very cold winters will become increasingly rare
Winters will become wetter and summers may become drier everywhere
Summer soil moisture may be reduced by 40% or more over large parts of England by the 2080s
Daily maximum temperatures of 33 °C, which currently occur about 1 day per summer in the south-east, could occur 10 days per summer by the 2080's
Snowfall amounts will decrease throughout the UK
The occurrence of heavy winter precipitation will increase
Mean sea level will continue to rise around most of the UK's shoreline
Extreme sea level events will occur more frequently
Winter depressions (low pressure systems or storms) could increase from 5 at present to about 8 by 2080s. The incidence of summer depressions could fall from 5 to 4 per season by 2080s
The Gulf Stream may weaken in the future, but it is unlikely that this weakening would lead to a cooling of UK climate within the next 100 years

It should be noted that these outcomes are from the Hadley Centre's climate model. There are other credible climate models that produce slightly different results for temperature and precipitation. Scientists are carrying out work to assess the output from a range of models and to present a series of climate probability assessments. These would be useful for risk assessment and planning.

2.2.1 Changes in precipitation

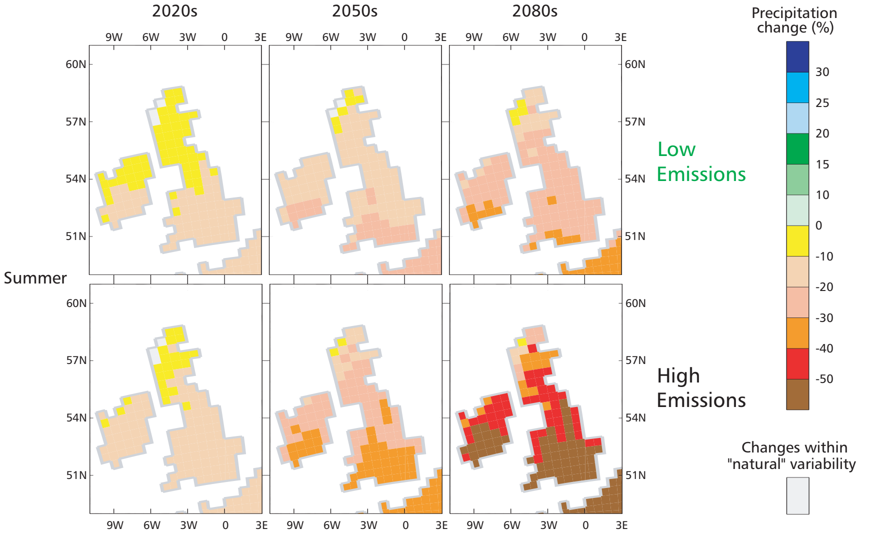
The following Figures[1] 2.3, 2.4 and 2.5 present the results of the models for the changes in precipitation based on the low and high emissions scenarios for the decades 2020, 2050 and 2080, on a map of the UK as represented by the 50 km grid boxes used for modelling. Potential changes in precipitation are presented for annual, summer (June, July and August) and winter (December, January and February) periods.

Figure 2.3: Modelled annual average precipitation changes for 2020s, 2050s and 2080s for low and high emissions scenarios



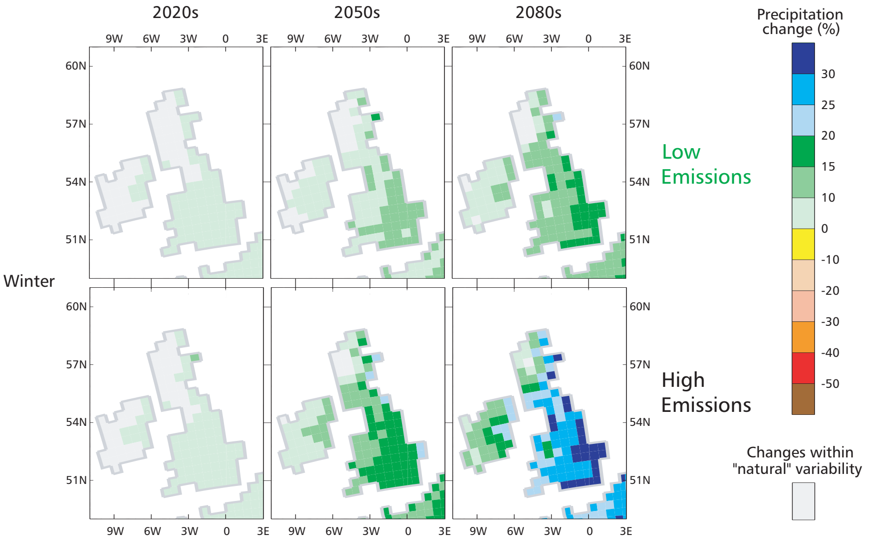
Source: UKCIP02 Climate Change Scenarios (funded by DEFRA, produced by Tyndall and Hadley Centres for UKCIP)

Figure 2.4: Modelled summer (June, July and August) average precipitation changes for 2020s, 2050s and 2080s for low and high emissions scenarios



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

Figure 2.5: Modelled winter (December, January and February) average precipitation changes for 2020s, 2050s and 2080s for low and high emissions scenarios



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

Summary of Changes in Precipitation

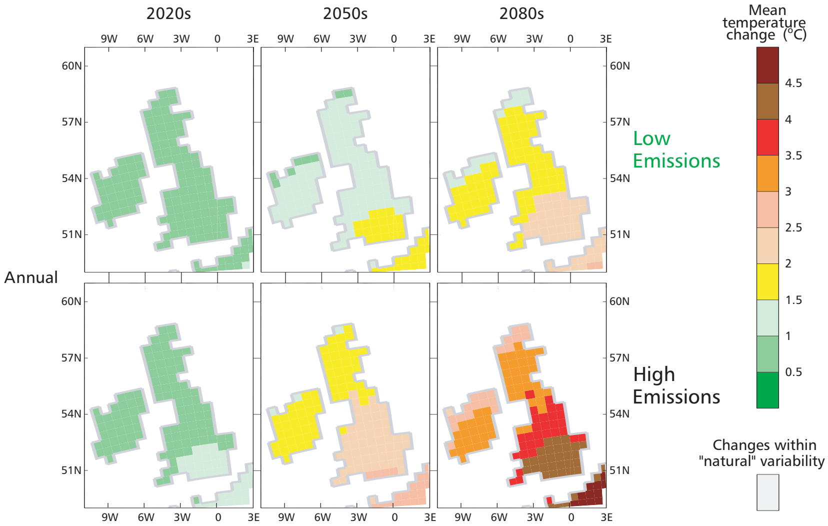
In summary, Figures 2.3 to 2.5 show:

- Wetter winters, by up to 30% by the 2080s for some regions and scenarios;
- Drier summers, by up to 50% by the 2080s for some regions and scenarios; and
- Little change, or slight drying, in the annual total.

2.2.2 Changes in temperature

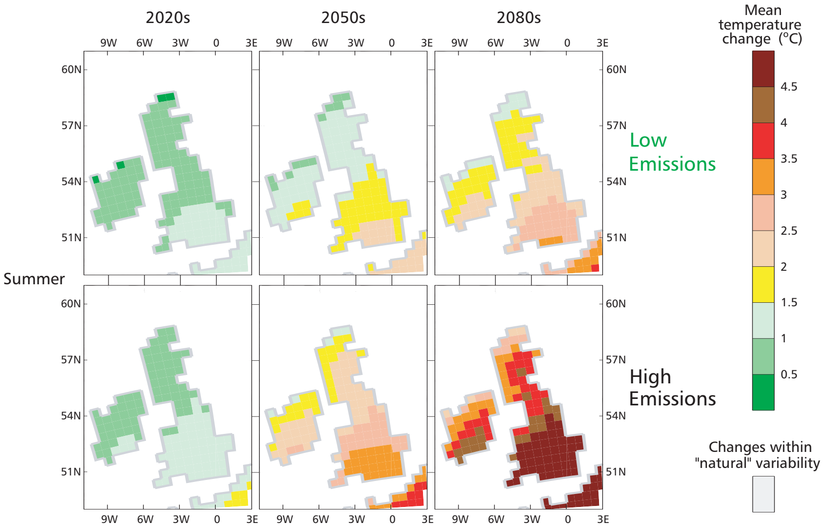
The following Figures[1] 2.6, 2.7 and 2.8 present the results of the models for the changes in temperature based on the low and high emissions scenarios for the decades 2020, 2050 and 2080, on a map of the UK as represented by the 50 km grid boxes used for modelling. Potential changes in temperature are presented for annual, summer (June, July and August) and winter (December, January and February) periods.

Figure 2.6: Modelled annual average temperature changes for 2020s, 2050s and 2080s for low and high emissions scenarios



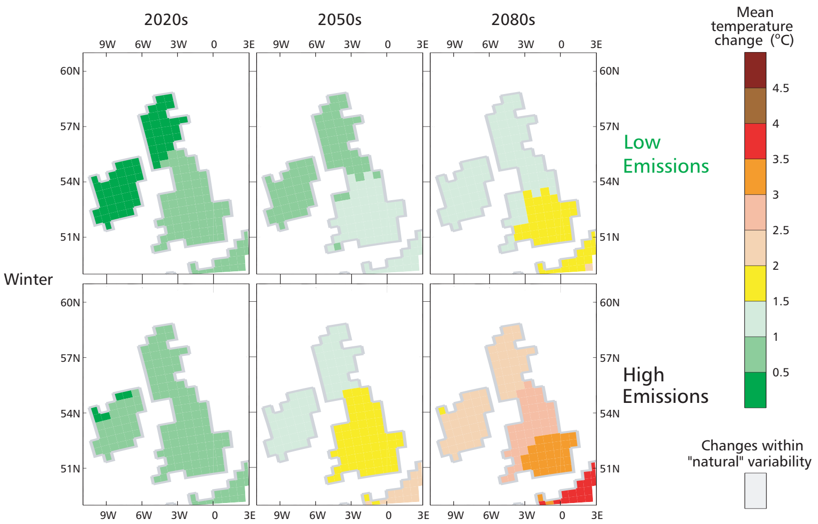
Source: UKCIP02 Climate Change Scenarios (funded by DEFRA, produced by Tyndall and Hadley Centres for UKCIP)

Figure 2.7: Modelled summer (June, July and August) average temperature changes for 2020s, 2050s and 2080s for low and high emissions scenarios



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

Figure 2.8: Modelled winter (December, January and February) average temperature changes for 2020s, 2050s and 2080s for low and high emissions scenarios



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

Summary of Changes in Temperature

In summary, Figures 2.6 to 2.8 show:

- an annual warming by the 2080s of between 1°C and 5°C depending on region and scenario;
- greater summer warming in the south east than the north west; and
- greater warming in summer and autumn than winter and spring.

2.3 What does this mean?

Recent examples of extreme seasonal conditions can be used to show what the climate may be like in the future. Table 2.3 presents some climate analogues to illustrate the potential changes. This shows that the occurrence of extremes could increase over the coming decades; for example, a dry 1995 type summer could be occurring once in every ten years by the 2020s, once every three years by the 2050s and once every other year by the 2080s.

Table 2.3: Percentage of years in which extreme temperature and precipitation could occur

MEAN TEMPERATURE	Anomaly	2020	2050	2080
A hot '1995 type' or '2003 type' August	3.4°C warmer	1	20	63
A warm '1999 type' or '2003 type' year	1.2°C warmer	28	73	100

PRECIPITATION	Anomaly	2020	2050	2080
A dry '1995 type' or '2003 type' summer	37% drier	10	29	50
A wet '1994/95 type' winter or '2004 type' autumn	66% wetter	1	3	7

Note: The percentage of years experiencing various extreme seasonal anomalies across central England and Wales for the Medium-High Emissions scenarios. The anomalies are shown relative to the average 1961-1990 climate.

2.4 How big is the risk of climate change?

The climate models[1] show a number of different possible effects; each with a different risk or chance of happening. Table 2.4 gives details of the risks of the seasonal changes and Table 2.5 gives details for daily changes. These could be used to inform the impact priorities and need for supporting work e.g. sensitivity analysis and use of approaches based on risk and uncertainty as laid out in UKCIP's recent publication developed with the Environment Agency[7].

There are many things we do not know that mean the risk of each effect could be different from what we now think. There is the need for us to know more about:

- the predicted levels of emissions in different parts of the world;
- how the chemistry of the seas and the atmosphere will change as the levels of carbon dioxide increase; and
- how big the changes in the world's weather patterns will be.

7. Climate Adaptation: Risk, uncertainty and decision making. UKCIP Technical Report, March 2003, Willows, R and Connell, R, (Eds)

Table 2.4: Summary statements of the risk of changes in average seasonal UK climate.

Variable	UKCIP02 scenarios	Risk
Temperature	Annual warming by the 2080s of between 1° and 5°C depending on region and scenario	H
	Greater summer warming in the south east than in the north west	H
	Greater night-time than day-time warming in winter	L
	Greater warming in summer and autumn than in winter and spring	L
	Greater day-time than night-time warming in summer	L
Precipitation	Generally wetter winters for the whole UK	H
	Substantially drier summers for the whole UK	M
Seasonality	Precipitation: greater contrast between summer (drier) and winter (wetter) seasons	H
	Temperature: Temperatures will increase in all seasons, this warming may be more rapid in summer than in winter, increasing the seasonal temperature contrast.	L
Variability	Years as warm as 1999 or 2003 become very common	H
	Summers as dry as 1995 or 2003 become very common	M
	Winter and spring precipitation becomes variable	L
	Summer and autumn temperatures become more variable	L
Humidity	Specific humidity increases throughout the year	H
	Relative humidity decreases in summer	M
Snowfall	Totals decrease significantly everywhere	H
	Large parts of the country experience long runs of snowless winters	M
Soil Moisture	Decreases in summer and autumn in the south east including Leicestershire	H
	Increases in winter and spring in the north west	M
Storm Tracks	Winter depressions become more frequent, including the deepest ones	L

In the above table quantitative statements are deliberately avoided: see the relevant UKCIP02 scientific report chapter for detailed numbers. Risk levels: H=high; M=medium; L=low.

Table 2.5: Summary statements of the risk of changes in daily weather extremes for the UK for the UKCIP02 scenarios

Variable	UKCIP02 Scenarios	Risk
Precipitation intensity	Increases in winter	H
Temperature extremes	Number of very hot days increases, especially in summer and autumn	H
	Number of cold days decreases, especially in winter	H
Thermal growing season length	Increases everywhere, with largest increases in the south east including Leicestershire	H
Heating "degree-days"	Decrease everywhere (Heating in buildings)	H
Cooling "degree-days"	Increase everywhere (Cooling in buildings)	H

In the above table quantitative statements are deliberately avoided: see the relevant UKCIP02 scientific report chapter for detailed numbers. Risk levels: H=high; M=medium; L=low

2.5 Impacts of climate change within Leicestershire

2.5.1 Climate change data

Data has been collected by UKCIP from a recent update (2002) to a global circulation climate model developed by the Hadley Centre (Met Office) and Tyndall Centre (University of East Anglia). This data provides an estimate of the potential changes in many climate variables under four distinct emission scenarios. The potential change in the spatial and temporal distribution of both temperature and precipitation is of most interest. Figure 2.9 shows the location of Leicestershire within the 50 X 50 km grid boxes used in the UKCIP climate change model.

The UKCIP data suggests that climate change could include the following adverse effects:

- A risk of less water available for domestic, industrial and agricultural purposes, this could effect Leicestershire more than other places as the county has a greater reliance on river catchment as the source of the water;
- A risk of more extensive and frequent flooding; and
- A risk of increased temperatures, with a greater number of 'hot periods', such as the summer of 2003.

Changes in Temperature

The general picture compared to the average for 1961 to 1990 for the Leicestershire area is for average annual temperature to increase by 0.5 to 1.0°C by the 2020s for all emissions scenarios, except for summer and autumn average temperatures which increase by 1.5°C for the medium-high and high emissions scenarios.

The range of differences between the scenarios becomes more extreme as the century progresses. The low emissions scenario predicts an annual average increase in temperatures of 2.5-3°C by the 2080s increasing to 3.5-4.5°C for the high emissions scenario; under the high emissions scenario summer temperatures may increase by more than 4.5°C by the 2080s.

Changes in Precipitation

Annual average rainfall shows little change over the whole range of emissions scenarios and time scales. The distribution and intensity of this rainfall, however, may change significantly. Winter rainfall shows increases across all scenarios with time, with the biggest increase of 'greater than 30% by the 2080s' under the high emissions scenario. Summer rainfall shows a corresponding decrease, with the greatest decrease (>50%) for the high emissions scenario for the 2080s.

The scenarios also predict an increase in the number of 'deep depressions' passing over the area during winter of up to 40%. The stormiest weather (intense rainfall and high winds) is associated with deep depressions. This would lead to the 'wrong sort of rain' in which the sheer volume of water would overwhelm the drainage system and result in flash floods in fairly small rivers at a localised level rather than the large scale 'slow' flooding that occurs in the flood plains of larger rivers. There is, however, greater uncertainty associated with this prediction than for the temperature and precipitation predictions.

Other Climate Changes

The UKCIP02 data also reports on a number of other climate parameters, although in less detail than for the temperature and precipitation predictions. The main highlights are:

- decreases in summer soil moisture content;
- increase in overall weather variability between years;
- decrease in cloud cover of up to 15% in summer;
- reduction in summer relative humidity;
- increase of up to 10% in winter daily wind speed; and
- a 60-90% decrease in snowfall.

2.5.2 Caveats

Choice of Scenario

The use of climate change scenarios for assessing both impacts and adaptation options is a major issue. It is very important that their use is consistent with the purpose of the study and the level of information required to meet that objective. Generally, this is related to the stage reached in the overall assessment process. The following guidance is from the UKCIP02 Scientific Report, Appendix 1:

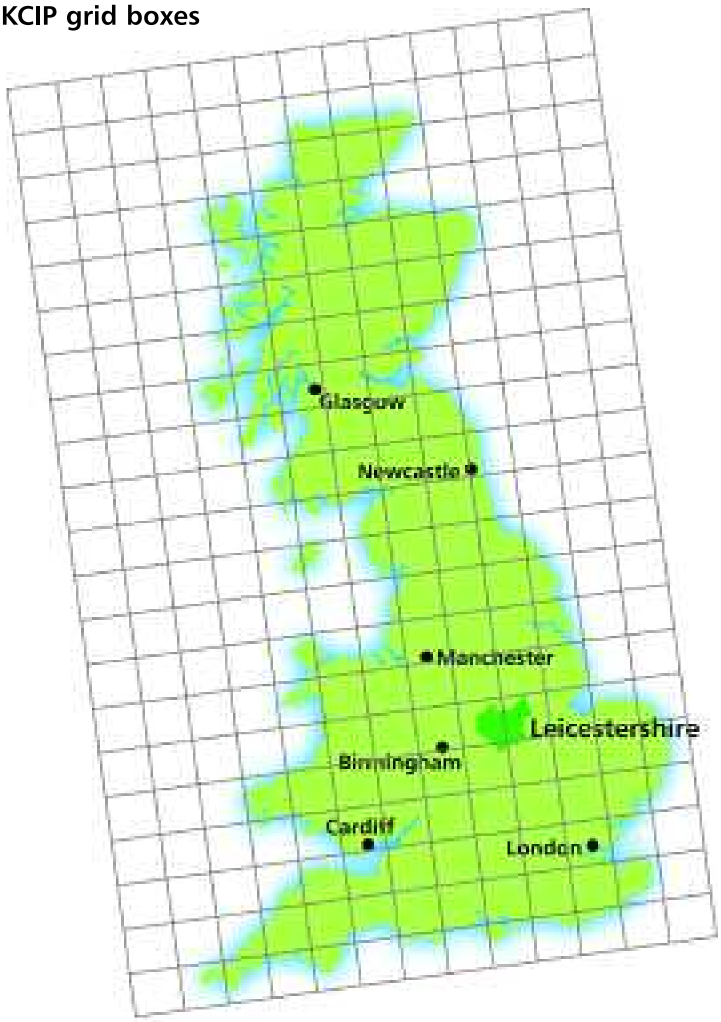
"For a general scoping study, using the four UKCIP02 scenarios, or even the highest and lowest, may be adequate to frame the extent of the problem, to decide if a more detailed investigation is necessary. For developing new research methodologies it may even be sufficient to use just one or two scenarios to test the appropriateness of different techniques.

For applications with major policy recommendations or specific design criteria in mind, however, users should investigate the impact of a wider range of climate change scenarios than are provided by the UKCIP02 report. Such an approach will reveal (again, at least in part) the extent of uncertainty in the response to climate change, and hence in the adaptation strategy which might be required." (Hulme et al, 2002)

Data Resolution

UKCIP strongly caution against the over-interpretation of data at the 50km scale from the regional climate model. Although the model has been validated for most of the major climate variables, this does not mean that every 50km grid box has been individually checked for every variable. Therefore the application of independent validation techniques, especially for impacts models, is strongly advised.

Figure 2.9: UKCIP grid boxes



2.6 Conclusions

The following conclusions can be reached from the preceding analysis:

- There is evidence that climate change occurred in the last century. This was due, at least in part, to human activities.
- A certain amount of climate change is inevitable because of past emissions of greenhouse gases.
- Leicestershire will have to learn to live with some level of climate change and adapt accordingly.
- Although climate change is likely to continue to occur in the future, its scale and nature will depend on the choices we make today about how much greenhouse gases we emit.
- There is growing scientific consensus on the causes and possible consequences of climate change but there are different levels of confidence in the outcomes that have been modelled and there are still many uncertainties surrounding climate change both in Leicestershire and globally.
- Climate change scenarios can help Leicestershire plan for future change.

3. Recent weather events

3.1 Introduction

The aim of this section is to provide illustrations of the potential nature of climate change. A direct comparison of the months of August 2003; that was very hot, and August 2004; that was very wet, gives a good example of the type of variation in weather that is predicted to occur as a result of climate change.

3.2 August 2003

3.2.1 What was the weather like in August 2003?

The following are extracts from the Meteorological Office's report on August 2003.

1st to 2nd - Low pressure to the north-west brought a breezy start to the month with occasional rain and drizzle, however it became sunny and warm by the 2nd.

Week of the 3rd to 13th - A notable and record breaking heat wave especially in the midlands, central southern and south-east England and East Anglia as high pressure took control bringing prolonged sunshine to most areas. Temperatures topped 30°C somewhere for 10 days in a row. **6th, 9th and 10th -** Temperatures exceeded 35°C in many places. New station records at Valley on Anglesey and Rocquaine on Jersey. 38.1°C was claimed by Gravesend, a new UK record. Carlton in Cleveland (North Yorks.) collected 48mm in 15 minutes with 20mm of hail on the ground.

Week of the 14th to 18th - Changeable with occasional rain or showers in places, mainly in western and southern areas and cooler, though still warm or very warm at times. There were good sunny periods generally, especially inland and in eastern areas.

Week of the 19th to 26th - Dry and mostly warm with sunny periods at first but more breezy in the north on the 21st as a low tracked eastwards passing by north Scotland.

Week of the 27th to 31st - An anticyclone near Iceland and low pressure over Scandinavia fed markedly cooler air from the Arctic. The cold front stalled over southern districts on the 28th as a depression from Biscay moved east-north-east bringing much needed rain to these areas.

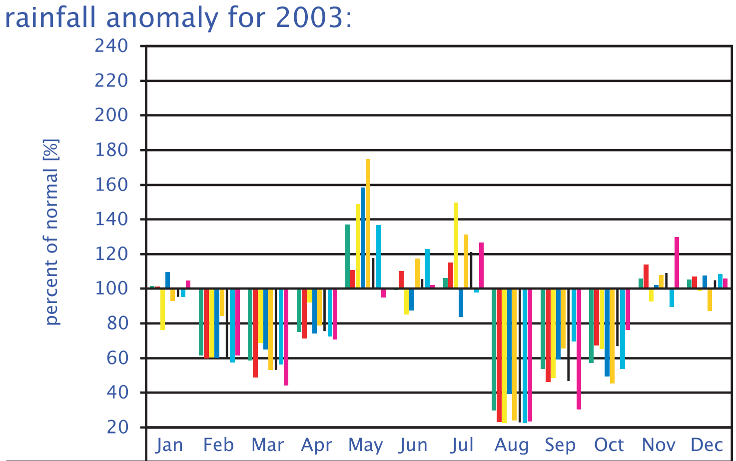
How unusual was the weather in August 2003?

Past summers have seen more prolonged heat waves. The long hot summer of 1976 saw temperatures exceed 32°C somewhere in the UK, on fifteen consecutive days starting on 23rd June. August 2003 temperatures topped 30°C somewhere for 10 days in a row. The initial value for the monthly average was 17.7°C, which is 2.4°C above the 1961-1990 average; according to the England and Wales Mean Temperature Series (begun in 1961). This is in the exceptionally above average category and was the fourth warmest in the series. The warmest August was in 1995 with 18.4°C.

The rainfall for August 2003 was in the exceptionally below average category at 21mm for the month, which is 27% of the 1961-1990 average; according to the England and Wales Rainfall Series (begun in 1766). The rainfall in other recent Augusts was: 276mm in 2002, 86mm in 2001, 66mm in 2000, 116mm in 1999, 47mm in 1998 and 101mm in 1997.

Figures 3.1, 3.2 and 3.3 illustrate the mean conditions for the whole of 2003 on a monthly basis for the UK as a whole and by region. These anomalies are expressed as either a percentage or absolute difference; as compared to the long term average for the years 1961 to 1990.

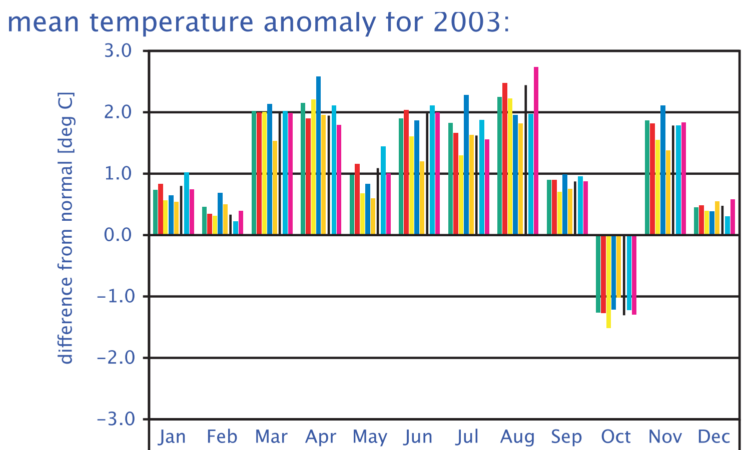
Figure 3.1: Percentage difference in rainfall



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
UK	101	62	59	75	137	99	106	30	54	58	106	105
England	101	60	49	72	111	110	115	23	46	67	114	107
Wales	76	61	69	92	149	85	149	23	49	65	93	99
Scotland	109	60	65	74	158	88	84	39	59	49	102	108
N Ireland	93	84	53	79	175	117	131	24	66	46	108	87
Eng and Wal	95	60	53	76	118	106	121	23	47	67	109	105
England N	95	58	56	73	136	123	98	22	70	54	90	108
England S	105	61	44	71	95	102	127	24	31	76	130	106

The anomalies represented in Figure 3.1 are illustrative of the effects that could be experienced under the UKCIP scenarios of drier summers. This type of summer could occur in about half of the years in the decade by the 2080s; as shown in Table 2.3.

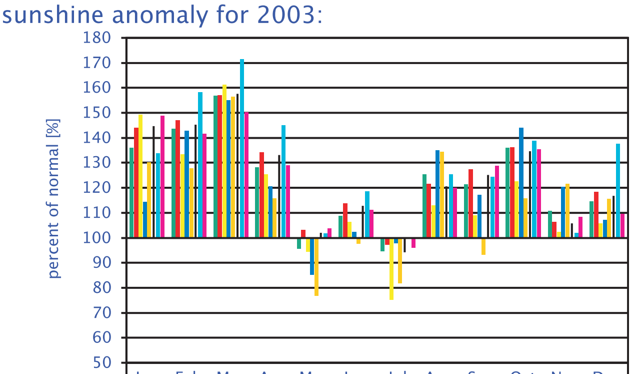
Figure 3.2: Difference in temperature



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
UK	0.7	0.5	2.0	2.2	1.0	1.9	1.8	2.3	0.9	-1.3	1.9	0.5
England	0.8	0.3	2.0	1.9	1.2	2.0	1.7	2.5	0.9	-1.3	1.8	0.5
Wales	0.6	0.3	2.0	2.2	0.7	1.6	1.3	2.2	0.7	-1.5	1.5	0.4
Scotland	0.7	0.7	2.1	2.6	0.8	1.9	2.3	2.0	1.0	-1.2	2.1	0.4
N Ireland	0.5	0.5	1.5	2.0	0.6	1.2	1.6	1.8	0.8	-1.0	1.4	0.6
Eng and Wal	0.8	0.3	2.0	1.9	1.1	2.0	1.6	2.4	0.9	-1.3	1.8	0.5
England N	1.0	0.2	2.0	2.1	1.4	2.1	1.9	2.0	1.0	-1.2	1.8	0.3
England S	0.7	0.4	2.0	1.8	1.0	2.0	1.6	2.7	0.9	-1.3	1.8	0.6

The anomalies represented in Figure 3.2 are illustrative of the effects that could be experienced under the UKCIP scenarios of annual warming. These types of temperatures could occur for the majority of the years in the decade by the 2080s; as shown in Table 2.3.

Figure 3.3: Percentage difference sunshine



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
UK	136	144	157	128	95	109	95	125	121	136	111	114
England	144	147	157	134	103	114	97	122	127	136	106	118
Wales	149	133	161	125	94	106	75	113	109	123	102	106
Scotland	114	143	155	121	85	102	98	135	117	144	120	107
N Ireland	130	128	157	116	77	98	82	134	93	116	122	116
Eng and Wal	145	145	158	133	102	113	94	121	125	135	106	117
England N	134	158	171	145	102	119	100	126	124	139	102	138
England S	149	142	150	129	104	111	96	120	129	135	108	110

The anomalies represented in Figure 3.3 should be compared with those shown in Figure 3.6 which shows the sunshine anomaly for 2004. 2003 and 2004 both have large positive temperature anomalies but very different sunshine patterns. This is an illustration of fact that the warming is independent of the amount of sunshine.

2003 was only the fifth warmest year in much of Britain since records began in 1659; despite record-breaking temperatures in the summer and a prolonged dry spell. The mean Central England Temperature in the summer was 17.3°C, making it the fourth warmest summer period on record. The record for the highest maximum temperature in the UK was broken on 10th August when the mercury hit 38.5°C at Brogdale, near Faversham in Kent. The CET between March and August was also the warmest March to August on record, at 1.73°C above the long-term average.

The England and Wales rainfall, up to the end of October 2003, was well below normal, with the period January to October being the eighth driest in a series that began in 1766. November 2003 was wet, however, with more than 60mm of rain falling between 21st and 23rd over much of South-east England, and the total November monthly rainfall for England and Wales being above average at 112mm.

World-wide, 2003 was the third warmest year according to figures compiled by the Met Office and the University of East Anglia for the World Meteorological Organisation, (WMO), since records began in 1861, with the global mean surface temperature estimated to be 0.45°C above the long-term average. All of the 10 warmest years have occurred since 1990, including each year since 1997.

3.3 August 2004

3.3.1 What was the weather like in August 2004?

The following is the Meteorological Office summary of the weather for August 2004:

A very wet month, with many areas receiving double their average August rainfall. Sunshine totals were close to average in most parts, although parts of south-east Scotland and north-east England had considerably lower than average amounts. Shetland's sunshine total was much higher than average. Mean temperatures were generally one or two degrees Celsius above average. On 16 August, there was devastation in Boscastle (north Cornwall) due to severe flooding, and at nearby Otterham 200.4mm of rain fell in 24 hours. Lesnewth near Boscastle had 64.8mm of rain in an hour. Eskdalemuir recorded over 300mm during the month.

Diary of highlights:

Week of the 1st to 8th - Over the week, the weather became more unsettled with showers becoming widespread and thundery.

3rd - 42.4mm of rain was recorded at High Wycombe in an hour.

7th and 8th - Very warm or hot with a temperature of 31.5°C recorded in central London and at Northolt.

Week of the 9th to 15th - The hot weather culminated in some warm, sultry nights.

9th - A minimum of 21.9°C was recorded on the morning at Marham, Norfolk. The warmest night there since at least 1957.

10th - Wittering recorded 90.8mm in the 24 hours.

Week of the 16th to 17th

16th - Devastation in Boscastle (north Cornwall) due to severe flooding and at nearby Otterham 200.4mm of rain fell in 24 hours. Lesnewth near Boscastle had 64.8mm of rain in an hour.

Week of the 18th to 29th - Low pressure dominated with temperatures generally close to average.

25th - 41.6mm of rain recorded in Manchester.

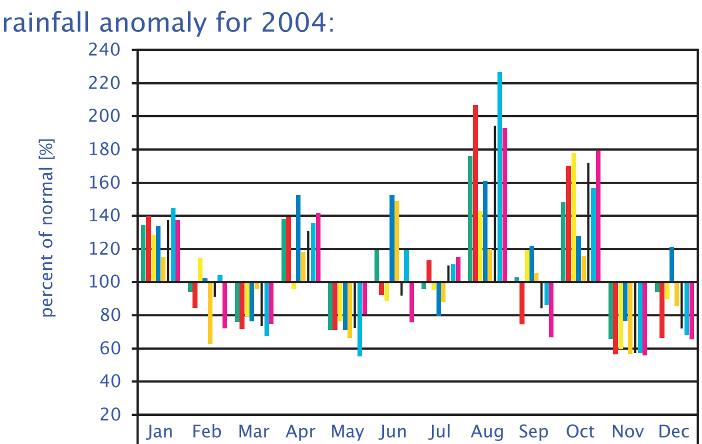
30th to 31st - The 30th was rather cool in many places with fresh winds and there were some showers in the east. A ridge of high pressure on the 31st brought a fine day to most places to close the month.

The initial temperature value for the month was 17.0°C, which is 1.8°C above the 1961-1990 average, in the well above average category. The initial rainfall total for the month was 152.9mm, which is 200% of the 1961-1990 average, which is in the exceptionally above average category.

August 2004 was the wettest in the England & Wales Rainfall Series (began in 1961). The previous wettest was 1992 with 127.7mm. The initial sunshine total (England and Wales Sunshine Series began in 1929) for the month was 171.9 hours, 100% of the 1961-1990 average, which is in the close to average category.

Figures 3.4, 3.5 and 3.6 illustrate the mean conditions for the whole of 2004 on a monthly basis for the UK as a whole and by region. These anomalies are expressed as either a percentage or absolute difference as compared to the long term average for the years 1961 to 1990.

Figure 3.4: Percentage difference in rainfall

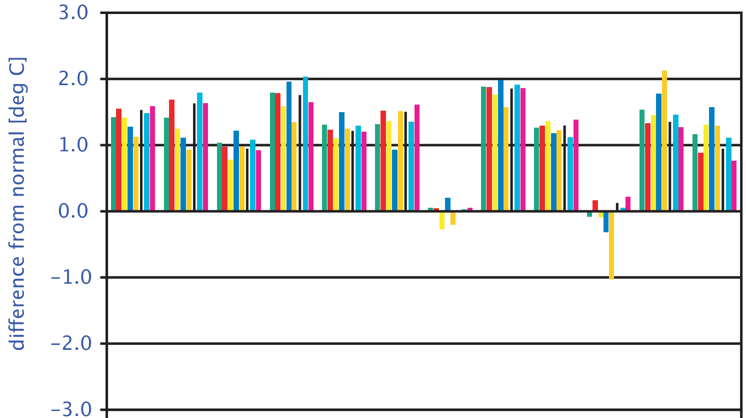


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
UK	135	94	76	138	72	119	96	176	103	148	66	94
England	140	84	72	139	71	93	113	207	75	170	57	67
Wales	128	115	80	96	77	89	95	143	119	178	60	90
Scotland	134	102	77	152	71	152	79	161	121	128	77	121
N Ireland	115	63	96	118	67	149	88	120	106	116	57	85
Eng and Wal	137	91	74	131	72	92	110	194	84	172	57	72
England N	145	104	68	136	56	119	111	227	86	157	57	68
England S	137	72	75	141	81	76	115	193	67	179	56	66

The anomalies represented in Figure 3.4 should be compared with those in Figure 3.1 are illustrative of the effects that could be experienced under the UKCIP scenarios of more unstable and unusual weather patterns. The incident at Boscastle illustrates what can happen when drainage and flood defences are inundated by extreme rainfall events.

Figure 3.5: Difference in temperature

mean temperature anomaly for 2004:

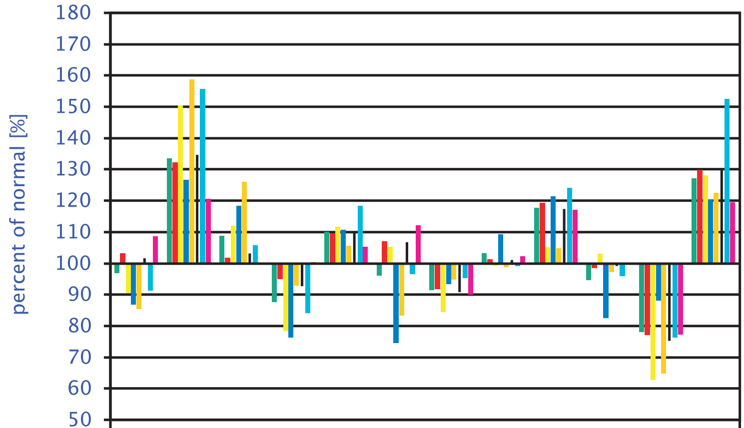


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
UK	1.4	1.4	1.0	1.8	1.3	1.3	0.1	1.9	1.3	−0.1	1.5	1.2
England	1.5	1.7	1.0	1.8	1.2	1.5	0.0	1.9	1.3	0.2	1.3	0.9
Wales	1.4	1.2	0.8	1.6	1.1	1.4	−0.3	1.8	1.4	−0.1	1.4	1.3
Scotland	1.3	1.1	1.2	2.0	1.5	0.9	0.2	2.0	1.2	−0.3	1.8	1.6
N Ireland	1.1	0.9	1.0	1.3	1.2	1.5	−0.2	1.6	1.2	−1.0	2.1	1.3
Eng and Wal	1.5	1.6	0.9	1.8	1.2	1.5	0.0	1.9	1.3	0.1	1.4	0.9
England N	1.5	1.8	1.1	2.0	1.3	1.4	0.0	1.9	1.1	0.1	1.5	1.1
England S	1.6	1.6	0.9	1.7	1.2	1.6	0.1	1.9	1.4	0.2	1.3	0.8

The anomalies represented in Figure 3.5 are illustrative of the effects that could be experienced in UKCIP scenarios of annual warming. These types of temperatures could occur for the majority of the years in the decade by the 2080s; as shown in Table 2.3. A comparison with the anomalies in 2003 shows that the relatively large temperature increase is independent of the level of precipitation and sunshine.

Figure 3.6: Difference in sunshine

sunshine anomaly for 2004:



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
UK	97	134	109	88	110	96	92	103	118	95	78	127
England	103	132	102	95	110	107	92	101	119	99	77	130
Wales	91	150	112	78	112	105	84	99	105	103	63	128
Scotland	87	127	118	76	111	75	93	109	121	83	88	120
N Ireland	86	159	126	93	106	83	95	99	105	97	65	123
Eng and Wal	102	135	103	93	110	107	91	101	117	99	75	130
England N	91	156	106	84	118	97	95	99	124	96	76	152
England S	109	121	100	100	105	112	90	102	117	100	77	120

3.3.2 Hurricane in the South Atlantic

There were some unexpected events in 2004. The following is an extract from the Met Office website.

South Atlantic Hurricane breaks all the rules

Pick up any text book on hurricanes and it will tell you that the one place where hurricanes do not occur is the South Atlantic Ocean. The atmosphere does not provide enough spin near the surface to get them started and winds higher in the atmosphere tend to shear off any that do make a start. Hence, it was with some amazement that meteorologists watched the first ever recorded hurricane develop off the coast of Brazil in the last week of March.

Figure 3.7 Tropical cyclone Catarina off Southern Brazil, 26 March 2004. The first hurricane recorded in the South Atlantic. *Image courtesy Jeff Schmaltz, MODIS Land Rapid Response Team http://rapidfire.sci.gsfc.nasa.gov at NASA GSFC.*

Initially the storm did not look much like a hurricane, but in common with some of its counterparts which develop in the North Atlantic Ocean, it acquired enough characteristics to convince the majority of the world's tropical cyclone experts that it was indeed a hurricane. It came ashore in the Brazilian state of Santa Catarina on 28 March 2004 with winds, estimated by the US National Hurricane Centre, of near 90 m.p.h., causing much damage to property and some loss of life. The Brazilian meteorologists dubbed it 'Catarina'.

Climate Change signal?

Climate change scientists, working in the Met Office Hadley Centre for Climate Prediction and Research, recognised this as a feature they see in their climate model. In a world made warmer by increased greenhouse gases, their model shows that this is one of the areas to watch in the future as there may indeed be more tropical storms for the South Atlantic.

The signal is not clear, however, as some aspects of the model are not realistic and don't exactly match the current storm, but the potential is there and the event is part of the climate change jigsaw, which experts are piecing together.

3.4 Evidence of the extreme conditions

The following sections describe some of the general impacts of the weather extremes experienced in summer in 2003.

3.4.1 Water supply

It was reported that thousands of homes in London were cut off on the 19th August due to a burst water main. The North Circular at Brent Cross was reduced to one lane because of the flooding. Thames Water said the problem was caused by the hot weather that caused pipes to fracture. Water supply was restored the next day. Shops ran out of bottled water and residents made deliveries to elderly neighbours suffering from diabetes.

On 6th August Thames Water supplied 2,603 million litres to London, the highest for eight years and 300 million litres above average. Thames Water was well prepared for the event, having been planning since early spring. They use forecasting services from the Meteorological Office.

The unusually warm weather was one of the reasons why the bottled water industry experienced high demand in the early part of 2003. One bottled water company reported double digit growth in March 2003 compared to last year. Stockpiling of bottled water due to fears about war were also thought to have contributed to the increase.

3.4.2 Storms

In August 2003 there were severe thunderstorms over north-east England. Carlton in Cleveland (North Yorks.) had 48mm of rain in 15 minutes with 20mm of hail on the ground. Middlesborough had 30mm of rain in a downpour. These events led to hospital services being disrupted in Middlesborough and Stockton-on-Tees. Middlesborough A & E department was closed for over six hours when the power supply was knocked out due to rainwater. Generators were brought in.

In July, France experienced heavy storms and it was estimated that as a result, four people died and 70 people were injured. Power was cut to more than 300,000 homes.

It has been estimated that the October 2002 storms in the UK cost £500 million, with damage to power supplies in eastern England and eight deaths. The Christmas/New Year floods (2002/03) cost around £9 million.

There were 562 tornadoes during May in the United States, resulting in 41 deaths. This was a record for the number of tornadoes in a month. The previous highest was 399 in June 1992.

3.4.3 Transport

A buckled rail is thought to have caused a freight train carrying a cargo of Guinness to come off the track near Lichfield in early August. The driver was uninjured but the crash closed the West Coast Main Line. Speed restrictions, causing delays, were also imposed by Network Rail and London Underground, amid concerns that tracks could buckle in temperatures of 30˚C and above. The London Eye was closed on 6th August; according to a spokeswoman this was "for the comfort of guests".

3.4.4 Fires

Forest fires occurred across Europe during the prolonged heat wave. Some people believe that the forest fires in Italy were started deliberately, but not by hooligans and petty arsonists. Farmers and shepherds wanting to gain new grazing and farmland or by those who want to be paid for reforesting the areas could have started some fires. Fire fighting itself also creates temporary jobs in regions affected by high unemployment and some have speculated that this also leads people to start fires deliberately. Whatever the cause, hot spells create the conditions for more widespread fires. Fires also affected Portugal and Greece.

3.4.5 Health

On 29th August the BBC reported that an estimated 11,000 people died in France's heat wave in the first half of August. Temperatures rose to over 40°C leading to an unusually high number of deaths of mainly elderly people and putting a heavy strain on mortuaries and funeral services. The country's leading undertakers estimated that the death toll had been higher than official government figures at 13,000. It is thought that certain issues exacerbated the situation including:

- the August leave system meant that the Cabinet was absent as the crises took hold; and
- the mass departure of doctors on holiday had a severe impact on the working of the emergency system.

Higher deaths were also reported in the Netherlands, Portugal, UK and Spain. Increases in hot spell mortality in the UK were considered as part of a Department of Health study into the potential impacts of climate change on health[8]. It is thought that reductions in cold spell related mortality due to higher winter temperatures are likely to be more significant than increases in hot spell mortality.

The Trade Union Congress called for the Government to impose a maximum temperature, beyond which workers would be allowed to go home as workers were at an increased risk of accidents and ill health during hot spells. A spokeswoman for Reed Recruitment told the BBC News Online that "When things get really hot in the UK, some workers do seem to get struck down with a mysterious illness - sometimes known as 'suntanitis' - which makes them phone in sick." Whether this is true or not it highlights the need to provide comfortable working conditions in order to maintain productivity and morale. The following quotes illustrate this.

- *"I'm lucky because my manager is very reasonable about dress code and refreshment breaks - but there again, he's in the same boat as the rest of us - no air conditioning and sweltering office temperatures. I feel really sorry for workers with stricter bosses."* Ali, Chelmsford, Essex.
- *"I am sat at the moment in a fully air conditioned office and I have to say it is really nice to come to work."* Craig Oddy, Halifax.
- *"If it gets any hotter I am going home. I can't stand much more of this."* Mark.

Berlin public sector workers stopped work under rules allowing them to leave their desks if temperatures went over 29°C. The London climate change impacts study[9] reported a study that showed that a small non air conditioned office in London could be outside of acceptable working conditions for nearly 25% of the time under future climate conditions.

The Health and Safety Executive (HSE) has issued guidance to help employers make hot conditions bearable for staff. Workplace regulations say that there must be a 'reasonable temperature' inside buildings during working hours. Hot weather could lead to lapses in concentration or irritability amongst staff. This could have health and safety implications. HSE recommended a number of steps:

- Provide air conditioning or fans (this would lead to more energy consumption);
- Provide blinds to shade windows;
- Site workstations away from direct sunlight;
- Provide additional facilities such as cold water dispensers;
- Allow breaks to allow employees to get cold drinks or cool down; and
- Introduce more flexible hours to avoid exceptionally high temperatures.
- HSE have an enquiry line (08701 545500).

8. Health effects of climate change in the UK, Department of Health, 2002
9. A climate change impacts in London evaluation study, 2002

3.4.6 Power supply

According to a report in the Guardian on 27th August 2003, concern about the impacts of the high temperatures on nuclear power stations led Electicite de France (EDF) to use fire crews to hose down concrete walls in order to reduce operating temperatures. The French Environment Minister also limited EDF's nuclear output because cooling water was being discharged into rivers at too high a temperature. 80% of France's electricity comes from nuclear power stations. This electricity is supplied to other European countries including Italy, Germany and Britain. In June 2003 the flow of electricity was from Britain to France for the first time, rather than the other way around as is usual. This contributed to a series of warnings from National Grid Transco (NGT) about potential power shortages.

Italy experienced an almost countrywide power blackout on Sunday 28th September due to an accident on a power line in Switzerland. Italy imports 17% of its energy compared to a Europe wide average of 2%. North East United States and Canada experienced blackouts in August. Denmark and Southern Sweden experienced blackouts in September. A storm affecting Sweden and Denmark, bringing down trees, may have contributed to the blackouts but officials said it was too early to say what the cause was. Two million consumers were affected in southern Sweden and 1.8 million were affected in Copenhagen.

Future changes in energy consumption due to climate change could have fundamental implications for power generation and transmission. On a typical summer's day 40% of the USA's electricity demand is for air conditioning. In some hot summers New York has experienced brown outs - a loss of power due to increased demand leading to lights dimming, machinery working at less than full capacity etc. These events can affect poorer households more severely, as the transmission system may not be as robust in poorer districts.

If Britain moves to a greater use of air conditioning in the summer this will increase energy use and emissions of greenhouse gases as most air conditioning is powered by electricity, mostly from fossil fuels. A move to greater use of renewables would offset these emissions.

3.4.7 Biodiversity

The BBC reported (9th August 2003) that the hot weather was causing water levels in the River Teme to fall, raising fears that trout could be caught in shallow pools without enough oxygen. Environment Agency workers in North Herefordshire used mild electric shocks to stun the trout prior to putting them in a holding tank and moving them to deeper water.

British Waterways said that the hot weather had increased algal growth leading to fish deaths on a stretch of the Grantham Canal near Cotgrave in Nottinghamshire. BW installed eight oxygen pumps, carried out daily inspections and continued to clear vegetation.

Environmental Officers from Crewe and Newcastle-under-Lyme said that the hot weather contributed to an increase in the fly population leading to a plague of flies in Betley, Wrinehill and Madeley on the Staffordshire-Cheshire border. The plague was linked to a local egg farm at Checkley.

At Amsterdam zoo ostriches were sprayed with cold water and iced fruit was fed to chimpanzees. Similar action was taken in UK zoos, where penguins and animals were given ice lollies made of fish, fruit and herbs to keep them cool. They also had suntan lotion applied to keep them from burning. The tigers at London Zoo found the heat too much and refused to feed. In order to cool them down they were fed ice lollies made from real frozen blood.

3.4.8 Agriculture

The hot spell had a number of impacts on farming across Europe:

- 54 of France's 98 departments requested state aid for drought hit farmers.
- Grass was burnt brown in the Massif Central in France, affecting livestock, as there hadn't been much rain since March. It was said that farmers had nothing to give cattle unless feed was brought in from Paris. The north east of France was also affected but fruit and arable crops were not so badly affected as there was enough water for them.
- In Italy farmers thought that the volume of wine produced would be the same as 2002 but the quality would be up. Other crops were badly affected especially soya, corn and sugar beet. The crops need a lot of water and there was competition between domestic, industrial and farming water users. Attempts were made to increase water levels in rivers by releasing mountain reserves but this only raised levels by 2-3cms.
- In the UK the National Farmers Union said that the hot summer meant that the wheat harvest was likely to start at least a week early.

3.5 Experiences within Leicestershire

Incidents like the ones reported below, such as extreme rainfall in summer; although not direct evidence of climate change, are illustrations of what could be expected if climate change continues. There will be effects like these on the people, property and livelihoods in Leicestershire.

The Environment Agency gave Leicester, including Leicester City, Melton Mowbray and Loughborough, Flood Watch status on 17th August 2004 meaning that flooding is possible and that the public, businesses and other organisations needed to: "Be aware! Be prepared! Watch out!"

The **Met Office** released the following diagram to illustrate the risk of disruption.

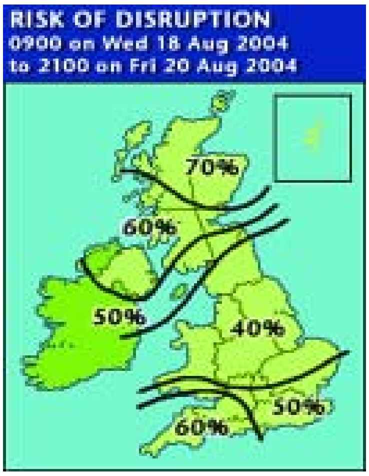


Figure 3.8 Risk of Disruption

In July 2004 over 60 shops in Market Harborough were affected by flash floods caused by torrential rain. Many businesses had to close with some buildings flooded to a depth of two feet. Drains overflowed and water ran down the High Street.

In August 2004 Leicestershire was hit by flash floods as the August heatwave once again turned to torrential downpours. Shops and homes in Loughborough, Market Harborough and Hinckley were the worst hit, with some streets submerged and cellars flooded by up to 5ft. Storms left the basement of Loughborough's new £45 million shopping complex awash with 3ft of water after a freak rainstorm swept across the county. As thousands of disturbed sleepers across the county could have guessed, the night of the 9th was the hottest August night on record. Temperatures reached a minimum of 20°C (68°F), the highest since Leicester Mercury weatherman Dave Mutton began his records in 1959.

Miserable weather throughout August was blamed for a massive slump in visitor numbers at county tourist attractions. Heavy rainfall during what is usually one of its most profitable months saw gates drop by thousands across Leicestershire's tourist industry. Bosses pinned their hopes on a more successful September, with a prolonged sunny spell said to be on the way. However, business leaders said tourist attractions should do more to pull in the punters - whatever the weather. Head custodian at Ashby Castle, Zoe King, said the landmark had seen nearly 800 fewer people through the gates last month than for the same period in 2003. She said: "It just goes to show

how awful the weather's been. Because we're a ruined castle without a roof, we're quite dependent on it."

In September it was reported that aluminium barriers, costing about £200 each, were being installed at shops in Market Harborough. They were placed in front of shop doors in heavy rain and were thought by many to be more effective than sandbags.

In October it was reported that Anglian Water was investing nearly £2 million in a flood alleviation scheme for Market Harborough. A large underground tank capable of storing more than two million litres of water is to be installed. About 100 spaces in a town centre car park will be closed during the work, which would also cause some periodic disruption to traffic during road works.

4. Key activities in Leicestershire which contribute to CO_2 emissions

The key activities in Leicestershire that contribute to emissions of carbon dioxide are road transport (43%), combustion at commercial, institutions and residential properties (35%) and industrial combustion (18%). In addition to these three activity sectors there are also five other sectors that contribute less than 6% between them.

The levels of carbon dioxide emission from activities in the Leicestershire area as reported to the National Atmospheric Emissions Inventory (NAEI) for the year 2002 are shown in Table 4.1.

Table 4.1: Emission of carbon dioxide by activity sector

Activity sector	Carbon dioxide (kt CO_2)
Road transport	2,072
Commercial, institutional and residential fuel use	1,701
Industrial combustion	860
Other transport (including airport)	198
Energy production and transformation	39
Industrial processes	1
Production and distribution of fossil fuels	0
Waste treatment and disposal	3
Total for Activities	**4,873**
Agriculture	12
Nature	139
Total for Activities, agriculture and nature	**5,025**

The total for the activities of 4.87 Mt CO_2 is estimated to be less than 10% of the area total for the whole East Midlands region[10], (estimated to be approximately 59.1 Mt CO_2 equivalent in 1997); this figure also includes other greenhouse gases. One feature of the data for Leicestershire is that the contribution from point sources to the activity total is only 48 kt CO_2. This would be expected as there are no large emission sources, such as coal fired generators, in the area. (A large power station such as that at Cottham in Nottinghamshire would contribute in excess of 15 Mt CO_2 per year).

There are other sources of greenhouse gases in Leicestershire in addition to carbon dioxide. These are difficult to estimate but are expected to be around a total of 820 kt CO_2 equivalent based on a pro rata approach to the data for the East Midlands area.

4.1 Airport emissions

The NAEI category Air Transport gives an estimate of emissions within a 1,000m ceiling of takeoff and landing. This roughly represents the boundary layer and emissions into it.

The estimates are calculated from the number of aircraft movements at British airports and emission factors calculated as the emission of pollutant per aircraft movement. It is however more usual to express emission factors as the emission per landing and takeoff cycle.

10. The Potential Impacts of Climate Change in the East Midlands Area; Entec UK Limited, August 2000.

For an aircraft landing and takeoff cycle (LTO) the following stages of operation are considered:

- approach from 1,000m;
- taxi;
- takeoff;
- climb out to 1,000m.

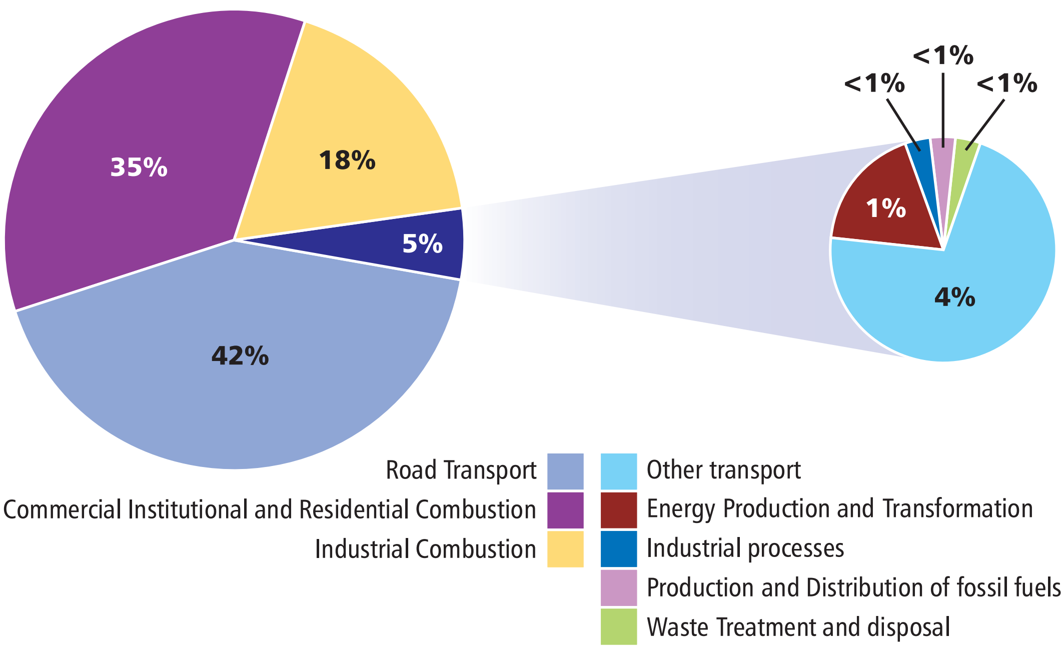
UK aircraft statistics are reported as aircraft movements (i.e. takeoff or landings) and so the emission factors are reported as emission per movement. It follows that one LTO is equal to two aircraft movements.

The estimated total emissions from the aviation activities at the East Midlands Airport in Leicestershire are approximately 42 kt CO_2 for 2004.

4.2 Energy imports

The emissions for the activities shown in Table 4.1 only cover the direct sources in Leicestershire. The figure for the energy production is low because there are no large power stations in Leicestershire. This means that a significant amount of carbon dioxide that Leicestershire causes through its electricity use is actually released outside the county. The same is also true for the emissions of carbon dioxide released in the manufacture of high energy goods such as aluminium and cement.

Figure 4.1 is a graphical illustration of Leicestershire's greenhouse gas emissions.



5. Mitigation Strategy

5.1 Introduction

The Leicestershire Community Strategy 2003[11] identified the need for a climate change strategy; with ENABLE being responsible for its production by March 2005. The development of the mitigation side of the strategy, as well as meeting the environmental requirements, will also provide benefits and opportunities to a number of other areas in the Community Strategy such as the aim to develop strong local communities, transport systems and energy efficient homes. The long term goal for the UK Climate Change Programme is to achieve a 60% reduction in the levels of emission of carbon dioxide on 1990 levels by 2050.

It is not expected that the mitigation strategy will operate in isolation nor will it need to "re-invent the wheel" in order to achieve its aims. A large number of policies and measures are being implemented at national and regional levels and there are many sources of information; despite this there has been difficulty in getting action at the local level. ENABLE; through the framework of the Community Strategy are ideally placed to implement an effective climate change mitigation strategy at local level.

The sections in this document provide information on the different aspects of the mitigation of climate change through the reduction of emissions of carbon dioxide. As well as reduction based strategies this document also makes reference to other techniques, such as tree planting, that can be used to capture carbon dioxide from the atmosphere. It should be stressed that these are not regarded as being reliable for national level strategies but can make an important contribution at a local level when combined with community and amenity value.

- Section 2 describes the factors that were identified as being key to the success of climate change mitigation projects.
- Section 3 provides details of the main strategies that should be considered for the mitigation of climate change.
- Section 4 examines how the other actions specified in the Leicestershire Community Strategy can support and in turn be supported by the climate change strategy.
- Section 5 provides an overview of available low energy technologies and techniques. These are categorised according to spatial scale and attributes, thus forming a guide to the suitability of particular technologies for a particular practitioner. This is intended to act as a starting point for selecting climate change mitigation methods.

The Sustainable Development Commission has done a large amount of work under the dCarb-uk programme to develop a framework for achieving deep cuts in the UK's emission of carbon dioxide and other greenhouse gases at different spatial levels, ranging from individual households through to UK regions. A large part of this work is applicable to the development of a climate change strategy for Leicestershire. The sections of this report are based upon the findings and information of dCarb-uk framework programme and associated reports. Further information on the framework and copies of the reports are available from the Sustainable Development Commission[12]. This document recommends that this framework be taken forward and applied in Leicestershire.

5.2 Key Success Factors

A study carried out for the Sustainable Development Commission identified the key success factors in the achievement of climate change mitigation. The key success factors are:

12. Leicestershire Community Strategy, The Leicestershire Local Strategic Partnership July 2003
13. Sustainable Development Commission, www.sd-comission.gov.uk

- adopting an integrated and innovative approach;
- partnership;
- leadership and personal motivation;
- organisational support;
- targeting successful technologies;
- effective communication strategy;
- funding;
- target setting, data capture and carbon dioxide monitoring.

The results illustrate the importance of leadership and personal motivation in achieving climate change mitigation. In tandem, they signal the importance of many contextual factors, including organisational support, partnership, integration, funding, data access and appropriate technology, which all affect the ability of individuals and organisations to innovate and deliver ambitious mitigation goals. The relationship between the person and the context in carbon reduction seems to be interdependent, with success most likely when a person is able to constructively work with or negotiate around contextual barriers to achieve their objectives.

Whilst key success factors were identified, it was also the case that no 'one best way' seemed to exist in the achievement of climate change mitigation, with diversity and flexibility in delivery commonplace, depending upon the local circumstance. The results suggest that a careful balance must be struck between mitigation delivery mechanisms that originate in, and are controlled by, central government (i.e. national agencies and institutions), and the benefits to be gained from a more devolved delivery approach that allows key individuals and organisations, based in local areas, the freedom to opportunistically choose appropriate and innovative solutions for their specific area based context that are optimal for success.

Key obstacles were also identified in the research; including lack of leadership; discontinuity; scepticism and cynicism from the public; lack of knowledge amongst professionals; regulation; the dominance of the short-term view and conflicting targets.

5.3 Mitigation Strategies

There are a number of different ways in which strategies to mitigate climate change can be considered. One of the difficulties with developing a strategy is getting the correct scale upon which to operate. The ENABLE strategy is a community based approach and consequently the mitigation strategies should be based on the context with which most people will be comfortable. The main feature of our lives are our homes, the places we work and our communities.

It is important to note that 35% of the emission of carbon dioxide from Leicestershire come from residential, institutional and commercial buildings[13]. The majority of this is from fuel use for heating. In addition to this the activities within these buildings, such as lighting, air conditioning and appliance operation also consume 50% of all the UK's generated electricity[14].

There is the need to consider the development of mitigation strategies at more specialised levels for activities such as transport planning, waste management and the development of renewable energy. These will be considered as separate sections in their own right.

5.4 Households

In general, households are existing properties where the domestic occupant or tenant cannot alter the building structure. There are however many behaviour patterns and technology decisions which can be made by an occupant of a house.

13. The National Atmospheric Emission Inventory, www.naei.org.uk
14. Digest of UK Energy Statistics 2004, www.dti.gov.uk/energy

The mitigation strategy of an energy-aware household would:

- make use of free impartial energy advice from the local Energy Efficiency Advice Centre (EEAC), thus obtaining an energy baseline and recommendations on energy efficiency measures, as well as details of relevant discount schemes and installers; (EEAC Helpline tel. 0800 512012)
- have the recommended depth; 250mm, of insulation in the loft, cavity wall insulation; where suitable, floor insulation where required and also good pipework insulation throughout the dwelling;
- always switch off lights when not needed and close windows when the heating is on, although some ventilation will be needed to avoid the build up of condensation;
- utilise effective heating controls with room thermostats set to 21°C, independent automatic timers for heating and domestic hot water and thermostatic radiator valves, bedrooms should have a temperature in the region of 18°C and living rooms 21°C;
- use double-glazing for windows, although this should not be fitted purely as an energy efficiency measure
- use draft-proofing for doors and windows that can be opened;
- use a condensing or condensing/combi boiler, which should have an A rating and be fitted by a Corgi register installer;
- purchase some or all of the electricity supply from renewable sources;
- use energy efficient light bulbs especially for most regularly used lights;
- cycle or walk for local trips rather than drive;
- use public transport for local and long distance journeys;
- use a modestly sized, fuel efficient car, diesel rather than petrol– with appropriate tail pipe technology e.g. catalytic convertor.

The more ambitious low energy household could take further steps, such as:

- use modern wood fuelled boiler for space and water heating, making use of available grant aid towards capital costs;
- install solar water heating panels on unshaded roof spaces, join local DIY ‘solar club, check what grants are available;
- install solar photovoltaic modules on roof spaces for electricity supply, check what grants are available;
- join a local car-share scheme to reduce private car ownership;
- investigate local supply options for bio diesel;
- use an ultra low carbon car such as petrol/electric hybrid, using available grant aid.

5.4.1 Route Map to 60% CO_2 Reduction

To devise a climate change mitigation plan, a household should begin with an assessment of their current emission baseline. An illustrative example is shown in Table 5.1.

Table 5.1: Typical Household Carbon Dioxide Emissions

	Average annual consumption	Carbon Dioxide Emissions [tCO_2/household/yr] Current levels	60% reduction
Household Electricity	4,000 kWh_e	1.66	0.66
Household Heating	19,000 kWh_{th}	3.69	1.48
Car Transport	17,000 km	3.15	1.26
Total		**8.49**	**3.40**

Average annual domestic energy consumption statistics for Table 5.1 are derived from Housing Energy Efficiency Good Practice Guide 301. The average UK car mileage is derived from a Europe-wide study. These figures will differ on a case by case and region by region basis. However, as a general rule households should aim to reduce their annual carbon dioxide emissions from current levels e.g. over eight tonnes, to below four tonnes.

Obviously, to achieve deep cuts in emissions, a twin approach of reducing energy demand plus switching to low carbon energy sources is needed. For example, to reduce electricity related emissions by 60%, a combination of energy efficiency and switching to renewable supply could be adopted. If the household's electricity demand were reduced by 20% through energy efficiency measures, and half the remaining electricity demand were procured from renewable supplies, the net result would be a 60% cut in CO_2 emissions.

5.4.2 Financial Benefits and Energy Savings

To select a climate change mitigation measure, the practitioner will want to answer some key questions, such as "How much will this cost me?", "How much money will I save?", "How much carbon dioxide emissions will I save?". The following table provides some illustrative figures for some of the domestic options discussed above.

Table 5.2: Financial and mitigation benefits of technologies and techniques

	Cost £	Financial Payback (years)	Carbon Dioxide Savings t CO_2/year
Reduction of annual car journeys by 30% through switch to public transport, walking/cycling, internet shopping etc.	0 (cost of public transport offset by avoided fuel and repair costs)	Instant	0.94
When replacing family vehicle, opt for low carbon (<120gCO_2/km) model e.g. hybrid, electric or petrol	Up to £2000	Up to 20	0.77[15]
Cavity Wall insulation	£50-£175 as at 2005 using EEC funding	1-3.75	0.78
Roof insulation (new insulation) From 0" to 10"	£50-£100 as at 2005 using EEC funding	.05-1.1	1.27
Replacement condensing Boiler, additional cost to a conventional boiler	£150	6.5	0.35
Full Heatings Control Package, excluding labour	£188	4.5	0.64
Replace 4 lights with energy efficient bulbs	£20	1	0.12
Purchase 1/3rd electricity from 'green' renewable supply	£0 (No changeover fee expected)	Up to about £10 year	0.42
TOTAL	**Up to £2,458-£2,633**	**-**	**5.29 i.e. 62% cut**

15. Assuming the 120g CO2/km model replaces a 185gCO2/km vehicle, this would yield a saving of 211 kgC/yr based on a 30% reduced annual mileage of 11,900 km

The figures used for domestic energy efficiency measures are based on averages derived from the Cost Benefit Tables within the Best Practice Guide 171: Domestic Energy Efficiency Primer[16]. This Guide, along with complementary guides for the domestic sector, was produced by the Building Research Establishment on behalf of Energy Savings Trust.

It can be seen that a 60% reduction in domestic emissions is feasible through a range of measures. In the scenario described above, the most costly element is the purchase of a low carbon vehicle rather than a standard vehicle, while energy efficiency measures generally pay for themselves within a few years. It is also interesting to note that the quickest and cheapest emission savings in transport are through reduction in car mileage, in other words more savings will be achieved through a switch to public transport and walking/cycling than buying a low energy vehicle.

5.5 Commercial Buildings

In the service sector, office-based organisations have many climate change mitigation opportunities. Many measures may already be adopted by companies in response to the Climate Change Levy (CCL) negotiated agreements. Some businesses will have a degree of control over the building infrastructure in which they operate, while others will operate from leased premises.

The model low energy business would:

- use free energy consultancy available e.g. from the Carbon Trust (details on their website) Helpline tel 0800 585794.
- establish an energy-footprint, reduction targets and programme;
- use highly efficient, condensing boiler for heat supply;
- use high standard of insulation throughout offices;
- good use of natural light in all office spaces, meeting rooms etc;
- use energy efficient lighting;
- lighting levels set at ‘natural’ brightness rather than intense ‘glare’;
- use of double-glazing, solar passive design for new offices or extensions;
- reduce energy required for paper-copying by encouraging electronic only documents;
- set PCs to switch to energy saving mode when unattended;
- use low energy PC monitors;
- procure electricity from renewable sources, thus reducing CO_2 and avoiding CCL;
- have staff awareness programmes to promote carbon reduction including energy saving, use of public transport etc;
- promote travel to work by public transport, car-sharing, cycling and ease of access through appropriate location;
- provide facilities to encourage staff to cycle, walk or run to work, such as secure sheds, showers etc.

A business ambitious to make deep cuts could consider further measures:

- combined heat and power plant on site, feeding a heat distribution network for the office;
- renewable energy generation on site through wind turbine, solar PV, hydro turbine, biomass or solar heating;
- carbon-offset measures such as tree planting, applied to offset carbon from ongoing operations or particular events e.g. a ‘carbon neutral conference’;

16. Available from www.housingenergy.org.uk, also see Appendix C

- join the UK Emissions Trading Scheme, whereby carbon reductions can be bought and sold;
- aim to become a carbon-neutral business;
- operate a low energy company car fleet, or even 'carbon neutral' fleet through offset measures such as tree planting;
- run internal 'climate champions' competition, reward innovation and initiative among staff;
- prioritise climate change solutions when appraising core business activities and developing new strategies. Examples include the diversification of oil companies into renewable energy sources. Companies which are in the 'low carbon business' will have greater success in the low carbon (low energy) economy.
- potential for obtaining energy savings from regular monitoring and management of energy consumption, e.g use of intelligent energy monitoring technology (available in Carbon Trust project at Leicester Energy Agency, tel. 0116 262 4698)

5.5.1 Route Map to 60% CO_2 Reduction

To devise an action plan, a business should begin with an assessment of their current CO2 emissions baseline. An illustrative example of a Small to Medium sized Enterprise (SME) with 100 employees is shown in Table 5.3 below.

Table 5.3: Example Business Carbon Dioxide Emissions

		Carbon Dioxide Emissions [tCO_2/yr]	
	Usage	Current levels	60% reduction
Carbon dioxide emissions from office energy use	1,500 m^2 [17]	385	154
Carbon dioxide emissions from work/business travel	1,300,000 km/year[18]	858	343
Total		**1,243**	**497**

This example shows a current annual emissions level of 12.4 tonnes of CO2 per employee.

For developing the range of climate change mitigation options, the DEFRA Climate Change website[19] includes a guide to business emission reduction: (Also information on Carbon Trust website)

Carbon dioxide offset measures can be delivered by means such as tree-planting, for example the scheme offered by Future Forests.

Since April 2002, the company car tax system has been based on CO2 emissions, providing a further incentive to tackle business emissions.

5.5.2 Financial Benefits and Energy Savings

Financial benefits and energy savings will vary widely from business to business. The Carbon Trust (formerly Action Energy; the Energy Efficiency Best Practice Programme) is a UK programme designed to help business reduce carbon dioxide emissions and cut energy bills. It provides independent advice and assistance to UK private and public sector organisations, including financial advice.

5.6 Institution

The definition of an institution would be a large complex such as a hospital. The estate or building management team of an energy-aware institution would take a range of measures:

17. Assuming an office floor area of 15m2/employee
18. This indicator may include daily travel to and from work (e.g. 5000 km/year), as well as dedicated business trips (e.g. 8,000 km/year), total 13,000 km/employee/yr.
19. http://www.defra.gov.uk/environment/climatechange/

- A heat distribution network throughout the institution;
- CHP system;
- Encourage public transport, ensure good bus services to and from the institution;
- Promote cycling and walking by providing safe facilities and well lit walkways;
- Vehicles for on-site transport, powered by biodiesel, fuel cells or hybrid;
- Energy footprint established, targets and programme set with buy-in from staff and visitors alike;
- Educational activity around low energy practices and technologies, e.g. wind turbine in grounds of institution with visitor board.
- Regular monitoring and management of energy consumption.
- The approach used in the UK pilot of the Councils for Climate Protection programme, based on ICLEI's international Cities for Climate Protection campaign, can help local authorities quantify greenhouse gas emissions from their own operations and also those from the wider community. It helps local authorities develop a strategy and action plan, set an emissions reduction target, etc. Further details are available at www.iclei.org/ccp
- The Carbon Trust runs a Local Authority Carbon Management programme helping local authorities to quantify greenhouse gas emissions from their own buildings and operations and developing a strategy to reduce them. (Details on Carbon Trust website)
- The Improvement and Development Agency climate change guidance for local authorities.

A carbon dioxide reduction route plan and associated benefits for an institution could be similar to those proposed for business and industry above. The climate change mitigation strategy and achievements of NHS Estates have been commented on in a separate report, Key Success Factors, available from the Sustainable Development Commission.

5.7 Community

A community could include any grouping of individuals and/or organisations from a certain neighbourhood. Such a group will often have common utility and transport requirements. A community has some control over their buildings and infrastructure.

A low energy community might become one where:

- a district heating network is used;
- the district heating could operate in conjunction with a CHP unit;
- the CHP unit could be biomass fired or co-fired;
- solar water panels could be used to pre-heat water for the district heating or on individual buildings;
- install a collectively 'owned' wind turbine or hydro system, using community funds plus grant aid;
- achieve high interest and engagement levels by running energy clubs e.g. DIY 'solar clubs' and energy efficiency clubs;
- local lift-share schemes are run;
- it has a local bike-share scheme and promotes cycling and walking, provides facilities;
- education and training is provided for carbon aware community members, using current practice e.g. introducing carbon/transport ideas for children taking cycling proficiency tests at schools.

A more ambitious community could, for example:

- establish a mini-grid for electricity supply, fed by local renewable generation;
- look into energy crop production, processing and utilisation within the community.

A climate change mitigation plan and associated benefits for a community could be similar to those proposed for business and industry above.

Summary information on three example case studies is provided below. For further examples, Councils for Climate Protection provide information on successful carbon dioxide reduction at a community scale[20].

5.8 Specific Issues

The mitigation strategies described in the previous sections are generic, they can be applied to or carried out by anyone at home, or at work or by any community. There is another range of mitigation strategies that can be equally as effective at reducing the emissions of greenhouse gas but need to be addressed by specialist groups. These strategies can be applied to activities such as the operation of public services, the design of transport systems and the development of renewable energy sources.

The development and application of mitigation strategies in these areas is a complex process as it usually requires the close co-ordination of a number of commercial, administrative and community stakeholders. Many of the strategies at this activity scale are already partially included in national and regional plans. The application of these would require further investigation and cost analysis.

5.8.1 Public Services

Councils for Climate Protection has produced many examples of future town and city level good practice, including:

- Encourage low carbon technology at a domestic/business/institution level on a city-wide scale;
- Establish city-wide energy footprint, set targets on carbon dioxide reduction via energy efficiency, renewable energy and public transport;
- Provide incentives to reduce carbon dioxide emissions, through competitions, prizes, grants, etc;
- Actively attract low energy businesses and experts to the area;
- Establish a city administrative structure for climate change mitigation, including energy efficiency, renewable energy, transport emissions reduction etc; and
- Sponsor low energy technology training courses, vocational and academic, in local colleges and universities. The successful realisation of all the above measures is dependent on developing the human resource and skills base for carbon reduction.

Councils for Climate Protection provide a range of case studies on successful climate change mitigation in an urban scale.

The measures suggested above for various practitioners are intended for illustration, and some may be more appropriate than others for particular circumstances. Many additional measures could be realised, limited only by the imagination and motivation of prospective climate change mitigation practitioners.

5.8.2 Transport

The issue of the environmental impact of transport is complex and attempts to tackle it at a "user" level by instruments like fuel price are often not popular. However it is critical to the UK achieving its climate change target of a 60% reduction by 2050. The East Midlands region saw a motor vehicle traffic increase from 38.0 billion vehicle km in 2001 to 39.2 billion vehicle km in 2002, an increase of 1.2 billion vehicle km in just one year[21]. This level of growth causes many problems for people and communities in the form of air quality, health and quality of life.

20. Councils for Climate Protection is a scheme run under ICLEI's Cities for Climate Protection programme. www.iclei.org/co2/index.htm
21. East Midlands State of the Region Report, The East Midlands Regional Assembly, 2003

In the development of the Leicestershire Community Strategy traffic congestion was identified as a key priority for all the focus groups and the citizen's panel. Generally, the issue is about problems for travellers, however, there are issues of safety and 'more cars on the road are also creating greater pollution levels so pollution is an ongoing priority. Farmers (1% of population) are recorded as particularly rating pollution as a problem; followed by business. The citizens panel thought that in the last 18 months levels of pollution and traffic congestion had got 'considerably worse'

There are many different strategies that can reduce emissions from transport. Many of these have already been used in cities and towns around the UK. These include:

Ensure that new developments are located and designed to encourage the use of public transport, walking and cycling.

- Improve and promote public transport.
- Develop a cycle network.
- Reduce emissions from motor vehicles through the use of alternative fuels and technologies.

5.8.3 Waste Management

There are a range of climate change mitigation measures for the collection and treatment of waste. These can be grouped into three different areas.

- The reduction in emissions of greenhouse gases through changes in the collection, handling and direct disposal of waste by incineration and other treatment technologies.
- The reductions in the emissions of a potent greenhouse gas; methane, that arise from the degradation of the waste in landfill sites.
- The reduction in greenhouse gases that occurs through the action of waste minimisation, re-cycling and re-use.

There are a large number of different strategies that can be adopted in the optimisation of waste collection in the area.

5.8.4 Renewable Energy

The development of generation capacity from renewable sources has significant potential to offset the emissions of carbon dioxide from fossil fuel use and to provide business growth and job opportunities. There are a number of different strategies that can be implemented. These include:

- The capture and use of methane from old coal mines.
- The development of bio mass fuel sources such as oil seed crops and woodland.
- The generation of electricity using waste gas from landfill sites and wastewater treatment works.
- The development of local, solar, wind and, where feasible, hydro energy.

5.8.5 Building Development

Mitigation strategies aimed at building development need to be implemented at a level appropriate to the type of building concerned. The emission of carbon dioxide resulting from the inefficient heating and lighting of buildings has significant potential for reduction. It is difficult to retrofit energy efficiency measures such as cavity wall insulation, it is far more efficient to ensure that they are built in. Buildings also have a long lifetime so it is important that any current developments address the climate change issue seriously.

5.9 The Community Strategy

The principal document for the development of policies and actions on climate change is the Leicestershire Community Strategy. The mitigation measures described above contribute to the objectives of the strategy in a number of key areas. It is important that any mitigation measure considered is aligned with the other objectives as adopting an integrated approach is one of the key success factors.

The sections below describe how the climate change mitigation strategy fits with the community objectives.

Diverse economy in rural and urban areas.

One of the features of the development of renewable energy sources such as bio mass fuels and wind is the fact that it will be implemented at a local level. This will generate job and business development opportunities in rural and urban areas. The East Midlands region has a strong energy technology base already and is well placed to benefit from this.

Cleaner air, less pollution, reduction in climate change impacts and efficient use of natural resources.

The implementation of mitigation measures will contribute to the reduction in the climate change impacts and will result in cleaner air and less pollution. Many of these measures will lead to reduction in air pollution. The reduction in emissions from transport, the move away from coal fired generation towards renewable energy and the implementation of energy efficiency and waste minimisation will all have additional benefits

Increase participation in learning.

The implementation of many of the mitigation measures suggested in this document are an opportunity for the people of Leicestershire to develop new skills. One key area will be the running of demonstration mitigation projects in a whole range of different areas; household, business, property development and public service provision. This activity can be supported by the dCarb uk low carbon information exchange framework.

Learning would also fit in well with the target for "community spirit", as much of the action can be local community based. One example would be a series of workshops designed to allow people to learn about the grants and actions that they can take.

Access to good quality energy efficient homes.

This objective has a very strong link to many of the possible mitigation measures and is also supported by the provision of training and the development of goods and services for energy efficient living.

Reliable and safe public transport and walking and cycling facilities.

The mitigation measures aimed at transport and the development of a bio mass fuel network will contribute to the achievement of this objective.

5.10 Low Carbon Dioxide Emission Technologies and Techniques

5.10.1 Cross-Sector Review

A wide range of low carbon dioxide emission technologies have been considered and categorised according to the major sources of carbon emissions, under the following headings:

- Energy in Buildings;
- Electricity Generation and Supply;
- Transport;
- Land Use.

5.10.2 Technology Scales

Many low carbon practices, such as improved insulation, public transport or renewable generation, can be adopted by those operating at a range of spatial scales. In other cases, the technology is more limited in the range of scales at which it can be applied. Operation at the following scales has been considered:

- Household - domestic dwellings;
- Business - commercial organisations with associated offices, transport fleet etc;
- Institution - any large establishment e.g. university, hospital etc;
- Community - any group of households or institutions i.e. multiple buildings;
- Town or city
- Region or sub-region.

For the purpose of spatial categorisation, industrial operations lie within the Business/Institution scales.

5.10.3 Technology Attributes

Low carbon dioxide emission technologies are highly diverse. A guide to the scale at which the technologies can be adopted is presented above. There are many other important attributes of the technological options however, including current availability, cost, emission savings potential, employment opportunities and planning/regulatory requirements.

An inter-comparison of the technology attributes is required in order to identify the most promising means of reducing carbon dioxide emissions. A simple scoring of each attribute has been adopted to provide an overview of these many factors; as follows:

★★★ Good ★★ Medium ★ Poor

For each technology, the more points scored in each category, the more attractive the technology from a 'low carbon dioxide emission' perspective.

Table 5.4: Assessment Attributes

Attribute	Score	Description
Availability	★★★	Commercially available at present, wide range of suppliers
	★★	Available but under development, availability may be limited by small number of suppliers
	★	R&D phase, not commercially available
Cost	★★★	Cost is equivalent to current practice or may offer savings over the product lifetime
	★★	Requires some 'carbon-motivated' investment
	★	Requires significant 'carbon-motivated' investment
	★	Currently eligible for grants or allowances [Enhanced Capital Allowances, Community Renewables Initiative etc.]
Carbon-Saving Potential	★★★	Very low or zero carbon, i.e. avoids virtually all carbon emissions compared to current practice
	★★	Avoids significant portion of carbon emissions compared to current practice
	★	Avoids small portion of carbon emissions compared to current practice
	N/A	Not applicable, e.g. hydrogen infrastructure represents an alternative energy vector, rather than an alternative energy source.

These scores of carbon saving potential are intended to be rules of thumb, indicating the potential savings on a per-installation basis. This does not necessarily represent total carbon savings on a regional basis from each technology.

Employment	★★★	Adoption of technology requires significant local workforce, with some permanent jobs likely to be created
	★★	Adoption of technology requires moderate and/or temporary local workforce
	★	Adoption of technology requires little or no local workforce
Employment merit scoring assumes widespread uptake of technology within the region		
Planning/ Regulatory Issues	★★★	Easy: No detailed planning requirements
	★★	Moderate: Planning requirements pose some barriers to uptake
	★★	Difficult: Planning requirements pose significant barriers to uptake

The technology scale and attribute assessment is shown in Tables 5.5 to 5.8.

It is intended that any practitioner within a region can use these tables to determine which technologies and techniques are available at their scale of operation. The attributes can then be considered in order to prioritise the available options.

Table 5.5: Low Carbon Electricity Supply

	APPLICABLE SCALE OF TECHNOLOGY							ATTRIBUTES OF TECHNOLOGY				
TECHNOLOGIES AND TECHNIQUES	Household	Business	Institution	Community	Town	City	Region	Availability	Cost	Carbon saving potential	Local Employment	Planning/regulatory issues
Wind turbine		✓	✓	✓	✓		✓	★★★	★★★	★★★	★★	★
Biomass CHP (e.g. power + district heating)		✓	✓	✓	✓	✓	✓	★★	★★	★★★	★★★	★★
Biomass (power only)		✓	✓	✓	✓	✓	✓	★★	★★	★★	★★★	★★
Hydro-electric scheme		✓	✓	✓			✓	★★★	★★★	★★★	★	★
Sewage sludge digestion or thermal conversion			✓	✓	✓	✓		★★★	★★	★★	★★	★★
Solar photovoltaic	✓	✓	✓	✓	✓			★★★	★	★★★	★★	★★
Wave				✓			✓	★	★	★★★	★★	★★★
Tidal barrage							✓	★★	★	★★★	★★★	★
Tidal stream				✓			✓	★	★	★★★	★★	★★★
Fuel cells		✓	✓	✓				★★	★	★	★★★	★★★
Energy storage to balance intermittent renewables				✓	✓	✓		★	★★	★	★	★★
Demand management to allow high efficiency operation			✓	✓	✓	✓	✓	★★	★★★	★★	★★	★
Hydrogen production for transport or storage				✓	✓	✓		★	★	★	★★★	★★
Net metering, local mini-grid				✓			✓	★★★	★★	★	★	★
Grid-strengthening for embedded generation							✓	★★★	★★	★	★★	★
Carbon sequestration							✓	★	★	★★★	★★	★★

Table 5.6: Low Carbon Heat and Power in Buildings

TECHNOLOGIES AND TECHNIQUES	APPLICABLE SCALE OF TECHNOLOGY							ATTRIBUTES OF TECHNOLOGY				
	Household	Business	Institution	Community	Town	City	Region	Availability	Cost	Carbon saving potential	Local Employment	Planning/regulatory issues
HEAT AND POWER IN BUILDINGS (Domestic, Commercial Sectors)												
Insulation: cavity/wall/loft/floor	✓	✓	✓					★★★	★★★	★★	★★★	★★★
Natural ventilation	✓	✓	✓					★★	★★	★★	★★★	★★★
Double-glazing	✓	✓	✓					★★★	★★★	★★	★★★	★★★
Efficient appliances (use of energy labelling)	✓	✓	✓					★★★	★★★	★★	★★	★★★
Natural lighting, skylights, sunlight pipes	✓	✓	✓					★★★	★★★	★★	★★	★★★
Intelligent lighting control		✓	✓					★★	★★★	★★	★★	★★★
Low-energy light bulbs	✓	✓	✓					★★★	★★★	★★	★	★★★
Passive solar space heating	✓	✓	✓					★★★	★★★	★★	★★	★★★
Solar water heating	✓	✓	✓	✓				★★★	★★	★★	★★★	★★
Condensing boilers	✓	✓	✓					★★	★★★	★★	★★★	★★★
Wood-fuelled boilers	✓	✓	✓					★★	★★	★★★	★★★	★★★
Optimum start controls		✓	✓									
Thermostatic radiator valves	✓	✓	✓									
Boiler management system		✓	✓									
Building Energy Management System		✓	✓					★★★	★★	★★	★	★★★
District heating network		✓	✓	✓	✓			★★★	★★★	★★★	★★★	★★★
Combined Heat and Power		✓	✓	✓				★★★	★★★	★★	★★	★★★
Ground source Heat Pump	✓	✓	✓					★★	★★	★	★★	★★
Well-sealed washers for hot water taps	✓	✓	✓					★★★	★★★	★	★	★★★
Low embodied energy materials for new build		✓	✓	✓	✓			★★	★★★	★★	★★	★★★
Replace old equipment with energy efficient units which qualify for enhanced capital allowances		✓	✓					★★★	★★	★★★	★★	★★★

Table 5.7: Low Carbon Transport

TECHNOLOGIES AND TECHNIQUES	APPLICABLE SCALE OF TECHNOLOGY							ATTRIBUTES OF TECHNOLOGY				
	Household	Business	Institution	Community	Town	City	Region	Availability	Cost	Carbon saving potential	Local Employment	Planning/regulatory issues
'Leave the car at home'	✓	✓	✓	✓	✓	✓		★★★	★★★	★★★	★	★★★
Cycling instead of driving	✓	✓	✓	✓	✓	✓		★★★	★★★	★★★	★	★★★
Cycle infrastructure - paths and facilities			✓	✓	✓	✓	✓	★★★	★★	★★	★★	★★
Car/lift-sharing		✓	✓	✓	✓			★★★	★★★	★★	★	★★★
Public transport				✓	✓	✓	✓	★★★	★★	★★★	★★★	★★★
Reduce commuting by locating businesses close to workforce, encouraging home e-Office etc.		✓	✓	✓	✓	✓	✓	★★★	★★★	★★	★★★	★★★
Switch to smaller, more efficient vehicles	✓	✓	✓					★★★	★★★	★★	★	★★★
Switch from petrol to diesel engines	✓	✓	✓					★★★	★★★	★★	★	★★★
Biodiesel fuel		✓	✓	✓				★★	★★	★★★	★★★	★★★
Ethanol fuel		✓	✓	✓				★★	★★	★★★	★★★	★★★
Battery vehicles, charged by R.E.	✓	✓	✓	✓				★	★★	★	★★	★★★
Hybrid electric/I.C. vehicles								★★	★★	★★	★★	★★★
Fuel cell engines for buses, cars		✓	✓	✓				★★	★	★★★	★★	★★★
Hydrogen production from renewable sources				✓			✓	★	★	★★★	★★★	★★★
Hydrogen Infrastructure Development				✓	✓	✓	✓	★	★	N/A	★★★	★★

Table 5.8: Low Carbon Land Use

TECHNOLOGIES AND TECHNIQUES	APPLICABLE SCALE OF TECHNOLOGY							ATTRIBUTES OF TECHNOLOGY				
	Household	Business	Institution	Community	Town	City	Region	Availability	Cost	Carbon saving potential	Local Employment	Planning/regulatory issues
Forestry management, reforestation etc.				✓			✓	★★★	★★	★★	★★★	★★★
Switch to low carbon agricultural practices, fertiliser choice etc.				✓			✓	★★	★★	★	★★★	★★★

6. The key sectors in Leicestershire which are sensitive to climate change

The sectors and environmental systems that may be sensitive to climate change and examples of the possible impacts of climate change are listed in Table 6.1.

Table 6.1: Sectors sensitive to climate change

Sector	Potential climate change impact
Public Health	Increased health risk due to heat stress
	Increased health risk due to greater flooding episodes
	Decreased health risk from reduced cold spells during winter
	Arrival of new pests and pathogens
Water Resources	Increased pressure on water supply as a result of more frequent droughts and dry years
	Increased pollution concentrations due to lower river flows
	Increased flooding as a result of stormier winters and heavier precipitation events
Agriculture and Horticulture	Increased temperature creates longer growing seasons
	Loss/migration of traditional crops
	Potential to grow different crops (e.g. grain maize, sunflowers, soya)
	Increased risk of summer drought
	Increase in soil erosion
	Increased need for irrigation, particularly for horticulture
	Risk of heat stress to livestock
Transport	Reduced road and rail delays in winter due to fewer frosts and snowfalls
	Increased flooding of transport infrastructure as a result of higher intensity rainfall
	Warmer summers could increase traffic pressure on already busy roads (increased tourism)
	Increase in maintenance costs of roads due to hot weather events
Biodiversity	Low river flows reducing aquatic habitat availability
	Lower water tables reducing wetland habitats
	Changes in the distribution of climate-sensitive species
	Lengthened plant growing seasons
Financial Services/ Insurance	Insurance claims are driven by hot/dry weather-induced subsidence, wind damage, freezing weather, flooding
	Increased hot/dry weather, windspeeds and flooding may increase insurance claims
	Insurance sector has the ability to respond to changes in risk by rapidly adjusting premium charges
Built Environment	Increased temperatures and wind speed may affect safety of construction sites
	Greater need for 'climate proofing' in building design - ventilation, ability to withstand storms, flood mitigation

Table 6.1: Sectors sensitive to climate change (continued)

Sector	Potential climate change impact
Manufacturing, Services and Retail	Adjustment needed in those processes sensitive to high temperatures and/or requiring significant quantities of water
	Greater air conditioning/cooling required for offices/factories/shops to maintain amenable working conditions
	Reduction in retail spending in hot weather as people prefer to spend time outdoors
Leisure & Tourism	Hotter drier summers are likely to increase tourist numbers and spending
	Increased length of the 'tourism season' as a result of warmer temperatures
Cultural Heritage	Impacts on archaeological sites - e.g. exposure/erosion
	Changes in valued landscapes (erosion, land use change, biodiversity change)
	Impacts on parks/gardens as a result of water shortages/drought
	Impacts of changes in tourism numbers and patterns
Forestry	Increased tree stress/loss from drought
	Increased risk of fire damage
	Higher growth rates from higher temperatures
	Potential for increased pest/pathogen damage
	Change in mix of forest species

6.1 Impacts on key service providers

The potential impacts of climate change listed in Table 6.1 will have an effect on many of the services and organisations that make up the ENABLE partnership. A few examples of the types of effects are described below.

6.1.1 Health services

The impacts on public health such as the increase in the incidents of heat stress and the possible arrival of new pests and pathogens may need to be addressed by the four primary care trusts, the hospitals and the health authorities in the Leicestershire area. More sunshine could result in higher incidents of sunburn with a need for public information campaigns about the increased risk.

6.1.2 The emergency services

Hotter and drier summers could lead to an increase in fire risk. Emergency services may see the demand for their services changing, including an increased need to respond to more flooding incidents following extreme rainfall events.

6.1.3 Planning

Changes to water resources availability and flooding patterns could also affect the strategic planning activities within Leicestershire and the design, location and development of housing and road networks could need to be adapted. Plans and policies will need to address climate change. Strategic Environment Assessment (SEA) highlights the need to consider climate change in plans and policies.

6.1.4 Tourism and leisure

Higher temperatures and increased sunshine could lead to increased demand for tourism and leisure services and facilities in Leicestershire, including water based activities. This could represent an opportunity for service providers but will require appropriate planning. Increased visitor numbers could also result in increased erosion and pressure on tourist attractions.

6.1.5 Biodiversity

Higher temperatures, increased sunshine and changing rainfall patterns could change patterns of flora and fauna in Leicestershire. Flooding following rainfall events could also present opportunities to replace lost habitats in suitable areas e.g. wetlands.

6.1.6 Transportation

Disruption to transport systems in higher temperatures and extreme rainfall events could result in the need for increased maintenance, refurbishment or replacement of some infrastructure elements, e.g. drainage.

7 Adaptation Strategy

7.1 Introduction

This section proposes some adaptation responses for Leicestershire based on current UK guidance but also some examples of how adaptive capacity needs to be developed in key sectors within the county which are sensitive to climate change. DEFRA[21] have commented that although "more attention is now being given to adaptation….technically the subject is in its infancy". Climate change adaptation is a new and evolving area and good practice is still being established.

UKCIP[22] have commented that adaptation is about building adaptive capacity and delivering actual adaptation. For example the former is about creating the information and conditions (organisational, managerial etc) that are needed before any adaptation actions can be undertaken. Delivering actual adaptation is about the practical actions that need to be implemented to reduce vulnerability to climate risks or exploit opportunities.

Examples and recommendations for both building adaptive capacity and delivering actual adaptation are provided in this chapter. An example of the potential costs of climate change impacts and adaptation is also included for illustrative purposes.

7.2 UKCIP Guide for Local Authorities

In July 2003 UKCIP[23] launched an adaptation guide for Local Authorities in the UK entitled "Climate Change and local communities – how prepared are you?" and includes a table of potential impacts and examples of adaptation responses service by service. This table has been presented in developing this strategy for Leicestershire County Council as a template against which adaptation actions need to be formulated, and examples of work ongoing within the county by the Council or other stakeholders can be captured.

This template is shown in Table 7.1 and has been customised to allow examples and priorities within Leicestershire to be added. It is recommended that this becomes a live document in the implementation of the strategy to help review progress and actions, but in the short term could also used to capture stakeholder views and examples at the workshop in late January 2005.

UKCIP[22] have also recently presented a ten point 'Principles of good climate adaptation' (UKCIP 2004a) and these are presented on the next page (Box 7.1) as a checklist for Leicestershire to use in the implementation of this aspect of its climate change strategy:

21. DEFRA (2004) Scientific and technical aspects of climate change, including impacts and adaptation and associated costs
22. UKCIP (2004a) Presentation at Adapting for Climate Change Conference, London, December 2004
23. UKCIP (2003) Climate Change and local communities – how prepared are you?

Box 7.1 UKCIP: Ten Point Principles of Good Climate Adaptation

1. Work in Partnership – Understand cross sectoral objectives; identify sustainable adaptation measures
2. Decide what risks are tolerable – take account of defined thresholds; consider attitudes to risk
3. Keep a handle on uncertainty – identify critical thresholds to focus attention on key uncertainties
4. Take a balanced approach to managing climate and non-climate risks – for many decisions, climate will not be the most significant issue
5. Focus on actions to manage priority climate risks – those currently most affected by weather; decisions with long term consequences; those with significant costs and expenditure
6. Use adaptive management to cope with uncertainty – develop incremental options rather than one fell swoop
7. Try to find no- or low-regret adaptation options – no-regret (deliver benefits that exceed their costs); low regret (potentially large benefits under climate change)
8. Try to find win-win options - options which contribute to climate adaptation and also to other objectives (e.g. managing increase flood risk to enhance wetlands and biodiveristy)
9. Avoid actions that will make it more difficult to cope with climate risks – decisions which make it more difficult to manage future climate risks (e.g. inappropriate floodplain development)
10. Review adaptation strategy regularly – good decision making includes monitoring, evaluation and review as climate change risks will change over time and knowledge on adaptation planning is evolving rapidly and there is a need to keep abreast of developments.

Table 7.1 UKCIP Local Authority Template

LOCAL AUTHORITY SERVICE	POTENTIAL IMPACTS OF CLIMATE CHANGE	EXAMPLES OF POSSIBLE ADAPTATION RESPONSES	ACTIONS AND EXAMPLES THAT COULD BE IMPLEMENTED BY LEICESTERSHIRE COUNCIL Priority Actions to be identified by Stakeholder Consultation at end January 2005.	WIDER EXAMPLES OF ADAPTATION BY STAKEHOLDERS IN LEICESTERSHIRE
PLANNING Forward Planning and Development Control	Higher risk of flooding / erosion of susceptible developments in floodplains or coastal margins	Ensure planning takes account of future trends in flooding and coastal erosion. Consider range of options for flood and coastal management, including promoting appropriate and sustainable defences (with the Environment Agency where appropriate) and locating new development away from areas of highest risk	Input into strategic environmental assessment major plans - transport - waste	River Soar Flood Management Strategy
		Incorporate landscape features to absorb water within developments	Implement in all capital projects	Encourage through planning
	Hotter drier summers could further increase pressure on water resources	Consider potential water supply / demand issues when siting new development	Rainwater harvesting in new buildings eg. schools	Severn Trent Water Water Resources Plan (WRP)
	Improved summer climate provides greater potential for outdoor living	Consider how Strategic and Local Plans can accommodate changes in recreational needs	Planners impacts for transport planning. Peak times may alter pressure for alternative modes	
Emergency Planning	Increased risk of flooding and severe weather	Ensure emergency procedures and equipment are updated to meet increased risk	Work with partners to promote awareness	Environment Agency Flood Awareness Campaign
HOUSING AND BUILDINGS Housing	Increased risk of subsidence as soils shrink in hotter drier summers	Plan for preventative and remedial maintenance of existing stock	Information and advice re trees proximity to buildings	
	Higher risk of houses in floodplain or coastal margins	Consider restricting development in the floodplain and coastal margins for new housing, and instigating a range of flood-proofing measures or sustainable defence measures for existing properties	Planning requirements	PPG25

LOCAL AUTHORITY SERVICE	POTENTIAL IMPACTS OF CLIMATE CHANGE	EXAMPLES OF POSSIBLE ADAPTATION RESPONSES	ACTIONS AND EXAMPLES THAT COULD BE IMPLEMENTED BY LEICESTERSHIRE COUNCIL Priority Actions to be identified by Stakeholder Consultation at end January 2005.	WIDER EXAMPLES OF ADAPTATION BY STAKEHOLDERS IN LEICESTERSHIRE
Housing (continued)	Temperature increases affect living space environment	Use thermal properties of materials to improve cooling and retrofit energy efficient systems	Provide more information and advice generally and specifically, eg. home care workers	Partnership working, eg. with energy efficiency centres
Management of public buildings	Temperature increases affect thermal comfort	Retrofit or upgrade energy efficient heating and ventilation	Implement	
	Wetter winters causing damp, condensation and mould problems	Upgrade weatherproofing systems and manage internal environment	Standard good practice	
	Higher risk to buildings currently located in floodplain or coastal areas	Consider flood-proofing measures relocate	(not applicable) Monitor situation	Promote possible adaptions
Building Control	Drier summers increase risk of foundation subsidence	Consider changes to procedures and inspections to ensure foundations are resilient		District level building regs enforcement
	Wetter winters and severe weather increase damp problems	Consider updating procedures to include measures for wetter conditions	Information	
Building Design Services / Architecture	Climate change influences future design (in response to above)	Rethink built environment design and revise practice to suit	Use new schools	Through building regs promotion of best practice
		Make use of thermal properties of materials to improve cooling	Increased insulation in walls - new build	Monitoring
		Reduce solar heating using recessed windows, roof overhangs and shades	New school programme - overhanging eaves and brize soleil	Use of planning guides such as Leicester City
TRANSPORT AND HIGHWAYS Transport Planning	Increased risk of flood disruption due to wetter winters and severe weather	Plan to flood-proof or re-site infrastructure and plan routes to minimise disruption	Planning controls on new developments. Encourage SuDs. Encourage 'soft' gardens	
	Increased temperature causing service disruption and heat stress to travelling public	Avoid exposed places and provide shade or cooled waiting areas		Incorporate planning for shade

LOCAL AUTHORITY SERVICE	POTENTIAL IMPACTS OF CLIMATE CHANGE	EXAMPLES OF POSSIBLE ADAPTATION RESPONSES	ACTIONS AND EXAMPLES THAT COULD BE IMPLEMENTED BY LEICESTERSHIRE COUNCIL Priority Actions to be identified by Stakeholder Consultation at end January 2005.	WIDER EXAMPLES OF ADAPTATION BY STAKEHOLDERS IN LEICESTERSHIRE
Highway Maintenance	Increased rainfall intensity affecting embankments and bridge piers and washing more debris into gullies	Increase monitoring and maintenance of embankments and bridge piers, and increase gully emptying activity	Build into maintenance specifications	
	Drier summers increase risk of road subsidence and higher temperatures increase risk of surface damage	Re-examine road structural design. Implement remedial work for existing roads		
	Higher risk to roads located in floodplain or coastal areas	Aim to flood-proof or re-site strategically important roads	Consider within strategic river corrridors	Environment Agency partnerships eg. on-Trent initiative
	Increase in rate of growth and length of growing season on road verges	Use slower growing plants in landscape schemes. Revise mowing / weed control schedule.	Changes in specifications. Impact on road verge nature areas?	
	Warmer winters with reduced risk of frost	Reduced need for road salting	Incorporate in maintenance regimes	
HEALTH AND SOCIAL Health and Social Services	Higher risk of skin cancer / sun burn due to hotter summers and increased outdoor recreation	Consider ways to increase awareness of dangers and exposure. Provide more shade in public recreational areas	Incorporate planning for shade in new projects	Work with primary care trusts Awareness raising
	Heat stress to the old, poor and vulnerable communities and people likely to increase	Ensure adequate shade and cooling available	Information via Social Services	
Environmental health	Higher temperatures likely to increase cases of food poisoning	Consider ways to increase awareness of food hygiene practices and revise best practice	Environmental health promotions	Information to catering establishments
	Higher levels of dust in the air due to drier summers	May need to hose down streets in urban areas		In conflict with water supply
ENVIRONMENTAL SERVICES AND AWARENESS Greenspace Management	Increase in rate of growth leading to year-round grass maintenance	Adapt maintenance schedules and resources to meet change	Information to encourage acceptance of longer grass	

LOCAL AUTHORITY SERVICE	POTENTIAL IMPACTS OF CLIMATE CHANGE	EXAMPLES OF POSSIBLE ADAPTATION RESPONSES	ACTIONS AND EXAMPLES THAT COULD BE IMPLEMENTED BY LEICESTERSHIRE COUNCIL Priority Actions to be identified by Stakeholder Consultation at end January 2005.	WIDER EXAMPLES OF ADAPTATION BY STAKEHOLDERS IN LEICESTERSHIRE
Greenspace Management (continued)	Loss of trees and shrubs due to drier summers and wetter winters	Plant trees and shrubs that will tolerate future conditions	Continuing programmes eg. Stepping Stones, free trees	National Forest encourage take up of tree planting grants. eg. via treewardens, landowners etc.
	Climate change influence on natural environment	Plan for wildlife corridors to allow natural migration	Awareness raising via Holly Hayes Resource Centre eg 'wild about'	Information through NFU, rural partnership, FWAG
Watercourse Management	Wetter winters and increased rainfall intensity causing local flooding	Increase ditch clearing and gully emptying activities to obviate blockages	Action within LTP	Encourage through new farm single payment
Waste Services	Rubbish will decay more rapidly in higher summer temperatures	More frequent waste collections particularly in summer	Encourage composting	Home composting initiatives, eg. Leicestershire Rotters
	Higher summer temperatures and higher, more intense, winter rainfall may affect landfill design and operation	Monitor condition of existing landfill sites. Check design and operation of future sites with regard to climate change	Climate proof household waste management strategy	Promote best practice
			Look at potential for methane collection	
Community Awareness	Climate change will impact on communities	Proactively raise awareness, and provide advice and information	Provide accessible information	Support/encourage local community groups in energy efficiency/waste minimistaion/with EEAC energy efficiency advice centre, extend ENVIRONS existing Solar Clubs scheme into County areas (solar water heating)
Business Support	Climate change provides changing markets, e.g. Tourism and agriculture, and demand for new products	Encourage business to adapt to new markets	Make information available to businesses/business advisors. Promote good practice	Encourage business champions, eg. in Charnwood one company increased business through improved environmental practice

7.3 Case Studies and Examples

This section provides some case studies of potential adaptation responses currently being implemented in the county. The case studies relate to specific topic areas from the ENABLE Strategic Overview of Leicestershire's Environment[24].

7.3.1 Biodiversity

The ENABLE[25] report comments that floodplain grasslands associated with the River Soar support some of the richest wildlife in Leicestershire and are important for many breeding birds. With the potential for increased flooding under climate change there is an opportunity to enhance these habitats and is an example of a positive adaptation

24. ENABLE (2004) Strategic Overview of Leicestershire's Environment
25. Department of Transport (2004) The Changing Climate: Impact of the Department for Transport

measure. The development of a flood risk management strategy for the catchment by the Environment Agency will take into account climate change and stakeholders need to look for opportunities to enhance this particular aspect of biodiversity in the county. The creation of wetlands is also an example of a 'win-win' adaptation measure as they could help to attenuate particulates and pollutants and contribute indirectly to water quality enhancements in the catchment.

7.3.2 Agriculture

This is a key issue for the county as 43.8% of the landscape is tilled agricultural land and 35% managed grassland. A shift to wetter winters and drier summers and potential water supply challenges is a key issue for this sector but also an opportunity to develop winter floodwater storage to support irrigation needs in the summer for example. This issue needs to be explored as part of a wider flood management strategy for the county with the Environment Agency and landowners.

7.3.3 Transport

This significance of climate change to transport in the county has been commented upon in section 6 of this strategy document. Climate change will have a wide range of impacts on the road network and maintenance costs, as identified in a recent report by the Department of Transport[25]. As hot summers become more frequent road subsidence cases will rise and there will be an increased risk of surface damage. However very cold winters are likely to become increasingly rare and winter maintenance costs should fall. Wetter winters and periods of heavy winter rain could lead to more flooding and dangerous driving conditions. Whilst sea level risk could mean that some coastal stretches of road may flood during periods of high winds.

Local authorities are responsible for the building, operation and upkeep of all roads except the trunk A roads and motorways, which are maintained by the Highways Agency. The highway network is not only there to travel to and from work and school, but for shopping, leisure and for access to all essential services including doctors, dentists and hospitals.

During weather extremes the highway network may become restricted or unavailable which will be of great concern. Highways contain utility services such as water, gas, electricity, telephone, surface water sewers and foul sewerage. During adverse weather the sub-soil below roads may change and cause movement, which is likely to damage these services. Because of bad weather and the loss of services to homes and business, it may be vital that sections of the highway be shut off irrespective of the disruption to road traffic to allow emergency or replacement repairs. This will have knock on costs to both businesses and the public.

Flooding is a known problem where smaller roads cross the River Soar between Sileby Mill and Barrow upon Soar and localised problems such as this could potentially worsen under climate change unless adaptation measures are implemented. The Environment Agency is addressing these issues through the Soar flood management strategy (see 7.3.5 below). A further issue for transportation is the cost of climate change induced maintenance and the example in section 7.4 of this document provides a case study on this aspect from the nearby county of Cambridgeshire.

7.3.4 Waste

The ENABLE study reports that the majority of waste in the county is disposed of to landfill. There are three household landfill sites in the county: Narborough, Cottesbach and Bradgate. The ENABLE report does not specifically identify climate change risk to waste management but recent research by Entec suggests that the following key issues need to be considered in waste management:

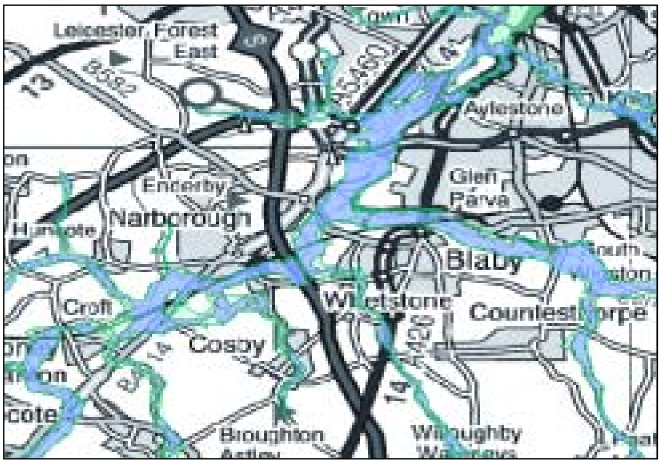
- Increased disruption to supporting infrastructure e.g. road and rail, from increased flooding from surface water, groundwater and drainage systems. This could also affect some on site facilities e.g. weighbridges and gas and leachate collection systems;

- Changes in site hydrology and temperature which in turn could affect waste management processes e.g. landfill degradation rates, leachate production and composition;
- Increased damage to site buildings from more frequent storms;
- Increased health risks to workers from increased sunshine and exposure to UV radiation and increased pathogen and vermin activity;
- Reduced worker comfort, with impacts on productivity, from increased indoor and outdoor temperatures;
- Increased site dis-amenity from odour, vermin, dust and litter;
- Increased risk of subsidence and slope instability from drying out of soils followed by rapid wetting due to heavy rainfall; and
- Inundation and/or erosion of low lying coastal facilities.

The potential significance of climate change to waste management and landfill in the county is from the risk of flooding from the River Soar. The River Soar Flood Risk Management Strategy Scoping Report[26] specifically mentions a potential increase in flood risk to the Narborough site unless adaptation measures are implemented. The potential adaptation measures for flooding on the Soar are summarised in section 7.3.5 below but this clearly shows the need to consider climate change risk on a broad spectrum.

Adaptation includes understanding risk and the development of hydrological models is an appropriate response to inform decision making for this specific site and the wider catchment as proposed in the River Soar scoping report. The flood risk map from the Environment Agency Web Site is shown below.

7.3.5 Water Management



Environment Agency Website; Flood risk map

Flooding

The key initiative in the county on flooding is the development of a flood risk management strategy for the River Soar and the Environment Agency[26] have recently produced a scoping report for consultation. This strategy makes specific reference to climate change but also recognises that a number of uncertainties exist in relation to the interactions between climate change, hydrology, storm events and ecology. These risks will be assessed by the Environment Agency in the development and implementation of specific flood management measures in the catchment. A wider range of potential flood management options have been identified at the Scoping stage and these are summarised below. They show the range of potential adaptation responses (including responses to climate change) that need to be considered:

- Do nothing;
- Do minimum;
- Improvements to existing flood management procedures;
- Traditional engineering methods such as constructing and maintaining defences and constructing flood flow routes;

26. A Flood Risk Management Strategy for the River Soar. Scoping Report June 2004. EA Scheme reference 3035

- Channel maintenance such as clearing debris, de-silting and dredging;
- Development changes such as implementing Sustainable Drainage Systems (SuDs);
- Removal of obstructions from the floodplain;
- Rural land management changes and provision of flood storage areas;
- Holistic approach involving various combinations of the above methods.

Water Supply

Water resources management is one of the key challenges under the predicted UKCIP02 scenarios and Severn Trent Water as the main water service organisation in the county have recently produced a Water Resources Plan which takes into account these scenarios. Like all water companies Severn Trent adopt the "twin track" approach to water supply involving demand management in parallel with developing new resources only where needed. Demand management plans include extension of domestic metering, wider conservation and continued leakage control. In the recently published AMP4 business plan to OFWAT[27] one of the key strategic objectives for the company is the "protecting water resources in the event of prolonged dry weather conditions, by planning on the basis of no more than 3 hosepipe bans should occur every 100 years, and by achieving a sustainable economic level of leakage of 497 Ml/d by 2010".

Further work to assess the impacts of climate change on water resources is being progressed by the Water Industry and Environment Agency and as the knowledge of potential impacts improves with updated research, there will be further consultation with stakeholders and customers in the county of Leicestershire on the choices and options to adapt to potential water supply pressures and increased drought frequency.

7.3.6 Historic Environment and Cultural Heritage

The ENABLE report comments that cultural heritage strongly influences the urban and rural character of Leicestershire and prominent historic features represent a significant tourism, recreational and educational resource. These include the Battle of Bosworth site, Donington-le-Heath Manor House and the Grand Union and Ashby canals for example. The resource includes the following statutory designations:

- 212 Scheduled Ancient Monuments (SAMs)
- 244 historic townscapes or villages which are designated as 'Conservation Areas'
- 16 parks or gardens identified on the English Heritage register of Historic Parks and Gardens
- 1 battlefield included on the English Heritage Battlefield Register
- 4337 buildings listed for their special architectural or historic interest

The impact of climate change on the historic environment is being addressed by English Heritage East Midlands Region and a briefing on the subject has been prepared for the East Midlands Regional Assembly Heritage Forum[28]. This document notes that there is a need for further research to understand the potential impacts of climate change and adaptation responses for the historic environment. English Heritage has commissioned research into the subject by University College London and the findings of this research will help inform climate change risk and possible adaptation responses. In terms of flood risk to properties English Heritage have issued guidance on ways to reduce flooding or damage without affecting their historic character by way of a Technical Advice Note. The key direct and indirect threats to the historic environment as identified by English Heritage East Midlands Region are listed below in Table 7.2 together with possible adaptation measures.

27. Severn Trent Water plc (2004) Final Business Plan, Public Summary
28. English Heritage (unpublished) Climate Change and the Historic Environment (Williams, J. 2004)

Table 7.2 Climate Change Threats and Possible Responses (from English Heritage)

Direct Threats

- Coastal and riverine erosion.
- Dehydration of wetlands.
- Shrinkage of clay soils and concomitant foundation damage to historic properties.
- Loss of historic trees.
- Loss of historic planting schemes in parks and gardens.
- Storm damage to historic properties.

Possible Adaptation Responses to Direct Threats

- There may need to be more excavation of archaeological sites threatened by erosion or flooding, which will have cost implications.
- We will need to work together and with other partners to reduce wetland drainage and put back natural river valley processes that will reduce dehydration.
- We need to ensure that historic buildings and standing monuments will be adequately protected from damage likely to occur with increased storminess.
- We need to encourage owners to put greater effort into building maintenance to prevent damage and deterioration due to climate change.

Indirect Threats

- Increase in installation of ventilation systems or air conditioning which would damage historic properties.
- Potential cultivation of different crops (e.g. drought resistant) and their impact on below ground archaeology.
- Increased irrigation which would involve increased abstraction, possibly dehydrating deposits elsewhere.
- Construction of reservoirs for summer storage of winter water.
- Changes to below ground water infrastructure, e.g. SUDS – sustainable urban drainage systems, may damage historic sewers and archaeological deposits.
- Impact of flood risk management work, including setting issues for SAM's and historic buildings, as well as damage to below ground archaeological sites.
- Individual flood protection measures, such as temporary flood barriers attached to historic properties – see EH Flooding and Historic Buildings Technical Advice.
- Abandonment of historic environment features to rising sea / river levels.
- Impact of change to renewable and non-fossil energy, e.g. wind farms, or cultivation of Miscanthus sp, which has high water requirements.
- Impact of installation of greater capacity gutters etc on historic properties, although the need for these can be reduced by regular maintenance.
- Impact of installing energy efficiency products in historic properties – see "Building Regulations and Historic Buildings – balancing the needs for energy conservation with those of building conservation: interim guidance on the application on Part L."

Possible Adaptation Responses to Indirect Threats

- We need to recognise the need for adaptation, and that this will focus on protecting people and property.
- We must help others to seek ways of ensuring that such changes are sympathetic to the historic environment.
- We must promote retention and improved energy efficiency of existing building stock as opposed to demolition and construction of new buildings.
- We should ensure that historic environment professionals are consulted at the beginning of any development plans driven by adaptation to climate change.
- We need to carry out our own sector study to gain a better picture of how future climate change and adaptation works may affect the historic environment.

Climate change is tackled in the Regional Assembly Environment Strategy in Policy ENV6. One of the principal actions stemming from this policy is for the identification of key champions for each sector to take forward the recommendations and work proposed in the regional climate change report. As the historic environment did not feature significantly in this report, there has been no attempt, to date, to identify a sector champion.

In the future, the Heritage Forum will act as key champion for the sector and has formalised this role by adopting it as an action as part of the Regional Assembly Environment Strategy Policy ENV1. This is also recognised within the Regional Assembly Environment Strategy policy ENV6, which lists the Heritage Forum as the Key Champion for the historic environment. One of the key outcomes will be the production by the East Midlands Heritage Forum of a document which highlights the impacts and opportunities of climate change on the historic environment for the region. Additionally, the Heritage Forum also maintains a place on the Regional Assembly Climate Change Steering Group.

7.3.7 National Forest

Approximately half of the National Forest (256 sq.km) is located in North West Leicestershire. The National Forest is a forest in the making and when fully planted, the forest cover in Leicestershire will reach around 16 million trees. This represents a considerable opportunity for mitigating climate change through carbon sequestration as trees soak up carbon dioxide; provision of wood for wood fuel heating leading to the possible replacement of coal-fired boilers in public buildings.

In terms of adaptation, forestry provides the potential to attenuate peak runoff and erosion which may be associated with changing rainfall regimes under climate change. The potential for sustainable tourism in the Forest, based on increased accommodation, improved public transport and a network of footpaths, cycleways and bridleways is also considerable.

7.4 Costs of Climate Change

The context of this case example[29] is one in which Cambridgeshire County Council evaluates the impact of climate change on the highway maintenance costs for its roads in their area. This is done using the UKCIP Costing Methodologies Guideline for valuation based on preventative expenditure or replacement cost. It is not feasible within the context of this example to cost all the impacts of climate change on the road network. Therefore the case example focuses on the impact of hotter and drier summers on highway maintenance costs and the impact of milder winters on winter maintenance costs. The case example uses the UKCIP02 climate change scenarios for the 2020s, 2050s and 2080s.

This case study is of particular relevance to Leicestershire given the significance of transportation in the county. There are more than 4000km of roads in Leicestershire, the majority of which are minor roads, and therefore the following illustration provides a useful example of the potential scale of issues that could be encountered but this will of course depend on specific locations. The example provided by UKCIP is based on the risks of increased subsidence in hotter drier summers leading to cracking of roads. The costs of climate change induced repairs (after discounting) are estimated at £280k p.a. - £330k p.a. for the 2020's using this methodology.

7.5 Indicators of Climate Change

DEFRA[30] have recently undertaken a review of UK climate change indicators at a national level and the current list of indicators is provided in Table 7.3. In addition, the Environmental Change Network (ECN) collects a range of data relevant to DEFRA's climate change indictors which are appropriate for illustrating changes in National indicators at local level. These can be found on the ECN web site (www.ecn.ac.uk). The

29. UKCIP (2004b) Case Study on road maintenance costs. Unpublished
30. DEFRA (2003) Review of climate change indicators

ECN Climate Change Indicator pages generate graphs 'on-the-fly' direct from the ECN database to show recent changes in these indicators. When data is added to the ECN database it will be automatically included so it is possible to see the most up-to-date data available from ECN's sites. Both DEFRA and ECN indicators provide useful trend information relevant to the key sectors at risk from climate change in Leicestershire including agriculture, biodiversity and which could be used to track trends at a national level

The ENABLE Strategic overview of Leicestershire's environment recognises the need to improve biodiversity information and in developing this action there is an opportunity to develop a specific climate change indicator(s) of biodiversity in the county.

Table 7.3: Indicators of Climate Change in the UK

A.	**CLIMATE, HYDROLOGY, SEA LEVEL AND AIR POLLUTION**
1.	**Air Temperature in Central England** i) Annual mean Central England temperature ii) Number of hot days per year (mean temperature 20°C) iii) Number of cold days per year (mean temperature 0°C)
2.	**Seasonality of Precipitation** Percent of precipitation over England and Wales falling in winter
3.	**Precipitation Gradient across the UK** i) Scotland winter precipitation ii) SE England summer precipitation iii) The ratio of Scotland winter to SE England summer precipitation
4.	**Predominance of Westerly Weather** Index of the North Atlantic Oscillation, a measure of the strength of westerly winds across the N. Atlantic
5.	**Dry and Wet Soil Conditions in Southern England** i) Number of days per year when the soil moisture deficit exceeded 60 mm (dry soils) ii) Number of days per year when the soil moisture deficit was less than 10 mm (wet soils) at the CEH Wallingford, Oxon.
6.	**River flows in NW and SE Britain** Annual average flow in rivers in NW and SE Britain
7.	**Frequency of Low and High River Flows in NW and SE Britain** i) Number of days per year when rivers have low water flows (below those occurring 90% of the time) ii) Number of days per year when rivers have high water flows (above those occurring 90% of the time)
8.	**Groundwater storage in the Chalk in SE England** Annual mean groundwater level in three boreholes in chalk in eastern England.
9.	**Sea level Rise** Sea level, relative to the land, measured at Lowestoft in Suffolk and Newlyn in Cornwall.
10.	**Risk of Tidal Flooding in London** Number of times per year that the Thames barrier is closed.
11.	**Atmospheric Ozone Levels in Summer in Rural England** Accumulated exposure over the threshold of 40ppb during daylight hours during the months of April-September, averaged at three rural sites
B.	**INSURANCE, ENERGY, TOURISM AND FIRE**
12.	**Domestic Property Insurance Claims** i) Value of annual domestic (non-commercial) insurance claims for subsidence ii) Value of annual domestic claims for 'major weather perils'

13.	**Supply of Gas to Households** Proportion of UK domestic gas supply consumed in winter
14.	**Domestic Holiday Tourism** Number of holiday trips taken each year by British residents within Great Britain
15.	**Scottish Skiing Industry** Number of ski-lift and tow passes (number of ski-days) sold each year at the five commercial skiing areas in Scotland each winter season
16.	**Number of Outdoor Fires** Number of secondary (outdoor) fires each year in England and Wales
C.	**HEALTH**
17.	**Incidence of Lyme Disease in Humans** Number of cases of Lyme Disease reported to the Communicable Disease Surveillance Centre in the UK each year
18.	**Seasonal Pattern of Human Mortality** Proportion of annual all-cause deaths in England and Wales occurring in January
D.	**AGRICULTURE AND FORESTRY**
19.	**Use of Irrigation Water for Agriculture** Amount of water abstracted from rivers and boreholes for irrigation in England and Wales
20.	**Proportion of Potato Crop Area that is Irrigated** Percentage of the potato crop area irrigated in England and Wales
21.	**Potato Yields** Annual average yield of non-irrigated maincrop potatoes in England and Wales
22.	**Warmth-weather Crops: Grapes** Area of vineyards in production in the UK
23.	**Warmth-weather Crops: Forage Maize** Area of forage maize in the UK
D.	**AGRICULTURE AND FORESTRY**
24.	**Late Summer Grass production** Late summer hay yields at Rothamsted ('Park Grass')
25.	**Date of Leaf Emergence on Trees in Spring** Date of leafing of oak trees in Surrey
26.	**Health of Beech Trees in Britain** Percentage of beech trees in the UK with crown density reduction greater than 25%
E.	**INSECTS AND BIRDS**
27.	**Dates of Insect Appearance and Activity** i) Average time of appearance of the common footman moth in Britain ii) Peak flight time of the orange tip butterfly in Britain iii) First appearance of peach-potato aphids at Rothamsted
28.	**Insect Abundance** Abundance of: i) Common footman moths ii) Common Blue Butterfly iii) Peach-potato aphids
29.	**Arrival Date of the Swallow** Average date when the swallow is first observed at four coastal observatories in England
30.	**Egg-laying Dates of Birds** Earliest dates when the chaffinch and robin lay eggs (the dates on which at least 5% of Robins or Chaffinches have started egg-laying each year)

31.	**Small Bird Population changes** Numbers of wrens in farmland and woodland in the UK
F	**MARINE AND FRESHWATERS**
32.	**Marine Plankton** i) Total annual abundance of copepods (small shrimp-like crustaceans) in the North Sea ii) Abundance of a cold-temperate water copepod species, Calanus finmarchicus, averaged over two areas in the northern North Sea
33.	**Upstream Migration of Salmon** Percentage of annual salmon number moving upstream in the River Kent which did so in June-July
34.	**Appearance of Ice on Lake Windermere** Number of days each year when ice forms in a sheltered bay on the west side of Lake Windermere.

7.6 Building Adaptive Capacity

The recommendations for Leicestershire in building adaptive capacity depend on available resources but the following represent a low cost approach to keeping abreast of developments and issues in climate change impacts and adaptation research. The council may already have these actions in place but the key proposal at this stage would be to develop a linking/signposting service and the identification of the key climate change stakeholders in the county. This could form a useful discussion topic for the end of January 2005 workshop.

- Subscribe to UKCIP email alert for monthly news on events on regional climate change partnerships including the East Midlands;
- Designate a Climate Change Champion to act as signposting service/disseminate key information;
- Development of climate change awareness campaign such as the recent Environment Agency flood awareness campaign aimed at the elderly in the community.

8. Key national, regional and local policies and plans which are relevant to a climate change strategy

The UK has set itself an ambitious 20% reduction target for carbon dioxide emissions from 1990 levels by 2008 - 2012 and, as part of the EU Burden Sharing agreement, a 12.5% reduction target in the six "Kyoto" greenhouse gases over the same period. The policies and plans by which these targets will be achieved are extensive and are best considered by division into the following two areas; national and regional.

8.1 National policies and plans

The principal policy for the implementation of the UK's reduction in greenhouse gases is the Climate Change Programme, (Defra, 2000). There are a number of other policies and plans that have been developed from this.

8.1.1 Business sector

Policies focused on business at a national level include:

- The Climate Change Levy, a 10% energy tax paid by processes not covered by the rebate scheme.
- UK Emission Trading Scheme (UK ETS), by which large processes volunteered absolute reductions in the six Kyoto gases.
- The Renewable Obligation placed on the generators to supply electricity from renewable sources.
- The Climate Change Agreements under which the 40 largest UK industry sectors agreed to efficiency targets in exchange for an 80 % rebate on the climate change levy.
- Energy Efficiency - two measures, the enhanced capital allowances scheme for energy efficient plant and machinery and programmes to encourage lowering carbon use from the Carbon Trust.

8.1.2 Domestic sector

The policies focused on the domestic sector at national level included:

- Energy Efficiency Commitment (EEC) - phase 1 (2002-2005). The large electricity and gas suppliers have been set targets for improvement of energy efficiency of their household customers through the installation of insulation and efficient boilers. A significant proportion of the improvements must come form low income households.
- New Home Energy Efficiency Scheme (HEES)/Warm Front is a UK government funded programme to tackle fuel poverty through the provision of grants for insulation and boiler replacement.
- Community Energy 1 (2002-2005). This programme encourages the installation, extension and refurbishment of community heating schemes.
- Decent Homes, boiler and appliance standards. There is now a minimum standard for the fitting of replacement boilers and windows.
- Buildings Regulations 2002 (ODPM). These regulations allow for the energy performance of new and substantially refurbished buildings to be bench-marked and regulated.

8.1.3 Transport sector

Greenhouse gas emissions from road transport now constitute 18% of all greenhouse gas emissions compared with 14% in 1990. Greenhouse gas emissions from the road freight industry rose 48% during the 1990-2002 period, from 15.8 million tonnes to 23.4 million tonnes. Greenhouse gas emissions from all heavy goods vehicles used across all industries rose 39% from 22.9 million tonnes in 1990 to 31.8 million tonnes in 2002.[30]

The transport sector is becoming the single biggest threat to the UK's climate change policy. The rapid growth in the number of vehicles and the miles travelled has outstripped the fuel efficiency improvements of engines. There has recently been a shift to larger domestic vehicles and corresponding engine size.

There are a number of policies aimed at the transport sector.

- The voluntary agreements on carbon dioxide emissions from the cars by which there are a number of agreements with car manufacturers.
- Company car taxation policy assigns the benefit in kind value of a company car (P11(D) value) based upon the level of carbon dioxide emission for the type of vehicle.
- Vehicle Excise Duty is charged on a scale determined by engine size and fuel type.
- The Transport White Paper, Department of Transport, June 2004.

8.2 Regional and local policies and plans

The specific plans and policies to address climate change at a local level are currently under development. The Enable Climate Change strategy, of which this document will form a part, will be a significant local policy. There are a number of associated plans and policies that cover issues that have a strong association with emerging climate change strategy. These include:

- Leicestershire Rural Strategy 2001-2006.
- Leicestershire Local Transport Plans (2001-2006) - these are currently being rewritten.
- Leicestershire Municipal Waste Management Strategy.
- Leicestershire, Leicester and Rutland Waste Local Plan 1995-2006.
- Leicestershire and Rutland Biodiversity Action Plan.
- Biodiversity Challenge: An Action Plan for Leicester, Leicestershire and Rutland (1998). This is currently under review.
- The Welland sub regional strategic partnership covers two districts within the county and is mainly about rural issues, the economics of rural diversification and accessibility.
- East Midlands regional energy strategy.

The Environment Agency is developing a flood risk management strategy for the River Soar that considers the factors affecting flooding including climate change.[31]

8.3 Key climate change guidance documents and other literature

Defra

- The scientific case for setting a long term emissions reduction target (Feb. 2003).
- Ancillary effects of greenhouse gas mitigation policies (Feb. 2003).
- Assessment of technological options to address climate change.
- Community leadership and climate change - guidance for local authorities (June 2001).
- Climate Change: Assessing the impacts - identifying responses (2000).
- The impacts of climate change - implications for Defra (2003).

31. A Flood Risk Management Strategy for the River Soar Scoping Report June 2004. E.A. Scheme reference 3035.

ODPM

- The Strategic Environmental Assessment Directive: guidance for planning authorities (Oct. 03).
- The planning response to climate change - advice on better practice (Sept 2004).

UKCIP

- Costing the Impacts of Climate Change (Sept. 2004).
- Climate Adaptation: Risk, uncertainty and decision-making (2003).
- Living with Climate Change in the East of England (2004).
- Changing Climate for Business - strategy document.
- Climate Change and the Demand for Water (2003).
- Climate Change and local communities - how prepared are you? (2003).

Environment Agency

- Strategic Environmental Assessment and Climate Change: guidance for practitioners (2004).
- Water resources for the future: a summary for England and Wales (2001).

DTI

- Our energy future - creating a low carbon economy (2003).

If you require this information in another version e.g. large print, or an alternative language, please telephone 0116 265 7242 or e-mail: enable@leics.gov.uk

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