NSW GOVERNMENT
Office of Environment & Heritage

Observed changes in New South Wales climate 2010

Our climate is changing

New South Wales is experiencing more extreme climatic conditions

Rising temperatures are beginning to have an impact on our environment, creating more extreme fire danger days and more severe droughts. The sea is becoming more acidic – affecting marine life – and sea levels are rising, putting coastal property and ecosystems at risk.

Storm approaching Redhead Bluff, Newcastle/Photo: B. Leslie

New South Wales is getting hotter

2009 was the hottest year on record for NSW. The past ten years, 2000–2009, have been the State's hottest decade on record. Since the 1970s, every decade has been as warm or warmer than the last.

These rising temperatures are having significant impacts, including those explained below:

Greater bushfire danger

Climate change means many areas in NSW are experiencing an increased number of extreme fire danger days each year.

More severe droughts

Higher temperatures exacerbated the recent 13-year drought in south-eastern Australia, depleting soil moisture.

Changes for plants and animals

Scientists have noticed differences in:

- reproduction patterns of plants, butterflies and lizards
- bird migration patterns.

Falls in snow depth

The depth of snow in mid-spring in the Australian Alps is about 40% below what it was 50 years ago.

Rising sea levels

Sea surface temperatures off the NSW coast are rising steadily and faster than the global average, causing the water to expand. This, together with the contribution from melting polar ice caps, has raised the sea level in eastern Australia between 2.4 and 4.8 centimetres in the past 16 years.

Our oceans are becoming more acidic

Carbon dioxide is absorbed by the ocean, making sea water more acidic and affecting marine plants and animals.

Agricultural production, tourism, infrastructure and coastal settlements in particular will all feel the impact of these changes.

A decline in NSW rainfall has yet to be linked to climate change

Average rainfall in NSW has declined over the past 50 years, but whether this is linked to climate change is unclear. Researchers will continue to examine rainfall patterns to determine whether they too are responding to human-induced climate change.

The science behind these findings

The Office of Environment and Heritage (OEH) has compiled these observations of changes in New South Wales from peer-reviewed scientific journals, published up to 2010, and other credible scientific sources.

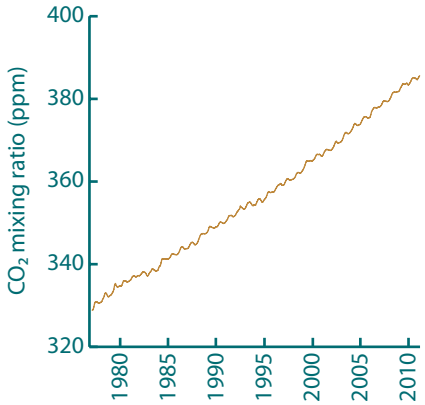

Figure 1: Growth in atmospheric concentration of carbon dioxide at Cape Grim, Tasmania (Australia's CO_2 monitoring station)[1]

Credible sources

Before an article is published in a scientific journal, it is scrutinised by other scientists who have expertise in the same area, a process known as 'peer review'. Peer review is an opportunity for independent experts to assess the research against accepted standards and prevent incorrect interpretations, personal views or unwarranted claims being made by an author. Peer-reviewed journals *only* publish scientific findings that have stood up to this rigorous scrutiny.

The findings in this document were made by respected scientific organisations, such as the Bureau of Meteorology (BoM) and Commonwealth Scientific and Industrial Research Organisation (CSIRO) or sourced from peer-reviewed scientific journals.

Although the number of scientific studies in NSW is relatively small, they are consistent with substantial evidence from around the world, such as studies recording earlier flowering in the United States and Europe and earlier bird migrations in North America.[2,3,4,5]

Our part in climate change

Climate change has happened many times in the Earth's history. However, the current changes are largely the result of humankind's increased emissions of carbon dioxide (CO_2) (Figure 1) and other greenhouse gases, such as methane.

The CO_2 in our atmosphere is now higher than levels observed over the past 650,000 years and possibly as long ago as 20 million years.[6]

Human activity is the reason for the build-up of greenhouse gases in the atmosphere.[6]

It is getting hotter

In New South Wales, 2000–2009 was the warmest decade, with 2009 the hottest year ever recorded. Since the 1970s, every decade has been as warm or warmer than the last.

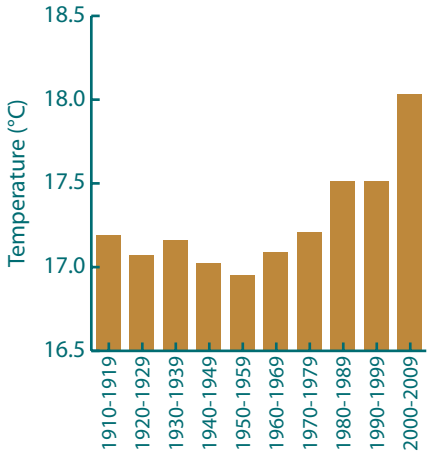

Figure 2: Average temperature each decade in NSW, 1910–2009[7]

The temperature is rising

Reliable temperature records for the whole of NSW begin in 1910. These show the average temperature has been rising steadily since the 1960s,[8] with 2009 the hottest year on record.[9] These records also show that since the 1970s every decade has been as warm or warmer than the last (Figure 2).[8]

Across Australia, 2009 was the second hottest year since records began (the hottest year was 2005).[10] The average temperature in NSW over summer in 2009–2010 was 1°C above the historical average (Figure 3).[11]

CSIRO and BoM report that since 1960 the average temperature in Australia has increased by around 0.7°C.[8]

Globally, 2010 equalled 2005 as the world's warmest year on record.[12]

A change in Australia's average temperature of 0.7°C may not seem very large, but because temperature records are very long-term, any change in the average is significant for the environment. This is especially true as a small change in the average can mean fewer extremely cold days, more extremely hot days, and more record high temperatures.

2009 saw three extreme heat events in NSW

1 The end of January to early February 2009 was a period of extreme heat in south-western NSW, with temperatures reaching into the high 40s in areas near the Victorian border.

2 In August 2009, the north of the State experienced extreme heat in winter (more than 37°C).

3 In November 2009, there was an exceptional heatwave – both in strength (41% of NSW set new November records) and duration (eight consecutive days above 35°C and 40°C in central and western areas of the State).[9]

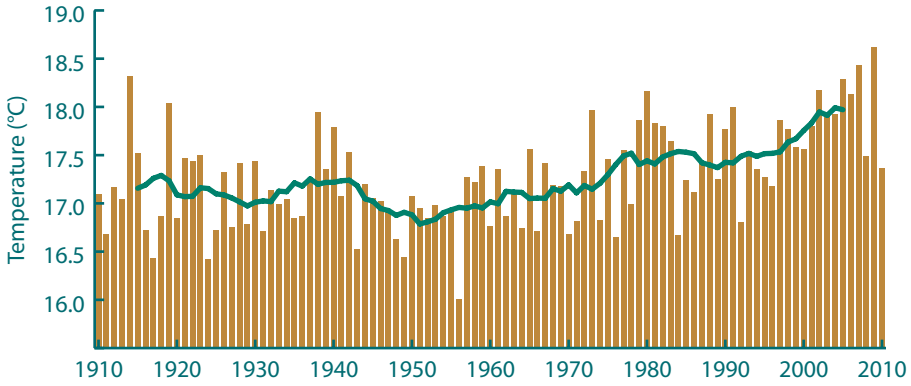

Figure 3: Annual average temperature in NSW, 1910–2010[7*]

* Unless indicated otherwise, the green line on the graphs represents the moving average, which is the average calculated each year using the values from the five years prior to and following that year. The moving average helps to clarify the trend in the data.

It is getting hotter

On extremely hot days, New South Wales has more emergency admissions to hospital due to heat-related illness and injury. Elderly people and those with respiratory and cardiovascular disorders are particularly at risk in extreme heat events.

Extreme heat increases mortality

High temperatures affect our health. On extremely hot days there is an increase in emergency admissions in hospitals around Sydney due to heat-related illness. People with respiratory and cardiovascular disorders are particularly at risk.[13]

In Victoria, over the five days between 27 and 31 January 2009, maximum temperatures were 12–15°C above normal. The temperature was above 43°C for three consecutive days, reaching a peak of 45.1°C. During this time, 374 more people died than would normally be expected and the number of ambulance emergency cases increased by 25%.[14] Australia is not alone in experiencing deaths due to high temperatures. Similar increases have been modelled and measured in many other countries.[15,16,17,18,19,20]

Heat and air quality

Increasing temperatures can worsen air quality, especially in urban areas such as Sydney. CSIRO research shows that rising temperatures can increase peak concentrations of ground-level ozone, a component of photochemical pollution which particularly affects people in urban areas. In 2005, an estimated 250 people in Sydney were admitted to hospital with respiratory conditions linked to exposure to ground-level ozone.[21,22]

Photochemical pollution (shown right over Sydney, compared with a clear day below) damages lung tissue. The effects of short-term acute exposure to ozone (a component of photochemical pollution) include reduced lung function, increased sensitivity to other irritants, and inflammation of the airways/
Photos: T. Solomon OEH

It is getting hotter

Bushfire danger is increasing. Many areas in New South Wales are experiencing a greater number of extreme fire danger days each year.

Photo: M. Lauder OEH

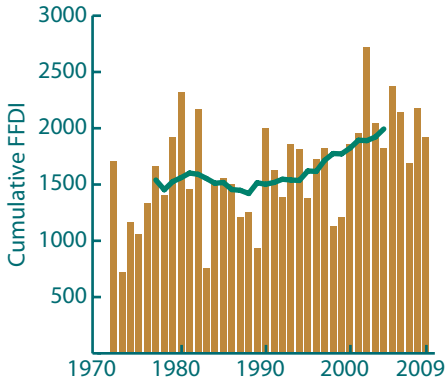

Figure 4: Annual sum of FFDI in Nowra, 1972–2009[24]

Bushfire danger is greater

Since 1950, rainfall has decreased in south-eastern Australia,[8] the effects of droughts have become more severe,[23] and the number of extremely hot days has increased.[8] Hotter, drier years can mean greater fire risk.

As a result, many areas in NSW are seeing an increase in both average and extreme fire weather.[24]

BoM and fire authorities across Australia, including those in NSW, use a forest fire danger index (FFDI) to measure the risk of fire. The FFDI takes into account temperature, relative humidity, wind speed and a 'drought factor', which is based on daily rainfall and the time that has elapsed since the last rain.

Between 1973 and 2007, fire danger, as expressed by the annual sum of the FFDI, rose by between 10 and 40% at many observation stations across the State.[24]

Nowra is an example from eastern NSW where FFDI has increased steadily (Figure 4).

Rainfall trends are unclear

The annual rainfall in NSW has varied between very dry years (such as 1940 and 2002) and very wet years (such as 1950, 1974 and recently in 2010). In the past 50 years, average rainfall has declined, compared with the very wet years of the 1950s.[8] But since the beginning of the 20th century, NSW as a whole has not seen an overall downward trend in rainfall (Figure 5). In contrast south-western Australia does show a clear decline in rainfall.[8]

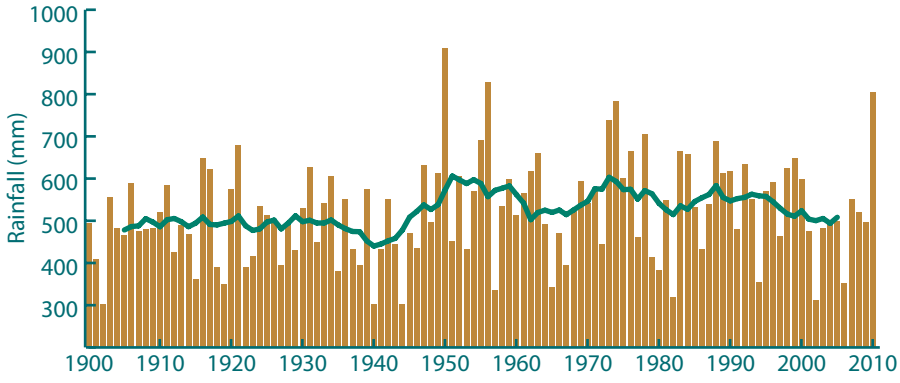

Figure 5: Average annual rainfall in NSW, 1900–2010[7]

It is getting hotter and drier

Climate change has resulted in higher temperatures which have made our droughts worse.

Remnant waterholes during drought, Darling River/Photo: N. Foster OEH

Droughts are getting worse

The recent dry period in south-eastern Australia may be connected to climate change. While the trend is not yet certain, CSIRO and BoM have indicated that south-eastern Australia has dried in the past 50 years[25] and increased greenhouse gas concentrations are likely to have influenced the climate of south-eastern Australia.[26]

The unprecedented intensity of the recent drought in NSW (the 'Big Dry') is associated with higher temperatures. With higher global average temperatures due to climate change, the effects of the recent Big Dry were almost certainly exacerbated by climate change. The drought in south-eastern Australia from 1997–2009 was the driest 13 years in the past 110 years of reliable climate records (surpassing the previous 9-year record from 1936–1945).[27]

While previous droughts showed similar declines in rainfall, this drought was different because it was confined to southern Australia and did not affect the whole continent, there were no 'wet years' during the period, and it had the greatest reduction in autumn rainfall.[27]

Higher temperatures have depleted soil moisture, leading to reduced evaporation. As well as exacerbating severe drought conditions across south-eastern Australia, this reduction in evaporation (which normally keeps temperatures cooler) has contributed to even hotter temperatures across the State.[23,26,28]

Rising temperatures have also affected the availability of water in the Murray–Darling Basin (Figure 6). While rainfall has decreased, inflow has decreased even more (compare Figures 6a and 6b). From 1997 to 2006, catchment runoff in the southernmost parts of the Murray–Darling Basin was the lowest on record. Higher temperatures due to climate change are likely to have played a significant role in these lower inflows. A rise of 1°C reduces annual inflows by approximately 15%.[29]

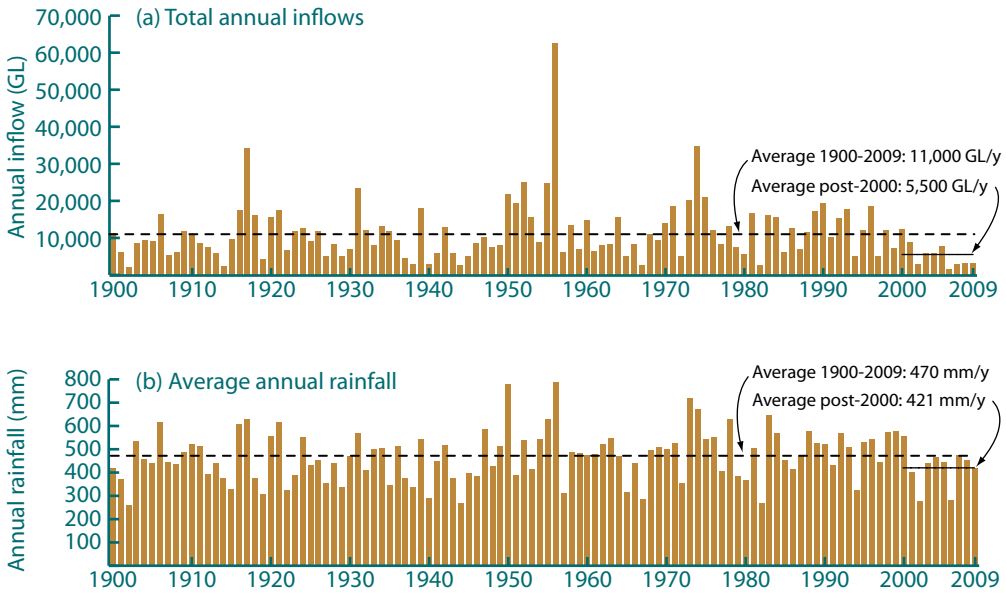

Figure 6: Total annual inflows and average annual rainfall in the Murray–Darling Basin, 1900–2009 (adapted from Cai & Cowan 2008[29])

Plants and animals are being affected

Reproduction patterns of plants, butterflies and lizards and the migration of birds are now being affected by warmer temperatures.

The depth of snow in spring is 40% less than 50 years ago.

Migratory birds, such as the double-banded plover, are arriving in Australia at different times due to climate change/Photo: G. Ross

Observable changes in wildlife behaviour

Climate change is affecting important aspects of the NSW environment.

Long-term studies of 24 species of migrating birds that come each year to south-eastern Australia indicate that 12 species are arriving earlier by 3.5 days each decade and leaving earlier by 5.1 days each decade.

Individual birds of the same species generally have a larger body size the further they live from the equator. In eight different species, birds of smaller body size are now found further south in NSW consistent with what we would expect in a warming climate.[30]

Over the past 13 years, the numbers of many aquatic invertebrates (water bugs) have changed significantly. Those that favour colder waters and faster-flowing habitats have declined while those that prefer warmer waters have increased.[31]

The maximum winter snow depth at Spencers Creek in the Snowy Mountains has decreased moderately since 1962. However, the depth in mid-spring has decreased significantly to approximately 40% less than it was 50 years ago.[32] This reduction has flow-on impacts. Australia's longest-lasting snow patches are now melting earlier. In 2006–07, researchers found the normal amount of snow-free time at the centre of a snow patch had increased to three times the average, causing the loss of distinct snow patch plant communities.[33]

Rising temperatures have caused bold-striped cool skinks in south-eastern Australia to change both the depth of their nests and the time at which they lay their eggs. Since nest temperature affects the sex of their offspring, a greater proportion of females are now being born.[34]

Similarly, in Melbourne over the past 65 years, the average date of emergence of the common brown butterfly from its cocoon has shifted 9.6 days earlier as local air temperatures have increased by nearly 1°C.[35]

Below left: Remnant spring snow, Kosciuszko National Park/ Photo: P. Sherratt OEH

Below right: Common brown butterfly (*Hetronympha merope*)/ Photo: J. Robinson

Fisheries and agriculture are being affected

Climate change can affect the fishing and agricultural industries. The sea is warmer and sea surface temperatures off the coast are rising steadily. Warm ocean currents are moving southwards.

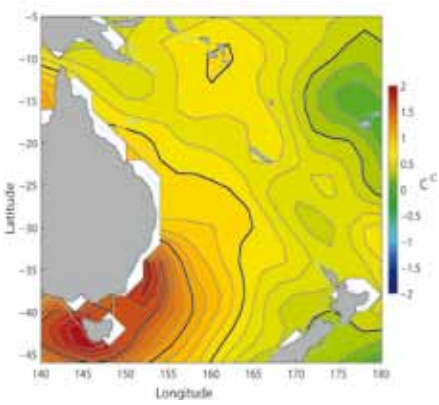

Figure 8: The trend in sea surface temperature, 1944–2005. The dark red indicates the strongest warming (2°C).[36]

Rising sea temperatures and changing ocean production systems

In the past 40 years, average sea surface temperatures in NSW coastal waters have increased by 0.5°C in the north of the State and up to 0.8°C in the south.[39]

The temperature in the Tasman Sea off the east coast of NSW has risen markedly (Figure 7). The East Australian Current has moved a further 350 kilometres towards the South Pole, making southern waters warmer (Figures 7 and 8) and saltier.[40] One observed impact of this change has been the spread of the black spiny sea urchin from NSW into Tasmanian waters, where it was not previously found. The urchin is a voracious predator of important algal species and threatens fisheries.[41] In addition, about 45 fish species have changed their distribution in south-eastern Australia in recent years with the change corresponding to warming observed in their local marine environment.[42]

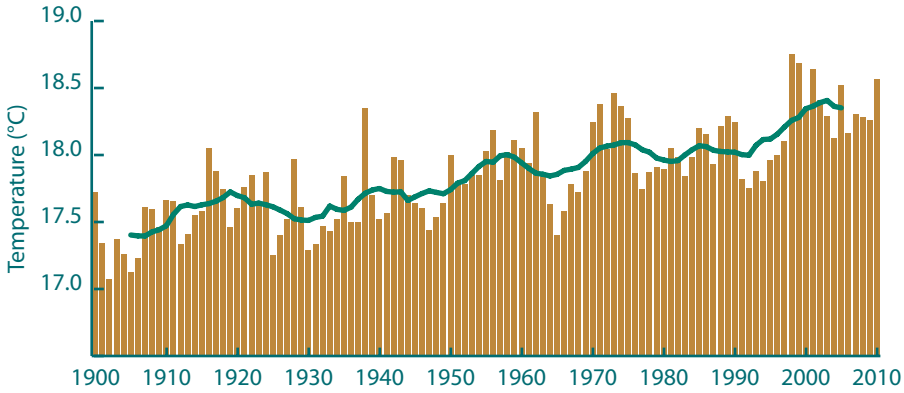

Figure 7: Average sea surface temperature in the Tasman Sea, 1900–2010[7]

Impacts on agriculture

While there has been considerable analysis of the effects of climate change on agriculture in other countries, to date there is little published scientific research specific to NSW and Australia. The changes in temperature are expected to favour an increase in the abundance and distribution of tropical grasses, including several significant weeds. These tropical grasses often have lower nutritional value for livestock. They may also favour pests and diseases that spread south from the tropics each summer.[37]

The southern distribution of the Queensland fruit fly, for example, is currently limited by temperature. Queensland fruit fly is the most economically damaging pest for Australian horticulture, infesting a wide range of crops and impeding interstate and export trade.[38]

Extreme heat can also adversely affect the health and welfare of livestock.[37]

Our oceans are changing

The sea level at Port Kembla has risen about 6 centimetres since 1991. Carbon dioxide is being absorbed by the oceans, making them more acidic.

Above: Coastal salt marsh/ Photo: S. Ruming OEH

Below: Tidal waters encroaching onto roads, Carrington, Newcastle/ Photo: B. Coates

Rising oceans

Global warming leads to sea level rise for two main reasons: water expands when it warms and, as average temperatures rise, the polar ice sheets begin to melt.[6]

Globally the sea level rose by an average of 17 centimetres in the 20th century. Sea level rise is not uniform around the world, but the average rise in eastern Australia has been between 2.4 and 4.8 centimetres since 1994.[8] Sea level at Port Kembla has risen about 6 centimetres since 1991[43] and about 11.1 centimetres at Fort Denison since 1914.[44]

The effect of rising sea levels can be seen with mangrove swamps taking over areas previously occupied by salt marsh. In 70% of estuaries surveyed from Queensland, NSW, Victoria and South Australia, the area of salt marsh taken over by mangroves is greater than 30%, and in some cases mangroves have completely replaced salt marsh. This change to the extent of mangrove and salt marsh in south-eastern Australia over the past 50 years has largely been attributed to subsidence and sea level rise.[45,46,47]

Rising sea level has significant repercussions for much of NSW, where 20% of the population lives on the coast and a further 63% live in the harbour city of Sydney.[48] The king tide in January 2009 gave some indication of what the impacts of sea level rise could mean. Many areas experienced sea water encroaching onto roads and approaching houses, such as in Carrington, Newcastle, shown opposite.

Flooding in estuaries and some coastal lakes will be exacerbated by higher sea levels.

Acidic oceans

The world's oceans currently absorb about 25% of the CO_2 generated by humans. About 40% of this is absorbed in the Southern Ocean.[8]

The CO_2 absorbed by the ocean increases its acidity, which is registered as a decrease in pH (the lower the pH the more acid the system). The pH of the world's oceans since 1750 has decreased by an average of 0.1.[49,50] Any measurable change in pH is significant and has a potential impact on the marine environment. Ocean acidification is irreversible during our lifetimes because it will take tens of thousands of years for ocean chemistry to return to a condition similar to that occurring at pre-industrial times (about 200 years ago).[51]

CSIRO and BoM[8] have reported that: 'Recent research has shown that ocean acidification decreases the ability of marine animals to form shells. Such effects are being observed at the bottom of the food chain in the Southern Ocean.' This has far-reaching implications for the health of ocean ecosystems around the world.

Responding to climate change

Global emission targets

The United Nations 2009 Copenhagen Accord recognised that deep cuts in global greenhouse gas emissions are required to keep average global temperature rise below 2°C above pre-industrial levels.[52] The Copenhagen Accord and subsequent Cancun Agreements (2010) include the USA and China and cover more than 80% of global greenhouse emissions.[53]

Australia's targets

The Australian Government has committed to reducing greenhouse gas emissions by 5% below 2000 levels by 2020 under the Copenhagen Accord. This target has bipartisan support. Australia has also agreed to a long-term target to cut pollution by 80% below 2000 levels by 2050.[54]

NSW approach

The NSW Government has a range of programs to ensure that NSW plays its part in addressing climate change and is prepared for the unavoidable impacts of climate change. The Government has established a clear direction for responding to climate change in *NSW 2021*, a plan which sets priorities for renewable energy, energy efficiency and minimising the impacts of climate change in NSW communities.[55]

Reducing emissions

Energy efficiency

Saving energy can reduce greenhouse gas emissions while also reducing power bills. The NSW Energy Efficiency Strategy contains a range of measures to help consumers save energy. In particular, the Energy Savings Scheme requires electricity retailers to save a certain amount of energy by improving energy efficiency in households and businesses. When the scheme started in July 2009, the target for retailers was a saving of 0.4% of electricity sales in NSW. This target will increase to 4% of sales by 2014. Over the next decade this will help reduce future rises in household electricity bills by an average $50 each year, support up to 1000 jobs and stimulate the growing NSW energy efficiency industry with up to $1 billion in additional investment.

Renewable energy

A major NSW Government focus is to support the State's renewable energy industry. *NSW 2021* sets a target of 20% renewable energy generation by 2020. Following the Solar and Renewable Energy Summit in 2011, an action plan is being developed to identify opportunities for investment in renewable energy sources and outline how the Government will build a prosperous and sustainable energy sector in NSW that also contributes to meeting Australia's 20% renewable energy target by 2020.

Helping individuals and business reduce their emissions

Activities to reduce emissions can be a 'win-win' for both consumers and the environment. For consumers, reducing emissions can also cut power bills and provide a buffer against future price rises. The NSW Government has a range of programs and initiatives designed to help consumers reduce their emissions. In *NSW 2021*, the Government has committed to assist businesses and households to realise annual energy savings of 16,000 GWh by 2020 and also support 220,000 low income households to reduce energy use by up to 20% by June 2014. The Save Power website is a one-stop shop that provides information and advice about what households and businesses can do to reduce energy consumption, bills and greenhouse emissions: visit www.savepower.nsw.gov.au.

Above: Power saver light globes/
Photo: A. Weeraratne OEH

Adapting to climate change

Despite the global effort to reduce greenhouse gas emissions, some level of climate change is now inevitable. *NSW 2021* includes a commitment from the NSW Government to minimise the impacts of climate change on the community. Climate change adaptation programs aim to build the resilience of the State's natural environment, economy and communities by:

- providing information on how to avoid, and adapt and respond to, a range of events associated with climate change
- building adaptive capacity so government, businesses and the wider community understand the importance of adapting to climate change
- reviewing policy and legislation to support the management of risks and adaptation decisions while coordinating and managing adaptation action across all levels of government
- collaborating with climate change scientists to ensure that research outcomes are appropriate for use by community, business and government in planning to minimise the negative impacts of climate change.

To find out more about the climate change measures in place, visit www.environment.nsw.gov.au/climatechange.htm.

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More information

For more information about climate change, refer to the references throughout and visit the following websites:

- Office of Environment and Heritage – www.environment.nsw.gov.au/climatechange
- Commonwealth Scientific and Industrial Research Organisation – www.csiro.au/science/Changing-Climate.html
- Bureau of Meteorology – www.bom.gov.au/climate
- Intergovernmental Panel on Climate Change – www.ipcc.ch

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Published by:
Office of Environment and Heritage
59 Goulburn Street, Sydney
PO Box A290, Sydney South 1232
Phone: (02) 9995 5000 (switchboard)
Phone: 131 555 (environment information and publications requests)
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ISBN 978 1 74293 203 3
OEH 2011/0203
November 2011

www.environment.nsw.gov.au