



Department of  
Primary Industries

# NSW Primary Industries Climate Change Research Strategy



Energy



Carbon  
Opportunities



Climate  
Resilience



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*Primary Industries Climate Change Research Strategy – building resilience and productivity*

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**More information**

Department of Primary Industries

[www.dpi.nsw.gov.au](http://www.dpi.nsw.gov.au)

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Disclaimer: The information contained in this publication is based on knowledge and understanding at the time of writing (November 2018). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of the Department of Primary Industries or the user's independent adviser.

## Executive summary

NSW's \$17.5 billion primary industries sector operates in one of the most variable climates in the world. Primary producers already deal with a changing and variable climate through responses to droughts and floods, storms and bushfires, and pests and diseases.

Climate projections indicate that in the future, areas of NSW are likely to face decreasing winter and spring rainfall, increased intensity of extreme rainfall events, increasing day and night temperatures, fewer frosts, and harsher fire weather. Evidence suggests that these changes are already impacting on agricultural productivity, water availability, soils, and the spread of pests, weeds and disease.

As our climate changes, these challenges are expected to increase. There is now broader recognition of these challenges from scientific organisations, rural research providers as well as peak farming groups.

In addition to the challenges of a changing climate, energy security and energy affordability are becoming increasingly critical issues for the sector. Whether it's for pumping water for irrigation, fuelling tractors and boats, or refrigerating packing sheds; energy is a fundamental input to the primary industries sector.

But there are also opportunities for the sector from climate change. A changing climate can provide an opportunity for new industries to establish and existing industries to expand into new areas of NSW. Policy responses to climate change may also create opportunities for the sector to participate in new markets in carbon sequestration and energy production and storage.

These risks and opportunities must be fully understood if primary industries are to continue to contribute to NSW's economic growth as the climate changes. To ensure the sector's continued growth and to safeguard the future of the regional communities that it supports, primary industries need to build resilience, adapt to changes in economic and environmental conditions, and embrace opportunities. The Primary Industries Climate Change Research Strategy (the Strategy) has been developed to support our primary producers in this challenge.

The Strategy builds on the important work already being undertaken in the sector and by the NSW Department of Primary Industries' leading scientists in supporting the sector to prepare for and adapt to climate change and the transition in the energy sector.

This Strategy is supported by an investment of \$29.2 million from the NSW Government's Climate Change Fund. The actions in the Strategy include building partnerships with key stakeholders and industry to pilot new and innovative energy sources, improving energy efficiency, and enhancing the ability of the sector to manage climate change risks.

The seven targeted actions within the Strategy are focussed on three key areas:

- Energy – **\$11.7 million**
- Carbon opportunities – **\$2.8 million**
- Climate Resilience – **\$14.7 million**

The Strategy will investigate policy and program areas that could support the primary industries sector to adapt to climate change. To enable primary industries to prepare for the challenges and opportunities climate change presents the Strategy seeks to identify through research and innovation:

- energy supply and demand solutions,
- carbon opportunities; and
- climate resilience building programs.

The results of this research will be useful in informing forward work programs and policy reforms to support the long term sustainability of primary industries for NSW.

The Strategy will be delivered by the NSW Department of Primary Industries. DPI is a major provider of rural research and development with scientific expertise and experience in delivering programs to improve the productivity and sustainability of the primary industries sector. This will ensure that the Strategy complements existing programs with new funding targeted towards key gaps and opportunities that address climate and energy risks and which will provide benefits to industry, regional communities and government.

# Research Strategy Overview

## Drivers

- ❖ Higher Temperatures
- ❖ Increased drought frequency & intensity
- ❖ Changes to water quality
- ❖ Electricity network capacity
- ❖ Falling cost of renewables
- ❖ Increased rainfall variability
- ❖ Creation of new carbon markets
- ❖ Increased energy costs
- ❖ More extreme weather events

## Risks

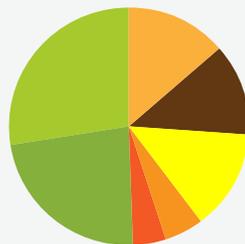
- ❖ Reduced agricultural productivity
- ❖ Decreased crop yields and pasture availability
- ❖ Reduced water availability
- ❖ Changes in the spread of pests, weeds and disease
- ❖ Impacts on ecosystems
- ❖ Social impacts on regional communities

## Opportunities

- ❖ Investment in renewable energy
- ❖ Increased energy efficiency
- ❖ Reduced reliance on energy grid
- ❖ Carbon sequestration
- ❖ Emissions reduction to achieve targets
- ❖ New and changing global markets
- ❖ Development of new climate smart technologies
- ❖ Increased resilience of farming systems

## The Primary Industries Climate Change Research Strategy

The Strategy will investigate policy and program areas that could support the primary industries sector to adapt to climate change. The Strategy seeks to identify through research, and innovation, energy supply and demand solutions, carbon opportunities and climate resilience building programs to enable our primary industries to prepare for the challenges and opportunities climate change presents. The results of this research will be useful in informing forward work programs and policy reforms to support the long term sustainability of primary industries for NSW.



An investment of \$29.2 million from the Climate Change Fund



Energy

Clean Energy Solutions \$4m

Energy Efficiency Solutions \$3.7m

Biomass for Bioenergy \$4m



Carbon Opportunities

Emissions Reduction Pathways \$1.5m

Accessing Carbon Markets \$1.3m



Climate Resilience

Vulnerability Assessment \$8m

Climate-Smart Pilots \$6.7m

## Research Strategy Outcomes

- ❖ Primary producers have new information to inform investment in renewable energy.
- ❖ Potential energy supply and demand management options for primary industries are better understood.
- ❖ Feasible options for primary industries to reduce their emissions are identified.
- ❖ Improved understanding of potential for primary industry producers to participate in carbon markets.
- ❖ Improved understanding of primary industry sectors risk to climate change.
- ❖ New understanding of technological and novel options available to primary industries to adapt to climate change.

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## 1. Introduction

NSW's primary industries sector face a range of risks from climate change and the changing energy sector. These changes range from reduced winter and spring rainfall, less water availability and higher temperatures and changes in ocean currents and ecosystems. Across agriculture, fisheries, water, biosecurity and forestry these changes will challenge the ability of primary producers to remain profitable and continue to positively contribute to regional communities and the NSW economy.

At the same time as the sector is facing the impacts of climate change, the rapid changes in the energy system are putting pressure on primary producers. Rising energy costs are eroding the profitability of primary producers while the sector is also facing challenges with energy security.

Climate change also presents opportunities for the sector, including for producers who may be able to grow crops or raise livestock in different parts of the state. Policy responses may also provide opportunities through programs that offer income for emissions reduction and carbon sequestration outcomes and satisfy community expectations to reduce carbon emissions.

In light of these challenges and opportunities, the primary industries sector needs to prepare and adapt in order to build its resilience and maintain its productivity. If the sector can achieve this, the sector's sustainability can be safeguarded. In turn, the employment and regional communities in NSW that the sector underpins can be secured for the future.

The Primary Industries Climate Change Research Strategy (the Strategy) has been developed to support the primary industries sector as it adapts to climate change and responds to the changes in the energy network. The Strategy will help primary industries maintain and grow its productivity and profitability and guide future projects, investment and stakeholder collaboration.

## 2. Climate change and energy

### 2.1. Climate and primary industries

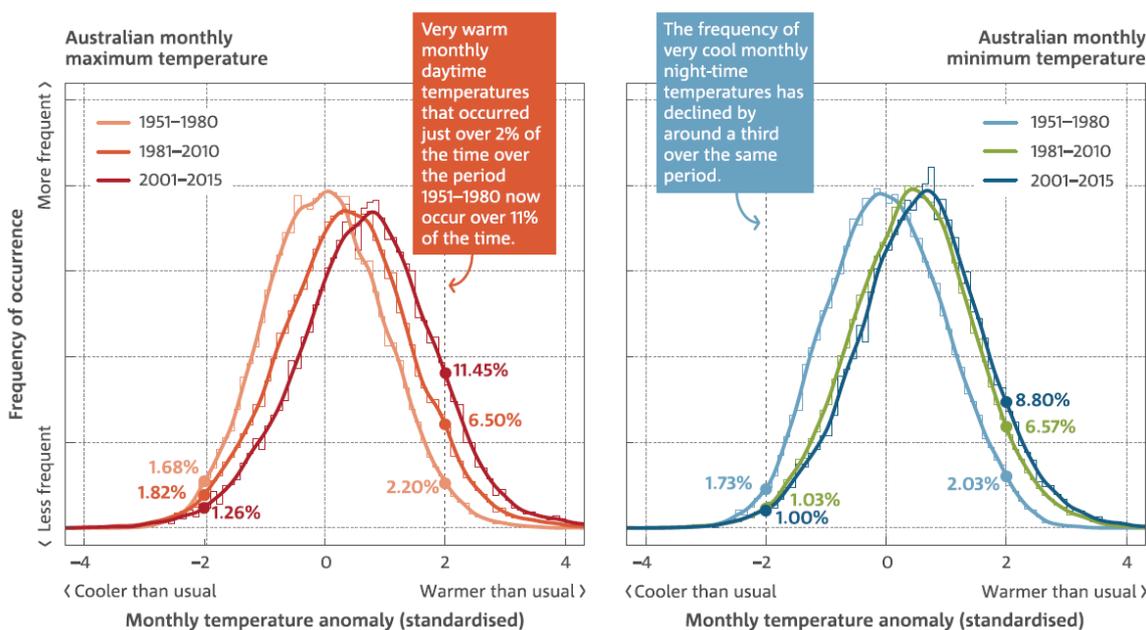
#### Recent climate

The Bureau of Meteorology and CSIRO produce a bi-annual report, the *State of the Climate*, which analyses and communicates observed changes in Australia's climate. Australia's weather and climate are changing in response to warming in the global climate system.

Australia's climate has warmed in both mean surface air temperature and surrounding sea surface temperature by around 1 °C since 1910. The duration, frequency and intensity of extreme heat events have increased across large parts of Australia. There has also been an increase in extreme fire weather and the length of fire season across large parts of Australia since the 1970s.

This warming trend occurs against a background of year-to-year climate variability, mostly associated with El Niño and La Niña in the tropical Pacific Ocean. Recent years (2013, 2014, and 2015) saw the warmest spring seasons on record, with attribution studies revealing that the underlying global warming trend was important in driving the unusually warm temperatures experienced.

The warming trend in Australia has resulted in both an increase in average temperatures and an increase in warm extremes. A trend of consistently high temperature maximums and minimums in Australia is also evident with more recent periods being successively warmer than the past (Figure 1). In respect to extremes, very warm monthly maximum temperatures that occurred around 2 per cent of the time during the period 1951–1980 occurred over 11 per cent of the time during the period 2001–2015.



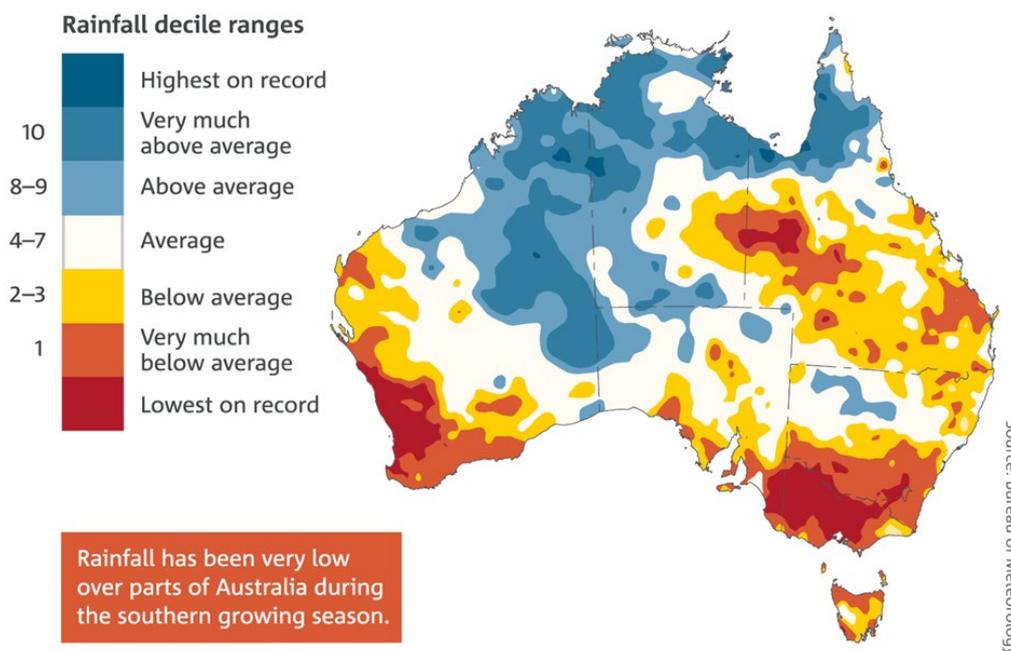
**Figure 1: Distribution of monthly day and night-time temperature anomalies (standardised with respect to a 1951-1980 base period) (Source: Bureau of Meteorology and CSIRO. State of the Climate 2016)**

According to the Bureau of Meteorology's 2017 Climate Statement, seven of Australia's ten warmest years have occurred since 2005. Australia has experienced just one cooler than average year in the last decade (2011). Most of this warming has occurred since 1950 and 2017 was Australia's third-warmest year on record.

Australian rainfall shows substantial variation from one year to the next as well as between decades. Rainfall averages across Australia have slightly increased since 1900, with a large increase in north-west Australia since 1970. A drier trend in winter rainfall persists in south-west Australia, while autumn and early winter rainfall has mostly been below average in the south-east since 1990. Unlike temperature, there is no

strong trend in annual rainfall across the country as a whole, despite a number of dry years in the period referred to as the Millennium Drought (2001–2009).

What is more evident have been changes in the growing season rainfall (April – October) for areas in south-west WA and large parts of Eastern Australia (Figure 2). There has been around an 11 per cent decline in growing season rainfall in the continental southeast of Australia since the mid-1990s.

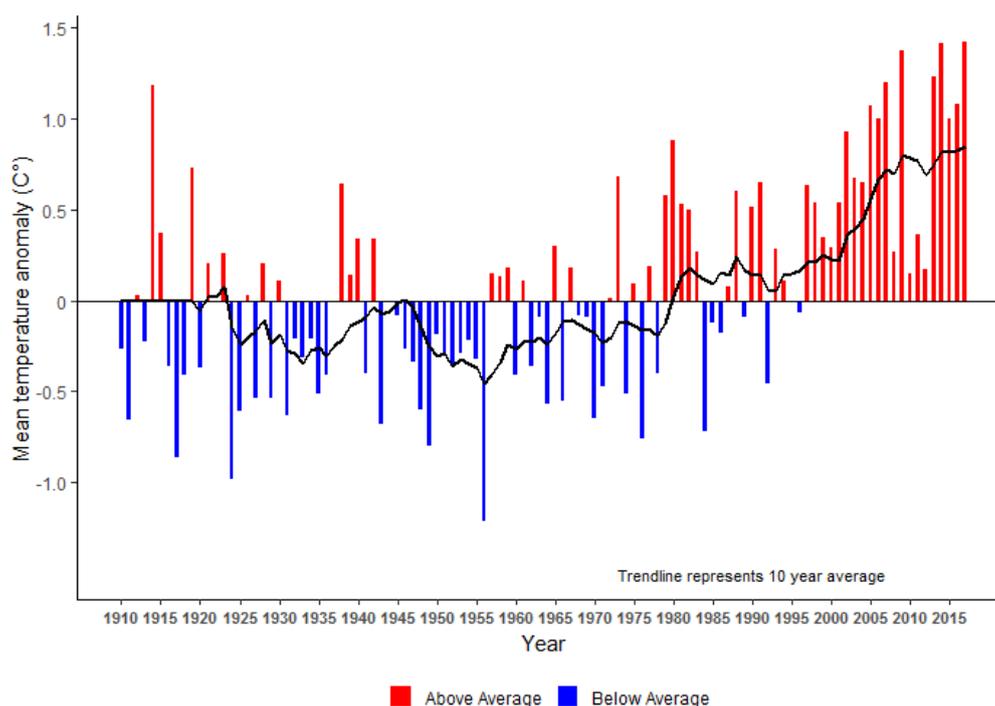


**Figure 2: Southern growing season (April–October) rainfall deciles for 1996–2015. This decile map shows where rainfall is above average, average or below average for this period, in comparison with the entire rainfall record from 1900 (source: Bureau of Meteorology and CSIRO. *State of the Climate 2016*)**

At a state level, NSW has experienced changes in temperature over time broadly consistent with national trends. Reliable temperature records for the state began around 1910 and show that the average temperature in NSW has risen steadily since the 1950s with the rate of increase accelerating in more recent decades (Figure 3).

In contrast to temperature and like the national picture, there is no clear trend in long-term rainfall for NSW as a whole. The long term rainfall record shows that NSW has experienced considerable variation in rainfall with periods of both wetter and drier conditions. The 1900 to 1950 period was much generally much drier than the 1950 to 2000 period.

The first decade of the 21st century saw a long period of below average rainfall during the Millennium Drought which was ultimately ended by two of the wettest years on record for Australia (2010-2011) (Office of Environment & Heritage). There is however, evidence that growing season rainfall for winter crops (April - October) has been particularly low over the last 20 years with falls that have been well below average in the southern half of the State (Figure 3).



**Figure 3: Mean temperature anomaly for NSW (1910 to 2017) (Australian Bureau of Meteorology Data)**

### Future climate

Climate change refers to underlying trends in climate over an extended period of time. These trends are superimposed on natural yearly to decadal climate variability which can either mask or enhance underlying trends.

The Bureau of Meteorology and CSIRO recently completed a program titled "Climate Change in Australia", which describes likely changes to Australia's climate over the coming century. The report and interactive materials are available at [www.climatechangeinaustralia.gov.au](http://www.climatechangeinaustralia.gov.au). Key points concerning future climate change in Australia arising from this work are reported in *State of the Climate 2016* and include:

- Australian temperatures are projected to continue increasing with more extremely hot days and fewer extremely cool days.
- An increase in the number of days with weather conducive to fire in southern and eastern Australia is projected.
- Extreme rainfall events are likely to increase in intensity by the end of the century across most of Australia.
- Winter and spring rainfall is projected to decrease across southern continental Australia, with more time spent in drought.
- Projections suggest fewer tropical cyclones will form in the southern hemisphere than are currently observed, but a higher proportion of those will be more intense with ongoing large variability from decade to decade.

NSW specific climate change projections are also available from the NSW and ACT Regional Climate Modelling project (NARClIM). These projections provide similar broad conclusions to national work in terms of projected increases in temperatures, more temperature extremes, declines in winter and spring rainfall and more severe fire weather. Further information is available at <https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW>.

## Impacts of climate change

The impacts of climate change on the NSW primary industries sector are significant and diverse. They affect the sector directly through production, but also indirectly through economic, environmental and social changes.

Without effective adaptation strategies, these impacts will adversely affect primary producers directly and will also have flow on impacts on the broader economy, particularly regional communities.

Climate change may impact the value of industry which reached a record \$17.5 billion in 2017-18 (gross value of production or GVP), of which 30% comprised irrigated crops including cotton, rice, fruit, vegetables and pastures. Beyond the direct benefits of GVP as income for farmers, the industry directly employed 87,325 people in 2015-16 and underpinned economic growth and community wellbeing across regional NSW, which may be affected by climate change.

### 2.2. Energy costs and reliability

Many of the production systems used in the primary industries sector are heavily reliant on energy and the issues currently facing the energy network are affecting the sector. These issues include the transmission and distribution of electricity and the use of gas and diesel on farms. These changes also present opportunities as new energy technologies are piloted and installed and more efficient ways to use energy are developed.

Increases in the cost of energy are impacting the ability of producers to remain profitable, as the cost of energy erodes their profit margins. In some cases, the cost of energy can also create perverse incentives. For instance, a farmer may choose not to use recently-installed, high-efficiency irrigation systems because of excessive energy costs even though it would significantly reduce water use and potentially increase crop yields.

Energy security is also a concern for the sector. For many producers in regional areas, transmission and distribution systems may be less reliable than in urban areas. Therefore when electricity supply is interrupted (e.g. if transmission lines are damaged during a storm), primary producers are likely to face more prolonged impacts. This can have severe impacts for primary producers, particularly intensive industries like horticulture or dairy which required constant energy supply for refrigeration.

These challenges coincide with opportunities for new types of energy generation and improvements to energy efficiency. For instance, the falling cost of solar photovoltaic panels can provide a viable solution for a farm wanting to increase energy security and reduce costs. In some cases, primary producers may be able to greatly increase their energy security through innovative new technologies such as micro-grids i.e. energy systems separated from the traditional electricity grid.

The challenges facing the sector around energy are occurring in the context of pressures on all industry sectors to lower emissions to reduce the rate and extent of future climate change. There is a further benefit to primary industries in adopting clean energy technologies because by reducing emissions, the sector can demonstrate strong environmental credentials to the community and contribute to reducing Australia's emissions.

### 2.3. Opportunities for primary industries

As the impacts of climate change are felt, and governments respond through new programs and policies, there will be opportunities for the primary industries sector to secure new income streams, protect against rising energy costs and build resilience.

Programs encouraging carbon sequestration and emissions reductions are already in place and likely to become more widespread in coming years. By enabling primary producers to better participate in these programs, the sector can diversify its income sources, build resilience and productivity, and deliver environmental benefits.

There are also opportunities for primary producers to adopt renewable energy and protect their businesses against rising energy costs. Improved knowledge about the costs and benefits of renewable energy (to both producer and the the energy supply network) would allow for producers to reduce their energy costs, improve energy efficiency and support the goal of reducing emissions.

Reducing the emissions intensity of agricultural systems will be important in achieving the NSW Government's aspirational target of net-zero emissions by 2050, as agricultural emissions account for 13% of NSW greenhouse gas emissions. The primary source of emissions from the sector is methane, released as cows and sheep digest their food, but agricultural emissions also include manure management, rice cultivation and nitrous oxide emissions from agricultural soils. The heavy dependence on diesel fuel for tractors and field machinery in agriculture but particularly irrigated agriculture, is also a significant source of emissions. By reducing emissions across these areas, the primary industries sector has an opportunity to be a major contributor to achieving the State target.

## 2.4. Strategy overview

The Primary Industries Climate Change Research Strategy is an investment of \$29.2 million into a strategic portfolio of new actions that will complement existing programs and support the NSW primary industries sector in the face of climate change. These actions include a mix of research projects partnering with leading industry bodies and research institutions, on-ground pilots (established through competitive grants) of new and emerging technologies and systems and communication and engagement with the primary industries sector.

The risks and opportunities of a changing and variable climate must be fully understood if primary industries are to continue to contribute to NSW's economic growth. The Strategy will support primary industries meet the challenges of climate change and capitalise on opportunities across three theme areas in line with the Climate Change Fund:

- **Energy** - innovative clean energy solutions; more information on new technologies/practices to address rising energy costs; and alternative electricity generation options
- **Carbon Opportunities** - preparing primary industries for net zero emissions by identifying emission reduction and sequestration opportunities and helping farmers access carbon markets
- **Climate Resilience** - develop cutting-edge knowledge on the vulnerability of our primary industries to climate change and test new technologies and adaptation options to respond to climate change

Table 1 contains a list of actions funded through the Strategy

**Table 1: Actions in the NSW Primary Industries Climate Change Research Strategy**

Theme	Action	Activities	Budget
Energy	<b>1. Clean Energy Solutions</b>	Invest in innovative energy solutions developed via feasibility studies focused on micro-grids, renewable energy and storage models suited to the key primary industries districts of NSW.	\$4.0m
	Fund innovative energy projects to support clean energy and local energy solutions for regional communities and primary producers in New South Wales		
	<b>2. Energy Efficiency Solutions</b>	Assess the impact of rising energy costs on the competitiveness of the most energy-intensive primary industries such as horticulture and poultry, and investigate options for primary producers to improve their energy efficiency.	\$3.7m
	Help energy-intensive primary industries identify options to improve their energy efficiency and reduce costs		

Theme	Action	Activities	Budget
	<p><b>3. Biomass for Bioenergy</b></p> <p>Investigate innovative approaches to electricity generation using organic matter (biomass) to prepare for new capacity in the electricity grid</p>	Partner with energy generators, industry and research organisations to identify opportunities to diversify NSW's energy mix using biomass for improved energy reliability.	\$4.0m
Carbon Opportunities	<p><b>4. Emissions Reduction Pathways</b></p> <p>Help primary industries plan for net zero emissions</p>	Investigate the feasibility of emissions reduction and carbon sequestration options for primary producers. This will include technical and economic assessments and will inform industry and government investment.	\$1.5m
	<p><b>5. Accessing Carbon Markets</b></p> <p>Increasing primary industries' access to carbon markets and optimising industry contribution to net zero emissions target</p>	Develop tools to enhance the opportunities for farmers to participate in market measures to reduce or offset emissions, including the Commonwealth Emissions Reduction Fund.	\$1.3m
Climate Resilience	<p><b>6. Vulnerability Assessment</b></p> <p>Deliver cutting-edge research and knowledge to better understand the vulnerability of primary industries to a changing climate</p>	Investigate the impacts of climate change on a sector-by-sector and region-by-region basis, to provide up-to-date climate information to primary producers. Conduct analyses across primary industries, including possible biosecurity impacts, to identify options for adaptation that best suit critical industries.	\$8.0m
	<p><b>7. Climate-Smart Pilots</b></p> <p>Support farmers to pilot projects that build resilience in rural communities and primary industry sectors</p>	Establish and pilot sensors and networking solutions to improve on-farm responses to climate risks, and invest in a series of on-ground pilots that showcase innovative adaptation.	\$6.7m

## 2.5. Other climate related support to primary industries

The Primary Industries Climate Change Research Strategy is an important component of a broad range of activities that the NSW Government is undertaking to support the primary industries sector adapt to climate change and manage the transition of the energy network.

Over the past two decades, NSW DPI has investigated the impacts of increasing climate variability and climate extremes on primary industries, and put in place programs to enable continued productivity. The Strategy will complement these programs which include:

- crop breeding for increased drought and heat tolerance, and for improved water use efficiency;
- enhanced drought monitoring;
- long-term water supply planning;
- drought resilience programs; and
- biosecurity monitoring programs.

The broader range of activities supported by the NSW Climate Change Fund includes actions that although not directed at the primary industries sector, will benefit the sector and allow primary producers to participate. For instance, the Energy Affordability Package targeted the state's small business sector with a number of measures, many of which may be applied to primary producers.

The Strategy will be implemented by NSW DPI and complement existing partnerships with key industry participants and its reputation as a world-class research organisation.

## 3. Key actions

### 3.1. Energy

#### Project 1: Clean Energy Solutions

**Fund innovative energy projects to support clean energy and local energy solutions for regional communities and primary producers in New South Wales**

**Budget:** \$4 million

**Issue:** Energy use and costs for the \$17.5 billion NSW primary industry sector have risen steadily over the past ten years, with electricity prices rising significantly over the last five. For example, energy costs have risen by 70-300% in parts of the irrigation industry. Although water use efficiency has improved over the last ten years, energy intensity has increased (44%) – partially as a result of switching to pressurised irrigation systems to enhance water use efficiency.

In addition, the Australian Bureau of Statistics and other reported data suggests that energy use in the sector remains dominated by diesel. This data suggests that the already dominant role of diesel has further increased in recent years due to increased electricity prices; continued lack of access to, or prohibitive costs of connecting to the grid; and unreliable supply.

It is also often the case that energy usage patterns in the sector do not align with the centralised electricity grid supply and pricing arrangements for NSW. For example, in the irrigation sector the need to access water when it is physically available, affordable, agronomically suitable and efficient to apply, make the energy usage patterns of irrigators lumpy and unpredictable which results in unaffordable energy when urban focused demand tariffs are applied.

There is a need to find a cost effective and equitable way to address the lumpy demand curves of primary industries businesses which integrates renewables, energy storage, network design and existing network customer requirements.

**Program:**

- Social research to identify the major impediments to adoption of hybrid or off-grid renewable energy for NSW primary industries businesses.
- Investigation of energy demand profiles in NSW in key regions.
- Development of an investment framework to select and test initiatives.
- Synthesis policy recommendations and develop information products in collaboration with industry.

**Benefits:**

- Improved water and energy and food productivity for NSW primary industries.
- Improved international competitiveness of primary industries' exports.

## Project 2: Energy Efficiency Solutions

### Help energy-intensive farms identify options to improve their energy efficiency and reduce costs

<b>Budget:</b>	\$3.7 million
<b>Issue:</b>	Energy productivity in agriculture has steadily declined compared to other industries increasing the sector's financial risk and vulnerability. Economically viable solutions are needed to optimise energy use and reduce the vulnerability of the sector to changes in energy prices. Pilots can be an effective way of demonstrating solutions and addressing information gaps that would otherwise act as a barrier to adoption.
<b>Program:</b>	<ul style="list-style-type: none"><li>• Benchmark farm-level, industry comparative information on energy productivity.</li><li>• For the most energy-intensive primary industries, including horticulture and poultry, identify points in the production system that the most cost-effective energy improvements can be made.</li><li>• Conduct desktop studies to assess the impact of rising energy costs on the competitiveness of the most energy-intensive industries.</li><li>• Pilot energy efficiency approaches with primary producers and industry bodies to test on-ground feasibility.</li><li>• Synthesise the findings of industry pilots to determine which are most effective at improving energy efficiency and are cost-effective for producers.</li><li>• Communicate the findings of the energy efficiency pilots to primary producers via education programs, media, joint publications with industry bodies, website materials and demonstration activities.</li></ul>
<b>Benefits:</b>	<ul style="list-style-type: none"><li>• Reduced exposure of primary industries to energy related business risk.</li><li>• Better information on the merits of a range of new technologies, equipment and production systems in the context of rising energy costs for energy intensive industries.</li><li>• Provision of real-world examples of energy efficiency approaches that work, providing increased investment certainty and enabling dissemination of these lessons to the broader sector.</li><li>• Reducing risks associated with the early adoption of energy efficiency options in agriculture.</li></ul>

## Project 3: Biomass for Bioenergy

### Investigate innovative approaches to electricity generation using organic matter (biomass) to prepare for new capacity in the electricity grid

**Budget:** \$4 million

**Issue:** The use of bioenergy for electricity generation in NSW has not to date been properly evaluated. There is a need to consider alternatives to the current fossil-fuel dominated electricity generation model. Biomass is a storable fuel that can be utilised in many applications including electricity generation, where it can provide baseload and create stability that allows the expansion of intermittent renewables (solar and wind) without the need for expensive storage solutions. Bioenergy could therefore play an important role in supporting the transition to low-carbon energy generation which is required to meet net zero emissions.

Although substantial volumes of biomass are available in the form of residues from forestry and other primary industries, it is anticipated that large-scale generation of electricity from biomass would increase the demand for biomass drastically. One option to assist in meeting the demand is large-scale planting of short-rotation energy crops, such as woody and grassy crops. Although a reality in several countries, this concept has not yet been adopted in NSW or in Australia in general. This project will evaluate key candidate crops in terms of planting strategies, configuration, management and the economics of harvest and transport.

There is limited understanding in Australia of the potential use of the pellets (white or torrefied) in electricity generation, either co-firing with coal or in stand-alone biomass power stations. This model is currently successful in several countries (e.g. England, Japan, South Korea). At a smaller, regional scale, the concept of hybrid-biomass solar power stations may be attractive, with the option to go off-grid. There is very limited understanding of the potential for this technology in Australia.

**Program:** The project has three main components:

- **Feedstocks:** The most prospective energy crop species will be planted at 10 demonstration sites across NSW. This will include mallees in low rainfall areas and potentially, grass crops in higher rainfall regions. The trials will provide information on realistic growth rates, and allow opportunity to demonstrate the energy crop concept to NSW landholders, including the mallee harvester that has been developed in WA.
- **Technology options:** Evaluation of the use of white and torrefied pellets for co-firing in existing coal-fired power plants in NSW. Review recent experience with white and torrefied pellets in Europe and North America. Undertake co-firing trials with pellets produced from several different biomass streams to determine the best feedstocks and potential co-firing rates. Techno-economic assessment of hybrid solar-biomass concepts for off-grid application that could provide the basis for a demonstration project.
- **Scenario modelling:** Develop scenarios for bioenergy, considering potential biomass supply (volume, quality), alternative bioenergy technologies and integration with current energy generation. Analyse contribution to greenhouse gas emissions reduction in short and long term.

**Benefits:**

- Generating evidence to provide confidence for the energy generation industry to invest in electricity generation from biomass.
- Provision of stability to the grid, allowing expansion of solar/wind option without reliance on expensive storage solutions.
- Opportunity for NSW to lead the way in large-scale implementation of bioenergy solutions for electricity generation.
- If co-firing or stand-alone biomass plants, significant advantage in using existing power station sites.

- Development of a new market for biomass that is currently wasted or under-utilised, promoting industrial regional activity.
- Addressing climate change targets by reducing reliance in fossil fuels and increasing carbon sequestration rates by establishment of large-scale energy crops.

## 3.2. Carbon opportunities

### Project 4: Emissions Reduction Pathways

#### Investigate the feasibility of emissions reduction and carbon sequestration options to help primary industries plan to reduce emissions

**Budget:** \$1.5 million

**Issue:** Progress towards meeting an aspirational objective of net-zero emissions in NSW by 2050 will require all industries to adopt new technologies and systems. While some studies have found that the land sector can make an important contribution to cost effective mitigation, there has not been a comprehensive or integrated assessment of opportunities in primary industries in NSW.

Mitigation opportunities cover a range of possibilities including reducing livestock methane and nitrous oxide emissions from soils as well as enhancing sequestration through soil carbon and revegetation. An understanding of the opportunities in primary industries is needed to complement studies in other sectors and will ultimately inform future investment decisions of industry and government.

**Program:** Investigate the feasibility of emission reduction and carbon sequestration options for primary producers. NSW DPI will lead the investigation of emissions reduction and carbon sequestration options for the NSW agriculture sector and collaborate with other agencies to devise emissions reduction pathways for NSW. There are three main stages:

- **Stage 1:** Technical assessment of mitigation options – review recent developments and research to determine extent of technical gains.
- **Stage 2:** Assess economic feasibility of mitigation options; integrating the findings of the technical assessment with spatial data sets on land use, soils and climate to determine the costs and returns associated with different options.
- **Stage 3:** Assess policy feasibility of mitigation options; Identifying how measures could be adopted and devising pathways for adoption.

**Benefits:** This action will help the primary industries sector prepare for net zero emissions, in line with the aspirational target in the NSW Climate Change Framework, and guide future adoption of mitigation options.

It will support the primary industries sector to identify and prioritise emissions reduction and carbon sequestration opportunities, achieving increased return on investment for emissions reduction projects, greater investment certainty for the sector and environmental benefits through reduced emissions. The project will also facilitate collaboration with primary producers and technical experts and leverage R&D investment over the last 5 years.

## Project 5: Accessing Carbon Markets

### Develop new tools so farmers can earn extra income by accessing carbon markets

**Budget:** \$1.3 million

**Issue:** Agricultural systems contribute to greenhouse gas emissions through energy use; direct contributions of nitrous oxide, methane and carbon dioxide to the atmosphere; through manufacture of system inputs; and waste disposal. Agricultural emissions account for 13% of NSW greenhouse gas emissions.

Reducing the emissions intensity of agricultural systems will be important in achieving the NSW Government's aspirational objective of a net-zero emissions target by 2050. The adoption of mitigation technologies may also be important to market access with increasingly stringent international markets seeking products with a lower environmental footprint.

Programs encouraging carbon sequestration and emissions reductions are already in place and likely to become more widespread in coming years. However farm businesses need better and more accessible information in order to understand the opportunities for their businesses. This includes understanding the risks, uncertainties and trade-offs that may need to be made to maintain agricultural production whilst earning income from carbon sequestration.

**Program:** In partnership with carbon market participants, develop a web-based decision support tool to enable farmers to identify the costs and benefits from carbon sequestration and emissions reduction activities. Collect on-farm data to develop and verify methods to assess and quantify environmental co-benefits from carbon farming.

In partnership with Local Land Services, develop an outreach program that communicates and promotes the benefits of incorporating carbon farming in agricultural enterprises and cost-effective emissions reduction activities.

**Benefits:**

- By testing the feasibility of new technologies and platforms, it will enable market access to be rolled out in a cost-effective manner for primary producers, remove barriers to participation in carbon farming markets and improve investor confidence.
- By setting up primary producers to participate in these programs, the sector can diversify its income sources, build resilience and productivity, and deliver environmental benefits.
- Strategic priorities will assist the transition of emissions reduction industry from government funded to private sector demand, positioning NSW to enter international off-set markets.
- Identification of co-benefits will mitigate impacts on resource condition and maintain agricultural production.

### 3.3. Climate Resilience

#### Project 6: Vulnerability Assessment

**Deliver high quality research to better understand the vulnerability and adaptability of our primary industries to a changing climate**

**Budget:** \$8 million

**Issue:** The \$17.5 billion NSW primary industries sector is particularly exposed to climate because production is intrinsically linked to the climate system.

The CSIRO and Bureau of Meteorology have projected increasing temperatures, decreasing winter and spring rainfall for most of NSW, greater drought frequency, increased intensity of extreme rainfall events, and warmer more acidic oceans.

NSW lacks comprehensive information on primary industries impacts, particularly at a regional and sector-specific level. This in turn hinders government and industry planning and investment in adaptation. This information gap heightens vulnerability, challenges existing planning frameworks, has the potential to lead to maladaptation. It may lead to lower productivity and profitability of the sector.

Increasing knowledge about the projected changes in climate highlights the need for industries and governments to understand the extent of climate change, its likely regional impacts and potential adaptation strategies.

**Program:**

- Invest in science and research to make sure NSW has up-to-date, high quality and relevant information to adapt to climate change.
- Investigate and review the capability of the primary industries sector to adapt to climate change to help prioritise long-term industry and government investment.
- Develop a vulnerability modelling approach to capture climate exposure risk and sensitivity of key primary industries and conduct modelling to evaluate adaptation options.
- Establish an independent governance and high level scientific review process with key industry and scientific representation.
- Develop adaptation options for the most vulnerable agricultural industries/regions that are suitable for investment and implementation by industry and government.
- Engage with identified government agencies, non-government organisations and industry bodies to ensure that the evaluation of climate risk and adaptation options have relevance, are practical and can be implemented.

**Benefits:**

- Enable key primary industry sectors like agriculture to better plan and respond to a changing climate by adopting new practices or technologies.
- Provide the evidence base for increasing the adaptive capacity of primary industries by supporting industry and government decisions subject to climatic risks.
- Reduce risks associated with the early adoption of adaptation strategies in primary industries.

## Project 7: Climate-Smart Pilots

### Support farmers to pilot projects that build resilience in rural communities and primary industry sectors

**Budget:** \$6.7 million

**Issue:** Technology is seen as an important factor underpinning the capacity of agriculture to adapt to changes into the future. New information technologies provide the means to connect the landscape, farmers and regional communities in ways that have not been possible before. This creates opportunities to improve climate adaptation responses through better management of short term variability, including extreme events or water resource management.

Open networks, where government provides the baseline infrastructure to establish connectivity, are being used to underpin energy and water savings in cities and regions around the world. There is currently an opportunity to invest in an Open Sensor Network in NSW, to create the environment where farmers and communities can be better prepared for climate events and underpin the adoption of new technological innovations for adaptation.

Investment in climate change adaptation is subject to considerable market failure because of the high levels of uncertainty in climate change projections over the next 20 to 100 years. Innovations that are resilient to a range of future climates and also provide improvements under current climatic settings provide a way to respond to this uncertainty, and are known as win-win options.

Future investment uncertainty in climate change adaptation can be further reduced by demonstrating actions through on-ground pilot programs. This moves adaptation beyond a research or assessment activity by providing farmers, regions and investors with improved security to make change.

- Program:**
- Invest in the enabling connectivity technology by piloting the Open Sensor Network in up to three vulnerable regions of NSW. This will allow the deployment of a network of water and climate monitoring devices to improve the underlying information to manage extreme events and water resources.
  - Promote and foster a culture of innovation in these regions by allowing others to utilise the Open Sensor Network. Monitoring the uptake and use of the network will help clearly identify the roles of government and the private sector in building future technological adaptations.
  - Establish an open tender mechanism for the public and private sector to nominate potential adaptation actions. Utilise an independent assessment panel to implement streamlined procedures for identifying feasible adaptation options.
  - Undertake an evaluation of the piloted adaptation options in terms of their on-site economic and environmental impacts.
  - Assess the likely uptake of the piloted adaptation options in terms of factors known to influence the level of adoption - relative advantage, compatibility, complexity, functionality and observability.

- Benefits:**
- Tangible improvements to the resilience of regional communities by generating improved information for the management of natural resources and extreme climatic events.

- Identification of adaptation pathways that are robust to uncertainty and address a market failure in adaptation investment.
- Tangible improvements to the climate change resilience of the organisations and individuals involved in the program.
- Reduce levels of uncertainty for those seeking to invest in adaptation options in NSW.

## 4. How the strategy will be delivered

The delivery of the NSW Primary Industries Climate Change Research Strategy will be supported through strong governance, project management, evaluation and reporting arrangements to ensure effective implementation and delivery of the program.

### 4.1. Project Management

Consistent with best practice, each project will have a program logic, also known as a logic model or theory of change model. This is fundamental for effective planning and evaluation and to clarify and communicate intended outcomes and assumptions. They are living documents that should be revisited throughout the delivery of the projects to inform adaptive management. The program logics will be supported by a project plan which will be reported against.

The project plans will capture scope, timeframes, milestones, consultation and communication processes and deliverables. They will also include details of the monitoring, evaluation, reporting; risk management; the stakeholders involved and their roles.

### 4.2. Evaluation

Evaluation plans have been developed for each of the seven projects which will inform the overall assessment of the success of the Strategy. They are informed by the program logics and are consistent with the principles of the NSW Government Program Evaluation Guidelines.

The evaluation plans will assess the appropriateness and effectiveness of the Strategy in contributing to the DPI Strategic Plan, the CCF objectives and the needs of stakeholders.

### 4.3. Reporting

The CCF Implementation Committee holds the responsibility for high level reporting of CCF programs. The Committee, which DPI is a member of, is responsible for supporting the Minister for the Environment to meet reporting obligations under the *Energy and Utilities Administration Act 1987* (the Act), including the tabling of the CCF Annual Report to NSW Parliament, and quarterly reporting to the Resources and Land Use Cabinet Committee.

DPI will also undertake its own internal reporting which will have a greater focus on the delivery of the program against the DPI Strategic Plan.

### 4.4. Governance

Robust governance arrangements have been established to successfully deliver the Strategy. The governance arrangements for the Strategy are illustrated in Figure 4. NSW DPI will regularly review these arrangements to ensure they remain effective and fit for purpose.

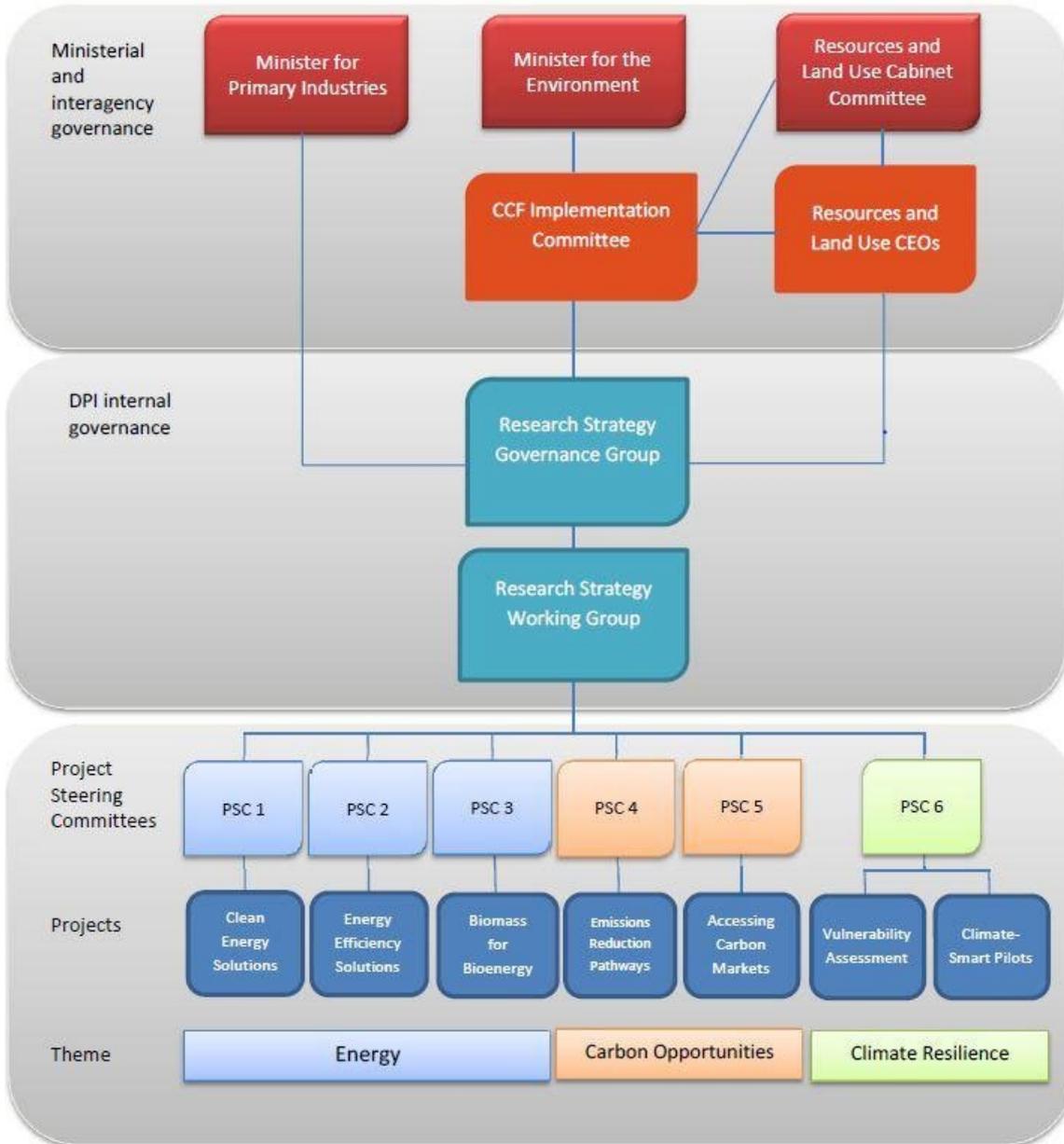


Figure 4: Governance Structure – Climate Change Fund and NSW Primary Industries Climate Change Strategy

#### 4.5. Interaction with the Climate Change Fund

The funding for this Strategy is provided from the Climate Change Fund and may be complemented with additional funds from key partners.

NSW DPI will be responsible for implementing, delivering and evaluating the projects. NSW DPI will collaborate with the Office of Environment and Heritage (as the managing agency of the CCF) to ensure progress of program implementation, budget management and program monitoring information is provided as required for management of the CCF fund.