South Australia's Climate Change Challenge and Opportunity

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Summary of key points

South Australia has a compelling interest in the success of the global effort to reduce damage from climate change. It can prosper exceptionally in success.

Low renewable electricity prices are the foundation for global competitiveness in new manufacturing, including the processing of South Australian raw materials.

- South Australia has led a transition to a more reliable and secure low-carbon power supply and now has lower wholesale electricity prices than the most populous states and is a net electricity exporter.
- Renewable energy and storage investment can quickly lift employment and incomes in South Australia's post-pandemic recovery as well as support electrification of transport and expansion of energy-intensive industry.
- The biggest constraint on renewables expansion is in planning and regulating the transmission and distribution network.

Priority: Facilitate investment in new energy transmission to enable increased energy generation, use and export, including reforming the regulatory framework.

Manufacturing and mining emissions are high and have not fallen since 2009. These industries can move towards zero net emissions over the next decade and during this time expand greatly.

- The largest miners and metal manufacturers are committed to zero net emissions. There are advantages for trading zero-carbon metals within European markets now and other markets thereafter.
- Green steel holds great opportunity in South Australia from magnetite deposits, low cost renewable energy for hydrogen, and bolstered by Whyalla human skills, education and training facilities. South Australia has the required physical infrastructure in place for expanding zero emission manufacturing.

Priority: Provide fiscal support for innovation to accelerate low-emission industrial inputs such as hydrogen in heavy industry, iron-processing and other minerals processing.

Transport is South Australia's largest source of emissions, mostly from road transport.

- Electrification of road transport is the biggest opportunity to reduce domestic emissions. This will be helped by the low cost of renewable electricity.

Priority: Support investment in charging infrastructure and time-of-use electricity pricing to encourage greater uptake of electric vehicles.

South Australia has large opportunities to increase the amount of carbon stored in sea, soils and plants, and to use biomass for industrial processes.

- A large per capita endowment of woodlands and rangelands offsets the disadvantage of low precipitation.
- Advantages are in plants adapted to a hot, dry and variable climate; human capital strengths in the applied land sciences and in resource project development.
- New biomass can replace fossil carbon in all uses and provides economic opportunities but will be reserved by price for processes in which there are no low-cost zero-emission alternatives.
- South Australia's coasts and gulfs provide rich opportunities for sequestering carbon.

Priority: Drive and develop comprehensive landscape carbon accounting that will reward landowners for increases in carbon sequestration; fiscal support for innovation in blue and green carbon technologies.

South Australia and other Mediterranean climates are experiencing the most significant warming and drying of any regions, requiring rapid adaptation.

- Excellent climate change information and public education are the main instruments.
- South Australia's agricultural future depends on adapting better than other countries with similar climates.
- Opportunities in more efficient water use include desalination with low-cost, low-emission energy.
- Infrastructure and buildings will have to withstand more extreme weather events.

Priority: Continue the South Australia Government's excellent climate risk and adaptation science publications; support innovation in water management; and improve building codes to embody climate resilience.

Introduction

South Australia is the driest state in the world's driest inhabited continent. Its rich agricultural areas share the Mediterranean climates that have been the first to experience disruptive warming and drying all over the world. It is damaged by the shrinkage of water flows through the Murray–Darling river system. South Australians' health and wellbeing have recently been disrupted by the most severe bushfires on record and are affected by more and more frequent extreme heat. South Australia stands out in a vulnerable world for its vulnerability to climate change.

At the same time, South Australia is better equipped to respond to the challenges and opportunities of climate change than any other Australian state and nearly all of the world's sub-national jurisdictions. It used to have more expensive and less reliable wholesale electricity than the more populous states. With more electricity coming from solar and wind and investment in balancing technologies, that has been reversed. Low electricity prices can be the foundation for global competitiveness in new manufacturing, including the processing of South Australian raw materials into zero-emission products experiencing strong international demand now and increasingly in future. South Australia has large opportunities for producing biomass on land and in the sea, which will become increasingly valuable as the world moves to zero net emissions. It has rich opportunities for sequestering carbon in its landscape, sea and geology.

The Government of South Australia, under both major political parties, has implemented productive responses to climate change. It has led transition to a lower cost and more secure and reliable low-carbon power supply, and is leading transformation elsewhere in the economy. It is providing sound and clear information about future climate change to which we must adapt.

The South Australian private sector has a rich endowment of human skills and experience for understanding, mitigating and adapting to climate change and utilising low-emission technologies for economic development. The Government of South Australia has always been at the forefront of innovation for the transition that the world must make soon to zero net emissions.

South Australia has a compelling interest in the success of the global effort to avoid the worst effects of climate change. It would be damaged immensely by failure. It can prosper exceptionally in success.

Now is the right time for high levels of investment in the low-carbon future

The international scene is right. While traditional trade and investment will remain weak in a depressed global economy, there will be opportunities in building the low-carbon global economy. For the time being, uncertainties exist in the United States (US), but the world now seems likely to emerge from the pandemic recession with strengthened commitment to meeting the objectives agreed in Paris in December 2015. The international economy is ready for deepening trade and investment with Australia if we embrace the low-emissions transition.

COVID-19 has tipped us into by far the deepest Australian recession since the Great Depression. South Australia has thus far fared better than the most populous states in containing the virus but shares the nation's need for large business investment to restore incomes and employment. Business is ready to commit large amounts of investment in the low carbon economy in South Australia. Regional South Australia in particular can prosper exceptionally by embracing the zero

emissions opportunities. Few South Australians are aware of how tall their state stands in innovation in the low-carbon economy.

Drive by electric car or bus from Adelaide, around the coast through Port Augusta and Whyalla to Port Lincoln, with a short detour through Jamestown, and you will see in operation or under development many of the leading zero-emission energy technologies. These include a solar-thermal-powered arid-zone greenhouse; the world's largest battery; innovative virtual power plants; floating solar; many large solar and wind farms; innovative use of algae; synchronous condensers; and development sites for pumped hydro and renewable hydrogen. No drive of similar length in the world would expose you so intensively to the energy systems of the future. Start in Mt Gambier on a longer journey and you will see even more, including the use of pyrolysis to convert wood waste into char and energy, and biomass heating systems for a greenhouse and aquatic centre. Along the journey, you pass centres of world-class research and innovation related to constraining the increase in temperatures and adapting to climate change. South Australia's high standing on climate change and the energy transition can attract interest, visitors, innovative new citizens and investment.

South Australian emissions and the mitigation challenge

South Australia, like all Australian states and territories, aims to achieve zero net emissions by 2050. This objective is broadly in line with the Paris Agreement goal of limiting warming to 'less than 2 degrees Celsius'. Zero net emissions would have to be achieved earlier for the higher 1.5 degrees Celsius ambition. The world is rapidly running out of time for 1.5 degrees. That is not because it is technologically impossible nor because the economic costs exceed the benefits. It is because governments around the world are moving slowly.

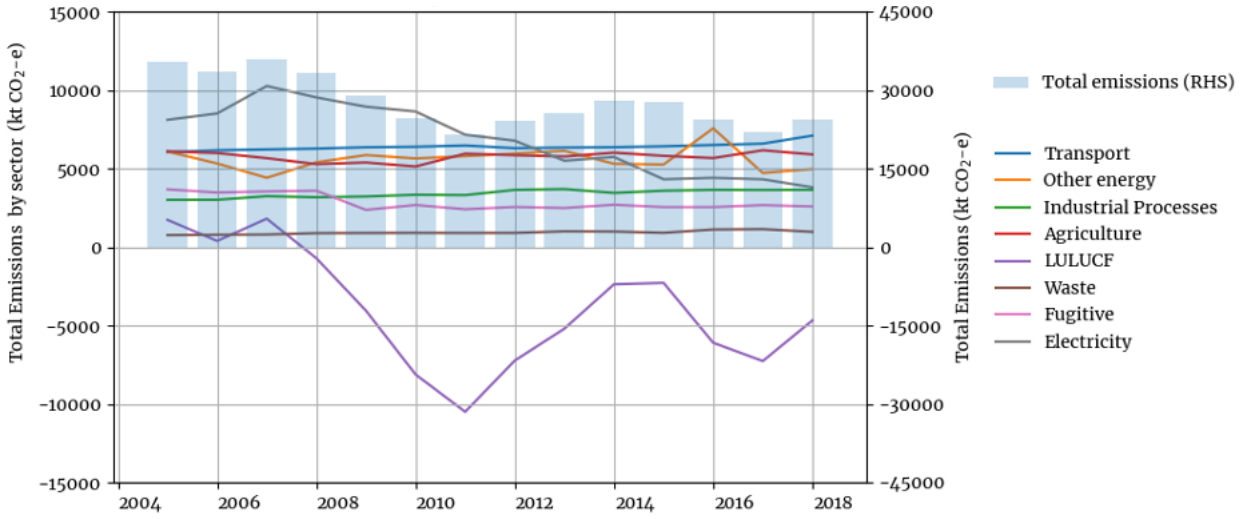
South Australia has much to gain from 1.5 degrees becoming the primary global goal. South Australia's prospering from early progress towards zero net emissions would be encouraging for others.

The Government of South Australia aims to achieve at least a 50 per cent reduction in net emissions from 2005 levels by 2030. The aim is a practical reflection of what is necessary to achieve zero emissions by 2050 without risks of failure and high costs of compressing adjustments in later years.

A 50 per cent reduction by 2030 is within reach, with major contributions from low-emission manufacturing and mining, renewable electricity and hydrogen, transport, and land use change. Moving from 50 to 100 per cent reduction requires doing some things that increase costs for those making the changes. Regulation or financial incentives are required to achieve optimal levels of carbon capture and storage in South Australia's landscape, sea and geology. Even in areas in which we expect costs to fall with transition to low emissions technologies, the firms and households that move first absorb the costs of learning that benefit others and therefore warrant public support for innovation.

South Australia's emissions between 2005 and 2018 are shown in Figure 1. The graph shows there has been no fall in fugitive emissions since 2009. Agricultural emissions have fluctuated with cattle and sheep numbers in response to climatic changes, without a clear trend. Emissions from transport have been tending to increase. These curves can all be bent downwards at reasonable and in some cases, negative cost.

Figure 1: South Australian Emissions Total and by sector[1]



1 Data from Australian National Greenhouse Accounts (May 2020) State and Territory Greenhouse Gas Inventories 2018. Electricity emissions data are as provided by Clean Energy Regulator (Electricity sector emissions and generation data (time period)), National Greenhouse and Energy Reporting.

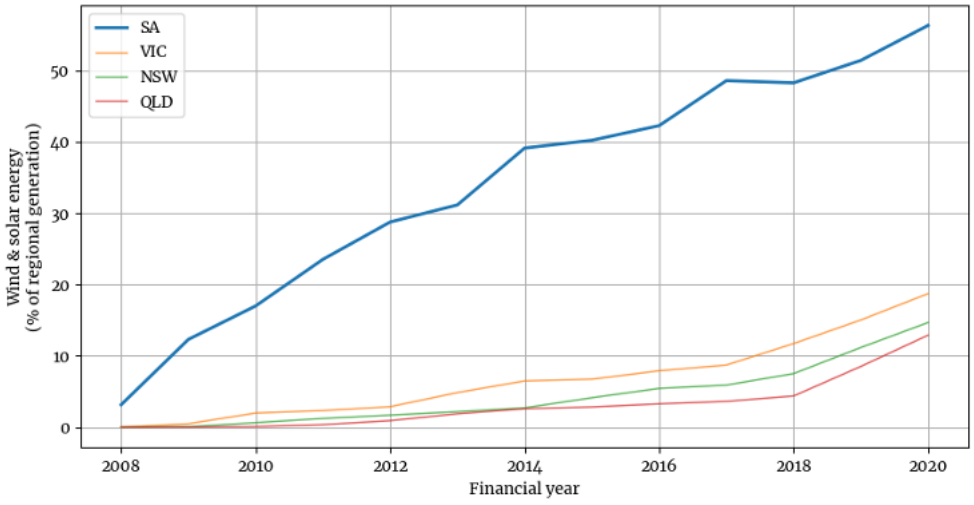
Completing the energy transformation

Prior to 2005, electricity in South Australia came predominantly from brown coal and gas power stations. Since then, over 2000 MW of wind capacity, 400 MW of utility-scale solar and 1000 MW of distributed solar have been installed. In 2019–20, renewable energy (including rooftop solar) provided over 57 per cent of the state's electricity generation[2]. Figure 2 shows this increase and comparable data for Victoria, New South Wales (NSW) and Queensland.

Until recently, South Australia had the highest wholesale electricity prices in the National Electricity Market (NEM). Increased renewable generation and reduced costs of renewable energy have begun to lower wholesale electricity prices in South Australia (Figure 3). For 2019–20, wholesale prices were lower in South Australia than in Victoria or NSW. The wholesale price advantage over the large states will tend to increase as others face the short-term effects of coal generation closures—an adjustment which has been completed in South Australia. Once a large net importer of power from other states, South Australia has been a net exporter over the past three years (Figure 4).

South Australia, at the end of one of the world's longest transmission grids, once experienced lower power security and reliability than Victoria and NSW. In 2019-20, South Australia had more reliable power supply, with proportionately less unserved energy and involuntary load shedding than either of those states. Since the shock of a blackout during an extreme storm event in 2016, South Australia is advanced in the use of electricity storage for security and reliability of power supply in a system with high and increasing use of intermittent solar and wind. Examples include the largest grid-scale battery when installed and soon to be expanded; other pending significant storage installations; the world's highest per capita use of distributed batteries (with South Australia Government and City of Adelaide support); Australia's first large virtual power plant; and pumped hydro storage (with three pumped hydro projects in the Upper Spencer Gulf selected under the Australian Government's Underwriting New Generation Investment program). Synchronous condensers are increasing security.

Figure 2: Wind and solar energy generation[3]



2 Australian Energy Market Operator (via openNEM) https://opennem.org.au/energy/sa1/.
3 Australian Energy Market Operator (via openNEM) https://opennem.org.au/energy/nem.

South Australia's renewable generation will continue to expand with and beyond interconnection capacity. South Australia will become a much larger exporter of power, contributing to investment, employment and incomes. Interconnection charges and generation in excess of interconnection capacity will keep South Australian power prices below eastern states once current excess coal-based power supply in NSW and Victoria has been removed. Low power prices will support new energy-using industries, increasing power demand and incentives for further expansion of domestic generation.

The South Australia Government's stated aim is for 100 per cent net renewables in the 2030s. Renewables, including rooftop solar, already contributed 57 per cent in 2019–20 and, with appropriate investment in transmission and enabling infrastructure, are likely to reach 100 per cent by 2030.

No area of investment has the potential quickly to lift employment and incomes in South Australia as much as solar and wind generation and power storage. That can be a major contributor to post-pandemic recovery. Investment in renewable generation and storage will continue to increase through the 2020s to supply electrification of transport and expansion of energy-intensive industry.

The main constraint on renewables expansion is the slow approvals and high costs built into established national approaches to planning and regulating the transmission and distribution networks. Globally competitive power prices to large new industry users will require transmission investments from the private sector, outside the established regulated system. World-class, low-cost renewable resources won't necessarily translate to lower prices to citizens and small and medium businesses without reforming the regulatory framework.

Figure 3: Wholesale electricity prices[4]

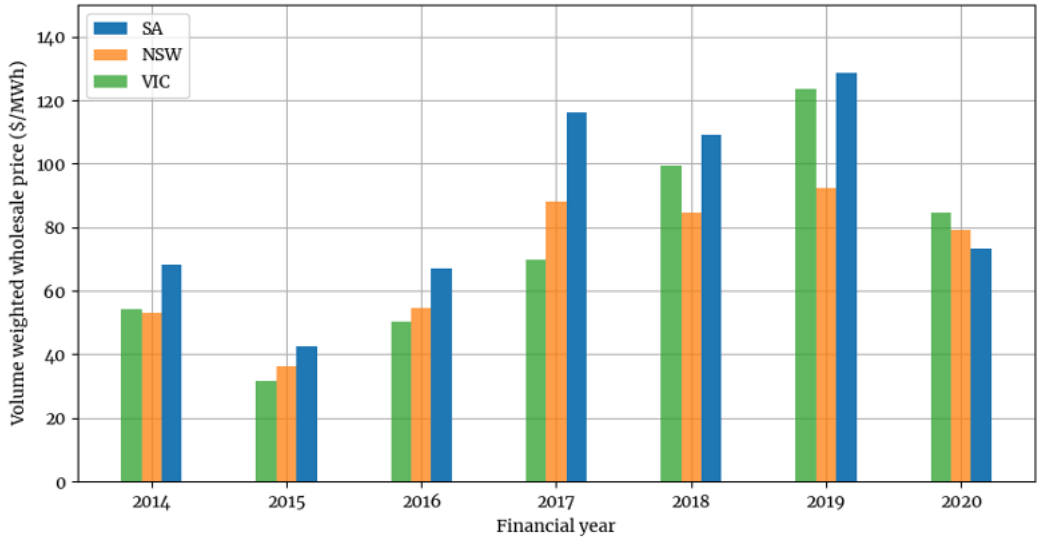
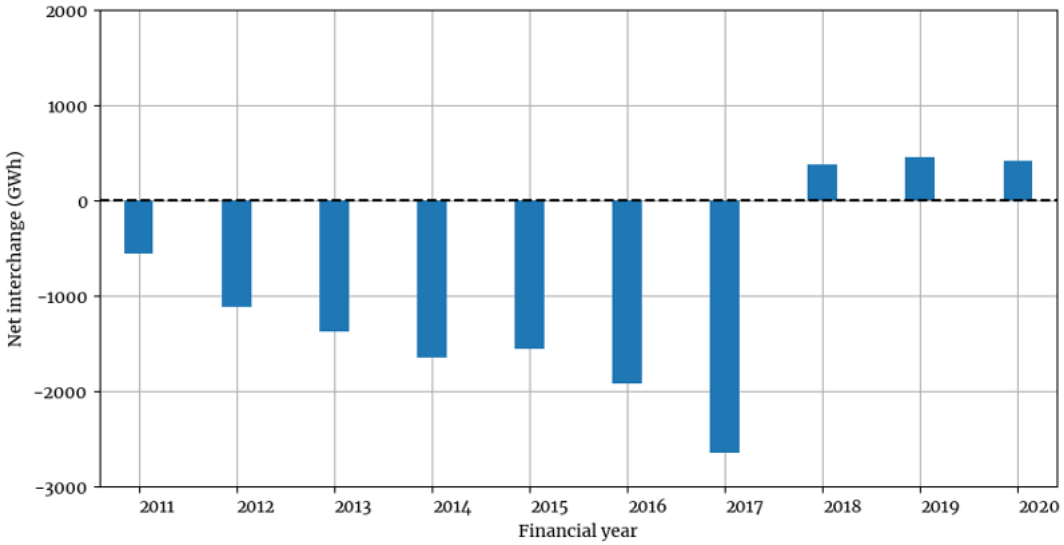


Figure 4: South Australia's Net Interstate Exports



4 Australian Energy Regulator Australian Energy Market Operator Annual volume weighted average spot prices – regions Electricity Spot Prices AER reference 11048184 https://www.aer.gov.au/wholesale-markets/wholesale-statistics/annual-volume-weighted-average-spot-prices-regions.

The transformation of transport

Transport is now the largest and a growing source of South Australian emissions; mostly from road transport (Figure 1).

Adelaide's size and climate support active transport: cycling and walking. The attractions have been enhanced by the pandemic. Investment in improvement of infrastructure for active transport and electrification of rail are useful components of post-pandemic expansion of investment.

Electrification of road transport provides an opportunity to reduce emissions while contributing to a stronger economy and improved standards of living. Technological improvements and falls in manufacturing costs in battery and hydrogen fuel cell electric vehicles (EVs) are driving early transition to the EV.

The special South Australian opportunity comes from the low cost of renewable electricity and the progress that has already been made in policy for, and deployment of, the new technology. Existing policy already places South Australia as one of the leading states in supporting public charging infrastructure. The planned policy under South Australia's EV Action Plan (currently in development) builds on the Government of South Australia's successful uptake of low-emission vehicles to date—the government has the highest level of uptake in Australia of low-emission vehicles in its passenger and light-commercial motor vehicle fleet.

Both hydrogen fuel cell and battery EVs are likely to have roles in future transport. Batteries are moving more quickly in countries in which the transport transition is most advanced. Hydrogen fuel cells may prove an important technology for heavy vehicles and long-haul freight.

The two policy requirements for greatly increased use of battery EVs are availability of charging infrastructure and early adoption of time-of-use electricity pricing. Early provision of charging infrastructure fits neatly into post-pandemic expansionary policies. Electricity pricing reform is more easily introduced early, before patterns of EV use are settled.

The initial capital costs of both battery and hydrogen EVs are still substantially higher than vehicles with internal combustion engines. The electric motor is inherently simpler than internal combustion engines and will become cheaper with larger scale and longer history of production. Capital costs of EVs are falling rapidly and will be at parity by the mid-2020s and continue to fall. The EV lasts longer, has lower maintenance costs, and uses less energy and a cheaper form of energy. Once parity in capital costs is established, there will be rapid movement towards EVs dominating new vehicle sales. Moving earlier than other states (it is too late to go earlier than other countries) will establish another source of South Australia's competitive advantage in the Australian Federation.

Early electrification of transport will, sooner rather than later, substantially lower costs of transport for businesses and households. It will establish opportunities for competitive production of goods and services for a new industry, as it has with renewable energy. It will have large benefits for public health, urban amenity and reductions in carbon emissions. The combination of renewable energy and transport electrification will incidentally solve the energy security problem that has troubled Australians and led to purchasing oil reserves in the US.

Electrification of transport could either reduce or increase the costs of delivering power through the grid to all South Australians. EV charging at peak times for grid usage would force new capital expenditure on the grid and increase charges to all users. EV charging at times of the day when there is surplus capacity in the grid would cause unit costs of grid services to fall by a large amount. Use of storage from EV batteries would increase security and reliability of power supply. Good outcomes require early introduction of time of use pricing to consumers. Experience in the UK shows 75 per cent of EVs are charging for less than 40 per cent of the time they are plugged in and demand can easily be shifted away from peak periods.

The transformation of industry

Emissions from South Australian manufacturing and mining are high and have not fallen since 2009. There are good prospects for these industries to expand greatly and benefit from progressing towards zero net emissions over the next decade.

Figure 1 covers only emissions from the industrial activities themselves— "Scope 1" emissions in the specialist language. Manufacturing and mining are also large sources of "Scope 2" emissions—those embodied in electricity and other inputs.

The four largest miners and metal manufacturers in South Australia are impressive in their commitment to zero net emissions. Electrification of mobile equipment will eventually lead to lower costs as well as healthier working environments. Achievement of the goal will be an important marketing asset, with "green" minerals and metals attracting a premium and avoiding penalties on entry into European and then other markets. Internal European Union (EU) targets and standards will place penalties on trade of materials derived from lower environmental standards as would those in the US should there be a change in President and control of the Senate as a result of the November election. Where the low-emission technologies involve innovation, they warrant public fiscal support.

Use of coal in reducing iron ore to metal accounts for 7 percent of global carbon emissions. South Australia has an opportunity to lead the world in decarbonising steel production. The absence of conveniently located metallurgical coal deposits is a barrier to globally competitive iron metal production in South Australia using the old technologies. In the low carbon world economy, in which hydrogen made from renewable energy reduces ore, the Upper Spencer Gulf can be a globally competitive location for producing iron metal. The unusual confluence of wind, solar and magnetite resources supports low raw material costs. The region has high quality human skills and capacities and education and training facilities for their expansion, and physical infrastructure, for iron and steel production. Innovation to accelerate the emergence of hydrogen-based iron-making is an appropriate focus of post-pandemic public and private investment.

South Australia is a major copper producer and there is a distinctive opportunity to remove carbon from the supply chain. Ammonia from renewables-based hydrogen for explosives and leaching and electrification of mobile equipment can make large contributions to reducing emissions.

The conversion of globally competitive renewable electricity in South Australia into hydrogen and ammonia (for explosives and fertilisers) is a promising large industry for the Eyre Peninsula and Upper Spencer Gulf.

Cement emits about 8 percent of the global carbon emissions[5]. Alternatives involve low-emission cement and cement alternatives which embody renewable stores of carbon, such as glued-laminated timber and cross-laminated timber. The South East of South Australia is well placed as a hub for plantation timber production to provide the renewable resource for this industry.

Fossil energy mining and preparation for sale — now only gas in South Australia—releases carbon dioxide. These "fugitive emissions" account for about an eighth of South Australia's total emissions. Early reduction or offsetting of these emissions is important to producers' social licence and standing with suppliers of capital. Most fugitive emissions are released in the Cooper Basin, where there are opportunities for low-cost geological sequestration of carbon dioxide at many times the rate at which new fugitive emissions are released into the atmosphere. Re-injection of carbon dioxide from current oil and gas production has the co-benefit of enhancing oil recovery. The largest Cooper Basin producer is committed to developing the geological sequestration potential. Innovation support is warranted for early movers in geological sequestration of carbon emissions in Australia.

5 Lehne, J. and Preston, F. (2018) Making Concrete Change. Innovation in Low-carbon Cement and Concrete. Chatham House, The Royal Institute of International Affairs: Cambridge, UK.

Carbon in the land and sea

The potential for low-cost geological sequestration is potentially valuable in capturing emissions from other industries. The location of the Cooper Basin gas fields in the far north-east of the state is a challenge. This locational challenge would be less severe in the South East, where there is a good—albeit smaller—geological structure for carbon storage in the Otway Basin. Capture and storage of emissions from industrial use of the region's rich biomass resources could create a leading example of negative emissions from carbon capture and storage.

South Australia's rich renewable energy resources and their advanced state of development, together with supportive business and government policies, place South Australia in a strong position in zero-emission mining and manufacturing. Success would enhance South Australia's reputation at the forefront of the transition to a low-carbon world economy. This would expand access to markets, capital and talent through a period of industrial expansion.

Managing waste is expensive and a large source of emissions. Sound policy can reduce both costs and emissions. Modern technologies allow conversion of most wastes into energy or valuable materials. South Australia has been ahead of the rest of Australia in waste management, enhancing its reputation for innovation and advanced performance on climate change.

There is as much carbon in plants and two and a half times as much carbon in the top two metres of soil as in the atmosphere. Moderate increases in the amount of carbon in soils and plants accompany a proportionately larger fall in the amount in the atmosphere.

Land use change for modern economic activity has greatly depleted the carbon content of the Australian landscape over the past two centuries. Land use change (LULUCF[6]) now substantially reduces emissions (Figure 1). In South Australia, the Native Vegetation Act 1991 limits native vegetation clearance and promotes native vegetation regeneration. Increases in carbon stored in native vegetation have led to landscape carbon sinks. Changing farming practices are leading to greater storing of carbon in plants and soils. Change in land and farm management can go much further to store carbon and reduce emissions while increasing the value of farm and station production.

Australia has unusually large opportunities to sequester carbon in its land and sea. The disadvantage of low precipitation (slowing the growth of plants) is offset by much larger per capita endowment of land than other developed countries, and larger still compared with most developing countries.

These opportunities are enhanced by the special qualities of many plants adapted to Australia's dry and variable climate, and by Australia's leading position in the applied biological sciences and in farm management and food processing. South Australia as the second least densely populated state has more than its share of opportunity.

In South Australia, trees grow fastest and most densely in the wetter South East. Valuable plantations have been established with government support, much of them to provide employment during the Great Depression. These provide raw materials for important processing industries today. Planting trees in lower productivity areas on farms can enhance farming

6 Land Use, Land Use Change and Forestry

values while adding to carbon stocks and biomass resources for industry[7]. There is an opportunity now to expand the plantation estate to create employment through the post-pandemic recovery.

Managing land to increase carbon in soils can also retain water and enhance productivity. Small increments of carbon stored in plants and soils over large areas add up to absolutely large amounts, so there is great potential in the dry rangelands. Native Australian plants including saltbush and mallee provide exceptional opportunity for adding carbon to the land and soils while some can provide materials for industrial use and some of them feed for farm animals.

South Australia's coasts and sunshine, first of all in the two gulfs, provide opportunities for sequestering carbon in mangrove forests, seagrass and salt marshes. With 1.1 million hectares of existing blue carbon[8], South Australia is focusing on a Blue Carbon Strategy to remove more carbon from the atmosphere. Mangrove forests store carbon for longer than terrestrial forests and revegetation of mangrove forests can provide up to four times the carbon storage of rainforests[9].

The incomplete digestion of feed by sheep and cattle and its emission as methane is the major source of greenhouse gases from Australian including South Australian agriculture (Figure 1). Research over the past decade has established that seaweeds and algae, and also char from pyrolysis of biomass, can reduce methane emissions from cattle and sheep while increasing commercial production. The South Australian native seaweed Asparagopsis yields much more per hectare than any land-based crops. When added to feed for cattle and sheep, it can reduce methane emissions by around 95 per cent—converting methane into dairy products, meat or wool[10]. Biochar application to soils locks carbon into the soil, alongside multiple added benefits such as reduced fertiliser runoff and increased soil fertility.

Management of the landscape is crucial to the transition to zero emissions in another way. In the low carbon world economy, biomass will replace fossil carbon in manufacture of plastics and petro-chemicals and some other industrial uses.

Carbon sequestration in the landscape, and use of biomass with low-cost energy to build new industries, can be large new sources of employment and incomes. The labour intensity of planting trees makes it especially appropriate in the restoration of employment after the pandemic—as it was in the Great Depression in South Australia, other Australian states and the US.

If farmers were able to sell carbon at its true economic value, this would become South Australia's most valuable rural commodity. In a world of open carbon markets, Australia would be a major exporter of carbon credits. The combination of abundant biomass and low-cost energy could see Australia become a major exporter of zero-emission manufacturing. Investment now to build this future would be helpful to post-pandemic growth in jobs and incomes.

7 O'Grady, A. P. and Mitchell, P. J. (2018) Agroforestry: realising the triple bottom line benefits of trees in the landscape. CSIRO. **https://publications.csiro.au/rpr/download?pid=csiro:EP185003&dsid=DS4**.

8 Goyder Institute (2019) New research advances blue carbon opportunities in South Australia. **http://www.goyderinstitute.org/news/2019/new-research-advances-blue-carbon-opportunities-in-south-australia/**.

9 Donato, D. C., Kauffman, J. B., Murdiyarso, D., Kurnianto, S., Stidham, M. and Kanninen, M. (2011) 'Mangroves among the most carbon-rich forests in the tropics', Nature Geoscience, 4(5), pp. 293–297. **https://doi:10.1038/ngeo1123**.

10 CSIRO Future Feed FAQs **https://research.csiro.au/futurefeed/faq/**.

Adapting to the inevitable

The climate change that has already occurred has imposed large costs on South Australians. An average global temperature increase of around 1 degree Celsius has been associated with significant sea level rise; significant fall in rainfall, especially in winter; intensification of storm events; more frequent and severe heatwaves, bushfires and droughts; and damage to human health and infrastructure.

Average temperatures will continue to rise until the world has achieved zero net emissions. An increase of 1.5 degrees Celsius averaged over land and sea will be more than 2 degrees Celsius on land. In the best of circumstances, the warming still to come will be almost as large as that already experienced in South Australia. Comprehensive failure of international cooperation would see much larger temperature increases—over land in South Australia, 4 to 5 degrees Celsius higher on average at the end of this century than in the middle of the last century.

We have to be prepared for the warming that is inevitable even if the most ambitious of the Paris goals are achieved, and for the larger increases in temperature that would come with global failure on emissions reduction.

The starting point for adaptation is good information on what is likely to happen, widely disseminated and understood through the community.

One challenge in informing the public is uncertainty about the success of global mitigation. Will we have to deal with average temperature increases over land of 2, 3, 4 or 5 degrees Celsius - an increment of 1 to 4 degrees Celsius from where we are now?

The most productive approach may be to focus on the most likely of the successful outcomes—2 degrees Celsius for the whole surface of the Earth and more on land—alongside explanation that we are working for better and acknowledging that it may be much worse. We can shift the focus to the worst outcomes if it becomes clear that the global mitigation effort is failing.

Many of the important risks and impacts from inevitable warming are canvassed in South Australia's unpublished work on climate projections for risk assessment and planning.

I would emphasise a few points:

- Warming and drying in other Mediterranean climate—south-west Australia, south-west Africa, the middle latitudes of Chile, central and northern California, and the Mediterranean itself—is disrupting agricultural activity in many regions that compete in global markets with South Australian agriculture. This will tend to raise global prices for products from these places. South Australian agriculture can improve its competitive position if it adapts better than other Mediterranean regions to warming and drying. More efficient water management, including through using low-cost renewable energy for desalination and greenhouse horticulture, are important aspects of adaptation. South Australia has made a start, including with the solar-based desalination and greenhouse in Port Augusta.

- The cost of desalination comprises mainly capital and energy costs. Both costs have fallen dramatically over the past decade; capital costs especially for governments. These can be brought to account in managing water for high-value agriculture.

- Wise planning of the built environment can reduce the damage of a hotter climate for human health and public amenity. Green spaces and building design are important. The City of Adelaide and several councils in the metropolitan area have laid foundations for larger efforts.

- Infrastructure and buildings will have to withstand more extreme weather events. Building codes must reflect this need—recognising that increased capital costs can reduce maintenance and operational costs.

- It will not be possible for firms and households to insure against all of the damaging effects of climate change. The effects of climate change will affect very large numbers of assets all over the world within similar time frames. For example, sea level rise will damage coastal properties in many places at similar times. Insurance companies will not be able to accept these correlated risks. It is government's responsibility to inform the community of risks on the basis of the best available scientific knowledge. Firms and households can take that information into account in their private decisions on where and how to build houses and business assets.

- Good scientific research, including on how climate change will affect particular regions, is the starting point for adaptation policy. Australia is fortunate to be home to much excellent science. This science needs and warrants more government support. Knowledge from research can be embodied in town and infrastructure planning and other regulatory decisions. Governments at all levels will need to establish capacity to manage more frequent and extreme natural disasters. Public education on the knowledge from research allows private firms and households to take climate risks into account in their own decisions. The cost to the community would be too high to compensate private parties who incur great costs because they choose to ignore risks about which they have been warned.

What comes next in policy, in the post-pandemic recovery?

South Australian policy has placed the state in a good position on reducing emissions, expanding output and increasing security and reliability in the electricity sector, and adapting to climate change. Past successful efforts need to be continued, including using government purchasing of goods and services to support innovation in the low-carbon economy; providing support (sometimes alongside Australian Government grants) to encourage innovation; using regulatory powers to guide decisions on investment and consumption; and providing knowledge on the adaptation challenge. The shift within the power sector from the encouragement of zero-emission power generation to storage has produced early fruit and should be continued. The main unfinished business in the energy transition is the slow pace and high cost of grid connection, use and augmentation. Correction will require facilitation of private unregulated investment in transmission.

I suggest focusing on two areas in which the Government of South Australia could play a transformational role. The first is to accelerate the expansion of low-emission manufacturing production for international markets. The second is to promote the growth of plants and algae on the land and in the sea, and increase carbon in soils, to absorb emissions and increase the availability of biomass resources for industrial production.

Both goals require fiscal support for innovation. The South Australia and Australian governments together provided strong fiscal support for innovation to promote the growth of renewable energy and storage. The emphasis can now shift to support for innovation in low-emission industries and the growth of biomass and sequestration of carbon on land

(including soils) and in the sea. The Government of South Australia can encourage increased Australian Government assistance for innovation alongside its own efforts. Prime candidates for fiscal support for innovation in low-emission industries include the use of hydrogen, including for iron and ammonia production (already prominent in Australian and South Australia government articulation of priorities); and geological sequestration of industrial emissions, including the industrial use of biomass to create negative emissions.

Unleashing the immense potential for sequestration of carbon in the land and sea and the growth of biomass for industrial use requires access to markets for carbon. Research, development and commercialisation of low-cost measurement of carbon in the biosphere and soil is crucial. The Australian Government has shown interest in this area and should be encouraged to follow through. Reliable measurement can support a shift to comprehensive carbon accounting, with owners of land (and people with property rights over biomass in parts of the sea) being able to opt in to carbon pricing arrangements, where they accept penalties for reductions in the carbon stock and to receive payments for increases. Reliable measurement is a precondition for the development by the Australian Government's Clean Energy Regulator of methodologies for comprehensive carbon accounting. The development of credible methodologies is a precondition for large-scale entry into voluntary and official carbon markets.

The scale of carbon markets is limited by the absence of official Australian carbon markets or formal links to foreign markets. South Australia's interest as potentially a large-scale exporter of carbon credits and of low-emissions goods warrants exploration of participation in sub-national carbon markets in other countries. The Californian emissions trading scheme, now with Quebec and other Canadian provinces as members, may view positively an application for membership by South Australia, alone or with one or more other Australian states. This would vastly expand the markets available for South Australian carbon farming and low-emission industrial production.

In the meantime, the interest of the large miners and metal manufacturers in net zero emissions production may support the phasing in of requirements to offset Scope 1 emissions, so expanding the market for offsets from carbon farming. This would be more powerful in promoting carbon farming if such policies were adopted nationally, either by the Australian Government or through cooperation between the states and territories; however, a good start could be made by one state alone. In the post-pandemic climate, there is a strong case for government – Australian, state or both together – to support employment creation through major tree planting, as the Government of South Australia and other governments did during the Great Depression.

South Australia, like the rest of the country, needs high levels of investment to increase employment and incomes in the aftermath of the pandemic recession. A high proportion of the economically valuable opportunities are contained in the building of a leading low-carbon economy, as discussed in this paper.