BANKWEST CURTIN ECONOMICS CENTRE

GREEN SHOOTS

Opportunities to grow a sustainable WA economy

Focus on Industry Series, No. 5

November 2020

About the Centre

The Bankwest Curtin Economics Centre is an independent economic and social research organisation located within the Curtin Business School at Curtin University. The Centre was established in 2012 through the generous support of Bankwest, a division of the Commonwealth Bank of Australia. The Centre's core mission to deliver high quality, accessible research that enhances our understanding of key economic and social issues that contribute to the wellbeing of West Australian families, businesses and communities.

The Bankwest Curtin Economics Centre is the first research organisation of its kind in Western Australia, and draws great strength and credibility from its partnership with Bankwest, Curtin University and the Western Australian government. The Centre brings a unique philosophy to research on the major economic issues facing the State.

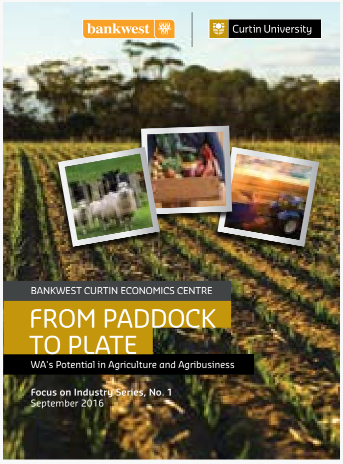
By bringing together experts from the research, policy and business communities at all stages of the process – from framing and conceptualising research questions, through the conduct of research, to the communication and implementation of research findings – we ensure that our research is relevant, fit for purpose, and makes a genuine difference to the lives of Australians, both in Western Australia and nationally.

The Centre is able to capitalise on Curtin University's reputation for excellence in economic modelling, forecasting, public policy research, trade and industrial economics and spatial sciences. Centre researchers have specific expertise in economic forecasting, quantitative modelling, micro-data analysis and economic and social policy evaluation. The Centre also derives great value from its close association with experts from the corporate, business, public and not-for-profit sectors.

"The climate emergency is a race we are losing, but it is a race we can win. The climate crisis is caused by us and the solutions must come from us. We have the tools: technology is on our side."

Antonio Guterres (2019)
UN Secretary-General

BCEC REPORT SERIES



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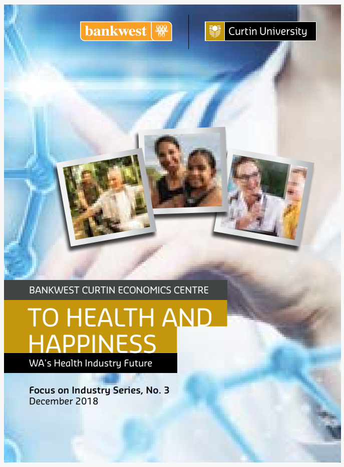

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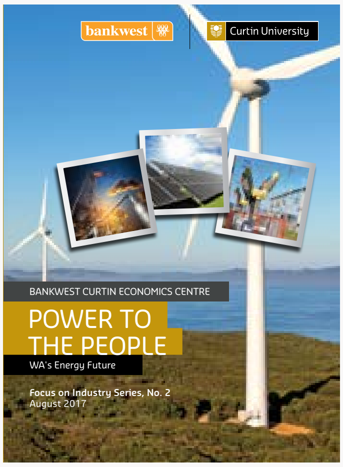

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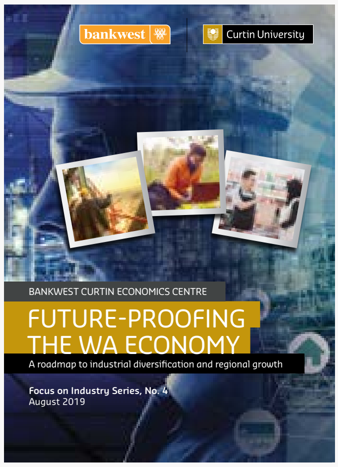

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FOREWORD

The Western Australian economy has developed at an incredible fast pace over the last couple of decades. But the innovation that allowed us to grow, has also contributed to the deterioration of our natural resources and has increased the carbon footprint of our economy. Furthermore, an increasing population and the expansion of industry activity is placing extra pressure on our water, land and waste management systems. As a consequence, there has been significant loss of biodiversity and increasing health risks in our community.

It is important that our economy has the opportunity to thrive, but doing so in a responsible and sustainable way that respects our natural environment has to be our main priority to secure the future for generations to come. Transitioning towards a more sustainable economy will foster growth, create new job opportunities and reduce investment uncertainty.

While our understanding of the factors deteriorating our environmental resources has improved, much is left to explore about the possible paths to achieve sustainable growth – particularly in Western Australia.

Green Shoots the fifth *Focus on Industry* report series informs debates relating to the green economy by taking stock of the current environmental footprint and development of 'green' sectors as well as identifying further opportunities to grow a sustainable and diverse Western Australian economy.

Our report provides evidence-based solutions to make our economy more sustainable, forward-looking and environmentally driven.

Our analysis highlights the enormous role that Western Australia can play in the transition towards a sustainable future. This path should not be seen as a burden but instead, Western Australia should embrace the opportunity to foster growth, create jobs and develop new industries.

Professor Alan Duncan
Director, Bankwest Curtin Economics Centre
Curtin Business School, Curtin University

EXECUTIVE SUMMARY

Western Australia is at a critical juncture in developing its long-term strategy to drive economic and social progress. As the state seeks to chart a course through and beyond the COVID-19 pandemic, the case to balance future economic growth with achievable targets to reduce the state's environmental footprint have never been more compelling.

The challenges brought by climate change have highlighted the significant pressure we put on our resources. The pollution of our air, growing water scarcity and the increasing amount of waste has aggravated the loss of biodiversity and caused growing health concerns in our community.

Our economy can thrive without hindering the development of our biodiversity and natural resources.

This latest *BCEC Focus on Industry* report identifies some of the main challenges in balancing economic prosperity with environmental sustainability, and provides a roadmap for Western Australia to transition to a more sustainable and resilient economic future.

Sustainable industry diversification will deliver Jobs to WA's regions.

Through the creation of a new 'green index' we have identified significant opportunities to factor environmental sustainability more explicitly into WA's regional diversification strategy.

Our index captures both the intensity of environmental impacts across WA's regions and industries and combines this with trade data, building on current industry capabilities to diversify into green sectors that are forward-looking and will give WA a strategic advantage in the future.

Our estimates suggest that diversifying into more sustainable industries would create a pathway to greater economic value and better employment opportunities for the state – especially across WA's regions.

In addition to reducing our environmental footprint, a green diversification strategy could create 55,000 additional jobs, 49,000 of which would be in regional WA. This would also see some $16 billion added to the WA economy.

A renewable energy target will reduce WA's greenhouse gas footprint

First and foremost, our report highlights the critical need to address and take action on global warming by significantly reducing greenhouse gas emissions generated by both industries and households.

While Western Australia has clearly benefited from sustained growth in its resource sector resources, its greenhouse gas emissions have risen significantly growing by 12% in the last five years. This has largely been driven by mining activity, which produces more than half its industry emissions, and continued activity will make it challenging for Australia to meet its Paris Agreement target.

Electricity generation is the biggest single producer of emissions Australia-wide. Renewable energy has the potential to transform this sector to solve the biggest problems our planet now faces – climate change.

WA has the lowest proportion of renewable electricity generation of any state at only 8.9%. In contrast, the ACT has already reached its 100% renewable target and SA increased its renewable generation from 13% to 50% over the last decade, with a target of reaching 100% renewables by 2030.

WA remains one of only two states without a renewable energy target. Introducing a bold but achievable target, backed up by strong policies will drive greater investment in renewable energy in WA and reduce our emissions.

Smarter buildings, more efficient industries and better use of our resources will help ...

Households and businesses can decrease energy use by building smarter, using solar-passive designs, environmentally friendly materials with less embodied energy, better insulation and glazing.

Smart buildings do not need to cost any more to build and our report estimates that simple measures such as double glazing, integrated window shading, and decreasing air leakage can save households $681 per year in energy bills, or around $34,000 over fifty years.

Water security will become one of the biggest challenges for the state

Our report also highlights the increasing threat to water security faced by Western Australia – particularly the South West – with decreasing rainfall and rising temperatures resulting in a decline in streamflow into Perth's dams of more than 80% over the last century.

However, despite the scarcity of our water supplies, WA households continue to use 26% more water than the average Australian household, while industry in WA uses five times as much again as households.

Perth has increasingly had to rely on groundwater and desalination to maintain water security, both of which require more energy to supply. While more recently its second desalination plant has been offset entirely by renewable generation, WA can do more to improve its energy and water sustainability. We can reduce our use, recycle more water for industry and extend our aquifer replenishment program, and we can use more renewable energy along the way.

Waste Management represents an opportunity........and a cost

Waste management remains a significant challenge for Western Australia. Despite significant improvements over the last decade, reducing waste per capita by 37%, WA still ranks second worst in household per capita waste.

We have made great strides recently in reducing construction and demolition waste, but more needs to be done to reduce industry and commercial waste and much higher amounts of waste from regional households.

WA still recycles less than half of its waste and produces more plastic waste than any other state, 96% of which ends up in landfill. We need to do much better on organic waste, metals and toxic waste if we wish to secure a clean and safe environment for future generations.

Ultimately we need to strive to create a circular economy, where all of our resources are stewarded, we get the best value out of our products and services, and nothing is wasted unnecessarily.

Key Findings

State of the environment

Air pollution

Australia's total net emissions decreased by 13% between 1990 and 2018, led by a lower emissions intensity and reduced emissions from agriculture, forestry and fishing.

Emissions from energy grew by 48% during the same period.

Emissions from Australian households have remained relatively stable, going from 7.9 to 7.3 tonnes per household between 2004-05 and 2016-17.

In 2016-17, one in eight megatonnes of emissions were produced by households, and the remaining seven by industry.

Australia's per capita air pollution emissions are the highest in the OECD and sixth highest in the world, only surpassed by Qatar, Kuwait, the United Arab Emirates, Bahrain and Saudi Arabia.

In 2018, the largest sectoral emissions at a national level come from electricity, gas, water and waste services, contributing more than a third of total net emissions.

The sector overtook agriculture, forestry and fishing as the largest contributor to emissions from 1995.

The largest sectoral emissions in WA come from mining, at 40% of the state's emissions in 2018.

The mining sector overtook agriculture, forestry and fishing in 2011, which now ranks third after electricity, gas, water and waste services.

The construction, commercial services, and agriculture, forestry and fishing sectors in WA outperformed their Australian counterparts in emissions reduction between 1990 and 2018.

Emissions from oil and gas extraction in Australia have more than doubled since 2004-05, going from 17 to 39 megatonnes. They now represent the largest share of mining emissions, at 48% in 2016-17.

WA generated 17% of Australian emissions in 2018, against a population share of 10.4%.

WA has been the largest contributor to Australia's rise in emissions from energy and industrial processes, with increases of 150% and 167%, respectively, since 1990.

In 2016-17, households paid 40% of environmentally-related taxes in Australia, through a combination of energy and transport taxes.

In the same year, households produced 12% of total emissions (68 megatonnes) compared to 477 megatonnes from industry.

Land Use

In 2018, the largest source of greenhouse gas emissions in Australia's land use, land-use change and forestry sectors is the conversion of land to grassland, generating 40 megatonnes of emissions. This is five times greater than the next four sectoral sources combined.

Around 99% of the carbon stored in Australian forests is found in native and other types of forests, with the remaining 1% in plantations.

Areas burned in temperate forest due to wildfires were on a noticeable rising trend in WA and Queensland by 2018. Prescribed burning was on a steady decline in both states during the same period.

Fertiliser use has risen steadily in Australia, matching the proliferation of non-irrigated crops, with fertiliser use in WA increasing fourfold between 1990 and 2018.

Australia's flora and fauna face biodiversity pressures from all economic sectors.

Only around 25% of Australia's vegetation cover remains intact, with 62% subject to varying degrees of disturbance and modification and 13% completely converted to other land uses.

Australia's built-up area per capita is 33% higher than the OECD average.

The share of protected land area in Australia went from 1.1% in 1970 to 19.2% in 2020; protected marine areas went from 0% to 41% in the same period, driven by changes in the last decade.

Severe climate-driven mass coral bleaching events have affected around 80% of the coral reef area of the Great Barrier Reef.

In 2015, almost one third of known mammal species in Australia were critically endangered, endangered or vulnerable, along with 17% of bird species and 7% of plant species.

Water

Since the 1970s, there has been a 17% decline in average rainfall in the South West.

Between 1920 and 1980 an average of 400gL of streamflow ran into Perth dams, almost 6 times more than in the last decade.

Half of the rivers in the state have marginal, brackish or saline quality.

In Australia, 18% of sites were brackish or saline while almost three quarters of sites in WA reached similar conditions.

During 2018-19, between 60% to 80% of WA groundwater by area was below the average level.

Water consumption in Australia grew by 29% between 2008-09 and 2016-17, and in WA by 6% over the same period.

Total water use per capita declined by 7% in WA over the last ten years.

WA's industries use 476kL of water per capita, compared to 536kL per capita nationally Australia.

Household water use in WA reached 91kL per person in 2016-17, 26% more than the national average.

The mining sector in WA uses 252kL of water per capita each year - almost six times the Australian average.

The manufacturing industry in WA has a higher per capita use of water (29kL) than the average for Australia (21kL).

WA farmers use 83% less distributed water than Australian farmers, and 50% less self-extracted water.

While one in four agricultural businesses irrigate in Australia, just under one in six irrigates in WA.

The average holding of agricultural land per business in WA is close to 10,000 hectares, more than twice as much the average land size of Australians farms.

Prices of agricultural land in WA have increased by 28% in 2019 alone, almost 15 percentage points more than the Australian average.

In places with reliable rainfall such as the South Coast close to Esperance, land prices have risen by almost 60%.

WA's South West and Wheatbelt regions will be among the top 10% places on earth where rainfall decline will be the most severe.

1 BOM collects information on river salinity by surveying multiple streamflow and rivers sites.

WA industry uses the least amount of distributed water than any other state (162kL per capita).

In WA, households paid on average $2.9 per kilolitre while industry only pays $0.7.

Waste
WA is the state with the lowest per capita waste in Australia.

In 2017, WA produced 2 tonnes of waste per capita, a reduction of 37% since 2010.

In WA, 27% of waste comes from Construction and Demolition, 46% from Commercial and Industry and 27% from Municipal Solid Waste.

Construction and Demolition waste in WA is the lowest share among all states.

Forty six per cent of waste in Western Australia comes from Industry.

South Australians produce almost half the household waste of West Australians.

Regional areas produce more than three times the amount of waste than metropolitan areas across Western Australia.

Construction, Electricity, gas, water and waste services and Manufacturing account for 83% of waste in Australia.

The construction sector produces more than two million tonnes of hazardous waste each year - more than any other industry.

Masonry materials and organics make up over half of all waste products.

WA generates more than 700kt of mining waste, 3.5 times more than the second largest producer, QLD.

Annually, WA produces 132kg of plastic waste per capita, more than any other state in Australia.

Overall, Australia could recycle more than half (52%) of its plastic waste.

Thirty eight per cent of Australian plastic waste is composed of non-recyclable types of plastic.

In proportion, WA generates the largest quantity of food organic waste than any other state by far (45%).

WA produced 190kt of timber waste in 2016-17, the lowest of all states.

Australia produced 465kt of e-waste in 2016-17, of which 67% comes from metals, 25% from plastics and 8% from glass.

Households contribute to more than 80% of e-waste while all other industries generate less than 5%.

Societal attitudes towards environmental protection

Perceptions of environmental issues
Ninety per cent of females and 74% of males surveyed in 2020 think of bushfires as a very serious issue facing Australia.

There are vivid gender differences in environmental views with females more likely to perceive various environmental issues as very serious.

The share of individuals who perceive various environmental issues as 'very serious' is considerably higher among those who have directly experienced severe consequences from 2019/2020 bushfires.

2 Trnka, M., Feng, S., Semenov, M. A., Olesen, J. E., Kersebaum, K. C., Rötter, R. P., & Hlavinka, P. (2019). Mitigation efforts will not fully alleviate the increase in water scarcity occurrence probability in wheat-producing areas. Science Advances, 5(9), eaau2406.

Sixty-four percent of Australians with direct experience of 2019/2020 bushfire consequences think of global warming or greenhouse effect as a serious issue; compared to 50% among those lacking direct experience.

With higher educational attainment there is a higher appreciation among individuals of the threat posed by global warming to their lives.

Among individuals surveyed in 2020, 41% of those who held at least a bachelor degree and only 33% of those with an educational attainment of secondary or below thought that global warming was a very serious threat to their lives.

Perceptions of the threat posed by global warming have changed significantly over time with the share of those who see it as a serious threat significantly higher now compared to 12 years ago.

Environmental activism

Pro-environmental action, captured through boycotting and buying certain products out of environmental considerations, appears to increase with educational attainment, especially among females.

Based on the latest data from the World Values Surveys, 1.4% of Japanese, 11.6% of Germans, 15.7% of Australians, 18.1% of New Zealanders and 19.7% of Americans said they held membership in environmental organisations.

There is evidence to suggest that those who opt for membership in environmental organisations are significantly more likely to be active in that role now compared to 13 years ago.

The share of individuals who report a great deal or quite a lot of confidence in environmental organisations is 53.8% in Japan, 55% in the US, 59.6% in Australia, 63.5% in New Zealand and 67.8% in Germany.

The degree of confidence in environmental organisations is instrumental in the take-up of membership in such organisations in Australia.

Based on the latest data from the World Values Surveys, 50.7% of Japanese, 53.3% of Americans, 66.5% of Germans, 67.3% of Australians and 70.5% of New Zealanders have the view that protecting the environment should be given priority even if it causes slower growth and some job losses.

Around 81% of tertiary-educated females and just over the half of females with secondary or lower educational attainment in Australia express the view that protecting the environment should be given priority, even if it causes slower economic growth and some loss of jobs.

Nearly 38% of low income-earners in Australia believe that economic growth and creating jobs should be the top priority, even if the environment suffers to some extent; 27% of high income-earners share this view – a difference of 11% percentage points.

Support for government policies for environmental protection
Over 51% of Australian men aged 65 or above believe that the government should allow the opening of new coal mines; only around 24% of males aged 18-29 share this belief.

Among individuals who see global warming as a very/fairly serious threat to their lives, nearly 80% say Australia is doing too little to protect the world environment; however only 28% of those who don't see much threat associated with global warming say Australia is doing too little.

Among individuals who trust in government only 7.5% express preference for less government spending on the environment; in contrast over 16% of individuals who distrust the government express the same preference.

The vast majority of Australians think that it should be the government's responsibility to impose laws to reduce industry damage to the environment.

There are significant generational differences in preferences over government spending on the environment with preference of more government spending increasing with decrease in age.

As of 2019, 48.5% of generation Y Australians said environment or global warming was a top two important issue in their voting decisions; this compares to 26% among builders and 24% among boomers.

In 2019, 57% of females but only 43% of males reported that environment was extremely important in their voting decision – a difference of 14% percentage points.

Sixteen percent of females and 28% of males surveyed in 2019 said global warming was not very important when deciding to vote.

State of play of green economic sectors

Renewable Energy
Electricity generation sourced from renewables in WA is the lowest among all states, but has increased from 2.9% in 2008-09 to 8.9% in 2018-19.

Western Australia remains one of only two states without a renewable energy target, the other state being New South Wales.

Green Buildings
Western Australia ranks fifth in terms of energy efficiency of new homes and apartments built between May 2016 and July 2020.

Eighty one per cent of new WA residential buildings have the poorest performing window insulation installed compared to 51% nationally.

A passive building design including installing double glazing, internal integrated window shading devices, and decreasing air leakage will save WA households $681 per year in energy bills over a 50 years horizon.

Sustainable Transport
In 2019, Western Australia had the third highest ownership of electric cars per 10,000 people, at around 5 per 10,000 people.

In Western Australia, the CO_2 emissions from driving 100,000km in an electric car were around 22 times worse compared to that of Tasmania, at 10.8 tonnes of CO_2 emissions due to the type of electricity sourced.

Driving a more fuel-efficient petrol car (5L per 100km) in Queensland, New South Wales, and Victoria would currently generate less CO_2 emissions compared to driving an electric car because of the electricity generation.

In 2019, nearly 40% of new non-electric cars purchased in Australia produced, on average, more than 20 tonnes of CO_2 emissions per 100,000km.

In terms of passenger train usage per capita, Western Australia ranked third in 2017-18, at 22.4 metropolitan rail passenger journeys per capita.

Between 2010-11 and 2018-19, Western Australia had the largest increase in CO_2 emissions from petrol and diesel oil sales, increasing from 17,779 to 22,118 million tonnes.

Waste management
WA sends 37% of its waste to landfill.

WA recycles 46% of its waste, only QLD fares worst, with a recycling rate of 42%.

Landfill disposal in WA has decreased by a one tonne per capita in the ten years to 2017.

Ninety six per cent of WA's plastic waste is disposed of in landfill, 10 percentage points higher than the Australian average.

WA has the lowest recycling rate of plastic waste (4%) of all states, and has not improved since 2006-07.

The recycle rate of masonry materials has increased by more than 50 percentage points since 2006-07.

The construction sector recycled 42% of its waste in 2014-15, but with the waste levy in place in 2016-17 more than 76% of materials were recycled.

WA recycles only 34% of organic waste, the lowest of any state.

WA sends more than 28% of its waste from garbage bins to an alternative waste technology plant, the highest in the country.

The Perth and Peel regions recover 42% of the waste compared to 29% in regional areas.

The export of metal waste is the largest export of recycled waste in Australia, with 2,141kt exported in 2017.

In Australia, 70% of recycled plastics waste has been shipped overseas in 2017.

The state recovers 184kt of energy, close to that of SA (149kt).

Water Management
In Perth, in 2019, dams were only 41% full, the lowest levels in all the country and this for four years in a row.

In 2016, the water storage in the city fell to only 20% of its full capacity.

In 2018-19, 42% of WA's water was sourced from groundwater, the largest share of any state by far.

Overall, 86% of groundwater licenses were allocated to support industry and only 9% to ensure household supply.

In 2018-19, only 30% of WA water was sourced from surface water, compared with 88% for NSW, 85% for VIC and over 99% for Tasmania.

In drought years such as 2016-17, no water was sourced from surface water, instead groundwater and desalinated water each provided almost half of the city's water.

WA recycled around 15,000 litres per person in 2017-18 and is the state with the second largest quantity of recycled water in Australia.

By 2060, the groundwater replenishment scheme aims to provide around 115gL of water, enough to supply 500,000 households.

Direct water reuse opportunities include industry consumption, public and horticultural irrigation and water to the tap.

In 2014-15, each person in WA consumed on average 3,000 litres less of water from rainwater tanks relative to the 2000-01 levels (8,000 litres per capita).

WA has the cheapest household expenditure per unit price of rainwater tanks (2.4 per kL).

In 2018-19, Perth had less than 1 complaint of sewage problems per 1,000 properties, the lowest of all states.

A fourth of WA's water is lost in the pipes and never delivered. This percentage is higher than in any other state.

Wa's opportunities for a sustainable future

A green diversification strategy could create 55,000 additional jobs, 49,000 of which would be in regional WA, and increase WA's economic output by some $16 billion.

Many of the new growth opportunities from sustainable diversification occur in higher GVA industry sectors.

Product and process innovation plays a critical role in delivering environmentally sustainable economic growth.

Western Australia has an abundance of natural resources from which to produce and export energy storage technologies to meet high global demand.

INTRODUCTION

Over the last century leaps in technological advancements have enabled a rapid expansion of human population and living standards. Many individuals in Australia are more mobile and empowered than our great grandparents could have imagined possible – but it has come at a cost. Our way of life has been driven by industrial processes that enable us to more easily transform energy and resources into goods and services. Many of those resources, such as minerals, are non-renewable. They are finite, and hence our consumption of them now limits or exhausts the opportunities for future generations.

Climate change has evidenced the significant pressure that is placed on resources and the devastating consequences can be seen all around the world and here in Australia. Increasing temperatures and declining rainfall together with the increasing likelihood of bushfires have now become a common part of the Australian landscape. However, climate change is not the only environmental problem that needs to be handled. The management of land and water resources is key to ensure a sustainable future for generations to come as well as the preservation of flora and fauna.

In recognition of the integral importance of our environment, a key feature of the Sustainable Development Goals (SDG) set by the United Nations seeks in 2015 is to thwart environmental degradation and climate change by creating a roadmap to address key areas where immediate action is needed.

The Western Australian economy relies heavily on the mining sector, which in turn is driven by mineral extraction. The nature of these productive sectors as well as the way we, as households, consume, represent a significant challenge to make the economy more sustainable and honour the commitment to the SDG's. Indeed, industrial processes of production and consumption demand a significant amount of energy and are often wasteful. Increasingly complex materials have allowed leaps in product innovation but have also generated a rise in the production of inorganic materials that are harder to dispose of. The energy powering industry produces gasses which gradually accumulate in the atmosphere, slowly influencing the interaction of the planet with heat radiating from the sun, and ultimately transforming the climate in unanticipated and disastrous ways.

However, this is not just a story of doom and gloom. Recent decades have seen incredible innovation in the face of these challenges. Part of that innovation has been and will continue to be technical and scientific – better understanding of industrial materials and processes that enable more efficient and sustainable products and services. Further motivation will be come from focussing on the opportunities that Western Australia's other natural resources – solar, wind and thermal power – afford us. And additional opportunities will be uncovered by understanding what's possible with the current natural and human asset and skills base that exist in WA.

That's where this report comes in – our intention is to help map the transition to a greener, more resilient and inclusive economy that can foster sustainable growth, create new job opportunities and reduce investment uncertainty.

We do this by first taking stock of the current environmental footprint in Western Australia and examine how attitudes to sustainable and environmentally friendly practices have changed over time and differ across generations. We then trace the development and contribution of key existing and emerging 'green' sectors within the WA economy – from renewable energy to green buildings, sustainable transport, water and waste management and recycling. Finally, we examine the opportunities for WA to grow and diversify sustainable industries and transition to a circular economy, given our current capabilities, resources, regional opportunities and industry configuration.

"**WA GREENHOUSE GAS EMISSIONS** HAVE INCREASED BY 12% IN THE LAST FIVE YEARS."

STATE OF THE ENVIRONMENT

INTRODUCTION

Australia's luck as a country derives in no small part from its natural wealth. As the sixth largest country, with close to 7.7 million square kilometres, it accounts for 5% of the world's land area. The country's oceans and seas are even larger: its Exclusive Economic Zone (EEZ) is made up of 8.2 million square kilometres, surpassing 10 million when the Australian Antarctic Territory is included.[1] The Australian landmass is inhabited by more than half a million species of animals and plants,[2] and its marine territory contains one of the most diverse arrays of organisms, with 50,000 species catalogued and to-be-catalogued, and as many as half a million yet to be discovered.[3] This advantageous condition extends to the economy. In 2020, Australia is the 13th richest country on the planet, and Australians rank 10th in the world for Gross Domestic Product (GDP) per capita.[4]

Western Australia (WA) shares a large part of this wealth. As the country's largest state or territory, it represents 32.9% of Australia's total land area and 28.2% of its marine area.[5] WA is home to almost three quarters of Australia's mammal species, 25 of which are unique to the state; more than 400 reptile species, with four in ten unique to the state; 1,600 fish species; and hundreds of thousands of invertebrate species. Home to some of the most diverse and unique flora in the world, up to 80% of plant species are unique to the state.[6]

This has a long history, as plants and animals in south-west WA, a biodiversity hotspot, belong to older, deeper branches of the evolutionary tree.[7] Additionally –and perhaps its most well-known, yet non-renewable natural endowment– WA is home to rich mineral and petroleum resources, accounting for a large share of the state's economy.

When one is in possession of such wealth, there are enormous opportunities –but also much to lose.

In recognition of this risk, Australia, along with 192 other countries, adopted in 2015 the Sustainable Development Goals (SDGs); 17 strategies to build economic growth while tackling climate change by 2030, aiming to set the world on a path of prosperity and opportunity for present and future generations.

1 Geoscience Australia. "Dimensions". https://www.ga.gov.au/scientific-topics/national-location-information/dimensions.

2 Morton, S., Sheppard, A. & Lonsdale, M. (eds). (2014). *Biodiversity: Science and Solutions for Australia*, Victoria: CSIRO Publishing, p. 41.

3 Evans K., Bax, NJ. & Smith, D.C. (2016). "Marine environment: State and trends of marine biodiversity: Species Groups". In: *Australia State of the Environment 2016*, Canberra: Australian Government Department of the Environment and Energy. https://soe.environment.gov.au/theme/marine-environment/topic/2016/state-and-trends-marine-biodiversity-species-groups.

4 International Monetary Fund. (2020). "World Economic Outlook". October. https://www.imf.org/external/datamapper/datasets/WEO.

5 Geoscience Australia. "Dimensions". https://www.ga.gov.au/scientific-topics/national-location-information/dimensions.

6 Government of Western Australia. Department of Biodiversity, Conservation and Attractions. "Plants and animals". https://www.dpaw.wa.gov.au/plants-and-animals.

7 Morton, S., Sheppard, A. & Lonsdale, M. (eds). (2014). *Biodiversity: Science and Solutions for Australia*, Victoria: CSIRO Publishing, p. 13.

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At the end of 2020, challenges in the pursuit of these goals have multiplied, but their achievement may have been pushed back decades by the multidimensional crisis brought on by COVID-19. However, just a third of the way into the 15-year plan, the world was already off track to achieve the goals and its targets by the 2030 deadline. As the United Nations Department of Economic and Social Affairs highlights, climate change has been occurring faster than anticipated, with rising global temperatures causing climate disasters, such as the 2019-2020 Australian bushfire crisis; droughts; hurricanes and floods across the globe.[8]

The issue has a marked human component: that of unsustainable production and consumption patterns leading to rising temperatures, the deterioration of terrestrial and marine areas, and the increasing threat of species extinction.[9] This is especially relevant for Australia. When compared to 15 countries with a similar GDP per capita, the country has been found to perform poorly in environmental quality, due to its level of greenhouse gas emissions and biome protection.[10] Similar to their high GDP per capita, Australians rank 6th in the world for their greenhouse gas emissions per capita, only surpassed by Qatar, Kuwait, the United Arab Emirates, Bahrain and Saudi Arabia.[11]

In response to these challenges, swift, comprehensive action is needed, since the cost of inaction extends beyond environmental considerations and into every aspect of the economy, the financial system and people's well-being.

SUSTAINABLE DEVELOPMENT GOALS

1. No poverty.
2. Zero hunger.
3. Good health and well-being.
4. Quality education.
5. Gender equality.
6. Clean water and sanitation.
7. Affordable and clean energy.
8. Decent work and economic growth.
9. Industry, innovation, and infrastructure.
10. Reduced inequalities.
11. Sustainable cities and communities.
12. Responsible consumption and production.
13. Climate action.
14. Life below water.
15. Life on land.
16. Peace, justice and strong institutions.
17. Partnerships.

Source: https://www.un.org/

8 United Nations Department of Economic and Social Affairs (2020), "Policy Brief #81: Impact of COVID-19 on SDG progress: a statistical perspective," 27 August, https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-81-impact-of-covid-19-on-sdg-progress-a-statistical-perspective.

9 United Nations Department of Economic and Social Affairs (2020), "Policy Brief #81: Impact of COVID-19 on SDG progress: a statistical perspective," 27 August, https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-81-impact-of-covid-19-on-sdg-progress-a-statistical-perspective/.

10 Social Progress Imperative. (2020). "Social Progress Index 2020 - Australia". https://www.socialprogress.org/?tab=2&code=AUS.

11 OECD. (2020). "Air and GHG emissions (indicator)". October. https://www.oecd-ilibrary.org/environment/air-and-ghg-emissions/indicator/english_93d10cf7-en.

As the Productivity Commission has assessed, the expenditure required on mitigation is lower and has the potential to reduce very high levels of expenditure on recovery and rebuilding; preparedness thus reduces the costs and the economic repercussions that come with natural disasters and external shocks.[12]

The costs of environmental inaction to the economy and the financial system, and the pressing need for risk reduction, are increasingly echoed by institutions like the International Monetary Fund, the United States Commodity Futures Trading Commission (CFTC) and the Australian Prudential Regulation Authority (APRA). Based on the protection gap experienced in the 2019-2020 Australian bushfires, floods and hailstorms, with economic damage far exceeding insured losses, APRA predicts that responding to future disasters is likely to be 11 times costlier than preventing them.[13] Impacts from rising global average temperatures are already being felt on all areas of the economy, the CFTC warns, adding that unless regulators move to measure, understand and address these challenges, they will increasingly have a negative ripple effect on productivity, employment, incomes and opportunity.[14] Regulation is a key part of the equation: along with physical risks, transition risks can occur when business models are not adapted to the economics of a world with low-carbon emissions, as can be the case with fossil fuel industries, or when the shift is poorly planned or left to the last minute, when inaction is no longer an option.[15]

The international business community has also expressed the urgent need for climate change mitigation. In its 2020 communiqué to G20 leaders, the B20 –or Business 20, the business engagement arm of the G20, of which Australia as one of the world's largest economies is a member country– called for governments to accelerate the pace of science-based, corrective action to substantially reduce carbon emissions; improve the circularity of materials; clean up air, land and water pollution; and preserve the oceans.[16] These areas are aligned with the G20 2020 priority of safeguarding the planet by fostering collective efforts to protect the global commons, following in the steps of Australia's 2014 G20 presidency, which pursued sustainable development as one of three priorities in the agenda.

Lastly, the October 2020 election results in the Australian Capital Territory –which, along with much of the Australian east coast, welcomed 2020 covered by thick bushfire smoke– demonstrate that Australians know that what is at stake goes well beyond the business case for the mitigation of climate change, increasing their preference for environmentally-minded platforms.

As with the COVID-19 response, there is an opportunity for Australia and for WA to leverage their privileged position and become international leaders in the path to overcome current environmental challenges, planting new seeds towards a sustainable, more resilient future.

12 Productivity Commission. (2012). "Barriers to Effective Climate Change Adaptation". Productivity Commission Inquiry Report no. 59. 19 September. pp. 256, 104.

13 Australian Prudential Regulation Authority. (2020). "Executive Board Member Geoff Summerhayes - Speech to Australian Business Roundtable for Disaster Resilience and Safer Communities webinar". 14 October. https://www.apra.gov.au/news-and-publications/executive-board-member-geoff-summerhayes-speech-to-australian-business.

14 Climate-Related Market Risk Subcommittee. (2020). "Managing Climate Risk in the U.S. Financial System". Washington, D.C.: U.S. Commodity Futures Trading Commission, Market Risk Advisory Committee. https://www.cftc.gov/sites/default/files/2020-09/9-9-20%20Report%20of%20the%20Subcommittee%20on%20Climate-Related%20Market%20Risk%20-%20Managing%20Climate%20Risk%20in%20the%20U.S.%20Financial%20System%20for%20posting.pdf.

15 Grippa, P., Schmittmann, J. & Suntheim, F. (2019). "Climate change and financial risk: central banks and financial regulators are starting to factor in climate change". *Finance & Development*. Washington: International Monetary Fund. December.

16 B20. (2020). "B20 Policy Recommendations to the G20. Realizing Opportunities of the 21st Century for All. Transforming for Inclusive Growth". September https://www.b20saudiarabia.org.sa/wp-content/uploads/2020/09/Policy-recomendations-to-the-G20_IMG_update_Chair_compressed-min.pdf.

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AIR POLLUTION

Air pollution has a significant negative impact on the health of both the people and the planet. Exposure to ambient particulate matter –most of which comes from mobile or stationary fuel combustion– can cause respiratory and cardiovascular disease, putting pressure on health systems and leading to premature mortality. The World Health Organisation estimates that, in 2016, air pollution was the cause of one in nine deaths worldwide.[17] Importantly, respiratory and cardiovascular diseases can compound the health risks and severity from viruses like COVID-19.[18]

While ambient particulate matter is the form of air pollution humans are exposed to 'on the ground' in their daily life, greenhouse gases are the air pollution affecting the planet's atmosphere. The term typically refers to seven gases with direct effects on global warming and climate change: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). Greenhouse gases result from human activities, such as fuel combustion, industrial processes, farming –particularly livestock– and land clearing, since fewer trees lead to less CO_2 captured from the atmosphere. Although, on a base level, greenhouse gases make the Earth liveable by reflecting some of the sun's warmth into space, the United Nations notes, human activity, industrialisation and large-scale agriculture have led to an accumulation of greenhouse gases in the atmosphere not seen in three million years, with irreversible changes on our climate.[19]

Worldwide, greenhouse gas emissions continue to grow, and in the case of OECD countries like Australia, a particular rise has taken place since 2018, after a period of stability, driven by fossil energy use.[20]

This, despite international legal obligations to combat climate change and curb emissions, such as the United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Paris Agreement; clearly established targets in the Sustainable Development Goals; and G20 commitments to phase out fossil fuel subsidies. All these are initiatives to which Australia has subscribed.

17 World Health Organisation. (2020). "Ambient air pollution". https://www.who.int/gho/phe/outdoor_air_pollution/en/.

18 Centers for Disease Control and Prevention. (2020). "Coronavirus disease. People with certain medical conditions". October. https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-with-medical-conditions.html.

19 United Nations. "Climate change". https://www.un.org/en/sections/issues-depth/climate-change/.

20 OECD. (2020). "Environment at a glance 2020". Paris: OECD Publishing.

Australia's total net emissions decreased by 13% between 1990 and 2018, led by a lower emissions intensity and reduced emissions from agriculture, forestry and fishing. Emissions from energy, however, grew by 48% during the same period.

Greenhouse gas emissions in Australia

Consistent with overall OECD trends, Australia's total net emissions decreased by 13% in the last three decades, going from 618 megatonnes of CO_2-equivalent emissions in 1990 to 537 megatonnes in 2018. The trend has fluctuated, however, reaching its lowest point of the period in 1995, at 498 megatonnes; peaking again in 2007, at 635 megatonnes; decreasing through 2016, and going back to an upward trend in 2017 (Figure 1).

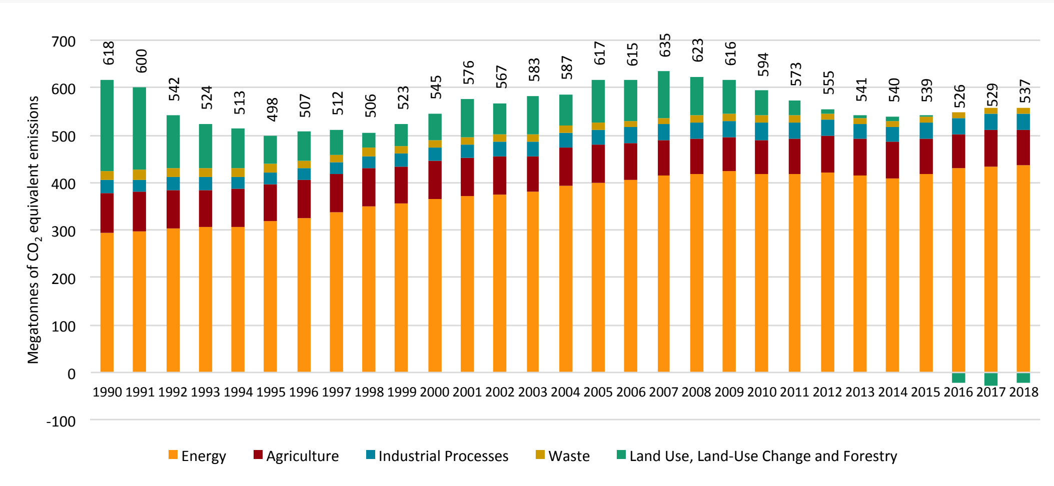
This long-term trend puts Australia's 2030 emissions reduction target into perspective. The target, which aims to reduce emissions by 26% to 28% on 2005 levels, looks admittedly less ambitious when compared to the possibility of having 1995 as its base year. In fact, 2005 is amongst the five years with highest emissions between 1990 and 2018.

These decades also saw a change in the make-up of emissions by category. Emissions from energy continued to increase throughout the period, except for the years of 2010, 2013 and 2014; the latter two a result of Australia's short-lived carbon pricing mechanism. Overall, energy emissions went from 294 megatonnes in 1990 to 436 megatonnes in 2018; a 48% increase.

Looking deeper into energy subcategories, 87% of energy emissions in 2018 came from fuel combustion; from these, almost two thirds corresponded to energy industries, and almost a quarter to transport. The remaining 13% corresponded to fugitive emissions released during the extraction, processing and delivery of fossil fuels, with slightly more than half coming from oil and natural gas and other emissions from energy production, and the rest from solid fuels.

FIGURE 1

Greenhouse gas emissions, Australia, 1990 to 2018



Note: Energy comprises stationary energy (energy industries - electricity generation and other energy industries; manufacturing and construction; and other sectors), transport and fugitive fuels.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on DISER 2020, State and Territory Greenhouse Gas Inventories: 2018.

The Australian Government has projected a substantial increase of fugitive emissions in the near term due to the high-flaring activity in the initial years of new Liquefied Natural Gas (LNG) developments, such as the Gorgon project in WA.[21]

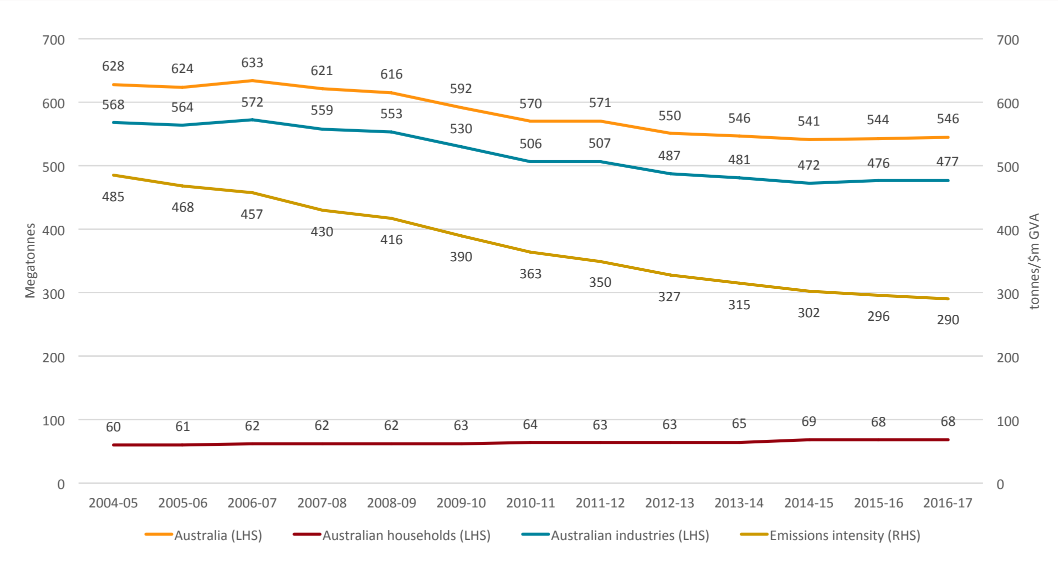
The reduction in total net emissions despite the growth in those from energy was led by a lower emissions intensity and lower emissions from agriculture, forestry and fishing; the latter, driven in the last decade by the decline in log harvesting activity in Australia's native forests.[22]

Emissions intensity, or the amount of emissions generated per million dollars of Gross Value Added, decreased from 485 tonnes/$m GVA in 2004-2005 to 290 tonnes/$m GVA in 2016-17, reflecting a 40% reduction.

Total emissions from households, based on the consumption by Australian households divided by the number of households, have remained relatively stable, with a slight increase of 13% from 2004-05 to 2016-17, going from 60 to 68 megatonnes per year and showing a small downward trend since 2014-15. Emissions from Australian industries have shown an opposite trend, decreasing by 18% from 2004-05 to 2014-05, and ticking upward in 2015-16 and 2016-17 (Figure 2).

FIGURE 2

Greenhouse gas emissions trends, Australia, 2004-05 to 2016-17



Note: In this ABS release, energy calculations for Australia are based on total net energy use in Australia plus exports.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4655, July 2019, Table 1.1.

21 Australian Government Department of the Environment and Energy. (2019). "Australia's emissions projections 2019". December. pp. 26-27.

22 Australian Government Department of the Environment and Energy. (2019). "Australia's emissions projections 2019". December. pp. 26-27.

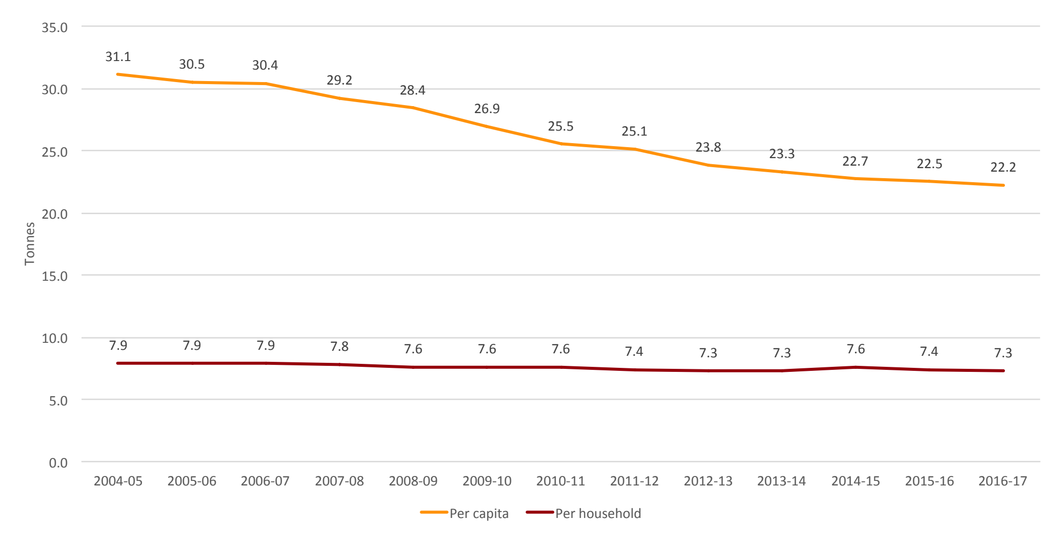
Emissions from Australian households have remained relatively stable, going from 7.9 to 7.3 tonnes per household between 2004-05 and 2016-17. In 2016-17, one in eight megatonnes of emissions were produced by households, and the remaining seven by industry.

The increase in total emissions from Australian households is the result itself of an increase in the number of households, which the Australian Bureau of Statistics (ABS) estimates went from nearly 7.6 million in 2004-2005 to 9.4 in 2016-17, or a 24% increase. Annual emissions per household in fact decreased during the period, going from 7.9 tonnes in 2004-05 to 7.3 tonnes in 2016-17, an 8% reduction (Figure 3).

Emissions per capita, however, are more than three times the emissions per household, landing at 22.2 tonnes per year in 2016-17. This is due to the inclusion of Australian energy exports in the calculation. According to the OECD, Australia is the world's second largest coal net exporter by volume, exporting more than three quarters of the country's coal output, as well as large volumes of natural gas. In total, around 80% of the country's energy production is exported.[23]

FIGURE 3

Greenhouse gas emissions per capita and per household, Australia, 2004-05 to 2016-17



Note: In this ABS release, energy calculations for Australia are based on total net energy use in Australia plus exports.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4655, July 2019, Table 1.1.

23 OECD. (2020). "Fossil fuel support country note - Australia". June. http://stats.oecd.org/wbos/fileview2.aspx?IDFile=3a9e9066-f0cd-4f49-97ff-534cf2c16cf.

Hence, Australian emissions per capita are the highest of any OECD country. Australia's per capita emissions started to diverge from the OECD average since the early 1970s, when annual tonnes per capita were at 10.9 for Australia and 10.4 for the OECD. In 2017, however, Australia's figures are almost twice the OECD average.[24] When energy is considered, or if offsets from land use, land-use change and forestry are excluded, the gap with the OECD further increases.

In 2016-17, one in eight megatonnes of emissions were produced by households, and the remaining seven by industry. This reveals that, although reducing the emissions generated by households and individuals is desirable, the most efficient and effective path to mitigation is through cleaner energy generation and industrial processes, and an increased emphasis on nature conservation as a way to offset existing emissions. Comprehensive policy design must address both consumption and production patterns detrimental to the environment, wellbeing, and long-term economic resilience.

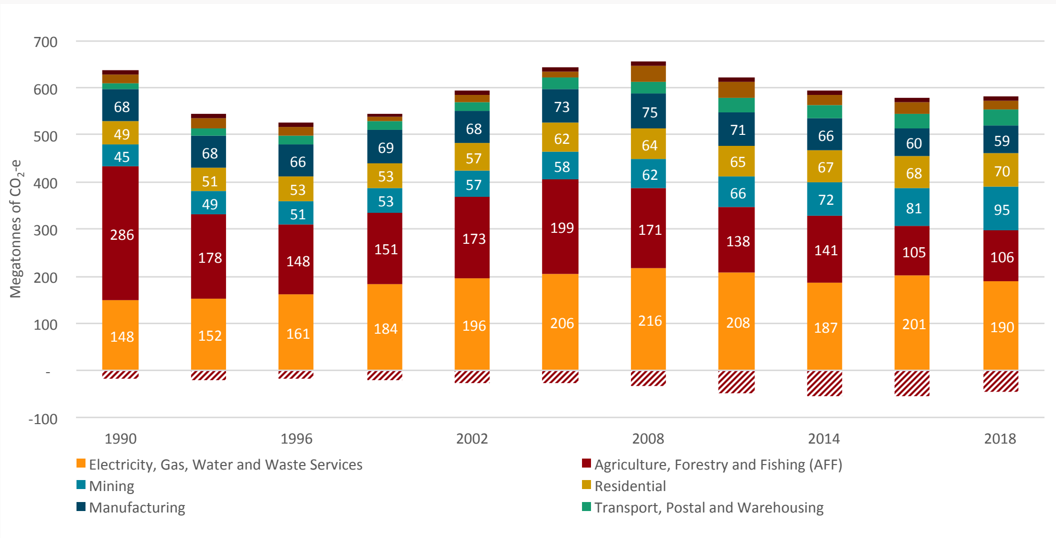
Although reducing the emissions by households and individuals is desirable, the most efficient and effective path to mitigation is through cleaner energy generation and industrial processes, and an increased emphasis on nature conservation as a way to offset existing emissions.

Changes in the make-up of emissions in the last three decades spanned all sectors of the economy (Figure 4).

Australia's emissions per capita are the highest in the OECD and sixth highest in the world, only surpassed by Qatar, Kuwait, the United Arab Emirates, Bahrain and Saudi Arabia, due to the country's fossil-fuel based energy exports.

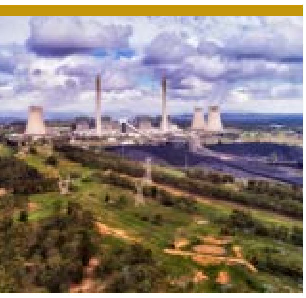
FIGURE 4

National direct emissions by economic sector, Australia, 1990 to 2018



Source: Bankwest Curtin Economics Centre | Authors' calculations based on DISER 2020, National Inventory by Economic Sector 2018, Data Table 1.

24 OECD. (2020). "Air and GHG emissions (indicator)". October. https://www.oecd-ilibrary.org/environment/air-and-ghg-emissions/indicator/english_93d10cf7-en.



In 2018 the largest sectoral emissions at the national level came from the electricity, gas, water and waste services sector, making up more than one-third of net emissions. The sector overtook agriculture as the largest contributor in 1995.

Between 1990 and 2018, national direct emissions from agriculture, forestry and fishing experienced a 63% reduction, led by an increase of 134% in the inventories in forest and wood product stocks. Emissions from manufacturing decreased by 13% in the same period, and emissions from construction were reduced by 3%. This led to the overall 13% reduction in Australian emissions, despite considerable growth in emissions from other economic sectors, led by transport, postal and warehousing, with a 144% increase between 1990 and 2018. Emissions from mining grew by 113% during the same period; residential emissions by 41%; electricity, gas, water and waste services, grew by 28%; and commercial services experienced a 16% growth in emissions.

Given these changes, agriculture, forestry and fishing went from 286 megatonnes of CO_2 equivalent emissions in 1990 to 106 megatonnes in 2018. In this way, electricity, gas, water and waste services overtook it as the largest sectoral source of emissions at the national level, going from 148 megatonnes in 1990 to 190 in 2018. Mining is now the third largest source of national direct emissions, having increased from 45 to 95 megatonnes, followed by residential emissions, which grew from 49 to 70 megatonnes. Manufacturing, the fifth largest source, decreased from 68 to 59 megatonnes during the 1990-2018 period. Despite its large increase, transport, postal and warehousing is the sixth source emissions, going from 13 to 33 megatonnes. Commercial services, at number seven, grew from 17 to 20 megatonnes, while construction, number eight, experienced a small decrease from 10.2 to 9.8 megatonnes. The change in inventories in forest and wood product stocks, which has a negative contribution to emissions, went from a 19 megatonnes offset to a 45 megatonnes one. This after sustained losses since 2013, when inventories reached 57 megatonnes.

The largest sectoral emissions in WA come from mining, at 40% of the state's emissions in 2018. Emissions from mining have more than doubled in Australia since 1990. The trend is more marked in WA, where mining emissions increased fourfold between 1990 and 2018.

Emissions trends in Western Australia

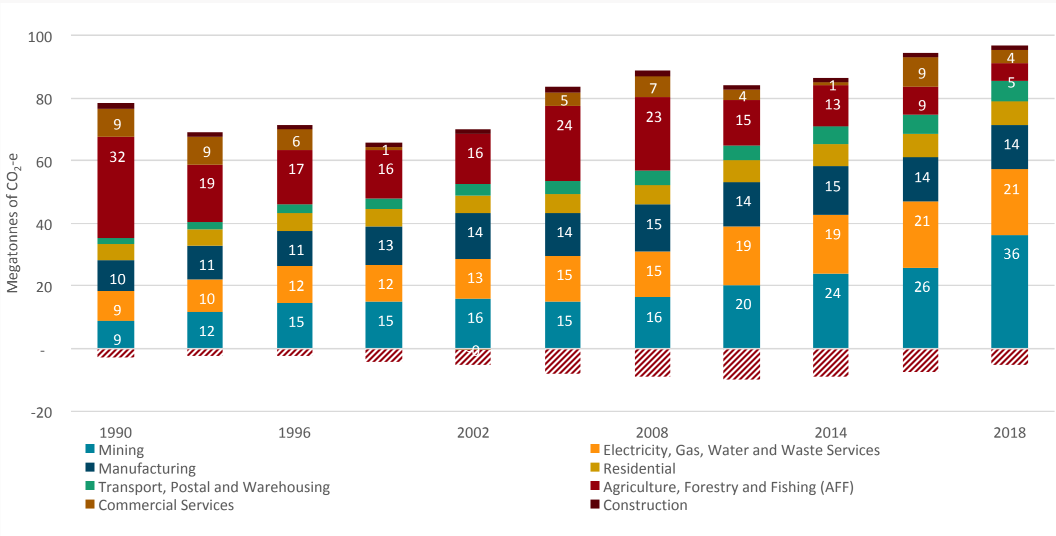
Western Australia's make-up of sectoral emissions differs considerably from Australia, due to the growing role mining has played in the state's economy and to significant reductions in emissions from agriculture, forestry and fishing. In 2018-19, mining accounted for 36% of Gross State Product (GSP) in WA,[25] and for 40% of its direct emissions (2018; Figure 5).

In 1990, agriculture, forestry and fishing was the largest source of direct sectoral emissions in WA, with 32 megatonnes of CO_2 equivalent emissions, followed by manufacturing; electricity, gas, water and waste services; commercial services; and mining, all ranging from 10 to 9 megatonnes of emissions. The residential sector ranked sixth, with 5 megatonnes; transport, postal and warehousing produced 2 megatonnes of direct emissions, as did construction. Finally, changes in inventories in forest and wood product stocks represented a 3-megatonnes offset, leading to a total of 76 megatonnes of emissions for WA.

In 2018, mining was the largest source of direct sectoral emissions in WA, at 36 megatonnes, having overtaken agriculture, forestry and fishing in 2011. Electricity, gas, water and waste services, the second largest source, produce 21 megatonnes; followed by manufacturing, 14 megatonnes; residential, 8 megatonnes; and transport, postal and warehousing, at 7 megatonnes. Agriculture, forestry and fishing, now the sixth source of emissions, generates 5 megatonnes; followed by commercial services, at 4 megatonnes, and construction, at 2 megatonnes. Changes in inventories in forest and wood product stocks now represent a 5 megatonnes offset, leading to total net emissions of 91 megatonnes for the state.

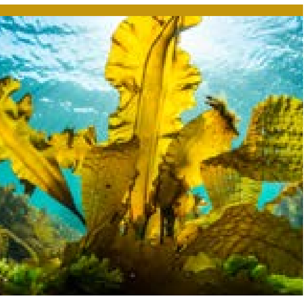
FIGURE 5

Direct emissions by economic sector, Western Australia, 1990 to 2018



Source: Bankwest Curtin Economics Centre | Authors' calculations based on DISER 2020, National Inventory by Economic Sector 2018, Data Table 1.

25 Government of Western Australia. Department of Jobs, Tourism, Science and Innovation. (2020). "Western Australia Economic Profile". September. https://jtsi.wa.gov.au/docs/default-source/default-document-library/wa-economic-profile---september-2020.doc?sfvrsn=6ff761c_6.



'Blue carbon' refers to the capture of carbon by marine organisms and ecosystems - and the importance of these ecosystems in regulating global CO_2 emissions.

BLUE CARBON: THE ROLE OF OUR OCEANS IN CLIMATE CHANGE MITIGATION

'Blue carbon' refers to the capture and sequestration of carbon by marine organisms and ecosystems. The term, coined in 2009, highlights the central role of our oceans in the carbon cycle – with an estimated 83% of global carbon circulating through the ocean (Nellemann *et al.* 2009, IPCC 2013).[26] Oceanic carbon stocks are around 50 times greater than the atmosphere and 10 times greater than on land (IUCN 2009, Laffoley *et al.* 2014[27]).

This means that ocean conservation, ecosystem management and recovery can play a critical role in carbon sequestration. However, it also highlights that the degradation and loss of oceanic and coastal ecosystems may be responsible for significant greenhouse gas emissions.

In fact, oceanic ecosystems are thought to have captured around 20-30% of anthropogenic atmospheric CO_2 emission in the last two decades, acting in effect as a balancing mechanism that mitigates the impacts of atmospheric CO_2 increase. Furthermore, vegetated coastal ecosystems account for only 0.2% of the ocean's surface, but contribute an estimated 50% of the carbon sequestered in marine sediments (Le Quéré *et al.* 2018[28], Duarte *et al.* 2004[29]).

Recent research[30] has also found that Australia contributes 5–11% of the organic carbon storage in vegetated coastal ecosystems globally. Their future potential as carbon sinks is significant. Just as carbon storages from terrestrial's ecosystems could sequester carbon emission, storages from vegetated ecosystems could play the same role at sea. Given the large marine jurisdiction of Western Australia, this represent an important opportunity for carbon sequestration and greenhouse gas emission reductions.

As a resource-intensive economy, Western Australia faces significant challenges into the future in offsetting its greenhouse gas emissions from mining and gas production. While our declining rainfall and ancient nutrient-poor soils limit our capacity for terrestrial bio-sequestration, blue carbon is likely to play a critical role in the State's future green economy.

26 Nellemann C., *et al.* (eds) (2009) Blue Carbon. A Rapid Response Assessment. United Nations Environment Programme (GRID-Arendal).

27 Laffoley D, Grimsditch GD (eds). 2009 The management of natural coastal carbon sinks. Gland, Switzerland: IUCN.

28 Le Quéré, C. *et al.* (2018) *Global Carbon Budget 2017*. Earth System Science Data 10, 405–448.

29 Duarte, C. M., Losada, I. J., Hendriks, I. E., Mazarrasa, I. & Marba, N. (2013) The role of coastal plant communities for climate change mitigation and adaptation. Nat. Clim. Change 3, 961–968.

30 Serrano, O., Lovelock, C. E., Atwood, T. B., Macreadie, P. I., Canto, R., Phinn, S., ... & Carnell, P. (2019). Australian vegetated coastal ecosystems as global hotspots for climate change mitigation. *Nature communications*, 10(1), 1-10.

Overall, WA's total net emissions grew by 21% from 1990 to 2018 (Figure 6). Emissions by sector grew as follows: Mining, a 305% increase; transport, postal and warehousing, a 213% increase; electricity, gas, water and waste services, a 119% increase; residential, a 58% increase; and manufacturing, with a 44% increase. On the side of reduced emissions, construction lowered its emissions by 15%; commercial services, by 57%; and agriculture, forestry and fishing, the sector which achieved the highest emissions reduction, lowered its emissions by 83% during the period, reflected by an increase of 85% in its inventories in forest and wood product stocks.

The change in sectoral emissions in WA looks like a magnified version of the changes in Australia.

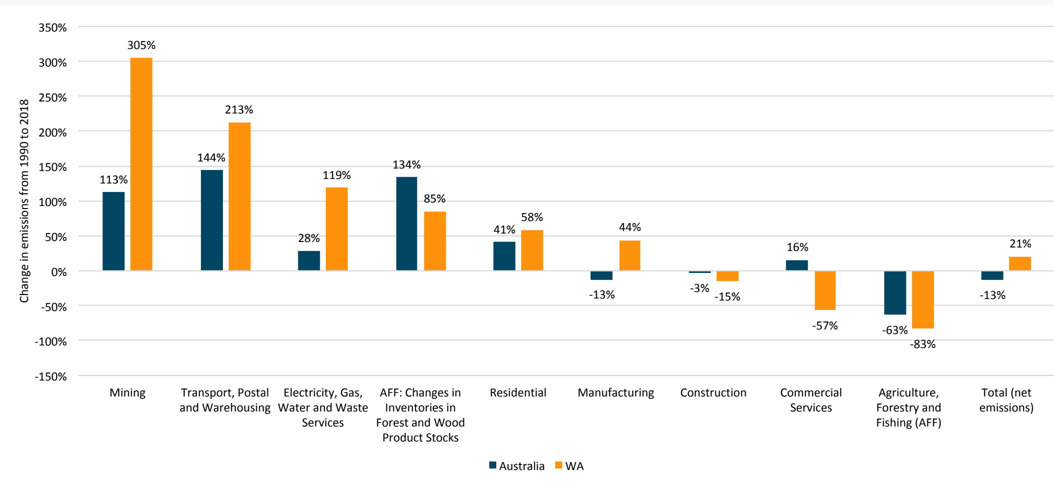
In the sectors where national emissions increased between 1990 and 2018, WA's emissions grew by a much larger magnitude. Emissions from mining, for instance, grew by 113% in Australia versus 305% in WA; emissions from transport, postal and warehousing, 144% versus 213% growth; electricity, gas, water and waste services, 28% versus 119% growth; residential, 41% versus 58% growth; manufacturing, negative 13% versus 44% growth; total net emissions, negative 13% versus 21% growth. Australia also performed better regarding changes in inventories in forest and wood product stocks, with stocks increasing by 134% compared to 85% in WA.

On the other hand, in most sectors where national emissions decreased, WA outperformed Australia. Emissions from construction decreased by 3% in Australia versus 15% in WA; commercial services, whose emissions grew by 16% at the national level, in fact decreased by 57% in WA; finally, in emissions from agriculture, forestry and fishing, Australia achieved a 63% reduction versus a reduction of 83% in WA.

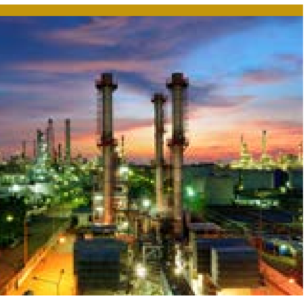
The construction, commercial services, and agriculture, forestry and fishing sectors in WA outperformed their Australian counterparts in their emissions reduction rate from 1990 to 2018.

FIGURE 6

Change in emissions by economic sector, Australia and Western Australia, 1990 to 2018



Source: Bankwest Curtin Economics Centre | Authors' calculations based on DISER 2020, National Inventory by Economic Sector 2018, Data Tables 1 and 10.



Emissions from oil and gas extraction in Australia have more than doubled since 2004-05, going from 17 to 39 megatonnes. They now represent the largest share of mining emissions, at 48%.

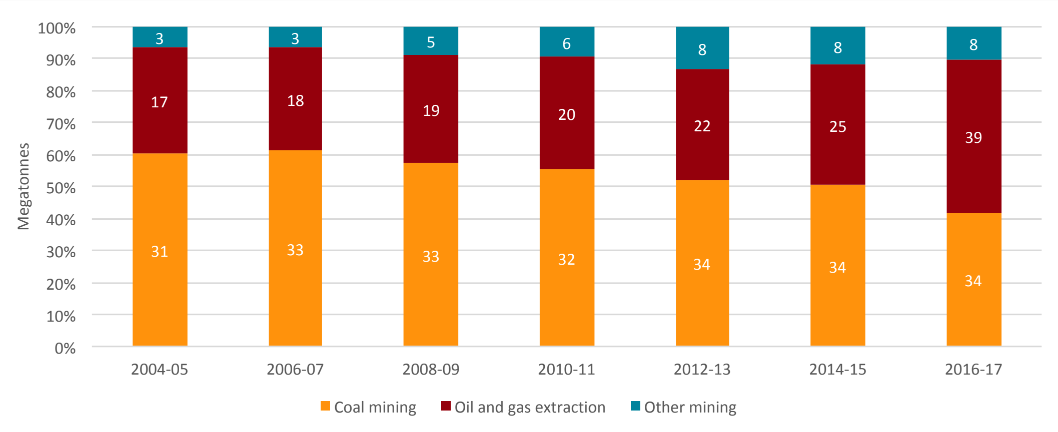
Mining

The make-up of emissions within Australia's mining sector has also changed in recent years. While coal mining accounted for 61% of the country's mining emissions in 2004-05, at 31 megatonnes, in 2016-17 it is oil and gas extraction that represent the largest share of emissions, at 39 megatonnes, or 48% (Figure 7).

Emissions from all mining subtypes increased in net terms between 2004-05 and 2016-17. Coal mining emissions grew from 31 megatonnes to 34 megatonnes, with an 8% increase; oil gas and extraction emissions grew from 17 to 39 megatonnes, with a 128% increase; and other mining emissions grew from 3 to 8 megatonnes, with a 148% increase.

FIGURE 7

Mining emissions by subtype, Australia, 2004-05 to 2016-17



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4655, July 2019, Table 5.1.

Emissions from States and Territories

In 1990, Queensland accounted for 30% of Australia's emissions (at 184 megatonnes), followed by New South Wales, at 29% (or 177 megatonnes); Victoria, at 18% (or 110 megatonnes); Western Australia, at 12% (or 76 megatonnes); South Australia, at 6% (or 37 megatonnes); Tasmania, at 3.3% (or 20 megatonnes); the Northern Territory, at 2% (or 13 megatonnes); and the Australian Capital Territory, at 0.2% (or 1 megaton).

By 2018, Queensland accounted for 32% of Australia's emissions (at 171 megatonnes), followed by New South Wales, at 25% (or 132 megatonnes); Victoria, at 19% (or 102 megatonnes); Western Australia, at 17% (or 91 megatonnes); South Australia, at 5% (or 24 megatonnes); the Northern Territory, at 3% (or 16 megatonnes); the Australian Capital Territory, at 0.3% (or 1 megaton); and Tasmania, at -0.4% of Australia's emissions (or -2 megatonnes).

The trend that arises from this is that, although the ranking occupied by each state and territory has remained mostly stable, their emissions as share of Australia's total have experienced noticeable changes after three decades (Figure 8). Western Australia's share of the country's emissions grew by 5% during the period, followed by Queensland's, at 2%; Victoria's and the Northern Territory's, both at 1%; and the Australian Capital Territory, whose share grew by 0.1%. On the other hand, between 1990 and 2018, New South Wales' emissions as share of Australia's total decreased by 4%; Tasmania's by 3.7% and South Australia's by 1%.

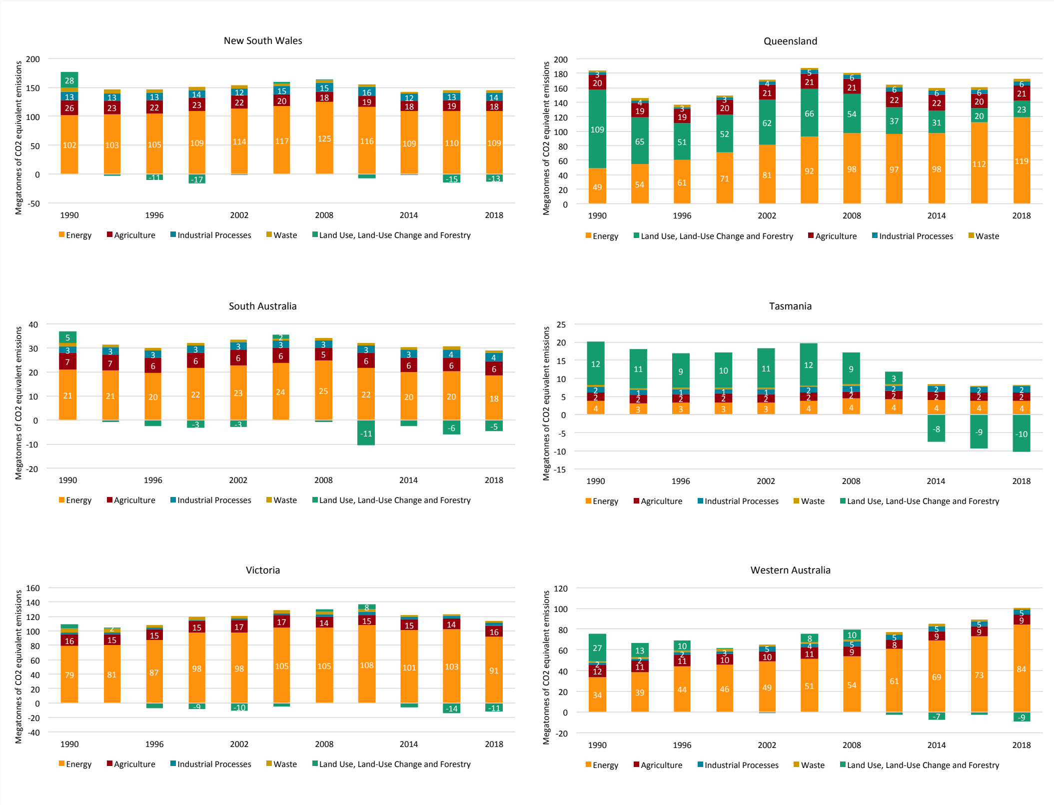
Thus, WA generated 17% of Australia's emissons in 2018, when the state's share of the population was 10.4%. WA represents 15% of Australian economic output as at October 2020. New South Wales represents 32% of the country's output share, followed by Victoria, at 23%; Queensland, at 19%; South Australia, at 6%; and Tasmania, at 2%.[31]

WA generated 17% of Australian emissions in 2018. The state's share of the population was 10.4%

[31] Reserve Bank of Australia. (2020). "Composition of the Australian economy. Snapshot." 12 October. https://www.rba.gov.au/education/resources/snapshots/economy-composition-snapshot/.

FIGURE 8

Greenhouse gas emissions, select States and Territories, 1990-2018



Note: Energy comprises stationary energy (energy industries - electricity generation and other energy industries; manufacturing and construction; and other sectors), transport and fugitive fuels.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on DISER 2020, State and Territory Greenhouse Gas Inventories: 2018.

What distinguishes the trends of Western Australia and Queensland from the rest of the country is a sustained and substantial growth in emissions from energy. While land use, land-use change and forestry (LULUCF) was the largest source of emissions in Queensland in 1990, at 108 megatonnes or 60% of the state's emissions, that place is now occupied by energy, at 120 megatonnes or 70% of Queensland's emissions in 2018. In the case of WA, while emissions from energy represented 45% of the state's total in 1990, in 2018 they constitute 92% of net emissions, at 84 megatonnes.

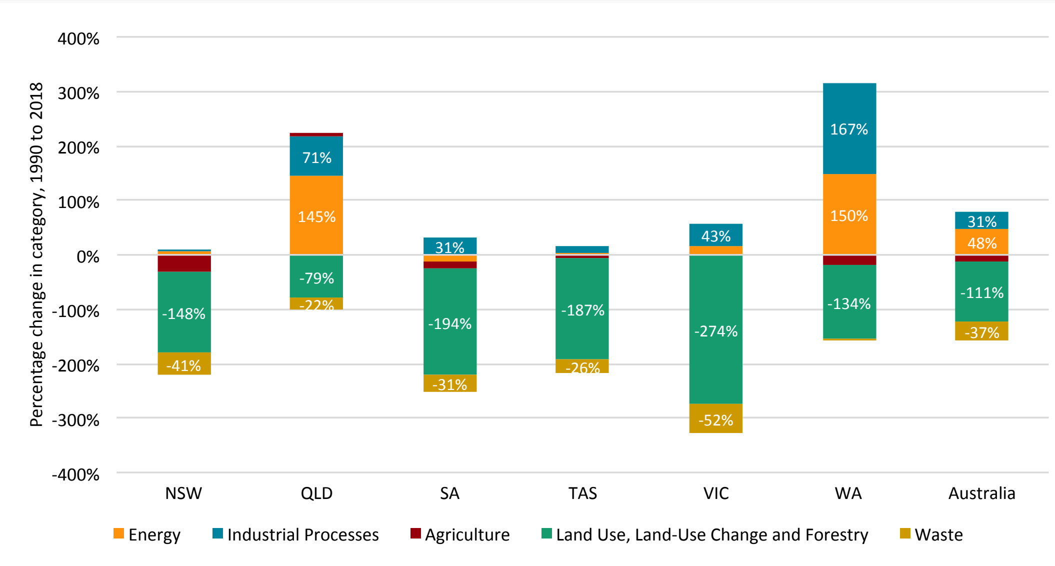
On the other hand, Queensland was successful in reducing its LULUCF emissions by almost 80% in the same period, going from 109 megatonnes to 23 megatonnes. Similarly, Tasmania reduced its LULUCF emissions by almost 200%, going from 12 megatonnes to an offset of 10.4 megatonnes (Figure 9).

Nature conservation through land use, land-use change and forestry is a crucial mechanism to both lower emissions being generated and reduce the amounts of carbon already in the atmosphere through its capture in sinks.

WA has been the largest contributor to Australia's rise in emissions from energy and industrial processes, with increases of 150% and 167%, respectively, since 1990.

FIGURE 9

Percentage change in emissions and sink categories, select States and Territories, 1990 to 2018



Note: Energy comprises stationary energy (energy industries - electricity generation and other energy industries; manufacturing and construction; and other sectors), transport and fugitive fuels.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on DISER 2020, State and Territory Greenhouse Gas Inventories: 2018.

In 2016-17, households paid 40% of environmentally-related taxes in Australia, as a combination of energy and transport taxes. In the same year, households produced 68 megatonnes of emissions, or 12% of the total, compared to 477 megatonnes from industry.

Incidence of environmentally-related taxes

Environmentally-related taxes are an instrument governments can use to influence the relative price of goods and services, therefore shaping production and consumption decisions.

In Australia, examples of this are energy taxes such as fuel excise and duties (based on energy content and indexed to consumer prices) and transport taxes, such as stamp duty on vehicle registration, luxury car tax, import duties, road transport and maintenance taxes, among others.

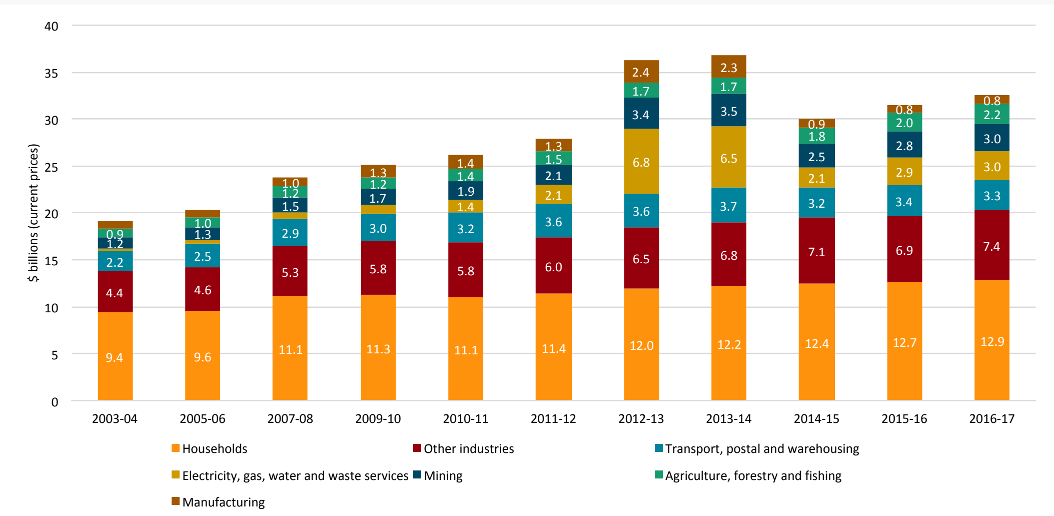
According to the OECD, environmentally-related taxes in Australia amounted to 1.77% of Gross Domestic Product (GDP) in 2016, with 1.03% coming from energy, 0.69% from motor vehicles and 0.05% from others. In contrast, the OECD-total for the same year amounted to 1.63% of GDP, with 1.17% coming from energy, 0.4% from motor vehicles and 0.06% from others. Australia's share is higher due to a higher relative share of environmental taxes coming from motor vehicles (58% higher than OECD levels), which compensates for the lower relative share of taxes from energy (12% lower than OECD levels).[32]

An important issue on this topic are fuel tax credits, which provide businesses with a rebate of the tax embedded in the price of fuel, and which the OECD catalogues as a support measure for fossil fuels; measures that can take the form of budgetary support or of a tax expenditure (revenue forgone). For the 2018-19 fiscal year, the OECD estimates that fuel tax revenue was AUD $19.86 billion and that businesses claimed AUD $7.5 billion of fuel tax credits, net of road user charges.[33]

As a whole, Australian households pay a larger share of total environmental taxes than do other economic sectors (Figure 10; Table 1).

FIGURE 10

Environmentally-related taxes paid by households and industry, sum of energy and transport taxes, 2003-04 to 2016-17



Notes: Energy includes Excise on Crude oil and LPG, Carbon pricing mechanism, Renewable energy certificates, Energy Savings Scheme, Greenhouse Gas Reduction Scheme, The Queensland Gas Scheme, The Retailer Energy Efficiency Scheme and Victorian Energy Efficiency Target scheme. Transport includes Stamp duty on vehicle registration, Luxury car tax, Passenger motor vehicles import duty, Road transport and maintenance taxes, Heavy vehicle registration fees and taxes, other vehicle registration fees and taxes. Passenger motor vehicle import duty was not available form 2003-04 to 2005-06.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4655, July 2019, 4655003_2019, Tables 6.2, 6.3.

32 OECD. (2020). "Environmental tax (indicator)". October. https://data.oecd.org/envpolicy/environmental-tax.htm.

33 OECD. (2020). "Fossil fuel support country note - Australia". June. http://stats.oecd.org/wbos/fileview2.aspx?IDFile=3a9e9066-f0cd-4f49-97ff-534cf2c16cfa.

TABLE 1

Share of environmentally-related taxes paid by households and industry, Australia, 2016-17

	Total (energy + transport) taxes	Energy taxes	Transport taxes
Households	39.6%	31.0%	55.4%
Other industries	22.8%	17.5%	32.5%
Transport, postal and warehousing	10.1%	12.8%	5.2%
Electricity, gas, water and waste services	9.2%	13.6%	1.1%
Mining	9.1%	13.9%	0.4%
Agriculture, forestry and fishing	6.7%	8.0%	4.2%
Manufacturing	2.5%	3.3%	1.2%

Notes: Energy includes Excise on Crude oil and LPG, Carbon pricing mechanism, Renewable energy certificates, Energy Savings Scheme, Greenhouse Gas Reduction Scheme, The Queensland Gas Scheme, The Retailer Energy Efficiency Scheme and Victorian Energy Efficiency Target scheme. Transport includes Stamp duty on vehicle registration, Luxury car tax, Passenger motor vehicles import duty, Road transport and maintenance taxes, Heavy vehicle registration fees and taxes, other vehicle registration fees and taxes. Passenger motor vehicle import duty was not available form 2003-04 to 2005-06.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4655, July 2019, 4655003_2019, Tables 6.2, 6.3.

Between 2003-04 and 2016-17, the total amount of environmentally-related taxes paid in Australia increased by 70%, going from $19 billion to AUD $32.5 billion. However, the share of these taxes paid by households and industries has remained stable, except for 2012-13 and 2013-14, when the carbon pricing mechanism was in force and the amount paid by industries increased, although households remained the largest contributor. After the scheme was repealed in 2014, the government introduced an Emissions Reduction Fund, a voluntary offset program for businesses.

In 2016-17, Australian households paid a total of $12.8 billion as a sum of energy and transport taxes. Transport, postal and warehousing paid $3.3 billion; electricity, gas, water and waste services paid just under $3 billion; mining paid close to $3 billion; agriculture, forestry and fishing paid $2.2 billion and manufacturing paid $821 million. Other industries paid $7.4 billion in energy and transport taxes combined.

The share of environmentally-related taxes paid by each sector differs between energy and transport taxes: while households pay almost a third of energy taxes, they pay more than half of transport taxes. As such, in 2016-17, 31% of energy taxes were paid by households; 13.9% by mining; 13.6% by electricity, gas, water and waste services; 12.8% by transport, postal and warehousing; 8% by agriculture, forestry and fishing; 3.3% by manufacturing; and 17.5% by other industries. In contrast, for the same year, 55.4% of transport taxes were paid by households; 5.2% by transport, postal and warehousing; 4.2% by agriculture, forestry and fishing; 1.2% by manufacturing; 1.1% by electricity, gas, water and waste services; 0.4% by mining; and 32.5% by other industries.

As seen in Figure 2, this is not commensurate with the share of total emissions produced by households or each economic sector. This is a missed policy opportunity on two fronts. First, fuel tax credits are a price-distorting mechanism, which interferes with market signals and the decisions of consumers and producers. Damaging consumption and production patterns are one of the main challenges in the fight against climate change, and fossil fuel support is antithetical to the SDGs and international climate commitments. As such, international organisations like the United Nations, the International Monetary Fund (IMF), the OECD and the International Energy Agency (IEA) have called for the phasing out of these measures. Additionally, G20 Leaders agreed to phase out inefficient fossil-fuel subsidies in the 2009 Summit in

Good, accessible data, produced with the relevant frequency and relevant granularity, is essential for accountability.

Pittsburgh, reaffirming their commitment in St. Petersburg in 2013.[34]

The OECD and IEA have also warned of an increase of 38% in the support for the production of fossil fuels –such as gas- in 2019, across 44 advanced and emerging economies. This is missing the mark on international energy prices, given the current historically low prices for oil and gas. Government expenditure should instead be redirected into sustainable, low-carbon energy investments, the agencies suggest.[35]

Second, the Productivity Commission already identified in 2012 the potential for the tax system to assist in climate change adaptation, warning against measures that diminish incentives for households to manage risks in the context of ongoing economic, social, political and technological change. This can be extended to industry.[36] Although Target 12.c of SDG Goal 12, *Responsible production and consumption*, seeks to restructure taxation and phase out fossil-fuel subsidies to reflect their environmental impacts, the entity in charge of providing the indicator, the Australian Treasury, is reported as not having yet investigated potential data sources to measure Australia's performance against this target.[37] Such a measurement would be useful to determine, for instance, whether the current configuration of environmentally-related taxation primarily based on households is the best option for Australians, in terms of abatement and distributional impact.

For every one of the SDGs, good, accessible data, produced with the relevant frequency and relevant granularity, is essential for accountability. But data and evidence are not enough: strong political commitment is also needed.

Good, accessible data, produced with the relevant frequency and relevant granularity, is essential for accountability.

Green shoots – policy opportunities and considerations

To preserve Australia's wealth, adapting the age-old maxim, it is important to not put all eggs in one basket. Especially when the basket is already moving on or likely to catch on fire. An exports sector less reliant on fossil fuels, green investment, and a cleaner energy mix is crucial in growing a sustainable, resilient economy in Australia and in WA. Maintaining our natural wealth should be a goal in itself, but it is also a means to an end.

In October 2020, the output share of key sectors in Australia is as follows: health and education, 13%; mining, 10%; finance, 9%; construction, 8%; and manufacturing, at 6%. At the same time, resources represent 62% of Australian exports, followed by services, at 17%; rural, at 10%; and manufacturing, at 9%.

As trading partners make their own commitments to carbon neutrality, Australia's emissions-heavy exports may consequentially suffer a downturn. Currently, 34% of Australian exports go to China; 12% to Japan; 8% to the European Union; 6% to Korea; 5% to the United States; and 4% to India.[38] The first four destinations have recently reaffirmed their pledge to reach net zero emissions by 2050-2060.

34 B20. (2020). "B20 Policy Recommendations to the G20. Realizing Opportunities of the 21st Century for All. Transforming for Inclusive Growth". September. https://www.b20saudiarabia.org.sa/wp-content/uploads/2020/09/Policy-recomendations-to-the-G20_IMG_update_Chair_compressed-min.pdf.

35 OECD. (2020). "Governments should use Covid-19 recovery efforts as an opportunity to phase out support for fossil fuels, say OECD and IEA". 5 June. https://www.oecd.org/environment/governments-should-use-covid-19-recovery-efforts-as-an-opportunity-to-phase-out-support-for-fossil-fuels-say-oecd-and-iea.htm.

36 Productive Commission. (2012). "Barriers to Effective Climate Change Adaptation". Productivity Commission Inquiry Report no. 59. 19 September. p. 9.

37 Australian Government. "Sustainable Development Goals. Indicator 12.c.1" https://www.sdgdata.gov.au/goals/responsible-consumption-and-production/12.c.1#metadata2.

38 Reserve Bank of Australia. (2020). "Composition of the Australian economy. Snapshot." 12 October. https://www.rba.gov.au/education/resources/snapshots/economy-composition-snapshot/.

Additionally, as China switches from low to middle-income commodity needs, it is expected that its demand for iron and coal will decrease.

The counter scenario, where Australia's fossil-fuel based exports somehow continue to thrive while the world gets greener, presents a dire picture in the long term: it could effectively turn Australia into a carbon leakage spot, which is when emissions-intensive production shifts to countries with lower carbon prices.

As trading partners make their own commitments to carbon neutrality, Australia's emissions-heavy exports may consequentially take a hit, or turn the country into a carbon leakage spot.

Economic diversification is also important for jobs, particularly in WA. In 2018-19, additional to representing a 36% share of GSP, mining employed more than 130,000 people.[39] These jobs are susceptible not only to changes in international markets, but also to increasing automation and remote operations technology in mining, as the industry switches investment from non-dwelling construction to machinery and equipment, and as natural gas projects transition into their production phase.[40]

This is a well-timed opportunity for WA. Recent IMF modelling shows that renewable-based electricity generation and investments to enhance energy efficiency are more job-intensive than the generation of electricity from fossil fuels. Low carbon sectors like renewable energy, retrofitting of buildings and services typically use more labour in the short term –when the asset is created– and in the long term –due to subsequent operation and maintenance– compared to high-carbon sectors such as fossil fuel energy, transportation and heavy manufacturing.[41]

The international financial markets are sending clear signals of the road ahead, with the stock market value of coal companies collapsing in the United States and that of oil and gas significantly reduced. Additionally, wind and solar power are now the cheapest form of new electricity in the world. BloombergNEF estimates that, by 2025, it will be cheaper to build solar arrays and wind farms than to operate an existing gas power plant.[42] Policy decisions should be based on a clear view of the future rather than on narratives of the past, to transition to a safe environment also characterised by energy security and economic efficiency.

This does not mean to abruptly switch away from fossil fuels, but rather, it constitutes an opportunity to reduce the amount of carbon entering the economy by increasingly bringing renewables into the energy mix; reusing and recycling carbon; diversifying exports through new green technology; and using geological and natural carbon sinks as a way to remove carbon from the atmosphere.

Timely research, development and deployment of new technologies can allow industries to continue being a driving force in economic development.

WA is in a strong fiscal position to make these changes, leading to higher investment confidence in the future and a more resilient economy –and a better environment that preserves its natural wealth.

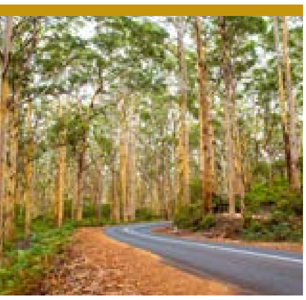
39 Government of Western Australia. Department of Mines, Industry Regulation and Safety. "2019-20 Economic indicators resources data". https://dmp.wa.gov.au/Documents/Investors/2019-20-Economic-indicators.xlsx.

40 Australian Bureau of Statistics. (2019). "Australian System of National Accounts 2018-19". 25 October. https://www.abs.gov.au/statistics/economy/national-accounts/australian-system-national-accounts/2018-19.

41 International Monetary Fund. (2020). World Economic Outlook, October 2020: A Long and Difficult Ascent". p. 98. https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020.

42 Hodges, J. (2020). "Wind, Solar Are Cheapest Power Source In Most Places, BNEF Says". *Bloomberg*. 19 October. https://www.bloomberg.com/news/articles/2020-10-19/wind-solar-are-cheapest-power-source-in-most-places-bnef-says.

LAND USE



In 2018, the largest greenhouse gas source in Australia's land use, land-use change and forestry sector is the conversion of land to grassland, generating 40 megatonnes of emissions. This is five times greater than the next four sectoral sources combined.

Land use, land-use change and forestry are a fundamental aspect to consider in the reduction of greenhouse gas emissions, and in water, land and ecosystem conservation.

The way in which land is used can either increase emissions or help combat them. Emissions increase, for instance, when forests and natural vegetation are cleared for croplands, livestock grazing, or residential or industrial settlements. Emissions are reduced when these forests and vegetation are preserved or regrown. Along with the ocean, forests and vegetation act as natural carbon sinks, lowering the concentration of CO_2 from the atmosphere.

A changing Australian landscape

As seen in Figure 1, land use, land-use change and forestry (LULUCF) has been the main driver of emissions reduction in Australia since the 1990s, going from 193 megatonnes of CO_2 equivalent emissions in 1990 to an offset, or negative emissions, of 21 megatonnes in 2018; a 123% reduction.

In 2018, the largest greenhouse gas source in Australia's LULUCF sector is the conversion of land to grassland, generating 40 megatonnes of emissions (Figure 11).

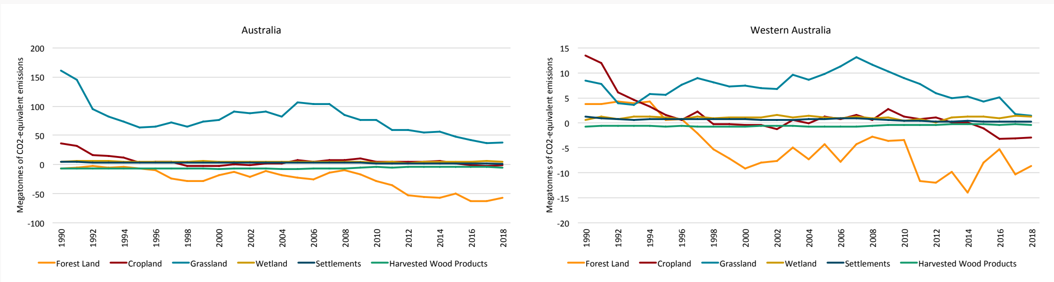
The magnitude of emissions from this change in land use is five times greater than the next four sources combined: wetlands, with 5 megatonnes of emissions; land converted to cropland, with 2 megatonnes of emissions; and land converted to settlements, with 1 megaton of emissions. However, conversion of land into grassland has been on a mostly steady decline since 1990 at the national level, when it generated over 150 megatonnes of emissions, reaching a peak of 89 megatonnes again in 2005 before continuing to drop.

On the other side of the equation, the largest carbon sink in Australia in 2018 comes from forest land, its reforestation and preservation, offsetting 57 megatonnes of CO_2 equivalent emissions. From this, the reconversion of land into forest land accounted for an offset of 35 megatonnes, 20 of which come from plantations and natural regeneration and 15 from regrowth on deforested land. The remaining 22 megatonnes came from forest land remaining forest land.

The pattern is similar in Western Australia, with the conversion of land into grassland being the largest source of LULUCF emissions in 2018, at 3.5 megatonnes. Unlike the national trend, conversion of land into grassland in WA had been on a steady rise from the early 1990s through to 2007, when it reached a peak at 7.7 megatonnes of emissions, following a declining trend since.

FIGURE 11

Land use, land-use change and forestry, Australia and Western Australia, 1990 to 2018



Source: Bankwest Curtin Economics Centre | Authors' calculations based on DISER 2020, State and Territory Greenhouse Gas Inventories: 2018.

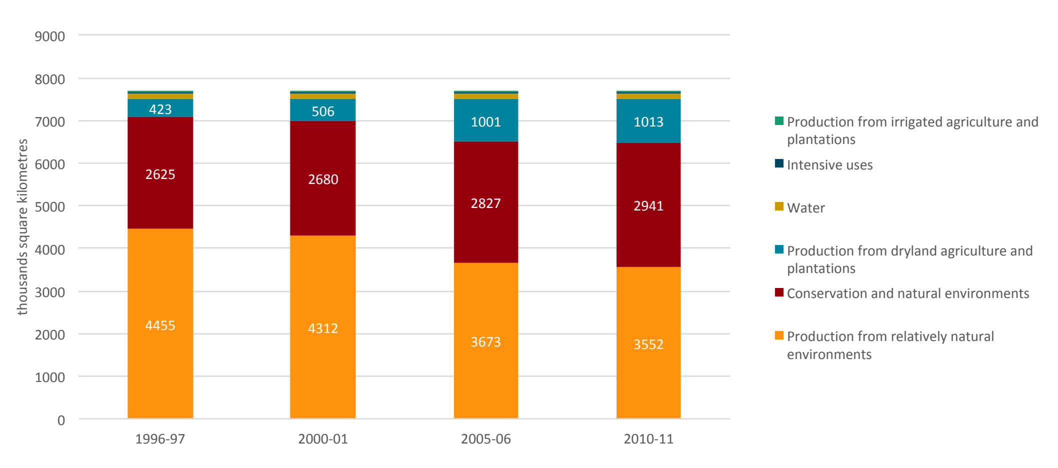
As with Australia, the largest carbon sink in WA comes from forest land, where the conversion of land into forest land accounts for an offset of 10 megatonnes, 8 of which come from plantations and natural regeneration and 2 from regrowth on deforested land.

It is of note that the severe Millennium Drought took place between 2001 and 2009. In these circumstances, larger areas of land may have been required to maintain the level of crop outputs.

Change of land to grasslands is also reflected in patterns of primary land use. Between 1996-97 and 2010-11, there was an increase of 139% in land used for dryland agriculture and plantations at the national level, led by grazing modified pastures (Figure 12). Overall, land used for production from dryland agriculture and plantations went from 423,441 square kilometres (km^2) to over 1 million km^2. The second largest change in primary land use came from intensive uses (such as horticulture, livestock, manufacturing, residential, services and mining), which doubled during the period, going from 17,350km^2 to 34,712km^2. Conservation and natural environments also grew by 12%, going from 2.6 million km2 to 2.9 million km^2 during the period.

FIGURE 12

Area by primary land use, Australia, 1996-97 to 2010-11



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABARES, National Land Use 1996/1997 (Version 3) Summary Statistics; National Land Use 2000/2001 (Version 3) Summary Statistics; National Land Use 2005-06 (Version 4) Summary Statistics; Land Use of Australia 2010-11 Summary Statistics [Version 5]. Due to changing methodologies between versions, comparison has been limited to primary land use.

Between 1996-97 and 2010-11, there was an increase of 139% in land used for dryland agriculture in Australia, led by grazing modified pastures, and a 100% increase in intensive uses. Conversely, there was a reduction of 16% in land used for irrigated agriculture, and of 20% in land used for production from relatively natural environments.

Inversely, there was a reduction of 16% in land used for irrigated agriculture, and of 20% in land used for production from relatively natural environments. Land used for production from irrigated agriculture and plantations went from 24,413km^2 to 20,527km^2 between 1996-97 and 2010-11, while production from relatively natural environments decreased from 4.5 million km^2 to 3.6 million km^2 during the same period.

The rise in grazing modified pastures plays a dual role in the generation of emissions, both from a land use and an agricultural perspective. Currently, nearly half of agricultural emissions come from grazing beef, followed by sheep and dairy. The three categories are projected to increase between 5% and 13% in the next decade, following grain-fed beef, which has the largest projected increase at 29% due to ongoing drought conditions.[43] At the same time, the conversion of natural land into grassland reduces its capacity for carbon sequestration and, in the long term, can lead to soil degradation.

With warmer temperatures and changing rainfall patterns leading to water scarcity and a decline in yield and crop suitability, a sustainable water, energy and food nexus will also require an evaluation of consumption patterns. Given the 'long shadow' livestock has on the environment, the UN has cautioned, changes in dietary choices, reduced post-harvest losses and a reduction of food waste can improve good health, clean water and sanitation, climate action, and life on land.[44]

Looking more closely at the changes in pasture crops in Australia and WA, legume pastures had a stark decrease in the last three decades, going from 52 million hectares nationally in 1990 to 32 million hectares in 2018, after a steep decline in 1999-2000. Perennial pastures also decreased from 32 million hectares in 1990 to 19 million hectares in 2018, with the same steep decline in 1999-2000. On the other hand, grass clover mixture increased substantially in 1999-2000, going from none to more than seven million hectares nationally. Annual grasses had a slight increase from under 26 million hectares to nearly 28 million.

Western Australia followed a similar pattern, going from nearly 31 million hectares of legume pastures in 1990 to under 19 million hectares in 2018, after a drop in 1999-2000. Perennial pastures went from nearly six million hectares to under two million. Conversely, annual pastures increased from under a million hectares to more than four million.

43 Australian Government Department of the Environment and Energy. (2019). "Australia's emissions projections 2019". December. pp. 34-35.

44 Food and Agriculture Organisation of the United Nations. (2006). "Livestock's long shadow. Environmental issues and options". Rome. And: Intergovernmental Panel on Climate Change. (2019). "Climate change and land. An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems".

Australian forests

In 2016, 99% of carbon stocks in Australian forests were in native forests and other forests, which sequestered 22,000 million tonnes of carbon. At the same time, 258 tonnes, or a little over 1%, were sequestered in plantations; a trend that has remained stable since 2001.

Conservation of natural environments is crucial because land clearing has longer-term implications that cannot be immediately undone by reforestation. Even if forests are regrown, they require time to reach previous levels of carbon stocks. Cutting trees for land clearing or wood products, for instance, is a loss of their high carbon stock, which reduces overall carbon sink levels. Therefore, new growth or regrowth may not have the same value to the environment as did original vegetation.

As such, it would be advisable for reforestation and carbon sequestration to be seen as an option to capture the already-existing greenhouse gases accumulated in the atmosphere, rather than as license to generate more emissions in the present, on the premise of a future offset.

It takes time for new or regrown forests to reach high levels of carbon stock. Reforestation and carbon sequestration should be seen as an option to capture carbon already accumulated in the atmosphere, rather than as license to generate more emissions on the premise of a future offset.

Amongst key states, annual area of forest cleared has been on the decline since the early 1990s, accompanied by a relatively larger share of reclearing and regrowth (Figure 13). The National Greenhouse Accounts define forests as woody vegetation with a minimum 20% canopy cover, at least 2 metres high and a minimum area of 0.2 hectares.[45]

In New South Wales, clearing went from 67 thousand hectares in 1990 to 12 thousand hectares in 2018; reclearing from 63 thousand to 58 thousand hectares (peaking in 2006, at 103 thousand hectares); and regrowth from 46 thousand to 34 thousand hectares in the same period, with a sustained decline since 2010, when it reached 92 thousand hectares.

For Victoria, the annual area of forest cleared went from 17 thousand hectares in 1990 to 1 thousand hectares in 2018 (with a peak in 2004, again at 17 thousand); reclearing went from 14 thousand to 12 thousand hectares, peaking in 2006 at 43 thousand hectares; and regrowth went from 9 thousand to 14 thousand hectares during the same period, with a sustained decline since 2013, when it reached 38 thousand hectares.

Around 99% of the carbon stored in Australian forests is found in native and other types of forests, with the remaining 1% in plantations.

45 Australian Government. (2020). "National Forest and Sparse Woody Vegetation Data". https://data.gov.au/data/dataset/national-forest-and-sparse-woody-vegetation-data-version-4-2019-release.

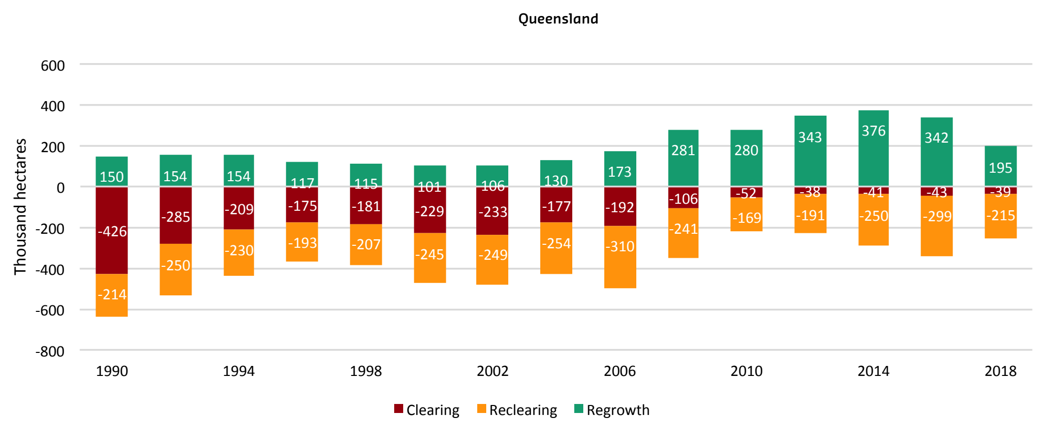
FIGURE 13

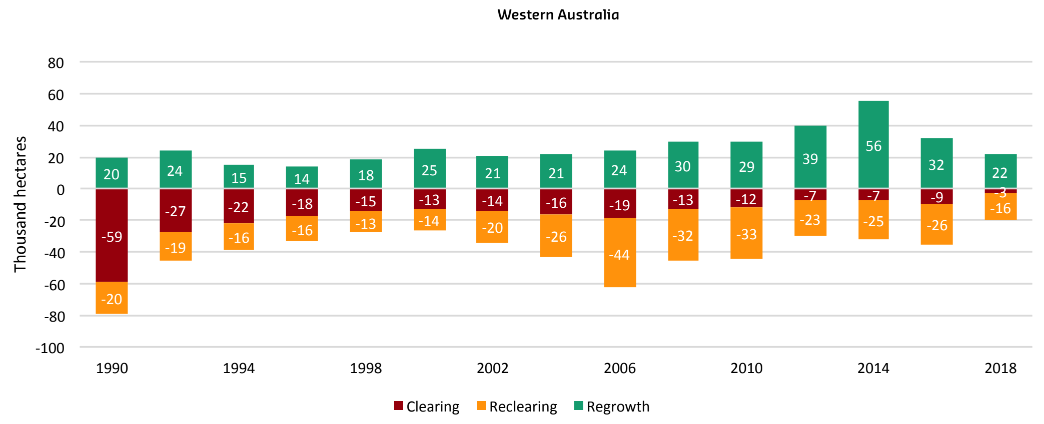
Annual area of forest cleared, recleared and regrown, by select states, 1990-2018

Source: Bankwest Curtin Economics Centre | Australian Greenhouse Emissions Information System (AGEIS), Department of Industry, Science and Energy and Resources, Australian Government.

FIGURE 13 (continued)

Annual area of forest cleared, recleared and regrown, by select states, 1990-2018





Source: Bankwest Curtin Economics Centre | Australian Greenhouse Emissions Information System (AGEIS), Department of Industry, Science and Energy and Resources, Australian Government.

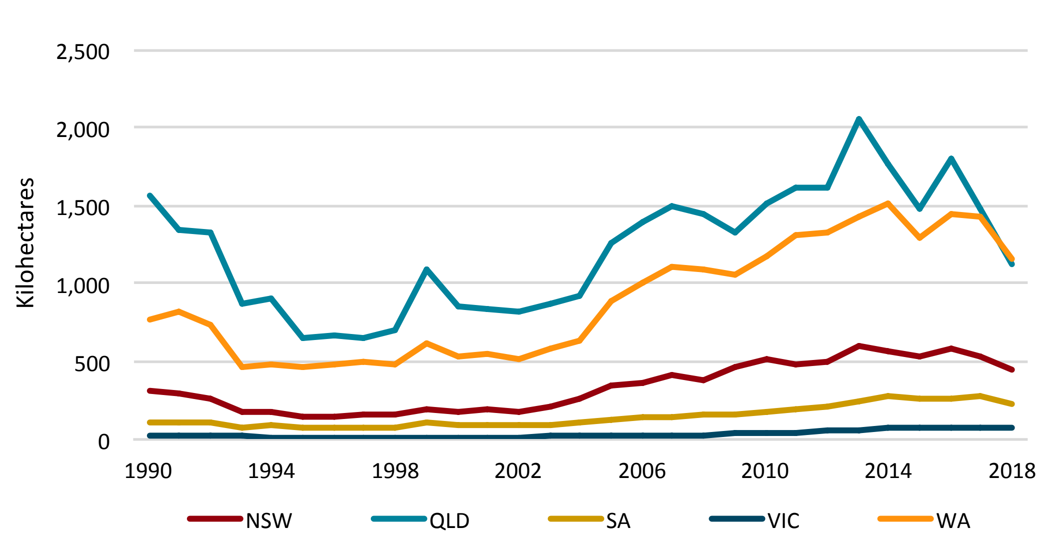
For Queensland, during the 1990-2018 period, clearing went from 426 thousand hectares to 39 thousand hectares, the largest change by state; reclearing went from 214 thousand to 215 thousand hectares, nevertheless fluctuating during the period with a peak in 2006, at 310 thousand hectares and again in 2016, at 299 thousand hectares; and regrowth growing from 150 thousand hectares to 195 thousand hectares, with a peak in 2014 at 376 thousand hectares.

Finally, Western Australia had forest clearing go from 13 thousand hectares in 1990 to 0 thousand hectares in 2018; reclearing go from 7 to 6 thousand hectares, reaching a peak in 2006 at 18 thousand hectares and again in 2014 at 17 thousand hectares; with forest regrowth going from 5 thousand hectares in 1990 to 9 thousand hectares in 2018, reaching a peak in 2012, with 24 thousand hectares.

Sparse woody vegetation, defined as woody vegetation with a canopy cover between 5-19%, has experienced increasing losses during the 1990-2018 period, peaking in 2013 and 2014 led by losses exceeding 2,000 kilohectares in Queensland and 1,500 kilohectares in WA (Figure 14).

FIGURE 14

Net sparse woody vegetation losses, by select states, 1990-2018



Source: Bankwest Curtin Economics Centre | Australian Greenhouse Emissions Information System (AGEIS), Department of Industry, Science and Energy and Resources, Australian Government.

Areas burned in temperate forest due to wildfires were on a noticeable rising trend in WA and Queensland by 2018, in mirror image of prescribed burning, which was on a steady decline in both states during the same period (Figure 15).

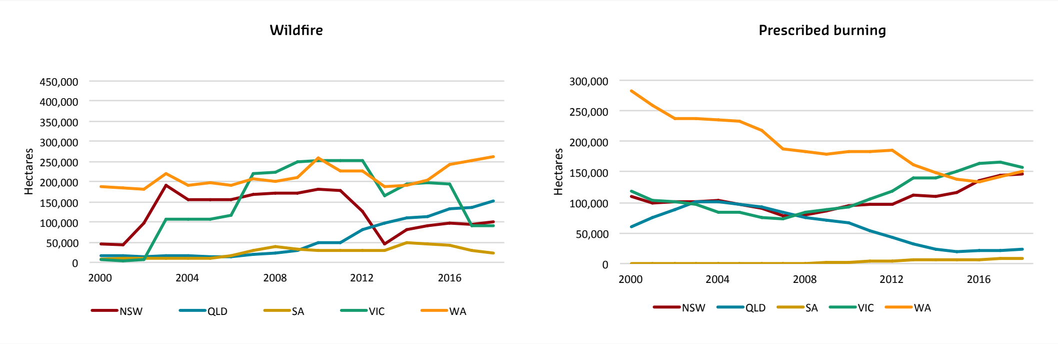
In WA, the ten-year running average of temperate forest burned in wildfire amounted to 196,000 hectares in 2000, compared to 262,000 hectares in 2018. This followed an opposite trend to prescribed burning, which decreased from a ten-year running average of 283,000 hectares in 2000 to less than 150,000 hectares in 2018.

For Queensland, temperate forest burned by wildfires went from a ten-year running average of 17,100 hectares in the year 2000 to nearly 152,000 hectares in 2018. Conversely, while prescribed burning was at 61,200 hectares in 2000, it decreased to less than 24,000 hectares in 2018.

Areas burned in temperate forest due to wildfires were on a noticeable rising trend in WA and Queensland by 2018, in mirror image of prescribed burning, which was on a steady decline in both states during the same period.

FIGURE 15

Areas burned in temperate forest, ten year running average, by select states, 2000-2018



Source: Bankwest Curtin Economics Centre | Australian Greenhouse Emissions Information System (AGEIS), Department of Industry, Science and Energy and Resources, Australian Government.

Fertiliser use is on a steady rise in Australia, appearing to go hand in hand with the proliferation of non-irrigated crops, especially in WA, where fertiliser use increased fourfold between 1990 and 2018.

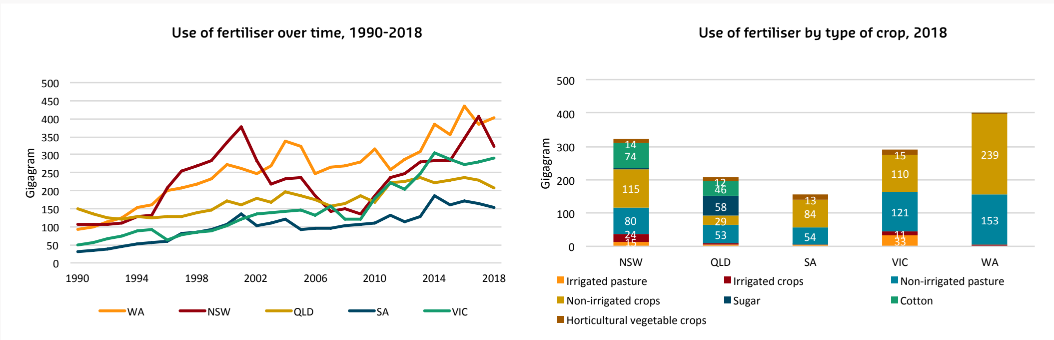
A similar trend arose with areas of grassland and non-temperate forest burned, led by the Northern Territory, Western Australia and Queensland. The ten-year running average for the Northern Territory grew from 13.7 million hectares in 2000 to 18.3 million hectares in 2018. In Western Australia, the figures grew from 10.3 million hectares to 16.2 million hectares in the same period; while Queensland had an increase from 6.3 million hectares to 10.5 million hectares.

Along with air pollution through greenhouse gas emissions, agriculture can have negative environmental impacts through the use of fertilisers. Fertilisers affect the physical and chemical properties of soil and create water pollution due to runoff. It is due to this that countries like Germany, for instance, set a minimum distance or buffer zone between water bodies and the areas where fertiliser may be used.[46] Moreover, over-abstraction and lower rainfall may exacerbate the issue due to reduced dilution capacity. Coastal water areas like the Great Barrier Reef are especially affected by this type of accumulation, being downstream from large agricultural zones.[47]

Fertiliser use is on a steady rise in Australia, appearing to go hand in hand with the proliferation of non-irrigated crops, especially in WA, where fertiliser use increased fourfold between 1990 and 2018, going from 93 gigagrams to 401 gigagrams during the period [Figure 16]. Western Australia is closely followed by New South Wales, which saw an increase from 107 to 324 gigagrams; Victoria, with an increase from 50 to 291 gigagrams; Queensland, with an increase from 151 to 209 gigagrams; and South Australia, with an increase from 31 gigagrams in 1990 to 154 gigagrams in 2018.

FIGURE 16

Use of fertilisers over time and by type of crop, by select states, 1990-2018



Source: Bankwest Curtin Economics Centre | Australian Greenhouse Emissions Information System (AGEIS), Department of Industry, Science and Energy and Resources, Australian Government.

46 OECD. (2013). "Policy instruments to support green growth in agriculture". OECD Green Growth Studies. OECD Publishing. p. 56.

47 OECD. (2019). "OECD Environmental Performance Reviews: Australia 2019". OECD Environmental Performance Reviews. Paris: OECD Publishing. p. 91.

In 2018, the largest share of fertilisers used in Western Australia went to non-irrigated crops, at 239 gigagrams, followed by non-irrigated pasture at 153 gigagrams. Combined, horticultural vegetable crops, irrigated crops and irrigated pasture amounted to 8 gigagrams.

For New South Wales, the main uses of fertiliser in 2018 were non-irrigated crops, with 115 gigagrams; followed by non-irrigated pasture, at 80 gigagrams; cotton, at 74 gigagrams; and irrigated crops, at 24 gigagrams. In Victoria, the main fertiliser use was non-irrigated pasture, at 121 gigagrams; followed by non-irrigated crops, at 110 gigagrams; and irrigated pasture, at 33 gigagrams. In Queensland, sugar plantations have the largest share of fertiliser used, at 58 gigagrams; followed by non-irrigated pasture, at 53 gigagrams; cotton, at 46 gigagrams; and non-irrigated crops, at 29 gigagrams. In the case of South Australia, fertiliser is mainly used in non-irrigated crops, at 84 gigagrams; and non-irrigated pasture, at 54 gigagrams –a similar share to WA, albeit to a smaller scale.

Although continued application of fertilisers may not necessarily increase yields, it does create more contamination and production costs.[48] The intensification of agricultural production can in this way lead to adverse effects on the environment, soil and water quality –both marine and freshwater– and biodiversity.

48 OECD. (2016). "Farm management practices to foster green growth". OECD Green Growth Studies. Paris: OECD Publishing. p. 23.

Australia's flora and fauna face biodiversity pressures from all economic sectors.

Biodiversity loss

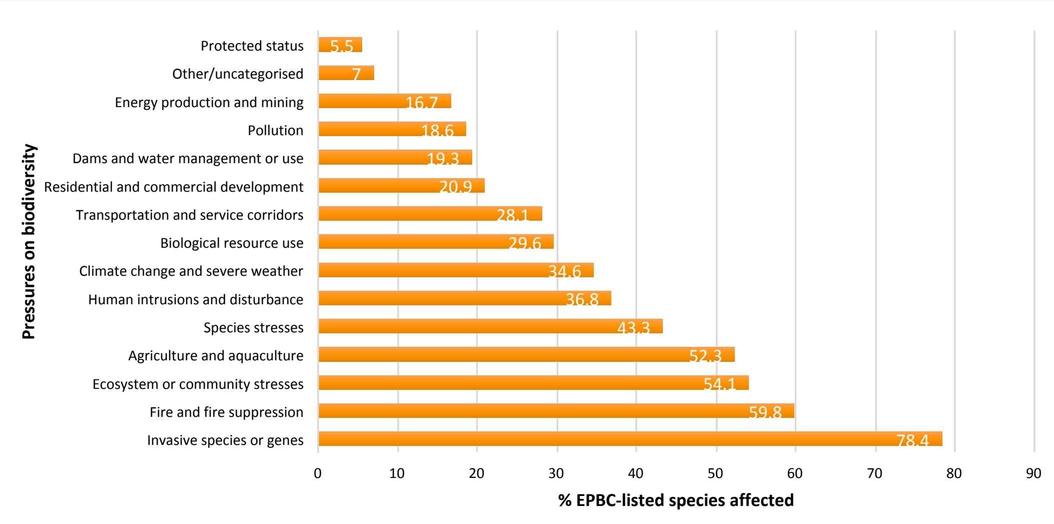
Australia –one of 17 megadiverse countries in the world– is responsible for around 10% of the biodiversity of the planet. It is home to nearly 700,000 native species, out of which 85% are unique to the country.[49] As previously mentioned, this level of natural wealth provides great opportunities, but there is also much to lose. In 2017, Australia was found to have the second highest rate of biodiversity deterioration in the world, just behind Indonesia.[50]

The pressures on Australia's biodiversity are wide-ranging, and the flora and fauna listed on the *Environment Protection and Biodiversity Conservation (EPBC)* Act face many threats (Figure 17).

The top five threats are invasive species, affecting almost four out of five EPBC-listed species; fire and fire suppression, affecting three out of five; ecosystem and community stresses (such as habitat fragmentation or degradation) affecting more than half of species, as do agriculture and aquaculture; and species-specific stresses, affecting more than two out of five. This is followed by human intrusions and disturbance (37%); climate change and severe weather (35%); biological resource use (30%); transportation and service corridors (28%); residential and commercial development (21%); dams and water management use (19%); pollution (19%); energy production and mining (17%); along with other reasons (7%) or protected status (6%).

FIGURE 17

Pressures on Australia's biodiversity



Note: Fire suppression activities often involve land clearing, and some species depend on fire. Ecosystem or community stresses include restricted geographical distribution; loss and/or fragmentation of habitat; decline in habitat quality; and habitat deterioration due to soil degradation and erosion.
Source: Bankwest Curtin Economics Centre | Bankwest Curtin Economics Centre | OECD Environmental Performance Reviews: Australia 2019. StatLink - https://doi.org/10.1787/888933889761.

49 Australian Government Department of Agriculture, Water and the Environment. (2020). "Australia's Sixth National Report to the Convention on Biological Diversity. 2014-2018". 24 March. p. 160.

50 OECD. (2019). "OECD Environmental Performance Reviews: Australia 2019". *OECD Environmental Performance Reviews*. Paris: OECD Publishing. p. 175.

Land use, land-use change and forestry are underlying components in many of these areas, representing the possibility to either improve biodiversity or contribute to its pressures, since loss of natural and semi-natural vegetated land can be used as a proxy for pressures on biodiversity and ecosystems.

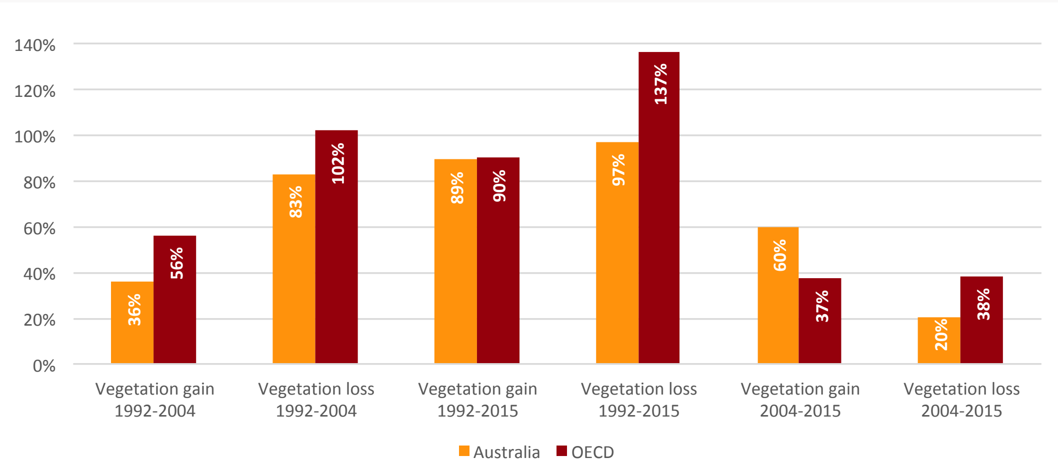
The Australian Government estimates that only around 25% of Australia's vegetation cover remains intact, with 62% subject to varying degrees of disturbance and modification and 13% completely converted to other land uses. Furthermore, even the vegetation cover that has gone unmodified or partially modified is in variable conditions, since clearance has not been evenly spread across the country. This leads some ecological communities now being highly fragmented, and others occupying less than 1% of their original territory.[51]

Both in Australia and in the OECD, the extent of vegetation loss between 1992 and 2015 has been larger than that of vegetation gain when land cover changes are compared, particularly from 1992 to 2004 (Figure 18). For Australia, a vegetation loss of 97% in land cover change was met with a vegetation gain of just 89% between 1992-2015; in the OECD, a vegetation loss of 137% was met with a vegetation gain of just 90% during the same period, with the situation nevertheless improving during the second part of the period, between 2004 and 2015.

Only around 25% of Australia's vegetation cover remains intact, with 62% subject to varying degrees of disturbance and modification and 13% completely converted to other land uses.

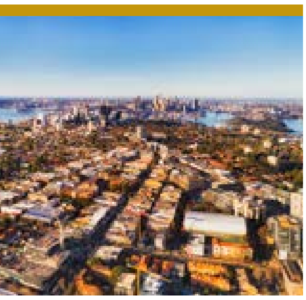
FIGURE 18

Land cover change, Australia and OECD, 1992-2015



Source: Bankwest Curtin Economics Centre | Bankwest Curtin Economics Centre | OECD 2020, Land cover change (indicator). doi: 10.1787/3dee7330-en. Loss of natural and semi-natural vegetated land includes tree cover, grassland, wetland, shrub land and sparse vegetation converted to any other land cover type. Gains of natural and semi-natural vegetated land are conversions in the opposite direction. The denominator used is the 'stock' of natural and semi-natural land at the start of the period.

51 Australian Government Department of Agriculture, Water and the Environment. (2020). "Australia's Sixth National Report to the Convention on Biological Diversity. 2014-2018". 24 March. p. 160.

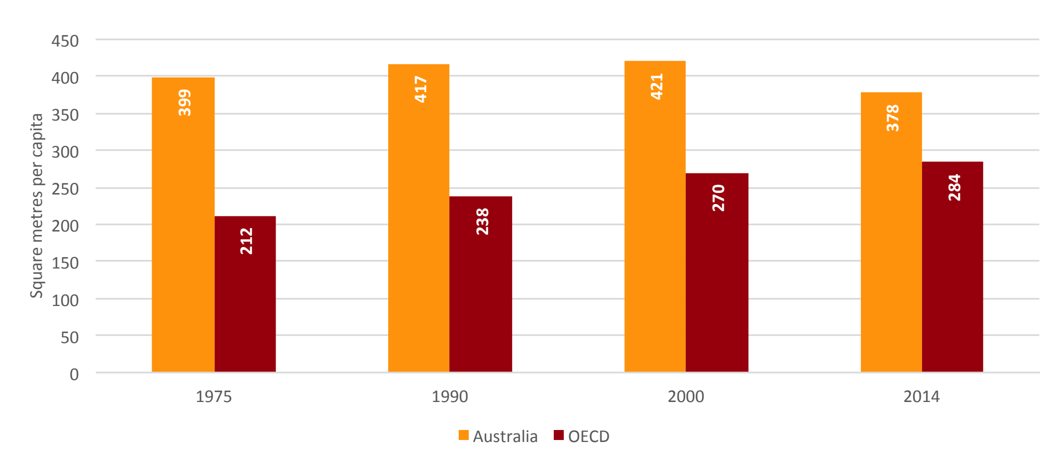


Australia's built-up area per capita - square metres of built structures per capita - is 33% higher than the OECD average.

Residential and commercial developments, and the transportation and human intrusion and disturbance that come with them, are some of the main pressures on Australian biodiversity. In 2014, Australia's built-up area per capita –that is, square metres of built structures per capita– was 33% higher than the OECD average (Figure 19). Built-up area per capita rose in Australia from 1975 to 2000, going from 399 square metres per capita to 421 square metres per capita, before starting to decline, landing at 378 square metres per capita in 2014. This is partly due to population growth, as the built-up area as a percent of total land area in fact increased from 0.07% to 0.12% between 1975 and 2014. The OECD average also increased throughout the period, going from 212 square metres per capita in 1992 to 284 square metres in 2014, with built-up area as percentage of total land area rising from 0.58% to 1.06%.

FIGURE 19

Built-up area per capita, Australia and OECD, 1975-2014



Source: Bankwest Curtin Economics Centre | OECD 2020, Built-up area (indicator). Doi: 10.1787/7c06b772-en. "Built-up area" is defined as the presence of buildings (roofed structures). This definition largely excludes other parts of urban environments or human footprint such as paved surfaces (roads, parking lots), commercial and industrial sites (ports, landfills, quarries, runways) and urban green spaces (parks, gardens).

VALUING OUR BIODIVERSITY

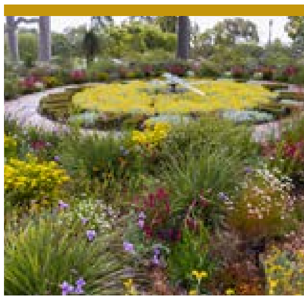
Western Australia has more than 12,800 vascular plant species and contains over half of Australia's known flowering plants. The southwest botanical province is a global biodiversity hotspot with nearly 80% of its species endemic, and the 'super rich' Fitzgerald River National Park area alone has over 1,800 species. WA also has 220 of Australia's 305 mammal species, 34 of which are endemic, 5,120 reptile species (187 endemic) and 3,028 fish species.[52, 53]

At the same time our economy is driven by resource extraction. We are one of the world's largest exporters of iron ore and natural gas, and are now expanding into lithium and rare earth metals to meet growing global battery demand. Taken with a large agricultural export sector, ongoing population growth, urban and industrial expansion, we face significant challenges balancing our economy and living standards against the need to protect and conserve our environment.

Existing environmental impact assessment processes have become more complex and time consuming as our knowledge of environmental threats have grown. At the same time regulatory oversight is usually limited to the footprint of each individual proposal for development, without consideration of the cumulative impacts across existing industries. As a consequence, huge amounts of data on threatened species and vulnerable ecosystems is collected every year by industry proponents and ecological consultants, but the coverage is patchy, data and methods can vary widely, and the information is seldom connected up to provide a comprehensive picture at an ecological community or bioregional level.

Western Australia is looking to develop and trial a digital environmental assessment model that enables strategic assessment of cumulative regional impacts. With the support of industry, the state can develop and legislate a regulatory model that puts in place a shared analytic framework of the environment and provides access to common data tools and protocols – so that all environmental assessment data is joined up, shared and accessible ... and of a known, and increasingly high quality (WABSI 2019).[54]

The end result should give WA the best of both worlds – reducing the time and cost of environmental approval processes and ongoing reporting, while ensuring better understanding and management of threatened ecosystems, identification of cumulative impacts, and delivering better environmental outcomes.



Western Australia has more than 12,800 plant species and contains over half of Australia's known flowering plants.

To address the pressures on biodiversity through coordinated global action, United Nations member countries agreed in 2010 to the Strategic Plan for Biodiversity 2011-2020, under the Convention on Biological Diversity. The strategy is built on 20 GSPC Biodiversity Targets (known as the Aishi targets) to be achieved by 2015 and 2020. However, in its 2020 assessment, the Convention finds that none of the 20 targets have been fully achieved by the international community, and only six targets had partial achievements. The rate of biodiversity decline has increased to an unprecedented rate, with pressures intensifying; as a zoonotic disease, the

52 Wege, J.A. & Shepherd, K.A. (2020). 50 years of botanical discovery: a golden anniversary edition of Nuytsia, the journal of the Western Australian Herbarium. Nuytsia, 31: 1-7.

53 Beard, J.S., Chapman, A.R. & Gioia, P. (2000). Species richness and endemism in the Western Australian flora. Journal of Biogeography 27: 1257–1268.

54 WABSI (2019). Digitally Transforming Environmental Assessment: Leveraging digital information to streamline environmental assessments and approvals. Report of the Digital Environmental Impact Assessment Working Group. The Western Australian Biodiversity Science Institute, Perth WA. (In partnership with the Western Australian Marine Science Institution).

The share of protected land area in Australia went from 1.1% in 1970 to 19.2% in 2020; protected marine areas went from 0% to 41% in the same period, driven by changes in the last decade.

Severe climate-driven mass coral bleaching events have affected around 80% of the coral reef area of the Great Barrier Reef.

report notes, COVID-19 is an additional reminder of the consequences of biodiversity loss and the degradation of ecosystems.[55]

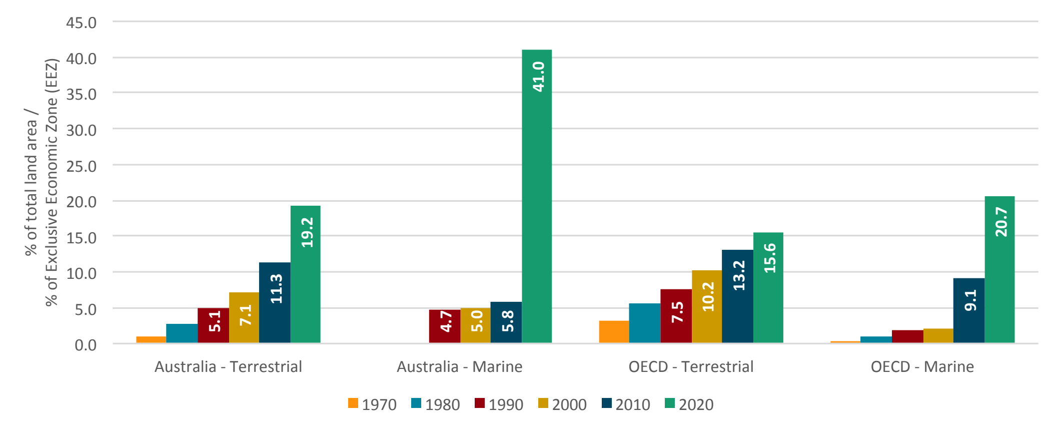
From amongst the six targets with partial achievements, Australia in fact exceeded Aishi target 11, calling for the protection of at least 17% of terrestrial areas and 10% of marine areas by 2020. Similar to OECD trends, the share of Australia's protected areas had been slowly rising since the 1970s, picking up pace between 2010 and 2020 (Figure 20). The share of protected land area in Australia went from 1.1% in 1970 to 19.2% in 2020; protected marine areas went from 0% to 41% of its Exclusive Economic Zone in the same period,[56] mainly due to an increase from 11% to 41% between 2017 and 2018. After having lagged behind the OECD average, these gains now place Australia above it. In 2020, 16% of OECD terrestrial areas and 21% of marine areas have protected status.

The Australian Government has noted that the country's achievement of target 11 was facilitated in part by giving recognition to the important role Indigenous Australians play in caring for country, managing many of these unique and significant areas.[57] This is reflective of Aishi target 18, which calls for the incorporation of traditional knowledge, innovations and practices of indigenous and local communities, reflected in national legislation and in effective inclusion.

Although the level of protected areas was achieved by Australia, a related target, Aishi target 10 –for the protection of coral reefs and vulnerable ecosystems impacted by climate change and ocean acidification– was missed by both the 2015 and the 2020 deadlines. Australia's coral reefs have been adversely impacted by cyclones and severe climate-driven mass coral bleaching events, affecting an estimated 80% of the coral reef area of the Great Barrier Reef Marine

FIGURE 20

Protected areas, Australia and OECD, 1970-2020



Source: Bankwest Curtin Economics Centre | OECD 2020, Protected areas (indicator). Doi: 10.1787/112995ca-en. This dataset provides country-level protected area coverage for the terrestrial and marine domains calculated from the World Database on Protected Areas (WDPA). The exclusive economic zone (EEZ) of a country extends 200 nautical miles from the coastline, or to the mid-point between coastlines where the EEZ of different countries would otherwise overlap.

55 Secretariat of the Convention on Biological Diversity. (2020) "Global Diversity Outlook 5". Montreal. pp. 8-17.

56 OECD data accessed on September 2020. March 2020 reporting by the Australian Government places the 2020 share of marine area protection at 37% rather than 41%. Australian Government Department of Agriculture, Water and the Environment. (2020). "Australia's Sixth National Report to the Convention on Biological Diversity. 2014-2018". March. p. 161.

57 Australian Government Department of Agriculture, Water and the Environment. (2020). "Australia's Sixth National Report to the Convention on Biological Diversity. 2014-2018". March. p. 161.

Park.[58] Overall, the UN cautions, there is an increasing threat of extinction, particularly if protected areas are not those with highly biodiverse environments.[59] The multifaceted nature of biodiversity pressures is evidenced in the need for a comprehensive approach to tackle these pressures.

In 2015, almost one third of known mammal species in Australia were critically endangered, endangered or vulnerable, along with 17% of bird species and 7% of plant species (Figure 21). This is a stark number of species given Australia's megadiversity, and the amount of species yet to be catalogued or discovered –if time remains.

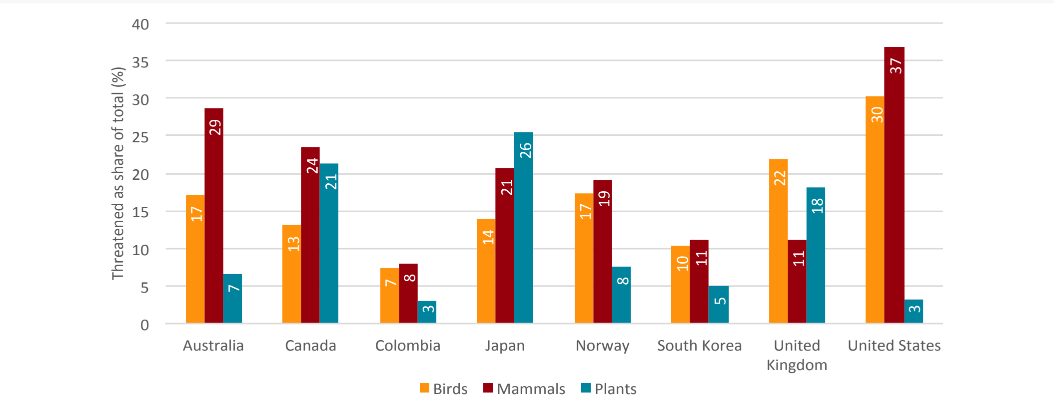
Threats to Australia's fauna and flora are also particularly relevant to WA, having nearly three quarters of Australia's mammal species –many unique to the state – and its even more unique and diverse flora, with up to 80% plant species existing only in WA; as well as its diverse reptile, fish, and invertebrate populations.[60]

One of the challenges in analysing the country's biodiversity trends is that data and monitoring are carried out in fragmented sources, and across different entities and levels of government. In its 2019 environmental review of the country, the OECD advised filling gaps in data on the status and trends of species and ecosystems, as well as the establishment of national biodiversity indicators to facilitate progress measurement. Broadly, the Organisation recommended more investment in biodiversity conservation and ecological restoration, at a level that is commensurate with the scale of the issue.[61]

In 2015, almost one third of known mammal species in Australia were critically endangered, endangered or vulnerable, along with 17% of bird species and 7% of plant species.

FIGURE 21

Threatened species as share of total, select countries, 2015



Source: Bankwest Curtin Economics Centre | OECD 2020, Threatened species (indicator). Doi: 10.1787/70964619-en. Number of threatened mammal species expressed as percentage of total known species. The threatened category refers to critically endangered, endangered and vulnerable species, that is those plants and animals that are in danger of extinction or likely soon to be.

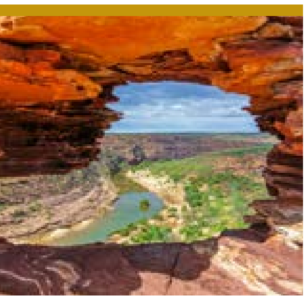
58 Australian Government Department of Agriculture, Water and the Environment. (2020). "Australia's Sixth National Report to the Convention on Biological Diversity. 2014-2018". March. p. 94.

59 United Nations Department of Economic and Social Affairs (2020), "Policy Brief #81: Impact of COVID-19 on SDG progress: a statistical perspective," 27 August, https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-81-impact-of-covid-19-on-sdg-progress-a-statistical-perspective/.

60 Government of Western Australia. Department of Biodiversity, Conservation and Attractions. "Plants and animals". https://www.dpaw.wa.gov.au/plants-and-animals.

61 OECD. (2019). "OECD Environmental Performance Reviews: Australia 2019". *OECD Environmental Performance Reviews*. Paris: OECD Publishing. p. 3.

WATER USE



The scarcity of water combined with climate change is increasing concerns about water security.

Western Australia is one of the driest regions on earth. In the state's most populated region – the South West - rainfall is concentrated in winter periods but scarce in summer and has been reducing over time. Crucially, the South West of WA has seen what may well be the earliest and most dramatic impacts of climate change on rainfall and water supply on Earth, with a significant step change in historic rainfall and runoff in the mid Seventies (Figure 23) precipitating a water supply crisis in metropolitan Perth. This led to water restrictions and the development of alternative water supplies (particularly groundwater use, then later desalination and wastewater recycling).

The scarcity of water combined with climate change is increasing concerns about water security. Managing our water to guarantee all economic agents including the environment receive an adequate share of our water resources is key for a sustainable future. But creating a management plan that responsibly allocates water can be difficult. This is evidenced by the challenges that management of the Murray-Darling Basin (MDB) has and continues to grapple with, where valuable and intricate water systems spanning five states and territories have been the subject of countless highly contested negotiations, plans and allocations. In WA, the Fitzroy River water allocation plan presents a similar challenge and much can be learnt from poor management practices of the MDB. Environmentally, one of the biggest challenges for the Fitzroy River will be to ensure enough water is retained to allow significant downstream flows.

WA's water resources

Rainfall

As temperatures rise weather patterns change from one region to another. The average model predicts that drier places will become drier and wet places will become wetter. With this in mind, Western Australia is set be one of the worst affected regions on earth as a consequence of climate change, with an average decrease in rainfall of 10% to 20% in the South West of WA since the 1970.[62] WA has already started seeing the consequences of climate change, with increased severe cyclone activity in the north and a shorter rain season in the south.[63]

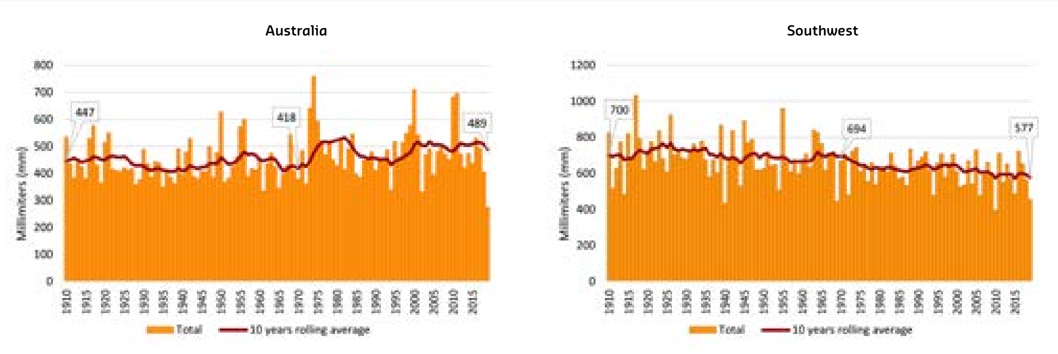
Figure 22 shows the average rainfall per year in Australia and in the South West of WA. Australia's rainfall patterns do not seem to have changed significantly. We observe that, in the 1910s, the ten year rolling average of rainfall (maroon line) was around 450mm. This figure has remained relatively stable all the way through 2019, where the ten year average reached 489. However, the distribution of rain has changed, with some areas recording slight increases in average rainfall like the north of Australia and others a decrease, such as the South West of WA.

62 Recent rainfall, drought and southern Australia's long-term rainfall decline (2015). Bureau of Meteorology, Australian Government.

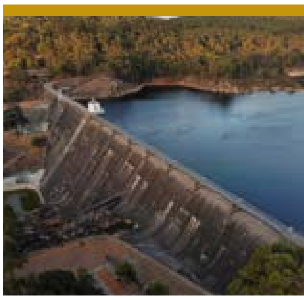
63 Climatology of tropical cyclones in Western Australia Bureau of Meteorology, Australian Government. http://www.bom.gov.au/cyclone/climatology/wa.shtml.

FIGURE 22

Average annual rainfall, Australia and Australian Southwest, 1910-2019



Source: Bankwest Curtin Economics Centre | Authors' calculations based on the Climate change trends and extremes, Bureau of Meteorology, Australian Government.



Since the 1970s, there has been a 17% decline in average rainfall in the South West.

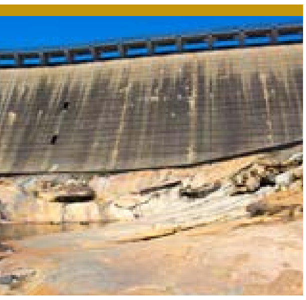
Over the last 100 years, there has been a significant decrease in rainfall in the South West of WA, especially since the 1970s. In the 1910s, the ten year rolling average was close to 700mm, much higher than the Australian mean, decreasing only by 4mm by 1970. Since then, there has been a steep decline in rainfall in the region and in 2019 only 577mm of rain fell in the South West. This implies a 17% decline in rainfall since the 1910s.

The magnitude of rainfall decline is concerning for a number of reasons. First and foremost, the survival of our fragile ecosystem largely depends on the quantity and frequency of water available. As average temperatures increase along with the frequency of extreme weather events, including heatwaves, most plants and animals are likely to need water more to cope at the same time that evaporation of open water sources means water is lost more quickly.

Secondly, rainfall becomes runoff that feeds our streams and fills our dams, and soaks through the soil to recharge subterranean aquifers on which we have become increasingly reliant. When there is less rain, but particularly less large winter rainfall events in the South West, the ground and plants soak up more so that much less runoff flows into streams and dams. This has meant that a 23% decline in rainfall to Perth catchments translated into a 65% decrease into runoff into Perth dams in recent decades (Swan River Trust).

Multiple factors have contributed to the decrease in rainfall, with increasing GHG emissions and climate change the core driver. Deforestation of native forests have also contributed to lower rainfall through the last century. Indeed, it is estimated that 55% to 62% of the decline in rainfall in the South West of WA is due to land clearing alone.[64] This is why preserving our water resources is necessary to curb our GHG emissions trajectory to prevent further increases in the earth's temperatures. But deforestation of native forest also needs to stop and the surface of the vegetation needs to increase. This measure alone will greatly affect the amount of rain water collected in our rivers.

64 Andrich, M. A., & Imberger, J. (2013). The effect of land clearing on rainfall and fresh water resources in Western Australia: a multi-functional sustainability analysis. International Journal of Sustainable Development & World Ecology, 20(6), 549-563.



Between 1920 and 1980 an average of 400gL of streamflow ran into Perth dams, almost 6 times more than in the last decade.

Streamflow

Streamflows are directly affected by the quantity of rain that flows into rivers. Most of Australia relies on streamflow's for drinking water, crop irrigation and industry processes. According to the Bureau of Meteorology, 66% of the streamflow gauges in Australia recorded lower than average annual flows in 2018-19.[65] Further, one quarter of all sites in NSW, ACT and SA recorded the lowest streamflow in history in that same year and record lows in the lower Darling river were responsible for fish deaths in the 40km up to Menindee Lakes.[66]

Commensurate with the decline in rainfall, Western Australia has also observed a reduction in streamflows over time. Figure 23 shows the level of streamflows running into the Integrated Water Supply Scheme (IWSS) of the Water Corporation between 1920 and 2019. It comprises the dams that feed Perth, Goldfields and Agricultural Region and some parts of the South West.

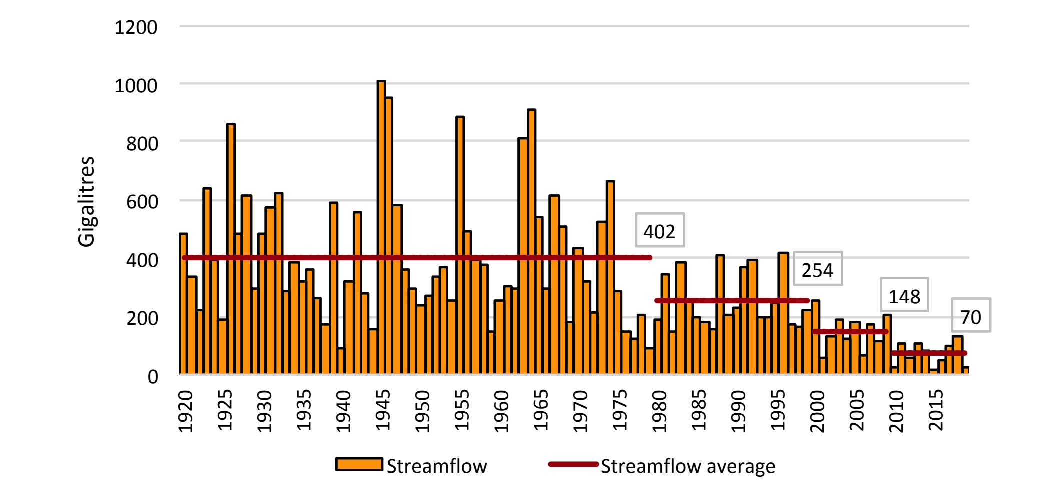
The maroon line shows the period average between 1920 to 1980, 1980 to 2000, 2000 to 2010 and 2010 onwards.

The difference between these four periods is striking. During 1920 to 1975, around 400gL of water ran into West Australian dams. This amount decreases as time goes by and has now reached an average of merely 70gL in the last decade (2010-2019). This means that there was on average almost 6 times more streamflow between 1920 and 1980 than during the last decade.

As a consequence, Perth has had to diversify into other sources to meet demand for water. Groundwater (bores) has replaced surface water (dams) as the main source of our water supply, with a growing proportion supplemented by desalination of seawater. However, this has come at a cost, as these two sources of water are much more energy intensive than surface water.

FIGURE 23

Streamflow running into dams of Perth, Goldfields and Agricultural Region and some parts of the South West, 1920-2019



Source: Bankwest Curtin Economics Centre | Authors' calculations based on the Climate change trends and extremes, Bureau of Meteorology, Australian Government.

65 Water in Australia, 2018-19. Bureau of Meteorology.
66 Water in Australia, 2018-19. Bureau of Meteorology.

Another consequence of low flows in WA rivers is the increasing salinisation of fresh water streams. Indeed, low rainfall affects not only the streams levels but also the quality of the water. When rivers run at high levels, the minerals and salts naturally present are diluted with water and the salinity rate is reduced. This makes water easier to treat to drinkable standards.

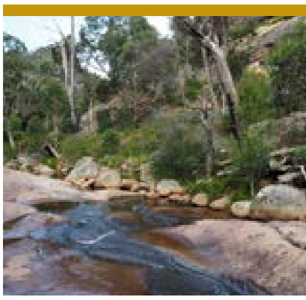
Western Australian rivers naturally have a higher concentration of salinity compared to the rest of Australia. Earlier research has shown that more than half of the rivers in the state have marginal, brackish or saline quality and only 44% of the South West rivers remain fresh.[67] Furthermore, the clearing of large sections of land for agriculture through the Wheatbelt region led over time to rising water-tables, mobilising geological salt layers trapped underneath ancient soils, resulting in rising salinity and degraded landscapes. The salinity of WA rivers has increased in 66% of the rivers studied between 1993-2002 relative to 1983-1992. For instance in 2018-19, measures of the Bureau of Meteorology (BOM) show that, in Australia, 18% of sites[68] were brackish or saline while almost three quarters of sites in WA reached similar conditions.[69]

Other events affect the quality of rivers and streams. Among those, agriculture animal husbandry activity has a large impact on the quality of water courses. Changes in landscape due to the clearing of perennial vegetation, as well as the use of chemicals and fertilisers in dryland and irrigated agriculture, have increased both the salinity and pollution of the river flows and catchment areas.

Fertilisers add a significant amount of nutrients to the water and in large quantities can increase the reproduction of algal blooms. Algal blooms absorbs large quantities of oxygen in the water which can cause the death of fish and other species.

The Western Australian government has started multiple initiatives to manage this problem. The Regional Estuaries Initiative (REI) and the Revitalising Geographe Waterways (RGW) are programs aiming to increase the quality of water and decrease the quantity of nutrients in the catchment area. The RGW program delivered interesting results since it managed to decrease by 75% the amount of nutrients entering the Geographe Catchment waterways.[70] Another promising initiative is the trial of algal-bloom preventing clay in the Serpentine river put in place on March of this year.[71]

These initiatives offer solutions that could be expanded to other estuaries across WA to help manage the quality of the water and the amount of nutrients in the water. Other initiatives such as a "nutrient trading scheme" have been put in place in countries such as New Zealand to prevent fertiliser entering water systems. The idea is to fix a maximum amount of nutrients that can leach into the catchment's water and then divide quotas between farmers that can then be traded. This scheme has proven successful in decreasing water pollution from agriculture activities.[72]



Half of the rivers in the state have marginal, brackish or saline quality and only 44% of the South West rivers remain fresh.

In Australia, 18% of water sites are brackish or saline while almost three quarters of sites in WA reached similar conditions.

67 Stream salinity status and trends in south-west Western Australia. Salinity and land use impact. Department of Environment, Government of Western Australia. 2005.

68 BOM collects information on river salinity by surveying multiple streamflow and rivers sites.

69 Water in Australia, 2018-19. Bureau of Meteorology.

70 Annual report 2019-10. Department of Water and Environmental Regulation. Government of Western Australia.

71 Annual report 2019-10. Department of Water and Environmental Regulation. Government of Western Australia.

72 Samarasinghe, O., Daigneault, A., Greenhalgh, S., & Sinclair, R. (2011). Modelling economic impacts of nutrient reduction policies in the Hurunui Catchment, Canterbury. In New Zealand Association of Economists Annual Meeting, Wellington, New Zealand (Vol. 29).

During 2018-19, between 60% to 80% of WA's groundwater was below average levels.

The quality of our streamflow is paramount for our survival and an ecosystem's health. To improve water quality, the WA should invest in re-vegetation, improve farming techniques and allow sufficient flow of streams whenever possible. Monitoring the health of our rivers should also be a priority and initiatives such as the Water Quality Australia website are a first step in the right direction.

Groundwater

Water security could not be achieved in Australia without the utilisation of groundwater resources. Rural and remote areas rely heavily on this asset, not only to fulfil households' needs but also to provide industry with a reliable supply of water. It has been estimated that at least one-fifth to one-third of water supply comes from groundwater sources.[73]

This is even more significant for WA, where 40% to 50% of water is sourced from groundwater aquifers to meet the demand from industry, public and household sectors.[74]

The Gnangara groundwater system stretches over 2,200 square kilometres and is composed of three large aquifers: the Leederville and Yarragadee deep aquifers and the superficial aquifer of the Gnangara mound. Along with the smaller Jandakot system, south of the river, these provide the largest share of Perth's groundwater. The increasing extraction of groundwater, along with declining rainfall, has caused a fall in groundwater levels and the drylands of wetland vegetation.[75] Furthermore, if groundwater levels and flows are low, salinity can infiltrate, which is already happening in some lower (shallower) aquifers inland.

The level of groundwater is measured by the maximum level observed in a bore during over a year in comparison to a five year average. This comparison gives an indication of whether groundwater is rising, stable or declining.[76] Figure 24 displays the groundwater level status and trends by state in 2018-19 financial year. Aquifers are divided into three types - lower, middle and upper according to the national aquifer framework. These classifications are based on grouping hydrogeological units.

Overall, we observe that Western Australia has a larger share of lower than average groundwater levels. In WA, during 2018-19, between 60% to 80% of our groundwater was below the average level. Furthermore, more than 40% of our lower aquifers have a declining trend while less than 10% of middle and upper aquifers follow the same fate. WA situation is not as dire as that of NSW, where over 80% to 90% of the aquifers have below average levels, but WA does place second immediately after them. Indeed, the health of our aquifer system is in worst shape than in most places of Australia. This is particularly concerning given that a larger share of our domestic and industrial water supply depends on groundwater extraction (See Chapter 3). However, according to the Bureau of Methodology, the level of the bores, even if still low, have increased over the last three years in the South West mainly due to higher precipitations and the groundwater of the Perth's aquifers reordered its highest peak of the past nine years.[77]

The Western Australian government started a consultation process at the end of 2018 that aims to restore the balance of the Gnangara system. New allocation limits and a renewed water allocation plan are the main measures being discussed under this plan.

73 Water in Australia, 2018-19, Bureau of Meteorology, Australian Government.

74 Please refer to Chapter 3 for a detailed explanation.

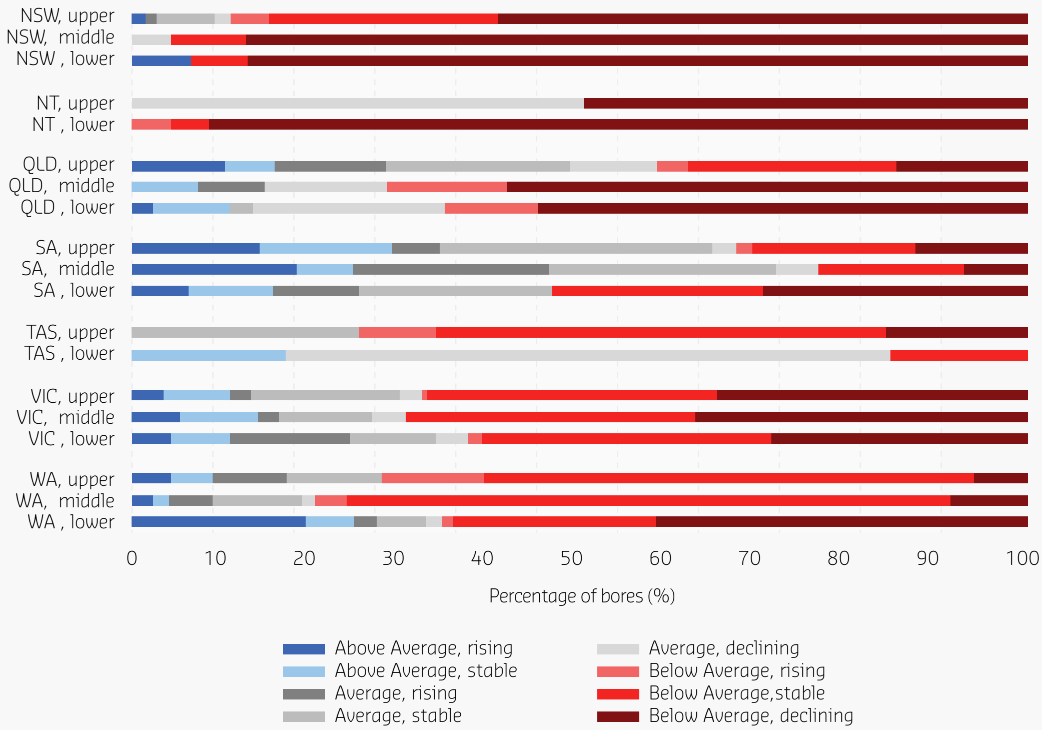
75 Our groundwater future in Perth: Securing Gnangara groundwater and adapting to climate change. Government of Western Australia, Department of Water and Environmental Regulation. May 2018.

76 Water in Australia, 2018-19, Bureau of Meteorology, Australian Government, p.32.

77 Water in Australia, 2018-19, Bureau of Meteorology, Australian Government.

FIGURE 24

Groundwater level status and trends by states, 2018-19



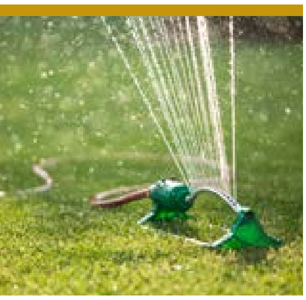
Source: Water in Australia, 2018-19, Bureau of Meteorology, Australian Government.

This is necessary to guarantee the protection of the aquifer system and ensure a secure water future (See more details in Chapter 3 – Water management).

Even though we do not yet fully know the extent of degradation of Perth groundwater resources, other measures can also enhance behavioural change. First, data on domestic and industrial bore water wells should be collected. Currently, only bores in confined or artisan aquifers and those irrigating an area larger than 0.2 hectares require a licence and therefore were accounted for in the system.

Having a complete overview of the actors in the system is necessary to deliver efficient public policy. It is estimated that around a quarter of households in Perth use bore water, which is extracted free of charge.[78] The government should tax or limit the usage of groundwater from the public if necessary. To some extent, farmers and industry are already under some sort of water limitation usage or cost. However, given the current imbalance of our groundwater system, these quotas should be expanded and prices increased to achieve and a sustainable water supply in WA future.

78 https://www.water.wa.gov.au/urban-water/bores.



Water consumption in Australia grew by 29% over the last decade. In WA it grew by only 6%, however, it remains higher than the national average.

Water Use in WA

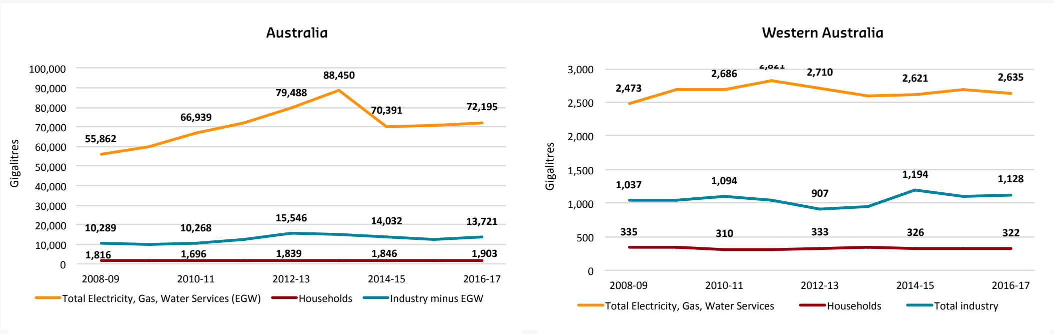
In 2016-17, Australia used more than 82,000 gigalitres of water – representing an increase of 29% relative to 2008-09 levels. This increase is in part driven by a growing population, but water use on a per capita basis has also grown over the same period - by nearly 8%.

WA has seen a more positive trajectory over time, where household consumption per capita has decreased by 16% and total water consumption per capita by 7.5% in the last ten years. Industry water use has also declined by 5% and that of Electricity, gas and water services by 7%. However, as in the case nationally, the total amount of water used in WA has also increased by 6%, reaching over 4,000gL in 2016-17 (Figure 25).

The decline of water use per capita in WA is mainly due to water efficiency initiatives that have been deployed between 2001 and 2018. One of the most important initiatives has been water restrictions, put in place since the early 2000s, where the use of sprinklers during winter is banned and significantly limited during summer. According to the WA Department of Water and Environment, these initiatives have saved 109 billion litres of water since 2001.[79]

FIGURE 25

Water use, Australia, 2008-09 to 2016-2017



Note: Reuse water is not included.
Note: Waste services are included in Industry water use.
Note: Year 2017-18 is not included because of changes in accounting.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4655.

79 Waterwise Perth. A growing city responding to climate change. Two year action plan. WA Department of Water and Environmental Protection. Government of Western Australia.

Often when we think about water use, we think about the tap water that is distributed to our house. However, household use of water represents only a small fraction of total water use. Most of our water use in Australia is used by industry and it is usually self-extracted rather than distributed through a central water corporation. Figure 26 shows the total water use per capita by households and industries across Australia's states.

WA's industries use 476kL of water per capita, compared to 536kL per capita nationally Australia. QLD is the state with the largest per capita industry use of water in the country (622kL) followed by NSW (606kL). These are the only two states that exceed 600kL of industry water use per capita, pulling the Australian average up. In comparison, VIC, WA and SA use fewer than 500kL per capita annually.

In terms of household water use, WA has the highest rate across all states. Household water use in WA reached 91kL per person in 2016-17, 26% more than the national average. Overall, household water use ranges from 62kL in VIC, the lowest in Australia to 79kL in SA, the second highest after WA. Even though household water use has decreased over time in WA, the figures are still relatively high compared to the rest of the states.

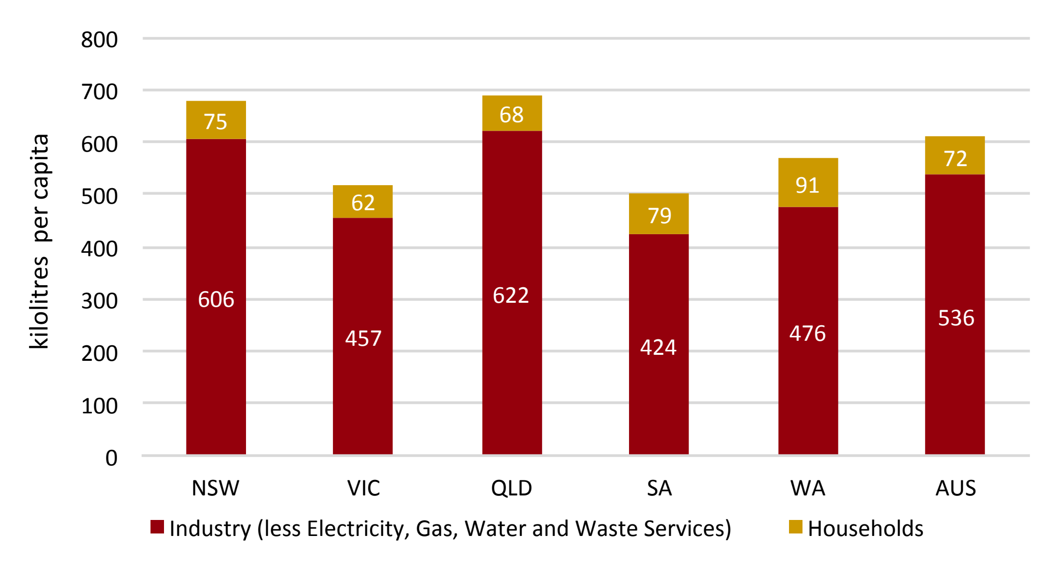
Comparing industry and household water use, we can see that WA industry uses 5.2 times more water relative to households and 7.4 times nationally. Reducing the amount of water households use is an important step to reduce water use, however, in order to make a significant impact on overall water use, industry should be more closely targeted when seeking public policy solutions in this area.

WA's industries use 476kL of water per capita, compared to 536kL per capita nationally Australia.

Household water use in WA reached 91kL per person in 2016-17, 26% more than the national average.

FIGURE 26

Total water use per capita by households and industry, by states, 2017-18



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4655, July 2019, Table 1.1

The mining sector in WA uses 252kL of water per capita each year - almost six times the Australian average.

WA manufacturing industry has a higher per capita use of water (29kL) than the average of Australia (21kL).

A key Western Australian government initiative to reducing water is the Waterwise Perth Action Plan, implemented in October 2019.[80] The main targets are to achieve a 20% decrease in the amount of water used per person in Perth and 10% less use of groundwater in the region by 2030. The scarcity of water resources, especially in WA's regions, increases the importance of water management in the region.

Other interesting initiatives include the implementation of an urban forest tree canopy to decrease the urban heat island effect, increase the building industry compliance with the Water Efficiency Labelling and Standards Scheme and the expansion of the waterwise school programs. All these initiatives will contribute to the reduction of water usage in Western Australia. The reduction of household water usage should remain one of the main priorities, especially since South West WA will be one of the hardest hit regions due to climate change.

Water use across WA industries

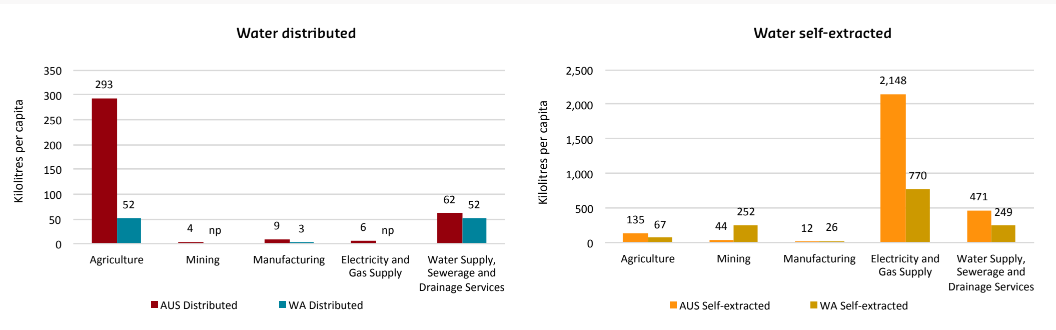
Industries in WA use at least five time more water than households and hence a better understanding of industry use is needed. But how does the distribution of water use differ across industries? We can first observe that industries use a larger amount of self-extracted water compare to distributed water (Figure 27). Indeed, less than half of the water used is supplied by the public water corporation (distribution), the rest is allocated and managed by the Department of Water through private licenses (self-extracted). In WA, 71% of water licenses in 2018-19 were allocated to industries.[81]

The electricity and gas supply sector uses the most amount of water per capita, both nationally and in WA – 2,148 and 770 kilolitres respectively (Figure 27). The larger per capita use by the electricity and gas sector at a national level is driven by the greater prevalence of hydroelectricity generation in the eastern states – particularly Tasmania.

The mining sector in WA uses 252kL of water per capita each year - almost six times the Australian average.

FIGURE 27

Distributed and self-extracted water use per capita by selected industries, Australia and WA, 2017-18



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4655, July 2019, Table 1.1

80 Waterwise Perth. A growing city responding to climate change. Two year action plan. WA Department of Water and Environmental Protection. Government of Western Australia.

81 Annual report 2019-10. Department of Water and Environmental Regulation. Government of Western Australia.

Greater water use in WA mining compared to national trends is driven by the large numbers of mining sites in WA relative to the rest of the states. Manufacturing in WA uses twice as much self-extracted water (26kL) than the Australian average (12kL). However, Australian manufacturing businesses use a larger quantity of distributed water, 9kL per capita against 3kL in WA. If we add these two sources, WA still holds a higher per capita use of water in manufacturing, a difference of 8kL per capita when compared to Australia.

The agricultural sector is the largest user of distributed water by far. This is especially true nationally, where on average 293kL of water per capita was distributed to the agricultural sector in 2017-18. There is substantially less water used by WA farmers, and this is true for both distributed and self-extracted water. WA farmers use 83% less distributed water than Australian farmers, and 50% less self-extracted water.

This is mainly due to the characteristics of farming in WA as seen in Table 2. WA agriculture is characterised by dryland farming, which means that crops depend on rainfall and are not irrigated. In fact less than 0.03% of land surface in WA is irrigated, against 0.5% in Australia, almost 17 times more. There are also a fewer number of businesses that irrigate in WA, 1,350 or the equivalent of 16% of farms. This contrasts with 24% of businesses that do irrigate nationally.

However, as rainfall levels plummet, WA farmers have struggled to maintain the same level of output. A response by farmers has been to increase the farms' size in order to increase profitability. The land area held by WA farms constitutes 21% of the Australian total. With under 10% of Australia's agricultural businesses, the average holding of a WA farm is close to 10,000ha, more than twice the size of an average Australian farm. Bigger farms, especially in the cereal sector, have on average larger profits because of higher economies of scales. Sizeable lands allows for tractors to sweep larger surfaces, makes some infrastructure work worthwhile (like silos for instance) and increase productivity. This has led farmers to increase their land holdings to increase profitability.

WA farmers use 83% less distributed water than Australian farmers, and 50% less self-extracted water.

While one in four agricultural businesses irrigate in Australia, just under one in six irrigates in WA.

The average holding of agricultural land per business in WA is close to 10,000 hectares, more than twice as much as the average land size of Australians farms.

TABLE 2

Water use on Australian and West Australian farms, key statistics, 2018-19

	Australia	WA	WA: Australia
Area of holding - Total area (ha)	383,801,493	82,200,911	21%
Number of agricultural businesses	89,441	8,533	10%
Average holding (ha per business)	4,291	9,633	224%
Number of agricultural businesses irrigating	21,928	1,349	6%
Share of businesses that irrigate	24.5%	15.8%	
Water source - Total volume of water from all sources (ML)	7,965,081	374,323	5%
Water use - Total area watered (ha)	1,954,789	21,928	1%
Share of total area that is watered	0.51%	0.03%	
Water use - Total volume applied (ML)	7,187,660	280,425	4%
Water use - Total application rate (ML/ha)	3.7	2.4	64%
Water use - Other agricultural water use - Volume used (ML)	777,420	93,898	12%
Water use - Total volume applied/used (including other agricultural water) (ML)	7,965,081	374,323	5%

Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4618, May 2020, 46180DO002_201819 Tables 1, 6.

The price of agricultural land in WA has increased by 28% in 2019 alone, almost 15 percentage points more than the Australian average.

In places with reliable rainfall such as the South Coast close to Esperance, prices have risen by almost 60%.

Recent climate modelling has shown that the South West of WA and the Wheatbelt regions will be among the top 10% of places on earth where rainfall decline will be the most severe.

The race for agricultural land has caused demand to soar. But with limited supply of land, prices have risen rapidly. According to the latest Rural Bank report, prices of agricultural land in WA have increased by 28% in 2019 alone, almost 15 percentage points more than the Australian average.[82] In places with reliable rainfall such as the South Coast close to Esperance, prices have risen by almost 60%. This shows that rainfall prone areas have already started to become a rare and valuable asset in WA.

Water security will continue to be the biggest challenge for WA farmers. As we have seen at the beginning of this section, rainfall has decreased significantly since the 1970s. Climate change will only cause the situation to deteriorate even further in WA. Recent climate modelling[83] has showed that the South West of WA and the Wheatbelt regions will be among the top 10% places on earth where rainfall decline will be the most severe. This combined with the fact that WA agriculture is mostly rainfed, means that the consequences for the agricultural sector are likely to be severe.

A number of programs have been put in place by the Western Australian government to help improve water management on farms. The Farm Water Supply Planning Scheme (FWSPS), offers farmers of dryland areas an internal water audit of their property. This scheme aims to improve water management in agricultural plots and provides advice on best practices and recognised conservation principles.[84]

Finding alternative crops that are less reliant on water, will also be necessary in the near future to maintain productivity. Even though still in its infancy, native perennial grasses and cereals could be a viable sustainable alternative for WA crops. They require very little water, are heat resistant and perennial (i.e. grow all year round), hence do not need replanting. Native grasses are a low risk option for cattle farming as they have already proven more reliable and dry resistant than traditional grasses.[85,86] In terms of native cereals substitutes, large scale trials are still needed to develop and demonstrate viable options. Developing the demand for these cereals will also be important for the future.

82 Australian farmland values 2020, Western Australia. Rural Bank.

83 Trnka, M., Feng, S., Semenov, M. A., Olesen, J. E., Kersebaum, K. C., Rötter, R. P., & Hlavinka, P. (2019). Mitigation efforts will not fully alleviate the increase in water scarcity occurrence probability in wheat-producing areas. Science Advances, 5(9), eaau2406.

84 Annual report 2019-10. Department of Water and Environmental Regulation. Government of Western Australia.

85 Moore, G A, Sanford, P, and Wiley, T. (2006), Perennial pastures for Western Australia. Department of Agriculture and Food, Western Australia, Perth. Bulletin 4690.

86 Clarke, S., Stevens, J., Ryan, M., Mitchell, M., Chivers, I., and Dixon K. (2010). Native Perennial Grasses for Sustainable Pasture Systems. Australian Government, Rural Industries Research and Development Policy. RIRDC Publication No.10/146.

REGENERATIVE AGRICULTURE

Regenerative agriculture aims to include more sustainable practices in the managements of crops and farmland. Regenerative agriculture is less labour demanding than organic farming and can be implemented at scale.

Regenerative agriculture seeks to rehabilitate the entire farm ecosystem, with an emphasis on soil health[87] and carbon sequestration. Common practices include low or no tillage, crop diversification and rotation, the introduction of ground cover crops, integrated pest management systems and significant reduction of chemical use.

A key aspect of regenerative farming concerns the improvement of biodiversity in the farm with significant use of animals for grazing and the natural fertilisation of land. Particular attention is paid to the interaction of plants and animals and how this can be optimised.

Regenerative farming also supports better water management. As soils becomes healthier and ground cover crops shade the land, water retention is gradually improved in the plots. As a result, crops need less water than in conventional agriculture practices.

One of the main advantages of regenerative agriculture is that it can be applied to large plots, such as those in WA, with relative ease. Some of these techniques such as no tillage and cover crops are already widely used among WA farmers.

There is also anecdotal evidence to suggest that regenerative agriculture can be successful in building financial resilience for farmers by smoothing out peaks in the harvesting process and that WA farmers involved in regenerative agriculture practices are also more likely to have higher levels of wellbeing and a better work-life balance.

Regenerative agriculture aims to include more sustainable practices in the management of crops and lands and can be implemented on scale.

Other types of farming more respectful of the environment, have started to become more mainstream. Regenerative agriculture is one, which sits in between conventional agriculture and organic agriculture, and has slowly started to make its path in WA. Although more niche, organic agriculture can also be used at small scale in horticultural farms. Agroforestry can also be considered, especially in some places in the South West where increasing forest cover can be beneficial for cattle and fruit farming for instance. As higher accountability by consumers increases, and higher prices reflect the slightly more costly production mode, regenerative agriculture, organic farming and agroforestry could be a viable option for some agricultural plots in WA.

Water use in households and cost

As seen previously, Western Australian households use more water than any other state in Australia. Figure 28 shows us the volume of distributed water per capita by households and industry and the amount of money paid by kilolitre of distributed water. First we observe that the industry sector in WA uses a relatively small percentage of distributed water (162kL per capita) compared to the other states. Most of the water used by industry in WA is self-extracted. For instance, NSW consumes 3.3 times more distributed water per capita than WA and VIC 2.8 times more.

87 Regenerative organic agriculture and climate change, a down-to-earth solution to global warming, Rodale Institute.

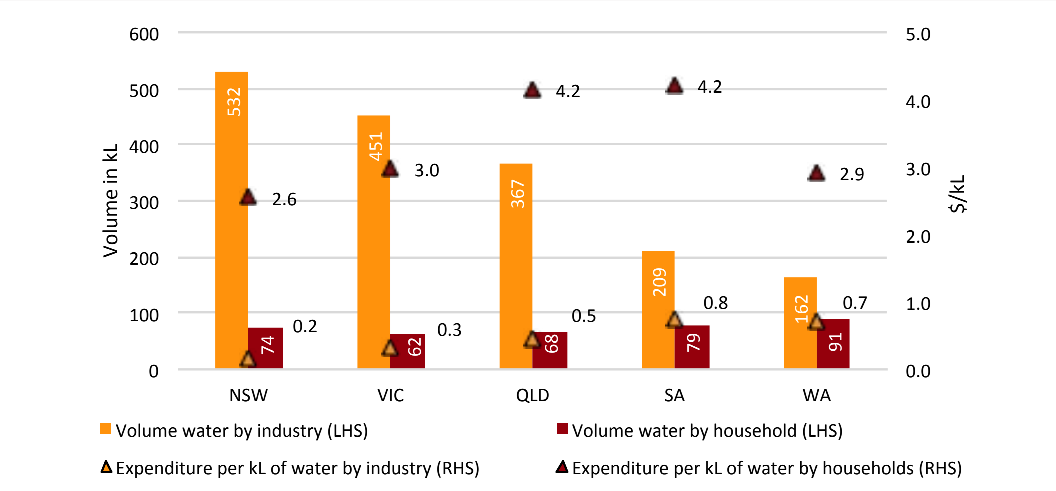
In WA, households pay on average $2.9 per kilolitre of distributed water, while industry pays only $0.70 cents.

In all states, households consume less distributed water than industry. In NSW, households use 86% less distributed water per capita than industry, roughly the same proportion than in VIC. WA households, on the other hand, consume 44% less distributed water than industry. Nevertheless, there is a significant gap in prices of distributed water between households and industry. In WA, households paid on average $2.9 per kilolitre while industry only pays $0.7. This difference in even larger in states such as QLD ($4.2 vs. $0.5) or SA ($4.2 vs. $0.8). Overall, prices are cheaper for both industry and households in NSW and VIC.

Hence, there is a very unequal financial burden of distributed water between households and industries. For instance, in WA, households use 44% less distributed water than industries but pay 4.1 times more per kilolitre. This proportion is worst for NSW and VIC where households use 86% less distributed water but pay 14.5 and 9.2 times more per kilolitre. The vast majority of distributed water in NSW and VIC is used by irrigated agriculture within the Murray Darling basin. Billions of dollars of public money has been spent on water reform by the Murray Darling Basin Commission in an attempt to achieve equity between basin states, reform water use and improve environmental flows and water quality within the basin. Significant concern remains that reform practices have been undermined in many areas by gaps in water accounting practices, while increasing speculation in water markets may be undermining access and affordability for producers. The inequality in public water supply should be considered when shaping our water management plans.

FIGURE 28

Water use per capita and water expenditure per kilolitre of distributed water, by households and industry, by states, 2017-18



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat 4655, July 2019, Table 1.1.

The price of water has also a significant effect on consumption. Cities such as Sydney, Darwin and Hobart have a flat rate for residential water use. This means that regardless of amount of water used, households pay the same price. Hence, there is no incentive to save water. Also, lower prices can increase the consumption of water dramatically. In Sydney, the decision to drop the price of residential water by 13.5% in 2016 is possibly the main contributor to the rise in water usage.[88] Price can be a very powerful tool to encourage more efficient water use, but it is also important to ensure lower income households, who may consume less water overall but spend a greater proportion of their disposable income on water services, are not disadvantaged or put under financial stress. This is particularly true where public housing and cheaper rental stock is of poor quality, contains inefficient appliances, and may be more prone to leaking.

The reuse of greywater is a widespread scheme to reduce the water usage by households and industries. This system diverts water from washing machines, dishwashers and showers to be employed in houses and companies for non-potable uses such as toilets and irrigation. Using greywater for irrigation purposes will certainly decrease the water bill and can significantly decrease household consumption, since about half of all residential use of water is allocated to gardens and outdoors. Even though we do not have recent figures, in 2007, the ABS estimated that around 42% of Perth residents used greywater as a source of water for irrigation.

More sophisticated systems such as dual reticulation in which a third (purple) piping system for non-potable water is included is also an alternative. These systems are costly to retrofit to existing homes, but can be cost-effective in new constructions. Alternatively, a dual system can be built at the neighbourhood or suburb level, such as the one installed in the Brighton residential estate in the Perth northern suburb of Butler. In this example, the Water Corporation provides both potable water for drinkable uses and non-potable water, previously treated but not to drinking standards. Including these systems in new developments can provide opportunities of scale that are more cost effective and easier to manage than individual household greywater systems.

Water is probably the most scare resource in Western Australia. The protection of our streams and aquifers is key to guaranteeing water sustainability for future generations. To do so, WA should introduce targets to reduce water consumption for households and industry. It should also adjust the water management plan to protect the Gnangara aquifer, with higher limits on water extraction. Fairer prices for self-extraction and distribution of water for industries and households are also an important tool to manage our water resources. Alternative solutions to divert greywater and employ it in non-potable uses should be strongly encouraged, particularly in new housing developments.

88 Why Sydney residents use 30% more water per day than Melburnians. Ian Wright. The conversation. May 2019.

HOW MUCH WASTE DOES WA PRODUCE?

In 2018-19, Western Australian local governments collected around 1.5 million tonnes of domestic waste, of which 39% was recycled or reused.

The United Nations has estimated that every year 11.2 billion tonnes of waste is produced worldwide, contributing to 5% of the global greenhouse gas emissions[89]. In 2017, Australia produced 560 kilograms per capita of municipal (household) waste, slightly higher than the OECD average of 525kg. Over time, Australia has managed to decrease its waste production by 0.31 tonnes per capita in the 10 years to 2017, however, the economy overall has generated almost 4 million additional tonnes of waste during the same period.[90]

As our living standards rise and our population continues to grow, so does our waste generation and there is additional pressure on our waste management systems. If done poorly, the contamination of land, water streams and seas as well as the pollution of our air is inevitable. This will cause a deterioration not only of natural resources and biodiversity, but it can also lead to health problems within the population. Air quality issues lead to increasing rates of asthma and lung disease in urban areas just as increased greenhouse gas emissions contribute to a warmer climate and more extreme weather events. Littering and poor waste management contaminates the water we drink and the food we eat, leading to the accumulation of toxins in the food chain, higher rates of cancer and chronic disease. The more we understand our health and the ecosystem processes around us, the clearer it becomes that the health of our planet is inextricably linked to our quality of life.

Waste also represents a significant economic cost. All the inputs and labour needed to extract and transform resources to create and distribute a product are lost once the product is discarded. This includes not only the raw materials but also all the energy, land and water used throughout the process. The process of extraction and transformation is often more energy intensive and more likely to produce other waste products (some of them toxic) than the process of cleaning or recycling the product for reuse.

For all of these reasons, it is paramount to reduce the amount of waste that we produce at both the household and industry level. In 2018-19, Western Australian local governments collected around 1.5 million tonnes of domestic waste, of which 39% was recycled or reused.[91]

This section examines the quantity and structure of waste we produce, and compares differences across states. To do so, we have relied on two main data sources, the *National Waste Database* from the Department of Environment and the *Experimental Waste Accounts* from the ABS. It is noteworthy that the latest available information for both datasets is the 2016-17 financial year and highlights a data gap in measuring the volume of waste production on a more frequent basis.

89 https://www.unenvironment.org/explore-topics/resource-efficiency/what-we-do/cities/solid-waste-management

90 Authors' calculation from the National Waste Database, Department of Environment.

91 The 2018-19 census of Western Australian local governments and recycling services, Waste Authority, Government of Western Australia.

Total Waste

Western Australia has experienced a steep decline in waste produced per capita over time. In 2010, an average citizen in the state generated 3.2 tonnes of waste per year. This has decreased sharply to 2 tonnes of waste per capita in 2017 (Figure 29). WA has effectively moved from last position to frontrunner and is today the state with the lowest per capita waste in Australia.

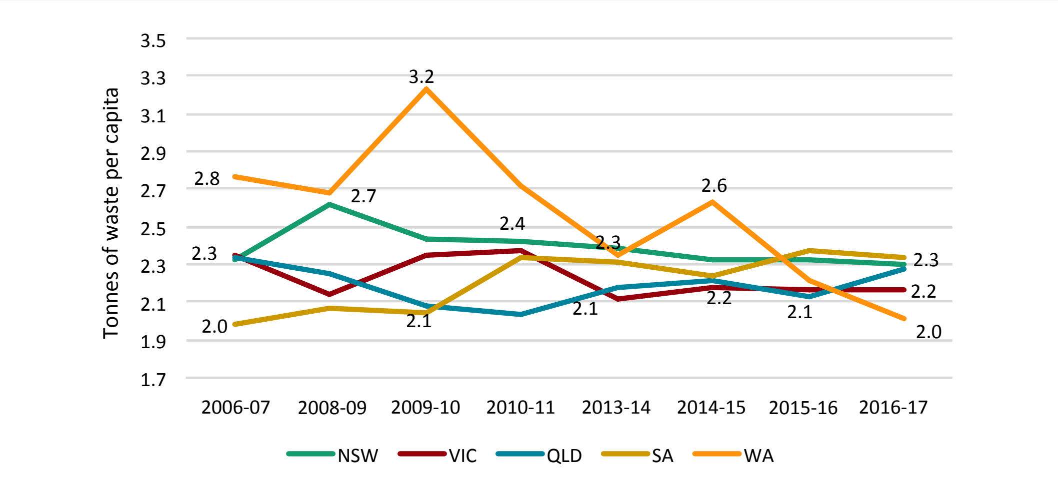
WA is also the only state that has decreased the overall production of core waste since 2010, from 7,388kt in 2009-10 to 5,182kt in 2016-17. This significant decline is mostly due to the creation of the inaugural waste strategy in 2012, *Creating the Right Environment*, which was replaced last year by the *Waste Avoidance and Resource Recovery Strategy 2030*. The 2012 waste strategy significantly increased the waste levy from $28 per tonne of putrescible (decomposable) waste in 2014 to $70 in 2018. The increase on the rate for inert (indecomposable) waste was even higher, increasing from $8 to $70 during the same period.[92]

WA is the state with the lowest per capita waste in Australia.

In 2017, WA produced 2 tonnes of waste per capita, a reduction of 37% since 2010.

FIGURE 29

Total waste per capita, by state, 2007-2017



Note: Ash waste is not included since data are only available at the Australian level. Years are in financial years, ending on 2016-17.
Source: Authors' calculations based on National Waste Database, Department of Environment.

92 Review of the waste levy, Consultation paper, 2020. Government of Western Australia, Department of water and environmental regulation.

27% of WA waste comes from construction and demolition, 46% from commercial and industry and 27% from household waste.

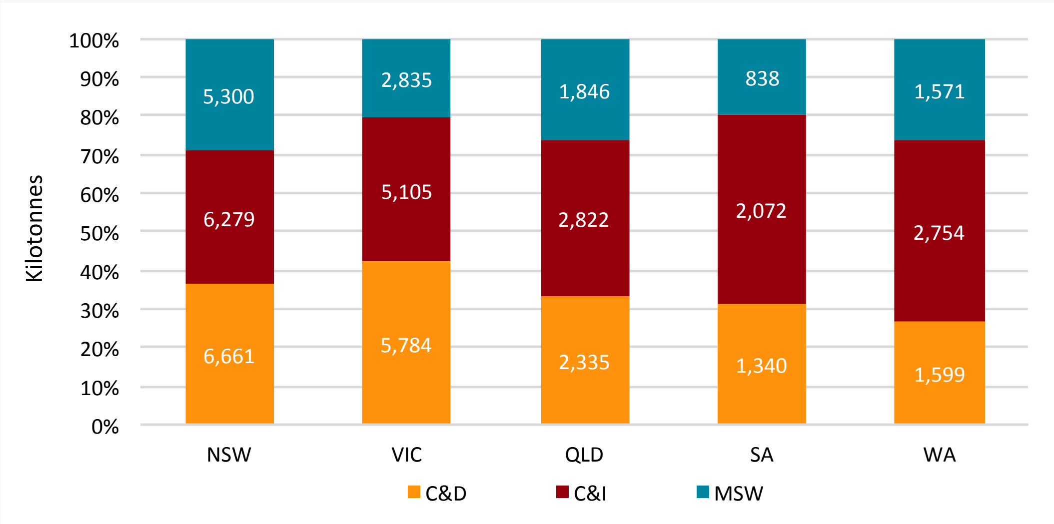
The waste levy created a price incentive to divert waste from landfill. Among all actors, the construction and demolition sector has been particularly responsive to the levy, diverting 75% of the sectors waste going to landfill and surpassing the 2020 target outlined in the 2012 strategy.[93] This sector has become one of the biggest contributors to the decline in WA waste production per capita.

However, more can still be done to reduce the amount of waste in WA.

The Western Australian government has recently put in place specific targets on waste reduction through the *Waste Avoidance and Resource Recovery Strategy 2030*. Specifically, the strategy calls for a 20% reduction of waste generation per capita by 2030. Changes to the waste levy, currently under review, are likely to be central to reaching this target. This includes potentially increasing the levy but also expanding it to include regional areas of WA.

FIGURE 30

Stream of waste, by state, 2016-17



Note: Ash waste is not included since data is only available at the Australian level.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Waste Database, Department of Environment.

[93] National Waste report 2018, Department of the environment and energy.

Typically, when we think about waste, we often have in mind the waste produced by households. In fact, household waste or domestic waste, only represents a small proportion of total waste. There are three common waste streams: Commercial and Industry waste (C&I), which stems mainly from medium and large companies, including schools, restaurants, offices and retail. Construction and Demolition waste (C&D), which is directly linked to the construction sector as well as road construction and excavation of land. Finally, Municipal Solid Waste (MSW), which is generated mostly by households and local governments in kerbside bins and yearly waste pick-ups.

Figure 30 shows the amount and proportion of waste generated by each stream in 2016-17 by state. WA produced almost 1,600kt of construction and demolition waste, 2,754kt of commercial and industrial waste and 1,571kt of municipal solid waste. Relative to other states, the C&D sector accounts for the lowest proportion of waste than in any other state (27%). MSW waste accounts for a similar proportion of total waste (27%), while the largest proportion comes from the C&I sector which generates almost half of the state's waste (46%). This figure (2,754 kilotonnes) is not only high in proportion, but also by the total amount of waste produced. Indeed, WA and QLD produce almost the same amount of C&I waste in total (2,754 vs. 2,822kt), even though WA has half the population of QLD. Furthermore, QLD has the same type of industry composition, with a large mining sector and mineral resources.

As explained above, the C&D sector was particularly reactive to the increase of the waste levy in WA, which largely explains the significant decrease of WA's total waste. We should note that a large share of the C&D sector is based in metropolitan areas, while a significant part of the C&I sector is located in regional WA, especially the mining sector that generates large amounts of waste.

Since the WA waste levy only applies to metropolitan areas, the mining sector in regional areas is not covered by the levy and hence not contributing its fair share to the cost of waste to our community. Given the scale of this industry in WA, a more comprehensive approach to waste management requires a levy on regional mining waste. This could mean introduction of an appropriate regional waste levy, possibly at a lower rate than metropolitan areas.

Construction and Demolition waste in WA is the lowest share among all states.

46% of waste in Western Australia comes from Industry.

South Australians produces almost half the household waste of West Australians.

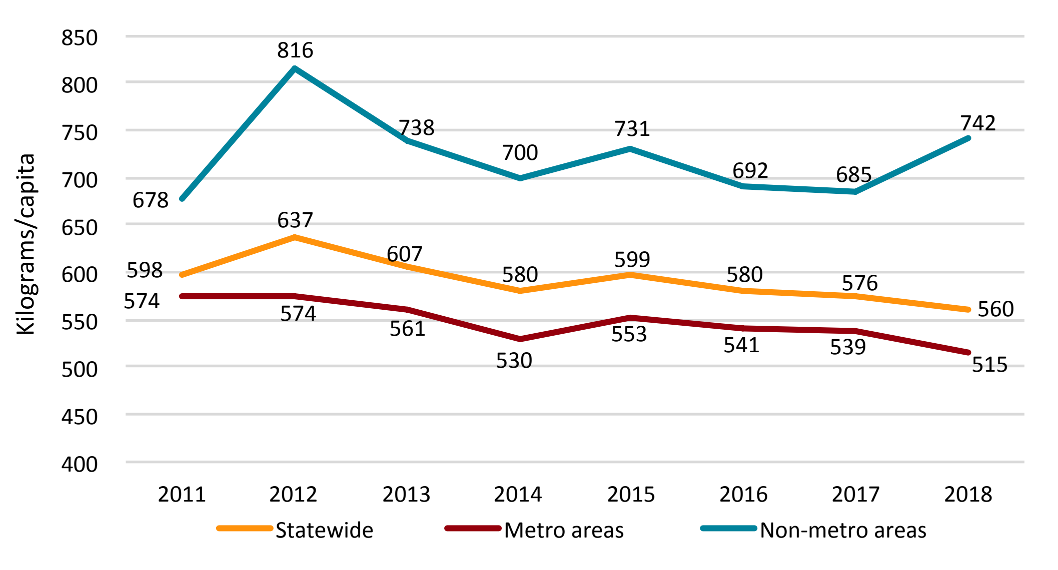
Regional areas produce over three times the amount of waste than metropolitan areas across Western Australia.

In terms of municipal waste, WA does not fare well either. Western Australia produces a larger amount of municipal waste than Queensland despite having half the population, and South Australia generates almost half the household waste of Western Australia. There are also important disparities between metropolitan and regional waste generation (Figure 31). Regional areas produce over three times the amount of waste than metropolitan areas across Western Australia. And while metropolitan areas have been reducing annual production of waste over time, regional areas have seen an increase of almost 10% in the last decade.

This difference likely reflects the intrinsic characteristics of regional areas, with poorer access to markets and a significant percentage of people living in remote and very remote areas with limited services. Nevertheless, significant efforts should be undertaken to reduce the amount of waste generated in regional WA. Better access to markets and educational programs, together with increased recycling services are key to achieve this goal.

FIGURE 31

Regional and metropolitan domestic waste per capita, 2011-2018



Source: Bankwest Curtin Economics Centre | Authors' calculations based on 2018-19 Census of Western Australian Local Governments waste and recycling services data.

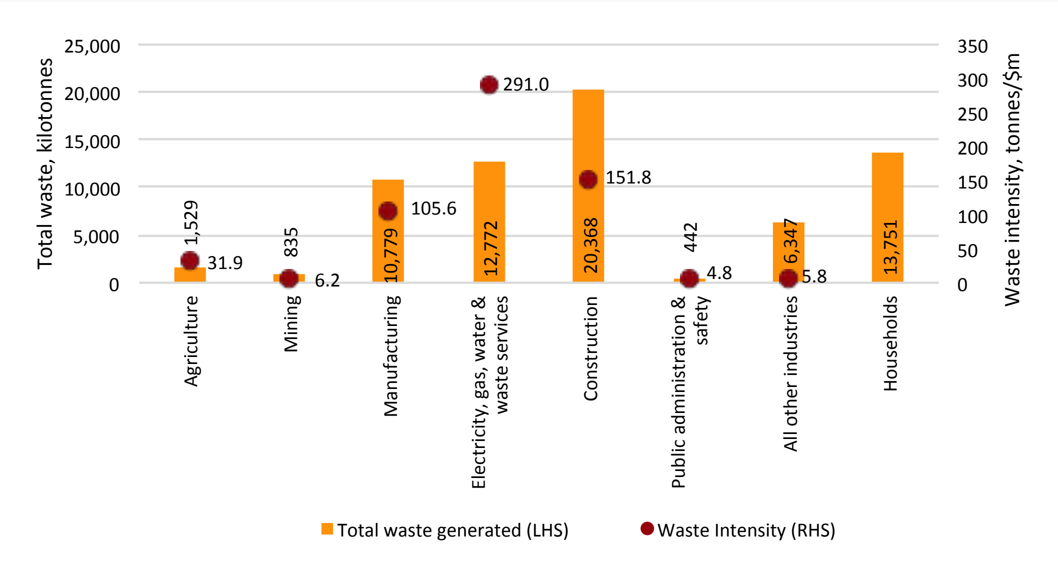
Waste Intensity and Composition

Waste intensity provides a measure of the amount of waste generated (in tonnes) by a particular product or industry in relation to the value of that activity (in $m), comparable to the gross value added. Waste and its intensity varies substantially across sectors (Figure 32). Relative to its economic output, the electricity, gas, water and waste services sector has the highest intensity, with 291 tonnes produced for every million dollars of activity. Note as well that this is only a measure of solid waste, and does not include amounts of greenhouse gases produced. The primary driver of this level of waste intensity is ash from coal-fired power plants (Table 3).

The construction sector has the second highest waste intensity and also produces the largest total amount of waste with more than 20,000kt produced nationally in 2016-17. Manufacturing has the third highest waste intensity relative to its economic output and also produces a significant volume of waste each year.

FIGURE 32

Total waste generation and waste intensity, Australia, 2016-2017



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat. 4602.0.55.005, Waste account.

The construction sector produces more than two million tonnes of hazardous waste each year - more than any other industry.

The composition of waste products also varies considerably across sectors (Table 3). While almost three-quarters (73%) of construction sector waste comes from masonry materials, there is also a significant share that stems from hazardous waste (10%). In fact, the construction sector produces more than two million tonnes of hazardous waste each year - more than any other industry. Manufacturing produces almost as much hazardous waste as the Construction sector, with a larger share of hazardous materials (20%) within its waste portfolio.

The second largest contributor to total waste are households (13,751kt), with organic waste representing more than half of this waste. This is followed by paper and cardboard (15%), metals (10%) and plastics (8%).

Despite similar volumes of waste contribution, the Electricity, gas, water and waste services and Manufacturing sectors have very different waste profiles. Ash represents almost the entire waste (96%) of the Electricity, gas, water and waste sector which mostly originates from coal-fired plants used to generate electricity (ABS 2019). Manufacturing, on the other hand, has a very mixed array of waste with none of the categories surpassing more than 25% of total manufacturing waste.

The remaining industries account for less than 17% of total national industry waste (excluding households and imports). Agriculture produces around 1,500kt of waste each year, mining around 800kt and Public administration and safety just under 450kt. Some products such as plastics and glass, generate almost their entire waste by the intermediate and final users: manufacturing and households.

It should be noted that the waste and pollution contributed by some industries is actually a result of the consumption of others. For example, the amount of waste and pollution generated by the electricity industry can be attributed to the amount of electricity consumed by other industries (e.g. to manufacture goods) and by households (domestic consumption). While the amount of electricity produced is ultimately determined by the choices of consumers, the emissions intensity of that electricity production depends on the manner in which industry players generate its power (e.g. their choice of renewables vs coal). Hence pollution and waste outcomes depend on the choices of both producers and consumers, and effective policy solutions need to balance both demand and supply-side solutions.

Similarly, the product choices made by consumers can influence the use of materials and packaging as well as quantity. Education campaigns geared at consumer choice can result in more sustainable outcomes, but only if and when producers provide a range of more sustainable options to choose from.

TABLE 3

Physical supply of waste, by material and industry, Australia, 2016-17, Tonnes

	Waste collection, & disposal services	Agriculture	Mining	Manufacturing	Electricity, gas & water services	Construction	Public administration & safety	All other industries	Households
Masonry materials	2,316	681	102,453	1,361,375	43,968	15,026,029	136	80,516	519,921
Metals	7,108	21,607	339,822	2,030,165	70,914	1,108,811	20,144	451,595	1,469,610
Organics	28,402	977,212	41,019	2,495,627	162,369	1,069,154	133,054	2,245,271	7,019,139
Paper & Cardboard	18,678	16,364	41,593	1,481,156	10,071	139,235	176,920	1,556,759	2,149,784
Plastics	3,444	9,164	17,158	884,014	40,449	121,853	15,957	288,918	1,168,396
Glass	0	0	161	179,915	0	32,344	1,452	73,418	791,539
Textiles, leather & rubber	5,498	7,794	25,983	166,209	5,321	19,770	30,389	245,034	277,022
Hazardous waste	11,304	488,243	225,826	2,099,467	58,017	2,119,619	43,275	1,259,623	0
Ash	0	0	0	0	12,296,980	0	0	0	0
Other	660	7,576	41,016	81,474	6,560	730,925	21,153	145,867	355,664

Notes: Imports not included. Textiles, leather and rubber does not include tyres.
Source: Bankwest Curtin Economics Centre | ABS Cat. 4602.0.55.005, Waste account.

Examining the composition of waste produced by state, there is a similar pattern across most states and territories, with masonry materials and organics making up more than half of all waste products. Organics make-up the highest proportion of waste in South Australia – around 37%. This compares to a national average of one-quarter of total waste nationally and 23.8% in Western Australia. Masonry materials make-up a quarter of all waste within Western Australia, however this is the lowest among all states.

Masonry materials and organics make up over half of all waste products.

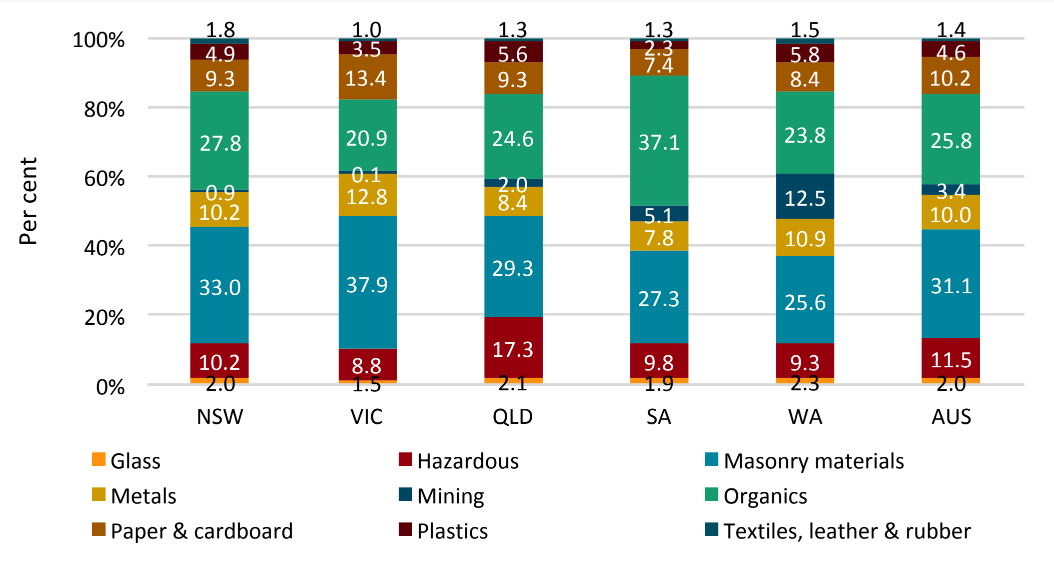
WA generates more than 700kt of mining waste, 3.5 times more than the second largest producer, QLD.

Annually, WA produces 132kg of plastic waste per capita, more than any other state in Australia.

A key difference in WA's waste profile is the contribution that Mining makes to total waste – 12.5% compared to 3.4% nationally. More than 700kt of mining waste is generated by our state each year, 3.5 times more than the second largest producer, QLD. WA also produces a large proportion of plastic waste, 340kt, equivalent to 5.8% of the state's total waste. Annually, WA generates 132kg of plastic waste per capita, more than any other state in Australia. WA generates 2.3 times more plastic waste per capita than SA, the lowest producer of plastic waste and 1.7 times more than VIC.

FIGURE 33

Type of waste generated, by state 2016-17



Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Waste Database, Department of Environment.

Focus on materials: Plastic, Organic and E-waste

Plastics

Plastic pollution can have a serious impact on our marine and coastal ecosystems, not only because it spoils the beauty of the beaches but because of the consequences of life threatening conditions for the marine wildlife. It is estimated that 8 to 13 million tonnes of plastic enters the ocean every year[94] and by 2050 there will be more plastic in the ocean than fish.[95] Once it is in our ecosystem plastics can become almost impossible to remove.

More than 8 million tonnes of plastic enter our oceans each year worldwide. 40% of marine mammals and 44% of seabirds are affected by plastic ingestion, killing an estimated 1 million seabirds and 100,000 sea mammals every year (UN Oceans Conference 2017 factsheet). Australian researchers have found that as many as 90% of seabirds are ingesting plastic, with this rate predicted to reach 99% of all species by 2050 (Willcox *et al.* 2015[96]).

Furthermore as plastics weather and fragment in the environment we are seeing an increasing accumulation of micro-plastics through the food chain, increasingly impacting on larger animals' health, behaviour and hormone levels, and ultimately making their way into our diets (Tosetto *et al.* 2016[97]). Micro-plastics are increasingly discovered contaminating the food we eat and the water we drink, with millions of particles recently found to be ingested by infants drinking baby formula (Li *et al.* 2020[98], Cox *et al.* 2019, Peng *et al.* 2018[99]). We do not yet know the ultimate impact micro-plastic contamination will have on our health and the health of the planet, with some suggesting it could be the next biggest threat after climate change (UNGA 2019[100]).

The pervasive use of plastic in packaging and manufacturing materials has contributed significantly to plastic pollution. The amount of plastic that ends up in landfill represents an important economic cost, especially as most types of plastic can be recycled and re-used. However, some plastic is easier to recycle than others and some can be extremely toxic if disposed of poorly.

PET (Polyethylene Terephthalate) is usually the most common type of plastic that is found in food packaging and soft drink bottles. HDPE (high density polyethylene) is a higher density plastic that can be found in things like detergents, shampoo, milk containers, etc. LDPE (low density polyethylene) is light and very flexible and is often called soft plastic and usually found in shopping bags, bread bags and chip packets. PP (polypropylene) can be used to create clothing, tubs and ropes and PVC (poly vinyl chloride) is often the type of plastic used for pipes, packing or toys.

94 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768-771.

95 Ellen MacArthur Foundation estimates.

96 https://www.theguardian.com/environment/2015/sep/01/up-to-90-of-seabirds-have-plastic-in-their-guts-study-finds.

97 Tosetto, L., Brown, C. & Williamson, J.E. Microplastics on beaches: ingestion and behavioural consequences for beach hoppers. Mar Biol 163, 199 (2016). https://doi.org/10.1007/s00227-016-2973-0.

98 Li, D., Shi, Y., Yang, L. et al. (2020). Microplastic release from the degradation of polypropylene feeding bottles during infant formula preparation. Nature Food. https://doi.org/10.1038/s43016-020-00171-y.

99 Kieran D. Cox, Garth A. Covernton, Hailey L. Davies, John F. Dower, Francis Juanes, and Sarah E. Dudas (2019). Human Consumption of Microplastics. Environmental Science & Technology 2019 53 (12), 7068-7074.

100 https://www.unenvironment.org/interactive/beat-plastic-pollution/.

Overall, Australia could recycle more than half (52%) of its plastic waste.

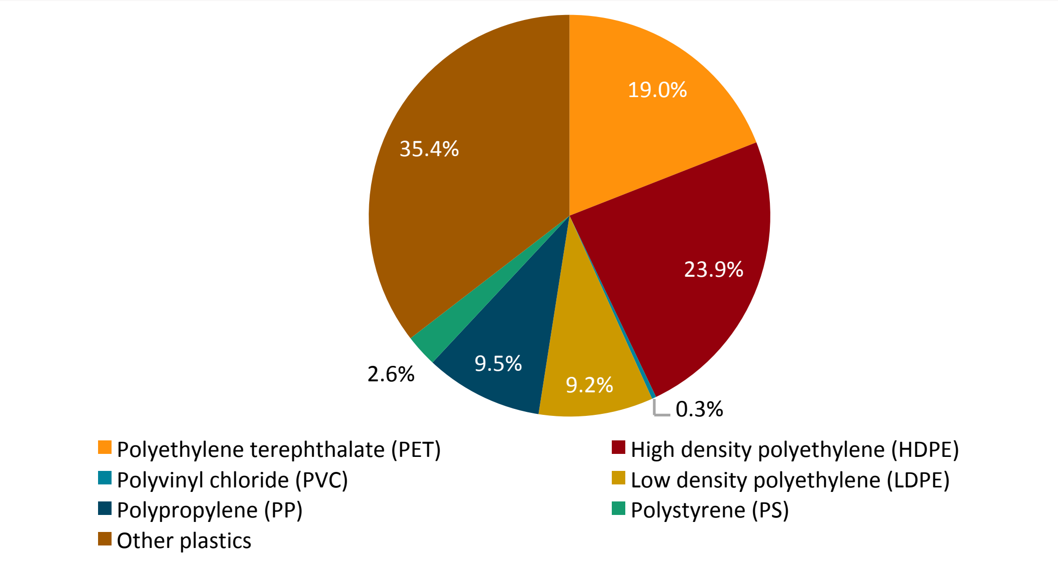
Even though all these types of plastic have the same origin, the recycle path can be easier for some than others. PET and HDPE are the easiest type of plastic to recycle, they constitute 19% and 24% of the plastic waste in Australia respectively (Figure 34). LDPE plastic accounts for 9% of our waste, and while this plastic can usually be recycled, the process is less straightforward. LDPE is often used as food packaging, and hence food contamination can complicate things. To make matters worse, LDPE packaging in chip bags and other snack foods often includes a thin layer of aluminium foil, which cannot easily be separated. As a result, kerbside services usually do not offer to recycle this type of plastic, and as a result few consumers make the effort to recycle it. Some programs such as REDcycle concentrate on soft plastics recycling, but they are only available in some supermarkets, and since consumers then have to remember to bring their LDPE waste with them, this decreases the proportion of soft plastics actually recycled. Furthermore, the amount of energy needed to recycle LDPE is much greater than that needed by harder plastics.

Polypropylene (PP) constitutes 9.5% of plastic waste and even though it is possible to recycle, kerbside collections do not usually allow this type of plastic and most goes to landfill.

Overall, Australia could recycle more than half (52%) of its plastic waste.

FIGURE 34

Plastic waste generation, by type, Australia, 2016-17



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat. 4602.0.55.005, Waste account.

Polystyrene (PS) plastic normally employed in the manufacturing of clothes is not recyclable, neither are other plastics such as nylons and acrylics. These two categories of non-recyclable plastic represent 38% of the Australian plastic waste and will almost exclusively end up in landfills. The last type of plastic, PVC, is not only very difficult to recycle but it poses a hazard to humans. PVC is one of the most dangerous consumer products ever created. Luckily, only 0.3% of plastic waste comes from this source. PVC should not be not thrown to landfills and should be properly handled.

A large part of plastic waste can be easily avoided, especially single use plastics. The lightweight plastic bag ban implementation is a successful story for the Western Australian government. Even when there was some resistance in the beginning, people easily changed their consumption habits and purchased long term bags for grocery shopping. Other type of single-use plastic such as straws, food containers and cutlery could be replaced by more sustainable solutions already available in the market or could be avoided entirely. The Western Australian government should extend its campaign against single-use plastic even further and cut the amount of waste streaming from this source.

Research shows that the WA residents are concerned about the plastic pollution in the environment[101], so the WA government should capitalise on this support to extend the fight against single-use plastics. Plastics that are more difficult to recycle could also be taxed. The damage to the environment and misuse of inputs in the production and disposal phase can justify this. A price signalling will encourage a transition to higher recyclable types of plastics to the detriment of more pollutive types.

Industries and consumers also have an important role to play. Solutions such as choosing and producing packaging with lesser amounts of plastic, replacing plastic for a more sustainable material and shifting to alternative type of plastic that are more easily recycled are all valuable solutions to decreasing our plastic waste. Companies such as ALDI have appointed targets in the reduction of plastic waste arising from their products. New small businesses such as bulk stores have completely eliminated plastic and packaging altogether to provide a waste-free grocery shopping. The waste industry is also producing great opportunities for innovators in processing materials.

Organics

Contrary to plastic, organic matter breaks down easily in the environment and does not pose a threat to biodiversity unless contaminated. Organic waste can be composted and used as a fertiliser in agricultural crops. As we have seen in Figure 33, WA produces less organic waste than any other state and the nature of our organic waste could tell us why. The composition of organic waste by state is shown on Figure 35. In proportion, WA generates the largest quantity of food organic waste than any other state by far (45%). Second to WA, QLD produces 36%, while SA, the state with the lowest food organic waste, only reaches 12%. WA also generates 31% of garden organic, slightly above the Australian average of 27%.

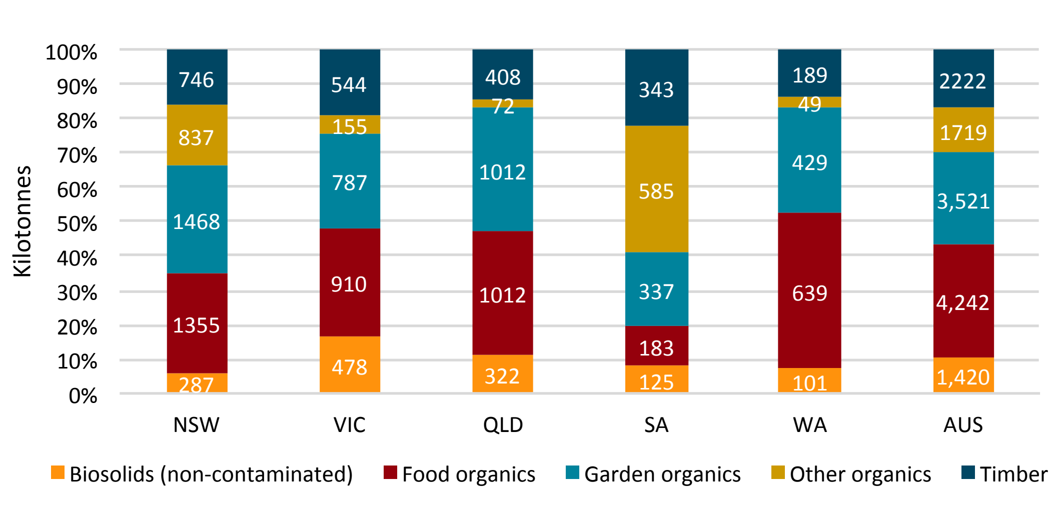
38% of Australian plastic waste is composed of non-recyclable types of plastic.

101 Ashton-Graham, C. (2017). Survey report: Western Australian households views on plastic waste 2017. Plastic Waste Survey of WA Household 2017. https://www.der.wa.gov.au/images/documents/our-work/consultation/Plastic_bag_ban/Attachment_1_Plastics_Survey_FINAL.pdf.

WA produced 190kt of timber waste in 2016-17, the lowest of all states.

FIGURE 35

Organic waste, by type and state, 2016-17



Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Waste Database, Department of Environment.

Interestingly, WA produced a very low amount of timber waste, about 190kt in 2016-17, the lowest of all states. If managed properly timber waste can be minimised significantly. Nevertheless, depending on the final product, the extend of waste from timber can vary significantly. For instance, softwood and wood chips produce little waste because most of the timber can be converted into final products. On the other hand, timber used as hardwood to construct furniture and fine craft generates more waste but it also creates more value added to the product. The WA forestry industry is mostly concentrated on the former, which might explain the little waste generated but also reflects a lost opportunity to produce higher value added products.

102 St Vincent de Paul, The Salvation Army, Foodbank WA, Oz Harvest, Second Bite.

WA'S FOOD RELIEF FRAMEWORK

Food insecurity is responsible for a growing social, health and economic burden in Australia, driven by poverty, inadequate income and financial hardship. During 2018, over four million Australians experienced food insecurity at least once, according to a Foodbank survey.[102] Western Australian charitable food services reported dramatic increases in the demand for food relief, with the number of people seeking food relief, up 39% between 2017 and 2018, and more than 508,000 meals provided each month.

To tackle this problem the WA Council of Social Service (WACOSS) and the emergency relief sector developed the Food Relief Framework, a two-year project dedicated to understanding and better coordinating food relief in WA. The report maps food insecurity across WA, identifies gaps in the state's food security systems, and recommends solutions for the State Government and community sector to alleviate food insecurity and ensure that everyone has access to healthy and nutritious food.

For the suppliers of charity food – including supermarkets and large organisations – this framework identifies systemic challenges and offers solutions, such as incentivising corporate business to use their logistics infrastructure for the storage and transportation of charity food.

The framework recognises what good practice looks like in the community and promotes more resources to achieve better outcomes through the coordinated delivery of charity food.

Australia produced 465kt of e-waste in 2016-17, from which 67% comes from metals, 25% from plastics and 8% from glass.

The amount of waste produced by the food waste in WA is worrisome. In 2017, the *National Food Waste Strategy* was put in place by the Australian government to reduce the amount of food waste coming from households and industry. In Australia, it is estimated that $20 billion dollars is lost to the economy through food waste, with households throwing away 3.1 tonnes of edible food per year.[103] The National Food Waste Strategy targets a 50% reduction of food waste by 2030. To achieve this goal, all of the production and consumption chain would have to make a significant effort to decrease the amount of waste produced. A change in behaviour from consumers is key in the reduction of food waste. Better connectivity between the producers' and consumers' market can help to deliver a lower food waste in the future. Countries like France have banned supermarkets from throwing away unsold food. Charitable and food recovery organisations such as Ozharvest could collect the unsold products and give them to people with food security problems. Similar solution can be considered in the WA context to reduce food waste. Identifying which parts of the process generates the largest amount of food waste is key to delivering viable and realistic solutions to food waste.

E-waste

E-waste has become more prominent in the past few years as waste from electronic equipment increases. Australia produced 465kt of e-waste in 2016-17, from which 67% comes from metals, 25% from plastics and 8% from glass. Households contribute to more than 80% of e-waste while each of all other industries generate less than 5%. Households are almost entirely responsible for the amount of e-waste produced in Australia. It is important to point out

103 National Waste Strategy, Halving Australia's food waste by 2030. Commonwealth of Australia 2017.

Households contribute to more than 80% of e-waste while all other industries generate less than 5%.

that the manufacturing and construction industries also produce a significant amount of e-waste in the form of metals. The former generated 11,500 tonnes of waste in 2016-17 and the latter 13,700 tonnes during the same period.

The *National Television and Computer Recycling Scheme* is a Commonwealth program aiming to reduce the amount of e-waste generated by households. As its name indicates, televisions and computers can be brought by households to collection points, where they are sent to a centralised treatment plant to recover mostly metals. The recovery and recycle of e-waste will be crucial for our future. Not only because the evolution and diversification of electronic devices will generate an increasing amount of waste; but also because materials such as rare earth will need to be recovered from renewable energy equipment.

Rare earths produce a significant amount of pollution at the extraction stage and such an environmental damage can only be justified if the materials extracted can be recycled after disposal. Furthermore, as its name indicates rare earth are scarce materials, mainly extracted in China, and therefore there only very limited quantities available. Nevertheless, Australia and in particular WA, have the 4th largest combined reserves of lithium and rare earth elements. Therefore, WA could become a front runner in the circular economy of rare earth and metals. It could extract and recycle them at the highest standards. To achieve this, an expansion of the national e-waste program to other sectors of the economy as well as to other type of electronic devices is paramount. The recovery and recycling of e-waste and rare earth will be key for a sustainable future in WA with low carbon emissions.

TABLE 4

E-waste generation, by type, by industry, 2016-17, Australia, Tonnes

	Metals	Plastics	Glass	Total
Waste collection, treatment & disposal services	283	105	34	422
Agriculture, forestry & fishing	498	186	59	744
Mining	3,725	1,390	445	5,560
Manufacturing	11,553	4,311	1,379	17,243
Electricity, gas, water & waste services	2,149	802	257	3,207
Construction	13,781	5,142	1,645	20,568
Public administration & safety	1,165	435	139	1,739
All other industries	31,659	11,813	3,780	47,252
Households	247,286	92,271	29,527	369,084
Total	**312,099**	**116,455**	**37,265**	**465,819**

Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Cat. 4602.0.55.005, Waste account.

In order to reduce the amount of waste generated in WA and achieve the 2030 targets on waste reduction, we need to work cooperatively with all the sectors of the economy. On one side, producers should aim to minimise the amount of waste generated. Changes in packaging materials, optimising the production and manufacturing process and shifting to alternative and more sustainable materials are some of the strategies that can be put in place to limit waste. Adopting a circular design of the production chain can also help to achieve this goal. On the other side, consumers should choose products more carefully in order to minimise household waste. Single-use plastic should be of the last resort instead of the rule. Consumers can also opt for more waste-friendly behaviour such as refilling goods, repairs shops and leasing schemes.

Food waste is a big challenge for families and more attention should be paid to it. Reducing the amount of food organic waste is also a key factor in decreasing WA's waste, especially since it represents almost half of its waste, far ahead any other state. Understanding and identifying where the organic waste is generated in the chain, will be key to achieving a reduction of the total waste of WA by 2030.

The Western Australian government should enable these practices by educating the public and providing price and regulatory incentives for households and business to limit the amount of waste. An increase and expansion of the waste levy, would send a price signal to producers and will enable a faster and smoother transition in the reduction of waste. Education of the general public is also paramount to achieve the 2030 targets of waste avoidance.

Waste reduction strategies focusing in regional WA waste should also be implemented as regional MSW per capita remains high and does not seems to be declining. Other type of policies such as the taxation of certain types of plastics or particular waste can also help to shift producer's behaviour. The banishment of unsold items disposal by supermarkets will not only reduce food waste but would help people in need and suffering from food insecurity.

CONCLUSION

The health of Australia's economy, environment and people are closely intertwined, in a fine balance that requires thinking not only of the present, but also of the future. Climate change is occurring faster than anticipated, and 2020 has shown the complexity of the risks we will face on a global scale. In order to continue enjoying the natural and economic wealth that led Australia to be one of the happiest[104] and richest countries in the world, we need to take bold action to strengthen our resilience to these challenges, as future-conscious, sustainably-minded producers and consumers.

In this chapter, we have covered how some of Australia's economic motors have also been –so far– the largest source of greenhouse gas emissions, land degradation, biodiversity pressure, water pollution and waste. We have also identified long-term trends, the current state of affairs and areas of opportunity for the country and for Western Australia.

Australia's reduction of 13% total net emissions between 1990 and 2018 provides important takeaways. First, it constitutes evidence of the positive impact that innovation and sectoral efforts can make. The change, partially led by a 40% reduction in emissions intensity (or the amount of emissions generated per million dollars of Gross Value Added), demonstrates that, by greening our processes, we could achieve both environmental gains and sustained output levels.

The reduction in emissions was also the result of changes in agriculture, forestry and fishing, driven by a decline in log harvesting activity in Australia's native forests, coupled with growing carbon sinks from regrowth. As the second takeaway, this reinforces the growing role that land and nature preservation will play in the fight against climate change, with positive impacts that extend beyond carbon sequestration and into the preservation of water, biodiversity and food security. It is for these reasons that carbon capture should be used as a way to reduce the emissions already accumulated in the atmosphere, rather than as license to create more emissions on the premise of a future offset.

Following this line, the third takeaway is that achievements in one sector of the economy risk being undone by rising emissions from other sectors; hence the need for a multisectoral approach to emissions reduction. Australia would have achieved a larger decline in emissions, had it not been for the 48% increase in energy emissions from 1990 to 2018, with energy now accounting for more than 80% of total net emissions. This is due to Australia's fossil-fuel based energy generation and exports, which represent a large share of WA's economic output, and whose emissions are forecasted to increase in the near-term due to large LNG projects.

The fourth takeaway is that, although households must help by changing their consumption patterns, they typically represent just a small part of the issue. By removing price-distorting mechanisms such as the fuel tax credits, governments could eliminate artificial incentives towards the use of fossil fuels by industry, at the same time levelling the playing field for households, who in 2016-17 paid 40% of environmentally-related taxes. As the world moves towards a greener economy and Australia's main trade partners commit to their own net-zero targets, and with falling oil and coal prices, it is important to prepare for the new economic environment, and for the goods, services and jobs it will demand.

104 Helliwell, JF., Layard, R., Sachs, J. & De Neve, JE. eds. (2020). World Happiness Report 2020. New York: Sustainable Development Solutions Network. https://worldhappiness.report/ed/2020/social-environments-for-world-happiness/.

The recent IMF findings about low-carbon sectors typically using more labour than do high-carbon sectors in both the short and long term, provide a positive outlook and pathway for Australia and WA, as they transition to this economy of the future.[105]

The fifth takeaway is based on the fact that, in regards to the natural environment, greening the economy is really a matter of self-preservation for Australia and for WA. Western Australia is set to be one of the regions on Earth most affected by climate change, with an average decrease in rainfall of 10% over the last century. Additional to the pressure this puts on ecosystems, on water and food security, it can also affect people's incomes, particularly on sectors such as agriculture, forestry and fishing.

Again demonstrating the interconnectedness and interdependence of these issues, the estimate that 55% to 62% of the decline in rainfall in WA is due to land clearing alone is a further call for safeguarding of our natural resources. This is heightened by the increasing rates in dryland agriculture and intensive land use in Australia –with a higher use of chemicals and fertilisers– and the rise in areas burned by wildfires across the country, particularly in WA.

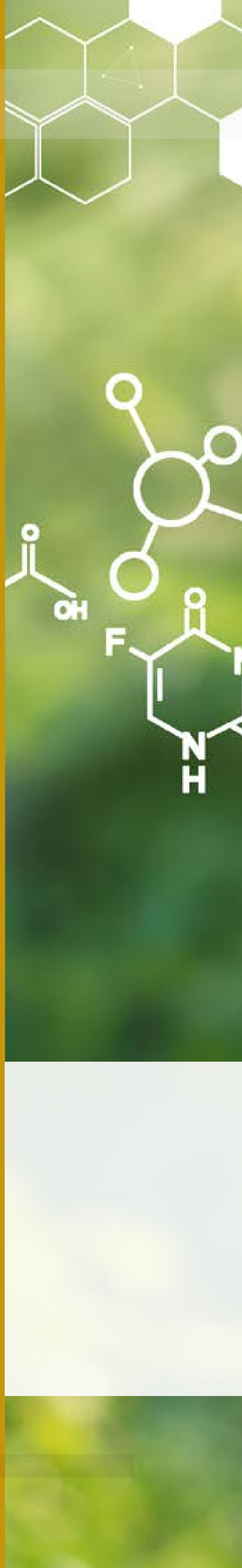
Pressures from the water-land nexus are already being felt in WA, with prices of agricultural land increasing by 28% in 2019, and by almost 60% in areas with reliable rainfall. WA farmers use less distributed water than the national average, with fewer businesses irrigating overall, and average land holdings are larger to maintain crop yield levels under these changing conditions. A solution that has started to gain mainstream attention is regenerative agriculture, which seeks to rehabilitate the entire farm ecosystem. As consumer awareness shifts, the slightly higher cost of this type of production can be met with higher prices, turning it into a viable option for most of the agricultural plots in WA. More diverse crops instead of monofarming, and the incorporation of indigenous knowledge in land management and food systems, can be additional solutions for WA.

Waste is a further area where a shift of consumption and production patterns is needed, particularly with rising living standards and population growth. Waste not only puts pressure on waste management systems; it also comes at a high economic and environmental cost, given the resource inputs and labour required. Although WA is the state with the lowest per capita waste in Australia, with a 37% reduction since 2010, it has higher rates of plastic and food organic waste than any other state in Australia.

Overall, the process of extraction and transformation often requires more energy and creates more pollutants than cleaning or recycling products for reuse. Future-conscious, sustainably-minded production and consumption require price signals to take environmental costs into account.

105 International Monetary Fund. (2020). World Economic Outlook, October 2020: A Long and Difficult Ascent". p. 98. https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020.

"TWO THIRDS OF AUSTRALIANS AGREE THAT **PROTECTING THE ENVIRONMENT SHOULD BE GIVEN PRIORITY** EVEN IF IT CAUSES SLOWER ECONOMIC GROWTH."



CARING FOR THE ENVIRONMENT: INDIVIDUAL PREFERENCES AND BEHAVIOURS IN AUSTRALIA

INTRODUCTION

This chapter provides an overview of environmental attitudes and behaviours in Australia. How environmentally-oriented are Australians today? How much pro-environmental action do they take? How much willingness is there in our society to support pro-environmental policies? Are there differences in environmental behaviours by gender, educational attainment and age cohort? How do Australians compare to their counterparts in other OECD countries in their environmental attitudes and behaviours? We respond to some of these questions drawing on several nationally-representative survey data sources including the Australian Survey of Social Attitudes 2016; World Values Surveys waves 2005-2009 and 2017-2019; ANU Polls 2008 and 2020; and Australian Election Studies 2016 and 2019.

Our analysis explores a wide range of environmental views prevalent in Australia today and whether and how these have been shaped by direct exposure to fires that have occurred over the 2019/2020 spring/summer months. Not only do we consider the environmental views of Australians, we also look at environmental action undertaken by individuals through participation in boycotts, purchase of certain products, or membership of environmental organisations. Moreover, we analyse the degree of confidence in environmental organisations present today and how that confidence might contribute to willingness to take up membership of such organisations.

This chapter explicitly focuses on individuals' support for pro-environmental policies even in cases when these could potentially incur some economic loss. We document Australian's views on what the government's role should be in protecting the environment and whether more government action and spending towards the environment is required. We analyse whether individual support for more government environmental action is shaped by perceptions of the threat posed by global warming to individuals' lives. Finally, our analysis covers the extent to which environmental concerns feature in Australians' voting decisions and draws inferences on government responsiveness to individuals' environmental preferences in environmental policy-making in Australia.

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ENVIRONMENTAL VIEWS AND ACTIVISM

Perceptions of environmental issues

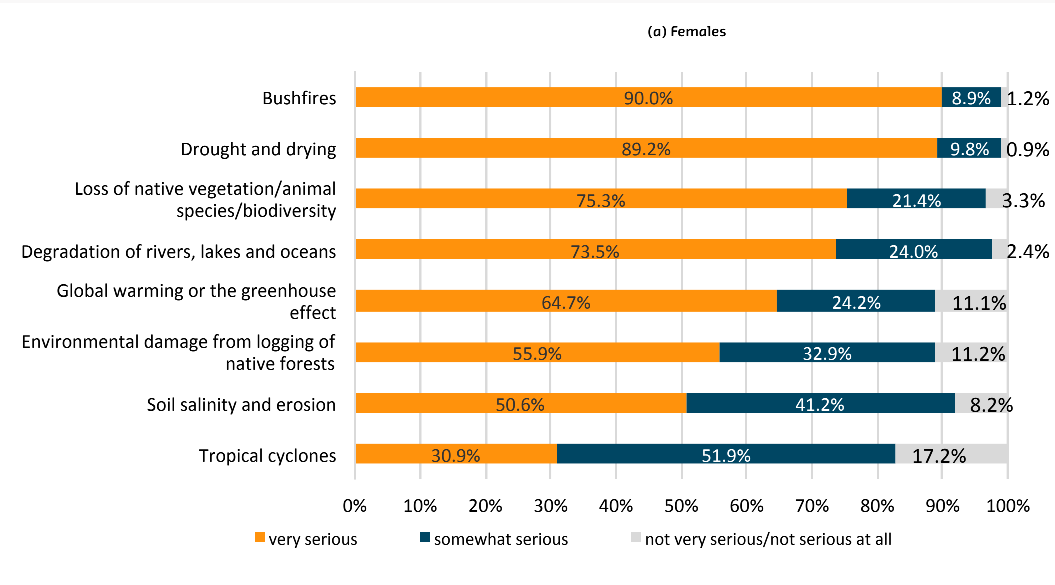
What are the perceptions of seriousness of environmental issues in Australia? And are there gender differences in such preferences? Figure 36 presents perceptions across 8 different environmental issues. Overall, a vast majority of Australians think of environmental issues facing Australia as somewhat or very serious. However, there are differences in views depending on the specific environmental issue. Ninety percent of females and 74% of males surveyed in 2020 think of bushfires as a very serious issue facing Australia. Similarly, drought and drying are seen as a very serious environmental issue among 89% of females and 74% of males. On the other hand, relatively small proportion of individuals think of tropical cyclones as a very serious issue – 31% of females and 23% of males do so. Yet, a further 52% of females and 46% of females think tropical cyclones are somewhat serious issue for Australia.

There are vivid gender differences in environmental views with females more likely to perceive various environmental issues as "very serious". For example, there is a 16 percentage points difference in the shares of females and males who see bushfires as a very serious issue facing Australia. Furthermore, 75% of females and only 62% of males think of loss of native vegetation, animal species or biodiversity as a very serious issue. Such gender differences may be related to a number of things, including the differences in the ways females and males are socialised as well as the different roles they perform in the society, with males more likely to be in occupations that directly contribute to exacerbation of some of the environmental issues.

90% of women and 74% of men surveyed in 2020 think of bushfires as a very serious issue facing Australia.

FIGURE 36

Views on seriousness of various environmental issues facing Australia by gender, Australia, 2020

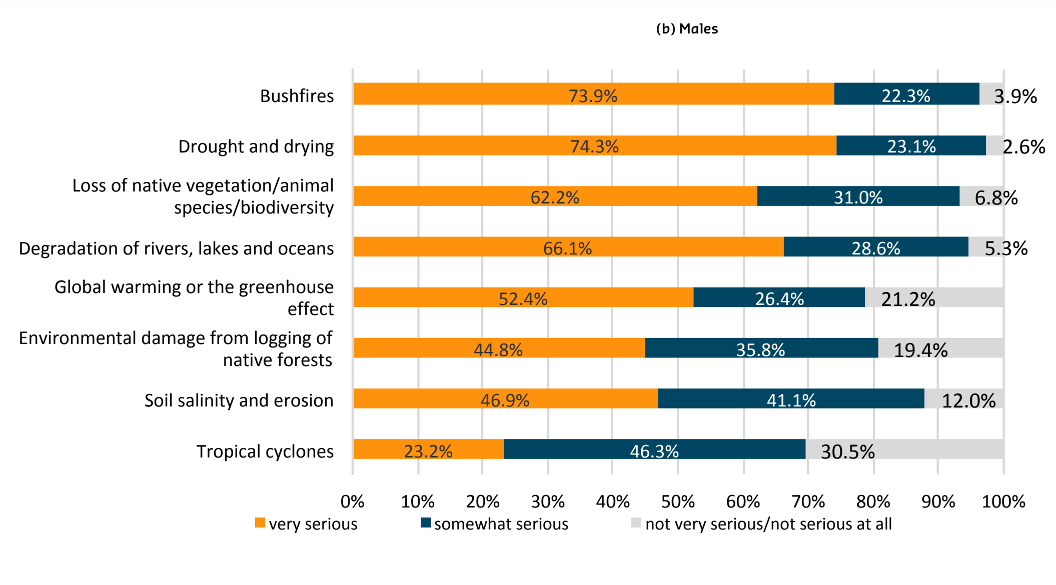


Source: Bankwest Curtin Economics Centre | Authors' calculations based on January 2020 ANU Poll.

There are substantial gender differences in environmental views, with women more likely to perceive various environmental issues as very serious.

FIGURE 36 (continued)

Views on seriousness of various environmental issues facing Australia by gender, Australia, 2020



Source: Bankwest Curtin Economics Centre | Authors' calculations based on January 2020 ANU Poll.

Like many social attitudes, environmental values and beliefs often have deep cultural roots[106] and are therefore resistant to change. But exposure to environmental disasters, such as bushfires, might change the way individuals see environmental issues and the threat these may pause to their lives. In Figure 37 we explore whether views on eight different environmental issues vary across individuals who have and have not experienced severe consequences from fires over the 2019/2020 spring/ summer.

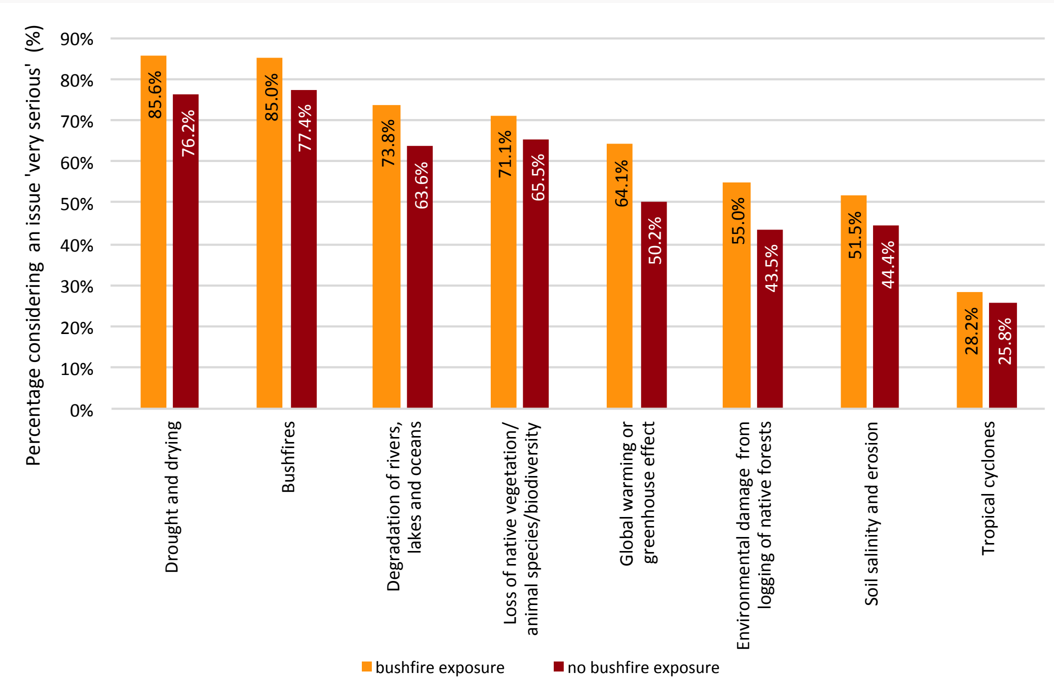
The share of individuals who perceive various environmental issues as 'very serious' is considerably higher among those who have directly experienced severe consequences from 2019/2020 bushfires. Sixty-four percent of Australians with direct experience of 2019/2020 bushfire consequences think of global warming or greenhouse effect as a serious issue; this rate is 50% among those lacking such experience.

The share of individuals who perceive various environmental issues as 'very serious' is considerably higher among those who have had direct exposure to the 2019/20 bushfires.

64% of Australians with direct exposure to the 2019/2020 bushfires thinks of global warming as a serious issue, compared to 50% among those without direct exposure.

FIGURE 37

Views on seriousness of various environmental issues facing Australia by bushfire exposure status, Australia, 2020



Note: Bushfire-exposed individuals are those who have directly experienced severe consequences from fires that have occurred over the 2019/2020 spring/summer in Australia, including having their property damaged or threatened, having to be evacuated or physically feeling affected by smoke.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on January 2020 and September 2008 ANU Polls.

106 Mavisakalyan A., Tarverdi, Y., Weber C. (2018):"Talking in the present, caring for the future: Language and envirioment," Journal of Comparative Economics 46, pp 1370-1387.

With higher educational attainment there is a higher appreciation among individuals of the threat posed by global warming to their lives.

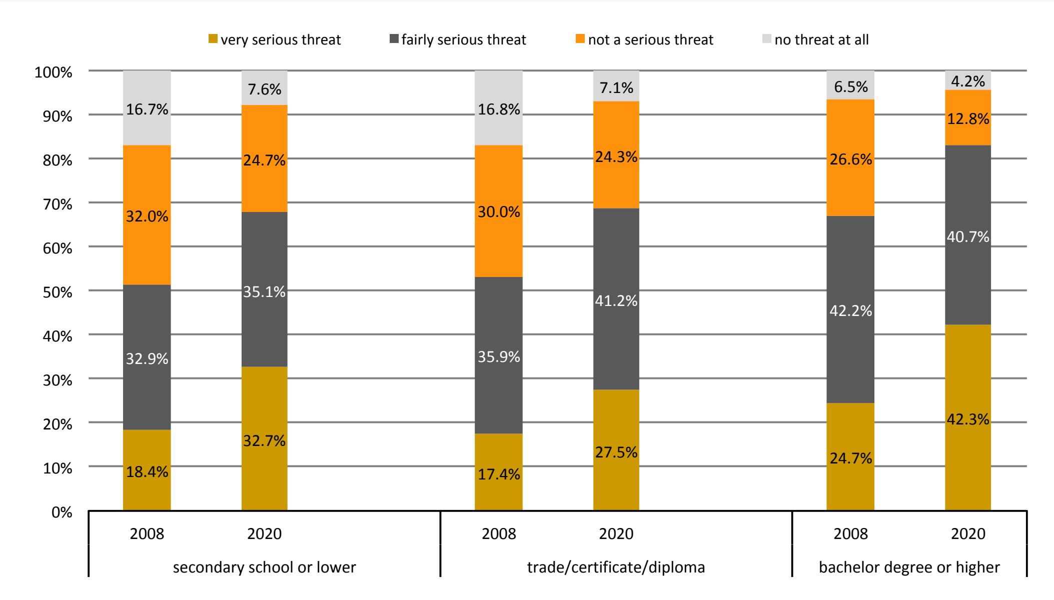
Among individuals surveyed in 2020, 41% of those who held at least a bachelor degree and only 33% of those with educational attainment of secondary or below thought that global warming was a very serious threat to their lives.

Perceptions of the threat posed by global warming have changed significantly over time with the share of those who see it as a serious threat significantly higher now compared to 12 years ago.

We specifically focus on the views on global warming and the degree to which individuals perceive it as a direct threat to their lives in Figure 38. One question we pursue in this analysis is whether those with higher educational attainment have a greater appreciation of the threat posed by global warming to their lives. Indeed this appears to be the case, with 41% of those surveyed in 2020 who held at least a bachelor degree, and only 33% of those with educational attainment of secondary or below, concerned that global warming was a very serious threat to their lives – a difference of 9 percentage points. On the other hand, the prevalence of individuals who express the view in 2020 that global warming poses no serious threat or no threat at all is 17% among the tertiary degree-holders and over 32% among individuals with a secondary education or below. What we also observe from Figure 38 is that perceptions of the threat posed by global warming have changed significantly over time, with the share of those who see it as a serious threat significantly higher now compared to 12 years ago across all three groups.

FIGURE 38

Views on threats posed by global warming to oneself and one's way of life in their lifetime, Australia, 2008 and 2020



Source: Bankwest Curtin Economics Centre | Authors' calculations based on January 2020 ANU Poll.

Environmental activism

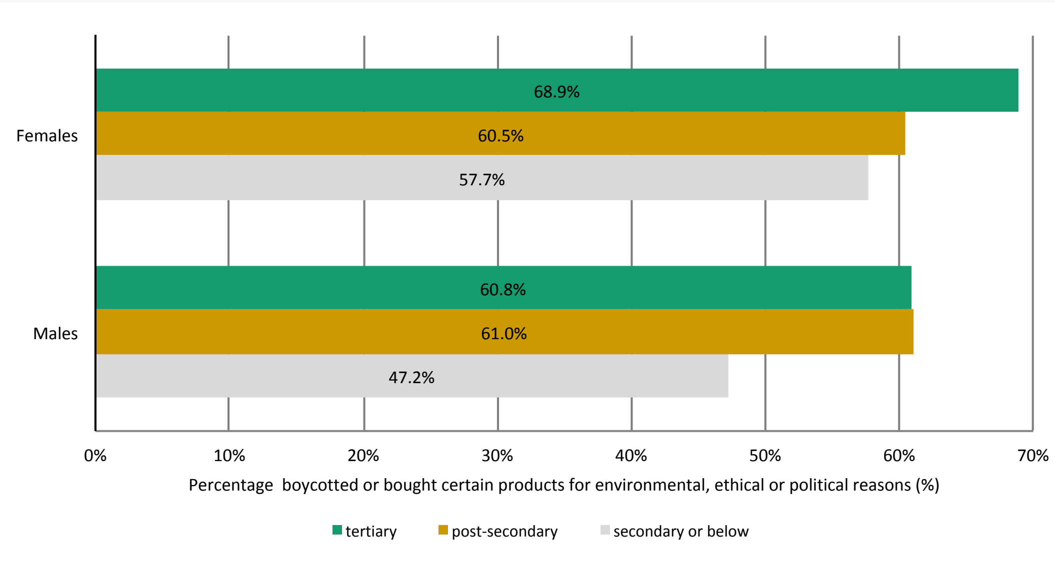
Moving from environmental views to action, we take a look at experiences of boycotting or buying certain products out of environmental or ethical considerations in Figure 39. Pro-environmental action appears to increase with educational attainment, especially among females. Sixty-nine percent of females with tertiary educational attainment reported having boycotted or bought products out of environmental considerations over a two-year period in 2016; only 58% of females with secondary or lower educational attainment did so.

In the previous sub-section we reported gender differences in environmental beliefs; such differences also extend to action. We observe 8 percentage points difference in actions of boycotting or buying products out of environmental considerations between tertiary educated males and females. On the other hand, 58% of females with secondary or lower educational attainment and only 47% of males with similar educational attainment report having undertaken such environmental actions over a two year period.

Pro-environmental action, captured through boycotting and buying certain products out of environmental considerations, appears to increase with educational attainment, especially among females.

FIGURE 39

Pro-environmental action undertaken over the past two years, Australia, 2016



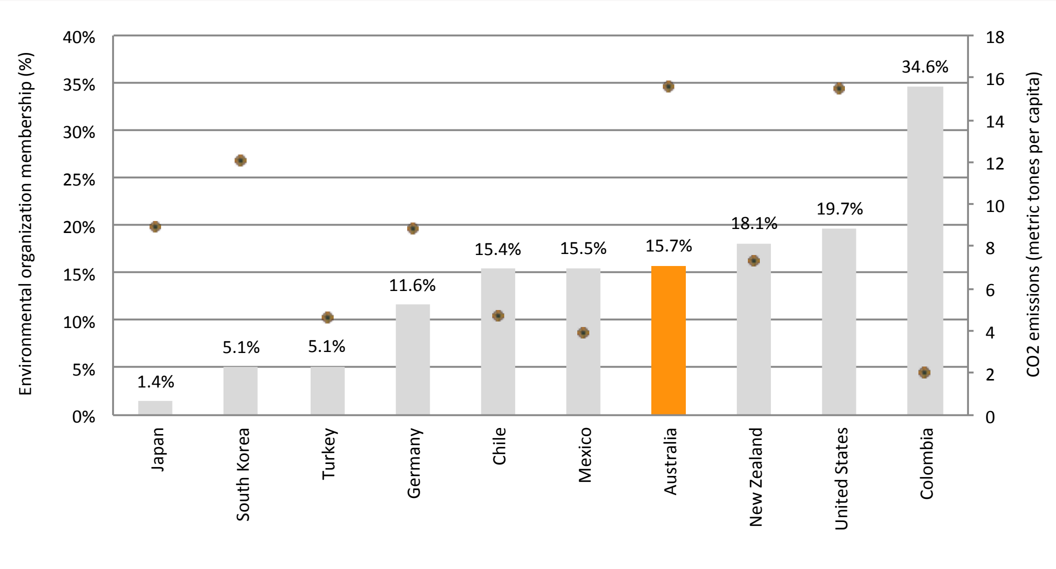
Source: Bankwest Curtin Economics Centre | Authors' calculations based on the Australian Survey of Social Attitudes 2016.

Based on the latest data from the World Values Surveys, 1.4% of Japanese, 11.6% of Germans, 15.7% of Australians, 18.1% of New Zealanders and 19.7% of Americans said they held membership in environmental organisations.

Membership in environmental organisations is another form of environmental activism that we turn to in Figure 40, comparing prevalence of such membership across selected OECD countries. Based on the latest data from the World Values Surveys, 1.4% of Japanese, 11.6% of Germans, 15.7% of Australians, 18.1% of New Zealanders and 19.7% of Americans say they held membership in environmental organisations. Colombians report the highest rate of environmental organisation membership at nearly 35%. However, as seen in the same figure, the differences in environmental activism rates across countries appear to be largely uncorrelated with the differences in their per capita emissions.

FIGURE 40

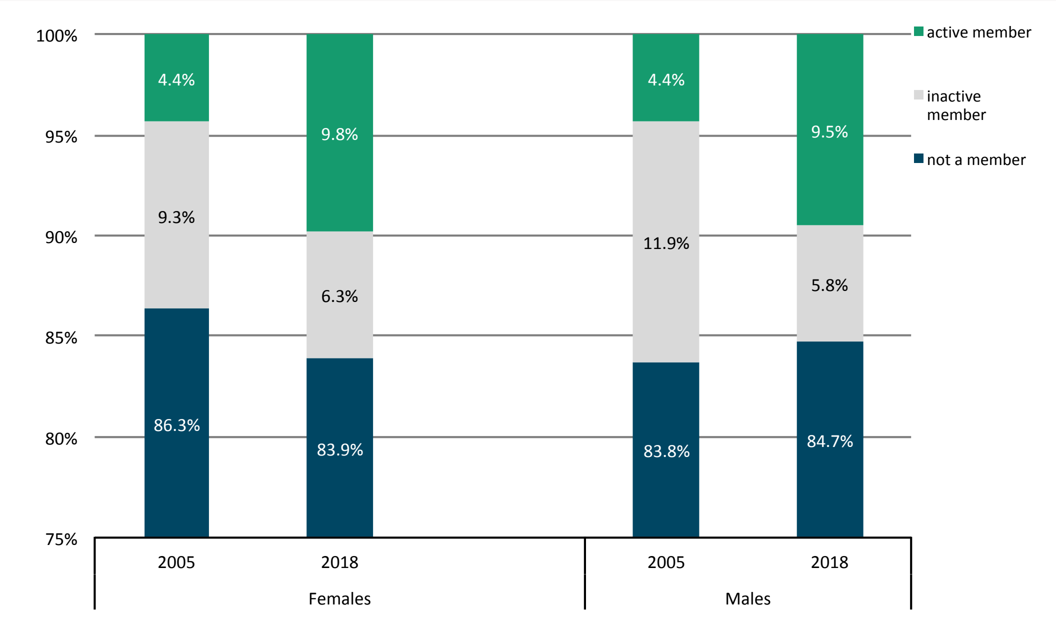
Membership in environmental organisations, OECD countries, 2017 to 2019



Source: Bankwest Curtin Economics Centre | Authors' calculations based on World Values Surveys wave 2017-2019 and World Development Indicators data on per capita CO_2 emissions as of 2016.

FIGURE 41

Membership in environmental organisations by membership status and gender, Australia, 2005 and 2018



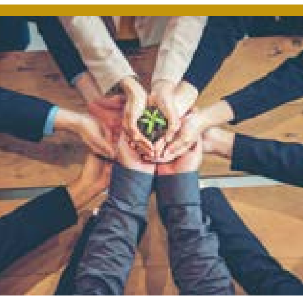
Source: Bankwest Curtin Economics Centre | Authors' calculations based on World Values Surveys waves 2005-2009 and 2017-2019.

We take a closer look at membership in environmental organisations in Australia in Figure 41. We do not observe significant changes in the shares of individuals opting for membership in an environmental organisation over the period between 2005 and 2018. However, there is evidence to suggest that those who opt for membership in environmental organisations are significantly more likely to be active in that role now compared to 13 years ago.

The share of active members of environmental organisations has more than doubled between 2005 and 2018 among both men and women. On the other hand, we see a significant decrease in the share of inactive members of environmental organisations in the same period.

There is evidence to suggest that those who opt for membership in environmental organisations are significantly more likely to be active in that role now compared to 13 years ago.

The share of individuals who report a great deal or quite a lot of confidence in environmental organisations is 53.8% in Japan, 55% in the US, 59.6% in Australia, 63.5% in New Zealand and 67.8% in Germany.



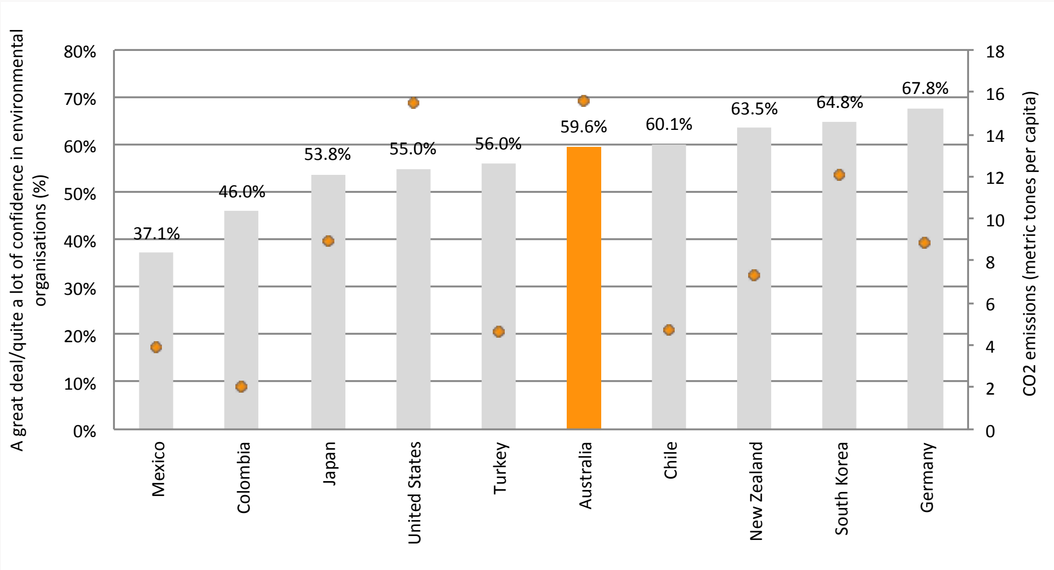
The degree of confidence in environmental organisations matters for take-up of membership in such organisations in Australia.

How much confidence is there in environmental organisations and does such confidence matter for willingness to take up membership in environmental organisations? We address these questions in Figure 42 and Figure 43.

The share of individuals who report a great deal or quite a lot of confidence in environmental organisations is 53.8% in Japan, 55% in the US, 59.6% in Australia, 63.5% in New Zealand and 67.8% in Germany (Figure 42).

FIGURE 42

Confidence in environmental organisations, OECD countries, 2017 to 2019

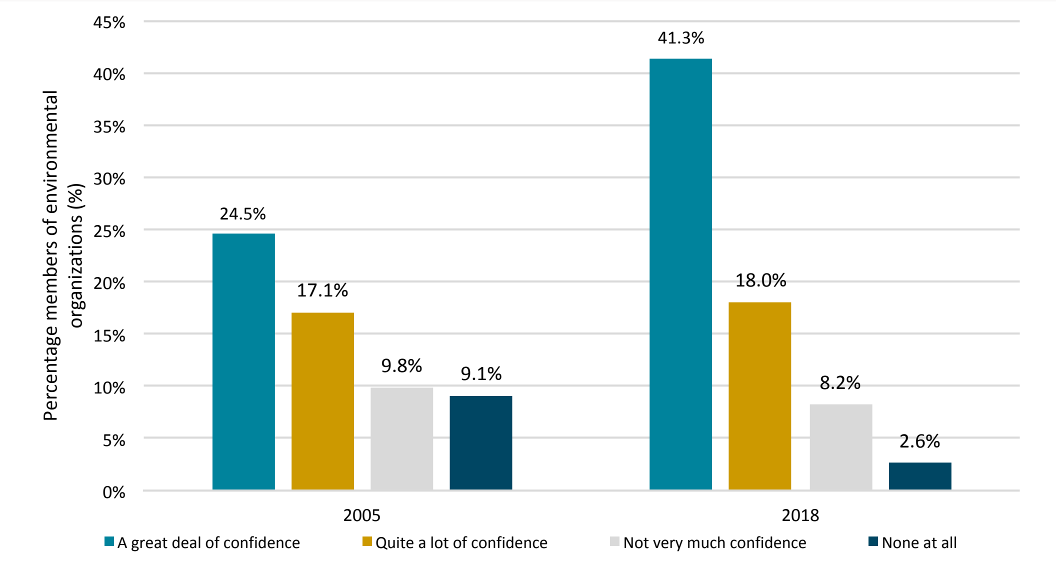


Source: Bankwest Curtin Economics Centre | Authors' calculations based on World Values Surveys wave 2017-2019 and World Development Indicators data on per capita CO_2 emissions as of 2016.

As Figure 43 illustrates, the degree of confidence in environmental organisations matters for take-up of membership in such organisations in Australia. As of 2018, among individuals who reported a great deal of confidence in environmental organisations, the environmental organisation membership rate was 41%; among those who said they had no confidence at all in environmental organisation, the membership rate was under 3%. In fact, there is significant difference, at around 23 percentage points, even in environmental organisation membership rates of those who report a great deal of confidence and those who report quite a lot of confidence in environmental organisations.

FIGURE 43

Degree of confidence in environmental organisations and membership of environmental organisations, Australia, 2005 to 2018



Source: Bankwest Curtin Economics Centre | Authors' calculations based on World Values Surveys waves 2005-2009 and 2017-2019.

SUPPORT FOR ENVIRONMENTAL POLICIES

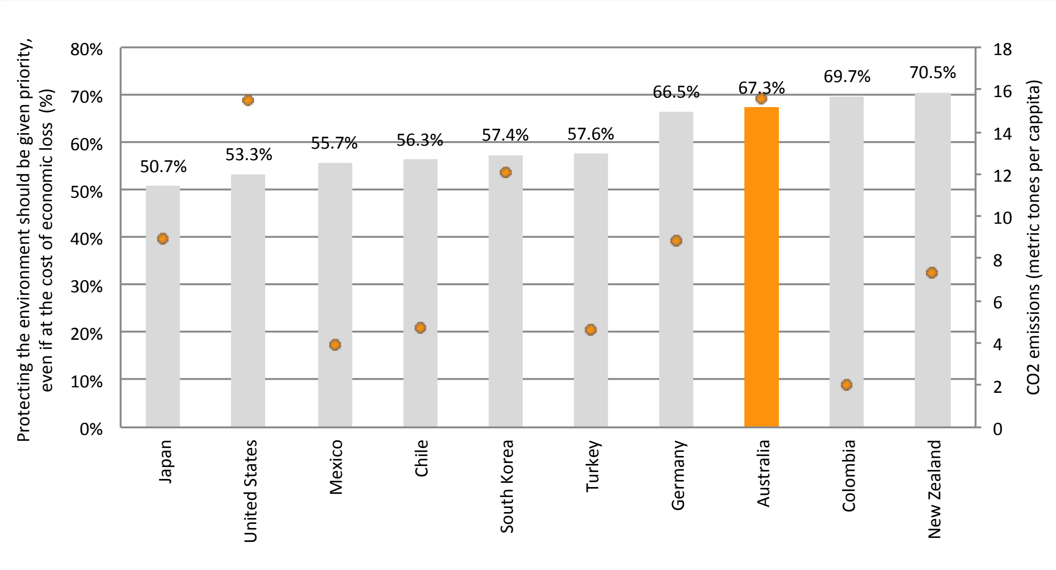
Based on the latest data from the World Values Surveys, 50.7% of Japanese, 53.3% of Americans, 66.5% of Germans, 67.3% of Australians and 70.5% of New Zealanders have the view that protecting the environment should be given priority even if it causes slower growth and some job loss.

Priorities over policies: environment vs economy

Should environmental protection be a priority, even if it may come at the cost of slower economic growth and loss of jobs? The majority of populations across selected OECD countries seem to think so. Based on the latest data from the World Values Surveys, 50.7% of Japanese, 53.3% of Americans, 66.5% of Germans, 67.3% of Australians and 70.5% of New Zealanders have the view that protecting the environment should be given priority, even if it causes slower growth and some job loss.

FIGURE 44

Views on environment and economy - should protecting environment be given priority, even if it causes slower economic growth and some loss of jobs, OECD countries, 2017 to 2019



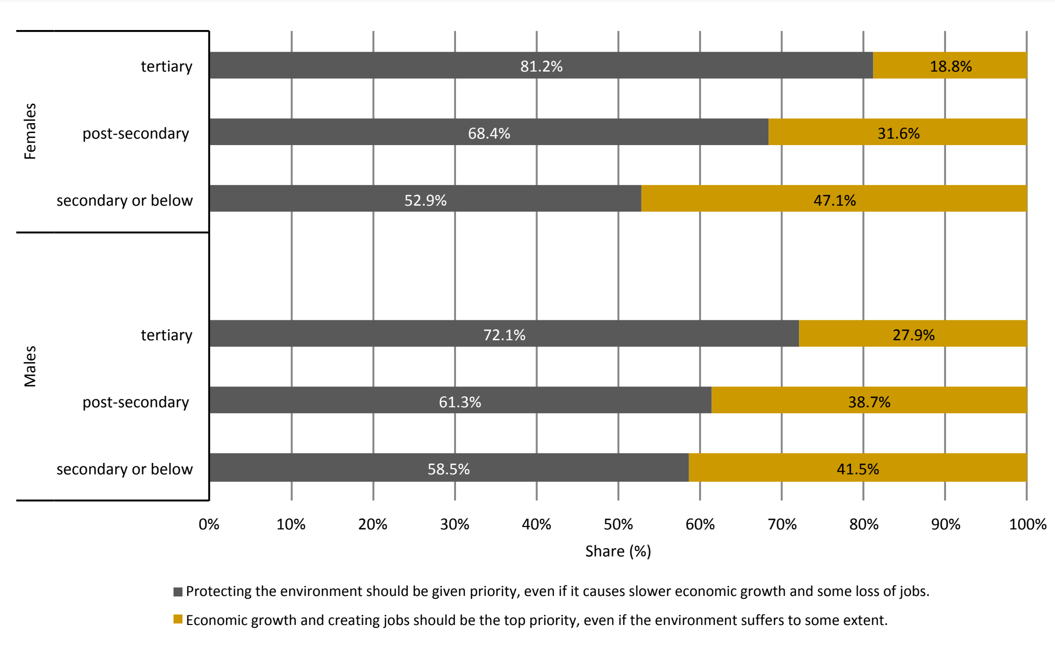
Source: Bankwest Curtin Economics Centre | Authors' calculations based on World Values Surveys wave 2017-2019 and World Development Indicators data on per capita CO_2 emissions as of 2016.

The share of individuals willing to prioritise environment over the economy grows in educational attainment among both females and males (Figure 45). Around 81% of tertiary-educated females and just over half of the females with secondary or lower educational attainment in Australia express the view that protecting the environment should be given priority, even if it causes slower economic growth and some loss of jobs. This opinion gap across the two educational attainment groups is smaller, at around 14 percentage points, among males.

Around 81% of tertiary-educated females and just over the half of females with secondary or lower educational attainment in Australia express the view that protecting the environment should be given priority, even if it causes slower economic growth and some loss of jobs.

FIGURE 45

Views on environment and economy by gender and educational attainment, Australia, 2018

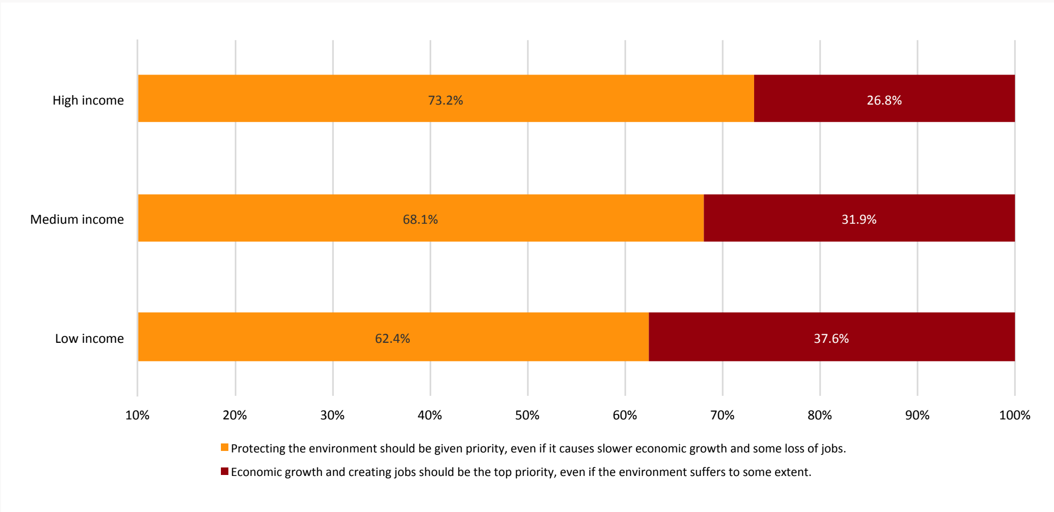


Source: Bankwest Curtin Economics Centre | Authors' calculations based on World Values Surveys wave 2017-2019.

Nearly 38% of low income-earners in Australia believe that economic growth and creating jobs should be the top priority, even if the environment suffers to some extent; 27% of high income-earners share this view – a difference of 11 percentage points.

FIGURE 46

Views on environment and economy by self-reported household income group, Australia, 2018

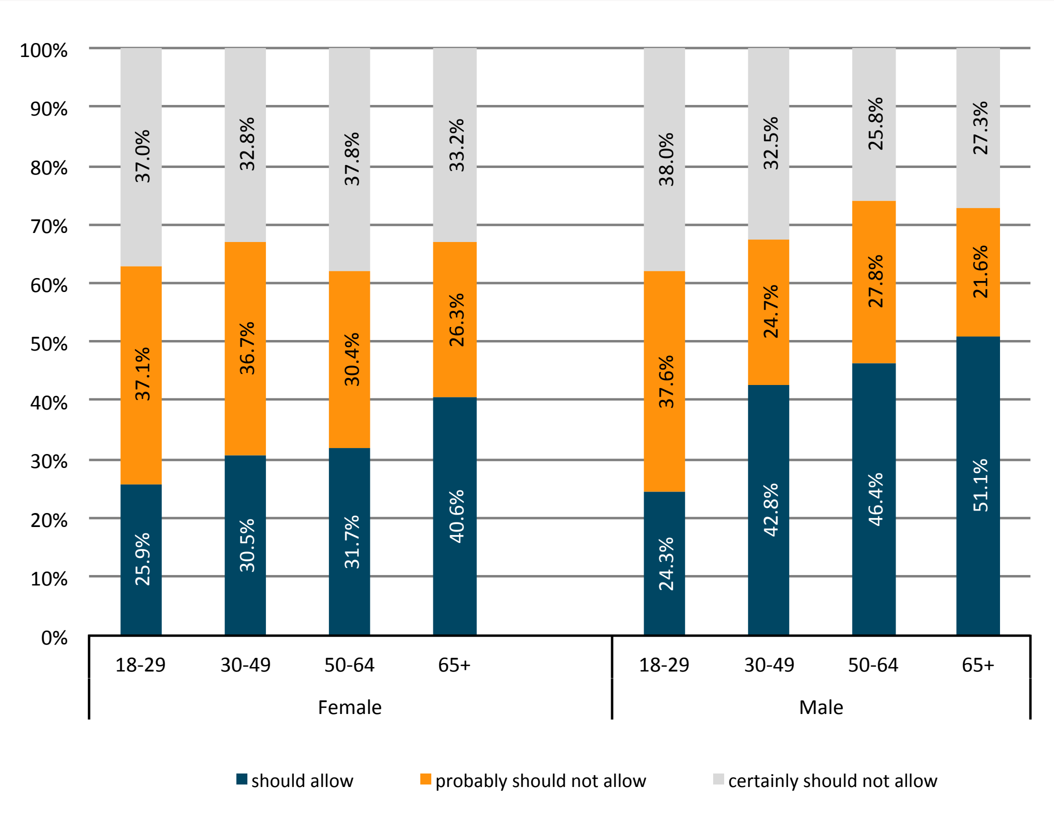


Source: Bankwest Curtin Economics Centre | Authors' calculations based on World Values Surveys wave 2017-2019.

However, some groups in the society, particularly the low income-earners, may find it harder to accept the costs of slower economic growth and loss of jobs, if that's what it takes to protect the environment. As we see in Figure 46, nearly 38% of low income-earners in Australia believe that economic growth and creating jobs should be the top priority, even if the environment suffers to some extent; 27% of high income-earners share this view – a difference of 11 percentage points.

FIGURE 47

Views on whether the government should allow the opening of new coal mines by gender and age group, Australia, 2020



Source: Bankwest Curtin Economics Centre | Authors' calculations based on January 2020 ANU Poll.

In the Australian context, coal mining is often seen as an activity that may be directly contributing to the increase in the country's CO_2 emissions. Yet the Federal Government frequently promotes the expansion of fossil fuels, for example it approved the opening of the highly controversial Adani coal mine in April 2019. But do Australians actually support the government allowing the opening of new coal mines? The share of Australians who believe that the government should allow the opening of new coal mines increases with age cohort for both males and females (Figure 47). Over 51% of Australian men aged 65 or above believe that the government should allow the opening of new coal mines; only around 24% of males aged 18-29 share this belief. Similarly, nearly 41% of females aged 65 and above but only 26% of 18-29 years old females believe that government should allow the opening of new coal mines – a difference of 15 percentage points.

Over 51% of Australian men aged 65 or above believe that the government should allow the opening of new coal mines; only around 24% of males aged 18-29 share this belief.

109

Among individuals who see global warming as a very/fairly serious threat to their lives, nearly 80% say Australia is doing too little to protect the world environment; however only 28% of those who don't see much threat associated with global warming say Australia is doing too little.

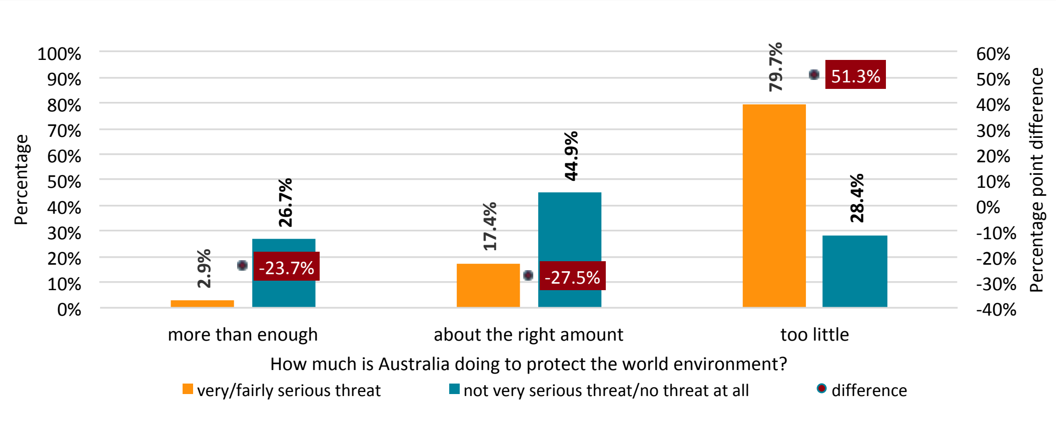
Support for government policies for environmental protection

What do Australians think of their country's contribution towards protecting the world environment? Is Australia doing too little or perhaps too much? We address this question in Figure 48, where we consider the views around Australia's contribution to protect the environment by the degree to which individuals feel threatened by the effects of global warming on their lives. The more the individuals perceive global warming as a threat to their lives, the more likely they appear to think Australia's contribution to protect the world environment is too little.

Among individuals who see global warming as a very/fairly serious threat to their lives, nearly 80% say Australia is doing too little to protect the world environment; however only 28% of those who don't see much threat associated with global warming say Australia is doing too little. On the other hand, 45% of individuals who think global warming poses hardly any or no risk think that Australia is doing about the right amount for the world environment while only 17% of individuals who see global warming as a serious threat to their lives think the same.

FIGURE 48

Views on Australia's contribution to protect the world environment by perceived threat that global warming will pose to one's way of life in their lifetime, Australia, 2020



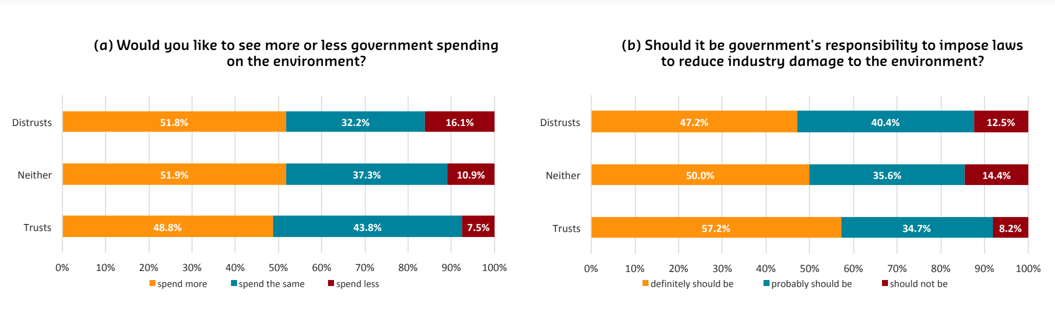
Note: Perceived threat from global warming is defined based on responses to a question on how serious a threat one thinks global warming, climate change, global heating will pose to oneself and one's way of life in their lifetime.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on January 2020 ANU Poll.

What should be the government's role in protecting the environment? Should there be more or less government spending? Should there be regulations to reduce industry damage? Figure 49 looks at how the views on these questions vary by individuals' trust in government. Looking at preferences over the amount of government spending on the environment in panel (a), we see that among individuals who trust in government only 7.5% express preference for less government spending on the environment; in contrast over 16% of individuals who distrust the government express the same preference. Across all three groups, however, nearly half of individuals think that there should be more government spending on the environment.

The vast majority of Australians think that it should be the government's responsibility to impose laws to reduce industry damage to the environment (panel (b) of Figure 49). This preference too varies with the presence of trust in government. Among individuals who trust in government, over 57% believe that the government's responsibility should include imposing laws to reduce industry damage to the environment. Among individuals who distrust in government, only 47% share the same view.

FIGURE 49

Trust in government and preferences over government role in protecting the environment, Australia, 2016



Note:Trust in government is defined based on responses to a question on whether most public servants can be trusted to do what is best for the country.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on the Australian Survey of Social Attitudes 2016.

Among individuals who trust in government only 7.5% express preference for less government spending on the environment; in contrast over 16% of individuals who distrust the government express the same preference.

The vast majority of Australians think that it should be the government's responsibility to impose laws to reduce industry damage to the environment.

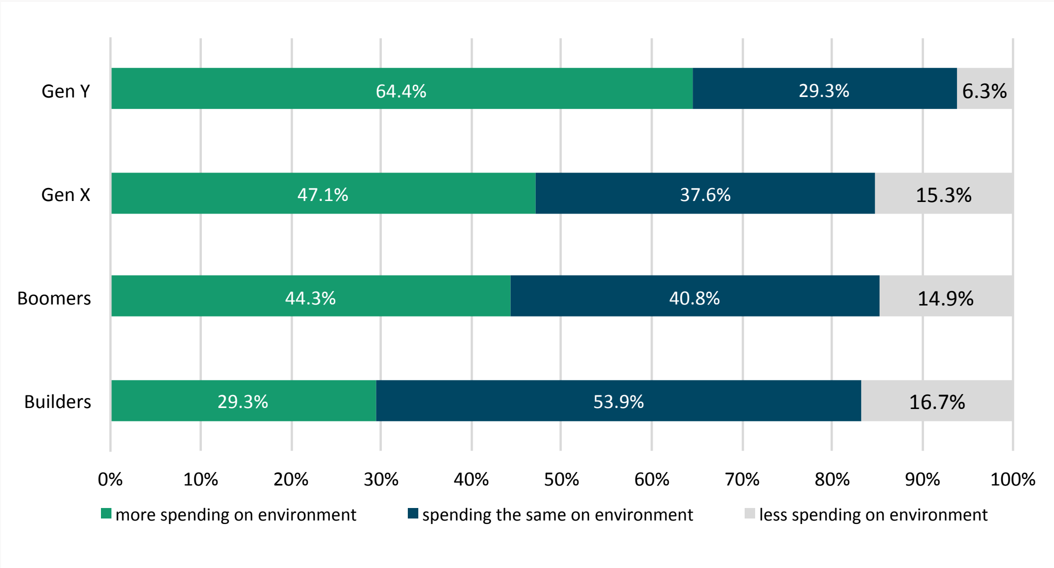
There are significant generational differences in preferences over government spending on the environment with preference over more government spending increasing with decrease in age.

There are significant generational differences in preferences for government spending on the environment. Figure 50 shows that younger generations prefer much greater government spending on the environment than their elders. Over 64% of the individuals from Generation Y believe that the government should spend more on the environment than it currently does.

By comparison, only 29% of Builders, our oldest generation, think that government should spend more on the environment. Meanwhile, the prevalence of those who prefer less government spending on the environment is only 6% among Generation Y cohort compared to nearly 17% among Builders.

FIGURE 50

Preferences over government spending on environment by generation, Australia, 2016



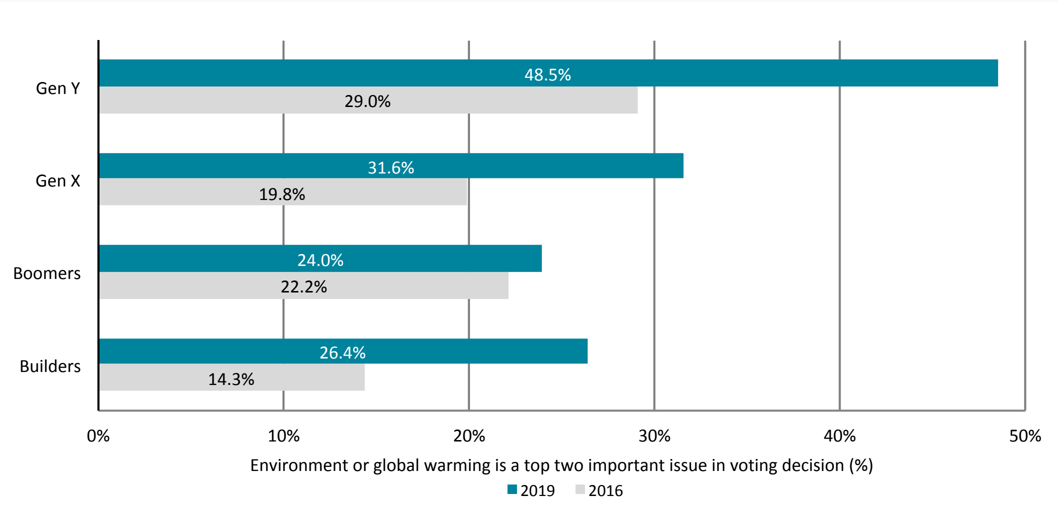
Source: Bankwest Curtin Economics Centre | Authors' calculations based on the Australian Survey of Social Attitudes 2016.

Are preferences over the government role in protecting the environment reflected in individuals' voting decisions? Increasingly so, as Figure 51 suggests. In the period from 2016 to 2019, there has been a significant increase in the share of Australians across four different generations who say that the environment or global warming is among the top two important issues featuring in their voting decisions. Further, there are strong differences in voting preference by generation. As of 2019, 48.5% of Generation Y voters said environment or global warming was a top two important issue in their voting decisions; this compares to 26% among Builders and 24% among Boomers.

As of 2019, 48.5% of generation Y Australians said environment or global warming was a top two important issue in their voting decisions; this compares to 26% among builders and 24% among boomers.

FIGURE 51

Importance of environment or global warming in voting decisions by generation, Australia, 2016 and 2019



Note: Respondents are asked to choose, out of a list of 10 issues, whether environment or global warming were the first or the second important issues for them during the election campaign. Other issues on the list included: taxation; immigration; education; government debt; health and Medicare; refugees and asylum seekers; superannuation; management of the economy.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on the Australian Election Studies 2016 and 2019.

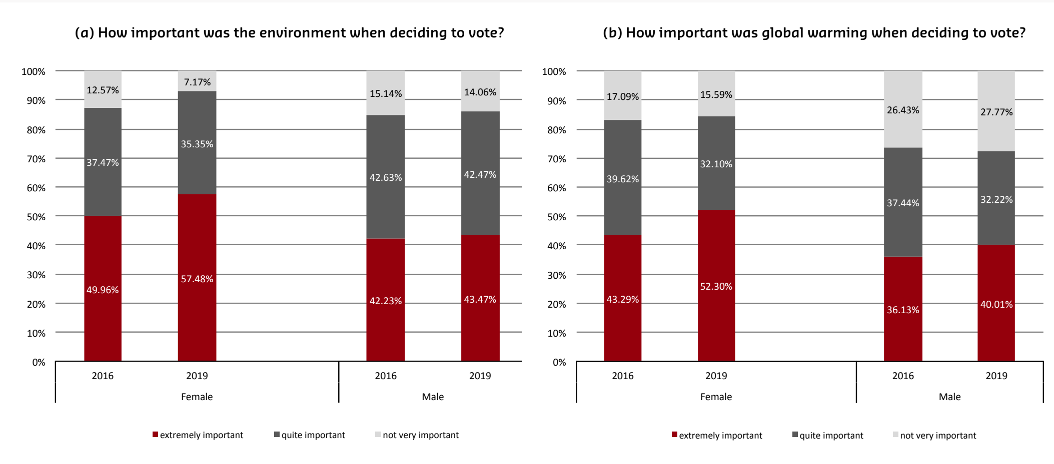
In 2019, 57% of females but only 43% of males reported that environment was extremely important in their voting decision – a difference of 14 percentage points.

Sixteen percent of females and 28% of males surveyed in 2019 said global warming was not very important when deciding to vote.

Environment and global warming feature particularly highly in women's voting decisions, as we see in Figure 52. In 2019, 57% of females but only 43% of males reported that environment was extremely important in their voting decision – a difference of 14 percentage points (Figure 52 panel (a)). This is consistent with the higher pro-environmental concerns and behaviours we observed among women earlier in this chapter. Only 7% of females in 2019 said environment was not very important in their voting decisions; whereas 14% of males expressed the same view. Global warming, as a specific type of environmental concern, features less prominently in voting decisions of both males and females (Figure 52, panel (b)). Sixteen per cent of females and 28% of males surveyed in 2019 said global warming was not very important when deciding to vote.

FIGURE 52

Importance of environment and global warming in voting decisions by gender, Australia, 2016 and 2019



Source: Bankwest Curtin Economics Centre | Authors' calculations based on the Australian Election Studies 2016 and 2019.

CONCLUSION

Overall, a vast majority of Australians are concerned about the environmental issues facing the country, and many act pro-environmentally through purchasing certain products or taking up membership of environmental organisations. However, there are significant differences by gender, education and age cohort. Pro-environmental orientation appears to be higher among women. Interestingly, research shows that gender differences in environmental views are likely to extend beyond the general population: across countries, increase in female representation in national parliaments leads countries to adopt more stringent climate change policies.[107] Furthermore, we find that environmentalism increases with educational attainment and decreases with age. Builders, our oldest generation, exhibits the lowest amount of support for pro-environmental interventions, while Generation Y exhibit the greatest support.

Our analysis suggests that environmental attitudes also vary by exposure to environmental disasters, with those having had direct exposure to bushfires showing more concern over environmental issues. Anticipated threat associated with global warming matters too: the more threatened Australians feel by global warming, the more likely they are to think that Australia is doing too little to protect the environment. Trust in institutions also shapes environmental attitudes and behaviours, including take up of membership of environmental organisations and support for government intervention to protect the environment.

Concerns over the environment and global warming among Australians have been increasing over time, and feature strongly in their preferences for policies and voting considerations. Yet, policy responses to such widespread preferences have been far from adequate. In fact, recent evaluations of Australia's climate policies suggest that the country's climate policy performance has worsened at both national and international levels. Australia received the lowest rating for both its national and international climate policies in this year's Climate Policy rating produced by Germanwatch as part of its Climate Change Performance Index (CCPI) – an index that evaluates and compares the climate protection performance of 57 countries and the European Union based on performance rating provided by around 400 climate and energy policy experts from NGOs, universities and think tanks within the countries that are evaluated.[108]

This research highlights a number of key issues for those concerned with increasing the effectiveness of our response to environmental challenges and public support for effective policy development and implementation.

Firstly, it highlights the significant gap between the environmental preferences of the population, their influence on voting intention and government policy making. The significant gap between our attitudes and our ongoing emissions shows something more is going on politically.

Research shows that gender differences in environmental views are likely to extend beyond the general population: across countries, increase in female representation in national parliaments leads countries to adopt more stringent climate change policies.

107 Mavisakalyan, A., Tarverdi, Y. (2019): "Gender and climate change: Do females parliamentarians make difference?" European Journal of Political Economy 56, pp 151-164.

108 Burck, J., Hagen, U., Hoehne, N., Nascimento, L., Bals, C. (2020). The Climate Change Performance Index Results 2020. Germanwatch and CAN.

Secondly it demonstrates a clear link between education, age and attitudes that suggests any efforts to strengthen public support for environmental action should focus on awareness raising among these groups. At the same time, with comparatively high levels of population awareness failing to translate into government policy, simply raising awareness may not be sufficient to achieve positive change.

The evidence on gender and caring for the environment may point to another way forward, as countries with more women MPs implement more effective climate change policies. While Australia was one of the first countries to have women in Parliament, our current rates of representation are more or less average in world terms and we could do more in this space.

Our findings also show that trust in institutions is strongly linked to attitudes. While strengthening trust in environmental organisations is likely to increase membership and action, it is unclear how voters can reconcile increasing trust in government with an ongoing failure of effective policy implementation. Conversely, the door is open for governments, concerned with declining levels of trust among their citizens, to act decisively on issues they care about as a way of engendering greater support.

"**WA HAS THE LOWEST PROPORTION OF RENEWABLE ELECTRICITY GENERATION** OF ANY STATE AT ONLY 9%."

STATE OF PLAY OF THE GREEN ECONOMIC SECTORS

INTRODUCTION

This chapter examines current trends in the green sectors of the economy in Western Australia and Australia. The UN Environment Programme (2020) defines a green economy as "low carbon, resource efficient, and socially inclusive". Green economic sectors of the economy include renewable energy, green buildings, sustainable transport, water management, and waste management.

Growth in green economic sectors is an important issue because it leads to the reduction of greenhouse gas emissions and the protection and preservation of the environment more broadly. Another important objective of some green economic sectors, such as the green building sector, is to reduce the energy used in the life cycle of the products they produce, thus reducing the life cycle greenhouse gas emissions generated from these products.

This life cycle paradigm highlights the importance of considering not only the greenhouse gas emissions and energy used to produce a final good or service, but also those of the intermediate products that are required as inputs for the manufacturing process. This chapter provides an overview of how green sectors in Western Australia and Australia are travelling and how these green sectors compare to other states.

RENEWABLE ENERGY

Renewable energy has the potential to transform one of the major contributors to the production of greenhouse gases and solve one of the biggest problems our generation is facing – global warming.

The world is moving towards renewables in preference of high carbon-emission fuels such as coal and gas at a remarkable rate, as advances in renewable technology and consumer demand, along with renewable energy targets set by governments driving this trend (Cassells *et al.* 2017).

Whole jurisdictions and regions across the world are demonstrating clearly that it is possible to source 100% of electricity needs from renewable sources and investment in the solar and wind renewable resource sector reached $282 billion in 2019.[109]

In 2018-19, just over 20% of electricity generated in Australia was from renewable sources, representing a five percentage point increase in the last five years alone. Over the past decade, progress in moving towards renewable energy sources has varied widely across the states and territories, with some progressing faster and others making relatively little ground (Figure 53).

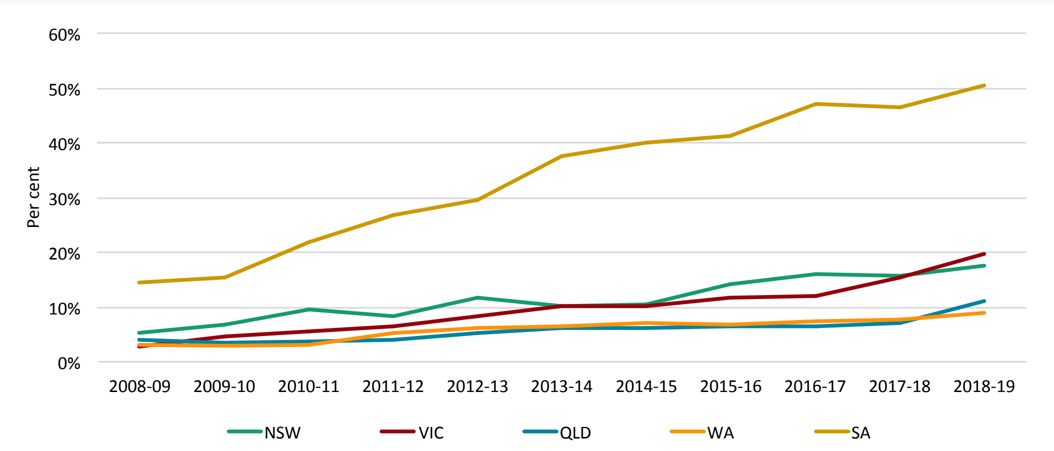
Tasmania has led the way and currently generates 94.6% of its electricity from renewable sources. This is due to the high percentage of hydroelectric energy generated with its natural geography allowing rivers to be dammed.

South Australia has the second highest level of electricity generated using renewable sources, at 50.5% and recently made history by sourcing 100% of its electricity from renewables[110] – primarily rooftop solar. This is followed by Victoria, where the state has seen a steep increase in renewable energy for electricity generation from just over 10% in 2016-17 to 20% in 2018-19. Western Australia has the lowest level of electricity generation sourced from renewables, however this has increased from 2.9% to 8.9% over the last decade (see Figure 53).

Electricity generation sourced from renewables in WA is the lowest among all states, but has increased from 2.9% in 2008-09 to 8.9% in 2018-19.

FIGURE 53

Percentage of Electricity Generated by Renewables, selected States 2014 to 2019



Notes: Data on the percentage of electricity generated from renewable sources is based on generation by power plants, and by businesses and households for their own use, in all states and territories. The data also include both on and off grid generation.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on Department of Industry, Science, Energy and Resources, Australian Energy Statistics, Table O, May 2020.

109 https://www.weforum.org/agenda/2020/06/global-clean-energy-investment-research/.

110 https://www.abc.net.au/news/2020-10-25/all-sa-power-from-solar-for-first-time/12810366.

Western Australia remains one of only two states without a renewable energy target, the other state being New South Wales.

The trajectory of South Australia as a leader in renewable energy has no doubt been driven by significant targets put forward by the South Australian government, which have continued to be exceeded each year. The current target put forward by the South Australian government is to achieve 100% renewables within 10 years. The ACT managed to achieve exactly this, reaching its 100% renewable target for electricity generation in 2019. However, Western Australia remains one of only two states without a renewable energy target, the other state being New South Wales.

Renewable Generation and Storage

The composition of energy sources used to generate renewable energy varies substantially across states and territories (Figure 54). The vast majority of Tasmania's renewable energy over the past decade has been generated by hydro energy. In contrast, around 80% of South Australia's renewable energy has been generated by wind energy. For Western Australia, a mix of wind and small scale solar photovoltaic (PV) generated around 80% of the state's renewable energy, with the proportion generated by small scale solar photovoltaic (PV) nearly doubling from 21.6% in 2012-13 to 39.3% in 2018-19.

RENEWABLE HYDROGEN

Hydrogen is an emerging technology that offers diverse applications as an energy carrier. Hydrogen can be produced either via thermochemical processing of hydrocarbons, or from water by applying electrolysis using any source of electricity, including renewables like wind and solar. Renewable hydrogen has the potential to displace the use of fossil fuels in energy applications including transport, heat and power generation and provide carbon-neutral feedstock for different industrial processes. As such, it is expected to play an important role in the decarbonisation of energy and industrial sectors.

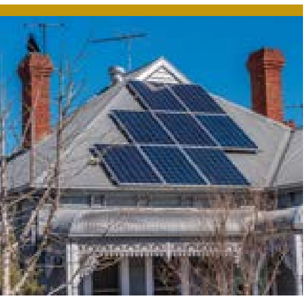
Research suggests that some of the facilitating factors for a hydrogen transition include: increased research and development efforts; potential synergies and learning from established energy industries like natural gas and LNG (in terms of the processes, technologies and market structures); and a growing desire around the world to implement climate policies in order to reduce CO_2 emissions (Aguilera and Inchauspe 2020). On the other hand, the main challenges include the technical and commercial barriers to developing hydrogen on a significant scale.

Western Australia has comparative advantage for the production, use and export of renewable hydrogen, including renewable energy resources due to its climatic conditions, large land, low population density, existing infrastructure and workforce and access to Asian markets. WA Renewable Hydrogen Strategy 2019 aims to support industry efforts to grow the emerging renewable hydrogen industry in practical and strategic ways.

A number of important initiatives have started to emerge within the state. For example, in a significant step towards decarbonising the ammonia production sectors in WA, Yara Fertilisers has recently partnered with the French power company ENGIE to undertake a feasibility study to produce hydrogen and ammonia entirely with renewable energy in Pilbara. Yara's Pilbara site accounts for five per cent of the world's ammonia production, thus the project promises to demonstrate the potential of renewable hydrogen at an industrial scale. Pilbara also hosts the Asian Renewable Energy Hub which has 1,600 large wind turbines and a 78 square kilometre array of solar panels working to power 14 gigawatts of hydrogen electrolysers. The hub plans to use the hydrogen to create "green ammonia" replacing gas in the ammonia production process.[111]

Hydrogen is an emerging technology that offers diverse applications as an energy carrier.

[111] Sources: Aguilera RF and J Inchauspe (2020) "An Overview of Hydrogen Prospects, Focusing on Synergies with Natural Gas and LNG". Manuscript submitted for publication; Government of Western Australia Department of Primary Industries and Regional Development (2019) "Western Australian Renewable Hydrogen Strategy"; Australian Government Department of Industry, Science, Energy and Resources (2019) "Australia's National Hydrogen Strategy".

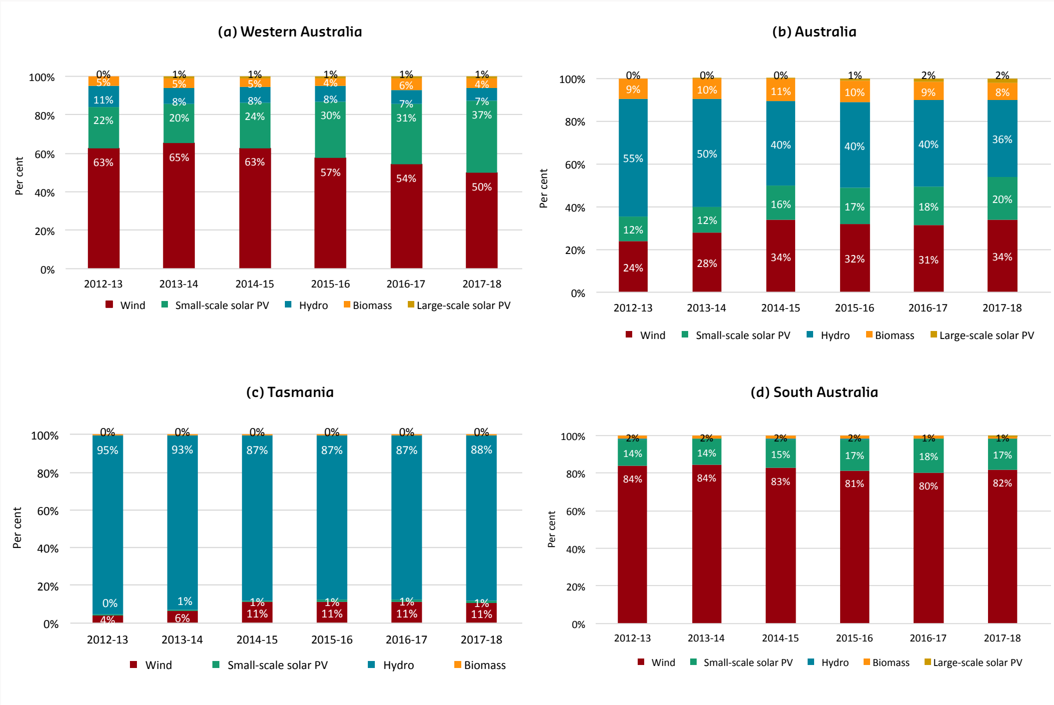


Wind and small scale solar generated around 80% of WA's renewable energy.

Rooftop solar has nearly doubled since 2013, from 21.6% to 39.3%.

FIGURE 54

Total Renewable Energy Generation by Generation Type for selected States and Australia, 2012-13 to 2018-19



Source: Bankwest Curtin Economics Centre | Authors' calculations based on Department of Industry, Science, Energy and Resources, Australian Energy Statistics, Table O, May 2020.

Central to the performance and take-up of renewable energy sources is the ability to store this energy when there is no sun or wind. Take-up of battery storage by households has been very limited in Western Australia. According to the Energy Transformation Taskforce (2019), as at June 2019, less than 1,000 households had installed battery storage units, with price of storage units cited as the main barrier.

An alternative to household battery storage is community storage systems (or micro-grids), which can reduce the up-front costs for households. However, as noted by the Energy Transformation Taskforce (2019) there are not yet widespread opportunities for households to participate in this form of battery storage. There are currently two trials of community batteries being undertaken in Western Australia - one in Alkimos Beach and another in Meadow Springs. Arguably storage is more efficient and effective at a neighbourhood or suburb level as part of a distributed energy network or micro-grid.[112] Grid scale storage also introduces cost efficiencies at scale that reduce the payback period for the investment.[113]

112 Intelligent grid. A value proposition for distributed energy in Australia (2009). National research flagships, energy transformed. CSIRO.

113 Breaking down battery storage value streams. Incentives and virtual power plants in the evolving investment case for home battery storage. SwitchDin 2019.

Battery storage can also be used within main electricity grids. For example, South Australia's Hornsdale Power Reserve has a 100MW/129MWh lithium-ion battery. According to Hornsdale Power Reserve (2020), this lithium-ion battery is currently the largest in the world, with stored energy able to be provided to the grid whenever it is needed and estimates of households savings of around over $150 million in its first two years of operation. Further, its capacity to instantly respond as programmed to achieve voltage and demand management outcomes significantly outperforms existing demand response generation options, such as gas fired turbines – reducing both emissions and the cost supply management responses.

Rooftop solar photovoltaic units, battery storage, thermal energy storage, electric vehicles and charges, smart meters, and home energy management technologies used by household and businesses are classified as Distributed energy resources (DER). These types of DER solutions are often referred to as "behind the meter" because the electricity is generated or managed behind the electricity meter (Australian Renewable Energy Agency, 2020). However other DER solutions, such as grid-scale storage operating at a neighbourhood level can be in front of multiple meters (creating some challenges for energy regulation and pricing).According to the Energy Transformation Taskforce (2019), the uptake of PV and DER has the potential, if not properly managed, to affect the power system security and network reliability in Western Australia. They note that the issue with small scale photovoltaic systems is that they reduce day-time demand for electricity from the main electricity grid to very low levels. This is subsequently followed by a rapid increase in demand for electricity from the main electricity grid, in the late afternoon, as the electricity generated from small scale photovoltaic systems reduces to zero.

As the uptake of small-scale photovoltaic systems increases, these large swings in the demand for electricity from the main electricity grid will increase, thus effecting power system security and network reliability. Energy Source and Distribution (2020), note that these devices create backfeeds and voltage challenges, as well as hidden load, balancing, and inertia issues. These are grid management issues with known solutions, as demonstrated by the capability of other networks systems with much higher rates of uptake of household PV in Australia and around the world. Their management requires investment in different types of network capacity by distribution network companies (such as Western Power), often referred to as 'smart grid' solutions.

GREEN BUILDINGS

Green buildings are those that use less energy and resources throughout the life-cycle of the building. This includes both embodied energy - energy and resources used in building construction and ultimately their fate when it is demolished - as well as the operational energy and resources of a building: that is, energy and water used in heating, cooling, lighting, ventilation and access. Vatalis *et al.* (2013) note that one of the central objectives of green buildings is to "reduce the overall impact of the built environment on human health and the natural environment."

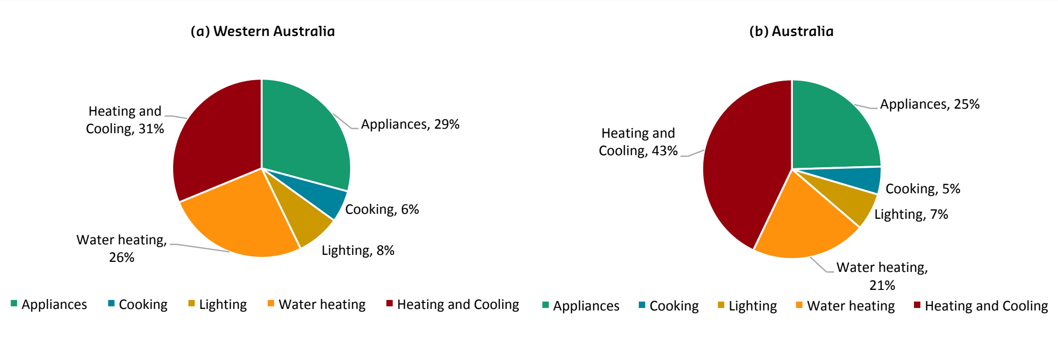
Building Energy Performance

The climate conditions across Australia vary greatly, which affects the type of building envelope used in the construction and operational costs of buildings within each climate zone within Australia. The Australian Building Code Board (ABCB) has produced an Australia wide climate zone map, consisting of eight different climate zones. The Perth metropolitan area is classified as a Zone 5 climate zone, which is defined as warm temperate.

Figure 55 shows the composition of energy use for households in Australia and Western Australia in 2014. Heating and cooling formed the largest component of household energy use in Western Australia (31%) and Australia (43%). One possible explanation for the 12-percentage point difference in heating and cooling energy use between Australia and Western Australia is the difference in climate zones across Australia.

FIGURE 55

Composition of Average Household Energy Use in Australia and Western Australia, 2014



Source: Bankwest Curtin Economics Centre | Authors' calculations based on data from the Department of Industry and Science. (2015). Residential Baseline Energy Study: Australia.

WITCHCLIFFE ECOVILLAGE CASE STUDY

The core concept of an ecovillage as an indefinitely sustainable settlement is that it should be at 'human scale' – that is, large enough to support environmentally sustainable economic and social activities, but small enough to ensure everyone in the community who wants to can participate effectively in decision making (Gilman 1991).[114]

The Witchcliffe Ecovillage,[115] just south of Margaret River, is an excellent West Australian case study in leading best practice in sustainable planning and development that looks to create the most sustainable and liveable development possible with today's technology.

The village aims to be 100% self-sufficient in renewable energy, water and organic fresh produce, 100% carbon neutral, to generate ongoing economic and social opportunities for the area while being socially and demographically diverse and to care for and fit into the local environment.

Some of the features of this ecovillage include cluster solar microgrid and battery storage, passive solar design, rainwater tanks for water consumption, sustainable dams for food production and irrigation and, to the largest extent, locally sourced building materials.

The development extends the footprint of the historic town of Witchcliffe, adding a village square with a café, tavern, creative hub, aged care and child care centres, nature playground shops, and an outdoor meeting space.

It also includes short-stay tourist accommodation and services, a light industrial area, 14 hectares of organic agricultural lots and a winery and ultimately adds around 360 extra homes to the town over the next 5-7 years.

114 Gilman (1991). The Eco-village Challenge. In Context #29. Context Institute. www.context.org/icliv/ic29/.

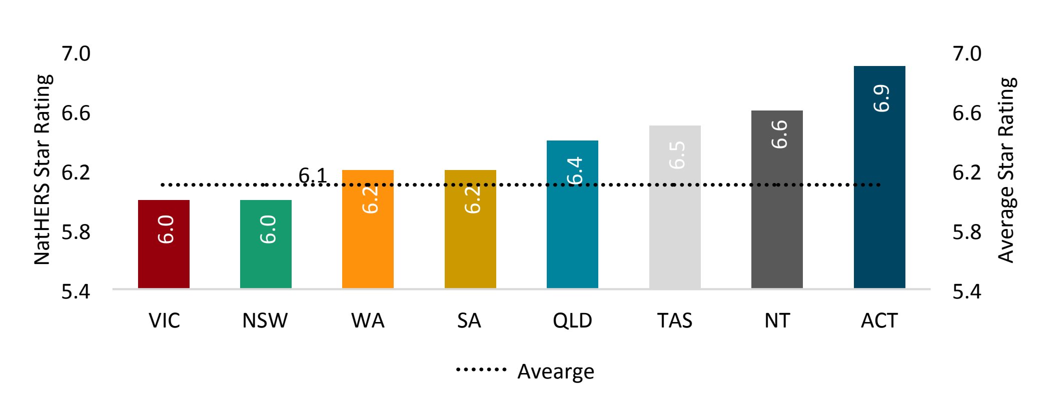
115 https://www.ecovillage.net.au/.

Western Australia ranks fifth in terms of energy efficiency of new homes and apartments built between May 2016 and July 2020.

How energy efficient are West Australian homes compared to other states and territories? Since 2016, the energy efficiency of homes in Australia has been measured using the Nationwide House Energy Scheme,[116] which provides homes with a star rating out of ten based on estimates of its heating and cooling energy use and taking into account information based on the home's design, construction materials and climate zone. Western Australia ranks fifth, alongside South Australia in these ratings with a 6.2 average energy efficiency of new homes and apartments built between May 2016 and July 2020 - slightly above the national average of 6.1, and far below the ACT.

FIGURE 56

Average Energy Efficiency for New Buildings, Alterations, and Additions by State



Source: Bankwest Curtin Economics Centre | Authors' calculations based on data from the CSIRO Australian Housing Data Portal.

116 NatHERS is administered by the Department of Industry, Science, Energy and Resources on behalf of the states and territories.

The regulation of all buildings built in Australia is covered under the National Construction Code. The energy efficiency requirements for new residential buildings in Australia is defined in volume two of the Building Code of Australia, which is part of the National Construction Code. The energy efficiency requirements for new residential houses built in Perth (climate zone 5) from 2019 onwards, now require an energy rating of 6 stars or greater.

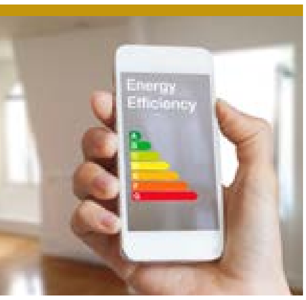
It should be noted, however, that while the 2019 National Construction Code is now in effect, Western Australia has transitional provisions in place which allow the applicant of a building permit to comply with either the National Construction Code 2019 Amendment 1 or National Construction Code 2016. These transitional provisions will now remain in place until 30 April 2021 (Department of Mines, Industry Regulation and Safety, 2020), effectively delaying the implementation of the national building code in WA behind all other states. This disadvantages developing green businesses and industries in WA, as those who invested in more expensive and efficient materials and practices at the same time as their eastern state counterparts now face greater costs and unfair competition from less efficient and sustainable materials that do not comply with the new standards being dumped on WA by interstate and international suppliers.

The National Construction Code only covers the construction of new residential houses in Australia. Thus, residential homes built prior to changes in energy efficiency requirements do not need to comply with current building regulations and consequently have potentially poorer thermal performance compared to new residential houses. To increase the thermal performance of older residential houses, and reduce the operational energy levels and greenhouse gas emissions, incentives could be provided, as part of the WA Recovery plan, to homeowners of older residential houses to improve the thermal performance of their homes. This would not only help reduce household energy bills and greenhouse gas emissions, but would also provide additional stimulus to the West Australian economy.

Another incentive that has proved successful in other states and territories is regulation that requires those selling or renting a property to include a certified energy efficiency rating in their advertising, enabling purchasers and renters to make informed choices about the cost of living in that property and hence driving a shift to greater efficiency in existing properties.

Unwanted heat gain and loss can be minimised through a well-designed building envelope – or exterior (Australian Government (2020). One method of reducing heating and cooling energy usage in a home is through passive design, which involves designing a building so that it retains heat during the winter (passive solar heating) and allows built up heat to escape during the summer (passive cooling). Energy cost savings from implementing passive design can be up to 40% of the total energy used in an average Australian home (Albayyaa *et al.* 2019).

One measure of a materials effectiveness in terms of passive design is its "U-Value", also known as thermal transmittance. The lower the U-Value of a material - the greater the material's resistance to heat flow and the better its insulating properties (Lawaina and Biswas 2016). Design elements such as thermal mass, window glazing, insulation, sealing of air leakages, and site orientation of a house all contribute to the passive design of a house (Australian Government, 2020). These design elements are explored further below and are derived from a sample of new residential construction built in Western Australia and Australia between 2016 and 2020.



81% of new WA residential buildings have the poorest performing window insulation installed compared to 51% nationally.

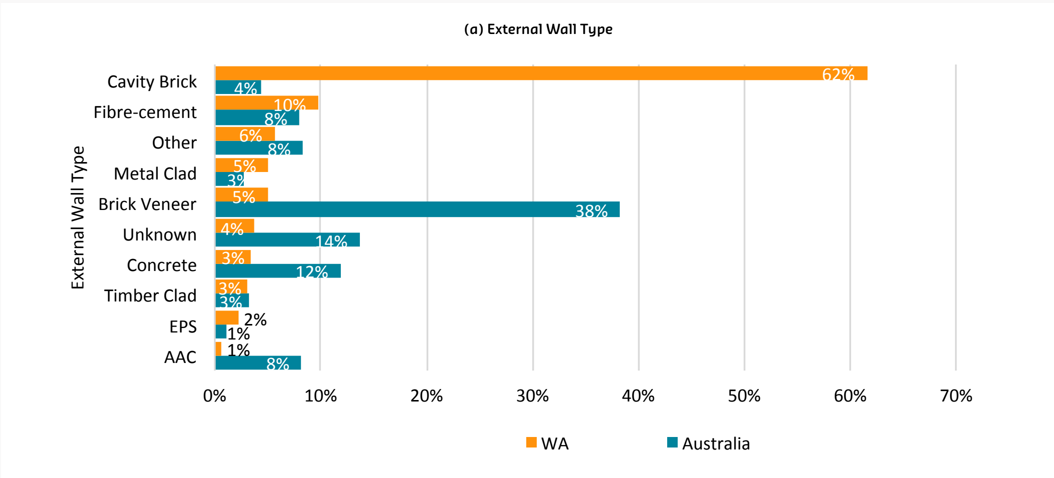
As can be seen from panel (a) in Figure 57, nearly two-thirds of external walls in new residential buildings in Western Australia were cavity brick, whereas this makes up only 4% of external wall types nationally. For Australia, brick veneer external walls were the most common type of external wall construction in new residential buildings, making up 38% of all. Brick veneer is considered to have higher energy performance with a maximum start rating of 6.6 compared to 5.9 for cavity brick (Gregory *et al.* 2008).

Insulation is also an important component of passive design and its performance is measured through what's known as an "R-value". The higher the value the better the insulation properties. On average, ceiling insulation in new residential buildings in Western Australia have a higher R-Value compared to Australia – panel (b) Figure 57. In terms of the R-Value of roofing insulation used in new residential buildings WA households were more likely to either have no added insulation or a R-value of 1-1.9 panel (c).

Turning to window glazing (panel d) - there is a large difference in the proportion of windows installed in new residential buildings in Western Australia with poor thermal performance, compared to that for Australia. Of the windows installed in new residential buildings in Western Australia between 2016 and 2020, 81% had a U-Value of 6 that is a low resistance to heat flows. This is in contrast to only 51% of windows installed in new residential buildings in Australia.

FIGURE 57

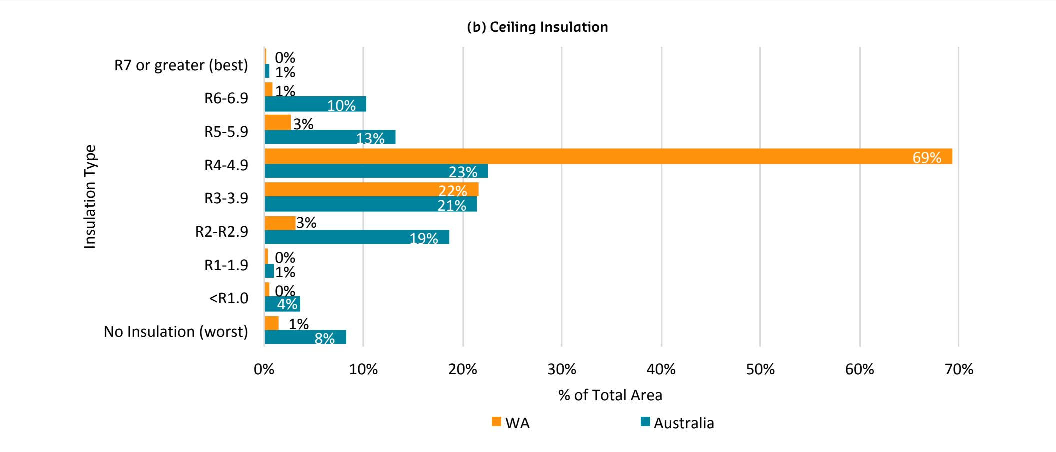
Construction Overview of New Residential Buildings in Western Australia and Australia, built between 2016 and 2020

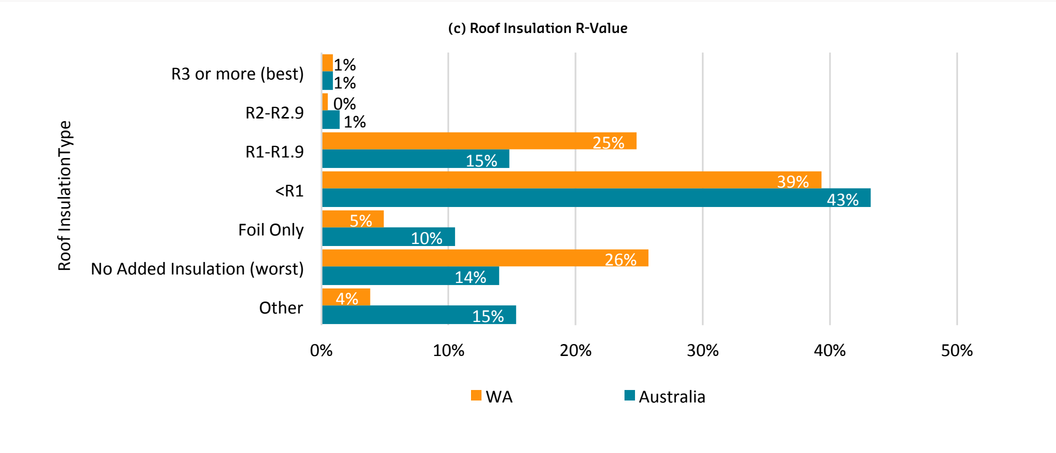


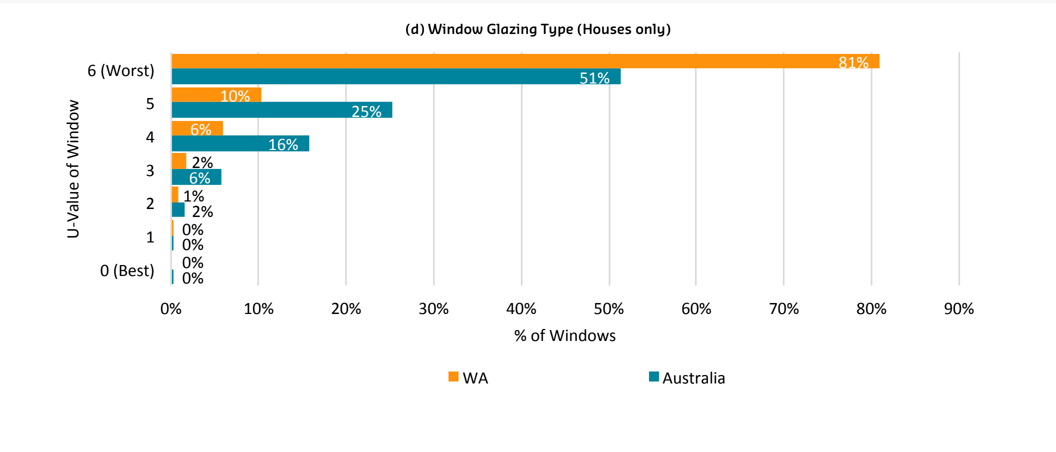
Source: Bankwest Curtin Economics Centre | Authors' calculations based on data from the CSIRO Australian Housing Data Portal.

FIGURE 57 (continued)

Construction Overview of New Residential Buildings in Western Australia and Australia, built between 2016 and 2020







Source: Bankwest Curtin Economics Centre | Authors' calculations based on data from the CSIRO Australian Housing Data Portal.

A passive building design including installing double glazing, internal integrated window shading devices, and decreasing air leakage will save WA households $681 per year in energy bills over a 50 year horizon.

As an illustration of the effect of passive solar and energy efficient design on household energy use, Allbayyaa *et al.* (2019) conducted a study applying passive solar and energy efficient design strategies to two types of standard detached residential houses – brick veneer and fibre-cement buildings in Sydney.[117] Both houses were two storeys, with each having a total floor area of around 400m². The passive solar and energy efficient design strategies involved changing the windows from single glazing 4mm glass (5.8 U-Value) to double glazing 4mm glass – 12mm air gap – 4mm glass (2.9 U-Value); adding internal integrated window shading devices; and decreasing air leakage rate. The total cost of the upgrades for each house was around $13,200.

As can be seen from Table 5, the implementation of the passive solar and energy efficient design strategies had a substantial and similar effect on the energy used for electric heating in both house construction types, with energy used for electric heating in the fibre-cement house reducing by 76.9% and 72.6% for the brick veneer house. The reduction in energy used for electric cooling in both house construction types was much smaller, with only a 2.2% reduction for the fibre-cement house and a 4.3% reduction for the brick veneer house. The authors calculated the cost savings on energy consumption costs for the two houses. For the brick veneer house, they estimated that cost saving from implementing the passive solar and energy efficient design strategies would equate to around $1,150 per year over 50 years, while for the fibre-cement house the cost saving would equate to around $1,820 per year over 50 years. These cost savings were based on 400m² house, so would be less for a standard size house in Western Australia,[118] which is around 237m², but would still equate to around $681 per year for a brick veneer house and around $1,078 per year for a fibre-cement house.

TABLE 5

Heating and Cooling Loads for Standard and Improved Fibre-Cement and Brick Veneer Houses

House Construction Type	System Description	Without Passive Solar and Energy Efficient Design Strategies (PSEEDS)		With Passive Solar and Energy Efficient Design Strategies (PSEEDS)		Energy Savings	
		kWh/yr	kWh/(yr.m²)	kWh/yr	kWh/(yr.m²)	kWh/yr	%
Fibre-Cement	Electric Cooling	16,652	41.6	16,281	40.7	371	2.2%
	Electric Heating	14,069	35.2	3,255	8.1	10,814	76.9%
	Total	**30,721**	**76.8**	**19,537**	**18.0**	**11,184**	**36.4%**
Brick Veneer	Electric Cooling	10,749	27.2	10,292	25.7	457	4.3%
	Electric Heating	9,100	23.0	2,497	6.2	6,603	72.6%
	Total	**19,849**	**50.2**	**12,789**	**32.0**	**7,060**	**35.6%**

Source: Bankwest Curtin Economics Centre | Authors' calculations based on data from Allbayyaa *et al.* (2019).

117 Both houses were located in ABCB Zone 6 climate zones, which is classified as mild temperate.

118 Source: ABS 8752 Building Activity Australia December 2019.

SUSTAINABLE TRANSPORT

Currently, there are two main forms of sustainable motor-powered transport in Australia - electric cars and electric trains. The benefit of electric cars and electric trains is that they emit zero greenhouse gas emissions when they are operating. However, the overall greenhouse gas emissions generated by electric cars and electric trains is dependent upon the energy resources used to generate the electricity which they consume. Consequently, a critical assumption in classifying electric cars and electric trains as sustainable forms of transport is that 100% of their power is drawn from electricity generated using renewable energy sources. For this and other reasons (policy support, access to charging stations and cheap renewable energy from hydro), Tasmania is the best place to own an electric vehicle.

Electric Cars

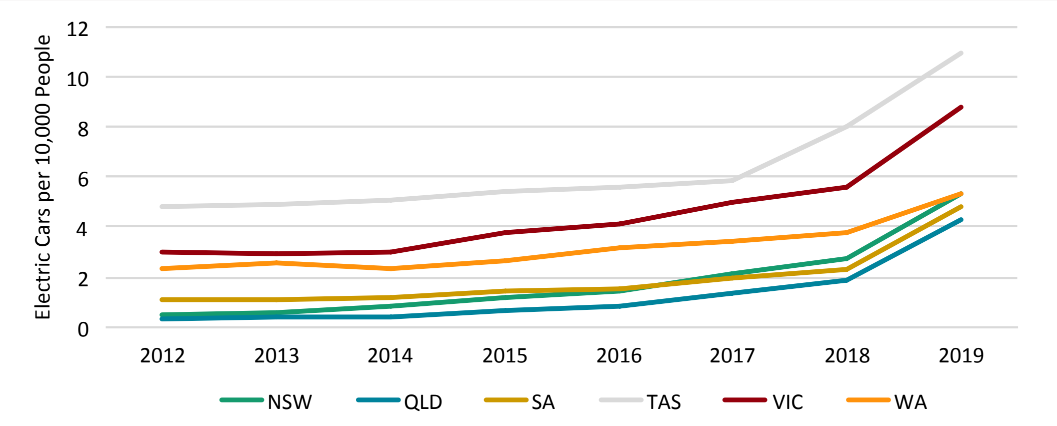
There are a number of variations of car types with an electric drivetrain – those that are exclusively electric (referred to as battery electric vehicles or BEVs), hybrid electric vehicles (where a petrol engine together with regenerative braking both power an on board battery and drive an electric motor, resulting in a more efficient version of a petrol driven vehicle) and plug in hybrid electric vehicles (or PHEVs), which are a variation on the hybrid, whereby the battery can also be recharged from the grid prior to use, while the presence of a petrol engine extends the range and reduces battery size. Only BEVs are truly sustainable fully-electric vehicles.

As can be seen from Figure 58, the uptake of electric cars has been relatively slow across Australia. In 2019, Tasmania had the highest ownership of electric cars per 10,000 people, at around 11 per 10,000 people. This was followed by Victoria at around 9 electric cars per 10,000 people, while Western Australia had the third highest ownership of electric cars at around 5 per 10,000 people. One factor likely driving the rate of electric car ownership in Tasmania is the government's commitment to support a coordinated approach to electric vehicle uptake in the state as part of its Climate Action 21: Tasmanian Climate Change Action Plan 2017-2021.

In 2019, Western Australia had the third highest ownership of electric cars per 10,000 people, at around 5 per 10,000 people.

FIGURE 58

Electric Cars per 10,000 People by State, 2012 to 2019



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS Motor Vehicle Census. (2020). Fuel type by State, Counting: Vehicles (TableBuilder).

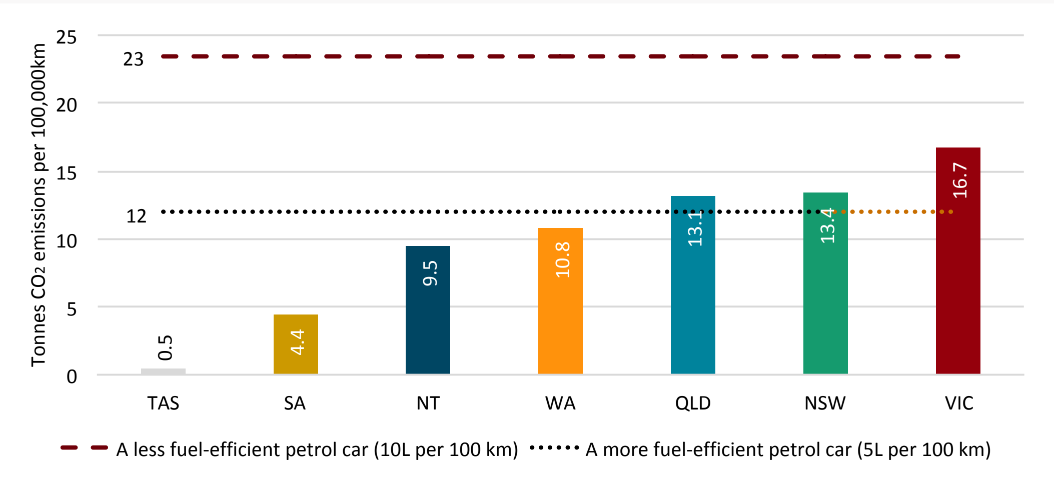
In Western Australia, the CO_2 emissions from driving 100,000km in an electric car were around 22 times worse compared to that of Tasmania, at 10.8 tonnes of CO_2 emissions.

One of the current disincentives for purchasing an electric car in Australia is price. In 2020, the average price of an electric car in Australia was $91,796, with the cheapest costing $47,490 and the most expensive costing $191,100 (RAC, 2020). To encourage greater uptakes, an incentive to purchase electric vehicles in Western Australia could be provided through the WA government offering concessions on vehicle licensing fees for new and used electric cars and vehicle registration fees. In 2020, the stamp duty on an average new electric vehicle was $5,966.70 in WA (Department of Transport, 2020). However, it is important to remember that although electric cars do not generate any CO_2 emissions, the overall emissions they do generate are dependent upon the composition of the fuel types used to generate the electricity they use.

Figure 59 presents an estimate of the tonnes of CO_2 emissions generated per 100,000km driven in an average electric car available in Australia in 2020, by state. In 2018-19, the best state to drive an electric car, in order to reduce CO_2 emissions was Tasmania, where driving 100,00km would generate an estimated 0.5 tonnes of CO_2 emissions. This is due to the high share of renewables in power generation in Tasmania. The worst state was Victoria, where driving a 100,000 km in an electric car would generate an estimated 16.7 tonnes of CO_2 emissions. In Western Australia, the CO_2 emissions from driving 100,000km in an electric car were around 22 times worse compared to that of Tasmania, at 10.8 tonnes of CO_2 emissions.

FIGURE 59

Tonnes of CO_2 Emissions per 100,000 km Driven for the Average Electric Car by State, 2018-19



Source: Bankwest Curtin Economics Centre | Authors' calculations based on Clean Energy Regulator Electricity sector emissions and generation data, 2018-19; Department of Industry, Science, Energy and Resources, Australian Energy Statistics, Table O, May 2020, and Western Australia Royal Automotive Club. (2020b) Electric cars available in Australia in 2020; Department of Industry, Science, Energy and Resources (2020). Households – Transport.

As can be seen from Figure 59, driving a more fuel-efficient petrol car (5L per 100km) in Queensland, New South Wales, and Victoria would actually generate less CO_2 emissions compared to driving an electric car in the same state. This highlights the need to take a holistic approach when formulating policies aimed at reducing greenhouse gas emissions, and not just focus on individual components of a system. To be effective in reducing greenhouse gas emissions, electric cars need to be recharged using electricity generated from 100% renewable fuel sources.

Non-Electric Cars

In 2019, nearly 40% of new non-electric cars purchased in Australia produced, on average, more than 20 tonnes of CO_2 emissions per 100,000km. This was mainly composed of Large SUV's (12%) which produce, on average, 20.5 tonnes of CO_2 emissions per 100,000km and Pick-up/Chassis 4x4 (16.5%) which produce, on average, 22.5 tonnes of CO_2 emissions per 100,000km.

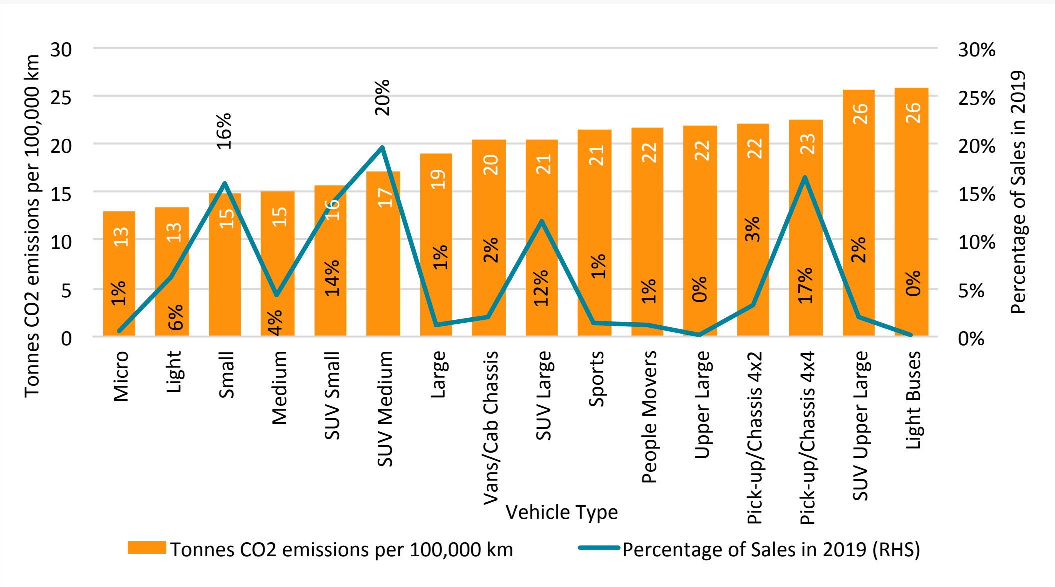
The non-electric car which produced the least amount of CO_2 emissions per 100,000km was the micro, producing 13 tonnes of CO_2 emissions per 100,000km. However, it only comprised 0.6% of new non-electric cars sales in Australia in 2019.

Driving a more fuel-efficient petrol car (5L per 100km) in Queensland, New South Wales, and Victoria would currently generate less CO_2 emissions compared to driving an electric car.

In 2019, nearly 40% of new non-electric cars purchased in Australia produced, on average, more than 20 tonnes of CO_2 emissions per 100,000km.

FIGURE 60

Average Tonnes CO_2 Emissions per 100,000 km by Vehicle Types of New Cars Sales, Australia, 2019



Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Transport Commission. (2020). Carbon Dioxide Emissions Intensity for New Australia Light Vehicles 2019. Table 12: Average emissions intensity and annual sales by segment, 2018 and 2019.

SHIPPING – GREENHOUSE GAS EMISSIONS

It has been estimated that shipping emitted around 2.6% of the annual global CO_2 between 2013 and 2015 or approximately 924 million tonnes of CO_2 emissions per year.[119]

The main contributor to CO_2 emissions from shipping is international shipping. The International Council on Clean Transportation (2020)[120] estimated that international shipping represented about 88% of total CO_2 emissions from ships each year. Olmer, Comer, Roy, Mao, and Rutherford (2017), note that in addition to CO_2 emissions, shipping also contributes to climate change through the emissions of Black Carbon, which are tiny black particles produced by the combustion of marine fuel. According to Clean Transportation (2017), black carbon accounts for 21% of CO_2 emissions from ships.

Increasing growth in the size of the international fleet, the rise in the power of engines as well as speed are the main contributors to the CO_2 emissions of the shipping industry.

Shipping is not subject to the Paris Agreement, which is aimed at reducing global greenhouse gas emissions. However, in 2018 the International Maritime Organisation (IMO) agreed a draft greenhouse gas strategy aimed at reducing emissions from shipping by at least 50% compared to 2008 levels, by 2050. A number of possible short, medium, and long term measures have been proposed in the draft greenhouse gas strategy. One of the proposed measures is to consider and analyse the use of speed reduction (slow steaming) and speed optimisation. According to Transport and Environment (2020), reducing ship speed by 10% will lead to a 27% reduction in the ship's emissions. Given the substantial size of the reduction in ship emissions from slow streaming, the implementation of this measure should be a priority for the International Maritime Organisation.

119 Olmer, N., Comer, B., Roy, B., Mao, X., and Rutherford, D. (2017). Greenhouse Gas Emissions from Global Shipping, 2013-2015. The International Council on Clean Transportation.

120 Transport and Environment. (2020). Shipping and climate change. Retrieved from: https://www.transportenvironment.org/what-we-do/shipping-and-environment/shipping-and-climate-change.

Public Transport

Arguably, when it comes to sustainable transport, electric trains powered by renewable energy are the most efficient. Just as in green building construction we need to consider both embodied and consumed energy to assess total life-cycle energy use, so too when we compare transport options we also need to consider the energy embodied in the vehicles, their roads and rails and infrastructure (including stations and carparks), while also taking into account the opportunity costs to society as a whole of congestion, travel time and land use.

Western Australia's metropolitan public transport network, Transperth, consists of buses, trains, and ferries. The Public Transport Authority (2020) notes that Transperth's 1,484 buses consists of a combination of 490 compressed natural gas and 994 diesel-powered vehicles which produce fewer emissions per kilowatt than the average family car.

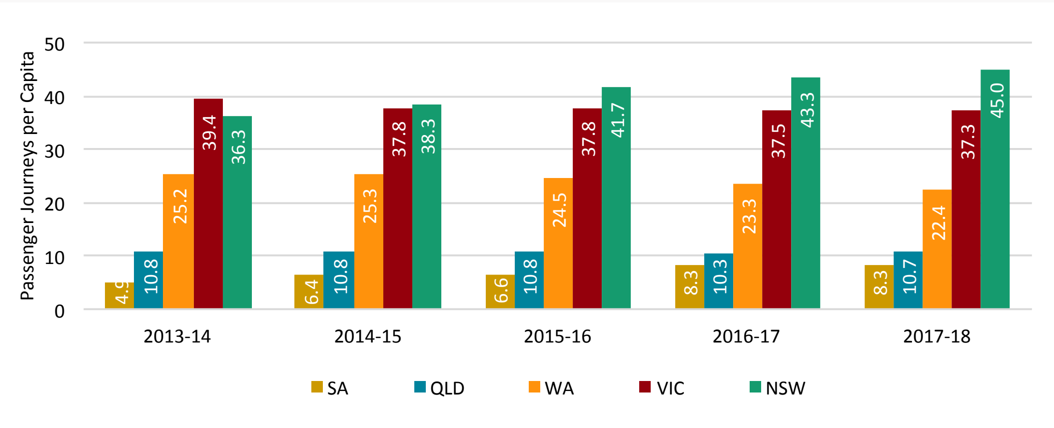
Of the total fleet of buses, 873 buses (58.8%) conform to the Euro5 and Euro6 emissions standards, 480 buses (32.3%) conform to the Euro4 emissions standard, and the remaining 131 buses (8.8%) conform to the Euro2 emissions standard.

The WA metropolitan passenger train network consists solely of electric passenger trains, which were first introduced in 1992 when the system was electrified (Public Transport Authority, 2020). In terms of passenger train usage per capita, Western Australia ranked third in 2017-18, at 22.4 metropolitan rail passenger journeys per capita (Figure 61).

In terms of passenger train usage per capita, Western Australia ranked third in 2017-18, at 22.4 metropolitan rail passenger journeys per capita.

FIGURE 61

Metropolitan Rail Passenger Journeys per Capita by Selected States, 2013-14 to 2017-18



Source: Bankwest Curtin Economics Centre | Authors' calculations based on Bureau of Infrastructure, Transport and Regional Economics - Statistical Report.

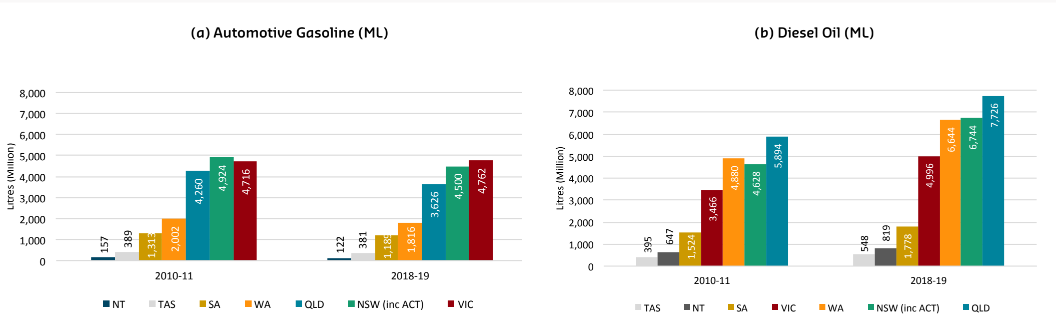
New South Wales had the highest passenger train usage per capita at 45 metropolitan, which was just over double that of Western Australia. As with electric cars, electric trains do not directly generate any CO_2 emissions per se, but the overall emissions they do generate are dependent upon the composition of the fuel types used to generate the electricity they use. The authors calculated that in 2018-19, in Western Australia, a GWh of electricity generated 600 tonnes of CO_2 emissions. Transperth also operates a small fleet of diesel passenger ferries. The ferries provide a passenger service between the Elizabeth Quay jetty in Perth and the Mends Street jetty in South Perth (Public Transport Authority, 2020). However, without more data on the energy requirements of our train journeys we are unable to do a direct comparison of the CO_2 emissions generated per passenger per 100,00km.

Petrol Consumption

Between 2010-11 and 2018-19, the sale of automotive gasoline in Western Australia has declined by 9.3% from 2,002 to 1,816 million litres. Conversely, over the same period the sale of diesel oil increased by 36.1% from 4,880 to 6,644 million litres. Interestingly in 2018-19, the total sale of diesel oil in New South Wales (6,744 million litres) was only 1.5% higher compared to that for Western Australia, at 6,644 million litres (Figure 62).

FIGURE 62

Automotive Gasoline and Diesel Oil (ML) by State Marketing Area, 2010-11 and 2018-19

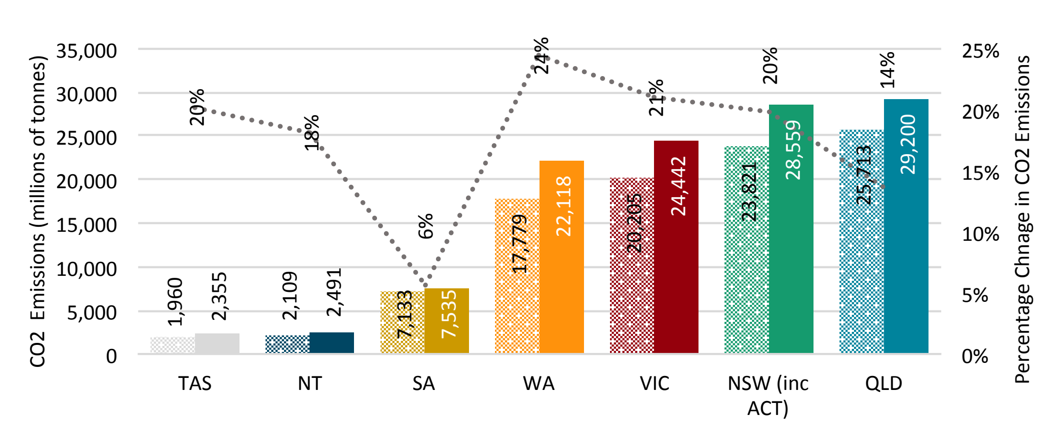


Source: Bankwest Curtin Economics Centre | Authors' calculations based on Department of Industry, Science, Energy and Resources. (2020). Australian Petroleum Statistics, Issue 286, May 2020.

According to the National Transport Commission (2020), 1 litre of petrol produces about 2.3kg of CO_2 and 1 litre of diesel produces about 2.7kg of CO_2. Based on these values, Figure 63 shows the estimated amount of CO_2 generated by the combination of automotive gasoline and diesel oil sales in each state, in 2011-12 and 2018-19.

FIGURE 63

CO_2 Generated by the Combination of Automotive Gasoline and Diesel Oil Sales by State, 2010-11 and 2018-19



Source: Bankwest Curtin Economics Centre | Authors' calculations based on Department of Industry, Science, Energy and Resources. (2020). Australian Petroleum Statistics, Issue 286, May 2020 and National Transport Commission (2020) carbon dioxide emission values.

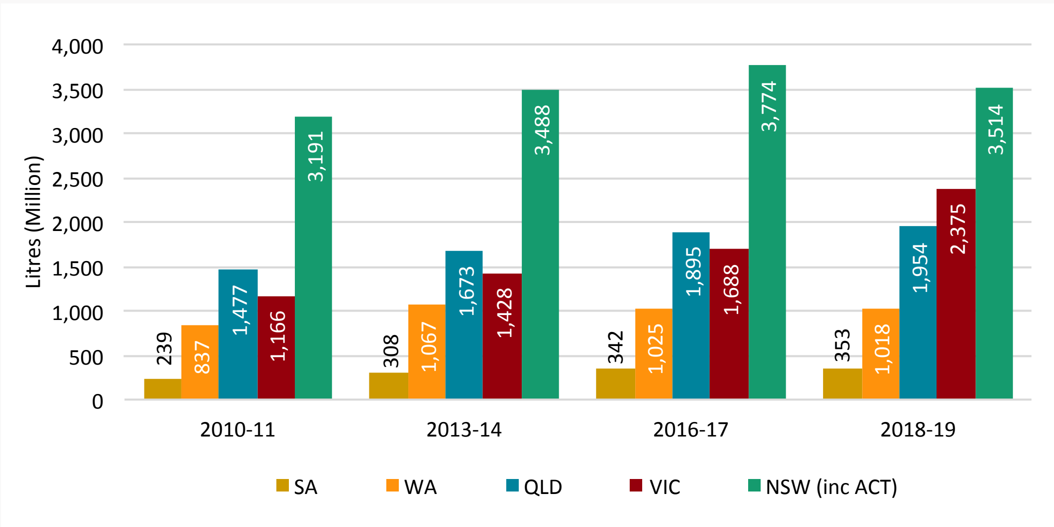
Between 2010-11 and 2018-19, Western Australia had the largest increase in CO_2 emissions from petrol and diesel oil sales, increasing from 17,779 to 22,118 million tonnes.

Western Australia had the largest estimated increase in CO_2 emissions, between 2010-11 and 2018-19, from the combined sales of automotive gasoline and diesel oil, increasing 24.4% from 17,779 to 22,118 million tonnes over the period. In contrast, South Australia had the lowest increase in CO_2 emissions over the period from the combined sales of automotive gasoline and diesel oil, only increasing its emissions of CO_2 by 5.6%. In terms of volume of CO_2 emissions from the combined sales of automotive gasoline and diesel oil, Queensland had the highest in both 2010-11, at 25,713 million tonnes and in 2018-19 at 29,200 million tonnes. Whilst, Tasmania had the lowest in both 2010-11 at 1,960 million tonnes and in 2018-19 at 2,355 million tonnes.

Over the period between 2010-11 and 2018-19, New South Wales had the highest sales in aviation turbine fuel, amongst the states. Over the period sales have increased by 10% in New South Wales, from 3,191 (ML) in 2010-11 to 3,514 (ML) in 2018-19. Over the same period, Western Australia's sales of aviation turbine fuel were, on average, less than one third compared to those of New South Wales. In 2010-11, 837 (ML) of aviation turbine fuel were sold in Western Australia, increasing by 21.7%, to 1,018 (ML) in 2018-19 (see Figure 64).

FIGURE 64

Aviation Turbine Fuel (ML) by State Marketing Area, 2010-11 to 2018-19



Source: Bankwest Curtin Economics Centre | Authors' calculations based on Department of Industry, Science, Energy and Resources. (2020). Australian Petroleum Statistics, Issue 286, May 2020.

WASTE MANAGEMENT

As innovation increases, the discovery of new types of materials has accelerated and transformed many industrial products and processes. Unlike organic matter, most of these materials need more complex management and disposal systems, especially because of their slow decay rate. For instance, some plastics can take up to 1,000 years to decompose if thrown in landfill. Inefficient management systems can threaten our health and life, due to water, land and air contamination. It is therefore paramount to construct efficient waste management processes that allow us to reduce and minimise our waste footprint.

Australia produced 67 million tonnes of waste in 2016-17 of which 58% was recycled and 4% was recovered for energy generation.[121] This means that 27 million tonnes of waste ended in landfill. Looking at these numbers, waste management would seem like a burden when, in fact, it represents an opportunity. While upgrading waste processes and facilities to meet the highest standards will require significant investment up-front, in the long-run it can reduce wastage, create jobs and foster new business opportunities.

An efficient waste system will decrease the demand for new resource extraction by transforming waste into usable industrial materials. For instance, according to the United Nations environmental program, for every tonne of paper recycled, 17 trees and 50% of water can be saved. This will not only ease the pressure of our already strained natural resources, but it can also create jobs and help our economy thrive. It is estimated that the recycling sector employs some 12 million people in Brazil, China and the United States alone.[122] In Australia, the waste sector employs around 50,000 people and contributes to $7 billion of GVA to the economy.[123]

The fate of our waste: where does it end up?

The way we manage our waste determines the amount of pollution we create. WA should try to move up the *waste pyramid: avoidance, reuse, recycling, energy recovery, and disposal*. To do so, the first step is to avoid and minimise waste as much as possible, this is the option that we explored in Chapter 1. However, if waste cannot be avoided, it should be recovered and reused to the largest extent possible; otherwise reprocessing or recycling are the best third option. 'Energy recovery' (that is, incinerating waste to generate energy) should be considered if no other 'higher' alternative can be put in place but we should keep in mind that burning waste generates greenhouse gases and only actually recovers a fraction of embodied energy. Finally, the disposal of waste to landfill is the least preferred option in the pyramid and should be avoided entirely.

Figure 65 shows the fate of waste by state in 2016-17. WA recycles 46% of its waste, only QLD fares worst, with a recycling rate of 42%. SA is the best performer among the states recycling 75% of its waste, a rate almost 30 percentage points higher than WA. VIC is not far behind with a recycling rate of 68% while NSW recycles 58%. Given these numbers, it is unsurprising to see that WA sends to landfill 37% of its waste, the least preferred option of the waste pyramid.

WA recycles 46% of its waste, only QLD fares worse, with a recycling rate of 42%.

121 Author's calculation based on the National Waste Database, Department of Environment.

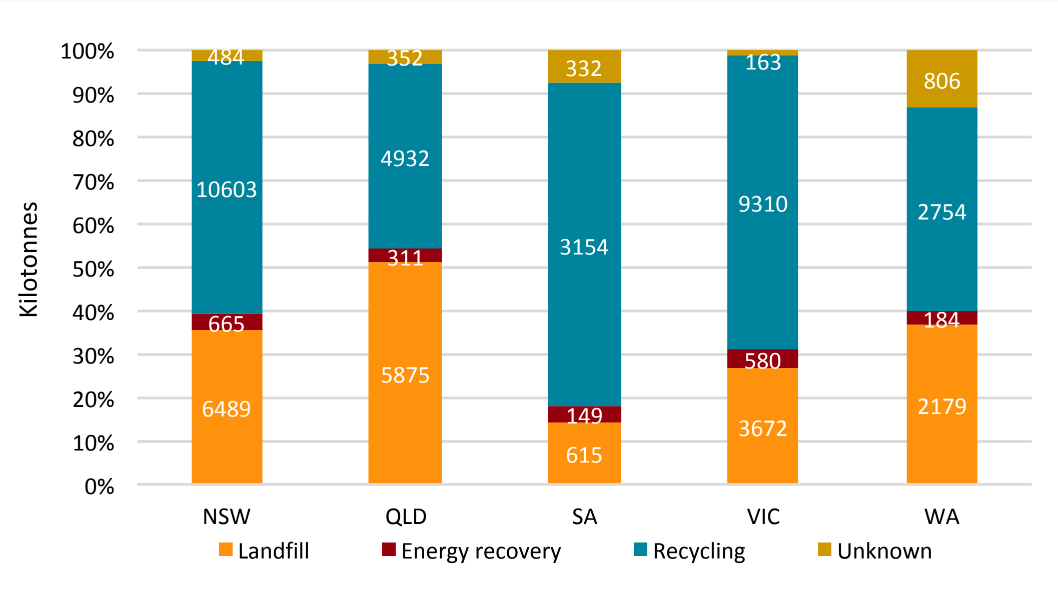
122 UN environment programme. Solid waste management. https://www.unenvironment.org/explore-topics/resource-efficiency/what-we-do/cities/solid-waste-management.

123 National Waste report 2018, Department of the environment and energy.

Landfill disposal in WA has decreased by a staggering one tonne per capita in the ten years to 2017.

FIGURE 65

Fate of waste, by state, 2016-17



Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Waste Database, Department of Environment

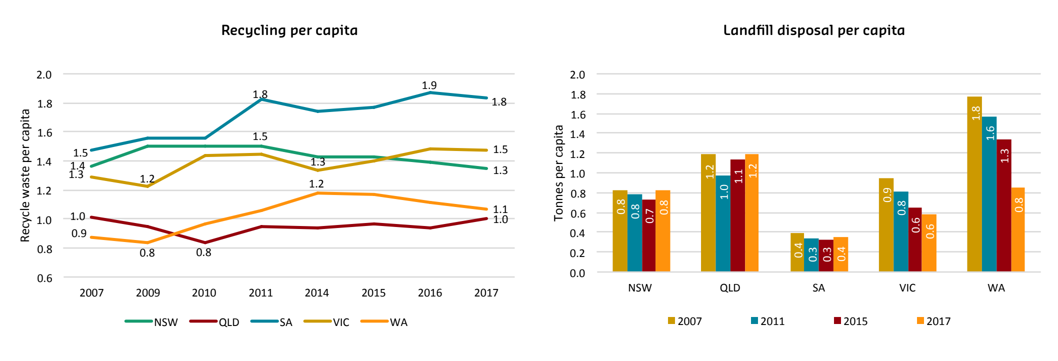
However, WA seems to be heading in the right direction. Figure 66 shows the rate of recycling and landfill disposal per capita over time. Landfill disposal in WA has decreased by a staggering one tonne per capita in the ten years to 2017, by far the best improvement of any state. In 2016-17, every resident of WA sent on average 0.8 tonnes of waste to landfill. Our recycling rate continues to rise, but progress has slowed. From 2008-09 to 2013-14 the increase was quite rapid, with 0.4 extra tonnes of waste recycled per person. Unfortunately since then the recycling rate has stabilised and we remain the second-worst state after Queensland.

The Western Australian government targets established by the Waste Avoidance and Resource Recovery Strategy 2030 aim to reuse or recycle 75% of waste generated in WA by 2030, and to decrease waste to landfill in the metropolitan area by more than 15%. As we observed, this target is far from being achieved and significant efforts need to be taken in both the diversion of waste to landfill and through increasing recycling capabilities.

Investigating the fate of the 13% of unknown waste treatment (Figure 65) should be one of the first steps to better understand the structure of our waste. Only then will we be able to fully understand the magnitude of the problem and ensure appropriate solutions for all waste issues. The issue is particularly concerning since all the unknown waste comes from hazardous materials (Table 6), however we do not know how this waste is treated. Although hazardous waste only represent a small proportion of WA waste (9.3%), it is composed of corrosive, flammable, toxic and reactive materials that represent an enormous risk to our health and ecosystem if poorly managed.

FIGURE 66

Recycling and landfill disposal of total waste by state, 2007-17



Note: Years are expressed in financial years, end years are displayed on the graphs.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Waste Database, Department of Environment.

Table 6 also shows the fate of waste by type of material for WA and Australia. We observe that, not only does WA consume a larger amount of plastic relative to other states, but a larger proportion also ends up in landfill. A startling 96% of WA plastic waste is disposed in landfill, almost 10 percentage points higher than the Australian average. WA also only recycles 42% of glass compared to 57% for Australia. Given that nearly all glass can be recycled, as can over half of the plastics we consume, WA needs to concentrate its efforts on these two materials in order to attain the target of recycling 75% of all waste by 2030.

Some of the problems with recycling are related to the limited uptake of recycled materials by industries and markets, with low demand making prices uneconomical. For example, WA has had an ongoing problem with recycled waste from construction and demolition (C&D). A growing stockpile of unprocessed C&D materials caused a distortion of the waste market because of weak demand for recycled products.

In response, the Western Australian Government has encouraged the civil and construction sectors to increase their uptake of recycled materials. The Roads to Reuse program (RtR) was created to address this problem by supporting the supply of recycled C&D products to meet the market specifications, such as the use of recycled road base in main roads construction. Part of the recycled sealed road materials come from glass recycling. Unlike other states, WA does not recycle glass into new glass bottles, but crushes it to produce road materials. This represents a less perfect form of recycling because glass recycled to road materials can only be recycled once, while glass recycled into glass can be recycled indefinitely. The Western Australian Government should look to invest in facilities that recycle glass into new glass products to make more efficient use of our waste, particularly now that the WA container deposit scheme has commenced.

TABLE 6

Management method of core waste, kilotonnes, WA and Australia 2016-17

	Western Australia				Australia			
	Landfill	Recycling	Energy from waste	Unknown	Landfill	Recycling	Energy from waste	Other disposal
Masonry materials	424.2	1092.5			4,871	12,266		
% Total Masonry materials	28%	72%			28%	72%		
Organics	788.7	474.0	145.0		6,710	7,299	162.0	
% Total Organics	56%	34%	10%		47%	52%	1%	
Metals	76.7	567.0			538	4,982		
% Total Metals	12%	88%			10%	90%		
Hazardous	166.8	320.5		64.3	3,731	1,729		24.0
% Total Hazardous	30%	58%		12%	59%	27%		0%
Paper & cardboard	240.9	229.5	30.1		2,230	3,361	0	
% Total Paper and Cardboard	48%	46%	6%		40%	60%	0%	
Plastics	327.6	13.1			2,182	306	28	
% Total Plastic	96%	4%			87%	12%	1%	
Textiles, leather & rubber	75.8	2.2	9.1		679	88	9	
% Total Textile, leather & rubber	87%	2%	10%		88%	11%	1%	
Glass	78.0	55.7			467	612		
% Total Glass	58%	42%			43%	57%		
Total	**2,179**	**2,754**	**184**	**64**	**21,726**	**37,030**	**200**	**7,006**
% Total	**42%**	**53%**	**4%**	**1%**	**33%**	**55%**	**0%**	**10%**

Note: Ash and other waste are not included.
Source: Bankwest Curtin Economics Centre | National Waste Database, Department of Environment.

Recycling can also help to reduce greenhouse gases emissions. Replacing new extracted materials with recycled materials decreases the amount of CO_2 emissions produced. The extraction process for raw materials is usually more energy intensive and creates larger amounts of greenhouse gases than recycling and repurpose treatment.[124]

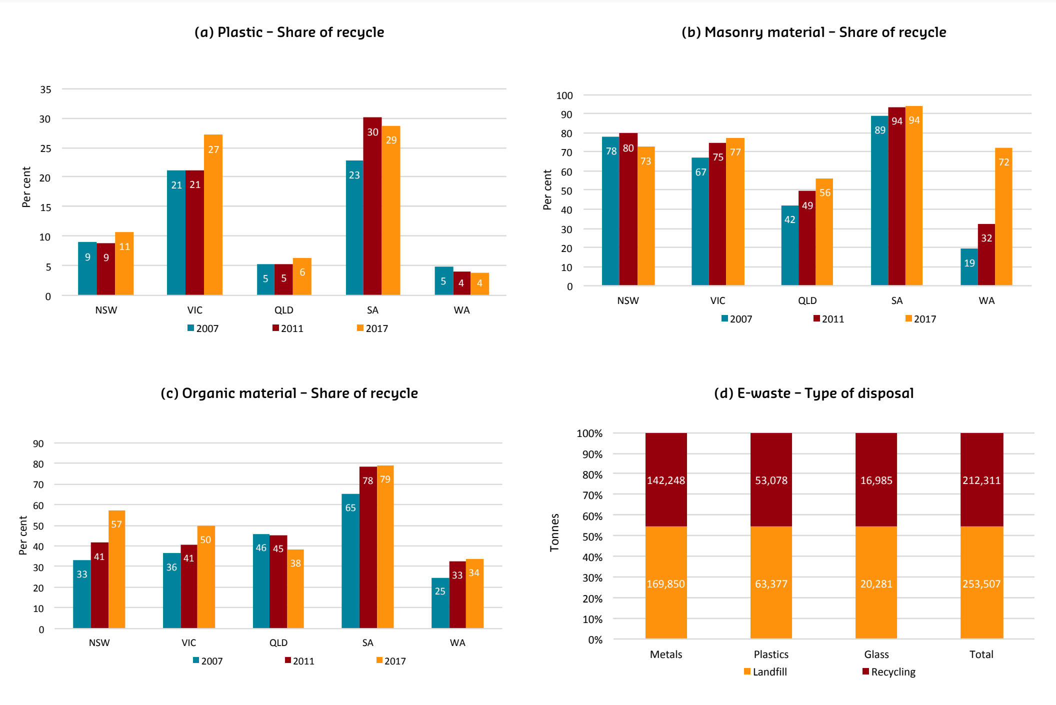
A more detailed look at trends in recycling for selected materials is shown in Figure 67.

Plastic, organics and masonry material have all evolved differently since 2006-07 and reflect legislation put in place in multiple states. As explained above, WA has the lowest recycling rate of plastic waste (4%) of all states, and has not improved since 2006-07. Other states such as VIC and SA manage to recycle a higher proportion of plastic waste. In 2016-17 VIC recycled 27% of plastic waste while SA reached almost 30%. In contrast, NSW only recycled 11% of plastic waste, QLD 6% and WA 4%.

WA has the lowest recycling rate of plastic waste (4%) of all states, and has not improved since 2006-07.

FIGURE 67

Share of recycling for selected materials, by state, 2006-07 to 2016-17



Note: Years are expressed in financial years, end years are displayed on the graphs.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Waste Database, Department of Environment and ABS Cat. 4602.0.55.005, Waste account.

124 Dormer, A., Finn, D. P., Ward, P., *et al*. (2013). Carbon footprint analysis in plastics manufacturing. Journal of Cleaner Production. In press. DOI: 10.1016/j.jclepro.2013.01. 014

145

The recycle rate of masonry materials has increased by more than 50 percentage points since 2006-07.

Industries have also played a role in the slower uptake of recycled plastic, with most company's preferring to buy virgin plastic rather than to utilise recycled plastic. Virgin plastic prices are tied to fossil fuel prices, and as a result, they can be cheaper than recycled plastic even if the energy used to transform them is significantly higher.[125] Low demand for recycled plastic has prevented the industry from fully developing. Solutions such as a "trading scheme" of recycled plastic can be considered. Businesses that opt for recycled plastic will have certain credits in their accounts that can be sold to other industries that prefer virgin plastics. This incentive mechanism will reward companies that choose recycled plastic. Most importantly, it will boost the demand for this material and will foster the market to larger recycling rates than currently in place.

PRECIOUS PLASTIC? – FROM BOTTLE LIDS TO SURFBOARD FINS

A local community initiative in Margaret River is finding new ways to create value from waste. *Precious Plastics Margaret River* identified a gap in existing recycling programs and came up with an innovative solution.

Plastic lids from milk bottles and a range of other food products are usually too small and fiddly to recycle. To make matters worse there is no consistency in the use of different plastics. An army of local volunteers (including visiting elders from a local aged care service and children with a disability from local schools) drop by to sort bottle tops by type and colour - identifying PET, HDPE, LDPE, PP, ABS, PS and PLA plastic types for separate recycling.

Once sorted the lids are shredded, heated and injection moulded using a range of specialised industrial machines. Surfboard fins are not the only product – there are a range of plant pots and bowls, with funky designs achieved by creative mixing of different coloured plastic.

Precious plastic products have taken off, with a wide range of southwest stores stocking their items to ply to the region's tourist trade. The pot plants and bowls have become a bit of a symbol within the local community, seen on display in many households as a badge of commitment to a more sustainable way of life.

125 Locock,K., Deane, J., Kosior, E., Prabaharan H., Skidmore, M., Hutt, O (2017). The recycled plastic market: Global analysis and trends. CSIRO, Australia.

Masonry materials on the other hand, have been a success story for WA. As observed in panel (b) of Figure 67, the recycling rate has increased by more than 50 percentage points since 2006-07. The increase between 2010-11 and 2016-17 represents the largest jump in the rate of recycling. As explained in the first chapter, the C&D sector has been particularly reactive to the significant increase of the waste levy in 2015.The waste strategy in 2012, *Creating the Right Environment*, aimed to reduce the quantity of waste of the construction sector and increase recycled rates for masonry. It is evident that these goals have been accomplished with the rise of the waste levy. For instance, prior to the levy in 2014-15 the C&D sector recycled 42% of its waste, but with the levy in place in 2016-17 more than 76% of materials were recycled, exceeding the original target set in 2012. This a clear example of how public policy can be used to reduce and transform the waste we generate.

The recycling of e-waste materials is crucial to embracing a sustainable future. The multiplication of electronic products has put an additional pressure on the mineral resources of our planet. Most of these materials, like metals can be recycled indefinitely and reused as components in new products. Panel (d) of Figure 67 shows the amount of e-waste that is currently recycled in Australia. The recycle rate of e-waste is remarkably stable for all types of materials and oscillates around 55%. Plastic from e-waste is recycled at a higher rate than plastic waste from other sectors. Metals, on the other hand, are recycled at a much lower rate relative to other types of metals. The e-waste recycling industry should concentrate its efforts to increase the recycling rate of metals, since more than 70% of e-waste relates to metal disposal. E-waste recycling programs should mirror the *National Television and Computer Recycling Scheme*.

This program concentrates on the collection of televisions and computers and its peripherals materials from households and small businesses. More than 290,000 tonnes of waste have been gathered since its inception. The success of this scheme is reflected in the fact that over 90% of materials from e-waste are recovered each year.

Panel (c) from Figure 67 shows the recycling rate and waste fate of organic waste. WA recycles only 34% of organic waste by far the lowest of any state. Relative to SA, the state with the largest recycle rate, WA recycles less than half the organic waste of SA and WA's organic matter recycling rate has remained stagnant since 2011. Only QLD seems to perform worse over time, with recycling rates declining since 2006-07, but still remain proportionately higher than those of WA.

Such a low rate of recycling implies that a large quantity of the state's organic waste goes to landfill (56%). Organic waste that is not repurposed is not only a misuse of economic and environmental resources, it also releases greenhouse gases (GHG) that go into the atmosphere. When organic materials decompose without oxygen in landfill conditions they create methane - one of the largest contributors to climate change. Organic waste can easily be transformed into compost and biogas through controlled anaerobic digestion. These materials can, in turn, be used as fertilisers in agricultural plots and as a source of energy for economic activities.

Some other sources of organic waste such as clothing and bedding, furniture and sawdust are usually not recycled. Paper and cardboard are organic matter than can be entirely repurposed, and yet only 46% is recycled in WA.

In 2014 the Construction and Demolition sector recycled 42% of its waste, but with the waste levy in place in 2016-17 more than 76% of materials were recycled.

Only 14% of households in WA have an organic bin, compared to 60% in NSW and 56% in VIC.

The Perth and Peel regions recover 42% of waste compared to only 29% in regional areas.

A more efficient management of organic waste is key to accomplish the 75% target on recycled materials by 2030. The Western Australian government has taken an important step in the reduction of organic waste with the rollout of the FOGO (food organics and garden organics) three bins collection system in metropolitan areas. If this service is made available by all local councils, it can decrease organic waste significantly. Previously, most organic waste gathered in WA was through green verge collections of garden waste. For now, the WA government has as a target to deliver the three FOGO bins to all houses from the Perth and Peel metropolitan area by 2025.[126]

Table 7 shows the proportion of households receiving kerbside services by states in 2016-17. We observe that only 14% of households had an organic bin in WA in 2016-17, relative to 60% in NSW and 56% in VIC. As we have seen above, SA is the state with the largest recycle rate of organic waste and also the state with the largest share of households with an organics bin – 92%.

As we observe in Table 7, WA sends more than 28% of its waste from garbage bins to alternative waste technology plants (AWT), a much better rate than the rest of the states. The AWT plants are in charge of separating recyclable materials that were mistakenly put into garbage bins. This is also one of the targets of the Waste Avoidance and Resource Recovery Strategy 2030, to send all waste to alternative waste technology facilities instead of directly sending it to landfills. WA is on the right track but should continue to implement efficient solutions to treat organic waste.

A closer look at waste by location in WA shows again the disparity between metropolitan and rural areas. The Perth and Peel regions recover 42% of the waste compared to only 29% in regional areas.[127] This means that regional areas in WA not only generate a larger amount of municipal solid waste per capita, but they also recycle waste at a significant lower rate. There are also significant gaps between councils in the Perth metropolitan area. For instance, the City of Melville sends all of its waste to an AWT facility, to be sorted and recycled. On the other hand, a close neighbour, the City of Nedlands conveys 40% of its waste directly to landfill without any previous treatment.

The Western Australian government should put in place strategies that would help decrease the gap between regional and metropolitan areas in terms of waste management. The government should also to help to unify a strategy of waste management between the different councils of metropolitan areas in order to increase efficiency and reduce waste.

TABLE 7

Estimated proportion of households receiving kerbside services by state, 2016-2017

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
Garbage bin	100%	91%	73%	96%	100%	93%	96%	97%
sent to landfill	100%	66%	73%	92%	100%	93%	96%	69%
sent to alternative waste technology	-	25%	-	4%	-	-	-	28%
Recycling bin	100%	89%	60%	86%	98%	93%	95%	92%
Organics bin	5%	60%	-	10%	92%	15%	56%	14%

Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Waste Report 2018, Department of Environment.

126 Action Plan 2020-21, Waste avoidance and resource recovery strategy 2030, Waste Authority, Government of Western Australia.

127 Data extracted from local government waste and recycling census projects, Data fact sheet 5. WA Department of Water and Environmental Regulation.

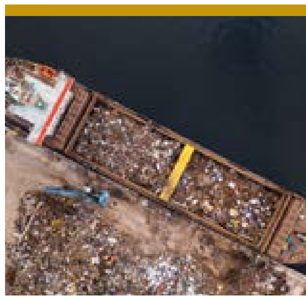
Exporting recycled materials

As we have discovered in 2019 a significant amount of our recycled waste is not treated in Australia but shipped overseas. Once abroad, the way this waste is recycled or disposed of varies greatly between countries and companies. This is problematic, because some of our shipped recycling waste may finish up in landfill in other countries, while some waste treatment requires toxic products or creates toxic waste. The legislation, environmental protection, and control mechanisms differ significantly from one country to the other, and some of the toxic materials used to treat our waste end up polluting water sources and endangering health.

In Table 8, we observe the amount of recycled waste shipped overseas for processing between 2006 and 2017 by type of material. The quantities exported varies every year, and there is no clear trend. The export of metal waste is the largest export of recycled waste in Australia, with 2,141kt exported in 2017. Paper and cardboard are second, with 1,453kt exported each year, and plastics are third with 215kt/yr. While the quantity of recycled plastic exported seems small, it actually represents 70% of recycled plastic in Australia. The share of recycled metals, paper and cardboard waste, on the other hand, accounts for around 43% of the total recycled waste.

There is a significant amount of recyclable waste exported overseas and in some cases it represents a large share of our recovered waste. Australia should take responsibility for the waste it generates. Adequate processing plants should be built to deal with this sort of waste, especially now that China has banned the import of some recycled waste materials.

The Western Australian government supports the national policy aiming to ban the export of plastic, paper, tyres and glass exports by 2024. As a response, it has committed to investing $15 million to support local processing of plastics and tyres, and contributed up to $5 million to enable access to industrial zoned land. The state contribution will be matched by the Australian government providing total of around $40 million to develop local recycling capability.[128]



Metal waste is the largest exported recycle waste in Australia, with 2,141kt exported in 2017.

Nationally, 70% of recycled plastic waste was shipped overseas in 2017.

TABLE 8

Exports of waste materials for recycling by type from Australia to all destinations, 2006-2017

	Kilotonnes exported							
	2007	2009	2010	2011	2014	2015	2016	2017
Metals	1,575	1,981	1,852	1,874	2,695	2,466	1,965	2,141
Plastics	100	249	207	233	268	256	226	215
Paper, cardboard	1,105	1,265	1,497	1,384	1,497	1,497	1,535	1,453
Other	84	137	111	255	309	326	327	400
	Kilotonnes exported as a percentage of recycled materials (%)							
	2007	2009	2010	2011	2014	2015	2016	2017
Metals	45.5	65.5	37.7	36.8	52.8	51.0	42.7	43.0
Plastics	39.4	89.6	70.4	79.8	82.2	76.6	65.5	70.3
Paper, cardboard	30.0	28.9	47.8	43.1	43.6	45.5	44.4	43.2

Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Waste Report 2018, Department of Environment.

128 Plastic and tyres processing fund, Government of Western Australia. Department of Water and Environmental Regulation.

Waste management should be seen as an opportunity and not a burden. WA should aim to develop a circular economy, where little or no waste is disposed of in landfill or incinerated, but materials are reused or recycled continuously.

Energy recovery

Waste that cannot be recycled can either end up in landfill or it can be incinerated. If incinerated, energy can be recovered from burned materials and replace electricity generated from fossil fuels. In this sense, energy recovery can reduce greenhouse gas emissions, if it is done efficiently and displaces less efficient coal powered generation.

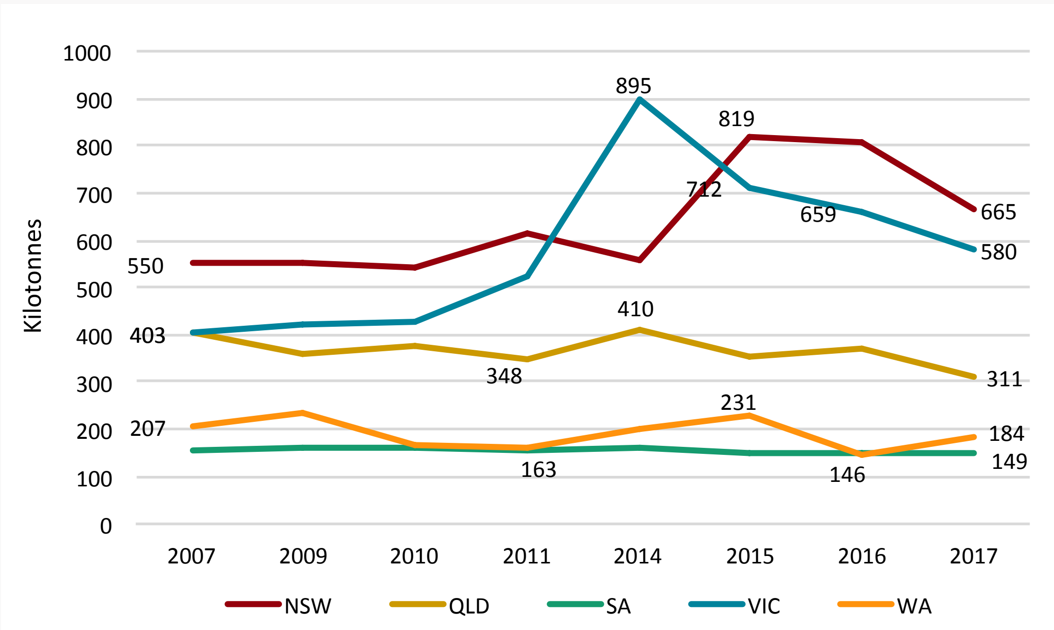
However, burning garbage also releases toxic gases into the atmosphere, and dust containing heavy metals and toxins can contaminate land and water. More efficient modern incinerators remove large quantities of these toxic materials and pollutants, decreasing the amount of pollution released to air, land and water. However, a large amount of what is burnt still ends up in landfill.[129]

The trend in energy recovery has remained quite stable since 2006 in WA. The state recovers 184kt of energy, close to that of SA (149kt). VIC and NSW have seen an increase in the amount of energy recovered during the same period and in 2016-17, 580kt of energy was recovered in VIC and 665kt in NSW. QLD is the only state with a decreasing trend with 311kt incinerated in 2016-17.

While energy recovery from waste may be preferable to landfill, all other solutions should first be exhausted before resorting to incineration. We should try to move up the waste pyramid and avoid less efficient and more wasteful methods.

FIGURE 68

Trends in energy recovery from core waste by jurisdiction, Australia 2006-07 to 2016-17



Note: Years are expressed in financial years, ending on.
Source: Bankwest Curtin Economics Centre | Authors' calculations based on National Waste Database, Department of Environment.

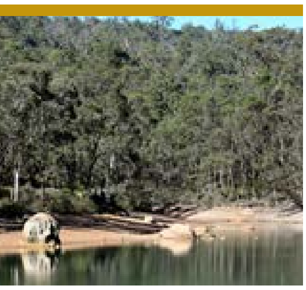
129 Planet natural research centre.

Western Australia's waste management should be seen as an opportunity and not a burden. The state should aim to develop a circular economy, where little or no waste is disposed of in landfill or incinerated, but materials are reused or recycled continuously.

To achieve this, all agents have a part to play. Households should consume more wisely by reducing the amount of waste they generate, shifting to more-environmentally friendly packaging and reducing food waste. Industries should re-think their production process to minimise all the waste through the entire value chain, opting for recycled material in the production processes and moving away from materials that are indefinitely recycled.

Governments should enable the transition to a zero waste future by creating appropriate infrastructure and policy incentives to reduce waste. Useful measures include extending producer responsibility, fostering the use of recycled materials among industries, banning landfill disposal of organic waste and direct landfill disposal without pre-treatment. This combined with an expansion of the waste levy, a comprehensive rollout of the FOGO system, data gathering and education can all work together to make significant contributions to the reduction of waste and help the state achieve its 2030 targets.

WATER MANAGEMENT



In 2019 Perth dams were only 41% full - the lowest level in all capital cities. This trend has remained for four years in a row.

In 2016 Perth dams fell to only 20% capacity.

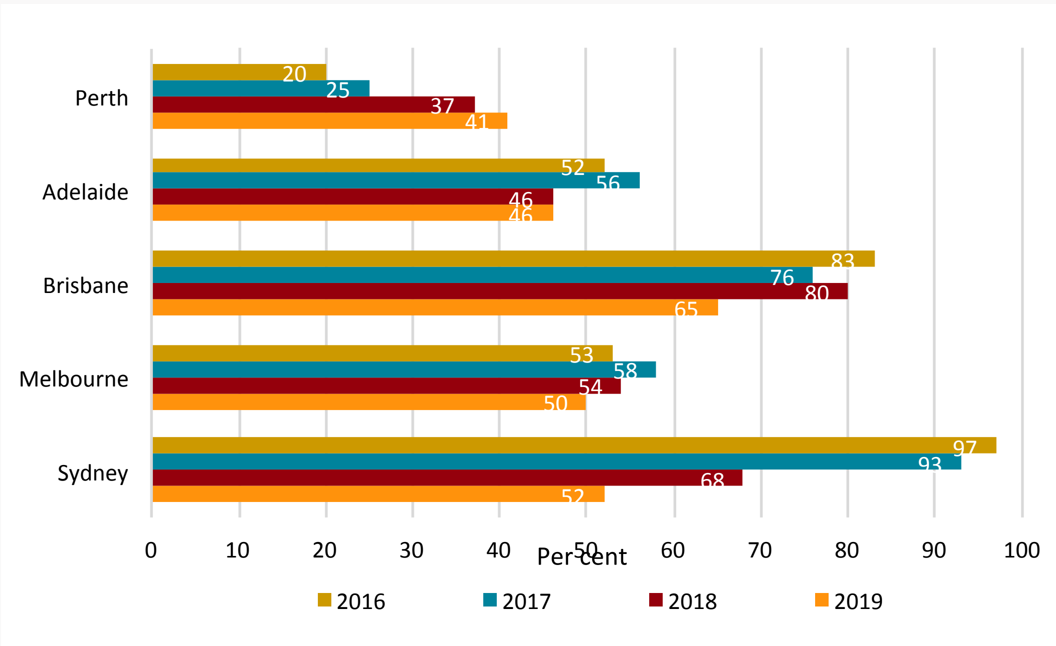
As outlined in chapter one, a combination of rapidly declining average rainfall and population are placing enormous pressure on WA's water resources.

We need a water management system that allows economic development, guarantees a fair share to the ecosystem and ensure the availability of water resources for future generations.

Water supply

A deeper look at the storage capacity in major urban centres is shown in Figure 69. Due to continuously dry winters over eastern Australia, most cities on the east coast have seen their water storage decline over the past 4 years. Sydney's storage has declined from 97% in 2016 to only 52% in 2019. Brisbane has also seen a decrease of 21% in the city's water storage during the same period. In Perth, in 2019, dams were only 41% full, the lowest levels in all the country and this for four years in a row. Nevertheless, 2019 was not the worst year for Perth. In 2016, the water storage in the city felt to only 20% of its full capacity. To put things in perspective, in 2018, Cape Town in South Africa almost run out of water and threaten to shut down the tap. At the worst moment of its crisis, Cape Town's reserves, were at a critical low of 23%, with the city officials planning to cut the tap water when the reservoirs hit 13.5%.[130]

FIGURE 69
Urban system storage capacity by major urban centres, per cent full, 2016-2019



Source: Bankwest Curtin Economics Centre | Authors' calculations based on Water information. Bureau of Meteorology (BOM), Australian Government.

130 How Cape Town is coping with its worst drought on record. Craig Welsh. National Geographic, March 2018.

Given the fall in rainfall in Perth and the decline of water dams levels, one can wonder why Perth has not experienced the dire situation of Cape Town a couple of years ago. The short answer is because of our Integrated Water Resources Management (IWRM) system. A performant IWRM maximises efficiency to make our water resources last, seeks equity in the water allocation to different economic actors and protects the environment and its eco-systems.[131] Western Australia's IWRM has focused on delivering water security to our regions. To do so, a diversification strategy was implemented in the early 2000's aimed at expanding WA's water sources.

Since then, the sources of Perth water have changed dramatically. Fresh water collected from dams has been replaced by groundwater and desalination water, which has become Perth's main sources of water nowadays. Since the 1970s, as rainfall levels declined, groundwater has rapidly become the state's main source of water. As observed in Figure 70, in 2018-19, 42% of WA's water was sourced from groundwater, the largest share of any state by far. Second to WA, SA only sourced 4% of its water from groundwater, followed by NSW with 3%. The other states have less than 1% of groundwater in the distribution system.

As explained in Chapter 1, even though Perth does not have important reserves of surface water, it has a large aquifer system under the coastal plain. These aquifers are mostly recharged with rainwater from winter precipitations. Because Perth is built under permeable sand dunes, rainwater is mainly captured in the sand particles and slowly makes its way down to the aquifers. The sand soak wells allow about 70% of local road runoff to be caught, that would otherwise end up in the ocean.[132] Therefore the aquifers represent an important storage source, by catching water in winter for use in summer. The aquifers work like a giant rainwater tank for the region of Perth.

Managing Perth's aquifers correctly to ensure a sustainable source of water for both public and private use is key for the state's development and survival. Private use of groundwater, accounts for more than half of all water use in Perth. Groundwater used for agriculture, industry processes, public irrigation and household garden bores all share access to the same aquifer along with public use. Licenses to private actors are distributed by the Department of Water. Efforts should focus on the coordination of groundwater access between the different economic actors.

The Department of Water and Environment is in charge of delivering groundwater licenses across the state. Overall, three out of four licenses granted in WA, concerned groundwater extraction. A total of 3,085gL of groundwater was licensed last financial year, 56% concerned mining activities, 15% agriculture, 12% commercial and institutional businesses and 9% the public water supply scheme. The remaining licenses were allocated to parks and recreation, industrial power generation and others.[133] Overall, 86% of groundwater licenses were allocated to support industry and only 9% to ensure household supply.

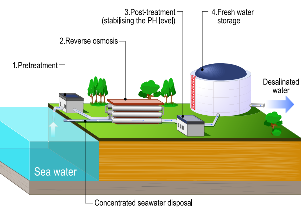
However, as we have seen in Chapter 1, the levels of the Gnangara aquifer system are declining and salinity levels are increasing. This unbalance is mostly due to the intense utilisation of the aquifers and low levels of rainfall. Therefore, at the end 2018, the Western Australian government started a consultation process aiming to set new allocation limits and renewed water

131 Water in the Green Economy. Global Water Partnership. Perspective papers, June 2012.

132 Is Perth really running out of water? Well, yes and no. Don McFarlane. The Conversation, February 2018.

133 Annual report 2019-10. Department of Water and Environmental Regulation. Government of Western Australia.

DESALT SALINE WATER



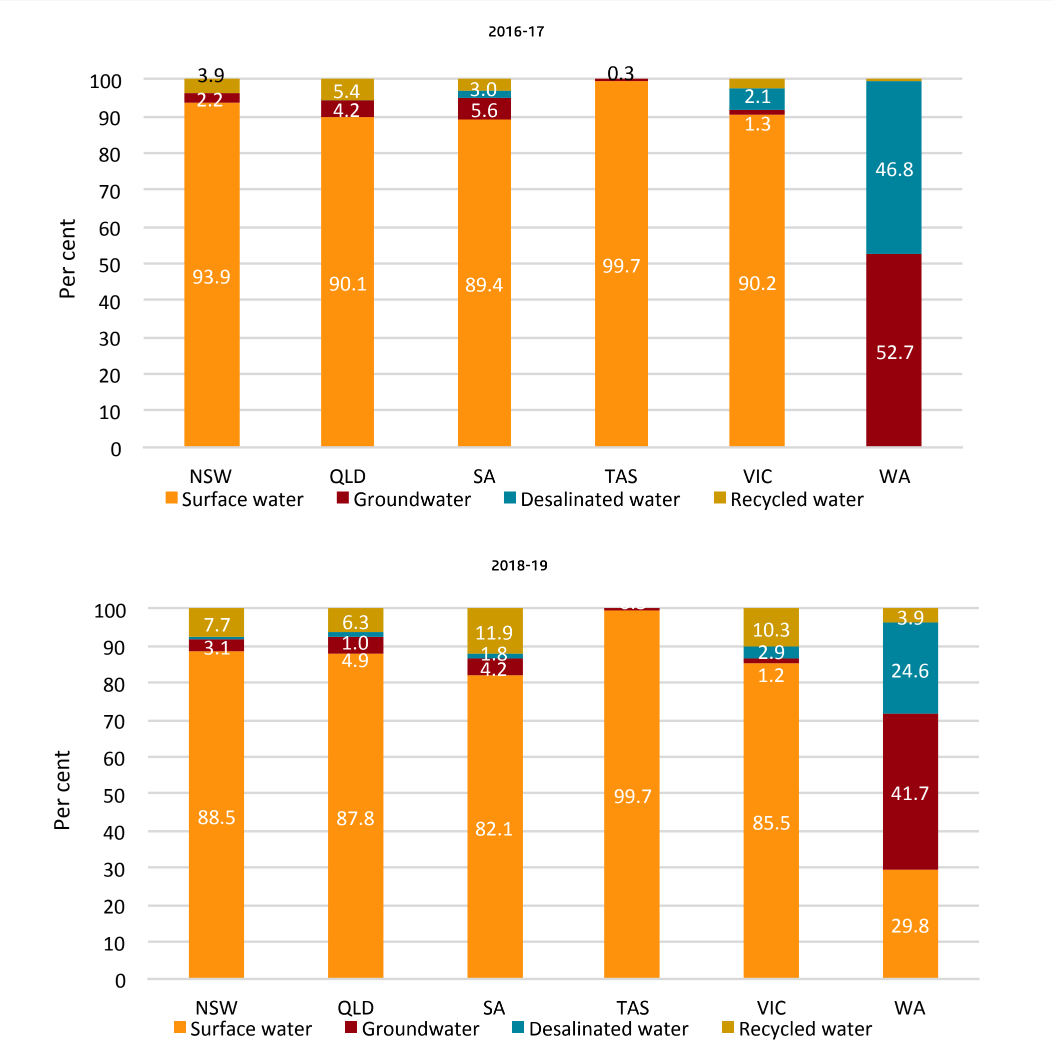
In 2018-19, 42% of WA's water was sourced from groundwater, the largest share of any state.

In 2018-19 only 30% of WA water was sourced from surface water, compared with 88% for NSW, 85% for VIC and over 99% for Tasmania.

allocation plans of groundwater resources. As we observed, groundwater allocated to households represent a very small fraction of the amount of water supplied. Industry development represents the lion's share and as such, the new allocation plan and the cost of licenses should account for this unequal distribution. Households already support a large burden in the extraction cost of groundwater, as seen in Figure 28. Industry should increase the financial contribution to the extraction cost of groundwater. At the same time, it should also decrease its use by implementing better water management techniques and technological advances to limit groundwater consumption (i.e. recycled water).

FIGURE 70

Volume of water sourced by state, 2016-17 and 2018-19



Source: Bankwest Curtin Economics Centre | Authors' calculations based on Urban NPR 2018-19 data. Bureau of Meteorology (BOM), Australian Government.

Figure 70 also shows the particularity of WA water system. Indeed, WA's share of surface water is very low relative to other states. In 2018-19, only 30% of WA water was sourced from surface water, compared with 88% for NSW, 85% for VIC and over 99% for Tasmania. Eastern states' water management systems are more reliable on surface water as rainfall is more abundant and lasts longer throughout the year. Nevertheless, the drought episodes in the beginning of the century have pushed local government to invest in different sources of water management. Most of the states opted for desalination plants, which are costly to construct and to operate.

Construction costs of desalination plants can vary greatly. The Sydney plant in Kurnell started construction in 2007 and opened in 2010, ultimately costing $1.9 billion with a capacity of 250 megalitres per day or 90 gigalitres per annum.

Perth's latest desalination plant located in Binningup near Bunbury cost a total of $1.4 billion with a total production capacity of 100 gigalitres per annum.

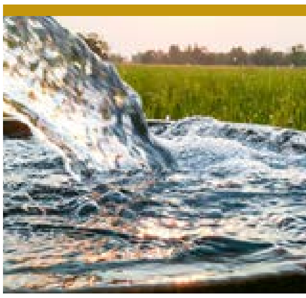
The Binningup plant along with Perth's first desalination plant in Kwinana now supplies 30%-50% of Perth's water supply, depending on demand and availability of other water sources. This is highlighted in Figure 70. The first figure illustrates the volume of water sourced in one of the worst drought years in WA, 2016-17, when dam levels fell to 20%-25%.

As a consequence, no water could be safely sourced from surface water, and groundwater extraction and desalination provided almost all of Perth's water. This integrated water management system allows the flexibility to source water away from surface water when needed, increasing the reliability of the system and guaranteeing water supply for the state's capital, even in extreme drought years.

There are concerns with sourcing water from desalination plants including how the plant is powered, and the extent to which this can lead to higher levels of greenhouse gas emissions. For example, Biswas (2009) conducted a life cycle assessment of greenhouse gas emissions using the Binningup desalination plant as a case study prior to its construction. He found that, if the plant was conventionally powered, around 3,900 tonnes of CO_2 would be generated to produce one gigalitre of desalinated water (based on national average grid emissions).

However, both the Kwinana and Binningup plants' electricity are sourced from renewable energy farms located elsewhere in the state, which has resulted in a net zero impact on grid emissions. This reflects the fact that renewable energy can be provided from places in the state with a higher comparative advantage. This does not of course include the embedded energy used in the construction of the desalination plants and wind and solar farms, which are taken into account in a life cycle analysis.

Current projections from the Water Corporation indicate an additional 20 gigalitres of water will be needed to meet population demand by 2030, and we will need to reduce our level of groundwater extraction from 116 gigalitres down to 89 gigalitres, with less surface water also available. At the same time we will need to increase desalinated water supply from 128 to 181 gigalitres (+53 gigalitres) in 2030. This is in addition to the projected 7% increase in recycled and replenished water.



Both the Kwinana and Biningup desalination plants operate on electricity that is sourced from renewable energy.

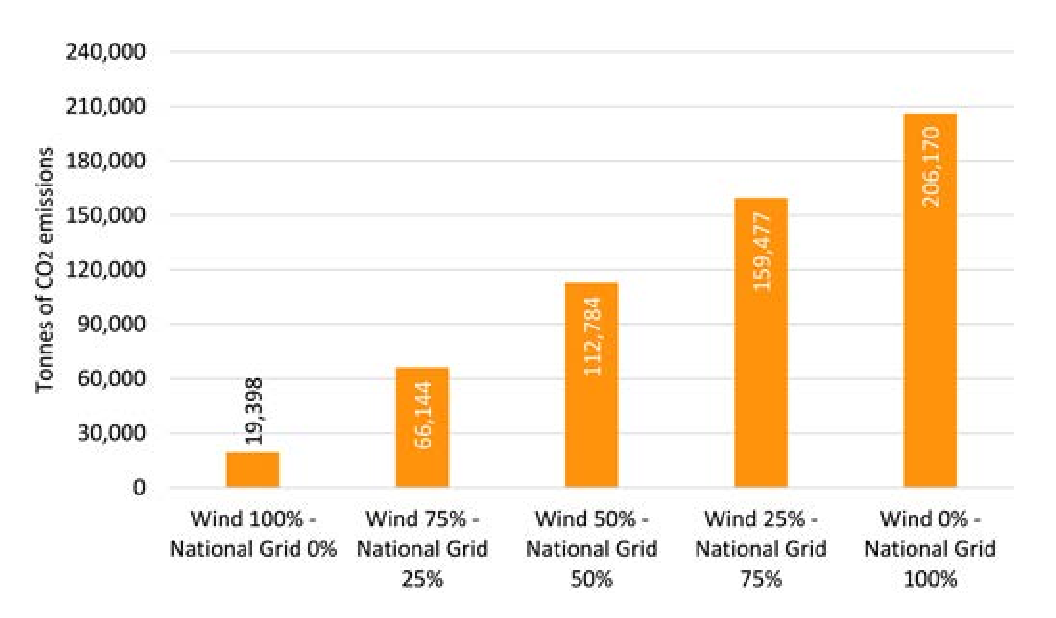
In drought years like in 2016-17, no water was sourced from surface water, instead groundwater and desalinated water each provided almost half of the city's water.

Following Biswas (2009), Figure 71 shows the estimated levels of CO_2 emissions that would be emitted from producing 53gL of desalinated water, using different combinations of renewable energy (wind) and national grid power based on Biswas calculations.

As can be seen, there is a very significant difference in the level of CO_2 emissions produced between using 100% wind (19,398 tonnes) and 100% grid (206,170 tonnes) to produce 53gL of desalinated water. This equates to nearly 11 times more CO_2 emissions being produced using national grid electricity compared to wind generated electricity.

FIGURE 71

Total greenhouse gas emissions from producing 36 gigalitres of desalinated water with different combinations of renewable energy (Wind) and national grid electricity



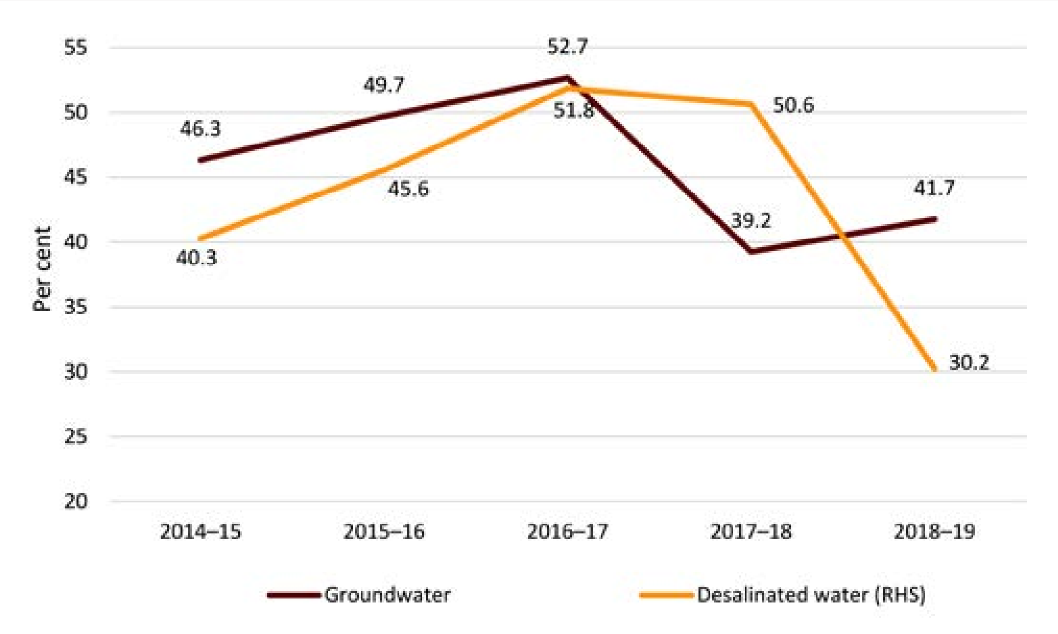
Source: Bankwest Curtin Economics Centre | Authors' calculations based on National performance report 2018-19, urban water utilities and Urban NPR 2018-19 data. Bureau of Meteorology (BOM), Australian Government.

Figure 72 shows the increase in water sourced from desalination plants over the last five years, increasing from 40.3% in 2014-15 to over 50% in 2016-17 as the drought intensified. This has decreased to 30.2% on most recent data. Had the desalination plants been powered by non-renewable energy, the increased dependency on this water source would be accompanied with a significant increase in greenhouse emissions.

The decision to balance desalinated water production with equivalent renewable energy production significantly reduces the potential carbon footprint of these plants. Given the findings from the Water Forever community consultations of significant public concern about the impacts of increased desalination on emissions, and their desire to reduce groundwater extraction to sustainable levels, it would seem reasonable to expect any further desalination capacity would also be matched by renewable generation in the future.

FIGURE 72

Proportion of water sourced from desalination and ground water - Perth



Source: Bankwest Curtin Economics Centre | Authors' calculations based on Biswas (2009).

WA recycled around 15,000 litres of water per person in 2017-18 and is the state with the second largest quantity of recycled water in Australia.

Water reuse and water collection

Water use

Water reuse is a concept that has captured increasing attention from public officials in Australia and internationally. Being able to recycle our wastewater indefinitely to meet our present and future needs, will significantly alleviate the pressure on our water resources and ecosystems. Because wastewater increases as the city grows, recycled wastewater is the most sustainable source of water currently available.

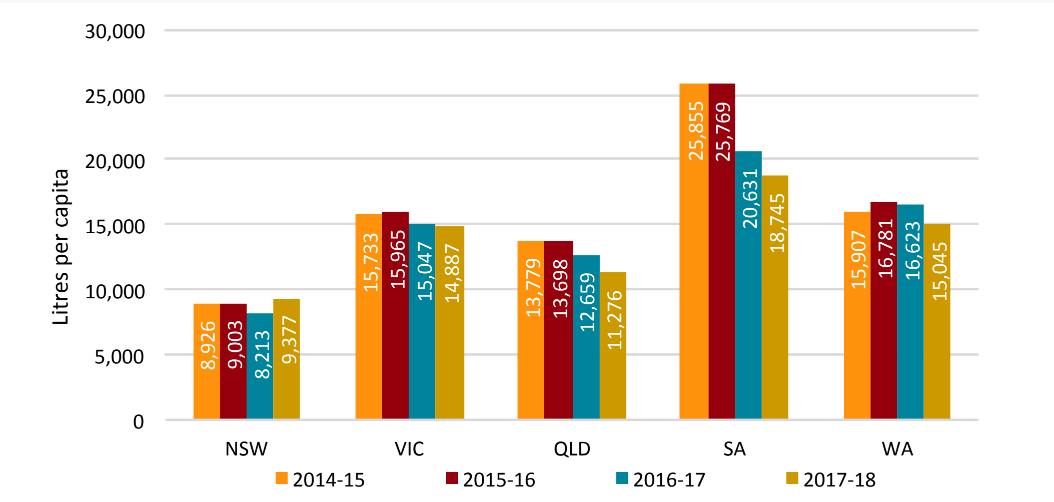
It is estimated that every year, 140 billion litres of treated wastewater is discharged into the ocean in the Perth metropolitan area.[134] In coastal towns, we can consider that, all of this discharged water is "wasted" when disposed to the ocean as it doesn't contribute to the river flow ecosystem. This water could be recovered instead and reused in our economic activites.

Australia already consumes more reuse water than one might think. For instance, a large proportion of Sydney water comes from recycled water from towns that have treated their water and discharged it into Sydney's upstream river catchments. Dr Ian Wright has estimated that in dry summers, roughly 32% of the Hawkesbury-Nepean flow of the Sydney's water supply catchment comes from treated sewage.[135]

In Perth, most of the reuse water does not come from upstream river flow but is recycled in the city to be used by industry and local governments. As shown in Figure 73, WA recycled around 15,000 litres per person in 2017-18 and is the state with the second largest quantity of recycled water in Australia. Only SA performs better, with almost 19,000 litres of reused water per capita but the quantity has decreased rapidly since 2014-15. As with WA, VIC has similar per capita reuse rates and the trend seems stable as well. Finally, QLD and NSW have the lowest rates of recycled water and are also stable through time.

FIGURE 73

Water reuse by state, 2014-15 to 2017-18



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS 4610.0 Water Account, Australia

134 Is Perth really running out of water? Well, yes and no. Don McFarlane. The Conversation, February 2018.

135 More of us are drinking recycled sewage water than most people realise. Ian Wright. The Conversation, March 2018.

In Perth, approximately 10% of the water is recycled.[136] The Water Corporation target in the Forever Water initiative is to recycle 60% of wastewater in the Perth metropolitan area by 2060 and 30% by 2030. This could be possible thanks to the groundwater replenishment scheme that has been operating since 2017.[137] First in Australia, the scheme recovers water from Perth's sewage and cleans it to drinking water standards. The resulting recycled water is then injected into Perth's deep aquifers where it remains until re-extraction. The idea is for the aquifer to work like a huge storage facility, much like a huge rainwater tank. The system is meant to work in a circular cycle:

> *Groundwater from the aquifer is extracted for consumption → water is cleaned to drinking levels → water is used in economic activity and disposed of → water is treated to potable levels → water is injected back into the aquifer.*

And the cycle starts again. Nowadays, groundwater replenishment only makes up 3% of Perth's IWRM but the idea in the long-term is to reinject most of Perth's recycled water into the aquifer.[138] This is an ingenious method to stock and reuse our water since the aquifers act as a storage solution for recycled water. By 2060, the groundwater replenishment scheme aims to provide around 115gL of water, enough to supply 500,000 households.

Nevertheless, this solution is less optimal than directly utilising the recycled water for consumption. Indeed, the groundwater replenishment scheme is more costly than the direct recycling of water because of the cost of water re-extraction and re-cleaning. Basically, at the end of the first cycle the water is cleaned to a drinkable standard but instead of being reused, it is re-introduced to the aquifer after which it would be re-extracted and re-cleaned. Multiple solutions are possible for direct utilisation such as industry consumption, public and horticultural irrigation and water to the tap.

A cost effective solution is for sewage water to be treated to a lower standard than drinkable water. This water can then be used in industry processes, public irrigation and agriculture. The most straightforward solution is to use recycled water for the public irrigation of parks and ovals. Because of Perth's sandy soil the recycled water will still end up in the groundwater system (unless evaporated), but additional use would be made out of it.

A second approach is to provide recycled water for industrial purposes. This is already being done at a lower scale in the Kwinana Water Reclamation Plant that treats 10mL of water per day and produces 7mL of recycled quality water to be reused by industry. Plans to expand the capability of this plant have been put in place but have not gone any further.

By 2060, the groundwater replenishment scheme aims to provide around 115gL of water, enough to supply 500,000 households.

136 More of us are drinking recycled sewage water than most people realise. Ian Wright. The Conversation, March 2018.

137 https://www.watercorporation.com.au/Our-water/Groundwater/Groundwater-replenishment.

138 Water forever, towards climate resilience. Water Corporation. October 2009 and How all Perth's sewage could be turned into drinking water, Rebecca Dollery, ABC News, February 2018.

Direct water reuse opportunities include industry consumption, public and horticultural irrigation and water to the tap.

Increasing the capability of this plant for the direct reuse of water could decrease the pressure of the Kwinana aquifer that currently provides 60% of industry needs in water (located in the Kwinana Industrial Area). In the Water Forever report of the Water Corporation it was forecast that by 2030, an additional 20gL could be provided by expanding the Kwinana Water Reclamation Plant and providing recycled water to the Neerabup and East Rockingham industrial areas.[139] These initiatives would greatly increase the sustainability of water resources and should be pursued by the Western Australian government to increase the efficiency of our recycled water.

Using recycled water to irrigate agricultural crops is also a feasible solution. The main problem resides in the distribution system that is needed between agricultural plots and wastewater treatment plants. However this solution could be considered for urban agriculture, where distribution costs wouldn't be too high. An example comes from SA, where a large water recycle project to irrigate crops is now in place. This project transfers 15gL of recycled water from Adelaide to the Virginia Plains agricultural district (35km north of Adelaide) where approximately 250 farmers use recycled water in their activities.[140] A smaller scale project is been considered in the Carabooda agricultural district which is located near the Alkimos wastewater treatment plant. A feasibility audit has been requested from the Waneroo council.

Another issue with recycled wastewater is to encourage industries and farmers to utilise it in the production process. A possible solution is to reduce the price of recycled water that has not been treated to drinking standards and sell this to industries. Because the treatment of this water is cheaper relative to groundwater replenishment schemes, a difference in price could be justifiable. Encouraging farmers and industry bodies to move away from bore water and increase water reuse could lead to efficiencies in the treatment of recycled water.

Finally, a more efficient approach to groundwater replenishment is probably the most controversial. It consists of the reuse of water from sewage directly into drinking water. The idea is that since reuse water has already been cleaned to drinking standards, why not use it directly as potable water. There is no city in Australia that uses *direct potable reuse* but other countries such as Namibia and the United States do. Windhoek city located in Namibia has implemented this strategy successfully for the past 50 years. However, successful implementation resides in the public acceptance of the “toilet to the tap” strategy. Education and communication are key to advance this agenda. In Australia, recent surveys have showed a wider public acceptance of direct potable reuse as a source of drinking water.[141]

In the long term, WA should aim to recycle 100% of its water. This can easily be achieved at a large scale though the groundwater replenishment strategy. Other uses of lower quality recycled water include the utilisation for public irrigation of parks and ovals, irrigation of agricultural crops, reuse water to industrial processes and direct potable reuse.

139 Water forever, towards climate resilience. Water Corporation. October 2009.

140 Inquiry into pricing of recycled water in Western Australia. Economic Regulation Authority, Western Australia. August 2008.

141 Stuart, K,. (2015). As drought looms again, Australians are ready to embrace recycled water. The conversation.

Water tanks

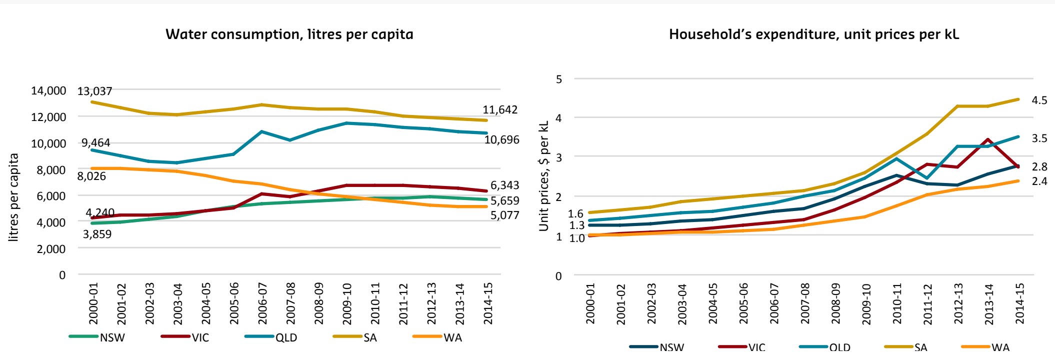
Another source of sustainable water management is the use of rainwater tanks. It has been estimated that rainwater tanks can supply up to 28% of household's water needs.[142] Even though half of the household's water consumption is destined for outdoor use, rainwater tanks are most efficient if connected to the pipes inside the house (for non-potable uses). This is even more true in places like Perth where rain episodes are concentrated in the winter months. Water tanks are especially useful in rural areas where no reticulated water supply is available. However, in the last decade, the uptake of rainwater tanks in the cities has decreased significantly.

As we observe on the left hand side of Figure 74, the water consumption from rainwater tanks has fallen sharply in WA since the 2000s. In 2014-15, each person in WA consumed on average 3,000 litres less water from rainwater tanks relative to the 2000-01 levels (8,000 litres per capita). WA and QLD are the only states experiencing a decline in consumption, although the decline rate is significantly less steep relative to QLD. The rest of the states had a steady increase of water consumption from rainwater tanks, averaging approximately 2,000 litres per person from 2000 to 2015. Storage capacity of rainwater tanks has also smoothly increased during the same period in all states except for WA, where it has stagnated.

In 2014-15, each person in WA consumed on average 3,000 litres less of water from rainwater tanks relative to 2000-01 levels - 8,000 litres per person.

FIGURE 74

Rainwater tanks consumption and unit prices by state, 2000-01 to 2014-15



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS 4610.0 Water Account, previous versions, Australia

142 Water forever, towards climate resilience. Water Corporation. October 2009.

WA has the lowest household expenditure per unit price of rainwater tanks (2.4 per kL).

Demand has not increase despite cheaper prices of rainwater tanks than in any other state.

The rise in rainwater tank consumption in the eastern states is possibly due to the increase in the uptake of water tanks in urban areas, a bigger uncertainty about water supply for irrigation purposes in summer months, and increasing concerns for our environment and the consequences of climate change. Institutional reasons such as regulatory requirements and the availability of rebates also contribute to the rise in demand. For instance, legislation in NSW, VIC and SA impose the inclusion of rainwater tanks in new residential constructions, which has expanded demand in rainwater tanks. Rebates are also in place to encourage the installation of tanks but they vary greatly between councils. In WA, the Water Corporation offers rebates up to $1,000 for tanks over 2,000 litres capacity in some towns of the South West and Great Southern.

An additional explanation for the divergence in trends between WA and other states is probably due to weather and rainfall patterns in the South West of WA, where most of the population is concentrated. Unlike some of the eastern states, the South West of WA has a Mediterranean climate, which means that rain is concentrated in the winter months. Because there is hardly any rain in summer time in Perth, it is almost impossible to recharge the rainwater tanks during these months. Therefore, rainwater tanks become less profitable for Western Australians explaining part of the gap. The existence of abundant groundwater available for households in the Perth metropolitan area, also contributes to this differential. Indeed, more than 25% of households in Perth have a bore water well on their property. In Perth, people seem to prefer bore water rather than rainwater tanks, as in the eastern states.

In terms of expenditure, we can see in the right hand side of Figure 74 that unit prices reach 2.4 per kL in WA and up to 4.5 in SA. WA has the lowest unit price per kL of all states, but even cheap prices in rainwater tanks have not managed to increase the demand. NSW and VIC have slightly more expensive prices than WA (2.8 per kL). However, we observe that with increasing prices for rainwater tanks, the demand of water use from tanks has declined. Indeed, from 2008-09 when prices started to pick up, the use of rainwater from tanks slowed down. This trend has remained stable since then in all states, except for WA, where the rainwater use from tanks has declined since the 2000s.

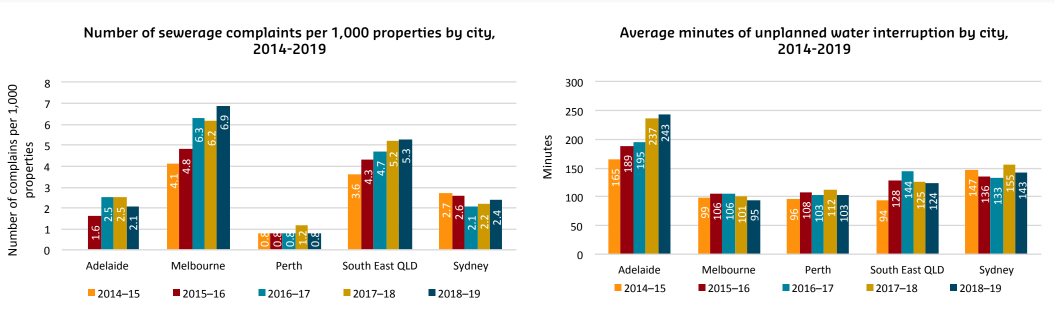
Water tanks are a valuable solution to increase the supply of water from sources other than surface water. They can be the only viable option in rural Australia, for places not connected to the sewage system. Nevertheless, factors such as weather patterns and economies of scale can impact the efficiency of this source of water. Communal rainwater tanks are probably one of the most efficient solutions, especially in new residential developments. Water collected from rooftops and roads can be used in the irrigation of gardens and green spaces.

Water reliability

The last crucial point in water management is the reliability of water supply. The United Nations sixth sustainability goal, clean water and sanitation, emphasises the right to access water and sanitation as well as a reliable water supply. This means that, even if being connected to the grid plays a crucial role, the quality of the service delivered is just as important.

FIGURE 75

Sewerage complaints per 1,000 properties and average minutes of unplanned water interruption, 2014-15 and 2018-19



Source: Bankwest Curtin Economics Centre | Authors' calculations based on National performance report 2018-19, urban water utilities. Bureau of Meteorology (BOM), Australian Government

To study this question, Figure 75 shows on the LHS the number of sewerage complains per 1,000 properties and, in the RHS, the average minutes of unplanned water interruption. It seems that in terms of these metrics, Perth is doing relatively well compared to the rest of the country. For instance, in 2018-19, Perth had less than 1 complaint per 1,000 properties and this percentage has remained stable since 2016-17. This is the lowest of all states and less than half the number of complaints than in Sydney and Adelaide. Melbourne and the South East of Queensland is another story. They have, on average, had a larger number of complaints relative to the Australian mean. Furthermore, the number of complains have increased in both states. Melbourne has an average of 7 complaints per 1,000 properties and South East Queensland 5 an increase of 68% and 47% respectively since 2014-15.

In terms of the average minutes of unplanned water interruptions, the numbers are relatively stable throughout the years. Adelaide is the only exception in terms of the magnitude as well as the direction of the increase. Adelaide has had an average of 243 minutes of unplanned water interruption in 2014-15, the worst performance of all states. On top of that, this number has increased by 78 minutes since 2014-15. Perth is one of the best performers along with Melbourne. Perth only had a 103 minutes of unplanned water interruption in 2016-17 and this number has remained stable.

Finally, Figure 76 forecasts a key aspect of the water management efficiency, the proportion of water losses. Contrary to the figures above, WA is the state with the largest percentage of water losses as a percentage of distributed water (20%). This means that a fourth of WA's water is lost in the pipes and is never delivered. NSW, QLD and VIC are all close to a 13% loss of distributed water, well below WA. The percentage of water losses is somewhat stable for WA and QLD but has decreased rapidly for VIC, NSW and SA. South Australia has indeed the smallest amount of water loss, only 3%. Even better, the decline in this rate from 10% in 2011-12 is remarkable.

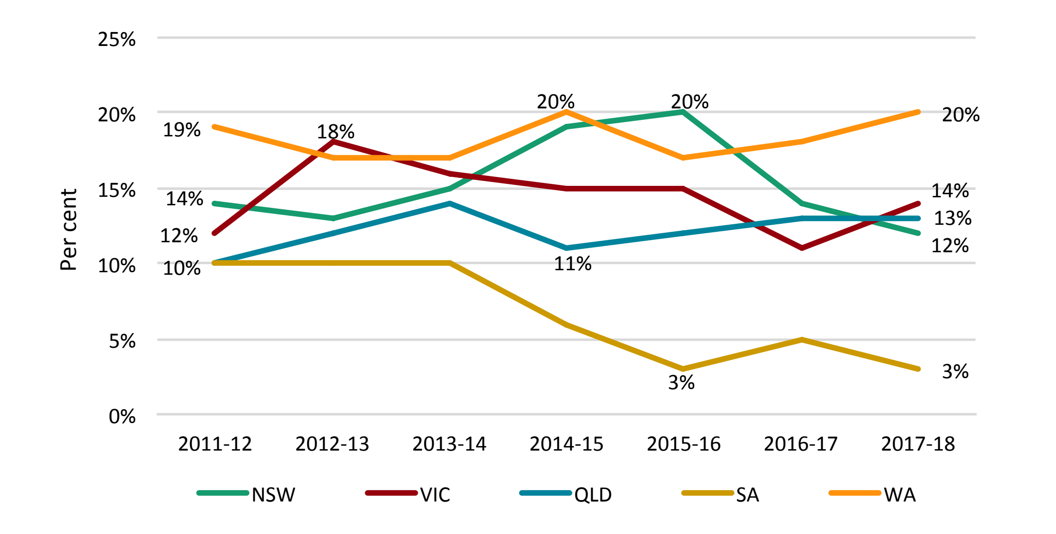
In 2018-19, Perth had less than 1 sewerage complaint per 1,000 properties, the lowest of all states.

Perth only had a 103 minutes of unplanned water interruption in 2016-17 and this number has remained stable.

A quarter of WA's distributed water is lost in pipes and never delivered. This percentage is higher than in any other state.

FIGURE 76

Proportion of water losses as a percentage of distributed water by state, 2011-12 to 2017-18



Source: Bankwest Curtin Economics Centre | Authors' calculations based on ABS 4610.0 Water Account, Australia

However, we should keep in mind that the water losses in Perth are not out of the ordinary. The World Health Organisation has estimated that, on average, developed countries lose 8-24% of its water in the pipes. This percentage oscillates between 25-45% for developing nations.

However to reduce water losses, WA should first start to gather data. It is difficult to know exactly how much water is lost if we do not know the exact amount of water that is being supplied. The monitoring of water distribution in Perth is somewhat easier since we rely on groundwater and desalination plants for water supply. It is therefore easier to determine how much water is extracted through these processes than with surface water. The latter is more challenging to measure as it is extracted from dams and rivers and we do not always know how much water is located in these reservoirs.

Given the proportion of water losses in WA, the state needs to first invest in a large collection of data gathering. Once the precise amount of water supplied can be evaluated, it will be possible to track pipe leakages and water losses through advanced monitoring tools such as digital leak-detection technology, advanced network software and smart metering. Smart metering allows detailed tracking of information on water supply and can detect abnormalities in the consumption of water that can be used to imputed losses in the water distribution system. This would allow the early detection and rectification of pipe leakages. Investing in these types of technologies can significantly help to reduce the amount of water loss in the distribution system.

Even if Perth preforms well in terms of the provisions of services to customers, improvements can be made to manage the water losses more efficiently. Water losses are an indication of the network's health and should be closely monitored.

CONCLUSION

In summary, this chapter has provided an overview of the current trends in the green economic sectors of the economy in Western Australia and Australia. Some of the main findings from this overview include the fact that Western Australia had the second worst record in increasing its use of renewable energy resources to generate electricity, over the past decade, only increasing the use of renewable energy resources from 2.9% in 2008-09 to 8.9% in 2018-19. One possible factor driving this poor performance is that Western Australia is one of only two states without a renewable energy target, with the other state being New South Wales. However, in August 2020 the Energy Transformation Taskforce presented its Whole of System Plan to the Western Australian government, with the plan outlining four possible scenarios for the generation of electricity in Western Australia, for the period up 2040.

Of the electricity generated from renewable energy sources in Western Australia, around 80% is generated from a mix of wind energy and small scale solar photovoltaic (PV), with the proportion generated by small scale solar photovoltaic (PV) nearly doubling from 21.6% in 2012-13 to 39.3% in 2018-19. Based on the composition of renewable and non-renewable energy sources used to generate electricity in each of the states in 2018-19, it was estimated that Victoria produced the highest volume of CO_2 emissions per GWh of electricity generated, at 929 tonnes of CO_2 emissions per GWh. Western Australia was ranked fourth in terms of estimated tonnes of CO_2 emissions per GWh of electricity generated, producing an estimated 600 tonnes of CO_2 emissions per GWh. It was also found that the uptake of small-scale solar photovoltaic (PV) and other distributed energy resources (DER) has the potential, if not properly managed, to affect the power system security and network reliability in Western Australia.

One of the strategies put forward by the Energy Transformation Taskforce (2019) to mitigate the effects of the increasing uptake of small-scale photovoltaic systems is to integrate small-scale photovoltaic systems and other distributed energy resources into the operation of the main electricity grid and allow them to be remotely controlled.

In respect to the green building sector, it was found that Western Australia ranks fifth, alongside South Australia, in terms of the energy efficiency of new homes and apartments built between May 2016 and July 2020. The ranking is based on the Nationwide House Energy Scheme, (NatHERS), which provides homes with a star rating out of ten based on an estimate of a home's potential (heating and cooling) energy use. The star ratings are based on information about the home's design, construction materials and the climate zone in which it is built. In addition, the results from a recent study by Lawania and Biswas (2016), which accessed the embodied energy and greenhouse gas emissions associated with the construction and use of a typical 4 x 2 x 2 house in Perth for sixty building envelope options, suggests that a building envelope consisting of cast in situ sandwich walls with polyethylene terephthalate (PET) foam core, double glazed windows, and concrete roof tiles had the lowest life cycle embodied energy consumption at 5,700 giga joules and greenhouse gas emissions at 403 tonnes. In contrast, their results suggest that a building envelope consisting of pre-cast light weight concrete sandwich panels (without insulation), single glazed windows, and metal profile sheet roof had the highest life cycle embodied energy consumption at 7,000 giga joules and GHG emissions at 498 tonnes.

Finally it was found that while the 2019 National Construction Code[143] is now in effect, Western Australia has transitional provisions in place which allow the applicant of a building permit to comply with either the National Construction Code 2019 Amendment 1 or National Construction Code 2016 (Volume One Amendment 1 and Volume Two). These transitional provisions will remain in place until 30 April 2021 (Department of Mines, Industry Regulation and Safety, 2020).

In terms of trends in sustainable transport, it was found that the uptake of electric cars has been relatively slow across Australia. In 2019, Western Australia had the third highest ownership of electric cars per 10,000 people, at around 5 per 10,000 people, whilst Tasmania had the highest ownership of electric cars, at around 11 per 10,000 people. One of the current disincentives for purchasing an electric car in Australia is price. In Australia in 2020, the average price of an electric car was $91,796, with the cheapest costing $47,490 and the most expensive costing $191,100 (RAC, 2020). In addition, it was noted that although electric cars do not directly generate any CO_2 emissions per se, the overall emissions they do generate are dependent upon the composition of the fuel types used to generate the electricity they use. Given this, it was estimated that driving an average electric car (18 kWh of electricity per 100 kilometres) 100,000km in Western Australia in 2018-19 would generate 10.8 tonnes of CO_2 emissions. This is based on one GWh of electricity generated in Western Australia in 2018-19 producing an estimated 600 tonnes of CO_2 emissions. The worst state to drive an electric car was Victoria, where driving a 100,000 km in an average electric car would generate an estimated 16.7 tonnes of CO_2 emissions. Furthermore, it was estimated that driving a more fuel-efficient petrol car (5L per 100km) in Queensland, New South Wales, and Victoria in 2018-19 would actually generate less CO_2 emissions compared to driving an electric car.

In regards to waste management, it was found that waste can be either recycled, used in energy recovery, or sent to landfill. Recycling is the most preferable method of waste management, while sending waste to landfill is the worst method of waste management. Energy recovery is also not an optimal method of managing waste, but is still preferable to sending it to landfill. Western Australia has the second worst recycling rate, with only 46% of waste recycled. Only Queensland has a worst rate, at 42%. South Australia has the best record in terms of recycling, recycling 74% of its waste. Most startling was the finding that only 4% of Western Australia's plastic waste is recycled, which is the lowest rate amongst the states. The remaining 96% of plastic waste ends up in landfill. In addition, Western Australia only recycles 42% of glass waste compared to 57% for Australia. In order to attain a 75% recycling of waste, we would need to concentrate our efforts particularly in these two materials. Indeed, glass can be almost entirely recycled and almost half of plastic waste generated in Australia can be easily recycled as well. Increasing the recycle rate of these two materials, will drastically reduce waste going to landfill and will actively help the WA waste strategy targets in 2030. Western Australia's record on recycling organic waste is also poor, with only 34% being recycled, which again is the lowest rate amongst the states. The only area of recycling where Western Australia has dramatically improved its performance is in the recycling of masonry waste, which increased by more than 50 percentage points between 2007 (19%) and 2017 (72%).

143 The regulation of all buildings built in Australia is covered under the National Construction Code.

Finally, in respect to water management, it was found that water in Australia is drawn from four main sources: surface water, groundwater, desalinated water, and recycled water. In 2019, Perth dams were only 41% full, which was the lowest level amongst the states. The situation was even worse in 2016, with water storage levels falling to 20% of full capacity. During the drought in 2016-17 no water was sourced from surface water, instead 52.7% of Western Australia's water was sourced from groundwater and the remaining 46.8% was sourced from desalinated water. Since then Perth's main sources of water have changed from water collected in dams to groundwater and desalination water. In 2018-19, 41.7% of Western Australia's water was sourced from groundwater, 29.8% was sourced from surface water, 24.6% was sourced from desalinated water, and the remaining 3.9% was sourced from recycled water. One issue with producing desalinated water is that it can lead to high levels of greenhouse gas emissions being emitted. For instance, Biswas (2009) estimated that 3,890 tonnes of CO_2 would be emitted per gigalitre of desalinated water produced, if 100% of the desalination plants electricity was drawn from the national grid. However, if 100% of the desalination plants electricity was drawn from renewable energy (wind), this would be reduced to 366 tonnes per gigalitre of desalinated water produced. Another alternative source of water is recycled wastewater or water reuse. In 2017-18, Western Australia recycled around 15,000 litres of water per person, which was the second largest quantity of water recycled amongst the states. South Australia recycled the largest quantity of water per person, with almost 19,000 litres per person.

In formulating policies aimed at reducing greenhouse gas emissions, there is a need to take a holistic approach when developing policy, and not just focus on individual components of a system. For example, policies aimed at increasing the ownership of electric cars needs to be formulated in conjunction with policies aimed at increasing the percentage of electricity generated using renewable energy resources.

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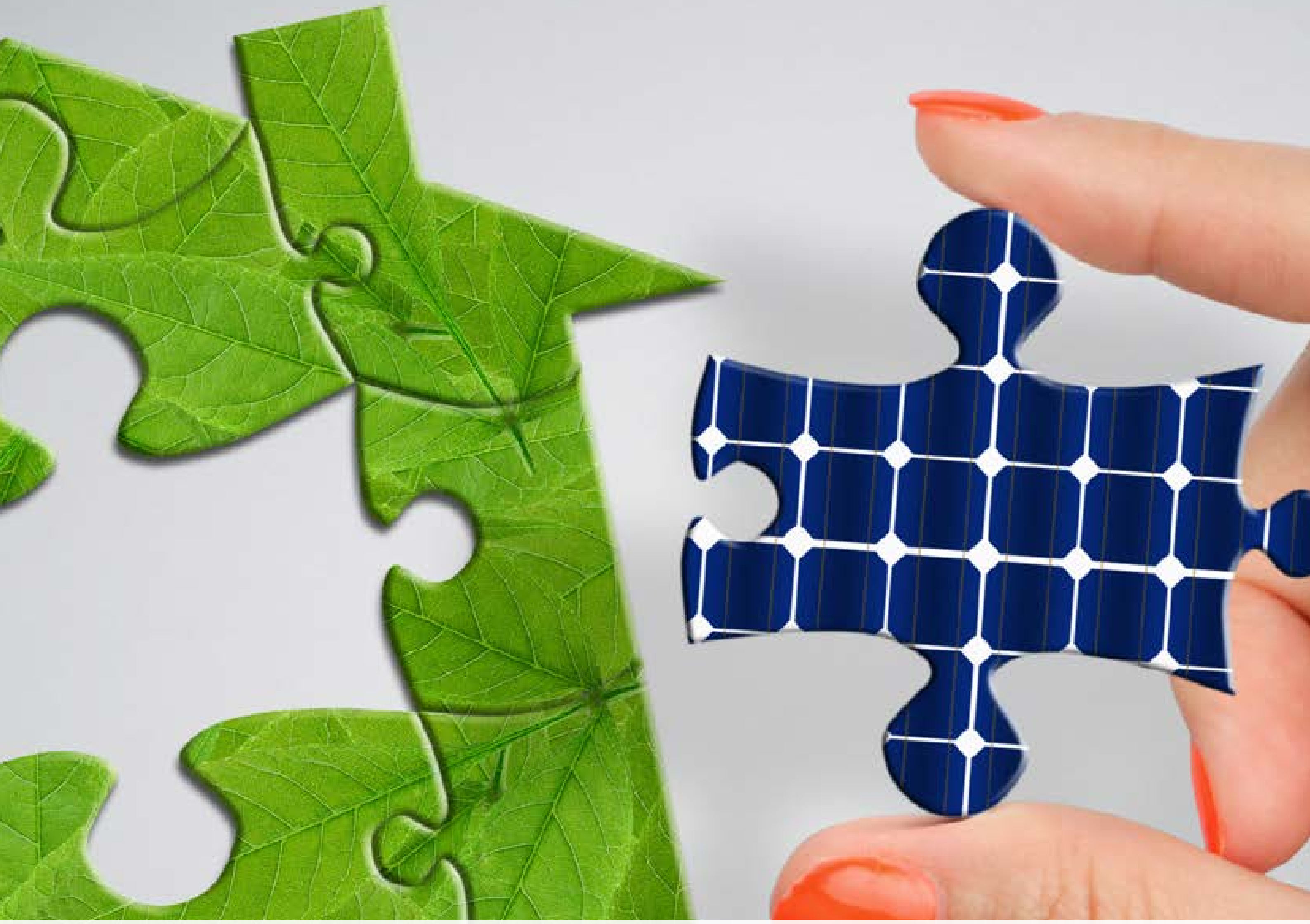
"A COMBINATION OF STRATEGIES INVOLVING **RENEWABLE ENERGY, STORAGE AND CLEANER MANUFACTURING** COULD PROVIDE SIGNIFICANT ECONOMIC AND ENVIRONMENTAL BENEFITS TO WA."



WA'S OPPORTUNITIES FOR A SUSTAINABLE FUTURE

INTRODUCTION

A green diversification strategy could create 55,000 additional jobs, 49,000 of which would be in regional WA. This would also see some $16 billion added to the WA economy.

This chapter examines opportunities to improve the environmental profile of WA's industries.

First we consider the environmental impact of industries in WA's regions and each region's main environmental challenges. These profiles provide a valuable tool to regional communities to prioritise environmental concerns that relate specifically to their local industries.

We then evaluate diversification opportunities in each region by including an environmental impact perspective in the choice of regional priority industries. This highlights a number of opportunities for industries with a lower environmental impact. While these industries require additional investment, the analysis shows they are also likely to offer significant economic value and environmental benefits in return.

Taking a state-wide perspective we consider strategies to improve existing industries.

In particular, a combination of strategies involving renewable energy, storage and cleaner manufacturing could provide significant economic and environmental benefits to WA.

Lastly, we consider exported products that provide environmental benefits. We examine WA's existing environmentally beneficial products and opportunities to diversify into other beneficial products.

Overall, we have found that, contrary to common belief, giving a green lens into the diversification strategy could create a large proportion of jobs and increase the state's GVA. We estimate that 55,000 additional jobs can be created. Of these, 49,000 jobs would be generated in regional WA alone. Taking into account the environmental impact of industries would generate a larger proportion of jobs in regional areas. Furthermore, $16 billion dollars of additional GVA could be added to the WA economy.

REGIONAL PROFILES

This section considers the environmental impact of industries across Australia. Based on this analysis, we examine regional industry profiles to consider the typical environmental challenges of regional industries and opportunities for reducing environmental impact.

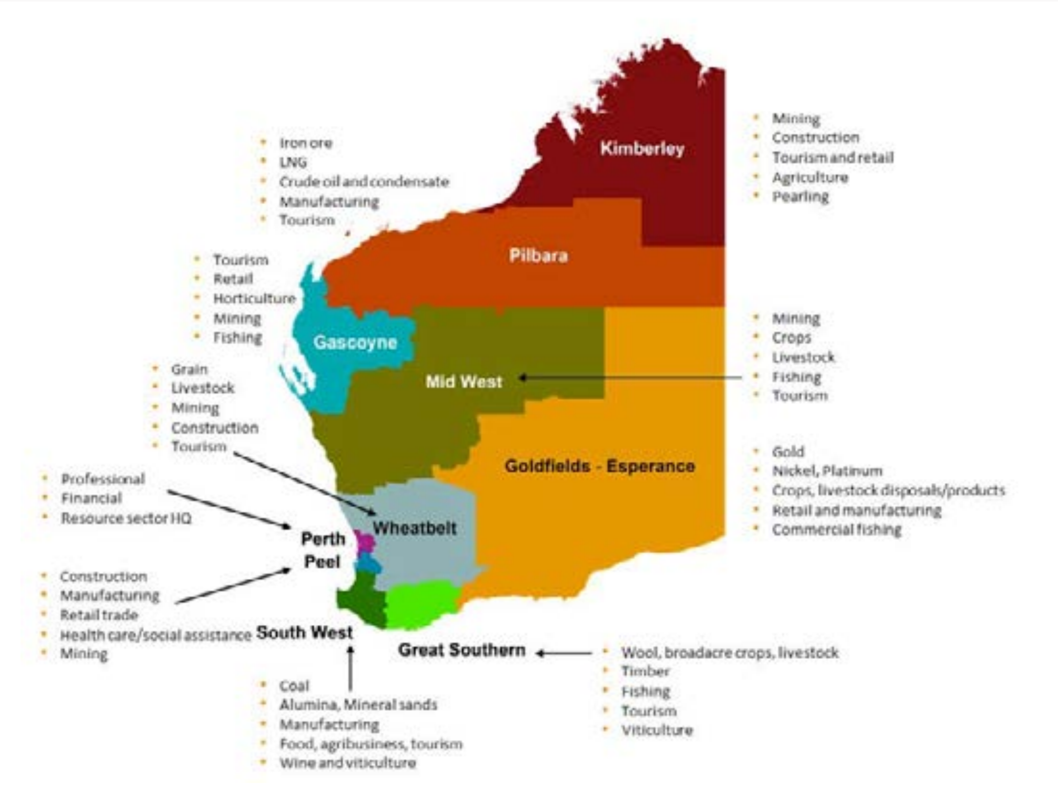
There are nine regions in Western Australia as delineated by the Regional Development Commissions Act 1993. Figure 77 shows their boundaries and predominant industries. In this section we treat Perth as the tenth region of WA.

We profile each region in terms of their main industries and the environmental impacts of those industries. Opportunities to reduce the environmental impact of the regional economies needs to take account of these local characteristics. Environmental challenges vary by region with differing levels of greenhouse gas emissions, resource use and pollution. Furthermore, there is an opportunity for local governments and regional development commissions to directly address these local, pressing environmental challenges.

Based on these regional profiles of industrial strucutre and environmental impacts, we identify priority industries for each region to diversify into that build on local capabilities with lower environmental impacts.

FIGURE 77

The regions of Western Australia and principal industries



Note: Principal industry identification from the Regional Development Commissions.
Source: Bankwest Curtin Economics Centre | BCEC, Regional Development Commissions.

Environmental Impact Index

There are a number of components that contribute to an industry's impact on the environment. We develop several sub-indexes to understand the dimensions of environmental impacts in Australian industries. There is an overall environmental impact index,[144] and seven sub-indexes that describe:

- Fossil Fuel use;
- Electricity use;
- Water use;
- Waste services use;
- Air pollution and direct greenhouse gas emissions;
- Water pollution; and
- Land pollution.

The indexes describe dimensions of the environmental impact of each ANZSIC industry class *relative to the value added* by each industry. Industries that have a very high value to the economy may have a low impact on the environment per dollar of value created, while very low value industries may have a high impact compared to the value created. In this way, the indexes capture the average impact on the environment, rather than the overall impact of those industries simply due to their size. Table 9 describes the 10 best performing industries with the lowest environmental impact relative to value added. Specifically, various financial services industries all score 0.1 in the index. These are typically investment, banking or insurance services, which are not energy intensive and do not pollute, but have high value-added.

TABLE 9

Eleven Best ANZSIC industry classes by the environmental impact index

Industry	Environmental Impact Index (/10)
Superannuation Funds	0.1
General Insurance	0.1
Health Insurance	0.1
Life Insurance	0.1
Financial Asset Investing	0.1
Non Depository Financing	0.1
Other Depository Financial Intermediation	0.1
Credit Union Operation	0.1
Building Society Operation	0.1
Banking	0.1

Source: Bankwest Curtin Economics Centre | Authors calculations based on pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

144 Note that this measure excludes biodiversity, landscape, or other environmental impacts that have limited available information. Evaluating the overall impact of an industry should also include analysis of these other impacts not captured by the index.

TABLE 10

Ten Worst ANZSIC industry classes by the environmental impact index

Industry	Environmental Impact Index (/10)	Potential for Environmental Improvement (^^^ = max)
Petroleum Refining and Petroleum Fuel Manufacturing	10.0	^^^
Oil and Gas Extraction	9.1	^
Waste Treatment and Disposal Services	8.5	^^
Fertiliser Manufacturing	7.6	
Industrial Gas Manufacturing	7.2	
Pulp, Paper and Paperboard Manufacturing	7.1	^
Basic Inorganic Chemical Manufacturing	7.0	
Explosive Manufacturing	6.8	
Alumina Production	6.8	^
Copper, Silver, Lead and Zinc Smelting and Refining	6.8	^

Source: Bankwest Curtin Economics Centre | Authors calculations based on pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Table 10 describes the 10 worst performing industries with the highest environmental impact relative to value added. These industries are big users of fossil fuels, energy intensive and have a variety of pollutants.

The third column describes each region's potential for improvement in the index, if industries were to meet clear targets in terms of fossil fuel use, greenhouse gas emissions, pollution, waste and water use. The potential for improvement is even greater if electricity generation also generates less greenhouse gas emissions.

We then examine the typical environmental impacts of regional industry portfolios. This describes the typical impact of those industries in Australia that are important regionally. It is possible that individual regions are doing better or worse than the national indicators used in this analysis. But it is an indicator of the relevant environmental concerns for those industries that regional communities should consider.

Opportunities for Green Shoots

We evaluate industries that regions could prioritise for diversification by taking account of existing capabilities *and* the environmental impact of new industries.

If a region has higher than average shares of employment in a particular industry compared to all Australian regions, this is revealed as a regional comparative advantage within Australia. If a pair of industry classes frequently appears together as a comparative advantage by employment then this pair of industries is considered related. Research has shown that economies typically grow by diversifying into related industries identified by these co-occurrence measures. Regional relatedness density measures the local intensity and frequency of potential related industries. This is both an indicator of likely diversification patterns and the feasibility for new industries to emerge because it describes the local presence of useful capabilities that a new industry can also make use of.

We use this as an indicator to identify new industries and evaluate their environmental impact using the environmental impact index. Industries are assigned scores according to a number of criteria as well as the environment. This identifies regional priorities for diversification that account for their impact on the environment.

Kimberley

Environmental footprint

The infographic of Figure 78 describes the industrial profile of the Kimberley and its environmental footprint. While the largest industry by GVA is Mining, the largest employment sectors are *Health Care and Social Assistance, Education and Training and Accommodation and Food Services.*

While the Kimberley has a lower impact on the environment relative to GVA than WA, its impact is still higher than Australia overall. This is the case across all indicators. Table 11 describes the detailed environmental impact of 11 industries in the Kimberley likely to have the greatest environmental impact based on their national profiles and the local size of the industry.

FIGURE 78

The environmental footprint of the Kimberley

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 11

Eleven highest environmental impact industries in the Kimberley

Industry	Environmental Impact Index (/10)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical in Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Other Non Metallic Mineral Mining and Quarrying	$74	5.4	8.0	8.0	1.0	-	7.5	9.0	-	Fossil Fuel Use	Antimony compounds		Antimony compounds	
Gold Ore Mining	$71	5.5	5.0	5.0	-	-	6.5	6.0	5.0	Land Pollution				
Iron Ore Mining	$93	3.8	6.0	4.0	-	-	6.5	6.0	-	Air Pollution and GHG Emissions				^^
Oil and Gas Extraction	$34	9.1	10.0	9.0	-	-	7.5	10.0	9.0	Land Pollution				^
Air and Space Transport	$55	3.1	10.0	-	-	-	4.5	-	-	Fossil Fuel Use				
Fossil Fuel Electricity Generation	$25	6.5	10.0	10.0	3.0	3.0	10.0	6.0	-	Fossil Fuel Use	Arsenic compounds	Arsenic compounds	Benzene	^^^
Water Supply	$26	4.7	3.0	6.0	10.0	-	5.0	8.0	-	Water Use				^^
Beef Cattle Farming Specialised	$20	5.1	8.0	7.0	9.0	8.0	4.5	-	-	Fossil Fuel Use				^^^
Accommodation	$58	1.7	2.0	7.0	4.0	-	1.0	-	-	Water Use				^^
Nickel Ore Mining	$14	4.5	5.0	5.0	-	-	8.0	4.0	2.0	Air Pollution and GHG Emissions			Chloroform trichloro-methane	

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

While Oil and Gas Extraction is relatively small in the Kimberley, it has a very high environmental impact. On the other hand Accommodation has a relatively low impact per dollar of GVA, but the size of the industry in the Kimberley means it is still one of the top industries in terms of its overall environmental impact.

Local environmental challenges

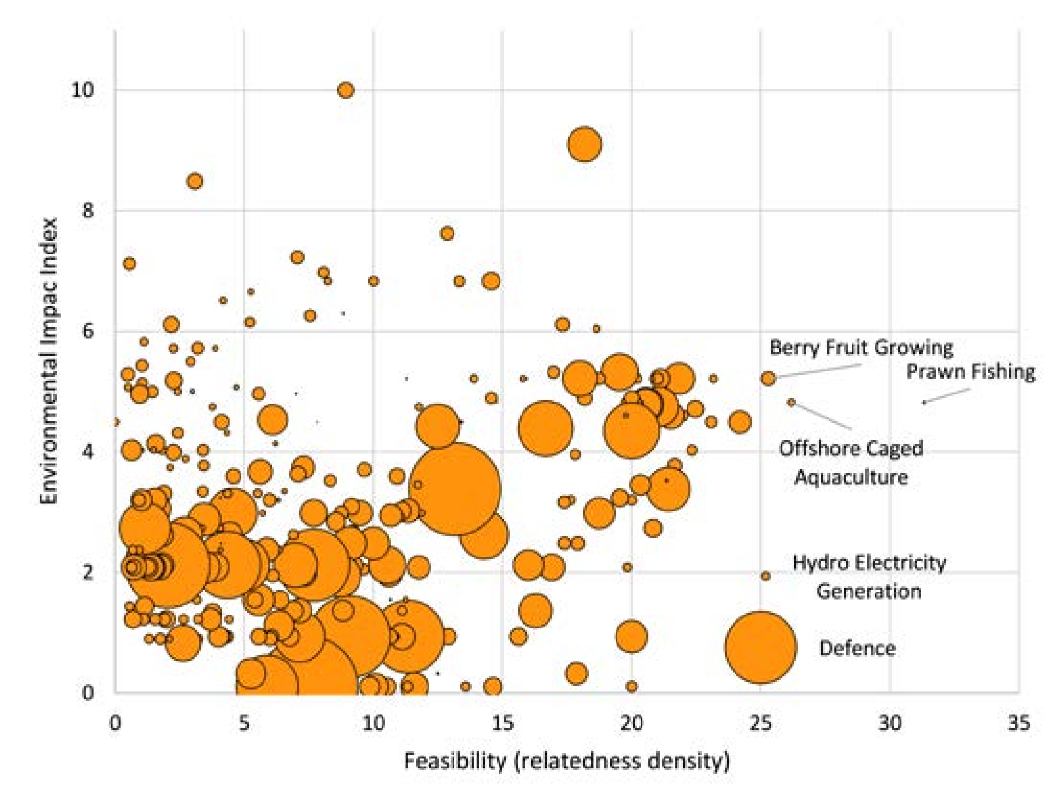
The main environmental concerns in the Kimberley in terms of our index are Fossil Fuel Use and Air Pollution and Greenhouse Gas Emissions. If electricity generation can transition to a greater share of renewable sources, this would reduce the environmental impact of industries across a number of dimensions within our index.

Opportunities for green shoots – new industries

Figure 79 describes the feasibility of diversifying into particular industries in the Kimberley and the environmental impact of those industries according to the index. The most significant employment opportunity, with relatively low environmental impact, is in Defence. Notably this is also one of the recommendations in the Federal Government's *Developing Northern Australia* White Paper.

FIGURE 79

ANZSIC industry classes by feasibility in the Kimberley (Regional Relatedness Density) vs Environmental Impact Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

We evaluate the opportunities based on the environmental impact index and a number of other criteria discussed in our report “Future-Proofing the WA Economy”.

Table 12 shows key criteria in this evaluation as well as the potential for job growth and additional GVA by 2025. In this table, the environmental impact index is translated to a score between zero and four.

Notably, a number of services are now recommended. In particular, *Superannuation Funds* is a financial services industry, which, given compulsory superannuation savings, has a large customer-base across regional Australia. The possibility for locally managed superannuation funds, or services to assist with self-managed funds, would offer a diversification opportunity with relatively low environmental impact.

Other industries with relatively low environmental impact include *Offshore caged aquaculture* and *Hydro-electricity generation*, although this would also require an evaluation of the local resource availability.

TABLE 12

Environmental diversification opportunities in the Kimberley

Industries	Feasibility	Environmental impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Defence	3	4	4	1073	$ -
Superannuation Funds	1	4	4	100	$ 66,240
Hydro Electricity Generation	3	4	4	65	$ 41,473
Scientific Testing and Analysis Services	2	3	3	40	$ -
Water Passenger Transport	3	2	3	43	$ 6,586
Offshore Caged Aquaculture	3	2	4	132	$ 11,273
Building Society Operation	2	4	2	16	$ 9,974
Other Transport nec	2	3	4	73	$ 18,252

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Pilbara

Environmental footprint

The infographic describes the industrial profile of the Pilbara and its environmental footprint. While the Pilbara region has a big environmental impact, it also provides significant economic value. The Pilbara generates Gross Regional Product of $46.6bn. The region is dominated by the very large iron ore mining industry providing 89% of the region's GVA and 46% of its employment.

Overall the Pilbara is a higher user of fossil fuels compared to WA and Australia. The Pilbara has higher levels of air pollution and greenhouse gas emissions and water pollution than WA and Australia overall. This gives the Pilbara an overall score of 4.7 in our index. It highlights Fossil Fuel Use as the main environmental issue.

Table 13 describes the detailed environmental impact of the 10 industries in the Pilbara likely to have the greatest environmental impact. This impact is based on the national industry profiles and the local size of the industry.

FIGURE 80

The environmental footprint of the Pilbara

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 13

Ten highest environmental impact industries in the Pilbara

Industry	GVA ($m)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical in Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Iron Ore Mining	$19,390	3.8	6.0	4.0	-	-	6.5	6.0	-	Air Pollution and GHG Emissions				^^
Oil and Gas Extraction	$5,393	9.1	10.0	9.0	-	-	7.5	10.0	9.0	Land Pollution				^
Gold Ore Mining	$1,362	5.5	5.0	5.0	-	-	6.5	6.0	5.0	Land Pollution				
Other Heavy and Civil Engineering Construction	$458	4.4	8.0	6.0	6.0	10.0	3.0	-	-	Fossil Fuel Use				
Coal Mining	$296	4.4	10.0	-	-	-	7.5	4.0	-	Fossil Fuel Use				
Copper Ore Mining	$255	3.5	5.0	5.0	-	-	6.0	5.0	-	Air Pollution and GHG Emissions				
Other Non Metallic Mineral Mining and Quarrying	$114	5.4	8.0	8.0	1.0	-	7.5	9.0	-	Fossil Fuel Use	Antimony compounds		Antimony compounds	
Engineering Design and Engineering Consulting Services	$220	2.1	2.0	1.0	8.0	5.0	0.5	-	-	Water Use				^
Fossil Fuel Electricity Generation	$67	6.5	10.0	10.0	3.0	3.0	10.0	6.0	-	Fossil Fuel Use	Arsenic compounds	Arsenic compounds	Benzene	^^^
Gas Supply	$208	1.8	2.0	-	-	-	6.5	-	-	Air Pollution and GHG Emissions	Arsenic compounds	Arsenic compounds		^^^

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

The environmental impact of iron ore per dollar of GVA is moderate at 4.0 in our index. But its size still contributes the greatest impact on the environment. Oil and Gas Extraction has a much higher impact on the environment for its value scoring 8.2 in our index due to water pollution and its use of electricity.

Arsenic and Antimony compounds are the main chemical pollutants in these 10 industries.

The last column describes the industries with greatest potential for improvement based on achievable targets for reducing their environmental impact. For the Pilbara, this is strongest in Gas Supply, Fossil Fuel Electricity Generation and Iron Ore Mining.

Local environmental challenges
Industries in the Pilbara are high emitters of greenhouse gases and other air pollution. While iron ore mining has a relatively low impact per dollar of GVA, its large size implies that it has the most significant impact in the Pilbara. Specifically, Iron Ore mining is a moderately high user of fossil fuels. Other industries in the Pilbara are also energy intensive. Reducing the carbon intensity of both transport and electricity for these industries would significantly improve the environmental impact of industries in the Pilbara.

In addition to the environmental dimensions considered by the index, iron ore mining generates further greenhouse gas emissions in its downstream processing into steel, but those emissions occur in our overseas export markets. Similarly, oil and gas extraction generates greenhouse gas emissions in its final use.

A focus on greenhouse gas emissions and air pollution of local industries is the main environmental challenge for the Pilbara.

Opportunities for green shoots – new industries
Figure 81 describes the feasibility of diversifying into particular industries in the Pilbara based on existing industries, and the environmental impact of those industries according to the index.

There are a few opportunities that are highly related to existing strengths in the Pilbara. However, some of the more feasible opportunities have significant environmental impacts such as coal mining.

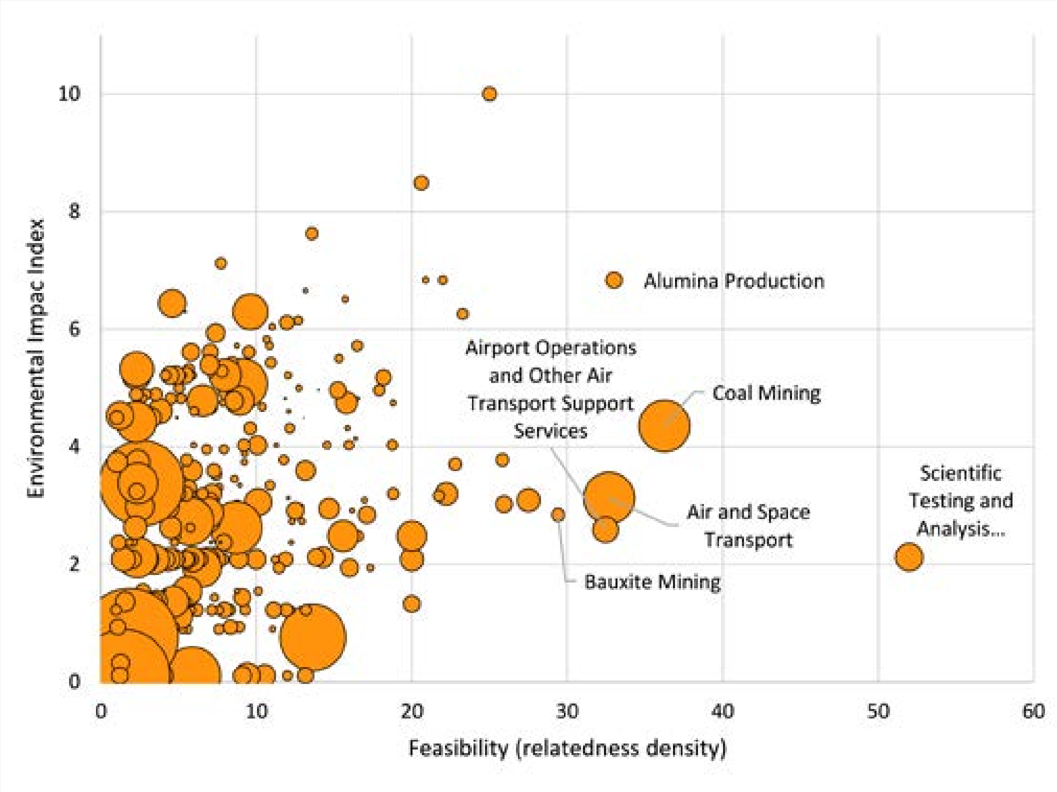
We evaluate the opportunities based on the environmental impact index and a number of other criteria discussed in our report "Future-Proofing the WA Economy". Table 14 shows key criteria in this evaluation as well as the potential for job growth and additional GVA by 2025. In this table, the environmental impact index is translated to a score between zero and four, with four representing low impact industries.

Air and space transport and its support services, are already a strong capability in the Pilbara due to the FIFO workforce. These have an opportunity to provide growth in jobs and GVA with moderately low environmental impacts.

Adding the environmental perspective to determining regional priority industries has promoted many service based industries with higher value that have lower environmental impacts than traditional industries. While these industries will need additional support to get established because they are less feasible, the additional benefits in terms of growth, jobs and the environment could justify this additional investment.

FIGURE 81

ANZSIC industry classes by feasibility in the Pilbara (Regional Relatedness Density) vs Environmental Impact Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

TABLE 14

Environmental diversification opportunities in the Pilbara

Industries	Feasibility	Environmental Impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Air and Space Transport	3	3	4	1468	$ 315,284
Scientific Testing and Analysis Services	4	3	1	27	$ 2,959
Airport Operations and Other Air Transport Support Services	3	3	4	328	$ 59,582
Non Depository Financing	1	4	2	75	$ 45,893
Corporate Head Office Management Services	1	3	3	102	$ 11,238
Financial Asset Investing	1	4	3	97	$ 59,697
Freight Forwarding Services	1	3	4	297	$ 53,914
Other Transport Support Services nec	1	3	3	160	$ 28,993
On Selling Electricity and Electricity Market Operation	1	4	3	145	$ 92,506

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Peel

Environmental footprint

The Peel region is a strategically important area to the south of metropolitan Perth, with a growing population currently numbering around 140,000. A number of commercial, administrative, professional and scientific support services are located in and around the regional centre of Mandurah, with mining, agriculture, forestry, transport and construction businesses located inland in the shires of Serpentine-Jarrahdale and Boddington. The region's coastline offers opportunities for fishing and aquaculture, recreational and residential services.

The size of the Peel economy has grown by an average of 3.1% annually over the last five years, with Gross Regional Product reaching $9.2 billion in 2019.

By value, the largest contributors to the Peel economy are in mining, particularly alumina refining and gold and bauxite mining. The mining sector overall contributes an estimated 47% to total industry GVA within the region, with manufacturing and construction also adding significantly to economic activity. Retail, health care and education and training services are among the top industries for employment.

Figure 82 presents a snapshot of the environmental footprint in the Peel region, based on the region's portfolio of industrial activities and strengths.

FIGURE 82

The environmental footprint of the Peel

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 15

Ten highest environmental impact industries in the Peel

Industry	GVA ($m)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical in Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Gold Ore Mining	$1,185	5.5	5.0	5.0	-	-	6.5	6.0	5.0	Land Pollution				
Alumina Production	$412	6.8	9.0	10.0	3.0	2.0	10.0	10.0	-	Air Pollution and GHG Emissions	Polycyclic aromatic hydro	Polycyclic aromatic hydro		^
Bauxite Mining	$983	2.8	5.0	5.0	-	-	6.5	-	-	Air Pollution and GHG Emissions				
Iron Ore Mining	$139	3.8	6.0	4.0	-	-	6.5	6.0	-	Air Pollution and GHG Emissions				^^
Real Estate Services	$98	2.1	-	5.0	9.0	5.0	0.5	-	-	Water Use				^
Other Metal Ore Mining	$34	6.1	5.0	5.0	-	-	7.0	7.0	6.0	Land Pollution	Antimony compounds			
House Construction	$44	3.8	6.0	-	10.0	7.0	2.5	-	-	Water Use				
Site Preparation Services	$41	3.6	7.0	-	6.0	8.0	3.0	-	-	Fossil Fuel Use				^
Mineral Sand Mining	$41	3.2	5.0	5.0	-	-	6.0	3.0	-	Air Pollution and GHG Emissions				
Road Freight Transport	$28	3.4	10.0	-	1.0	3.0	4.0	-	-	Fossil Fuel Use				

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

The overall environmental footprint for Peel pretty much matches the average for WA overall, with a weighted environmental index of 3.5. While the intensity of fossil fuel use also matches the state's overall score (relative to GVA), the electricity use index for the region, at 4.1, is some 0.5 points higher than the state average. Most of this high electricity utilisation by industry comes from the large scale alumina production capacity for the region, alongside other heavy industry activities in mining and construction.

Air pollution and greenhouse gas emissions represent the main adverse environmental behaviour for Peel. The intensity index for air pollution and GHG emissions for the region, at 4.8, is 0.7 points higher than the state average, with alumina refineries and mining activities among the main contributors. Water and land pollution scores for Peel come in a little lower than the state average, as do water use and waste generation.

Table 15 shows the potential environmental impacts of the top industry classes in the Peel region by gross value added. These include industry classes within the mining sector, especially alumina production, gold, bauxite and other metal ore mining, as well as construction.

Local environmental challenges
As Table 15 shows, the main environmental challenges in the Peel region relate to air pollution and GHG emissions from alumina production and bauxite mining. Along with greenhouse gases, the national environmental profile for these industry classes include air and water pollutants from antimony and ammonia compounds as well as hydrochloric acid and ethylbenzene. There are also risks of pollution from the release of arsenic and selenium compounds into the land.

The burning of fossil fuels by the heavier industries in Peel also leads to the release of polycyclic aromatic hydrocarbons (PAHs) into the air, which can cause health issues in high concentrations. This emphasises the environmental imperative to seek cleaner energy options to power industries in the resources sector, as well as the opportunities afforded by the development of renewable electricity generation at industrial scale.

House construction and site preparation services show as industry classes in Peel with relatively high levels of fossil fuels use, water use and waste generation, principally construction and demolition waste (C&D).

Opportunities for green shoots – new industries
Peel has a number of opportunities for sustainable growth and diversification, which take advantage of some of the region's unique endowments and well as related industry strengths. These options are shown graphically in Figure 83.

Adding an environmental lens to identify diversification opportunities in the Peel region provides increased support for the expansion of scientific testing and analytical services, reflecting the importance of product and process innovation and environmental testing to sustainable regional diversification. The geographical proximity of Peel to industries and networks in metropolitan Perth, along with the relative ease of access to a skilled scientific workforce, lend added weight to the development of a scientific knowledge base in Peel.

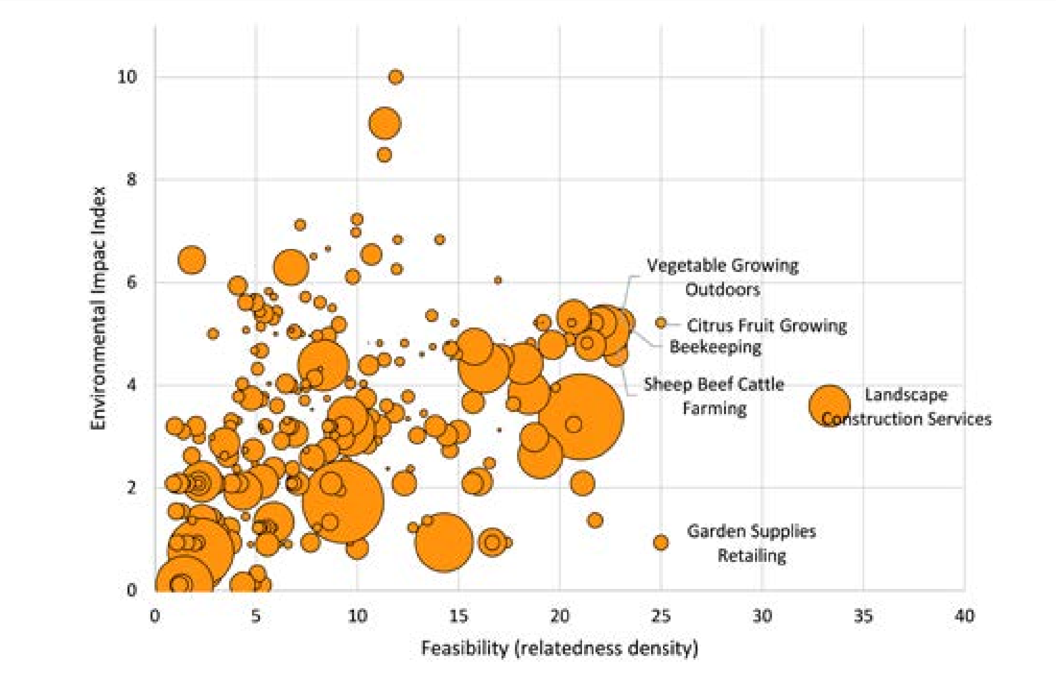
Vegetable and fruit production, landscaping and gardening services and other horticulture opportunities are shown as sustainable options for growth and diversification in the region.

The local natural forests provide strong opportunities for log sawmilling, high value hardwood timber preparation as well as complementary downstream timber processing and the manufacture of high quality wood products.

Sheep and beef cattle farming and meat processing services could also be further developed to capitalise on international demand for quality meat products.

FIGURE 83

ANZSIC industry classes by feasibility in the Peel (Regional Relatedness Density) vs Environmental Impact Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

TABLE 16

Environmental diversification opportunities in the Peel

Industries	Feasibility	Environmental Impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Scientific Testing and Analysis Services	2	3	3	127	$ 14,019
Cheese and Other Dairy Product Manufacturing	2	3	4	418	$ 39,464
Garden Supplies Retailing	3	4	1	22	$ 1,232
Rail Freight Transport	2	3	4	215	$ 43,397
Log Sawmilling	3	3	4	215	$ 23,516
Vegetable Growing Outdoors	3	2	4	385	$ 24,475
Meat Processing	2	2	4	1047	$ 98,916
Other Agricultural Product Wholesaling	3	3	2	61	$ 8,588
Beef Cattle Farming Specialised	3	2	4	1145	$ 72,752
Sheep Farming Specialised	3	2	4	1105	$ 70,248
Citrus Fruit Growing	3	2	4	251	$ 15,928
Floor Coverings Retailing	2	4	1	20	$ 1,135
Dairy Cattle Farming	3	2	4	1064	$ 67,644
Sheep Beef Cattle Farming	3	2	4	383	$ 24,327
Other Mining Support Services	2	3	4	174	$ 13,847
Prepared Animal and Bird Feed Manufacturing	2	3	3	127	$ 11,992
Other Agriculture and Fishing Support Services	3	2	3	151	$ 9,088
Boatbuilding and Repair Services	2	3	2	47	$ 5,559
Port and Water Transport Terminal Operations	1	2	4	213	$ 38,618

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

South West

Environmental footprint

The South West is endowed with an exceptional climate, beautiful coastline and natural landscape, and is one of Western Australia's most popular destinations for tourists - both for the state's own population as well as interstate and international visitors. These natural resources support a thriving horticulture industry, grape production and a number of Australia's most reputable wineries. The towns of Bunbury, Busselton and Margaret River attract an estimated 2.5 million visitors annually.

Overall, the South West's industry sectors contribute around $14.2 billion in Gross Regional Product to the region's economy, with solid annual growth of around 0.5% over the last five years. Mining, manufacturing and construction account for the largest shares of industry gross value added, with mining contributing around 24% to the local economy.

FIGURE 84

The environmental footprint of the South West

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 17

Eleven highest environmental impact industries in the South West

Industry	GVA ($m)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Coal Mining	$733	4.4	10.0	-	-	-	7.5	4.0	-	Fossil Fuel Use				
Fossil Fuel Electricity Generation	$285	6.5	10.0	10.0	3.0	3.0	10.0	6.0	-	Fossil Fuel Use	Arsenic compounds	Arsenic compounds	Benzene	^^^
Alumina Production	$199	6.8	9.0	10.0	3.0	2.0	10.0	10.0	-	Air Pollution and GHG Emissions	Polycyclic aromatic hydro	Polycyclic aromatic hydro		^
Bauxite Mining	$459	2.8	5.0	5.0	-	-	6.5	-	-	Air Pollution and GHG Emissions				
Mineral Sand Mining	$341	3.2	5.0	5.0	-	-	6.0	3.0	-	Air Pollution and GHG Emissions				
Water Supply	$134	4.7	3.0	6.0	10.0	-	5.0	8.0	-	Water Use				^^
Wine and Other Alcoholic Beverage Manufacturing	$152	3.0	4.0	5.0	5.0	4.0	3.5	-	-	Fossil Fuel Use				
Basic Inorganic Chemical Manufacturing	$62	7.0	9.0	9.0	9.0	2.0	9.0	7.0	-	Fossil Fuel Use		Chromium III compounds		
House Construction	$111	3.8	6.0	-	10.0	7.0	2.5	-	-	Water Use				
Meat Processing	$91	4.4	4.0	6.0	6.0	4.0	6.5	4.0	-	Air Pollution and GHG Emissions				^
Iron Ore Mining	$90	3.8	6.0	4.0	-	-	6.5	6.0	-	Air Pollution and GHG Emissions				^^

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

The region supports a number of large mining operations, particularly in alumina production, bauxite and mineral sand mining. The coal-fired Muja power stations in Collie were established in 1999, and supply much of the base load electricity to the South West Interconnected System (SWIS) using locally mined coal. A number of the Muja units are slated to be decommissioned from 2022.

Overall the South West has a relatively low score in our environmental impact index at 3.0, which is 0.4 points better than the average for Western Australia. The better environmental profile for the South West compared to the rest of WA is largely due to lower impacts in terms of water and land pollution, as well as a lower use of electricity by the region's industries relative to the GVA output.

Table 17 describes the detailed environmental impact of those industries in the South West based on their national profiles and the local size of the industry.

While electricity generation from fossil fuels is the fourth largest in terms of GVA, it has the second highest overall environmental impact due to greenhouse gas emissions. This implies that the planned downscaling of the Collie power plant from 2022 can be expected to substantially improve the environmental footprint of the South West region. The main chemical pollutants in the South West are compounds of arsenic, also as a result of fossil fuel electricity generation.

Local environmental challenges
Air pollution and greenhouse gas emissions are the main environmental challenge for most of the top industries in the South West. Fossil fuel electricity generation releases a number of toxins and pollutants to the air, including compounds of arsenic and beryllium, as well as oxides of nitrogen, dichloroethane and polycyclic aromatic hydrocarbons (PAHs).

The concern of greenhouse gas emissions is compounded by a few key industries that are energy intensive in terms of their use of electricity and fossil fuels.

Water use and waste services are both relatively high in the South West. The former is attributable to the high demand for water by agriculture and horticulture, while the latter derives from construction and demolition waste from the housing construction and site preparation sectors.

Opportunities for green shoots – new industries
While the South West's large coal mining and related fossil fuel electricity generation industries in Collie are being wound down, there are many new opportunities with lower environmental impacts.

Figure 85 describes the potential for sustainable diversification into particular industries in the South West, based on the conditions afforded by existing industry strengths and the environmental impact of those industries according to the index.

The environmental profile of the South West is relatively good in comparison to the rest of the state, apart from the impact of fossil fuel electricity generation. The region is also relatively diverse in its breadth of strengths across a variety of industry classes.

There are nevertheless a number of sustainable diversification opportunities that emerge from our ground-up analysis, many of which either build on or add to existing strengths in agriculture, aquaculture and horticulture.

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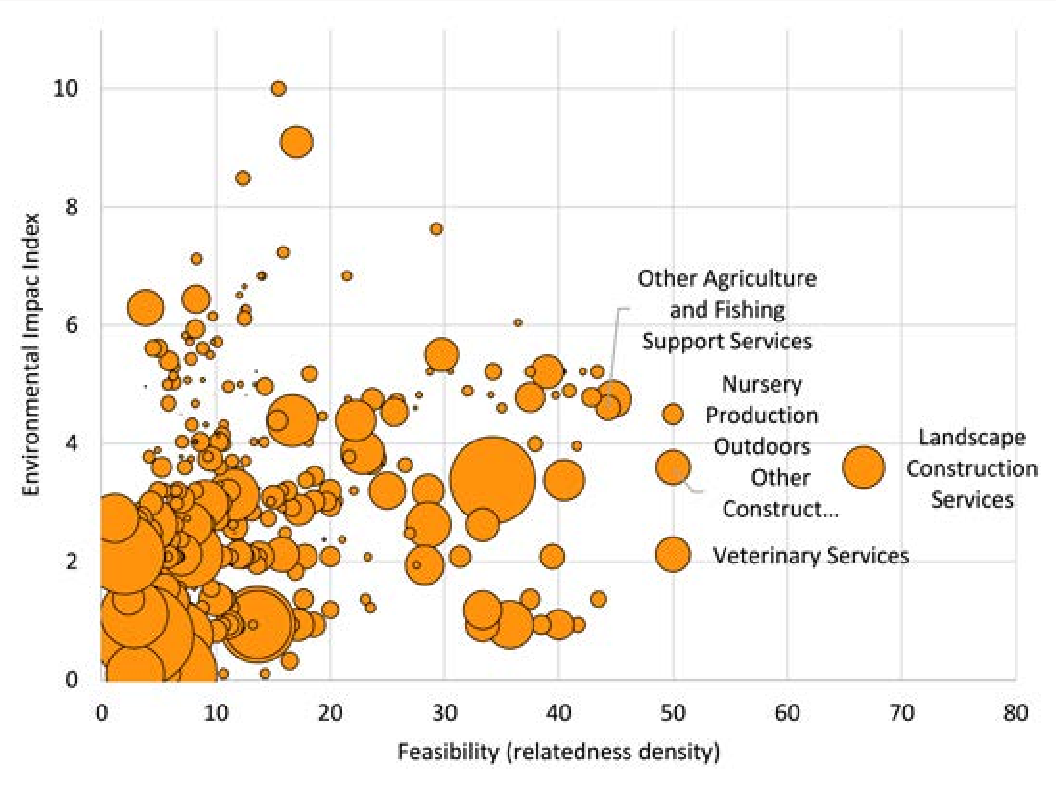
FIGURE 85

ANZSIC industry classes by feasibility in the South West (Regional Relatedness Density) vs Environmental Impact Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

Table 18 lists a series of potential sustainable growth and diversification opportunities in the South West. Many of these build on current industry strengths, rather than venturing into new activities. Nevertheless, a number of strong diversification options present themselves.

Hydroelectric power generation rates very highly in terms of environmental benefit as well as economic feasibility. This offers great potential to the South West to further expand renewable power generation through pumped hydro, building on the region's Wellington Dam Hydro power station. The potential is certainly there for the South West to lead the way in lifting the share of renewable energy generation across the South West.

With the scaling down of Collie, a strategy for expanded renewable electricity generation added to the already strong environmental profile enjoyed by the region offers an enticing prospect to position the South West as one of the cleanest regions of the country. Lithium mining at Greenbushes can also very clearly tap into the global demand for environmental solutions to renewable power storage, electric vehicles, communications devices and medical instruments.

Horticulture is already an industry strength in the South West, but there are opportunities for the sector to further development into berry and fruit growing, and nursery services. Aquaculture also features very strongly among the sustainable diversification options, especially in longline, rack and caged aquaculture. Leisure and lifestyle tourism also features among the diversification options for the South West.

TABLE 18

Environmental diversification opportunities in the South West

Industries	Feasibility	Environmental Impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Landscape Construction Services	4	3	3	99	$ 9,352
Sport and Camping Equipment Retailing	2	4	1	34	$ 1,915
Fruit and Vegetable Wholesaling	2	3	4	226	$ 25,119
Flower Retailing	2	4	2	38	$ 2,124
Hydro Electricity Generation	2	4	4	318	$ 203,408
Garden Supplies Retailing	3	4	2	48	$ 2,690
Nursery Production Outdoors	3	2	3	147	$ 9,365
Other Agricultural Product Wholesaling	2	3	3	130	$ 18,263
Offshore Longline and Rack Aquaculture	2	2	4	323	$ 27,697
Berry Fruit Growing	3	2	4	274	$ 17,399
Offshore Caged Aquaculture	2	2	4	645	$ 55,288

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Gascoyne

Environmental footprint

Figure 86 describes the industrial profile of the Gascoyne and its environmental footprint. The Gascoyne's overall score in our index is 3.5 which is comparable to WA overall at 3.4. However, this comes with relatively low gross regional product at $1.5 billion, so its overall impact on the environment may be lower than other regions simply due to less economic activity. Mining comprises nearly half of Gascoyne's GVA. Yet accommodation and food services is the industry that employs the highest share of the Gascoyne's population at 12%. Relative to WA and Australia, Gascoyne's fossil fuel and electricity use is particularly high. Gascoyne also has higher levels of air pollution and greenhouse gas emissions and water pollution relative to WA and Australia. However its level of land pollution is much lower relative to WA and Australia overall.

Table 19 describes the detailed environmental impact of 10 industries in the Gascoyne likely to have the greatest environmental impact based on their national profiles and the local size of the industry.

FIGURE 86

The environmental footprint of the Gascoyne

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 19

Ten highest environmental impact industries in the Gascoyne

Industry	GVA ($m)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Iron Ore Mining	$189	3.8	6.0	4.0	-	-	6.5	6.0	-	Air Pollution and GHG Emissions				^^
Other Non Metallic Mineral Mining and Quarrying	$62	5.4	8.0	8.0	1.0	-	7.5	9.0	-	Fossil Fuel Use	Antimony compounds		Antimony compounds	
Oil and Gas Extraction	$22	9.1	10.0	9.0	-	-	7.5	10.0	9.0	Land Pollution				^
Fossil Fuel Electricity Generation	$12	6.5	10.0	10.0	3.0	3.0	10.0	6.0	-	Fossil Fuel Use	Arsenic compounds	Arsenic compounds	Benzene	^^^
Scenic and Sightseeing Transport	$16	2.9	10.0	-	-	-	3.5	-	-	Fossil Fuel Use				
Accommodation	$23	1.7	2.0	7.0	4.0	-	1.0	-	-	Water Use				^^
Vegetable Growing Outdoors	$7	5.2	8.0	7.0	10.0	8.0	4.5	-	-	Fossil Fuel Use				^^
Water Supply	$6	4.7	3.0	6.0	10.0	-	5.0	8.0	-	Water Use				^^
Air and Space Transport	$8	3.1	10.0	-	-	-	4.5	-	-	Fossil Fuel Use				
Beef Cattle Farming Specialised	$5	5.1	8.0	7.0	9.0	8.0	4.5	-	-	Fossil Fuel Use				^^^
Engineering Design and Engineering Consulting Services	$10	2.1	2.0	1.0	8.0	5.0	0.5	-	-	Water Use				^

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

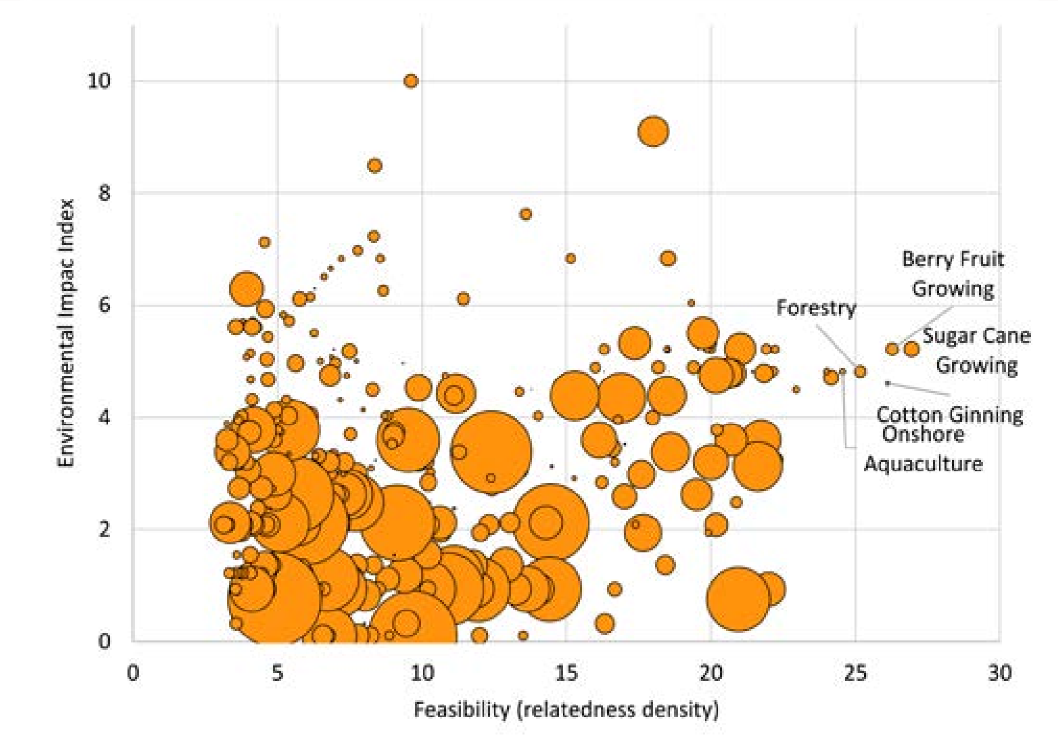
The environmental impact of iron ore per dollar of GVA is 3.8 in our index. Yet, due to its size, it has the greatest impact on the environment in the Gascoyne. The environmental impact per dollar of GVA from oil and gas extraction is much higher, at 9.1, but given its size, its environmental impact is lower.

Local environmental challenges
Fossil Fuel Use is the main environmental challenge of many industries in the Gascoyne. Many of its industries, specifically, Fossil Fuel Electricity Generation, Scenic and Sightseeing Transport and Air and Space Transport are high users of fossil fuels. Fossil Fuel Electricity Generation also contributes significantly to the greenhouse gas emission and other air pollution in Gascoyne.

Water use is another key environmental challenge in Gascogne largely driven by its engineering design and accommodation industries.

Opportunities for green shoots – new industries
Figure 87 describes the feasibility of diversifying into particular industries in the Gascoyne based on existing industries, and the environmental impact of those industries according to the index.

FIGURE 87
ANZSIC industry classes by feasibility in the Gascoyne (Regional Relatedness Density) vs Environmental Impact Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

We evaluate the opportunities based on the environmental impact index and other key criteria presented in Table 20. In this table, the environmental impact index is translated to a score between zero and four.

Defence is a promising opportunity for Gascoyne as the environmental impact is low and the job growth is high. The sector could bring 302 jobs to the region by 2025. Air and space transport promises to bring additional 104 jobs at relatively low environmental impact relative to value. This also highlights the potential for a number of services that serve tourism and FIFO workers making use of Air transport services.

TABLE 20

Environmental diversification opportunities in the Gascoyne

Industries	Feasibility	Environmental Impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Defence	3	4	4	302	$ -
Real Estate Services	2	3	4	61	$ 12,394
Air and Space Transport	3	3	4	104	$ 22,383
Fresh Meat Fish and Poultry Retailing	4	4	3	9	$ 537
Pharmaceutical Cosmetic and Toiletry Goods Retailing	2	4	4	33	$ 1,849
Other Store Based Retailing nec	2	4	4	24	$ 1,309
Hydro Electricity Generation	3	4	4	21	$ 13,219
Airport Operations and Other Air Transport Support Services	3	3	4	34	$ 6,211

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Mid West

Environmental footprint

The Mid West is a resource rich region with significant diversity within both Mining and Agriculture. Because of the value added in mining, it contributes 59% of the region's GVA even though it accounts for only 14% of employment. The environmental impact index in the Mid West slightly higher than for WA (3.7 vs. 3.4) but 1.6 times the index value for Australia.

The main environmental issue for the Mid West region is air pollution and GHG emissions. As we observe in Figure 88, Fossil Fuel Use and Electricity are also significant factors, which will exacerbate greenhouse gas emissions.

Water pollution and land pollution are also significantly higher in the Mid West than in the rest of WA and Australia. This is predominantly due to Oil and Gas Extraction and the significant size of its Gold Ore Mining and Iron Ore Mining industries. In Table 21 we observe in detail the 10 most pollutant industries of the Mid West.

FIGURE 88

The environmental footprint of the Mid West

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 21

Ten highest environmental impact industries in the Mid West

Industry	GVA ($m)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Gold Ore Mining	$1,046	5.5	5.0	5.0	-	-	6.5	6.0	5.0	Land Pollution				
Iron Ore Mining	$600	3.8	6.0	4.0	-	-	6.5	6.0	-	Air Pollution and GHG Emissions				^^
Copper Ore Mining	$233	3.5	5.0	5.0	-	-	6.0	5.0	-	Air Pollution and GHG Emissions				
Nickel Ore Mining	$124	4.5	5.0	5.0	-	-	8.0	4.0	2.0	Air Pollution and GHG Emissions			Chloroform trichloro-methane	
Oil and Gas Extraction	$48	9.1	10.0	9.0	-	-	7.5	10.0	9.0	Land Pollution				^
Mineral Sand Mining	$128	3.2	5.0	5.0	-	-	6.0	3.0	-	Air Pollution and GHG Emissions				
Silver Lead Zinc Ore Mining	$105	3.8	5.0	5.0	-	-	7.5	5.0	-	Air Pollution and GHG Emissions				
Other Basic Non Ferrous Metal Manufacturing	$43	6.8	9.0	10.0	3.0	2.0	10.0	10.0	-	Air Pollution and GHG Emissions	Chromium VI compounds	Chromium VI compounds	Chloroform trichloro-methane	^
Other Grain Growing	$41	5.2	8.0	7.0	10.0	8.0	4.5	-	-	Fossil Fuel Use				^^
Road Freight Transport	$47	3.4	10.0	-	1.0	3.0	4.0	-	-	Fossil Fuel Use				
Other Metal Ore Mining	$26	6.1	5.0	5.0	-	-	7.0	7.0	6.0	Land Pollution	Antimony compounds			

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Oil and gas extraction have the highest environmental impact in the region due to fossil fuel and electricity use as well as pollution to air, land and water. Other basic non-ferrous metal, other metal ore mining and gold ore mining are the second, third and fourth most environmentally detrimental industries by dollar of GVA in the Mid West. Pollution to air, water and land are the most concerning features of these industries.

Local environmental challenges
Air pollution and greenhouse gas emissions are the main environmental challenge in the Mid West. However, given the potential for renewable energy in the region, this is a relatively easy challenge to overcome. The decoupling of industry processes from fossil fuels by increasing electricity generation from renewables could help overcome this issue and improve the environmental impact of several industries. Mining industries could also reduce their use of fossil fuels if they can switch to electric powered vehicles and the electricity is generated from renewable sources.

Other grain growing and iron ore mining have high opportunities for environmental improvement through reduction in greenhouse gas emissions and use of fossil fuels.

Finally, the Mid West should strongly focus on addressing pollution in water, which is a significant issue for most of the high value industries of the region.

Opportunities for green shoots – new industries
Figure 89 describes the feasibility of diversifying into particular industries in the Mid West based on existing industries, and the environmental impact of those industries according to the index.

We evaluate the opportunities in the Mid West region based on the environmental impact index and a number of other criteria discussed in our report "Future-Proofing the WA Economy". Table 22 shows the key criteria in this evaluation, as well as the potential for job growth and additional GVA by 2025. In this table, the environmental impact index is translated to a score between zero and four.

Bringing a green lens to economic development highlights new potential opportunities. Hydroelectricity generation is related to a number of existing activities and has moved up in the list as a renewable source of energy. However, this depends on the capability of the region's rivers to provide enough flow to diversify into this activity.

Potential opportunities such as aquaculture, fossil fuel electricity generation and oil and gas extraction have completely dropped out from the list of top industries because of their environmental impacts. Furthermore, the downstream emissions of oil and gas extraction is problematic, especially the greenhouse emissions and air pollution components. Even if the pollution is at the consumer side, we should account for the long term environmental viability of this industry.

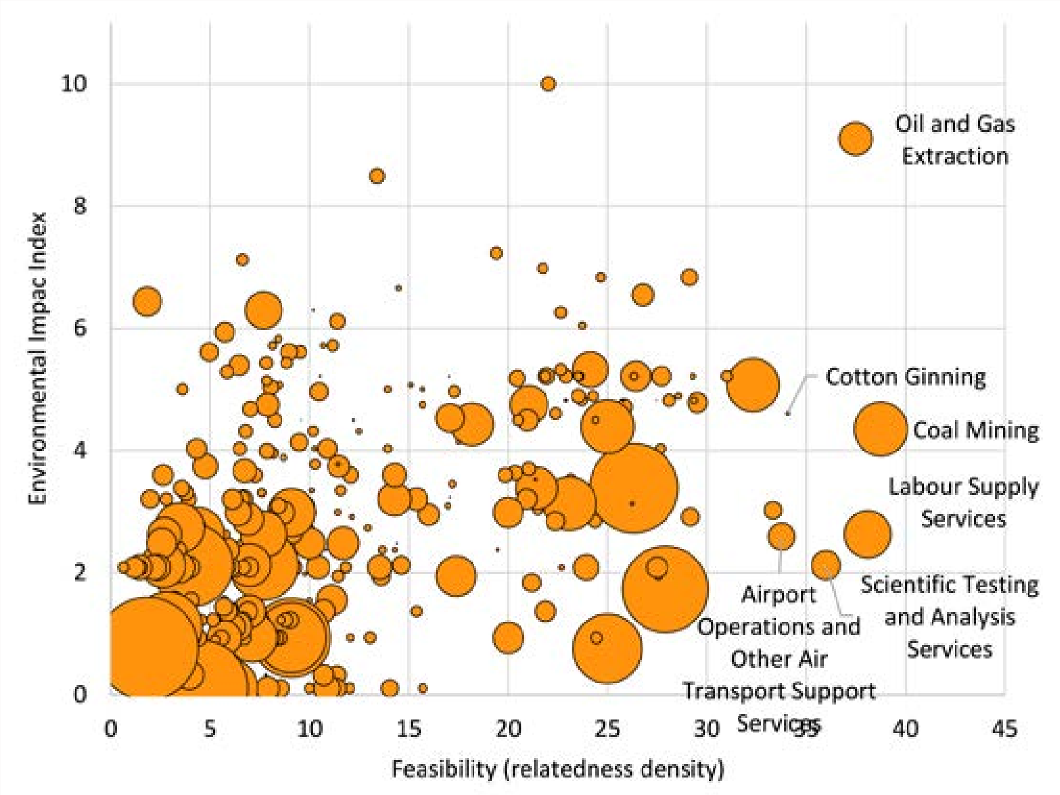
On the other hand, aquaculture could potentially become greener if the inputs are sourced from environmentally sustainable sources, the use of water properly managed and the pollution emissions going into the water are controlled.

Defence continues to be an interesting opportunity for the Mid West as the environmental impact is low and the potential job growth is high. If the Mid West can overcome some of the feasibility issues with political will, defence operations could potentially bring 1,700 jobs to the region. The Mid West Development Commission Blueprint has also highlighted defence as a potential expansion opportunity. The Mid West has the potential business and operation capacity to support an expansion of defence operations.

Finally, scientific testing and analysis remains a strong opportunity for the region. This industry builds on existing capabilities in mining and agriculture industries, which are local strengths and highly related to the scientific testing and analysis industry. Nevertheless, the potential for job growth and GVA is not particularly high in this industry.

FIGURE 89

ANZSIC industry classes by feasibility in the Mid West (Regional Relatedness Density) vs Environmental Impact Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

TABLE 22

Environmental diversification opportunities in the Mid West

Industries	Feasibility	Environmental Impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Labour Supply Services	4	3	4	103	$ 7,555
Defence	2	4	4	1749	$ -
Scientific Testing and Analysis Services	4	3	3	41	$ 4,503
Airport Operations and Other Air Transport Support Services	3	3	4	198	$ 35,975
Air and Space Transport	2	3	4	712	$ 152,974
Hydro Electricity Generation	3	4	4	105	$ 67,050
Scenic and Sightseeing Transport	3	3	3	69	$ 17,249
Water Passenger Transport	3	2	4	78	$ 11,842

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Goldfields-Esperance

Environmental footprint

Mining is the largest industry in the Goldfields-Esperance region by far in terms of industry share of regional GVA, at 81% and employment at 33% of all workers (Figure 90).

In terms of environmental impact, the Goldfields-Esperance region's environmental impact is relatively high with an index value of 4.7. This is just over twice that of Australia overall at 2.3, and almost 1.4 times WA's environmental impact index of 3.4.

Air pollution and GHG emissions are the main environmental issues in the Goldfields-Esperance region. This is exacerbated by relatively high use of fossil fuels and electricity relative to the region's GVA.

FIGURE 90

The environmental footprint of the Goldfields-Esperance

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 23

Ten highest environmental impact industries in Goldfields-Esperance

Industry	GVA ($m)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Gold Ore Mining	$5,915	5.5	5.0	5.0	-	-	6.5	6.0	5.0	Land Pollution				
Nickel Ore Mining	$925	4.5	5.0	5.0	-	-	8.0	4.0	2.0	Air Pollution and GHG Emissions			Chloroform trichloro-methane	
Iron Ore Mining	$251	3.8	6.0	4.0	-	-	6.5	6.0	-	Air Pollution and GHG Emissions				^^
Coal Mining	$121	4.4	10.0	-	-	-	7.5	4.0	-	Fossil Fuel Use				
Other Basic Non Ferrous Metal Manufacturing	$76	6.8	9.0	10.0	3.0	2.0	10.0	10.0	-	Air Pollution and GHG Emissions	Chromium VI compounds	Chromium VI compounds	Chloroform trichloro-methane	^
Oil and Gas Extraction	$40	9.1	10.0	9.0	-	-	7.5	10.0	9.0	Land Pollution				^
Mineral Exploration	$97	3.0	6.0	9.0	3.0	-	3.0	-	-	Fossil Fuel Use				^^
Other Mining Support Services	$93	3.0	6.0	9.0	3.0	-	3.0	-	-	Fossil Fuel Use				^^
Copper Ore Mining	$76	3.5	5.0	5.0	-	-	6.0	5.0	-	Air Pollution and GHG Emissions				
Fossil Fuel Electricity Generation	$36	6.5	10.0	10.0	3.0	3.0	10.0	6.0	-	Fossil Fuel Use	Arsenic compounds	Arsenic compounds	Benzene	^^^
Road Freight Transport	$63	3.4	10.0	-	1.0	3.0	4.0	-	-	Fossil Fuel Use				

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Table 23 shows the top ten industries that have the highest environmental impact in the Goldfields-Esperance region.

Due to the size of the industries and moderate environmental impacts, Gold Ore Mining, Nickel Ore Mining, and Iron Ore Mining are the main industries contributing to the Goldfields-Esperance region's overall environmental impact. These industries have moderately high levels of greenhouse gas emissions according to our index. While, Oil and Gas Extraction has the highest environmental impact per $GVA on the Goldfields-Esperance region, it is not the highest overall impact due to its size. For Oil and Gas Extraction, fossil fuel, electricity use, water pollution, land pollution and Air Pollution and greenhouse gas emissions are all substantial contributing factors to its environmental impact. The industry with the second worst environmental impact per $GVA in the region is Other Basic Non-Ferrous Metal Manufacturing. This is again due to fossil fuel and electricity use and also because of water pollution and air pollution and GHG emissions.

Local environmental challenges
Air Pollution and Greenhouse Gas Emissions is the main environmental challenge in the Goldfields-Esperance region.

Notably, Land Pollution is much higher in the Goldfields-Esperance region than elsewhere in Australia. This is largely due to the impact of Gold Ore Mining and Oil and Gas Extraction. Industries like Oil and Gas Extraction and Other Basic Non-Ferrous Metal Manufacturing also have a very high electricity use index. Thus, one way of reducing air pollution and GHG emissions in the region would be to increase the percentage of electricity generated from renewable energy.

Opportunities for green shoots – new industries
Figure 91 shows the feasibility of diversifying or expanding industries in the Goldfields-Esperance region that are not yet significant comparative advantages and their environmental impact.

As can be seen from Figure 91, there are some opportunities that are highly related to existing strengths in the Goldfields-Esperance region. For example, there are feasible opportunities in Labour Supply Services, which has a relatively low environmental impact. There are also feasible opportunities in Coal Mining, however, it has a more significant environmental impact.

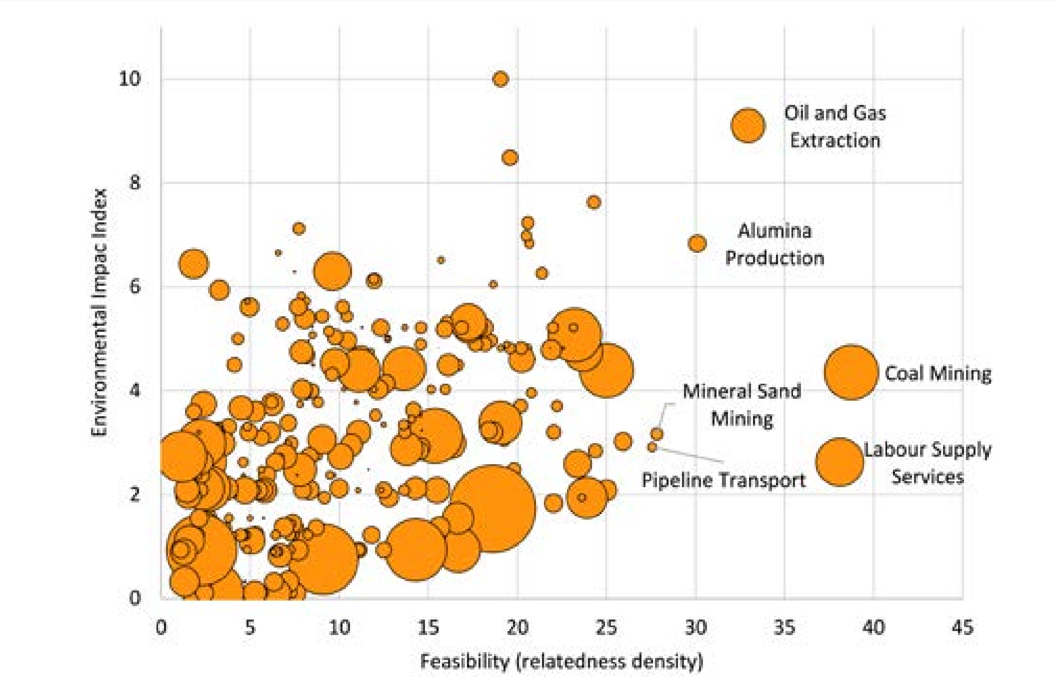
We evaluate the opportunities based on the environmental impact index and a number of other criteria discussed in our report "Future-Proofing the WA Economy". Table 24 shows key criteria in this evaluation as well as the potential for job growth and additional GVA by 2025. In this table, the environmental impact index is translated to a score between zero and four.

In terms of green economic development, environmental diversification opportunities in the Goldfields-Esperance region include Labour Supply Services, Hydro Electricity Generation, and Airport Operations and Other Air Transport Support Services. For example, Hydro Electricity Generation has the potential to create 120 new jobs and increase annual GVA by $76.5 million in the Goldfields-Esperance region by 2025. In addition, Airport Operations and Other Air Transport Support Services has the potential to create 211 new jobs and increase annual GVA by $38.3 million by 2025. Furthermore, Labour Supply Services has the potential to create 21 new jobs and increase annual GVA by $1.6 million by 2025.

Potential opportunities, such as Oil and Gas Extraction, Coal Mining, and Aluminium Production, have been excluded from the environmental diversification opportunities list for the Goldfields-Esperance region in Table 24 because of their environmental impact. In particularly, greenhouse gas emissions, air pollution, water pollution, and land pollution in industries such as Oil and Gas Extraction are problematic.

FIGURE 91

ANZSIC industry classes by feasibility in the Goldfields-Esperance (Regional Relatedness Density) vs Environmental Impact Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

TABLE 24

Environmental diversification opportunities in the Goldfields-Esperance

Industries	Feasibility	Environmental Impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Labour Supply Services	4	3	2	22	$ 1,621
Airport Operations and Other Air Transport Support Services	3	3	4	211	$ 38,316
Hydro Electricity Generation	3	4	4	120	$ 76,561
On Selling Electricity and Electricity Market Operation	1	4	3	76	$ 48,293
Air and Space Transport	1	3	4	835	$ 179,403
Bauxite Mining	3	3	4	477	$ 489,068
Rail Passenger Transport	1	3	4	117	$ 23,711

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Wheatbelt

Environmental footprint

With a population of around 75,000, the Wheatbelt is third largest of WA's regions. Agriculture has long been the region's highest employing industry sector, providing around 29% of all jobs in the region and contributing an estimated 15% to total regional industry gross value added (IGVA). The sector is the state's largest producer of broadacre cereal crops. Citrus, olive and canola products also feature strongly, along with grape growing for wine production. Gold, nickel and iron ore mining activities have also grown strongly, adding significantly to industry output by value.

The importance of tourism to the region's economy is reinforced by its proximity to Perth. More than 600,000 visitors are attracted to the area's historic Avon towns of Northam, York, Toodyay, Narrogin and Beverley, as well as the natural attractions of Wave Rock, Pinnacles and the many wildflower and conservation parks across the region.

A snapshot of the environmental footprint in the Wheatbelt is presented in Figure 92 through a series of indicators. As noted earlier, these have been constructed using an aggregate of environmental indicators across industries in the region, weighted by the importance of those industries to the region in terms of economic output.

FIGURE 92

The environmental footprint of the Wheatbelt

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 25

Ten highest environmental impact industries in the Wheatbelt

Industry	GVA ($m)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Gold Ore Mining	$396	5.5	5.0	5.0	-	-	6.5	6.0	5.0	Land Pollution				
Iron Ore Mining	$368	3.8	6.0	4.0	-	-	6.5	6.0	-	Air Pollution and GHG Emissions				^^
Grain Sheep or Grain Beef Cattle Farming	$155	4.8	8.0	7.0	7.0	8.0	4.5	-	-	Fossil Fuel Use				^^
Nickel Ore Mining	$155	4.5	5.0	5.0	-	-	8.0	4.0	2.0	Air Pollution and GHG Emissions			Chloroform trichloro-methane	
Other Grain Growing	$126	5.2	8.0	7.0	10.0	8.0	4.5	-	-	Fossil Fuel Use				^^
Water Supply	$81	4.7	3.0	6.0	10.0	-	5.0	8.0	-	Water Use				^^
Mineral Sand Mining	$90	3.2	5.0	5.0	-	-	6.0	3.0	-	Air Pollution and GHG Emissions				
Sheep Farming Specialised	$53	4.8	8.0	7.0	7.0	8.0	4.5	-	-	Fossil Fuel Use				^^
Road Freight Transport	$45	3.4	10.0	-	1.0	3.0	4.0	-	-	Fossil Fuel Use				
Site Preparation Services	$37	3.6	7.0	-	6.0	8.0	3.0	-	-	Fossil Fuel Use				^
Iron Smelting and Steel Manufacturing	$17	6.3	9.0	10.0	3.0	2.0	9.5	7.0	-	Air Pollution and GHG Emissions	Arsenic compounds	Arsenic compounds	Methanol	

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

The Wheatbelt performs well in comparison to the average for Western Australia in terms of its overall environmental footprint, with a weighted environmental index score of 3.1, around 0.3 points lower than the state's average. The intensity of fossil fuel use relative to economic value (IGVA) for the Wheatbelt is slightly lower than the state average.

The main environmental challenges for the Wheatbelt relate to water use and waste generation, with index values of 2.7 in both cases being some 0.7 points higher than the state average.

Water use in the Wheatbelt is necessarily high, given the concentration of businesses in the agriculture sector and the essential need for water in irrigation and propagation. And importantly, water security presents as one of the most serious issues facing the region's agriculture businesses.

These challenges are reinforced by progressively more severe climate change pressures. This *BCEC Focus on Industry* report has already noted that the region is among the top 10% of places worldwide facing the most serious decline in rainfall.

The construction and resource industry sectors both operate with a higher waste generation intensity, which goes a long way to explaining the higher value for the waste index component. This result signals a clear priority to mitigate the environmental impact of industrial waste generation by targeting effective waste management strategies.

Table 25 looks in more detail at the potential environmental impacts of the top industry classes in the Wheatbelt region by gross value added. These include a number of industry classes within the mining sector, including gold, iron ore, nickel and mineral sand mining. A number of agriculture industries also feature, especially sheep farming and combined grain and livestock industries.

Local environmental challenges

The analysis in Table 25 presents indicators of intensity across different domains of environmental impact for each industry class, based on those industries' environmental profiles at a national level.

The livestock, and combined grain and livestock industries within the Wheatbelt region are relatively intense users of water, with fossil fuel use also featuring as a key challenge.

The main environmental challenges that stem from iron ore and nickel mining include air pollution and GHG emissions, including antimony, chlorine compounds and particulate matter. Iron smelting and steel manufacturing processes also generate GHG emissions and air and water pollutants, including arsenic and methanol compounds.

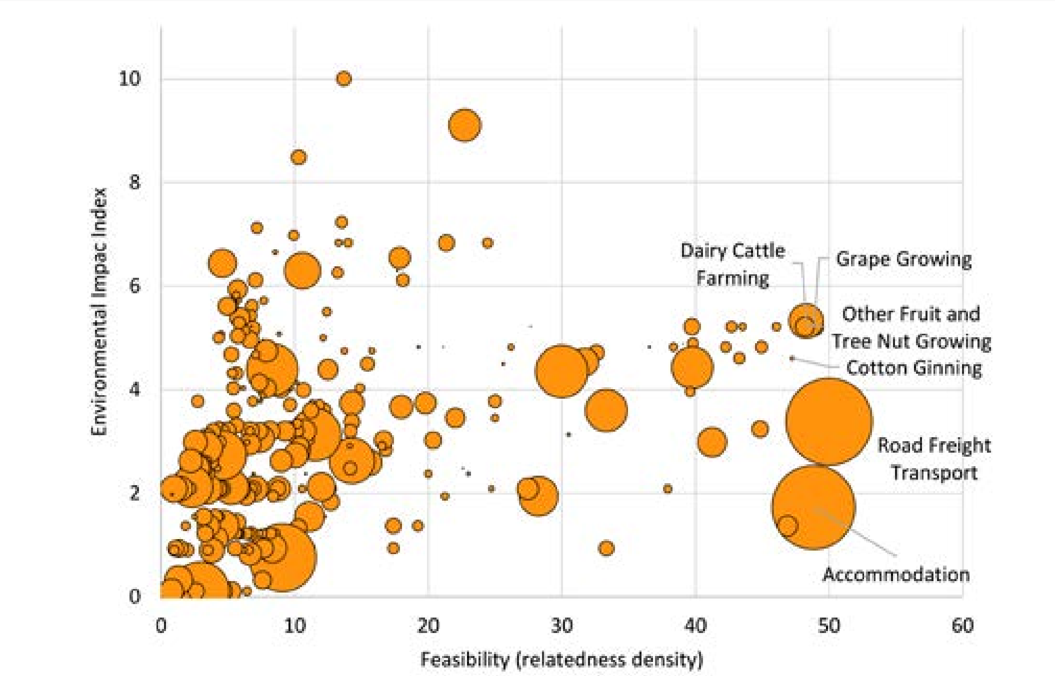
Land pollution presents as a potentially important issue in gold ore mining, both from the disturbance of land as part of the mining process itself, as well as the release into the soil of traces of toxic waste including antimony, cobalt, cyanide, mercury and selenium compounds.

Opportunities for green shoots – new industries

Figure 93 combines environmental impact considerations with a measure of the feasibility and economic benefit from diversifying into particular industries, to identify options for sustainable growth and diversification in the Wheatbelt. Those industry classes that appear in the bottom right quadrant of the chart represent opportunities that combine feasibility with low environmental impact, and the size of each bubble is a representation of the potential employment gain.

FIGURE 93

Wheatbelt: ANZSIC industry classes by feasibility and environmental impact



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

In Table 26, we evaluate the opportunities based on the environmental impact index alongside a number of economic feasibility criteria discussed in our 'Future-Proofing the WA' Economy report. More specifically, industry opportunities are assessed in terms of their feasibility to either develop or grow within the Wheatbelt region, their environmental rating as well as the potential for jobs growth and added economic value. As with other regional profiles in this section, the environmental impact index converted to a score between zero (denoting the most adverse impact) and four (corresponding to the least environmental impact).

TABLE 26

Environmental diversification opportunities in the Wheatbelt

Industries	Feasibility	Environmental Impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Accommodation	3	4	4	442	$ 31,144
Road Freight Transport	3	3	4	160	$ 14,365
Wine and Other Alcoholic Beverage Manufacturing	2	3	4	323	$ 59,485
Poultry Processing	2	2	4	233	$ 22,044
Log Sawmilling	3	3	4	115	$ 12,540
Meat Processing	2	2	4	387	$ 36,554
Dairy Cattle Farming	3	2	4	551	$ 35,046
Sugar Manufacturing	2	2	4	392	$ 37,032
Sugar Cane Growing	2	2	4	315	$ 20,038
Grape Growing	3	2	4	153	$ 9,740
Other Fruit and Tree Nut Growing	3	2	4	191	$ 12,144

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

A number of the most feasible options for sustainable growth in the Wheatbelt are related to the agriculture sector, given the existing strengths that exist in the regions.

Expansion of meat processing could add both value and jobs to the Wheatbelt, given the relatedness to existing strengths in grain sheep or grain beef cattle farming, and specialised beef cattle feedlots as well as the geographical proximity to the large population conurbations in and around Perth.

Metal mining other than iron ore, gold and nickel were presented as diversification opportunities for the Wheatbelt in the Centre's *Future-Proofing the WA Economy* report. However, the addition of an environmental lens to the assessment served to relegate these opportunities to a degree. This does not preclude other metal mining industries being supported as potential options for diversification, but does suggest that improvements in their environmental profiles would provide the region with greater environmental protections if those options were to be explored.

Fruit and tree nut growing feature among the sustainable diversification opportunities for the Wheatbelt, with important potential for jobs growth as well as increases in economic value.

Wine and beer manufacturing also displays strong potential for sustainable growth, given the specialisations already present in the region as well as the local availability of cereals required for beer manufacture. With accommodation also ranking highly as a development option, and given the proximity to Perth, these developments would provide a complementary opportunity to further develop the tourism prospectus offered to visitors to the Wheatbelt region, especially agri-tourism and cultural tourism opportunities.

Water supply remains a critical imperative in seeking to capture new opportunities for sustainable growth across the agriculture sector, as does the need to improve soil health, the development of new technologies to counter the adverse consequences of climate change, and the importance of new initiatives to improve the digital infrastructure of the region, as recommended in the Wheatbelt digital plan.

Great Southern

Environmental footprint

The infographic in Figure 94 describes the industrial profile of the Great Southern and its environmental footprint. As can be seen from the infographic, Agriculture, Forestry, and Fishing is the main industry in the Great Southern region in terms of both its share of regional GVA (12%) and share of employment (16%). In respect to environmental impact, the Great Southern region has a lower environmental impact relative to Gross Value Added compared to Western Australia and Australia overall. The environmental impact index for the Great Southern region is 2.2, which is significantly less than the Western Australian index value of 3.4, and just below the Australian index value of 2.3. Specifically, the indexes for air pollution and greenhouse gas emissions, water pollution, and land pollution are all lower for the Great Southern region compared to Australia and Western Australia. Notably, the land pollution index for the Great Southern region is zero compared to an average of 0.4 for Australia and 1.4 for Western Australia.

FIGURE 94

The environmental footprint of the Great Southern

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 27

Ten highest environmental impact industries in the Great Southern

Industry	GVA ($m)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Grain Sheep or Grain Beef Cattle Farming	$51	4.8	8.0	7.0	7.0	8.0	4.5	-	-	Fossil Fuel Use				^^
Water Supply	$45	4.7	3.0	6.0	10.0	-	5.0	8.0	-	Water Use				^^
Sheep Farming Specialised	$37	4.8	8.0	7.0	7.0	8.0	4.5	-	-	Fossil Fuel Use				^^
Meat Processing	$40	4.4	4.0	6.0	6.0	4.0	6.5	4.0	-	Air Pollution and GHG Emissions				^
Other Grain Growing	$30	5.2	8.0	7.0	10.0	8.0	4.5	-	-	Fossil Fuel Use				^^
Beef Cattle Farming Specialised	$29	5.1	8.0	7.0	9.0	8.0	4.5	-	-	Fossil Fuel Use				^^^
House Construction	$30	3.8	6.0	-	10.0	7.0	2.5	-	-	Water Use				
Road Freight Transport	$29	3.4	10.0	-	1.0	3.0	4.0	-	-	Fossil Fuel Use				
Wine and Other Alcoholic Beverage Manufacturing	$31	3.0	4.0	5.0	5.0	4.0	3.5	-	-	Fossil Fuel Use				
Real Estate Services	$43	2.1	-	5.0	9.0	5.0	0.5	-	-	Water Use				^
Electricity Distribution	$41	1.9	2.0	5.0	1.0	2.0	4.0	-	-	Air Pollution and GHG Emissions				^^

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

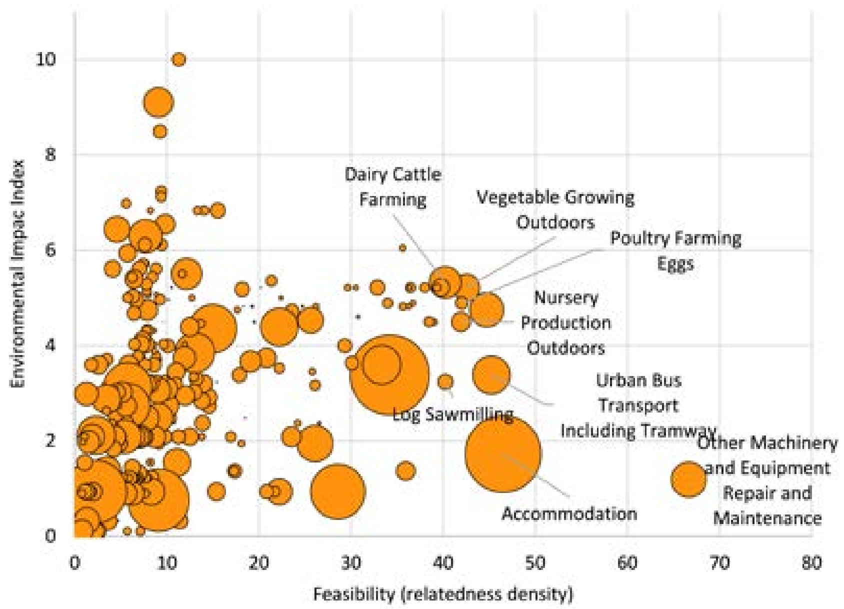
Table 27 describes the detailed environmental impact of 10 industries in the Great Southern likely to have the greatest environmental impact based on their national profiles and the local size of the industry. Five of the top 10 industries in the Great Southern which have the greatest environmental impact are related to agriculture. Other Grain Growing has the highest environmental impact index per $GVA, at 5.2 due to its use of fossil fuels and water. This is followed by Beef Cattle Farming Specialised at 5.1, then Grain Sheep or Grain Beef Cattle Farming Specialised and Sheep Farming Specialised, both with an environmental impact index per $GVA of 4.8. The main contributing factor to the environmental impact of these industries is air pollution and greenhouse gas emissions, with an index value of 4.5. This is also largely caused by the use of fossil fuels and electricity.

Local environmental challenges
Fossil fuel use is the main environmental challenge in the Great Southern, however, its level of fossil fuel use is equivalent to Australia overall and significantly better than the rest of Western Australia. It is also notable that air pollution and greenhouse gas emissions in the Great Southern is better than both WA and Australia overall.

Opportunities for green shoots – new industries
Figure 95 shows the feasibility of diversifying industries in the Great Southern region and the environmental impact of those industries according to the index.

FIGURE 95

ANZSIC industry classes by feasibility in the Great Southern (Regional Relatedness Density) vs Environmental Impact Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

From Figure 95 it can be seen that there are some feasible opportunities that are highly related to existing strengths in the Great Southern region. One feasible opportunity that stands out, is in Accommodation. Accommodation not only has a relatively high feasibility, but also has a low environmental impact and has a significant employment potential. Another opportunity is in Other Machinery and Equipment Repair and Maintenance, which has a low environmental impact index but builds on existing related activities.

We evaluate the opportunities based on the environmental impact index and a number of other criteria discussed in our report "Future-Proofing the WA Economy".

Table 28 shows key criteria in this evaluation as well as the potential for job growth and additional GVA by 2025. In this table, the environmental impact index is translated to a score between zero and four.

From Table 28 it can be seen that there are a number of diversification opportunities in the Great Southern region with moderate to low environmental impacts. As mention previously, Accommodation could be expected to provide 229 jobs and $16m in GVA by 2025. Many other opportunities build on existing capabilities across the Agriculture sector. The addition of an environmental impact criteria has particularly improved the prioritisation of Motor Vehicle Parts Retailing and Fruit and Vegetable Wholesaling. These service industries could provide significant additional value added in the Great Southern Region with lower environmental impacts than other alternatives.

TABLE 28

Environmental diversification opportunities in the Great Southern

Industries	Feasibility	Environmental Impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Accommodation	3	4	4	229	$ 16,142
Urban Bus Transport Including Tramway	3	3	3	60	$ 5,370
Fruit and Vegetable Wholesaling	1	3	4	74	$ 8,256
Water Supply	3	2	4	79	$ 39,487
Log Sawmilling	3	3	4	86	$ 9,360
Poultry Processing	1	2	4	175	$ 16,497
Nursery Production Outdoors	3	2	3	59	$ 3,730
Vegetable Growing Outdoors	3	2	4	140	$ 8,903
Motor Vehicle Parts Retailing	1	4	2	20	$ 1,212
Offshore Longline and Rack Aquaculture	2	2	4	97	$ 8,317
Dairy Cattle Farming	3	2	4	426	$ 27,087
Offshore Caged Aquaculture	1	2	4	200	$ 17,174
Timber Resawing and Dressing	1	3	3	41	$ 4,535
Mushroom Growing	2	2	4	81	$ 5,172
Other Fruit and Tree Nut Growing	2	2	4	182	$ 11,540
Apple and Pear Growing	2	2	4	80	$ 5,110
Berry Fruit Growing	2	2	4	72	$ 4,607
Prepared Animal and Bird Feed Manufacturing	2	3	3	54	$ 5,077
Grain Mill Product Manufacturing	1	3	3	46	$ 4,333

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

Perth

Environmental footprint

Perth is the most diverse region in WA, with a gross regional product of $173.8 billion. While there are no mines in Perth itself, mining activities contribute to the largest share of GVA (25%). This is followed by Financial and Insurance Services (11%), and Health Care and Social Assistance (8%). The latter also provides the largest share of employment in Perth at 14%.

Figure 96 describes the environmental footprint of Perth's industrial portfolio. Given a large service economy, Perth has a lower environmental impact than the rest of WA relative to value added, but higher than Australia overall. Perth's index of industry water use and waste is higher than for WA but less than in the rest of the country. Finally, the air, water and land pollution indexes are significantly higher than Australia overall. Note however, that some of the environmental impact of economic activity in Perth may occur beyond the Perth region, but is still attributed to Perth based on local industrial activity. A more comprehensive understanding of the top 10 industries in Perth with the greatest environmental impact is in Table 23, also accounting for the size of each industry.

FIGURE 96

The environmental footprint of Perth

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; GRP data from Government of WA, Department of Jobs, Tourism Science and Innovation WA Economic Profile June 2020, and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

TABLE 29

Ten highest environmental impact industries in Perth

Industry	GVA ($m)	Environmental Impact Index (per $GVA)	Fossil Fuel Use Index	Electricity Use	Water Use	Waste Use	Air Pollution and GHG Emissions	Water Pollution	Land Pollution	Main Env Issue	Main Pollutant Chemical Air	Main Pollutant Chemical Water	Main Pollutant Chemical Land	Potential for Environmental Improvement (^^^ = max)
Oil and Gas Extraction	$10,697	9.1	10.0	9.0	-	-	7.5	10.0	9.0	Land Pollution				^
Iron Ore Mining	$8,373	3.8	6.0	4.0	-	-	6.5	6.0	-	Air Pollution and GHG Emissions				^^
Gold Ore Mining	$2,584	5.5	5.0	5.0	-	-	6.5	6.0	5.0	Land Pollution				
Water Supply	$1,169	4.7	3.0	6.0	10.0	-	5.0	8.0	-	Water Use				^^
House Construction	$1,087	3.8	6.0	-	10.0	7.0	2.5	-	-	Water Use				
Real Estate Services	$1,866	2.1	-	5.0	9.0	5.0	0.5	-	-	Water Use				^
Road Freight Transport	$929	3.4	10.0	-	1.0	3.0	4.0	-	-	Fossil Fuel Use				
Air and Space Transport	$890	3.1	10.0	-	-	-	4.5	-	-	Fossil Fuel Use				
Iron Smelting and Steel Manufacturing	$432	6.3	9.0	10.0	3.0	2.0	9.5	7.0	-	Air Pollution and GHG Emissions	Arsenic compounds	Arsenic compounds	Methanol	
Other Heavy and Civil Engineering Construction	$611	4.4	8.0	6.0	6.0	10.0	3.0	-	-	Fossil Fuel Use				
Electrical Services	$732	3.6	7.0	-	6.0	8.0	3.0	-	-	Fossil Fuel Use				^

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

For Perth, activity in Oil and Gas extraction, Iron Ore Mining and Gold Ore Mining industries have the biggest environmental impact. Many of the specific environmental impacts of these industries will occur outside of Perth, but are still attributed to the Perth region on the basis of local economic activity in these industries. For example, the impact of head office activities, while not polluting directly, is apportioned with a share of the environmental impacts from its downstream activity.

Pollution from other industries such as Water Supply, House Construction, and Road Freight Transport are directly linked to Perth. Of those, Water Supply is intensive in electricity use and has also one of the highest indexes in water pollution. This is due to the use of desalination plants and groundwater extraction. Since the industry indexes are based on a national profile, these impacts may even be higher in Perth where desalination is a large share of water supply. As we have seen in Chapter 1, construction produces the largest amount of waste in WA. Iron Smelting and Steel Manufacturing has the second highest environmental impact relative to value added for industries in the Perth region, but ranks 9th in overall impact due to its relatively smaller GVA. This industry is a very intense user of electricity and fossil fuels but it also pollutes the air and water streams. Arsenic is main pollutant to air and land while methanol is also released into water.

Local environmental challenges

The main environmental challenge for the Perth region is fossil fuel use, however, it is notable that its air pollution and greenhouse gas emissions are better than WA but not Australia overall. This is possibly due to the attribution of fossil fuel that is used elsewhere in WA but linked to activity in Perth. Water and waste are also important challenges, especially relative to the rest of WA. Waste is mainly driven by industry classes in the construction sector which dominates waste generation in metropolitan areas. Although waste has been declining in this industry (see Chapter 1), it remains higher relative to others. Renewable energy offers an interesting opportunity for a lot of the industries in Perth. They would be able to decouple their GHG emissions from electricity supply. This is particularly true for Water Supply and Real Estate Services where electricity for these industries could be completely shifted from coal and fossil fuel to renewable energy.

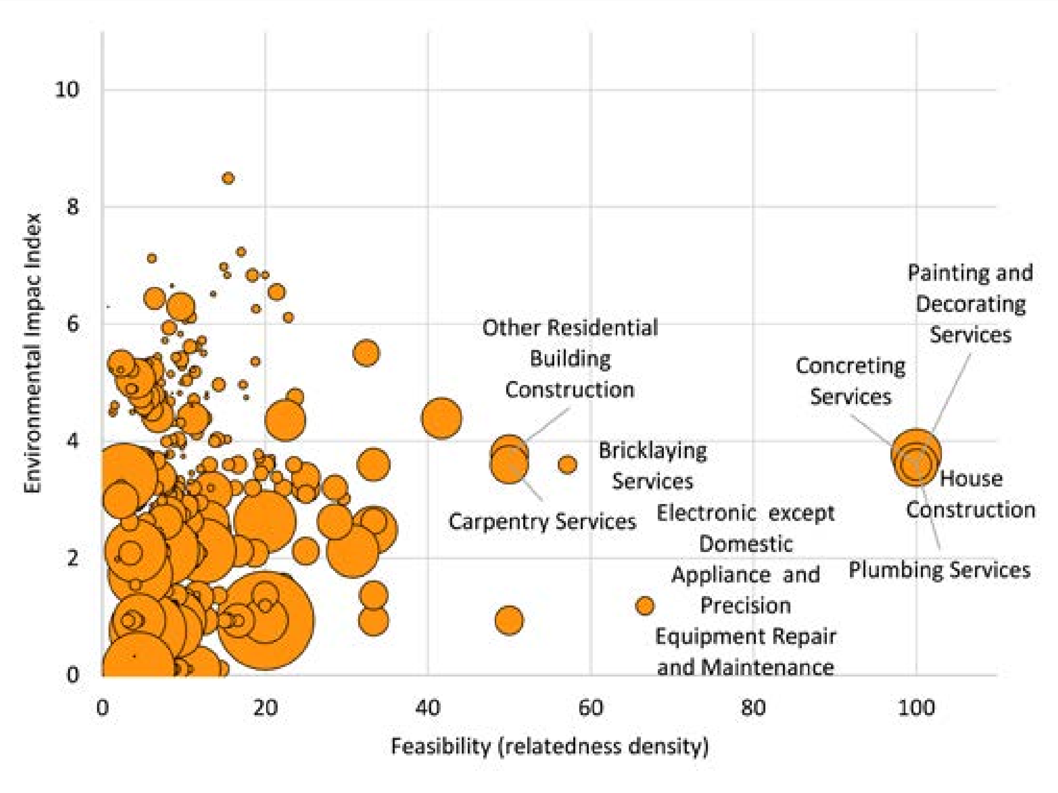
Opportunities for green shoots – new industries

Figure 97 and Table 24 show new industry opportunities for diversification in Perth. We evaluate the opportunities based on the environmental impact index and a number of other criteria discussed in our report "Future-Proofing the WA Economy". Non-residential construction along with related services such as Plumbing, Carpentry and Painting and Decorative Services have potential for expansion in Perth. Their environmental impact is somewhat low, except for waste. While these industries already exist in Perth, the region has not yet reached a significant comparative advantage. The construction sector has since been boosted by the stimulus packages from the Federal and WA governments as it is seen as a priority sector in the post COVID-19 recovery. However, as we have observed in the last two quarters, the skill shortages in construction could hinder Perth's recovery and will ultimately push prices up in these construction industry classes.

Inter Urban and Rural Bus Transport as well as Solid Waste Collection Services also features as a green opportunity in Perth. These industries have not yet reached their potential in Perth. As we have seen in chapter 3, these two sectors are crucial for the development of a sustainable future in WA. Expansion of bus transport would also see a reduction in greenhouse gas emissions from personal transport which is not included in the industrial activities analysed in our index. Perth should embrace an extended public transportation network that encompasses nearby cities to decrease GHG emissions. Also, an expanded waste collection service and better treatment of metropolitan waste is necessary to decrease the amount of waste going to landfill. Electronic and Precision Equipment Repair and Maintenance is a compelling opportunity for Perth and is also beneficial for a sustainable future as it would further decrease the quantity of waste generated by households and industries. Engineering Design and Consulting services has the largest potential job creation (1,700) and GVA growth ($190 million). The sector would help to achieve large infrastructure projects in the public and private sector and increase the skills stock of the Perth industry and overall in WA.

FIGURE 97

ANZSIC industry classes by feasibility in Perth (Regional Relatedness Density) vs Environmental Impact Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; and Use and Waste data from ABS 5217 Use Tables 2017-18.

TABLE 30

Environmental diversification opportunities in Perth

Industries	Feasibility	Environmental Impact	Potential Job Growth	Potential new jobs by 2025	Potential annual GVA by 2025 ($t)
Plumbing Services	4	3	4	532	
Electronic except Domestic Appliance and Precision Equipment Repair and Maintenance	3	4	3	342	$ 26,837
Engineering Design and Engineering Consulting Services	1	3	4	1758	$ 193,921
Non Residential Building Construction	1	3	4	1098	$ 163,372
Carpentry Services	2	3	4	771	$ 72,557
Painting and Decorating Services	4	3	1	0	$ 0
Newspaper Publishing	1	4	4	512	$ 60,171
Interurban and Rural Bus Transport	1	3	3	270	$ 24,348
Solid Waste Collection Services	1	2	3	214	$ 31,575

Source: Bankwest Curtin Economics Centre | Authors calculations based on employment data from ABS 2016 Census, pollution data from the National Pollutant Inventory; Greenhouse Gas Emissions data from the National Inventory by Economic Sector 2018, Australian Government Department of Industry, Science, Energy and Resources; Use and Waste data from ABS 5217 Use Tables 2017-18; Employment data by industry from ABS Census 2016; and industry GVA estimated from ABS Census 2016 and ABS Australian National Accounts Cat. 5220.

OPPORTUNITIES FOR A CLEANER WA

This section analyses a state-wide perspective on opportunities to improve the environmental impact of WA industries.

Opportunities for improving the environmental impact of existing industries

There is significant potential to reduce the environmental impacts of existing industries. This subsection outlines some of these opportunities.

Renewable energy
The main contributor of carbon dioxide emissions is the production of energy from fossil fuels. If energy can be produced without carbon dioxide emissions, this reduces greenhouse gas emissions for all industries and households. There are a number of opportunities for renewable energy generation in WA. Detail can be found in Chapter 3.

Battery Storage
Electrical energy must either be used immediately or stored. As noted in our report on energy "Power to the People" (Cassells *et al.* 2017), this represents a major barrier for 100% renewable electricity generation in WA because renewable generation typically peaks in the middle of the day to early afternoon when the sun is shining but electricity use peaks at the end of the day when people return to their homes. It is also a barrier for large-scale renewable generation in regional WA because of its isolation from electricity users.

The cost of renewable generation and battery storage has reduced dramatically in recent years to be jointly competitive with fossil fuel alternatives. In the longer term renewable generation combined with storage is expected to replace legacy fossil fuel generators. The long-term management of our electricity system must account for this pending renewable transition. It may also be possible for WA to become a world leader in renewable generation, given WA's extraordinary natural resource of space and sunshine, but this would require an active response to develop local capabilities.

Hydrogen
Establishing large scale renewable electricity generation in regional WA should be in conjunction with facilities that will use that energy – for example, a large scale solar farm combined with hydrogen production. As discussed in the case of study of Chapter 3, hydrogen generated through the electrolysis of water represents a useful storage technology for electrical energy that would also enable the exportation of renewable energy. Hydrogen could be exported, similar to the export of LNG, and used to re-generate electricity elsewhere or as fuel in vehicles with markets in Asia and Europe. Japan, a major importer of Australian coal and LNG, has recently committed to be carbon neutral by 2050, with hydrogen flagged as a key part of its future energy mix. Many other countries, including the European Union, have already set the same goal.[145]

As countries around the world continue to set targets to reduce carbon emissions, demand for hydrogen produced using renewable electricity is expected to increase. Western Australia could establish hydrogen as a competitive and premium export industry.

Green Steel/Iron
In addition, industrial processes could make use of hydrogen locally in Western Australia. Developing a local demand for hydrogen would reduce the risk associated with establishing a hydrogen export industry.

145 Japan Times (2020) Suga to declare Japan will go carbon neutral by 2050 in policy speech, https://www.japantimes.co.jp/news/2020/10/22/national/suga-carbon-neutral-2050/.

So-called ‘Green Steel’ is made by using hydrogen instead of coking coal to turn iron ore into iron and subsequently steel. Water vapour is emitted instead of releasing carbon dioxide. If the hydrogen is produced using renewable electricity it is considered ‘green’ because there are no carbon dioxide emissions.

There are likely to be both local and export markets for steel with zero emissions. Countries and companies are targeting net zero emissions in construction and the use of steel with zero carbon dioxide emissions would significantly reduce the need for costly carbon offsets, implying a potential premium for green iron or green steel.

Green manufacturing
All energy intensive industries could benefit in a similar way if electricity generation switches to renewable sources. This could apply to a number of electricity intensive manufacturing industries in WA.

For example, alumina and aluminium production has very intensive use of electricity. If the electricity is sourced from renewable generation, including stored sources such as from hydrogen or batteries, then WA could produce ‘Green Aluminium’.

As countries globally increasingly target zero emissions, the market for Green manufacturing is also likely to offer increased margins.

Transport fuels
Mining and other industries that are machinery intensive use a lot of diesel. If these machines can use electricity or hydrogen made using renewable sources then the greenhouse gas impact of these industries can be reduced considerably.

Construction
The construction industry is a significant user of carbon intensive products and produces a significant amount of waste sent to landfill. There are a number of opportunities to reduce its environmental impact.

Concrete made using Portland cement is carbon intensive. Carbon dioxide emissions are reduced if buildings use less concrete and if concrete is made with smaller amounts of Portland cement, supplementary cementitious materials such as fly ash, or alternatives such as geopolymer cement. There are also possibilities to reduce the carbon emissions from cement production with carbon capture and either storage or use.

As noted above, the use of steel produced using hydrogen made from renewable generation would also reduce the carbon intensity of construction.

Governments could also play a role in steering the construction industry towards more sustainable practices. While initially the switching of materials to more sustainable alternatives may be financially more expensive, increasing the scale of production and demand typically reduces costs over time and the switch may be financially beneficial in the long run. This is even more likely to be the case if the benefits of reducing the impacts of climate change are properly accounted for.

OPPORTUNITIES FOR ENVIRONMENTALLY BENEFICIAL EXPORTS

This section considers Western Australia's export industries, the extent that exported products are environmentally beneficial, and indicators of new opportunities for exporting environmentally beneficial products.

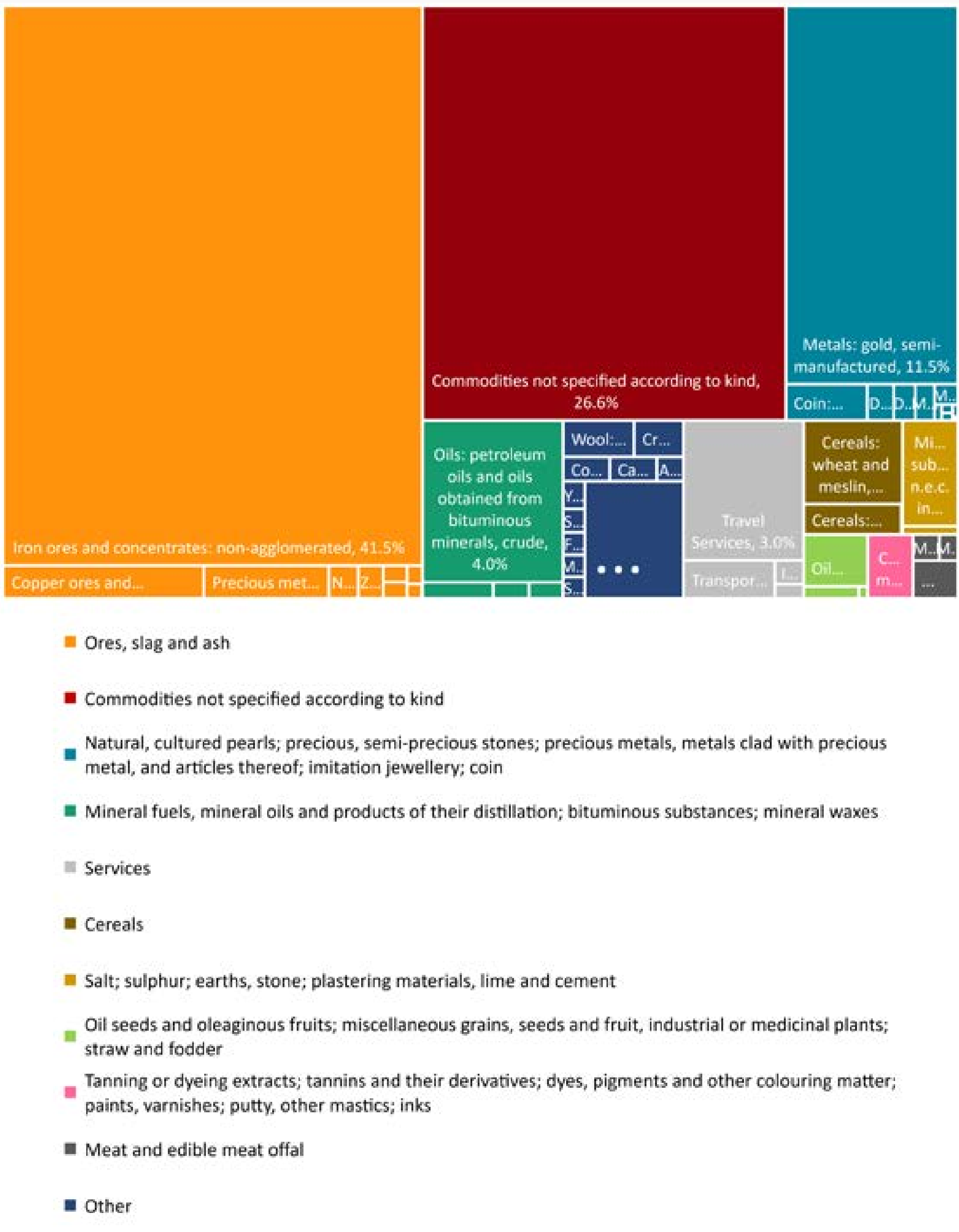
Exports

We analyse global international trade data for more than 200 countries and 5,384 traded products classified by HS2017 6 digit product categories and four services categories. Western Australia exports 2,568 of these products. Figure 98 shows WA's exports with colours grouped by colour for the top 10 HS2017 2 digit categories, plus services. In particular 41.5% of WA's exports are a single product: *Iron ores and concentrates*. The actual share is even greater because some iron ore will also be included in the product *commodities not specified according to any kind*.

220

FIGURE 98

2018 Exports from Western Australia, Percentage shares by value



Source: Bankwest Curtin Economics Centre | Authors calculations based on WA export data from ABS.

Comparative advantage

Revealed comparative advantage (RCA) is calculated by comparing the share of a jurisdiction's exports of each product with the global trade. A RCA greater than one describes the exported products in which a jurisdiction has a larger share than average. We analyse WA's exports against global trade to estimate WA's comparative advantages. While WA exports 2,568 of the 5,384 products, WA has a comparative advantage in only 108 of these products.

Table 31 shows the top 10 products by WA's comparative advantage. While iron ore is the largest export industry by value, with a share of WA's exports 118 times greater than country export averages and a strong comparative advantage, WA also has comparative advantage in a few unique niche products such as gold coins and crustaceans.

TABLE 31

Top 10 exported products from WA by comparative advantage

Product exported	Value of exports ($m)	RCA
Iron ores and concentrates: non-agglomerated	$62,641	162
Mineral substances: n.e.c. in chapter 25	$1,556	128
Crustaceans: live, fresh or chilled, rock lobsters and other sea crawfish (Palinurus spp., Panulirus spp., Jasus spp.), in shell or not	$481	89
Emery, natural corundum, natural garnet and other natural abrasives, whether or not heat-treated	$94	70
Precious metal ores and concentrates: (excluding silver)	$1,092	55
Metals: gold, semi-manufactured	$17,343	55
Wool: (not carded or combed), greasy (including fleece-washed wool), shorn	$694	37
Degras: residues resulting from the treatment of fatty substances or animal or vegetable waxes	$16	28
Sheep: live	$126	27
Steatite: natural, (not crushed or powdered), whether or not roughly trimmed or merely cut, by sawing or otherwise, into blocks or slabs of a rectangular (including square) shape: talc	$22	27

Source: Bankwest Curtin Economics Centre | Authors calculations based on WA export data from ABS, BACI global trade data from CEPII.

Environmentally beneficial exports

The international organisations APEC, OECD and WTO classify 516 of the 5,384 HS2017 product categories as providing environmental benefits. These products are often highly specialised, and very valuable. While these products only make up a small share of global trade, their environmental benefits can be much broader than their direct value.

Each organisation has multiple lists according to how environmental benefits are determined. Using these classifications we develop an Environmentally Beneficial Exported Product Index (EB Index) with a score between zero and five that describes the extent that exported products are classified as environmentally beneficial by these three organisations. Products not classified by APEC, the OECD or the WTO are given an index value of zero. The products with the highest index value are recognised by all three organisations for their role in reducing pollution of poisonous substances, and recognised across multiple lists within each organisation.

Table 32 shows the top 10 products according to this index.

TABLE 32

Top 10 Products by Environmentally Beneficial Traded Product Index

Rank	HS2017 Product Description	Environmental Benefit (EB)	EB Index
1	Furnaces and ovens: including incinerators, non-electric, for industrial or laboratory use, n.e.c. in heading no. 8417	"These products are used to destroy solid and hazardous wastes. Catalytic incinerators are designed for the destruction of pollutants (such as VOC) by heating polluted air and oxidation of organic components. [Ca, J, NZ, K, Au, M, US, BD] Used to achieve innocent treatment and disinfection of household waste through high- temperature incineration disposal.Used for radioactive waste disposal. [Ch]"	5.0
2	Furnaces and ovens: electric, for industrial or laboratory use, other than those functioning by induction, dielectric loss or resistance heated	"Catalytic incinerators are designed for the destruction of pollutants (such as VOC) by heating polluted air and oxidation of organic components. [Ca, J, NZ, K, CT, Au] These products are designed for the destruction of pollutants (such as VOCs) embedded in solid and hazardous wastes. Pollutants are destroyed by heating polluted air and oxidizing organic components. [US] These instruments are used to measure, record, analyse and assess environmental samples or environmental influences. [Ch]"	5.0
3	Machinery: for filtering or purifying water	"Used to filter and purify water for a variety of environmental, industrial and scientific applications, including water treatment plants and wastewater treatment facilities. [Ca, J, NZ, K, Au] Used to filter and purify water for a variety of environmental, industrial and scientific applications, including water treatment plants and wastewater treatment facilities. This line also includes newer water/wastewater filtration technologies like ozone and ultraviolet disinfection equipment. [US] For wastewater. Used to filter and purify water for a variety of environmental, industrial and scientific applications including water treatment plants and wastewater treatment facilities. For instance, membrane systems can be used to produce water from wastewater, seawater or brackish groundwater, either through purification or filtration; [S] Such devices are essential components for filtration and purification of drinking water. [Ch]"	4.8
4	Furnaces and ovens: parts of non-electric furnaces and ovens (including incinerators), of industrial or laboratory use	These parts can help maintain and repair products that are used to destroy solid and hazardous wastes. Similarly, the parts for catalytic incinerators can help maintain and repair items that can assist in the destruction of pollutants (such as VOC) by heating polluted air and oxidation of organic components. [Ca, J, NZ, US, K, Au, R, BD]	4.8

TABLE 32 (continued)

Top 10 Products by Environmentally Beneficial Traded Product Index

Rank	HS2017 Product Description	Environmental Benefit (EB)	EB Index
5	Machinery: for filtering or purifying gases, other than intake air filters for internal combustion engines	"Physical, mechanical, chemical or electrostatic filters and purifiers for the removal of COV, solid or liquid particles in gases, etc. [Ca, J, NZ, K, Au] Catalytic converters convert harmful pollutants, like carbon monoxide, into less harmful emissions. Other technologies in this line include physical, mechanical, chemical and electrostatic filters and purifiers for the removal of VOCs, solid or liquid particles in gases, etc. [US] For wastewater. Used to filter and purify water for a variety of environmental, industrial and scientific applications including water treatment plants and wastewater treatment facilities. For instance, membrane systems can be used toproduce water from wastewater, seawater or brackish groundwater, either through purification or filtration. [S] Air Pollution Control [Th] Indoor hazardous gas purification equipment, especially for formaldehyde and benzene. [Ch]"	4.6
6	Electric motors and generators: parts suitable for use solely or principally with the machines of heading no. 8501 or 8502	"Parts of the generators and generating sets listed under 848340 (for renewable energy systems). Relevant parts include for instance nacelles and blades for wind turbines. [Ca, J, NZ, K, M] See environmental benefit under 847989 [CT] Parts for aforementioned goods/ex-outs of headings 8501 and 8502. [US] Parts of the generators and generating sets listed under HS 850231 (for renewable energy systems). Relevant parts include for instance nacelles and blades for wind turbines. Renewable Energy [S] Parts and accessories for electricity generation from renewable resource. [BD]"	4.6
7	Machinery: parts for filtering or purifying liquids or gases	"Including sludge belt filter presses and belt thickeners [Ca, J, NZ, K, Au]. Parts for aforementioned goods/ex-outs ofheading 8421. [US]"	4.6
8	Heaters: instantaneous or storage water heaters, non-electric, other than instantaneous gas water heaters	"Uses solar thermal energy to heat water, producing no pollution. Use of solar water heating displaces the burning of other, pollution-creating fuels. [Ca, J, NZ, US, K, HK, Au, Th] Uses solar energy to heat water, producing no pollution. Use of solar water heating displaces the burning of other pollution-creating fuels. [S, BD] Used for water heating through solar energy which is regenerative and clean compared to burning fuel. [Ch]"	4.6
9	Boilers: auxiliary plant, for use with boilers of heading no. 8402 or 8403 (e.g. economisers, super-heaters, soot removers, gas recoverers)	"Components of industrial air pollution control plant which minimise the release of pollutants into the atmosphere. This equipment is also used to support waste heat recovery processes in waste treatment, or renewable energy resource recovery applications. [Ca, J, NZ, K, Au, BD] Components of industrial air pollution control plant which minimise the release of pollutants into the atmosphere. This equipment is also used to support waste heat recovery processes in waste treatment, [biomass energy generation - US only] and other renewable energy resource recovery applications. [US, HK, M] These are soot removers and components of industrial air pollution control plant, which minimise the release of pollutants into the atmosphere. This equipment is also used to support waste heat recovery processes in waste treatment or renewable energy resource recovery applications. [S]"	4.5
10	Furnaces and ovens: electric, for industrial or laboratory use, resistance heated	"Theseproductsareusedtodestroysolidand hazardous wastes. Catalytic incinerators are designedforthedestructionofpollutants(such as VOC) by heating polluted air and oxidation of organic components. These instruments are used to measure, record, analyse and assess environmental samples or environmental influences [Ch]"	4.4

Source: Bankwest Curtin Economics Centre | Authors calculations based on environmentally beneficial product data from APEC, OECD and the WTO collected in Mealy and Teytelboym (2020).

Overall, less than 0.8% of WA's exports by value are environmentally beneficial products. Only one of WA's top 20 products by comparative advantage, Aluminium Hydroxide, is considered environmentally beneficial, but it also ranks low in our index as it is only classified as beneficial in the WTO classification and not APEC or the OECD.

Figure 99 shows the comparison between WA's comparative advantage and the EB Index for the 130 products in which WA has a comparative advantage (note the x axis is in log scale).

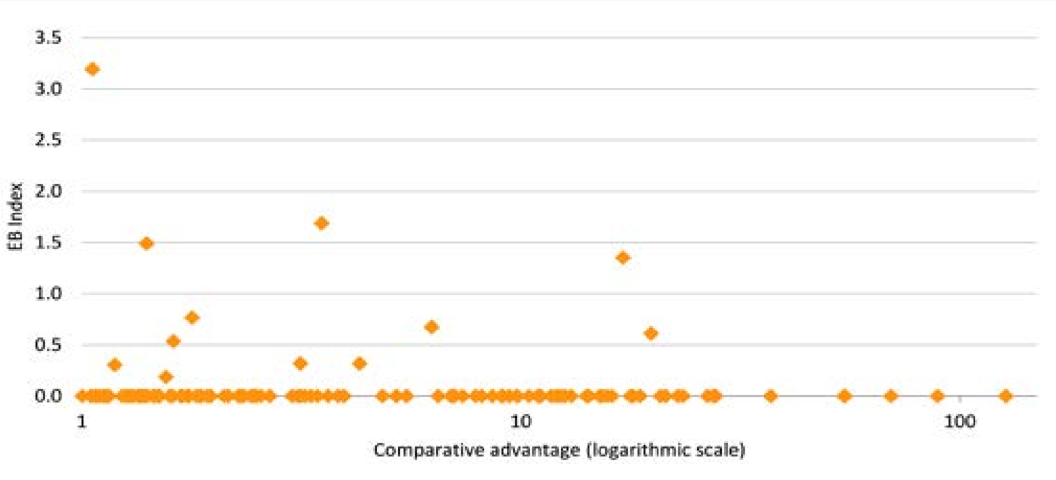
Of these 130 products exported by WA in which WA has a comparative advantage, 13 have a score in the EB Index above zero. Given approximately 10% of all products are in this list, this proportion should be expected on average. However, of the environmentally beneficial products in which WA has a comparative advantage, 12 do not score highly in the EB Index at less than 1.8. This means there is less confidence in classifying these products as environmentally beneficial. These are typically products which consume fossil fuels more efficiently, or carbon capture related products, rather than products that eliminate the use of fossil fuels.

The one exported product with a comparative advantage for WA that is classified as environmentally beneficial by all three organisations, is *'Surveying equipment: including hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances (excluding compasses)'*.[146] APEC and the WTO describe its benefits as:

"Includes instrument and appliances necessary for measuring the ozone layer and to monitor, measure and assist planning for natural risks such as earthquakes, cyclones, tsunamis etc."

FIGURE 99

2018 Exports from Western Australia RCA>1, Revealed Comparative Advantage vs Environmental Benefit Index



Source: Bankwest Curtin Economics Centre | Authors calculations based on WA export data from ABS, BACI global trade data from CEPII, and environmentally beneficial product data from APEC, OECD and the WTO collected in Mealy and Teytelboym (2020).

146 Surveying equipment not elsewhere classified in theodolites and tacheometers; levels; photogrammetrical surveying instruments and appliances; and parts and accessories for articles of heading no. 9015.

Likely export diversification patterns

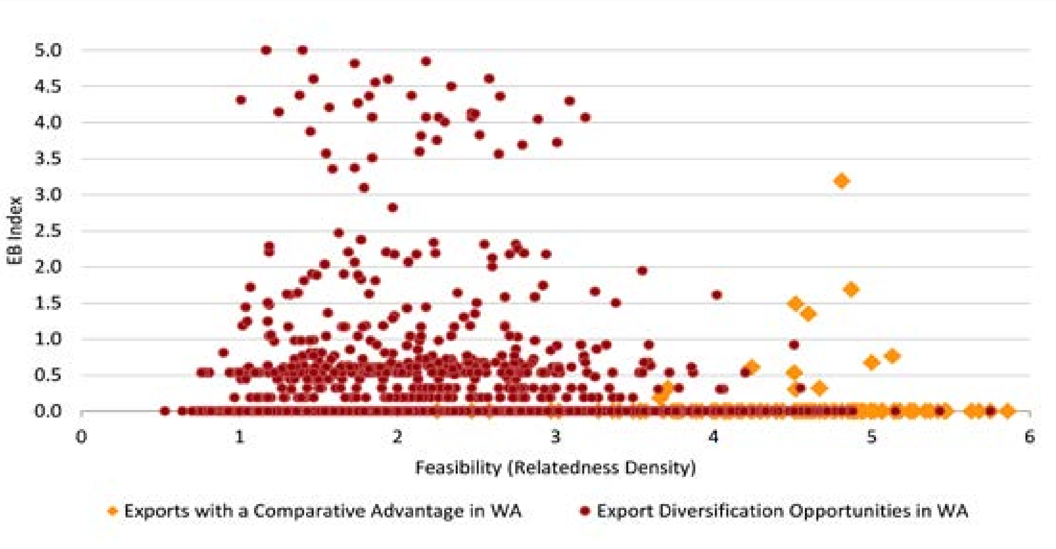
As an economy grows, the products more related to many of a country's existing products with a comparative advantage (relatedness density) are more likely to emerge than unrelated products. We use this relationship to identify likely patterns of diversification and evaluate them for potential environmental benefits using our index.

Figure 100 shows the feasibility and EB Index scores of WA's existing industries and diversification opportunities for all products in the HS2017 trade classification. The products in which WA has a comparative advantage, in orange, are typically more strongly related to WA's existing portfolio of exported products. Products that WA could diversify into, in dark red, are considered more likely to emerge in WA if they have a higher relatedness density.

Notably, the likely diversification pattern for WA contains very few products with environmental benefits. Of the environmentally beneficial products that WA could diversify into, they typically rank lower in our environmentally beneficial index. On this basis, the standard diversification pattern as WA expands into exporting new products over time are less likely to be environmentally beneficial products.

FIGURE 100

2018 Western Australia Relatedness Density HS2017 products



Source: Bankwest Curtin Economics Centre | Authors calculations based on WA export data from ABS, BACI global trade data from CEPII, and environmentally beneficial product data from APEC, OECD and the WTO collected in Mealy and Teytelboym (2020).

Environmentally beneficial export opportunities

There is an opportunity for WA to target new exported products with environmental benefits.

Table 33 shows the top 10 products based on relatedness density (or feasibility) with a score in the EB index greater than 0.75.

To expand the range of environmentally beneficial products exported from WA, policies could be designed to target expanding WA's capabilities in these products that are both feasible and offer significant environmental benefits.

TABLE 33

Top 10 Environmentally beneficial products that are not current comparative advantages for WA, by relatedness density

Product	Relatedness Density	EB Index
Turbines: gas-turbines (excluding turbo-jets and turbo-propellers), of a power not exceeding 5000kW	4.0	1.6
Generators: producer gas, water gas, acetylene gas and similar water process gas generators, with or without their purifiers	3.6	1.9
Instruments and apparatus: for measuring or detecting ionising radiations	3.4	1.5
Cells and batteries: primary, (other than manganese dioxide, mercuric oxide, silver oxide, lithium or air-zinc)	3.3	1.7
Microtomes and parts and accessories thereof	3.2	4.1
Instruments and apparatus: for measuring or checking the flow or level of liquids	3.1	4.3
Instruments and apparatus: for physical or chemical analysis, for measuring or checking viscosity, porosity, expansion, surface tension or quantities of heat, sound or light, n.e.c. in heading no. 9027	3.0	3.7
Pumps and liquid elevators: n.e.c. in heading no. 8413	2.9	2.2
Spectrometers, spectrophotometers and spectrographs: using optical radiations (UV, visible, IR)	2.9	1.7
Turbines: gas-turbines (excluding turbo-jets and turbo-propellers), of a power exceeding 5000kW	2.9	4.0

Source: Bankwest Curtin Economics Centre | Authors calculations based on WA export data from ABS, BACI global trade data from CEPII, and environmentally beneficial product data from APEC, OECD and the WTO collected in Mealy and Teytelboym (2020).

CONCLUSION

The mix of industries in WA is strongly related to the resource endowment with corresponding impacts on our environment. Natural diversification patterns build on existing capabilities so are likely to also use this resource endowment and further impact the environment. However there are a number of opportunities to target industries that build on related capabilities.

Through the creation of a new ‘green index’ we have identified significant opportunities to factor environmental sustainability more explicitly into WA’s regional diversification strategy. In addition to reducing our environmental footprint, a green diversification strategy could create 55,000 additional jobs, 49,000 of which would be in regional WA. This would also see some $16 billion added to the WA economy. Our results evidence that regional areas would benefit the most from a green diversification strategy, as a larger proportion of jobs would be created outside metropolitan areas.

In regional WA, Defence appears as a strong opportunity for economic diversification with lower environmental impacts. It also fits with wider government policies for the development of Northern Australia. Diversification in agriculture towards lower impact products would also help regional WA. Notably, an environmental perspective on regional development promotes a number of higher value-added industries. While these industries may be more difficult to establish than WA’s traditional resource-based industries, there could be significant economic and environmental dividends once they are established. In Perth, the industries in the construction sector offer a strong potential to expand, but ideally the construction sector should also address its high waste use, and emissions from the production of steel and concrete to achieve additional gains.

The greatest opportunities are likely to come from reducing the impacts of existing industries. In particular, electricity generation from renewable sources, along with storage has the potential to substantially reduce the environmental impacts of energy intensive industries. Given the dominance of mining in WA, the transition from diesel-powered to electric vehicles used in mining will also offer significant gains. The use of electricity from renewable sources to produce hydrogen offers the potential for a new energy export industry, a high capacity energy storage solution, and a key ingredient for producing steel with zero carbon emissions. A number of countries globally have announced targets for zero emissions by 2050. Specifically, Japan has indicated that hydrogen will become a critical component of its energy mix in this transition.

Lastly, there is the potential for Western Australia to produce a number of high value, environmentally-beneficial niche products. These green shoots would require targeted investments in order to become established.

"**OUR ECONOMY CAN THRIVE WITHOUT HINDERING THE DEVELOPMENT** OF OUR BIODIVERSITY AND NATURAL RESOURCES."

SUMMARY AND POLICY RECOMMENDATIONS

SUMMARY AND RECOMMENDATIONS

Summary and Discussion

The COVID-19 pandemic has forced us to reflect on our priorities and rethink our path forward. Facing the threat of illness, job-loss and financial hardship and a global recession has fundamentally shifted public attitudes.

Now is the ideal time to grasp this vision of a better future, to build the foundations of new industries and ways of working that we know can be both more sustainable and more productive, and to commit ourselves to transition to a circular economy.

Our report adds scientific based evidence of the challenges and opportunities presented to follow a sustainable path for Western Australia.

CHALLENGES

Greenhouse Gas Emissions

While Australia's net greenhouse gas (GHG) emissions have decreased a bit in recent years (dropping 13% between 1990 and 2018), our per capita emissions remain among the highest in the world. In fact, only the oil producing states of the Middle-East produce more emissions per person. Meanwhile other OECD nations, who had similar per capita emissions to us in the Seventies, now produce nearly half as much per capita.

Even worse, while WA has undoubtedly benefited from sustained growth in a number of industry sectors, especially in resources, there has also been an increase of 12% in GHG emissions since 2015, driven largely by mining (52%) and transport, postal and warehousing (10%). This will make it harder for Australia to meet its commitment to reduce GHG emissions by at least 26% from 2015 levels by 2030, as prescribed by the COP21 Paris Agreements.

Analysis across sectors and industries shows clearly that emissions-related taxes have not been targeted towards the largest polluters, suggesting there are opportunities to move towards more cost-reflective and efficient pricing of emissions. The analysis of environmental taxes paid by sector clearly shows that households are paying 40% of emissions-related taxes while only contributing 12% of emissions, while industry releases 88% of emissions and only pays 60% of taxes.

The financial burden should be shifted from households towards polluters. For example, fossil fuel tax credits to business and industry is costing Australia around $20 billion in forgone revenue in 2018-19 alone and further contributing to the inequity between industry and households. It is challenging to understand the rationale for providing this largesse, and counter-productive to provide industry incentives that give the most benefit to the greatest polluters. Public resources forgone to support industry development or subsidise essential services should be targeted based on the value they add and benefits they deliver to our community as a whole.

Waste management

In terms of waste, WA has made significant progress on reducing waste production over the last decade, reducing per capita waste from being the highest in Australia in 2007 to the lowest in 2017, at 2 tonnes per capita, a reduction of 37%. This drop in waste production appears to have been driven by effective policy, with significant increases in the waste levy in 2015 linked to reductions in metropolitan waste production. Despite these improvements, West Australians still rank second in per capita waste generated by both households and industries.

The increase to the waste levy rate in WA was only applied to industry and households in metropolitan areas, and lower rural waste levy rates are reflected in much higher per capita waste production in regional areas (742kg waste per person regionally versus 515kg per person in metro areas). There is no clear rationale for this difference in costs – while the cost of land (for landfill sites) may be higher in metro areas, the cost of waste collection and processing in rural local government areas is much higher due to greater distances and fewer economies of scale. WA should look to align waste levy costs by raising regional levies, accompanied by consumer education to reduce regional waste.

Plastic waste in particular is increasingly considered to be an emerging problem of monumental proportions. Western Australia produces more plastic waste per capita than any other state, with each of us generating 132kg of plastic waster every year. While over half of our plastic waste is composed of types of plastic that are readily recycled, in practice 96% of WA's plastic waste ends up in landfill where it will remain – forever. WA should introduce stronger regulation of plastics, including, measures to minimise and phase out plastic packaging - especially single use plastic, stronger product standards and labelling, including phasing out of mixed plastics and products that cannot be recycled. The introduction and extension of product stewardship laws that introduce lifecycle responsibilities for plastic products will also be an important step.

Importantly, a stronger waste management system should be put forward in the WA agenda. WA recycles only 46% of its waste, the second worst state after Queensland at 42%. The WA Government have set strong targets to continue this improvement, with the *Waste Avoidance and Resource Recovery Strategy 2030* aiming to reuse or recycle 75% of waste by 2030, and decrease landfill in the metropolitan area by more than 15%.

A more efficient management of organic waste is key to accomplish the 75% target on recycled materials by 2030. WA has taken an important step with the rollout of FOGO bins (food organics and garden organics) as part of the three bin collection system in metropolitan areas but further efforts in the recycling of plastic materials and metals could be achieved.

Water management

The drop in historic annual rainfall and absence of large winter rainfall events has resulted in a dramatic reduction in streamflow, falling from a historic average of 400gL down to only 70gL in the last decade. Perth and other southwest towns and cities have had to diversify water supplies and restrict water use, progressively developing alternative water supplies including groundwater extraction, desalination of seawater, wastewater recycling and aquifer recharge.

In 2019-20 desalination accounted for 43% of our water supply, groundwater for 42% (including 3% replenished) and 15% came from dams. Unfortunately, the southwest of WA continues to be one place where the climate models converge, indicating further declines in rainfall and rises in average and extreme temperatures in the future. The threat to our water security and the viability of agricultural production remain pressing into the future.

WA has been relatively successful in reducing per capita water use by 7% in the last decade, although population growth means we are still using more water overall. However, WA households still use on average 91kL per person, which is 26% more than the Australian average. This is largely driven by larger suburban blocks with thirsty lawns and gardens. At the same time industry in WA (excluding electricity, gas and water services) used five times as much as households. The WA mining industry is particularly thirsty, using 252kL of water per capita – which is six times the national average, and reflects the concentration of mining activity in our state.

While industry uses more distributed water, households pay more for the privilege, spending an average of $2.9 per kilolitre compared to a cost of only $0.7 per kilolitre for industry. Legacy water supply arrangements mean that many industrial processes continue to make use of potable water supplies, while paying a fraction that households pay. We should aim over time to ensure that all users are paying a fair and cost-reflective price for water, while putting in place incentives and infrastructure to encourage industries to use fit-for-purpose recycled water.

There are many other ways that we could efficiently and effectively make greater use of recycled water, including industrial uses, as well horticulture, parks and gardens. Fit-for-purpose water recycling takes less energy and additional processing than making recycled water potable and safe for domestic use. It can be safely and simply done with good planning and infrastructure to ensure supplies are well marked and kept separate. This can be achieved by co-locating industries to enable re-use, designing and building dual reticulation systems into new industrial and residential developments, and ensuring industry environmental impact assessment and approval processes include obligations for sustainable water management.

This combined with the expansion of the groundwater replenishment to potentially reuse 100% of Perth water usage in the long term, as well as shifting the energy of desalination plants to renewable energy will improve our water management system and ensure water security for generations to come. Nevertheless, this can also be achieved if households also decrease the quantity of water used. Educational campaigns and raising population awareness of water use will be key to deliver a reliable water supply to the population.

KEY SOLUTIONS

Our report has identified key solutions to deliver a sustainable WA economy. Increasing the uptake of renewable energy, expanding public transportation and building better are some of the solutions considered in our report. We also highlight the potential to diversify into new green economic sectors that would help us achieve a sustainable economy.

Setting a Renewable Energy Target

Western Australia has the lowest proportion of renewable energy generation of any state, and together with NSW is only one of two states without a renewable energy target. In 2018-19, only 9% of WA electricity was provided by renewable energy. The growth in renewable generation in WA also lags behind other states, improving only 6 percentage points over the last decade from 3% in 2008-09 to 9% in 2018-19. The small uptake of renewable energy in the state should be of concern if we seek to decouple most of WA's GHG through electricity generation.

At the same time, we can see that other states and territories are getting there well ahead of us. Putting aside the example of Tasmania (since we do not have the mountains, rivers and rainfall for large-scale hydro) we can still learn much from the successes of South Australia and the ACT. The ACT now sources its electricity from 100% renewables and South Australia expects to reach 100% renewables by 2030.

The transition strategy put forward for WA by the Energy Transformation Taskforce (2019) argues that the best way to integrate distributed household photovoltaic systems and other new distributed energy resources into the operation of the electricity grid is to allow them to be remotely controlled by the network operator.

There are concerns that this will in practice hinder the upgrading of the capability of the grid to better manage voltage and inertia issues so that it will ultimately be capable of supporting more distributed energy resources.

Given WA's natural resources, WA should embrace renewable energy and push it forward in the agenda. Renewable energy will decrease significantly GHG emissions from industry, electricity and water generation. Even better, this will open new markets for WA industry such as iron and steel transformation. Furthermore, this can become a potential export market with the possibility of hydrogen storage for renewable energy export.

WA should actively invest in switching to cleaner energy generation and update electricity distribution networks to better support renewable energy generation and storage. WA could also include distributed energy infrastructure and storage in planning assessment processes for new industrial and residential developments, moving to introduce efficiency and sustainability standards in larger development proposals over time.

Building green and smart

Households can also decrease energy use by building smarter, with environmentally friendly materials that incorporate less energy in their production but also with features that increase home insulation such as double glazing windows and ceiling insulation. However, WA ranks fifth lowest in terms of the energy efficiency rating of new homes and apartments.

Our report estimates that building with passive design such as installing double glazing, internal integrated window shading devices, and decreasing air leakage in houses will ultimately save $681 per year in energy bills over a 50 years horizon.

While design and good thermal insulation can dramatically reduce the cost and carbon emissions of living or working in a well designed and constructed green building, the choice of green or sustainable materials can have a huge impact over the life cycle of the building. For example, it is estimated that a typical new 4 x 2 X 2 house built in Perth in 2016 would generate between 403 and 498 tonnes of greenhouse gas emissions, while a more efficient house constructed using green materials would generate 24% less GHG emissions and use around 23% less embodied energy over the life-cycle of its use.

WA has twice delayed the implementation of the National Construction Code for new buildings, so that improved efficiency standards implemented by all other states in 2019 will still not be in place in WA until April 2021. This disadvantages developing green businesses and industries in WA, as those who invested in more expensive and efficient materials and practices at the same time as their eastern state counterparts now face greater costs and unfair competition from less efficient and sustainable materials that do not comply with the new standards being dumped on WA by interstate and international suppliers.

WA should adopt and implement the National Construction Code without delay and introduce sustainability requirements into planning processes for new housing developments to improve the use of more efficient and solar passive design.

Sustainable transport

Transport emissions, together with the embodied energy in vehicles and other transport infrastructure make a huge contribution to our carbon footprint. Currently, there are two main forms of sustainable motor-powered transport in Australia, electric cars and electric trains.

The benefit of electric cars and electric trains is that they emit zero greenhouse gas emissions during operation.

Currently only 5 per 10,000 people drive an electric car in WA. Along with greater use of public transportation, driving electric cars recharged with renewable energy has the potential to decrease GHG emissions. However, given our current electricity mix composition, driving an electric car in WA would still generate an estimated 10.8 tonnes of CO_2 emissions per 100,000 kilometres travelled. This is evidenced by the fact that in states such as VIC, NSW and QLD driving a fuel efficient car will actually produce less carbon emissions than an electric car.

In formulating policies aimed at reducing greenhouse gas emissions, there is a need to take a holistic approach when developing policy, and not just focus on individual components of a system. For example, policies aimed at increasing the ownership of electric cars such as a reduction of vehicle transfer and licencing fees for electric vehicles needs to be formulated in conjunction with policies aimed at increasing the percentage of electricity generated using renewable energy resources.

WA should also continue to expand the public transport system to decrease the overall GHG emission of this sector. Upgrading the bus fleet to less GHG intensity options such as gas should also be a priority for the government.

Diversifying our economy towards more sustainable industries

The mix of industries in WA is strongly related to the resource endowment with corresponding impacts on our environment. Natural diversification patterns build on existing capabilities so are likely to also use this resource endowment and further impact the environment.

However there are a number of opportunities to target industries that build on related capabilities. In addition to reducing our environmental footprint, a green diversification strategy could create 55,000 additional jobs, 49,000 of which would be in regional WA. This would also see some $16 billion added to the WA economy.

Our results find that regional areas would benefit the most from a green diversification strategy, as a larger proportion of jobs would be created outside metropolitan areas. This is because the environmental perspective elevates industries that would typically only be targeted by large cities. While these industries may be more difficult to establish than regional WA's traditional resource-based industries, there are significant economic and environmental dividends once they are established. In Perth, the industries in the construction sector offer a strong potential to expand, but ideally the construction sector should also address its high waste use, and emissions from the production of steel and concrete to achieve additional gains.

The greatest opportunities are likely to come from reducing the impacts of existing industries. In particular, electricity generation from renewable sources, along with storage has the potential to substantially reduce the environmental impacts of energy intensive industries. Given the dominance of mining in WA, the transition from diesel-powered to electric vehicles used in mining will also offer significant gains. The use of electricity from renewable sources to produce hydrogen offers the potential for a new energy export industry, a high capacity energy storage solution, and a key ingredient for producing steel with zero carbon emissions. A number of countries globally have announced targets for zero emissions by 2050, indicating a growing demand for zero carbon products.

There is also the potential for WA to produce and export a number of high value, environmentally-beneficial niche products. These green shoots offer environmental benefits from the use of these products, beyond their production.

WA has the potential to become international leaders in sustainable development given the natural resources endowments of the state. And environmental sustainability enjoys popular support among Australian society, perhaps more now than ever before. Our report finds that two thirds of Australians agree that protecting the environment should be prioritised above economic growth. While half of Australians believe climate change is a very serious issue, this percentage rises to 64% for those who have been exposed to bushfires.

With an increasing public acceptance and political will, WA has the resources and potential to become frontrunners in the fight against climate change and should embrace this opportunity. Better management of our water and land resources as well as more efficient waste systems will ensure the future for generations to come.

"ADOPTING A CIRCULAR ECONOMY WHERE **MOST OF OUR RESOURCES ARE RECYCLED** AND REUSED WILL MINIMISE OUR WASTE FOOTPRINT."

GLOSSARY
AND TECHNICAL NOTES

GLOSSARY AND TECHNICAL NOTES

Building Envelope

A building envelope consists of exterior walls, windows, external doors, roof, and floor (Lawaina and Biswas, 2016).

Embodied Energy (EE)

Embodied energy includes the energy used in the acquisition, processing, manufacturing, and transportation of materials during the construction phase of a building.

Life Cycle Assessment (LCA) Approach

The life-cycle assessment of a building is a procedure to assess the environmental impacts associated with all stages of a building's life, i.e. from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal and recycle (Vatalis, Manoliadis, Charalampides, Platias, and Savvidis, 2013).

Operational Energy (OE)

Operational energy is the energy used in a building during its operational phase, which includes energy used for heating, cooling, ventilation, hot water, lighting, and other electrical appliances.

Passive Design

Passive design involves designing a building so that it keeps heat in during the winter (passive solar heating) and allows built up heat to escape during the summer (passive cooling) (Australian Government, 2020).

Passive Solar Heating

Involves designing a building so that it keeps heat in during the winter (Australian Government, 2020).

Passive Cooling

Passive cooling involves designing a building to allow built up heat to escape during the summer (Australian Government, 2020).

R-Value

provides a measure of its thermal resistance, with the higher the R-Value, the better its thermal performance.

Thermal Mass

Thermal mass is a measure of the heat storage capacity of a material.

U-Value

The U-Value of a material refers to the rate of heat transfer due to conductive, convection and radiation through a given thickness of material (Lawaina and Biswas, 2016).

Cavity Brick (CB)

A cavity brick wall is a wall composed of inner and outer brick wall separated by an air space.

Brick Veneer (BV)

A brick veneer wall is a wall composed of outer brick wall and inner wood or metal stud wall lined with plasterboard. An air gap separates the two walls.

Reverse Brick Veneer (RBV)

A reverse brick veneer wall has outer wood or metal stud wall and inner brick wall, with an air gap between them.

Fibre-cement (FC)

A fibre-cement wall is a wood or metal stud wall, with an external cladding of fibre-cement.

"AIR POLLUTION, LAND USE, WATER SECURITY AND WASTE MANAGEMENT ARE SOME OF THE **BIGGEST CHALLENGES** CURRENTLY FACING WA."

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