CCWA SUBMISSION

Climate Change in Western Australia

Conservation Council of Western Australia
November 2019

Conservation Council of Western Australia
ccwa
Look forward

Preface

"The science of anthropogenic climate change has effectively been settled for two decades, and no serious government can ignore the policy implications."

Premier Mark McGowan, 12 Feb 2019

"After roughly 1°C of global warming driven by human activity, ice sheets in Greenland and Antarctica are already losing mass at an increasing rate. Summer sea ice is disappearing in the Arctic and coral reefs are dying from heat stress – entire ecosystems are starting to collapse. The social impacts of climate change from intensified heatwaves, droughts and sea-level rise are inexorable and affect the poorest and weakest first."

Christiana Figueres, Former head of the United Nations Framework Convention on Climate Change, 28 June 2017

"The world is decarbonising. With the right planning and vision, Australia can not only continue to be an energy-exporting superpower, we can also enjoy a new manufacturing boom. In the century that's before us, the nations that will transform into manufacturing powerhouses are those that can harness the cheapest renewable energy resources. We have the highest average solar radiation per square metre of any continent. We also have some of the best wind and wave resources. And we have some of the best engineers and scientists, breaking the barriers of what is possible. Australia can be the land of cheap and endless energy – energy that could power generations of metal manufacturing and other energy intensive manufacturing industries."

Opposition Leader Anthony Albanese,
Jobs and the Future of Work Speech, 29 October 2019

"Without concerted global action, the world is now on track for 4°C of global warming, with Australia the most vulnerable of developed countries. Australia's food bowl would become a dust bowl, going the way of the civilization-cradling Tigris and Euphrates rivers thousands of years ago, evaporating into today's Iraqi deserts. I fear that the challenge would be beyond contemporary Australian society. I fear that things would fall apart."

Professor Ross Garnaut,
Superpower: Australia's Low-Carbon Opportunity, November 2019

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1.0 About us

The Conservation Council of Western Australia (CCWA) is proud to make this submission as WA's peak conservation body representing over 148,000 supporters and 105 member groups.

CCWA is an independent, member and supporter-based organization providing strong, science-based advocacy for action on climate change.

CCWA acknowledges at the time of making this submission the intense concern in the community about climate change and the growing number of community actions and demonstrations in Western Australia and globally calling for stronger action on climate change. Climate emergencies have been declared in over 975 jurisdictions, covering more than 210 million citizens. 'Fridays for Future' School Strike 4 Climate actions have taken place in over 2000 locations in over 100 countries, with 7 million marching in October, including 20,000 Western Australian school kids.

Recent research on community attitudes reveals strong sentiments among Western Australians for action on climate change. A statewide survey of 924 people conducted in September 2019 by Patterson Research Group has shown that:

Action on climate change:

- 85% support for stronger action on climate change in Western Australia.
- One in five believe climate change should be treated as an emergency,
- Just 4% believe that there is no need to take greater action.
- Only 9% of respondents believe it is acceptable for WA's carbon pollution to continue to rise in the short or medium term.

New rules for polluters:

- 80% support requirements WA's biggest polluters to offset their climate damage

CCWA Principles for a WA Climate Policy

1. Western Australians overwhelmingly support strong action on climate change.
2. All levels of Government have a responsibility to respond to climate change, including to ensure that Australia's international obligations are being met. States have a particularly important role, especially in the absence of effective Commonwealth action.
3. Climate policy, including mitigation and adaptation efforts should science-based and informed by principles of intergenerational equity.
4. Western Australia will be disproportionately affected by climate change and can disproportionately benefit from strong climate action. Strong climate action here and globally is overwhelmingly in the State's strategic interest.
5. Limited progress over the last 30 years means incremental decarbonsiation is no longer an option. The technologies and solutions needed to cut emissions rapidly are available, can scale quickly and are affordable. They must be accelerated by strong policy and climate leadership.
6. Taking strong action on climate change will create economic and social prosperity and is the biggest economic opportunity of this generation.
7. Long term and interim targets and trajectories are essential and will provide businesses and investors the certainty they need to invest in low emissions technology, clean energy generation, infrastructure and processes necessary to decarbonise by 2050.
8. A Just Transition is our path to a fairer and more sustainable future. Our climate response should have particular regard to Western Australia's vulnerable communities and the opportunity to reduce the cost of living and create opportunities for collaboration and employment.
9. Action to reduce emissions must be informed by the 'polluter pays principle'. This means WA's biggest polluters must bear a responsibility for abatement that is proportional to their current and past pollution and this must not be transferred to individuals and small business.
10. Western Australia's greatest days and greatest wealth are ahead if it can seize the opportunity before us. In a carbon constrained world, Western Australia is a winner. We have the ability to become the future renewables superpower of the world.
11. We encourage the development of a world-class, proactive climate policy which provides a blueprint to achieve decarbonisation by 2050, enables WA to prosper from a clean energy boom, and safeguards the future of our communities.

Government following EPA advice:

There is a very high expectation that the WA Government should follow the advice of the EPA on controlling carbon pollution.

Rising pollution:

- 77% reject policies that would allow pollution to rise further, as currently proposed by the McGowan Government.

Expanding the LNG industry:

- A majority (58%) support a policy in WA to ban new gas developments to protect the climate, with only 21% opposing this policy.
- There is strong support (64%) for the proposition that gas should be phased out and replaced with renewable energy in WA, with only 14% disagreeing with this proposition.

A free ride for big polluters:

- Western Australians reject LNG industry arguments that the costs of reducing and offsetting pollution from oil and gas sector should be borne by other sectors, businesses or taxpayers.
- An overwhelming 80% of respondents support or strongly support requirements for LNG companies to offset their pollution as proposed by the EPA, with only 7% disagreeing.
- Only 23% of respondents believe that it is acceptable for the broader community and other states to bear the cost of reducing pollution from WA's LNG industry.

As the only state with significant pollution growth and emissions that have risen by 23% since 2005 (almost entirely driven by the LNG industry) we welcome this opportunity to provide input in response to the Climate Change in Western Australia Issues Paper (the Issues Paper) as part of the Government's development of the State Climate Change Policy.

Our submission draws upon and should be read alongside the following:

- CCWA/Clean State Initiative (2019) *Runaway Train: The impact of WA's LNG industry on meeting our Paris targets and national efforts to reduce emissions report.* **(Attached)**
- Reputex (2018) *Offsetting Emissions from Liquified Natural Gas projects in Western Australia.* **(Attached)**
- CCWA (2019) *Submission to the Environmental Protection Authority's proposed greenhouse gas emission guidance submission*
- CCWA (2018) *Submission to the State Government's Health Inquiry*
- Renew WA (2019) *Reliable Jobs, Renewable Energy and a Safe Future for All. A Joint Call for Climate Action in WA*. November 2019. **(Attached)**
- Climate Analytics (2019) *1.5°C Compatible Carbon Budget for Western Australia*, which CCWA puts forward as an independent, credible and detailed piece of work that provides an example of the approach that the WA Government should adopt to inform climate policy in WA. **(Attached)**
- SEI, IISD, ODI, Climate Analytics, CICERO, and UNEP (2019) *The Production Gap: The discrepancy between countries' planned fossil fuel production and global production levels consistent with limiting warming to 1.5°C or 2°C*. **(Attached)**

2.0 Comments on the Issues Paper Overall

CCWA is concerned with several major omissions in the Issues Paper.

2.1 The Issues Paper lacks vision and leadership

As it stands, the Issues Paper lacks the vision and leadership shown in other jurisdictions such as Victoria and the ACT. Incremental change and a lack of ambition is not compatible with the response needed in 2019.

2.2 A legal framework is needed

Net Zero by 2050 must be legislated
A climate policy based on an 'aspirational' target is not acceptable in 2019. We need a long-term emissions reduction target to be entrenched in legislation and coupled with a scientific based emissions budget process based on interim targets.

This approach has been successfully adopted in other jurisdictions including the United Kingdom, Norway, Sweden, France, New Zealand, Scotland, Victoria, ACT and South Australia.

CCWA also acknowledges the local momentum for such legislation, with 54 prominent WA scientists calling for a Zero Carbon Act during the submission period[2].

CCWA strongly recommends the introduction of a 'Zero Carbon Act', and in line with leading legal and scientific experts and existing examples it should include six key features:

1. Establish emissions reduction targets
To achieve the Paris Agreement goal of limit global warming to 1.5°C, WA's CO^2 emissions will need to decline by 50% by 2030 and reach net zero by 2050 at the latest. Some jurisdictions are aiming for net zero by 2045.

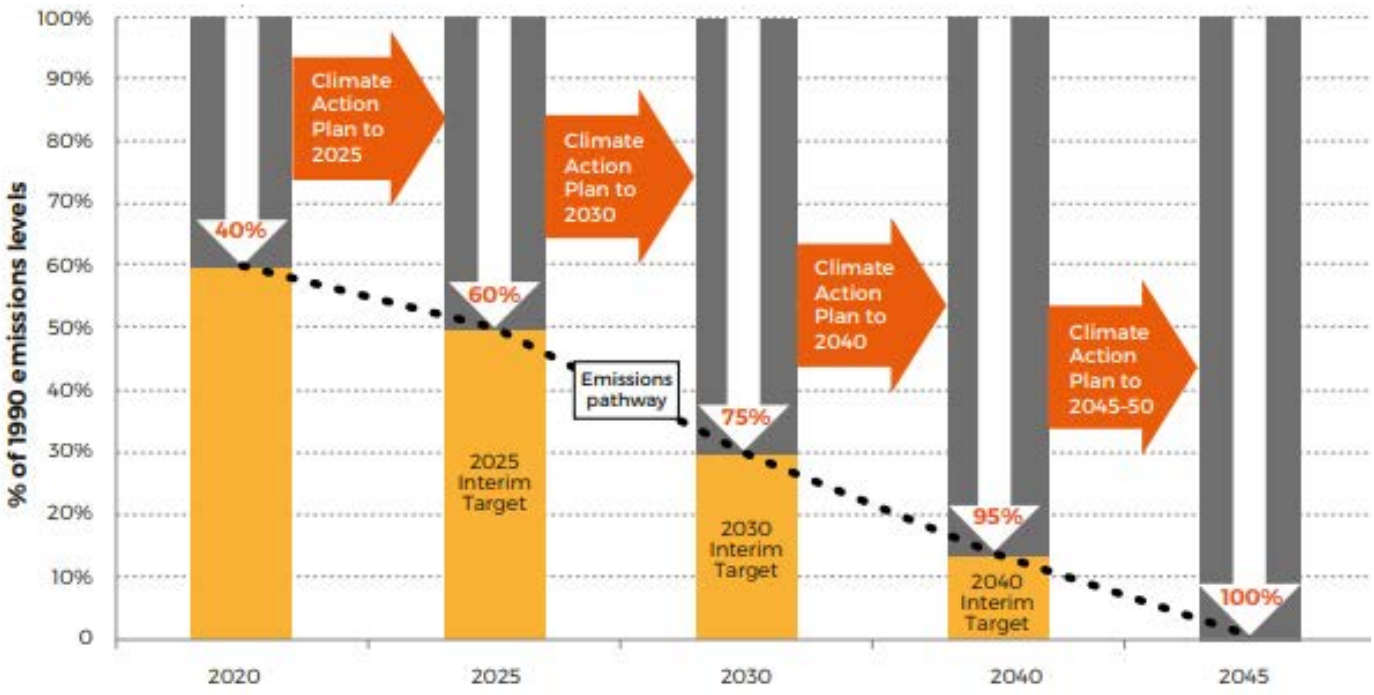
Legislation should establish targets to reduce carbon pollution in WA to 'net zero' by 2050 **at the latest**, with immediate reduction and shorter-term interim targets along the way.

The ACT Government as part of its 2017 *Climate Strategy to a Net Zero Emissions Discussion Paper* included interim reduction targets recommended by its Climate Change Council. These reduction targets were set below a 1990 base year and are:

- 50–60% by 2025
- 65–75% by 2030
- 90–95% by 2040

Figure 1 shows ACT's proposed pathway to net zero showing clear interim targets.

Fig. 1: ACT's Pathway to net zero emissions showing potential interim targets and climate action plans to 2050 at the latest



Box 1: Victoria's Climate Change laws

Victoria's *Climate Change Act 2017* commits Victoria to a long-term emissions reduction target of net zero greenhouse gas emissions by 2050, requires five-yearly interim targets starting in 2021, and establishes a pledging model for whole-of-government, key sectors and local government to meet these targets.

An Independent Expert Panel has also been appointed under the Act to provide advice on interim targets and how they could be achieved.

2. Set a 'carbon budget' for WA

It is essential for WA's climate policy to have a clear, science-based trajectory for all sectors to reach net zero by 2050 at the latest.

The best way to do this is to establish a 'carbon budget' process that sets emissions 'budgets' and reduction targets across all sectors of the economy, that are compliant with the Paris Agreement and global efforts to prevent warming of over 1.5 degrees. In November 2019 Climate Analytics released a '1.5 degree compatible Carbon Budget for WA'. **(Box 1)**

CCWA are advocating for a 1.5-degree compatible Carbon Budget for WA in the strongest possible terms. We make this as a standalone recommendation, separate to the matter of whether it is legislated or not. A Carbon Budget is an evidence-based approach to the translation of international emissions reduction and temperature goals into the necessary abatement efforts and scenarios for individual jurisdictions at the national and sub national level.

Many jurisdictions have already adopted this approach, including the UK which has legislated carbon budgets that restrict the amount of greenhouse gases the UK can legally emit in a 5-year period, every five years to 2050.

Oslo has also introduced an internal carbon budget, which aims to have emissions by 2020 and reduce emissions 95% from 1990 levels by 2030.

3. Require carbon budgets and pollution reduction plans for every sector of the economy

The ACT Government completed technical modelling of possible pathways to net zero by 2050 across the energy, building, transport, waste and land sectors, as part of its 2017 *Climate Strategy to a Net Zero Emissions Discussion Paper*. It used the concept of 'sectoral targets' to set individual targets for key sectors. It also analysed the costs and benefits of various emission reduction options and technical pathways for the impact on the ACT economy and released this to the community for discussion. Its modelling uses a range of assumptions around population growth, existing and emerging technologies, and the level of ambition that could be set.

4. Create an independent, expert, science-based Safe Climate Authority

Most jurisdictions with net zero legislation establish an independent expert body to provide advice to government and monitor progress towards mitigation and adaptation goals.

A 'Safe Climate Authority' or commission could be established under the Act to remove the politics and uncertainty surrounding our current policy. An independent body would set targets, review progress

Box 2: A 1.5°C compatible carbon budget for Western Australia

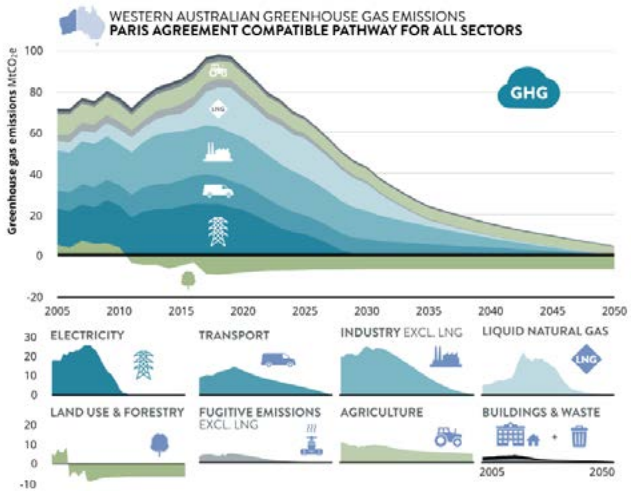
In a groundbreaking report released in November 2019, **Climate Analytics** have modeled a Carbon Budget for WA that is compatible with the Paris Agreement goals of limiting global warming to 1.5°C.

The report finds that without acting to reduce emissions, Western Australia is likely to use up 1.5°C compatible carbon budget within 12 years, but rapidly reducing carbon pollution will unlock significant economic opportunities for the state.

This study includes a detailed 1.5°C compatible carbon budget for **all sectors** of the Western Australian economy, from 2018 to 2050 and models GHG emissions pathway consistent with the Paris Agreement in each of those sectors. It also describes policy levers to get us there.

It shows WA's total GHG emissions peak around 2020 and decline to about 49% below 2005 levels in 2030, reaching net zero around 2050 contingent upon maintaining a large sink in the land use and forestry sector. The electricity sector decarbonises the fastest, reaching 100% renewable by the early 2030s.

Source: Climate Analytics (2019)



and report regularly on government, industry and community efforts to cut pollution.

The ACT's *Climate Change and Greenhouse Gas Reductions Act 2010* established a Climate Change Council to advise the Minister on matters relating to reducing emissions and addressing and adapting to climate change.

5. Measuring, reporting and verifying emissions
Currently there is a gap in the measuring and reporting of emissions in WA. The Issues Paper also lacked vital information on emissions for each sector it described.

In addition to establishing a transparent body that provides up to date information on WA emissions, the WA government should be required to regularly table reports to Parliament on progress towards meeting the carbon targets set out in legislation.

The ACT introduced the ACT Greenhouse Inventory (GGI) which is published each year to report on ACT emissions. The ACT GGI reports total emissions released minus those absorbed by their environment. Their issues paper included a clear summary of current emissions figures for each sector, and the statement that to achieve net zero by 2050 we need emission reduction measures in each of the sectors where emissions are generated.

6. Adaptation strategies
A separate whole-of-government adaptation strategy should also be established for WA, following the example of other Australian states and territories.

The ACT has 5-yearly implementation action plans and adaptation plans.

It's vital WA's climate policy includes the requirement for government to prepare an adaptation strategy for each 5-year carbon budget period.

2.2 The Issues Paper downplays the urgency

The IPCC have emphatically warned that 2020 is the critical year emissions must peak and then reduce rapidly, to have any hope of limiting global warming to 1.5 degrees.

We are entering the critical decade to take action strong enough to prevent a cascading series of impacts both locally and globally. As it stands, the Issues Paper badly misses the opportunity to inform the community on the urgency of the situation.

It also fails to fully inform the community of known global and local impacts from climate change.

Known Global Impacts

According to the IPCC Special Report the difference between limiting global warming to the 1.5°C target and reaching 2°C is catastrophic. According to 6000 works referenced in the report, at 2°C:

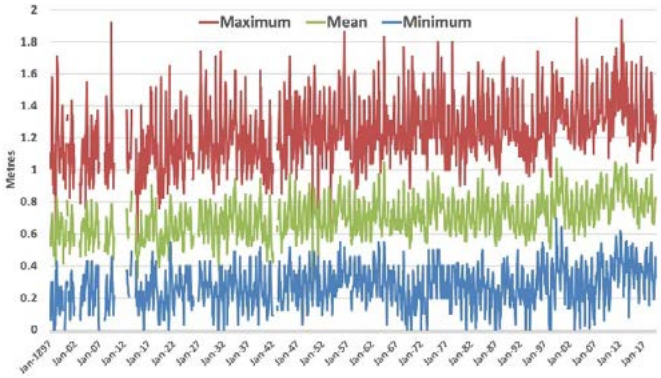
- 99% of coral reefs are lost
- Arctic sea ice disappears, and sea ice-free summers come every 10 years
- 10 million people are displaced by rising seas
- 65 million more people are exposed to deadly heat
- 50% more people are exposed to water stress
- Twice as many plants, twice as many insects (vital for crop pollination) and three times as many animals lose 50% of their habitat
- Fish populations decline by 3 million tonnes[3].

Known Local Impacts

The Issues Paper fails to fully inform the Western Australian community about our unique vulnerability to the impacts of climate change, the impacts that are currently being experienced and those that are projected to occur, most of which have been accurately observed by West Australian scientists for over a decade.

These impacts include rising sea levels which will continue to impact our coastal areas towns and cities **(Fig. 2)**, extended periods of drought which will continue to contribute to our drying landscape, and more frequent extreme weather events including floods and heatwaves. Western Australia is already one of the most fire-prone regions in the world, making us even more vulnerable to the impact of increasing temperatures, longer fire seasons and drying conditions driven by climate change[4].

Fig. 2: Fremantle Sea Level Data 1897–2019



(Source: Professor Ray Wills, December 3, 2019)

WA climate expert Professor Ray Wills has modeled and described impacts to WA for over a decade. He states forecasts from the Intergovernmental Panel on Climate Change (IPCC) suggest global temperatures are likely to rise in the range of 1.8°C to 4.0°C this century.

In Australia's latitudes, a warming of 1.0°C is enough to move climate belts in the southern half of Australia about 150 km south.

Warming of 2°C pushes the climate band 300 km south, Perth's climate would reach Margaret River, and would change the distribution and abundance of a huge range of species, and impact on agriculture, forestry, tourism and a raft of other economic activities.

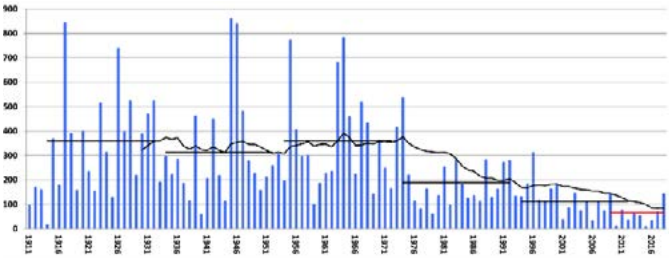
Warming at the more extreme range above 2°C has the potential to move climate belts 750 km, which would bring Carnarvon's climate to Perth, and push Eneabba's climate south past Albany in less than 60 years[5]. This would be completely catastrophic.

Specific impacts he describes based on 2 degrees of warming include:

- More frequent bleaching of coral and ocean acidification and impacts to tourism including damage to iconic natural areas such as coral bleaching at Ningaloo Reef. The Indian Ocean has warmed an average 0.6°C since 1960 – only another 0.4°C is needed for widespread and intense coral bleaching. The largest warming occurred off Northwest WA, and it is likely higher ocean temperatures will bleach coral and kill large parts of the Ningaloo Reef just as higher sea temperatures will kill large parts of the Great Barrier Reef.
- Shark Bay is particularly sensitive to changes in temperature and will impact the whole of the ecosystem – for example, changes in sea grasses are likely to impact the aquatic magafauna of Shark Bay
- Rising ocean temperatures and changes to the Leeuwin Current running along the entire WA coast will drive the southern migration of fish and marine creatures[6].
- Higher vulnerability to sea level rise, recording a rate almost three times the global average on the west coast since 1991. The Climate Council estimates for Fremantle that a one-in-a-100-year event would in 2100, presuming no action, would happen every month or so. **(Fig 2)**
- Declining rainfall and increased threat to and cost of water supply. **(Fig 3)**
- More intense, more frequent heat waves, impacting the vulnerable and elderly the most
- The southward spread of mosquito-borne-diseases

Further studies have suggested frequency of extreme weather increasing, with 'angry summers' now expected every 4 years for the next generation compared with about once in a lifetime for our great grandparents; and the decline of the Margaret River wine region, and the collapse of Western Australian crayfish and abalone industries.

Fig 3: Stream flows, South-West of WA 1911–2018



(Source: Professor Ray Wills, December 3, 2019)

In a landmark submission to the EPA guidelines consultation process, 30 Western Australian scientists recently presented their observations and research findings on climate impacts here in WA7.

These included:

In 2011–12 a marine heatwave killed more than 100km^2 of seagrass at the World Heritage region of Shark Bay, which resulted in emissions between 2-9 Tg CO2 being released into the atmosphere over the next 3 years[8].

Dr. Jatin Kala, Senior Lecturer in Atmospheric Science, ARC DECRA fellow and Contributor to the IPCC Special Report 2018 researched the impacts of more frequent, intense and longer lasting heatwaves on the southwest of Western Australia, and found the massive heat wave event of 2011 straddling terrestrial and maritime ecosystems triggered abrupt, synchronous, and multi-trophic ecological disruptions, including mortality, demographic shifts and altered species distributions, and had huge and cascading impacts across land and sea. In that period there were documented die-off events of plants and animals spanning many ecosystem types. Tree die-off and coral bleaching occurred concurrently in response to the heat wave, and were accompanied by terrestrial plant mortality, significant seagrass and kelp loss, population crash of an endangered terrestrial bird species, plummeting breeding success in marine penguins and penguin nest failures, and outbreaks of terrestrial wood-boring insects. These multiple taxa and trophic-level impacts spanned >300,000 km^2 – comparable to the size of California – encompassing one terrestrial Global Biodiversity Hotspot and two marine World Heritage Areas[9].

An iconic species of Banksia (*Banksia hookeriana*) has shown a >50% decrease in seed production since the 1990s, with the change attributable to decreased rainfall and increased temperatures. In combination with increased fire, the species is at risk of extinction. The researchers concluded it is likely that a number of plant species are facing similar circumstances[10].

The Southwestern region of WA is recognised as one of the most vulnerable regions to the effects of climate change. Researchers found the warming and drying climate in the southwest has many freshwater species and ecological communities already at the limits of their survival. Effects include reduced rainfall,

runoff and declining groundwater levels combined with increasing evapotranspiration and loss of unique cave fauna. Reduced flows and rising sea levels in WA have changed habitat distribution and quality in estuaries and rivers and have the potential for irreversible consequences in coastal freshwater wetlands[11].

Dr. Denis Saunders AM, Retired Chief Research Scientist at CSIRO, who recorded a dramatic decline in range and abundance of Carnaby's Cockatoo. Predictions of climate change in the southwest of Western Australia are that there will be an increased frequency of extreme weather events such as heat waves and severe hailstorms with detrimental impacts on species such as Carnaby's Black Cockatoo, and he found:

- Between October 2009 and March 2010, the species was subjected to a possible outbreak of disease in one of its major breeding areas and exposed to an extremely hot day and a severe localised hailstorm.
- Species such as Carnaby's Black Cockatoo which form large flocks are particularly susceptible to localised events such as hailstorms and contagious disease.
- Extreme temperatures may have major impacts on both flocking and non-flocking species.

2.3 The focus should be on structural change and economic transformation, not individual action

CCWA is concerned by the strong focus on individual action in the Issues Paper and the lack of an overarching narrative or leadership describing the structural, whole of economy, government-led solutions that are necessary for decarbonisation by 2050.

CCWA believes the underlying failure of the Issues paper, as it currently reads, is that it perpetuates the myth that individuals rather than specific sectors of the economy are driving Western Australia's rising emissions.

CCWA recommends the ACT and Victorian Discussion Papers as exemplars in addressing structural, rather than individual actions required to reach net zero emissions by 2050.

CCWA also recommends consideration of the *Exponential Climate Action Roadmap* – a detailed report outlining 36 areas identified by scientists, specialists, data modelers and academics to halve by scientists to halve global emissions by 2030[12].

Table 1: WA's 20 largest carbon polluters

	Facility name	Operator	Emissions* (million tonnes)
1	Wheatstone LNG*	Chevron	10
2	Gorgon LNG	Chevron	9.74
3	North West Shelf LNG	Woodside	7.65
4	Muja Power Station (black coal)	Synergy	3.98
5	Worsley Alumina Refinery/Mine	South32	3.58
6	Bluewaters Power 1&2 (black coal)	Synergy	2.96
7	Prelude LNG	Shell	2.7
8	Pluto LNG	Woodside	1.93
9	Collie Power station (black coal)	Synergy	1.85
10	YPF Ammonia Plant	Yara Pilbara Fertilizers	1.51
11	Pinjarra Alumina Refinery	Alcoa Australia	1.49
12	Wagerup Alumina Refinery	Alcoa Australia	1.45
13	Kwinana Alumina Refinery	Alcoa	1.25
14	Sino Iron Project Cape Preston	Citic Pacific Mining	1.18
15	Kwinana Refinery	BP Refinery	0.73
16	Pilbara Rail Operations	Pilbara Iron	0.68
17	CSBP Kwinana Facility	CSBP Limited	0.60
18	Telfer Gold Mine	Newcrest Mining	0.54
19	Murrin Murrin Operations	Murrin Murrin Operations	0.51
20	PRLO3 Rail – IOR Facility	BHP Billiton Iron Ore	0.51
TOTAL		**53 million tonnes** (60% of WA's total emissions)	

*Emissions for non-LNG facilities were for 2017–18 from the Clean Energy Regulator Safeguard Facility Reported Emissions data (May 2019)[1]; Emissions for LNG facilities use emissions figures anticipated at full production as reported in CCWA's Runaway Train Report (Nov 2019).

2.4 The focus should be on the biggest polluters not individuals

Western Australia has a unique emissions profile that is unlike most other countries or states, to the extent that it is dominated by a small number of very large polluters.

CCWA research shows just 20 facilities are responsible for 60% WA's emissions **(Table 1)**, and just 10 facilities are responsible for 52% of our pollution. These are owned by just 6 corporations including Chevron and Woodside.

WA's Climate Policy must prioritise emissions reduction strategies which target the biggest polluters first and this must be done in a way that avoids transferring abatement costs to other parts of the economy.

There are very sound reasons for this based on economic efficiency and equity. It is inequitable and economically inefficient to externalise, or transfer costs of pollution to others that are not in a position to avoid those costs by reducing the pollution. This is the basis of the 'Polluter Pays Principle' which must be adopted as a fundamental principle informing climate policy in WA.

Instead, various current policies do exactly the opposite. Emissions-intensive industries are encouraged to increase their emissions via:

- Ongoing subsidies which promote fossil fuel use
- Inadequate regulation of carbon pollution
- Inadequate policy settings and price signals; and
- No incentive to decarbonise.

2.5 Compared to other jurisdictions, WA's climate change measures are completely inadequate.

Figure 4 shows nine different policy measures that can be implemented by State governments. WA has only implemented one – compared to Victoria, Tasmania and the ACT which have implemented all nine.

CCWA recommends the State government adopt all nine policy measures in its climate policy.

2.6 The Issues Paper does not address WA's unique economic vulnerability

The Issues Paper fails to address the economic tipping points we have reached as the world begins to decarbonise, and downplays WA's economic vulnerability in a changing world, largely due to our reliance on mining and fossil fuel exports.

In 2019, just three products (iron, coal and gas) account for 60% of Australia's exports[13]. Western Australia is the main minerals and petroleum exporting region of Australia, and these products accounted for 85% ($109.6b) of WA's merchandise exports in 2017–18.

A recent Harvard University study describes policy trends which will leave Western Australia's economy blindsided by changing patterns of international demand. The study at Harvard's Center for International Development argues that in a changing world, prosperity will follow societies that hold a diversity of knowhow and are able to recombine it to create a larger variety of smarter and better products. A central measure of the study, the Atlas of Economic

Figure 4: A comparison of climate change measures implemented by State Governments
(at December 2018)

	WA	QLD	NSW	VIC	SA	TAS	ACT	NT
Decreasing pollution since 2005	✗	✓	✓	✓	✓	✓	✓	✓
Whole of government climate change policy	✗	✓	✓	✓	✓	✓	✓	✓
Climate change legislation	✗	✗	✗	✓	✓	✓	✓	✗
Net zero emissions target by 2050	✓	✓	✓	✓	✓	✓	✓	✓
Legislated emissions reduction targets	✗	✗	✗	✓	✓	✓	✓	✗
Renewable energy targets	✗	✓	✗	✓	✗	✓	✓	✓
Energy efficiency schemes	✗	✗	✓	✓	✓	✓	✓	✓
Legislated climate adaptation plan	✗	✗	✗	✓	✓	✓	✓	✗
Statewide climate risk assessment	✗	✗	✗	✓	✗	✓	✓	✓
Regional or sectoral vulnerability assessments	✗	✓	✓	✓	✓	✓	✓	✗

Complexity, expresses the composition of a country's productive output and reflects the structures that emerge to hold and combine useful knowledge.

By relying so heavily on a narrow range of products, and by failing to develop industries which value add to our competitive advantages, Australia has slipped to 93rd in the world on the study's economic complexity index, trailing behind developing countries like Namibia and Uzbekistan.

The study warns that after 28 years of growth, economic progress will be be hamstrung as the carbon bubble looms, particularly when policymakers continue to support new fossil fuel projects at the expense of policies which support the diversification of our economic structure.

Strong leadership and policies to decarbonise by 2050 will create many thousands of jobs and reposition Western Australia as a state ready to harvest the new wave in low carbon technology, energy, manufacturing and innovation. Rapid technological advances continue to drive significant reductions in the cost of renewable energy and battery storage, and compound Western Australia's competitive advantage in sun, wind and hydro. As net-energy importing countries like Japan and South Korea pledge to take steep decarbonising trajectories toward 2050, the Western Australian Government must create the right policy and investment environment to position ourselves as providers of clean energy, steel and aluminum exports, and harness the beginning of the zero emissions boom.

2.7 The Issues Paper lacks basic, crucial data on WA's sectoral emissions and trends

CCWA notes the lack of crucial data on emissions by sector in the Issues Paper is confusing, and has required dedicated resources to find this data ourselves. It also means the community has not been provided with the full picture when making their submissions, diminishing the quality of public debate on this critical issue.

2.8 State Government climate change policy should be guided by the Environmental Protection Act

As discussed previously, we advocate for new standalone climate change legislation to provide a statutory framework for action on climate change by all sectors in Western Australia.

In the absence of a dedicated legislative framework for as proposed, the WA Environmental Protection Act 1986 provides useful guidance for the development of climate change policy by the State Government.

In particular, the principles contained in Section 4a of the Act, which are the same or similar to the United Nations Principles of Sustainable Development should apply to any climate change policy. They are:

1. **The precautionary principle**. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
   In the application of the precautionary principle, decisions should be guided by –
   a. careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and
   b. an assessment of the risk weighted consequences of various options.
2. **The principle of intergenerational equity.** The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
3. **The principle of the conservation of biological diversity and ecological integrity.** Conservation of biological diversity and ecological integrity should be a fundamental consideration.
4. **Principles relating to improved valuation, pricing and incentive mechanisms:**
   a. Environmental factors should be included in the valuation of assets and services.
   b. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.
   c. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes.
   d. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.
5. **The principle of waste minimisation.** All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.

We submit that these principles are very relevant to the development of policy on climate change for WA and should be adopted as guiding principles for the development of such policy.

Recommendations: Overarching priorities

1. **WA's Climate Policy needs a dedicated legal framework.**
   CCWA join with 54 prominent scientists to call for 'Zero Carbon Legislation' which must include:
   - A legally binding emissions reduction target
   - Carbon budgets for all sectors which set interim emissions reduction targets
   - An emissions reduction strategy
   - An adaptation strategy
   - An independent, expert body to provide advice, set interim targets and monitor progress; and
   - A Greenhouse Gas Inventory (GGI) published each year to report on WA emissions.

WA's Climate Policy should:

2. Develop and implement a **1.5 degree compatible Carbon Budget for Western Australia** as a matter of policy priority. A Carbon Budget is an evidence-based approach to the translation of international emissions reduction and temperature goals into necessary abatement efforts and scenarios for individual jurisdictions at the national and sub national level. This approach should be adopted as the foundation for any credible science-based climate policy and should be codified in legislation but is necessary regardless.
3. Adopt a sectoral approach towards the decarbonisation of each sector of the economy by 2050 and target the largest pollution sources first as a matter of priority in line with the polluter pays principle.
4. Provide more information on known and projected global and local impacts of climate change and inform the community more accurately on the projected impacts in WA to 2050 and beyond.
5. Acknowledge WA's current economic vulnerability in a decarbonising world and work with industry and civil society to provide a roadmap for security and jobs in each sector of the economy.
6. Ensure adequate funding for Western Australian science and research to better understand the impacts of climate change here in WA, as well as innovations and opportunities in mitigation and adaptation.
7. Establish a dedicated Climate Change unit within the Department of Premier and Cabinet to reflect the importance and scale of the task ahead, and the need for whole of government approach.
8. Reflect the principles of Section 4 of the Environmental Protection Act.

3.0 Issues and opportunities for WA

3.1 Transforming energy generation

Our state boasts some of the best solar and wind resources in the world. Decarbonising WA's electricity sector holds the greatest potential for WA to reduce its rising emissions levels at the lowest cost. It will also unlock the benefits of cheaper, cleaner and more reliable power for households and businesses.

3.1.1 What are the main challenges for decarbonising WA's electricity sector?

The Electricity sector accounts for 29% of WA's total emissions[14], and emissions on the SWIS have increased by 16% since 2005[15].

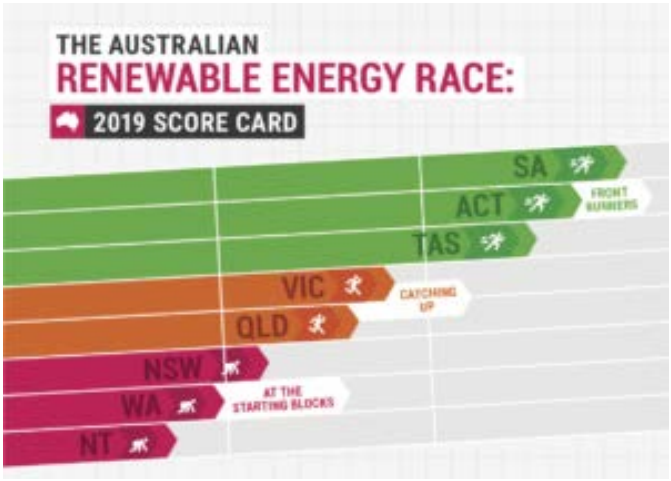
Despite having one of the best solar and wind resources on the planet, transformation in the power system has come slowly in WA and renewables only account for 16% of the total on the South West Interconnector System (SWIS), and 8% of the State's total energy use.

WA has the second lowest renewables mix of all states and territories[16]. **(Table 2)**

CCWA strongly believes the main challenges for decarbonising WA's electricity are not technological but political in nature.

A lack of planning and policy ambition have created an inertia that is inexplicable in such a renewables-rich state.

Fig 5: 2019 Renewable Energy Scorecard



(Source: Climate Council 2019)

WA is the only state without a Renewable Energy Target. WA also lacks an energy efficiency scheme, despite Victoria, NSW, SA and the ACT having schemes in place. **(Fig 1)**

WA also lacks a pricing mechanism on pollution. This would be one of the single most effective instruments to not only drive down pollution by our biggest polluters, and spur investment in our local renewable industry.

CCWA also acknowledge numerous examples of community energy projects and large-scale renewable

Table 2: Renewable Energy Targets and achievements in Australian States and Territories

	Renewable electricity (2018)	Wind & solar capacity per person (kW) (March 2019)	Renewable energy targets	Highlights
SA	51%	1.25	Net 100% in the 2030s	Over 50% wind and solar energy already in the grid. Is likely to reach 100 per cent renewables by 2025.
ACT	54%	1.27	100% by 2020	On track to achieve 100% renewable energy on 1 January 2020.
TAS	95%	0.60	100% by 2022	
VIC	17%	0.34	25% by 2020 40% by 2025 50% by 2030	Legislated 50% target b 2030. Greatest capacity of wind and solar projects in the pipeline.
QLD	9%	0.38	50% by 2030	Installed the most large-scale wind and solar per capita in the last year.
NSW	17%	0.25	-	Shortlisting large-scale renewables and storage and supporting uptake of rooftop solar and batteries.
WA	8%	0.28	-	
NT	4%	0.12	50% by 2030	

Adapted from Climate Council (2019) and Renew Economy

projects that cannot gain access to an already over-supplied grid described in WALGA's submission. Local governments want to partner with or support renewable projects (including via power purchase agreements) but cannot due to issues with being able to connect to the grid and regulatory barriers[17].

CCWA also strongly challenges the negative framing of renewables in this section in the Issues Paper.

The Issues Paper states that "greater levels of large-scale renewables generation will create challenges for security and reliability and for how electricity grids are operated" for example. While a shift toward renewable generation sources may require further investments in grid infrastructure and a mixture of technologies will be needed in the transition to maintain security, reliability and affordability, neither of these are a valid barrier to the inevitable transition.

The Issues Paper also estimates "over $10 billion of investment is required in infrastructure, storage and large-scale generation" if WA is to make a contribution to national emissions reduction. However, this figure seems arbitrary as it is not attached to any target or generation figures, it can only be concluded it's used to mischaracterise renewables as expensive and unreliable. This is an arbitrary and negative way to frame investment in a jobs-rich transition that is essential and inevitable.

In most parts of the world, renewables are now the cheapest source of new power generation. They have reached market maturity and outcompete fossil-fuel incumbents on price, performance and pollution. In Germany, policy support and decreasing costs have made renewables the number one source of electricity within two decades. Rapidly declining technology costs mean battery storage combined with wind and solar is now competitive with coal and gas. In some places it's cheaper to build new renewable installations than to keep existing fossil-fuel plants running[18].

On this point CCWA notes WA has consistently underperformed in applying for and receiving federal funding for renewable generation.

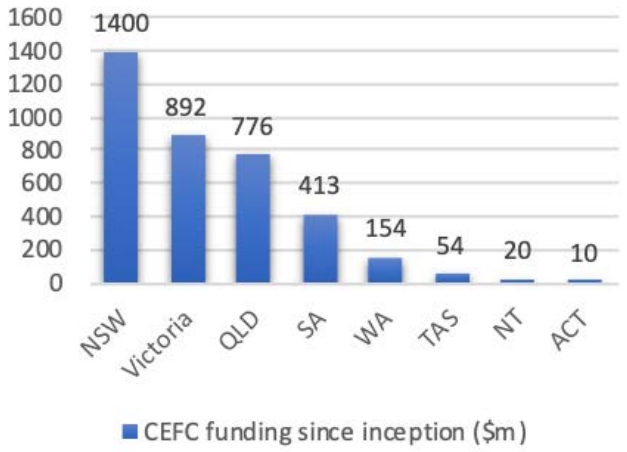
In 2018 just two renewable energy projects were completed. Meanwhile, the WA mining industry received $6.2 billion in subsidies from the State Government over six years from 2008–2014[19].

ARENA
Just 26 out of 486 projects funded by ARENA have been in WA, receiving funding of $130 million out of a total of $1.46 billion[20]. This is equivalent to just 5% of total funding.

The Clean Energy Finance Corporation (CEFC)
Since inception, the total value of CEFC commitments reached $3.7 billion (at 2017–18). Of this WA received only $153.3 million, equivalent to 4% of total funding. **(Fig 6)**

By comparison, QLD and SA (states with smaller populations than ours) received $775.2 million and South Australia $412.6 million[21].

Fig 6: CEFC funding since inception ($m)



3.1.2 What are the most effective ways to overcome these challenges by 2030?

Renewable Energy Target
WA's climate policy is meaningless without a legislated Renewable Energy Target.

CCWA recommends introducing a Renewable Energy Target of 100% by 2030 with an interim target of 30% by 2020.

It would also be valuable to investigate the establishment of a new government authority to oversee the transition, responsible for planning and leveraging investment into the construction of new energy generation, and phasing down our ageing fleet of thermal generators.

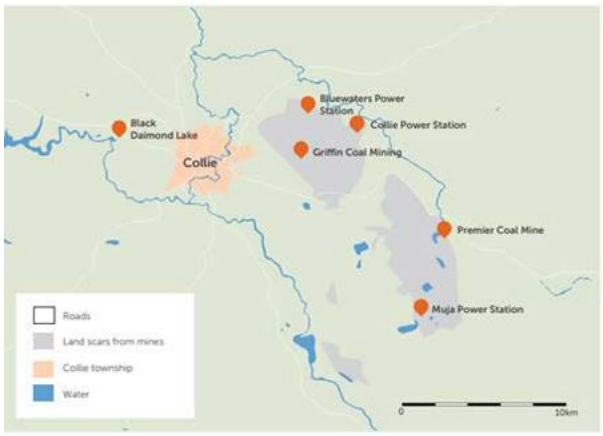
A staged, stable closure of fossil-fuel power stations
About 1000MW a year in new renewable capacity will need to be added to the grid as we power down our most polluting and inefficient coal and gas-fired power stations. CCWA recommends a timetable could be developed to phase down power stations based on emissions intensity and air pollution standards that will need to be developed. By 2030 all coal generation could be phased out and gas turbines can be retained and modified to run on sustainable biomass or hydrogen during shortfall periods of low solar and wind supply.

Box 3: Collie at the Crossroads: The opportunity to transition Collie to a renewable energy and low carbon industry hub

The *Collie at the Crossroads* report by Beyond Zero Emissions (BZE) describes how a local workforce geared towards sustainable industry and manufacturing can underpin the next century of prosperity for Collie's people. It outlines a range of industries set to grow rapidly in coming years and estimates the secure, well-paid jobs they can create in Collie. It found achieving a 100% renewable SIWS could help to create 1750 new jobs in Collie-Bunbury, including

- 1245 jobs in renewable energy transition, (including renewable energy manufacturing, operating a 200MW pumped hydro in the retired coal pits, coal plant decommissioning, and a green hydrogen peaking plant)
- 330 jobs in sustainable building materials (including low carbon cement, steel and wood products, and farm forestry); and
- 175 jobs in recycling renewable products (including lithium battery and solar PV recycling)

The creation of over 1750 jobs in Collie is estimated to be worth $15.4 billion in investment, and more than offsets the loss of 1250 positions in the coal industry. The transition described would also avert more than 14 million tonnes of carbon emissions per year by 2030.



Source: Beyond Zero Emissions (2019)

CCWA acknowledges we have a responsibility to ensure a just and stable transition for workers in the coal, oil and gas industries. The global energy market is undergoing massive structural shifts, and as the 197 signature countries to the Paris Agreement implement their decarbonisation plans there will be an inevitable and rapid shift to renewables and low or zero carbon industries.

While employment in coal, oil and gas in WA is a relatively small employer overall, it's important to develop a transition plan now.

According to the ABS, there were 14,700 people employed in oil and gas extraction in WA in April 2019[22], and about 1250 employed in Collie's coal mines and power stations[23].

A fair transition

The transition to a decarbonised electricity system must include a comprehensive workforce transition plan to ensure workers in Collie's coal industry are ensured secure, permanent jobs in renewable energy and clean industries. **(Box 3 & 4)**

WA's two black coal mines are located in Collie, employing almost 900 people. Hundreds more are employed at Collies Muja, Bluewaters and Collie 1 power stations.

Collie faces a challenge dozens of communities around Australia will confront over the coming years. For Collie and the wider region to prosper, a transition that provides certainty for workers in Collie's coal industry and its 9000 residents is vital.

WA's 'Sustainable Energy Now' (SEN) organisation has described Collie is an ideal future renewable energy hub due to its high quality solar, wind and biomass resources, is ideally located to supply energy to the SWIS where there are already billions of dollars invested in power generation and transmission infrastructure, and its local work force is already skilled in electricity generation and maintenance, with transferable skills relevant to large scale, utility size renewable generation.

Ambitious energy efficiency program

The worst energy efficiency program you can come up with will still be a cheaper way to abate emissions than the best renewable energy program[24]. Australia has a target of a 40% increase in energy efficiency by 2030, but it's not on track to meet it, and is the worst developed country for energy efficiency out of the top 25 energy-consuming countries. WA has no efficiency target.

In comparison California in the 1970s generated the equivalent of two power plants of energy just by improving the efficiency of fridges. China set a target of 20% improvement in just five years to 2010 (and exceeded it)[25].

CCWA strongly advocates for an 'energy efficiency first' approach to energy generation and capacity. Cutting our electricity demand by at least one third through energy efficiency by 2030 is also recommended.

A report by the Energy Efficiency Council in June 2019 found Australian households could save $790 a year on bills by adopting existing global standards on energy efficiency. Adopting measures used in Germany would also create 70,000 new full-time jobs, which could translate to about 7000 here in WA and range from advanced engineering to plumbing.

The report found that adopting best practice from around the world would "easily deliver half of the abatement required to meet Australia's target to reduce emissions by 26–28% by 2030"[26].

Removing perverse incentives
Removing fossil fuel subsidies, providing access to institutional capital for clean energy investments, investing in modernised grid infrastructure and decentralization of power production will also reduce the challenge to decarbonise[27].

Fair pricing of carbon emission will also accelerate the transition, and the WA government is encouraged to pursue this at a national level.

BOX 4: 'Life After Coal' legislation, LaTrobe Valley, Victoria

The Victorian Department of Environment developed a 'Life After Coal' report exploring what a just, and well-managed, transition process for the Latrobe Valley might look like in 2016.

In 2019 the government introduced legislation (the LaTrobe Valley Support Mineral Resources Amendment Bill) to extend the mine licenses of the Latrobe Valley's major power plants (which entered closure in 2017) to ensure at least 17 years of rehabilitation, giving certainty to local communities and mine workers. The extension does not affect the closure dates of the mines but creates thousands of jobs in mine site rehabilitation, which is far more labor intensive than coal mining or coal-fired power generation[1].

It also introduced the Latrobe Valley Worker Transfer Scheme, which is designed to support the workforce to transition to new opportunities prior to and following any closure of the power stations, by providing training, upskilling and support for workers and their families.

Incentives for battery storage and production
The Issues Paper acknowledges "declining technology costs may soon put battery storage combined with renewable sources such as wind and solar PV on a par with conventional energy sources. Decarbonising our electricity sector at reasonable cost will soon be within reach".

CCWA acknowledges 27% of WA households have adopted solar power, the second largest share in Australia. Incentives should be introduced to drive battery storage uptake. CCWA also notes the benefits of rooftop solar and battery storage are not shared equally, and people living in private rentals, social housing, and remote or vulnerable communities are most likely to live in inefficient housing without access to solar.

CCWA strongly recommends the urgent adoption of statewide program which provides a mass rollout of solar and battery storage to low income, social housing, rental households, and remote communities for the adoption of solar and battery storage. (This is covered in more detail in Section 3.11)

There are many examples of government support for battery storage around the world:

- California has a comprehensive battery storage policy, with rebates for consumers who install energy storage systems and a target of 1.3GW storage to be installed by 2020 for the state's three largest investor owned utilities.
- New York and Japan also have generous rebate schemes, with Japan covering two-thirds of the cost of a system.
- Germany provides financing for 30% of the initial investment in battery storage at low or fixed interest rates.

Electricity overbuild required to accommodate electrification of all sectors
The Issues Paper acknowledges that "reducing emissions from electricity supply has the potential to catalyze emissions reductions in other sectors, for example through electrification of transport."

This underplays the significance and opportunities that lie in decarbonising our energy system and electrification of other sectors including transport and industry simultaneously.

This will require modeling of the overbuild required to accommodate decarbonisation of other sectors (such as transport and industry) by electrification. Climate Analytics estimate electricity demand will increase by a factor of 3.7 by 2050 compared to current levels, due to electrification of end-use sectors (transport, buildings, industry), despite increased energy efficiency in end-use sectors[28].

3.1.3 Should the electricity sector make a pro-rata contribution to Australia's national greenhouse gas emission targets?

No. The electricity sector is the most effective and affordable of all sectors to achieve deep cuts to emissions. Achieving net zero emissions by 2050 means that wealthy states with high emissions per person such WA also have a responsibility to act faster. CCWA also emphatically emphasizes that Australia's commitment of 26–28% reduction by 2030 is completely inadequate and puts us on a trajectory to 3–4 degrees of warming.

3.1.4 How fast should the transition occur?

CCWA advocate for the transition to occur as fast as possible, especially given the electricity sector can reduce emissions much faster and at less cost than any other sector.

Many credible studies have found that the SWIS, WA's main grid, can transition to 100% Renewable sources by 2030. These include:

- *90–100% Renewable Electricity for the South West Interconnected System of WA* (ANU, 2017)[29]
- *Energy 2030* (Sustainable Energy Now, 2017)[30]
- *Collie at the Crossroads – Planning a future beyond coal* (Beyond Zero Emissions, 2019)

Climate Analytics modeled a Paris Agreement compatible and cost optimal emissions pathway for electricity generation to be one third renewable by 2025, 90% renewable by 2030 and 100% in the early 2030s. This means phasing out coal before 2030 and gas shortly afterwards. This would reduce emission by 95% by 2030 and be net zero by 2035[31].

The Beyond Zero Emissions (BZE) study estimated transitioning to 100% renewable energy will create 5000 jobs in construction and maintenance across WA, in addition to installation and maintenance jobs between 2020-2030. It would also avoid 86 Mt Co2-e by 2030 and 13 Mt annually from 2030 onwards and would cost $15+ billion in investment.

CCWA also acknowledges rapid transitions are already occurring rapidly in other jurisdictions, many with less favorable conditions than ours, including:

- South Australia recently saw solar reach an 80% share of demand, and its 100MW Tesla battery (the largest in the world) paid back a third of its cost in the first year through services provided to the local grid
- Germany's grid is running on a renewables share of 56.5% and has set a goal of 63% renewable power by 2030
- Denmark is currently generating 44% of its grid power from wind, and aims to have 100% renewable energy for heat and power by 2035; and
- India plans to build 100GW of solar capacity by 2022 to meet its Paris Agreement commitments, and 50% of all new energy capacity in India came from solar in 2018[32]

Box 5: 85% Renewable Electricity in WA by 2030

Sustainable Energy Now (SEN) is an independent WA-based organization comprised of energy professionals, engineers, coders and computer modelers.

Their Renewable Energy Roadmap '85% Renewable Energy on the SWIS by 2030' released in December 2019 provides a transition model for the SWIS with projections for employment in the wind, solar and coal industries.

It estimates transitioning to 85% renewable electricity by 2030 would create up to 6000 jobs each year, including:

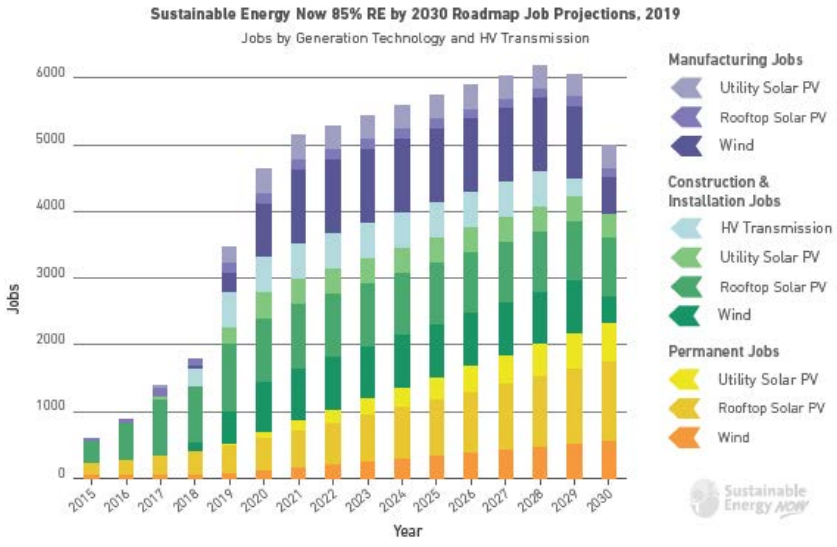
- 1600 manufacturing jobs
- 2600 construction and installation jobs
- 2300 permanent (operations and maintenance) jobs

It also recommended a transformation of this scale must be harnessed to create and support local manufacturing industries, and their figures assumed a 10–33% local manufacture component, depending on the technology.

The study proposes a total of 9300MW renewable capacity by 2030, including

- 5400 MW wind
- 2000 MW rooftop solar
- 1900 MW utility solar

It also includes a timetable for a staged, stable closure of WA's four coal fired power stations (Muja AB, Muja CD, Collie and Bluewaters). As the power stations wind down, approximately 930 MW of renewable energy is added each year.



- In October wind power generated 98% of Scotland's electricity needs
- In 2017 China installed the largest amount of solar PV and wind capacity of any country and has committed to generating 35% of its electricity from renewables by 2030

Sweden is aiming to eliminate fossil fuels from electricity generation by 2040 and has challenged everyone to joio them in the race to become the first 100% renewable country. Costa Rica aims to be entirely carbon neutral by 2021 and is already generating 95% of its electricity from renewable sources. Nicaragua has pledged 90% renewables by 2020, and Morocco has constructed the largest concentrated solar plant on earth, which along with its existing wind and hydro plants will provide half of Morocco's electricity by 2020[33].

CCWA acknowledges the State Government has established a Future Battery Industry Strategy, a $10 million hydrogen program and Renewable Hydrogen Council, and a $20 million Collie Futures fund. We also acknowledge the Government's recently released Energy Transformation Strategy, which includes a whole-of-system plan for the south-west, and a Distributed Energy Resource Roadmap to guide the integration of distributed energy sources including renewables and storage.

However, without being aligned to a state Renewable Energy Target and Roadmap to decarbonise the electricity sector by 2050, these initiatives are ad hoc, lack meaning, and aren't happening fast enough.

Recommendations: Energy Generation

The Climate Policy should prioritise the energy sector for faster, early emissions reductions and:

1. Develop a roadmap to decarbonise WA's energy sector well before 2050 and as soon as mid 2030's.
2. Introduce a Renewable Energy Target for the state with legislated interim targets. CCWA recommends the adoption of a 100% Western Australian Renewable Energy Target (WA RET) by 2030, with an interim target of 30% by 2020. This will require modeling of the overbuild required to accommodate decarbonisation of other sectors (such as transport, industry, buildings) by electrification. Climate Analytics estimate electricity demand will increase by a factor of 3.7 by 2050 compared to current levels, due to electrification of end-use sectors (transport, buildings, industry), despite increased energy efficiency in end-use sectors. Beyond Zero Emissions have recommended a Legislated 100% renewable energy target by 2030 to ensure WA becomes competitive with the east coast for investment and innovation.
3. Develop and fund a comprehensive workforce transition plan to secure jobs for workers in Collie's coal industry into secure, permanent jobs in renewable energy and clean industries. This could be part of a legislative package to reach the 100% RET.
4. Begin a genuine community engagement process with the Collie community and greater Bunbury region on how to best plan and manage an orderly phase out of coal-fired power stations, transition to cleaner energy sources and an industry-wide training, reskilling of workers to other sectors.
5. Consider establishing a new government authority to carefully plan, oversee and drive the transition to 100% renewable energy.
6. Introduce an Energy Efficiency Scheme, including energy efficiency retrofits to align with other states and a target to cut energy demand by one third
7. Shift the NWIS to clean energy sources and require large energy users to report energy efficiency opportunities
8. Assertively pursue more Commonwealth funding through ARENA and the CEFC to support the low-carbon transition
9. Fast track regulatory changes to the electricity market to enable community renewable energy projects, and allow large scale 'front of the meter' renewable energy projects and power purchase agreements (WALGA)
10. Provide funding and incentives for residential solar and battery installation
11. Introduce a program to enable lower income and rental households to install solar and battery systems.

3.2 Industry innovation

Decoupling energy use and emissions should be the major focus of our new climate policy, as this will largely shape WA's decarbonisation trajectory to 2050. Innovation will be a key driver of this transition, by creating efficiency improvements and helping local industry to capitalise on zero-carbon technology. The WA government must act as the facilitator of this decoupling process, by placing adequate controls on major polluters and supporting innovation for industry in WA.

CCWA welcomes the Issues Paper focus on WA's Resources sector, which is a huge consumer of energy and the largest single source of greenhouse gas pollution in the state.

CCWA strongly emphasise that the following points must be included in a fit for purpose climate policy.

1. The climate policy must explicitly rule out fracking and unconventional gas as a future industry or energy source on climate grounds.
A study published in March 2018 looking at the implications of exploiting Canning Basin and other unconventional gas resources showed that the domestic carbon pollution from the full exploitation of all of Western Australia's gas resources would be 4.4 times higher than what Australia's entire energy system can emit to comply with the Paris Agreement[34]. This included an estimate of between 19.5–28.9 billion tonnes of CO2-e from WA's unconventional gas resources.

In September 2018 more than fifty of Australia's top scientists and experts delivered an open letter to the WA Government, calling for a permanent ban on gas fracking to prevent a massive increase in carbon pollution, and to avoid dangerous climate change.

Signatories to the letter included Professor Fiona Stanley AC, former Australian of the Year; Professor Carmen Lawrence, former Premier of WA; Professor Peter Newman AO, WA's 2018 Scientist of the Year, Ian Dunlop, former Chairman of the Australian Coal Association and Shell executive, and some of Australia's leading climate scientists including Professor Graeme Pearman, Professor Andy Pitman, Professor John Church, Professor Will Steffen, Professor Katrin Missner, and Professor Steven Sherwood.

CCWA along with 38 prominent scientists rejected the findings of WA's Fracking Inquiry on climate change and carbon pollution, due to highly questionable assumptions which downplayed the climate change impacts of fracking and its finding supporting fracking in WA could not be relied upon by government or the community[35]. For example:

- The Inquiry ignored the largest pollution source from fracking, the combustion of the gas, which accounts for up to 80% of the total carbon pollution from fracking;
- The Inquiry assumed that the size and scale of the fracking industry would be small, supplying the domestic market only - despite government estimates of a much larger resource and potential for fracking to supply much larger export markets; and
- The Inquiry assumed that gas fracking would result in less conventional gas being developed in WA, and therefore only the marginal increase in pollution should be considered[36].

In addition to these climate impacts,

- Fracking uses and pollutes vast quantities of water which will be increasingly valuable and critical to preserve for food production in a drying climate
- Fracking fragments landscapes and impacts biodiversity in ways that reduce the resilience of natural ecosystems and make them less able to adapt to climate change
- Fracking impacts the health of communities through pollution to air and water and makes communities and individuals more vulnerable to the impacts of climate change events like heat stress and extreme weather events.

CCWA emphasise that unconventional gas mining (fracking) is completely inconsistent with a safe climate future. The climate policy must explicitly rule out fracking and unconventional gas on climate grounds.

2. The climate policy must also explicitly rule out uranium mining and nuclear energy in Western Australia as a future industry or energy source on climate grounds
The policy of the State Government to allow fracking and uranium mining in Western Australia must be reversed. These forms of mining are extremely energy intensive, harmful to the environment, produce toxic waste, is opposed to by Traditional Owners and local communities, is are completely inconsistent with any modern climate change policy. During 2019 there has been three inquiries into nuclear power in Australia, which have proven to be an expensive distraction from addressing the very real need to transition to renewable energy. Nuclear energy and uranium mining are dangerous, with lasting waste issues, high water requirements at every stage of the chain, is expensive and faces long delays to construct, and is deeply unpopular in the community. The industry has no social license and no place in a safe climate future.

3. The size of pollution produced by WA's mining industry is unsustainable and incompatible with the Paris goal.

WA's 20 largest polluters include 11 mining facilities (including 5 LNG facilities), three Alumina refineries, and three coal fired power stations. **(Table 1, page 9)**

WA's mining industry is the largest and fastest growing source of carbon pollution in WA, and this is being driven by the LNG industry.

While CCWA acknowledge WA's Resources Industry overall is a major polluter, the focus of this section is on WA's LNG Industry which is the state's single largest source of greenhouse gas emissions.

CCWA and the Clean State initiative's recent report, *'Runaway Train: The impact of WA's LNG industry on meeting our Paris targets and national efforts to tackle climate change'* provides a sobering picture of the scale and impact of greenhouse gas emissions from just five LNG facilities in WA. **(BOX 1 and Attached)**

At full production, WA's five LNG facilities will emit more than 32 million tonnes of greenhouse gas, equivalent to 36% of WA's total annual emissions[37].

3.2.1 What are the barriers to decoupling energy use and emissions in the resources sector?

The major barriers to controlling greenhouse gas emissions and decoupling energy use and emissions in the LNG industry are:

- Inadequate or unenforced controls on pollution
- No penalties for breaching pollution conditions
- No incentives to reduce emissions
- Perverse incentives to use fossil fuels
- A significant level of almost unavoidable fugitive emissions; and
- Significant political influence of major polluters

Clean State strongly advocates for all sectors of the WA economy to decarbonise by 2050, on a trajectory that involves deep and immediate reductions, and that will reach net zero by 2050. WA's Climate Policy will need to articulate how this can be done, and the WA LNG industry, or any major polluter for that matter, cannot be exempt from these policy settings or goals.

BOX 6: CLIMATE CODE RED: WA'S LNG INDUSTRY

CCWA and the Clean State initiative's report, *'Runaway Train: The impact of WA's LNG industry on meeting our Paris targets and national efforts to tackle climate change'* is attached.

It found:

1. LNG production in WA is the fastest growing pollution source in Australia and has been the primary driver of recent national emissions growth.
2. There are no effective restrictions, controls or regulation on WA LNG emissions.
3. Emissions from five current WA LNG facilities (32 million tonnes per year) will account for 36% of WA's total annual emissions at full production. This figure jumps to 47% if Woodside's proposed Burrup Hub expansion is approved.
4. WA's LNG facilities are amongst the ten biggest polluters and emit 2.5 times more carbon pollution than WA's oldest, dirtiest coal fired power stations.
5. Carbon pollution from WA's LNG production is breaching the Paris Agreement. Emissions from current and proposed WA LNG projects are equivalent to a 61% increase on WA's 2005 emissions baseline.
6. Greenhouse gas emissions from WA's current and proposed LNG facilities combined is as large as the total annual emissions of countries such as Ireland, Switzerland, Sweden, Hong Kong, New Zealand and Denmark
7. WA's LNG pollution is undermining Australia's national efforts to reduce emissions. Annual emissions WA's five LNG plants (32Mt) is almost five times greater than the annual savings made by Australia's 2.1 million solar rooftops every year.
8. The carbon abatement made over the lifetime of the $4.5 billion Emissions Reduction Fund will be cancelled out by just 12 years of WA LNG pollution.
9. Offsetting LNG pollution in WA would create 4000 jobs. These new jobs would be mostly in the regions and would include tree plantings, large scale renewable energy, rangeland regeneration and savannah burning activities.
10. There is no such thing as 'clean' gas. Elevated methane levels negate any advantage over coal, and a major international review found the threat to climate from LNG is as large or larger than coal.

CCWA emphatically notes that nothing outlined in this submission will make a difference if LNG operations continue without emissions controls.

To this end, CCWA recommend the following, as part of a coherent and effective State Climate Policy.

1. The LNG industry must completely decarbonise by 2050

Policy options for decarbonising the LNG industry
There are studies which have modeled how the LNG industry can become carbon neutral (Reputex) or fully decarbonise (Climate Analytics), discussed below.

The Climate Analytics *1.5°C Compatible Carbon Budget for WA* report found **the LNG industry could completely decarbonise by 2050 without using offsets at all**. It provides detailed modeling to show this would be possible through:

- Ensuring that reservoir CO2 for all facilities is captured and stored rather than released to the atmosphere;
- Processes in the LNG plant that require energy for refrigeration can mostly be electrified with renewable energy, with the recommendation to phase in renewable energy so that by 2030 50% of gas used in LNG manufacturing is replaced by renewables and 90% by 2035 and 100% by 2050; and
- Binding regulatory requirements on the LNG industry to meet or exceed greenhouse gas intensity benchmarks consistent with emission reductions or conditions.[38]

The Reputex *Offsetting Emissions from Liquefied Natural Gas Projects in Western Australia (*discussed in more detail in Section 3.4) found the potential for 80 million tonnes of offsets in WA, more than enough to offset the entire annual emissions the WA LNG industry produce every year (32 million tonnes).

To the extent that offsets are used, they should only be applied as part of a 'mitigation hierarchy' where all pollution should be avoided and reduced as far as possible at source, and offsets being used as a last resort only.

CCWA believes this approach should in fact be applied to all industries and is an approach supported in the Environmental Protection Act. (CCWA's submission to the EPA Guidelines provides more detail on the 'mitigation hierarchy'.

2. New fossil developments are incompatible with the Mitigation Hierarchy and must be ruled out in any effective climate policy
Under the 'Mitigation hierarchy' the avoidance of emissions is the first and highest priority mitigation measure. By definition this should count out all new fossil fuel developments because they, by definition do not avoid pollution.

3. The Mitigation Hierarchy should be embraced by the Department in its climate policy framework
CCWA believes there is a strong legal argument to make that the principles of the Environmental Protection Act do not just apply to the Environmental Protection Authority (EPA) but provide a framework for government policy more generally on this issue, and should be embraced by government.

4. Support an urgent review of current controls on pollution and supporting EPA processes and soon to be released Guidelines

5. Introducing a requirement for Offsets as a market signal to promote avoidance and mitigation at source
Currently there is little incentive for Western Australia's largest polluters to make investments that would reduce their pollution, however there may be significant opportunities to do this, particularly in the LNG sector, WA's largest emissions source. For example in May 2019 US petroleum giant ConocoPhillips announced it will install a 4MW battery storage array at its Darwin LNG plant to enable it to switch off one of the gas turbines that power the facility and cut its fuel and emissions by around 20 per cent[39].

Requirements to offset domestic carbon pollution will create a market incentive for the LNG sector to make such investments, in order to avoid paying for pollution offsets. Remaining carbon pollution which cannot be reduced by LNG proponents should be offset.

6. Improving energy intensity
Through renewable remote power generation, electrification of transport, and stricter conditions on fugitive emissions.

7. Fugitive emissions
The LNG industry is a significant source of WA's fugitive emissions.

Fugitive emissions currently account for 14% of total emissions in WA. Fugitive emissions are produced when methane and carbon dioxide are released (through either venting or leaks) during the extraction, processing and delivery of fossil fuels. Fugitive emissions are particularly harmful, as methane traps more than 86 times more heat than carbon dioxide over a 20-year period.

CCWA strongly recommends an urgent review of current regulation of fugitive emissions.

In the short term, methane burning (rather than simply venting into the atmosphere) from gas production sites could help reduce fugitive emissions.[40]

3.2.2 What exemptions should apply to trade-exposed sectors in reducing our emissions?

CCWA strongly argues that no exemptions should apply to trade-exposed sectors in reducing our emissions.

In fact, trade exposed sectors such as oil and gas producers currently have **no constraints at all on pollution here** so how can it get any worse?

CCWA notes oil and gas companies all claim to already be using an internal carbon pricing, so their businesses should be robust enough to exposure to carbon constraints.

CCWA notes the 'trade exposure' argument is that we should allow pollution to continue to occur here unabated so that we can benefit from the jobs here, rather than put on carbon constraints that would potentially cause the industry to move offshore.

The threat by large oil and gas companies to move their operations offshore in response to the prospect of improving our regulation of greenhouse gas pollution is embarrassing.

The argument used that an LNG plant and operation which has cost tens of billions will somehow shut down and relocate overseas is utterly ridiculous.

Another argument used is that the industries will go offshore where they will be dirtier, but this is unsubstantiated.

If fossil fuel companies did relocate, from a carbon perspective that means our fossil fuels will remain unexploited, which from is a good thing. It would also drive prices up for these products, also a good thing from a carbon perspective as it will encourage substitution.

3.2.3 How can the Government foster clean industries and technologies?

Greenhouse gas emissions from WA's Industry sector include emissions from mining, manufacturing, fugitive emissions (linked mostly to LNG processing), industrial processes emissions (mostly cement and ammonia production), and other industries including agriculture and fisheries.

It's WA's highest polluting sector, and emissions have increased in this sector by 74% since 2005[41].

There are many opportunities to decarbonise WA's industry sector. **The absolute priority is to align industry policy with climate policy, by:**

1. Adopting a no new fossil fuels policy
As discussed earlier in this submission, new or expanded fossil fuel projects are inconsistent with the Mitigation hierarchy (to avoid and reduce emissions as priority).

New or expanded fossil fuel projects are also inconsistent with the global carbon budget.

Especially relevant to WA are the findings of the most recent UN Environment Program report[1] headlining the fact that governments, including our own, are "*planning to produce about 50% more fossil fuels by 2030 than would be consistent with limiting warming to 2° and 120% more than would be consistent with limiting warming to 1.5°*." The report notes that oil and gas are on track to exceed global and local carbon budgets as countries continue to invest in fossil fuel infrastructure that "lock in" oil and gas use; while governments, including Western Australia's, are signalling their intentions to decrease emissions, they are doing the opposite in planning and subsidising the further expansion of fossil fuel production. In this context, the recent announcement[2] of WA government support and funding for industry sponsored research into technologies which enable the further expansion of the industry into fields previously considered unviable is astounding. How can this possibly be compatible with reaching net zero emissions by 2050?

2. Leading by example: decarbonise government and the public sector
The public sector represents one of the lowest hanging fruits for decarbonisation. It is the highest employer in WA, with almost 120,000 people across 19 different departments and entities employed in 2018[42]. A whole of government approach to procurement and projects funded by government would be an easy and effective way to show leadership and become carbon neutral in its operations.

3. Review existing industry support and subsidies
Between 2008–2014, the State government spent $6.2 billion – around $1 billion per year – supporting the mining and fossil fuel industry, via direct expenses or concessions. The WA mining industry received $6.2 billion in subsidies from the State Government over six years from 2008-2014. This includes $10 million spent each year on the Exploration Incentive Scheme for mining and fossil fuel projects, to repairing roads damaged by mining vehicles, to cash payments, discounted access to services provided by states, fuel subsidies, tax write-offs for capital works, and spending on roads and port infrastructure which mainly benefits the mining and gas industries, and deductions for exploration and prospecting. Industry development funds also directly channel funding into assisting these industries.[43]

Western Australia's 2013–14 budgeted assistance of $1.4 billion is more than the state has budgeted to spend on police and represents nearly one third of the entire West Australian health budget.[44]

4. Urgently reviewing perverse and inadequate tax and royalty arrangements

Chevron made $14.8 billion in 2018 but the Australian Tax Office in 2017 ruled Chevron had shifted profits offshore to avoid paying company tax; it paid none in five of seven financial years. A Senate inquiry was subsequently told the total amount of tax Chevron had in dispute with the Tax Office was more than $1 billion. In 2019 it was reported that Chevron has made $8.4 billion pre-tax profit from it WA operations but only paid $49.96 million in tax.[45]

In 2016–17 Woodside made a total income of $10.9 billion, reduced this to a taxable income of $2.6 billion, and only paid $508m tax on that – which translates to 4.6% tax rate. It has recently sought Australian taxpayer funds to build an oil and gas field off the coast of Senegal in west Africa.[46]

Chevron and Woodside pay no royalties. Concessions in the design of the petroleum resource rent tax (PRRT) means Gorgon won't be paying this tax until about 2035; in effect, Chevron could pump and sell about 300 million tonnes of Australian LNG before paying a dollar in royalties.

Chevron has paid $675,000 in political donations between 2011–2018 to WA and federal Labor, Liberal and Nationals parties, Woodside has paid $1.9 million over the same time[47].

5. Introducing an ambitious Energy efficiency program

Western Australia is lagging behind most other countries with policies to increase energy efficiency. Energy efficiency is an essential complementary measure to decarbonisation of the Industry sector and can reduce emissions significantly at a relatively low cost. The WA government should introduce policies to support energy efficiency improvements in industry by, for example, providing grants for energy assessments and improving efficiency.

6. Establishing a $1 billion WA Clean State Jobs and Investment Fund

CCWA strongly advocates for the creation of a significant annual fund that would operate in four important streams:

- 'Deep retrofit' and green infrastructure program
- A Clean Jobs & Industry Investment fund similar to the CEFC
- A Workforce transition package; and
- Dedicated funding for WA scientists & innovators

The creation of a dedicated 'deep retrofit' package would spur jobs and investment in WA's construction, low carbon home/energy efficiency and land care sectors. It would be targeted at WA's lower income and rental households with the aim to adapt all of WA's poorest performing housing stock by 2025.

The creation of a *WA Clean State Industry Investment Fund* would leverage private sector investment into clean energy, industry and manufacturing. It could be set up as a dedicated institution like the UK's Green Investment Bank or like Australia's Clean Energy Finance Corporation (CEFC) or could be administered from within government[48]. The fund would be required provide shareholders (usually the WA Treasury) with a positive return on investment.

The CEFC has made an 8–9% return on investment since it was established, generating more than $520 million for taxpayers' investment since it was established.

Money for the fund's initial investment pool could be sourced from a levy on Western Australia's gas producers, who pay low or no tax, and very low royalties.

The Clean State Jobs and Investment fund could be funded through diversion of existing subsidies to WA's fossil fuel industry, and tax and royalty reform.

7. Establishing a Green Hydrogen and Zero Carbon Steel and Heavy Industry Manufacturing hub

Green Manufacturing has been described by prominent economists as our 'next wave of prosperity'. **(Box 8)**

Full decarbonisation of WA's Industry sector implies replacing coal, oil and gas with renewable energy not only for power generation but also for heat demand in industry processes. Hydrogen is a renewable fuel option of high-temperature applications in the industry sector, along with biomass. Hydrogen can also replace gas as a feedstock for ammonia production. Research also shows the possibility for full decarbonisation of cement reduction, a notoriously difficult to abate sector, through low carbon alternative production methods using geopolymers instead of limestone for example.

In the Carbon Budget prepared for WA, Climate Analytics conclude

> *"Renewable energy alternatives exist for all applications of industrial natural gas use, not only for power generation but also for lower output temperatures and high temperature thermal process, as well as chemical feedstock."* [50]

A report by the Australian-German Energy Transition Hub released in September 2019 showed Australia could produce 200% of energy from renewable energy by 2050 – enough to power a green hydrogen export industry. It finds that with the right policy support, Australia could become a global leader "both in climate mitigation and the export of zero-carbon energy" in the form of green hydrogen, green steel and other products such as aluminum produced from green electricity[51].

Professor Ross Garnaut believes no other place on earth has a comparable opportunity for large-scale,

firm, low cost, zero-emissions power to provide energy-intensive manufacturing.

The development of a green hydrogen industry could establish Western Australia as a natural home for expanded industries in aluminum, steel, silicon and ammonia, which in turn would benefit regional centers including the Pilbara.

CSIRO recently estimated green hydrogen could be cost-competitive with existing industrial feedstock such as gas in many applications. With adequate policies it's more likely green hydrogen will become the least cost option[52]. Bloomberg recently estimated hydrogen technology can be competitive with coal-based plants for steel production by 2030.[53]

While WA does not have steel production currently, it does have incredible potential to introduce zero emission steel production based on its iron ore and renewable energy resources.

Apart from increasing efficiency and decarbonising energy supply, decarbonisation of industrial processes to produce (cement and ammonia production are among the most carbon intensive industries).[54]

With the right policy support, we could become a global leader both in climate mitigation and the export of zero-carbon energy in the form of green hydrogen, green steel and other products such as aluminum produced from green electricity.

8. Investigate the potential for a renewable export industry

Western Australia could maintain its position as an energy superpower in a carbon-constrained world. Instead of exporting the world's largest amount of gas, we could export renewables instead.

There's an increasing recognition – including by the WA Government in its Green Hydrogen strategy – of the opportunity we have in WA to develop a clean hydrogen market, given our prime solar and wind resources, availability of infrastructure and skilled workforce. There has been increasing interest in large scale projects to generate power from renewable energy and store it in hydrogen to export into neighboring Asian countries[55]. Two large scale combined wind and solar projects are already in development in the Pilbara and near Kalbarri to supply production of low-cost green hydrogen, for domestic and export markets, targeting mainly Japan and South Korea (two of our largest LNG customers).

Australian companies are also looking at other new ways to export mass volumes of renewable energy. The Sun Cable for instance is backed by Atlassian's Mike Cannon-Brookes, who is investigating a $20 billion plan to sell solar power from the Northern Territory to Singapore through an undersea cable[56].

It's vital that the green hydrogen and renewable export industry is supported in WA, to ensure we don't miss out on this once in a generation opportunity.

Box 8: WA's 'Green Steel' opportunity

WA is one of the world's largest producer and exporter of iron ore. Steel is largely manufactured elsewhere, by 'reducing' the iron ore using carbon rich 'coke' in huge blast furnaces that emit large amounts of carbon dioxide and liquid metal[1]. This highly emissions-intensive process has been largely unchanged for 150 years. Globally, steel making accounts for about 7% of emissions.

As Ross Garnaut has suggested, Australia can capitalize on rising international demand for low-carbon alternatives, by developing a green steel manufacturing industry here in WA. A new zero-emissions method of steelmaking is showing great potential in other countries, such as the 'HYBRIT' project in Sweden. Hydrogen, made by electrolysis using renewable energy, is used to reduce the iron ore, instead of coking coal. By using renewables to power the electric arc process and other small inputs, the only by-product of manufacturing the steel is water. Manufacturing steel here in WA, rather than just exporting the raw ore, could create hundreds of jobs and spur a new wave of zero carbon heavy industry and manufacturing in Western Australia.

Sweden's steel industry is planning to have the word's first zero-emissions steel plant using hydrogen fuel, operational by early 2030.

Source: The Chemical Engineer

Recommendations: Industry Innovation

The Climate Policy should:

1. Develop a roadmap to decarbonise the Industry sector by 2050
2. Prioritise emissions-intensive sectors and hold WA's biggest polluters to account.
3. The climate policy must explicitly rule out fracking (unconventional gas) and uranium mining on climate grounds.
4. As the single biggest and fastest growing polluter in WA, require the LNG industry to decarbonise as soon as possible, and in the interim it should be required to immediately offset 100% of its carbon pollution.
5. Prevent any new or expanded fossil fuel developments including coal, oil and gas developments in WA.
6. Conduct an urgent review into Tax and Royalties arrangements enjoyed by WA's fossil fuel and mining export companies.
7. Urgently review and redirect fossil fuel subsidies and industry support which support emissions production and distort the need for energy efficiency, fuel switching, or investment in clean energy or transport.
8. Investigate the feasibility of a Renewable Exports industry.
9. Create a $1 billion 'Clean State Jobs and Investment package' to drive the transition to clean energy, low carbon technologies, and sustainable construction and manufacturing industries. CCWA recommends funding in four streams including:
   a. 'Deep retrofit' and green infrastructure program
   b. A Clean Jobs & Industry Investment fund which operates like the federal Clean Energy Finance Corporation (CEFC) and is sourced by a levy on our largest polluters.
   c. A Workforce transition package; and
   d. Dedicated funding for WA scientists & innovators
10. Make climate disclosure mandatory and more transparent, including all business's emissions (Scope 1,2 and 3).
11. Adopt a roadmap to become a Carbon neutral government by 2020.

3.3 Future mobility

New transport technologies will transform our cities and lives in the coming decades. In preparation for these changes, investment in infrastructure and technology will help to support more West Australians to use low carbon means of transport. The decarbonisation of this sector presents challenges as well as big opportunities for job creation and transforming the way our communities and cities function and thrive. With ambitious, coordinated measures it's possible for the transport sector to reach net zero by 2050.

WA's transport sector is our second largest source of emissions (17% share, 61% increase since 2005). CCWA propose full decarbonisation of the transport sector by 2050, including a fully decarbonised passenger and freight transport fleet.

3.3.1 How can we ensure WA isn't left behind in the transition to cleaner transportation?

Western Australia is already being left behind in comparison to other states, and internationally too. While initiatives such as the Future Battery Industries Cooperative Research Centre and the Renewable Hydrogen Council are exciting developments, there is great potential for a sector-wide roadmap to transform the way that we move in our cities and across the state.

Decarbonising our entire transport sector and switching the state's transport task to an electric one powered by renewable energy is one of the most important tasks.

The six most important ways to ensure WA's not left behind in the transition are

1. Investing in Mass transit
Perth is one of the most car dependent cities on the planet. Investing in a world class mass transit network is one of the most effective ways to reduce private car use, increase livability, and reduce emissions.

CCWA was disappointed by the Barnett government's election promise backflip of building a metro-wide integrated light rail system. 'MAX' Light rail would have revolutionised the way people moved and could have facilitated low carbon, sustainable medium density developments along light rail routes. CCWA strongly advocates for Electric Light rail or trackless trams to be delivered to Perth. Trams are one of the most efficient forms of mass transit.

Professor Peter Newman believes the focus on urban regeneration of the older inner and middle suburbs can be facilitated by the new autonomous trackless trams. They will be able to transform corridors as they can bring a high capacity system, well beyond the present bus system, which will be able to beat car traffic in speed and ride quality. Each station precinct will be able to facilitate a major urban redevelopment that can help pay for the new technology.

CCWA supports the State Government's Metronet plan. the State's biggest infrastructure project, reshaping Perth again.

According to Professor Peter Newman, one of the world's most eminent transport and sustainability experts, rail has grown from 7 million passengers a year to nearly 70 million but has plateaued due to lack of investment. However, we passed Brisbane in terms of patronage and can now claim to have the fastest and most modern rail system in Australia. The $6 billion MetroNet program is about to provide Perth with a much bigger and faster system of rail options going deep into car-based suburbia along with the new hubs at stations.[57]

Box 9: Electric Bus revolution

Shenzen, China has 16,000 electric buses in operation and is targeting an electric taxi fleet by 2020. Shenzen Bus Group estimates that 440,000 tonnes of Co^2 emissions are avoided yearly.

The City of Chicago recently announced it will transition to renewable energy by 2035 with its entire fleet of buses to be electric by 2040.

2. Electric trains
Our heavy rail network is already electrified and could be powered renewably.

New technologies will mean higher capacity and higher speed. More pedestrian traffic will make our centres better places to live and work, as long as we don't let them get ruined by mass use of autonomous vehicles. The CBDs in Perth and Fremantle and the sub-centres along the lines can already begin planning for less parking as the economies of such places will continue to favour pedestrians.

This is the way to rebuild our older suburbs, keeping the qualities and fabric that were part of their original design as tramway estates. Pedestrian and cycle activity will be part of new station precincts.

3. Electric buses
In March this year the Minister for Transport announced the order of 900 new diesel buses to be delivered over the next 10 years for the Transperth fleet, at a cost of $549 million. It was also stated the PTA could consider

a trial of hybrid or electric buses *"if these were found to be viable in Perth"* [58]. In an age of climate emergency it is unfathomable that a new fleet of diesel powered buses could even be considered when the uptake of hybrid and electric buses is growing exponentially around the world. **CCWA views this as an extremely disappointing missed opportunity to transition away from highly polluting, noisy heavy vehicles running through our communities.**

Switching our buses to energy-efficient electric vehicles (EEEVs) is a priority. Electric vehicles are 3–5 times more efficient than internal combustion engines. Policy mechanisms can Incentivise the uptake of low emission buses to cut pollution and boost the efficiency of the public transport service.

4. Decarbonising the freight sector and shifting freight on to rail
A road to rail freight strategy is needed urgently, to take diesel-based trucks off the roads, and put our freight onto an efficient, electrified national network.

5. World class bike infrastructure and facilities
Perth could be one of the world's best cities for bikes, with high-quality walking and cycling infrastructure that is integrated with public transport networks.

CCWA notes with dedicated funding and a planned infrastructure rollout, we could dramatically increase the number of trips made on bikes in our cities and regions. CCWA has been inspired by examples including a bike infrastructure program in Melbourne increased the number of commuters riding to work from 2% to 10% in just ten years, Portland aimed to have 80% of its population living within 800m of a Bike Boulevard or Greenway by 2015, and Chicago committed to construct a 645-mile bike network of on-street bikeways within 8 years in 2013.

6. Demand side incentives
Demand side incentives are also much needed, such as free or much cheaper public transport.

Western Australia has a lot of expertise in Travel Demand Management (TDM) as the originator of the Travelsmart approach which is now almost de-funded, but was achieving an 8–10% or more durable reduction in single occupant car trips, and was paying for itself in deferred infrastructure and road maintenance costs, reduced congestion, as well as increased utilization of public transport assets, air quality improvements and other co-benefits.

This approach should be reinstated across all areas, with a program to require large trip generators to have a TDM plan and targets to reduce vehicle trip generation over time.

Affordability and efficiency are recognised as a key element of success in urban public transportation systems. In Singapore, offering a range of nine concessions rates, including a 15% discount for low wage workers, and a world-class predictive maintenance and information database, has seen its public transport system receive one of the highest rates of user satisfaction in the world[59].

3.3.2 What can be done to increase the uptake of Electric vehicles?

In 2018 the global electric car fleet exceeded 5.1 million, but only account for a small fraction (<1%) of all cars in circulation. Electric vehicles (EV) are expected to approach price parity with internal combustion engine vehicles before 2025.

WA's climate change policy is a great opportunity to facilitate this transition by delivering a roadmap for how we support a transition to electric vehicles, including planning for charging/refueling infrastructure and removing barriers to purchasing EVs. Dedicated policy measures can Incentivise uptake. **(Fig 7)**

CCWA recommends exploring the ten policies and incentives to increase the uptake of EV's put forward by Climate Works' State of Electric Vehicles report 2018, listed in Fig. 7, including:

- Stamp duty, registration and tax discounts
- Direct vehicle subsidies, and
- Fleet incentives.

3.3.3 What are the barriers to purchasing low-emissions vehicles?

Western Australian EV sales in 2017 were only 8 in every 10,000, or about 0.08% of the total, compared with just under 2 per cent globally. Polling by the Electric Vehicle Council shows a relatively high level of uncertainty about the distance that can be travelled per charge, the purchase cost and the reliability of electric vehicle technology[61]. In WA this uncertainty is compounded by a lack of policy support, very low levels of supporting infrastructure and a lack of public awareness about global electric vehicle trends.

Fig 7: Overview of federal, state and territory government policy to support EV uptake
(Source: Climate Works Australia, State of Electric Vehicles 2018)

		WA	QLD	NSW	VIC	SA	TAS	ACT	NT	Cwth
Uptake	EV purchases 2011–2017	375	688	1238	1324	957	61	165	13	4821
	EV sales per 10,000 vehicles	8	6	10	10	22	3	21	1	7
Regulation	Vehicle C02 emission standards	✗								🚗
Financial incentives	Stamp duty, registration and tax discoutns	✗	✓	✓	✓	🚗		✓	✓	✓
	Direct vehicle subsidy	✗								🚗
	Fleet incentive	✗								✓
	Charging infrastructure incentive	✗	✓		✓		✓	✓	🚗	🚗
	Toll and parking discounts	✗	✓							
Non- financial incentives	Vehicle lane and parking privileges	✗						✓		
	EV public transport trials	✗				✓		✓	✓	
	Government fleet policy	✗		✓		✓	✓	✓		
	Information and education programs	✗	✓	✓	✓	✓	✓	✓		✓

🚗 denotes policies under investigation

Attention to the policies and incentives described above and in Fig. 7 would reduce these barriers, in addition to:

- Grants to support government and non-government organizations to meet the gap between the cost on electric vehicle and a conventional vehicle
- Parking discounts
- Introducing vehicle CO2 emissions standards
- Planning controls and requirements for large trip generators to have charging stations; and Subsidies, incentives and partnerships to support local governments and car park operators to install electric vehicle charging infrastructure.

CCWA notes of these ten policy settings to increase the uptake of EV's, WA has implemented zero, compared with the ACT which has implemented 6/10 and has the second highest uptake in Australia. **(Fig 7)**

Leading EV nations such as Norway and Japan have shown how strong leadership and policy packages have helped to shape consumer preferences and facilitated high rates of electric vehicle uptake. Analysis of their policies shows purchase incentives are the most successful form of policy, public-private partnerships have also been highly effective in subsidizing the costs of building the infrastructure network, and public policy signals encourage vehicle manufacturers to more ambitiously electrify car and bus markets.

CCWA notes in facilitating the transition to electric vehicles a key consideration will be where the electricity is sourced from. To deliver the greatest emissions cuts, it can only come from 100% renewable sources, and the supply chain should also be considered – as mineral sourcing and battery production can involve substantial emissions[62].

In the meantime, improving the energy efficiency and carbon intensity of traditional vehicles through regulatory means is necessary. Enforceable world's best practice fuel efficiency standards and mandatory fuel efficiency labelling of new petrol and diesel vehicles.

3.3.4 How can we further encourage the use of public transport and active transport such as walking and cycling?

Special consideration should be given to incentivizing better use of mass transit in urban area (buses, trains and light rail, complemented by cycling and walking). *The Victorian Cycling Strategy 2018–2028* provides a great example of user-focused initiatives which encourage higher rates of public and active transport use; including prioritizing investment in strategic cycling corridors and better integrating cycling and public transport.

The WA Council of Social Services has also recommended free public transport for Concession card holders.

Recommendations: Future Mobility

1. Develop a roadmap to decarbonise WA's Transport sector by 2050.

Public transport

2. Electrify all public transport and freight.[1]
3. Increase the frequency and decrease the cost of public transport.
4. Cancel the order for 900 diesel-powered buses and replace with hybrid-electric or electric over ten years.
5. Free public transport for concession card holders.
6. Investment in demand side incentives and reinvest in the Travel Smart program.

Mass Transit and Light Rail

7. CCWA strongly advocates for an integrated, electrified light rail or trackless tram network to be planned and implemented in Perth by 2023.

Bikes and Active transport

8. Invest in strategic cycling corridors for metropolitan and regional areas.
9. Invest up to 5% of the state transport budget to deliver safe, separated bike lanes and paths across WA's cities and regional towns.

Electric Vehicles

10. Develop a roadmap and target for EV uptake in WA, using the ten policies identified by Climate Works and other peak bodies.
11. Invest in electric vehicle fast charging facilities in metropolitan and regional areas and provide funding for investment in WA companies and industries to manufacture and service electric vehicle infrastructure.
12. Adopt an EV government fleet policy and provide financial incentives for local government and private sector to phase electric vehicles into their fleets.

Freight

13. Revise the current freight on rail target and develop a funded plan to electrify the freight network.
14. Introduce and enforce world's best practice vehicle emission standards to improve fuel efficiency and carbon intensity of traditional vehicles.

3.4 Regional prosperity

While West Australia's regions are expected to be disproportionately affected by the impacts of climate change, they also stand to benefit greatly from strong climate policy. WA's world-class renewable energy resources, and many opportunities for reforestation and carbon sequestration are primarily located in our regions. With the right policy support, these opportunities have the potential to attract substantial investment and bring prosperity to regional communities.

Agriculture is responsible for 9% of WA's annual emissions and has risen since 2008. The Agriculture sector is the dominant source of methane and nitrous oxide emissions, accounting for 56% and 73% of WA's total, respectively.

3.4.1 How will climate change affect regional communities?

Climate change will, and already is disproportionately affecting regional communities.

The regions and the Agricultural sector are highly vulnerable to climate change, especially more severe temperature changes, heat waves, frost, rainfall intensity, drought and water supply issues, cyclones and fire risk.[63]

Impacts include:

Rainfall during the April-October southern growing season has dropped by 11% in the last 20 years, and under 'dry scenarios' wheat yields decline by 20% and farm profits decline by 50%.[64]

WA's Agriculture sector contributes around $8.6 billion to the State Gross Product, but it's estimated another $3 billion is being lost as potential income due to poor soil health, and some WA farmers are struggling with insufficient water resources.[65]

An estimated 4.3 million hectares (16 percent) of the southwest region has high potential for developing salinity from shallow water tables. This is predicted to rise to 8.8 million hectares (33 percent) by 2050[66]. Predictions based on current and perceived land uses indicate that approximately one-third of the agricultural areas in the southwest could be affected by shallow water tables and salinity by 2050.

Increased salinity of surface water resources also threatens flora and fauna. An estimated 1,500 plant species will be affected, with 450 at risk of extinction [67]. An interim assessment has put the annual cost of (losses from) dryland salinity at $664 million.[68]

CCWA understands that the threat of fire is now so significant in some parts of the Wheatbelt that that some farmer are unable to get insurance to insure their farms against fire.

Dr. Neville Ellis, Research Fellow UWA and Contributor to the IPCC Special Report 2018 researched the ways climate change is adversely impacting the mental wellbeing of Western Australian farmers. His research in the Wheatbelt shows that many farmers have observed large changes in their local climates over recent decades, and that these changes are adversely impacting vital relationships between farmers and their land. Notably, chronic dryness and increasing seasonal variability has been shown to undermine farmers' sense of self-identity and self-worth.[vi]

WA climate expert Professor Ray Wills has predicted the following impacts based on 2 degrees of warming, using IPCC projections:

- Wheat growing areas in south west Western Australia will be seriously impacted and the northern wheatbelt likely to disappear while production in the remainder greatly reduced, wiping out most of an industry worth more than $2 billion
- Tree crops are particularly sensitive because of longer lead times to reach production. Changes to stone fruit also be impacted as fruit production requires chilling to create bud set
- Dairy and beef cattle industry will face decreased pasture production, and increased temperature stress
- Honey production in Western Australia - some of the highest production rates in the world are also likely to be seriously impacted. Honey industry will face impact as native ecosystems and agricultural systems change, with honey production on the decline, complicated by the invasion of new diseases that will do better in WA's changed climate
- Climate is a key influence in grape selection. Shifting rainfall patterns and drier conditions are likely to change the way vineyards operate and will reduce the wine crop - Western Australia produces less than 5% of all Australian wine,but produces about 25% of the wine in the super-premium and ultra-premium categories. Shifting rainfall patterns and drier conditions will change the way vineyards operate and reduce the wine crop. At 2 degrees of warming the Margaret River climate will be closer to that of Perth, cabernet sauvignon and chardonnay will be lost, and a swap to varieties suited to warmer climates such as shiraz may occur – until they too are lost to temperature increases. The Swan Valley will no longer be suitable for vines.

Box 10: The Walcha Energy Project

The **Walcha Energy Project**, in the Northern Tablelands plateau of NSW, is a massive hybrid project proposed for unproductive farmland that will utilize a combination of wind, solar, and pumped hydropower generation to produce up to 4GW of clean electricity, equivalent to around 15% of New South Wales' total electricity demand.

3.4.2 Supporting the agricultural sector to participate in the low-carbon transition.

CCWA notes WALGA's recommendation for a commitment to the development of a comprehensive plan for the transition to low carbon business, industry and job opportunities in regional areas, including support and incentives for communities impacted by the transition.[69]

Emissions from agriculture include those from enteric fermentation (methane emitted from livestock digestion processes), manure management and use on crops, and land-related emissions from fertilizers and crop cultivation.

Key mitigation options described by Climate Analytics include best practice farming enhanced agricultural management on the supply side (for example improved livestock feeding practices, more efficient fertilizer use, and manure management) as well as demand side measures such as dietary shifts to more sustainable and healthier low-meat diets and measures to reduce food waste.[70]

Renewable regions

Decarbonising our energy system and the adoption of a WA 100% RET as described in Section 3.1 is not only the fastest and cheapest way to decarbonise but also offer significant benefits to WA's regions.

Large wind and solar farms can be located in Agricultural areas as another 'crop' and become another source of income for farmers.

A solar goldrush in the Goldfields

A comprehensive, peer reviewed study of potential locations for Concentrated Solar Thermal (CST) power stations in WA was completed in 2012 and provided the most detailed guidance on prospective areas for large-scale solar thermal installations, while giving order-of-magnitude estimates of technical production potential.[71]

The study identified that a full 70% of WA's land mass is technically suitable for CST – and if put into production under utility-scale parabolic trough CST plants, the theoretical output would be fifty times greater than the demand of the entire industrialised world.

The locations it found most suitable are the Wheatbelt, Mid-West, Kalgoorlie and the Pilbara.

The study overlaid existing grid infrastructure and a number of other variables to identify an estimated area of 11,200 km^2 as technically suitable. This land area if dedicated to CST electricity production would be capable of powering one third of the planet's electricity demand.

It's estimated every 100MW system creates about 500 jobs during construction, 38 permanent jobs during its operation and a further 56 indirect permanent jobs.

According to Sustainable Energy Now, a transition to 100% renewable energy will include between 2–12 CST power stations, would generate almost 5000 new jobs in the Mid-west and Pilbara regions[72].

Sustainable Agriculture

Fertilizer overuse and over-grazing on pastures and rangelands are high sources of emissions. There are a range of agricultural practices that can sequester carbon in the soil, including crop rotation and leaving unused parts of the crops on the field to prevent soil erosion, planting cover crops, to low or no-tiling systems, optimizing grazing, agroforestry (planting trees in croplands) and sowing legumes in planted pastures.[73]

Sustainable diet

Global food production is the single largest human pressure on earth. It's well recognised that a significant reduction of animal source foods and an increase in healthy plant-based diets will both reduce food-related greenhouse gas emissions and improve health.[74]

Research conducted by Roy Morgan has found that the trend in vegetarian eating continues to grow – with 2.5 million people (12.1% of the population) in Australia now eating all or almost all vegetarian, and one in three people already eating vegetarian or actively reducing meat.[74]

Sales of plant-based food products have soared over the past five years in Australia, which "represents a growing threat to local demand for meat and dairy products and related farming, processing and dairy industries, and the Australian Meat Processing industry now generates over 60% of its revenue from overseas."

However, many overseas markets are also reducing their consumption of meat. China has set a target of

halving meat consumption by 50% by 2030, which could reduce global agricultural emissions by 12%. China currently consumes 28% of the world's meat.[77]

CCWA notes the trend towards healthy and sustainable diets, including plant-based diets, and advocates for research into the impact on WA farmers of a reduction of animal-based food and the economic advantage of supporting farmers to switch to plant-based dairy and protein alternatives.

CCWA also notes dairy farms, beef feedlots, piggeries and poultry farms produce a large amount of methane and nitrous oxide, two particularly harmful greenhouse gases. Methane traps 86 times more heat than carbon dioxide over 20 years, and nitrous oxide has nearly 300 times the global warming potential of carbon dioxide.

Funding is available for projects which avoid methane production and compost organic waste under the Australian Government's Emissions Reduction Fund (now Climate Solutions Fund).[78] These include reducing emissions from beef cattle and milking cows through dietary supplements or efficient herd management, capturing and destroying the methane from effluent waste at piggeries, and building soil carbon through changed farming practices such as crop stubble retention.[79] Nationally there have been 64 agricultural projects funded through the Emissions Reduction Fund, but zero in WA! **(Table 3)**

Table 3: Projects funded by the Australian government for abatement and generation

	WA	National
ERF - Agriculture projects	0	6
ERF - All projects	26	486

Sources: ERF Project Register (2019); Emissions Reduction Fund – Opportunities for Australian businesses and farmers (2017)

The CEFC also recognises there are significant opportunities for agricultural businesses to reduce their operating costs through energy efficient equipment and renewable energy upgrades. Since inception it has invested $260 million in 790 projects specifically for practices and technologies to lower on-farm emissions across Australia since inception[80]. At the time of writing this submission it was not possible to determine what proportion of this funding went to Western Australian farmers.

Measures to capture and use methane from manure, such as covered ponds and the flaring or combustion of the captured biogas to provide heat or power are common in Europe but not in Australia, and should be explored and more strongly supported.

3.4.3 What opportunities do carbon offset markets present for WA land managers, including Aboriginal groups?

CCWA acknowledges the immense opportunities exist for First Nations groups in carbon offset markets. We acknowledge First Nations ongoing custodianship of country and strongly advocate for engagement with First Nation communities to develop and fund permanent programs and industries in this emerging market as a priority feature of WA's Climate policy. CCWA also recommend significantly increasing funding to the existing Aboriginal Ranger Program (See 3.10.3 for more detail.)

A number of nature-based solutions can be implemented in WA's regions to reduce emissions and sequester carbon at a very large scales.

Reforestation is the single greatest solution for absorbing carbon from the atmosphere, with the majority of this potential in the tropics, particularly in grazing lands and degraded croplands, according to the 'Exponential Roadmap' in which scientists offer 36 solutions to halve emissions by 2030.

According to Professor Ross Garnaut,

> *"We have immense opportunity for capturing and sequestering, at relatively low cost, atmospheric carbon in soils, pastures, woodlands, forests and plantations. Rewarding people and organisations that own and manage land with incentives equal to the true cost of carbon emissions would lead to sequestration in landscapes becoming a major rural industry."* [81]

Professor Garnaut believes WA is best placed in the world for carbon farming and found Australia has also barely begun to explore the extent to which it could build an industry out of capturing carbon in soils, woodlands and forests. In his new book Superpower he estimates up to 1 billion tonnes of offsets are available nationally, each year, which is almost twice our current national emissions.[82]

Capacity to generate offsets in Western Australia

CCWA has been a strong advocate for the creation of a WA carbon offset market.

CCWA has strongly advocated for the direct emissions from WA's largest existing polluters be offset here in WA (in line with the mitigation hierarchy of avoid and reduce emissions first).

CCWA commissioned Reputex Energy to complete a report into the abatement potential of offsets here in WA. Its report, *Offsetting Emissions from Liquified Natural Gas Projects in Western Australia* (November 2018) **(Attached)** shows Western Australia has abatement potential of up to **80 million tonnes of emissions offsets available per year** across activities

including reforestation plantings, renewable energy, rangeland regeneration, savannah burning, and other land sector jobs.

The figure of 80 million tonnes per year is just under Western Australia's total emissions in 2017, of 88.5 Mt CO2-e[83] and almost three times more than the annual emissions of WA's LNG sector at full capacity (32 MtCo2-e).

Around half of all abatement modelled was available at less than $40/tonne. While offset prices would rise in line with demand, these prices are competitive against modelled international carbon price benchmarks in California and Europe, and are projected to grow from A$25–35/t to more than $70/t by 2030 as policy ambition increases in those markets.

Potential for job creation and other benefits

The Reputex report also indicated offsetting WA's LNG emissions provides a very significant opportunity to create new jobs and economic benefits for WA. It found:

- The development of a carbon offset market in Western Australia has the potential large economic opportunities for investment and job creation across the state, particularly in pastoral communities, as well as co-benefits to biodiversity, landscape protection and water quality;
- The additional value for West Australian carbon offset industries may range between $67 million to $2.5 billion per year. Under a 'low demand' scenario, this represents a six-fold increase in investment in the Western Australian offset market, growing to an over 200-fold increase in investment under a 'high' scenario;
- In total employment terms, these activities create around 4,000 jobs (under a medium demand scenario/30 million tonnes per year). 5 out of 6 jobs are expected to be created in the land sector, with the largest portion of jobs in the South West and Southern Rangeland; and
- Jobs attributed to Reforestation Plantings are expected to be the largest source of new job creation (1,190), followed by Renewable Energy (614), Rangeland Regeneration (249) and Savanah Burning (186); with all remaining jobs attributed to other land-sector projects (1,694).

Proposed framework for offsets – a Carbon Pollution Offset Fund

A market for carbon pollution offsets is already established in Australia and is regulated by the Commonwealth Clean Energy Regulator. Activities that result in verified, additional carbon pollution reductions, or directly remove carbon from the atmosphere through carbon sequestration are eligible to be certified by the regulator which issues Australian Carbon Credit Units (ACCU's). ACCU's can be sold to polluters wishing to voluntarily offset emissions or comply with offset requirements. (With no market mechanism currently in place, the largest demand for ACCU's in Australia is the Commonwealth Government's Emissions Reduction Fund). The ACCU scheme provides an existing framework for the accreditation of carbon pollution offset units in WA and this does not need to be duplicated.

Box 11: Restoration and Reforestation in WA

The Yarra Yarra Biodiversity Corridor is a multi-species native reforestation project, located approximately 400km north of Perth and established by Carbon Neutral. Within the last 100 years, over 90% of the Mid West has been cleared for agriculture. The project aims to reconnect remnant vegetation sites and link 12 nature reserves across a vast tract of land covering approximately 10,000 square kilometres.

Built along the ancient Yarra Yarra drainage line, the project is the first Australian sustainability project to achieve the international Gold Standard certification. As Australia's largest revegetation project based on carbon capture and biodiversity, the Yarra Yarra Biodiversity Corridor has a carbon sequestration potential of 1.257 million tonnes CO2-e.

The **Bulga Downs Rangelands Restoration Project**, 340 km north of Kalgoorlie, is expected to sequester 80,000 tonnes of carbon per year over 25 years through low-cost revegetation activities and revised land management practices including livestock management, water point placement and additional fencing to encourage further revegetation.

Image showing the five main paddocks on Bulga Downs are fenced to country type and a minimum of one third of the property is spelled at any given time. Image courtesy of David McQuie

Source: Carbon Neutral and Desert Knowledge CRC

Instead of leaving it to proponents to decide how and where to purchase offsets, CCWA proposes that a Western Australian government **Carbon Pollution Offsets Fund** be established.

LNG producers would be required to make payments into this fund at a rate matching the Australian carbon price benchmark, in order to offset pollution unable to be reduced directly.

This fund would operate in a similar manner to the existing *Pilbara Biodiversity Offsets Fund* which has been established to ensure strategic delivery of biodiversity offsets required of the iron ore industry in the Pilbara. In this example, a Special Purpose Fund is created under the Financial Management Act, with appropriate governance arrangements to ensure the proper use of the fund for meeting its objectives. This allows proponents to discharge their responsibilities, while at the same time promoting a strategic use of these funds that is aligned with other Government and community objectives.

The key advantage to adopting this approach is that expenditure from the fund would be directed by Government rather than proponents.

This would enable:

- Compliance and auditing;
- Strategic investments in certain parts of the WA economy where they have the potential to unlock greater carbon pollution reduction in the future, such as new battery or renewable energy technology suited to WA conditions;
- Investments that maximise job creation or other co-benefits such as biodiversity protection, climate adaptation etc;
- Investments targeting particular regional areas or sectors; and
- Investments of a size and scale that would not be made by individual companies looking to offset pollution individually.

The proposal to require LNG projects in WA to offset carbon pollution is similar to approaches being adopted in other Australian jurisdictions.

Box 12: Queensland's Land Restoration Fund

The Fund was established by the state government to build a pipeline of Queensland-based carbon offset projects, that deliver economic co-benefits as defined by the government (including benefits to regional economies, soil health, and the Great Barrier Reef), and supports R&D into emerging areas where QLD has a comparative advantage for generating ACCUs.

The Fund supports new land sector carbon projects with long term contracts for ACCUs at prices that reflect the total value of the project– with the emphasis not on least cost abatement but instead projects at the upper cost curve that deliver the most in co-benefits.

Northern Territory 'buy NT-first' offsets policy

The NT Government has accepted the recommendations of its Independent Fracking Inquiry, which recommended offsetting emissions from onshore gas developments, including direct and indirect emissions. The NT government is currently developing policy to implement this recommendation, including a 'buy NT-first' policy for offsets. It has been reported that this would generate a fund of between $880 million and $3.4billion per year by 2022 to offset pollution from NT gas developments, depending on the carbon pollution reduction target assumed.[1]

Recommendations: Regional Prosperity

1. Develop a roadmap to decarbonise the Agriculture sector by 2050.
2. Undertake research to determine the opportunity for carbon offsetting here in WA and implement a Carbon Pollution Offsets Fund.
3. Collaborate with First Nations communities to identify opportunities for involvement and leadership in Carbon offset markets. This could include increasing funding to the Aboriginal Ranger Project to $100 million over 20 years to employ more First Nations rangers and practitioners on country in offsets programs. (This could be funded by the Offsets Fund, paid for by WA's biggest polluters including the LNG industry).
4. Create Ranger Parks across 5 million hectares of former pastoral leases with management by Indigenous Ranger groups.
5. Increase funding to support research and development into the decarbonisation of emissions intensive, regional industries such as agriculture and manufacturing.
6. Create a West Australian Sustainable Industry Investment Fund to drive the transition to clean manufacturing and industry with $2.5 billion in investments over ten years.[1]
7. Investment into a State Soil Health Strategy would improve the sustainability and efficiency of WA farmers and could boost wheat production.
8. Deliver a Community Power pilot program in three regional areas, which support regional communities to access the skills and expertise required to develop and deliver community-based renewable energy projects, characterized by local ownership, participation and benefit sharing.
9. Commit to a comprehensive package to support a just transition for workers in regional carbon intensive industries; including legislating a larger notice requirement for termination of employment and funding for additional training for workers to transfer compatible skills to renewables projects.[1]
10. Support the Forests for Life plan for Farm Forestry and Landcare, which includes the development and growth of the sustainable plantation sector in Agricultural regions as an opportunity to transition from logging native forests, and provide a more stable income stream.

3.5 Waste reduction

Waste accounts for 2% of WA's total annual emissions and emissions have increased by 5% since 2005. At present, policy measures focus on minimizing waste from households, however greater regulatory controls and solutions are needed in the management of industrial and commercial waste.

Emissions mitigation in the waste sector has been identified as highly cost effective and could even return a net profit, according to the IPCC.[84]

3.5.1 What areas can we target to further reduce greenhouse gas emissions from waste?

In the most recent national waste survey, WA had the second highest rate of waste generation per capita, generating 2.6 tonnes per person, and the equal second lowest resource recovery rate in Australia at 48% (13 percent below the national average).

The WA Government's *Waste Avoidance and Resource Recovery Strategy 2030* launched in 2019 is the centerpiece of the Issues Paper. CCWA supports its broad vision for a low-waste circular economy, the target for at least 75% of waste to be reused or recycled by 2030, and the headline 'three bin' kerbside collection strategy to be implemented by 2025 and divert organic waste from landfill to generate high quality compost which can store carbon in the soil. However, CCWA finds the 75% target to be too low. The ACT has increased its recovery rate target to 90% by 2025.

CCWA is also concerned that the primary focus of this section of the Issues Paper is the individual. We question why targets and regulations have not been described for more significant producers of waste, including the agricultural and manufacturing industries.

WA generated 7.3 Mt of waste in 2014–15, which is described in three streams:

- **Municipal waste** (1.6Mt) the smallest stream with a recovery rate of just 42%, which is 9% below the Australian average;
- **Commercial and Industrial** including fly ash (2.6Mt) with a higher recovery rate of 65% and is 8% above the Australian average; and
- **Construction and Demolition** (3.1Mt) the largest stream with a recovery rate of just 42%, 22% below the Australian average.[85]

Box 13: ACT's Carbon Neutral waste strategy

The ACT has one of the most ambitious waste strategies in Australia, with the aim for its waste sector to be carbon neutral by 2020. It also plans to double energy generated from waste, places a landfill ban on computers and televisions, and increases its recovery rate targets to 90% by 2025.

Municipal and organic waste

Emissions from waste are primarily due to the release of landfill gas from anaerobic decomposition of waste material in landfills as well as due to wastewater treatment. These would mainly include methane and nitrous oxide emissions.[86]

Western Australia needs to reduce organic waste levels and divert the rest of organic waste from landfill. Current organic material in landfill areas will continue to emit GHG emissions until fully decomposed, making it imperative to begin plans to divert all organic matter.

Western Australia's waste policy needs to be more ambitious and focus on organic material waste, with specific emissions targets for an emissions reduction pathway for this sector. Local government policy needs to align with state level policy and targets to tackle waste at the source.

Climate Analytics has projected that these efforts could reduce emissions from the waste sector could reduce by 69% in 2030 and 77% in 2050.[87]

Construction and Demolition waste

Construction and Demolition (C&D) waste account for almost half WA's total waste stream but has the lowest recovery rate.

From a climate perspective, steel and concrete production is a significant contributor to global emissions. Resource recovery from the C&D stream is therefore a crucial part of the picture.

Outside the Perth metropolitan region, limited access to markets for recycled products and relatively cheap disposal costs continue to restrict opportunities to increase waste recovery.

Improving landfill diversion rates and increasing re-use and recycling for this waste stream must be an urgent feature of the Climate Policy.

CCWA notes local markets for recycled C&D products are still developing and acknowledges the State Government has implemented programs to further encourage the development of markets for recycled C&D products. CCWA welcomes the Roads to Reuse program which commits to use more than 25,000

tonnes of recycled construction and demolition waste as road base.[88]

Analysis of the composition by material category of WA's waste in 2014–15 shows the majority of WA waste consisted of masonry materials, organics and metals.

Recovery rates by material were well below the national average except for hazardous waste and fly ash, which were well above the national average recovery rate.

3.5.2 What can households, businesses and governments do to reduce their waste and compost more?

Only one third of WA household waste is recycled.

CCWA also supports the current review of WA's waste levy fees which are $70/t across all streams . These fees are very low compared to other states including the ACT, which charges $90.55/t for municipal waste, $146.20/t commercial and industrial, and $199.20/t for mixed C&I with >50% recyclable material.

BOX 14: An App that has revolutionized reusing construction waste

The construction and demolition industry accounts for over 3 million tonnes of waste per year. Nearly two thirds of this ends up in landfills. Waste from this sector accounts for about half of the rubbish currently in Western Australian landfills.

In New Zealand, a new app called Civilshare is creating solutions to the mismanagement of waste and provides a good example for potential innovation in WA. CivilShare is a marketplace for people in the construction industry to buy, sell, trade, and share resources. It allows users to optimize waste generated from projects, by creating an accessible market for users to collect or purchase excess building materials, diverting these items from ending up in landfill, and reduces the demand for new, emissions intensive materials.

Source: http://civilshare.co.nz/

Recommendations: Waste

1. Develop a roadmap to decarbonise WA's Waste sector by 2050.
2. Set higher recovery rate target across all waste streams.
3. Construction and demolition waste is the largest stream of waste, and the production of construction materials such as concrete and steel is extremely emissions intensive. Reducing and reusing this waste is a priority, and funding should be provided for pilot programs which make it easier to recycle, share, sell and trade.
4. Incentivise the use of recycled materials in housing construction, and building methods such as sustainable modular housing which have significantly less construction waste than conventional housing.
5. Divert organic waste from landfill in both household and commercial sectors.
6. Introduce a second Waste Avoidance Strategy for Western Australian businesses; with regulatory measures to help reduce waste generation and enforceable impositions against companies who fail to appropriately dispose of construction features and waste.
7. Investment in recycling facilities and the circular economy and sharing economy models.
8. Investment in WA-based manufacturing of biodegradable, compostable packaging
9. Procurement policy to use recycled products rather than raw materials.
10. CCWA does not support waste to energy projects that rely on combustion of municipal waste.
11. **Introduce the best available technology for landfill gas capture.**

3.6 Safe and healthy communities

This section of the Issues Paper exhibits a narrow engagement with the relationship between communities and climate change. It focuses almost exclusively on the capacity of health and emergency services to respond to future risks while giving no meaningful consideration to current or future impacts to vulnerable communities who are disproportionately impacted by climate change.

A new climate policy for Western Australia must be built on an understanding of the inequalities that low-income and disadvantaged communities face in responding to climate change and should learn from and incorporate the experiences of these communities in its authorship and design.

In preparing our submission CCWA acknowledges the work and expertise of Doctors for the Environment Australia.

3.6.1 What are the main climate risks for households and communities and what can be done to manage these risks?

As the UN Sustainable Development Goals acknowledge, the 'poorest and most vulnerable people are being affected the most' by climate change. Our climate policy needs to afford extra consideration to how vulnerable West Australian communities will be impacted and lend support to community-led solutions for responding to climate change.

Risks to First Nations communities

Climate change threatens to compound existing disadvantage experienced by First Nations communities in Western Australia.

In 2018, 13% of the total Australian Aboriginal population, approximately 101,753 people, lived in Western Australia. A high proportion of this population (38%) live in remote and very remote areas.[91]

First Nations communities, particularly in regional and remote areas and the tropics are particularly vulnerable to the effects of climate change.

The Australian Journal of General Practice has warned, that climate change *"will increasingly affect the health of Aboriginal and Torres Strait Islander communities and, along with historical and socioeconomic determinants, multiply the challenges to closing the Aboriginal and Torres Strait Islander health gap"*.[92]

Box 15: The link between climate change and connection to country

Lack of rain and a dried-up waterhole as a result of the sadness of the country for its people is an example of the perception of the land as a sentient agent. The active partnership between country and custodians is seen as necessary for the health of the land.

Leonard et al (2013) describes how many places in Gija country (First Nations communities from the East Kimberley area of WA) that once had permanent water are either now dried up or have minimal water.

The Gija people often say that the environmental change is because the traditional owners no longer live in the country.

A Gija woman explained why a place that always had water and waterlilies when she was young was dry when we visited in September 2009.

> *"Daam, berra, mooloorroo berrani-berrewa.*
>
> *Nyamanani marra yirrayin-ngarri, marrarn berrayin-ngarri.*
>
> *Woolmoolmeyinbe loosembany-ngarri yirramanyji thamany-woorrarrem, gangga-woorrarrem damga. Well roog berrayin naw daam-boorroo, roog berrayin.*
>
> *'Gawoo-ngirri?' berrani daam. Roog boorroodboo, mooloorroo boorroorn daam."*
>
> (The country is sorry because of the people who have left.
>
> We and all the old women have gone, they all went away from the country.
>
> The old men, all those old grandparents, we have lost them now.)

Source: Leonard, S, Mackenzie, J, Kofod, F, Parsons, M, Langton, M, Russ, P, Ormond-Parker, L, Smith, K & Smith, M 2013, Indigenous climate change adaptation in the Kimberley region of North-western Australia. Learning from the past, adapting in the future: Identifying pathways to successful adaptation in Indigenous communities, National Climate Change Adaptation Research Facility, Gold Coast, p 73

For remote and isolated First Nations[93] communities, inadequate access to health and education services, infrastructure constraints and unique logistical challenges will undermine the capacity to cope with extreme weather events, such as water supply threats.

Unite Nations Water note that water is the primary medium through which we will feel the effects of climate change, with water availability becoming less and less predictable. Increased incidences of flooding

threaten to destroy water points and sanitation facilities and contaminate water sources.[94]

An Auditor General report in 2015 identified major systemic issues with the delivery of the state-run essential services in WA's remote communities, noting that 80% of the 84 surveyed Aboriginal communities failed national water standard safety tests, with the majority failing multiple times.[94] Leaving these communities without access to drinkable water contravenes the most basic of human rights.

This is covered in more detail in Section 3.7.

Significant investment, consultation and planning is required immediately to deliver essential service to an adequate standard, and to better support these communities to be resilient to the impacts of climate change.

Already unacceptable health disparities between Indigenous and non-Indigenous Australians are set to widen from the impacts of extreme weather events.

In Western Australia, First Nation peoples suffer a mortality rate twice as high as non-Indigenous people[96], and a drastically higher burden of disease rate, including cardiovascular and respiratory illness, and chronic kidney disease. It is predicted that these inequalities will be intensified by climatic conditions such as heat stress, water and food-borne illnesses, vector-borne infectious diseases and air pollution effects.

Most importantly, the vital link between connection to country and Aboriginal wellbeing is fundamentally impacted by climate change and sustained environmental degradation in Western Australia. Prolonged, extreme weather events such as bushfire, drought and sea-level rise may cause some traditional lands to become uninhabitable and force communities off Country. This in turn could create further separation, loss of culture, injustice and trauma. The foundational importance of connection to country must be better acknowledged and understood by policymakers. Policies must be informed by a holistic view of health and wellbeing in order to properly address the impact of the cultural and social determinants of health.[97]

As Professor Megan Davis notes, 'for decades and decades, the Aboriginal community controlled health services sector has been leading the way already in the realization of the most fundamental aspect of the right to self-determination: making decisions about one's health. Community control is intuitive to communities'. This sentiment encapsulates an urgent need to devise a state-wide strategy to ensure climate resilience, administered by the communities themselves.

Risks to Vulnerable communities

WACOSS has articulated the ways in which communities experiencing various forms of social exclusion and disadvantage will disproportionately bear the brunt of climate change. These include rises in the cost of living (e.g. water and food), increased exposure to extreme weather (because of low quality public and private rental housing) and associated threats to health.[99]

People with low-incomes and experiencing disadvantage struggle the most to cope, adapt and recover from climate change impacts. People experiencing poverty or disadvantage before an extreme weather event are often left worse off after the event due to factors such as under-insurance, loss of employment, loss of housing, and increased cost of living. Their needs must be incorporated into national and local climate change adaptation, resilience and emergency management strategies, including a focus on health, inclusion, communication and recovery services.[100]

Socio-economically disadvantaged communities

WA's climate change strategy should have a strong focus on ensuring climate change actions consider the costs placed on all residents and are fair to all members of the community. Any present costs should be coupled with cost saving measures and support for our most vulnerable.

Policy responses to climate change may affect low-income and vulnerable people more than others. Low income earners spend a greater portion of household income on energy and water, and therefore are more susceptible to price hikes[101]. Over 60 WA homes and businesses each day are having their electricity cut off for failing to pay their bills, with the number doubling in just three years.[102]

Low-income earners tend to live in areas or conditions more likely to be adversely affected by climate change and have far less ability to move or adjust their living circumstances to adapt to it. Disaster preparedness and resilience is often not a priority for people who deal daily with problems such as poverty, crime, violence, serious illness, or unemployment.[103]

Risks to human health overall

The following impacts on health and health services were described by Doctors for the Environment:

- Studies in Perth have shown a 4–18% increase in emergency department presentations during heatwaves, depending on the severity of the heatwave.[104]
- Predicted drought trends for WA with up to a 70% increase in drought months by 2070 will almost certainly impact on the mental health of farmers. Drought impacts on farmers in NSW from 2007–2013 highlight the importance of the issue and the need to prepare and adapt.[105]
- Floods impact on health through food borne disease,

decreased water quality, injury and skin infection. The Queensland floods earlier this year highlighted this issue with at least 10 reported cases of Melioidosis. The estimated 'tangible cost' of damage to infrastructure and communities was $6.9 billion.[106]

- Flood events can also have huge social and health impacts. 'Intangible costs' associated with the 2010-11 Queensland floods included mental health issues, substance abuse following these events, impacts on chronic and non-communicable diseases, family violence and loss of employment and were estimated to be as large as the tangible costs[107]; and
- Bushfires Fire risk, fire weather and the length of fire seasons have increased since the 1970s. Bushfires are devastating to communities and have lasting impacts. The Yarloop bushfire of 2016 killed 2 people, destroyed 181 homes and buildings. There are reports of the community still suffering psychologically.[108] Experience from the Black Saturday fires of 2009 detail ongoing psychological impacts in survivors 5 years later with intangible costs amounting to $3.9 billion.[109]

Heat stress has killed more people in Australia than all other natural hazards combined, and the risk of heat-related deaths in WA will increase as the climate warms.[110]

Climate change is causing an increase in both the frequency and intensity of extreme weather and weather-related events such as extreme heatwaves, drought, heavy rains, tropical storms and bushfires.[111]

The COP24 Special Report on Climate Change and Health highlights the severity of the predicted impacts of climate change to health calling it the greatest challenge of the 21st century.[112] Leading medical journal The Lancet has warned climate change is "the biggest global health threat of the 21st century", and in September this year, The Australian Medical Association joined other health organizations around the world – including the American Medical Association, the British Medical Association, and Doctors for the Environment Australia – in recognizing climate change as a health emergency.

Health services in Australia are already experiencing the destructive effects of climate change, which is damaging vital health infrastructure, impacting the health workforce, and putting at risk the ability of some services to continue to provide care for the community. These threats will only amplify in the future, putting more lives at risk. Fortunately, as the Lancet noted, the silver lining of addressing climate change in the context of health, is that "the economic health benefits of mitigation strategies far outweigh mitigation costs."

3.6.3 How do we ensure communities are better prepared for possible climate impacts?

Policy response to climate change in the form of climate adaption does not substitute the urgent need for strong climate mitigation policy now.

The scientific consensus is that introducing adequate controls for emissions intensive industry will be the most effective way to curb the impacts of climate change for the future generations. As the Doctors for the Environment group warned in 2015, climate change affects the foundations of children's health, and failure to act now 'would be a major intergenerational injustice.'[117]

CCWA addresses the issue of better preparedness in Section 11 which covers adaptation.

Recommendations: Safe and Healthy Communities

1. Develop a roadmap to decarbonise WA's Health sector by 2050, including a target to halve emissions from this sector by 2030. The WA healthcare system a significant source of carbon pollution. A program to decarbonise the healthcare system must be undertaken to reduce carbon pollution as fast as possible and done according to the 'mitigation hierarchy' starting with the avoidance of pollution through energy efficiency, purchasing of renewable energy and systematically removing gas as a fuel source. Such actions could also make significant savings on utility expenses.
2. The findings and recommendations of the Climate Health Inquiry should inform and be considered in the development of the State Government Climate Change Policy
3. A formal Health Impact Assessment (HIA) of all projects and proposals that cause carbon pollution, including all new fossil fuel projects. Such assessment must include the impact of these developments on health including water pollution, air pollution, mental health and climate change.
4. A public investigation on the impacts of climate change on public health in Western Australia based on different temperature scenarios (at 1.5, 2, 3 and 4 degrees of warming) and the impacts they would have on WA health and the WA health system.
5. A WA Climate Health Levy should be introduced on WA's largest polluters to cover the costs of responding to climate change impacts on public health in Western Australia. WA's largest polluters in the LNG industry whose corporate activities and investments are in line with a 3 degrees plus temperature rise should be required to bear the cost of the projected health impacts and costs of such a scenario here in Western Australia.
6. Increase funding for disaster mitigation and preparedness (only 3% of national disaster funding)
7. Commission research to better understand which Western Australian communities and groups are most pre-disposed to the impacts of climate change and use this to inform the demographic dispersion of climate policy effects.
8. In conjunction with Commonwealth and Northern Territory governments, adopt the recommendations from the 2009 *Risks From Climate Change to Indigenous Communities in The Tropical North of Australia*[1] DoEE report as a joint-initiative policy program, spearheaded by a northern summit on climate change related matters to be hosted by an Indigenous institution; which will help by;
   a. Presenting most recent climate change knowledge directly to an Indigenous audience
   b. Allow First Nations communities to present climate change perspectives and adaption strategies from a community-based approach
   c. Establish a clearing house to provide services and boost a long-standing research partnership between remote First Nations communities and the scientific community
9. Be informed by a review of the impact on low-income households, affected workers and communities, and energy-intensive trade exposed industries, and include appropriate equity measures to assist those affected.
10. Support the transition for vulnerable groups including households with low incomes, and investment in clean technology and climate resilience.
11. Significant investment, consultation and planning is required immediately to deliver essential service to an adequate standard, and to better support First Nations communities to be resilient to the impacts of climate change.

3.7 Water security

The effects of climate change on water supply is one of the greatest public health challenges that Western Australia will face. There is a strong sense of community expectation that the water industry will be an effective steward of this essential resource.

Western Australia has already experienced a marked impact on its water supply. From a steady decline in rainfall in the south-west since the 1970s, the volume of water flowing into the Perth supply has fallen from an annual average of 338 gigalitres (1911–1974) to less than 50 gigalitres a year (2010–2016), with run-off into metropolitan dams falling by 90% over the past century[118].

Over the same period, the population continues to grow making Perth the most water-stressed city in Australia.[119]

Today, Perth relies on two industrial-scale seawater desalination plants at Kwinana and Binningup to supply 48% of Perth's water. These plants are highly expensive and emissions intensive, with the Kwinana plant consuming about 185 GWh of energy per year, equating to 220,000 tonnes of CO2.[120]

The rest of Perth's drinking water comes from the Gnangara and Jandakot groundwater mounds, but these underground aquifers are being depleted at a faster rate than they can recharge through rainfall. Levels have now reached a historic low and substantial infrastructure spending is required. This includes the recent announcement of a $50 million upgrade to the groundwater replenishment program to increase capacity from 14 to 28 billion liters.

The situation in our regional and remote communities is also dire. In Denmark, $7 million is being spent to truck water in order to relieve dwindling drinking water levels, as the towns water supply is solely reliant on rain.[121]

Water insecurity and contamination in remote communities

As discussed in Section 3.6, many First Nations people in Western Australians do not have access to safe drinking water, particularly in remote communities because they are small, remote and challenged by additional issues to secure essential power and water services. Climate change exacerbates these pre-existing challenges and create new risks. **(Box 16)**

Very few remote communities in Western Australia have access to treated drinking water, and cost-effective water treatment systems are required to provide potable water at the local scale. Existing infrastructure also needs to be adapted to cope with severe weather events such as flooding and extreme temperatures. This must be addressed urgently.

Box 16: Climate Code Red: Water insecurity in Remote First Nations Communities

An Auditor General report in 2015 identified major systemic issues with the delivery of the state-run essential services in WA's remote communities, noting that 80% of the 84 surveyed Aboriginal communities failed national water standard safety tests, with the majority failing multiple times. Leaving these communities without access to drinkable water contravenes the most basic of human rights.

Most remote communities rely on rawgroundwater to supply domestic water, often without treatment. In these cases, it is extremely likely that the communities are unwittingly ingesting high levels of nitrates and uranium including a probability of the presence of uranyl nitrates.[1]

A study in 2018 focusing on remote Aboriginal communities examined a possible causal relationship between the occurrence of Chronic kidney disease and the presence of contaminants in drinking water, particularly uranium and nitrates found in the local groundwater. Chemical analysis of groundwater used for drinking has shown that both uranium and nitrates are present in remote Western Australia and the recorded data exceeded the safe drinking water guidelines.

A traditional owner in the Kimberley said,

> *"Our water is contaminated with nitrates … They say the level is … too high for babies under three months and pregnant women … now the whole community (150 people) cart water from this one tap for drinking and cooking. … We feel fear and we don't know how much damage is being done to us."*[1]

Significant investment, consultation and planning is required immediately to deliver essential service to an adequate standard, and to better support these communities to be resilient to the impacts of climate change.

3.7.1 What can we do to encourage Western Australians to use water more efficiently and adapt to a drying climate?

To address our water crisis, improvements have been made in water efficiency, conservation, re-use and recycling, but much more can and must be done. This includes practical and regulatory measures to increase water efficiency, on an individual, community and industrial scale. Equally necessary is a major overhaul of how we manage and monitor our water resources, especially our groundwater.

CCWA recommends exploring and adopting the following 9 measures, which have been estimated to save between 190–260 billion litres a year, which is significantly more than is currently provided by Perth's two desalination plants[122]:

- Mandate water conservation targets (average annual per capita residential water consumption);
- Mandate leak reduction targets and invest in mains repairs, improvements and pressure management;
- Roll out water saving advice and assistance to all WA households. If just 30% took up the H20me Smart program 6 billion litres could be saved annually;
- Conduct a cost benefit analysis of a staged statewide roll-out of smart water meters;
- Expand aquifer recharge projects in new areas of Perth; and
- Increase investment in re-use of treated wastewater for open space and industry and raise the water recycling target for the Perth-Peel region to 30% by 2030. Only 8% of treated wastewater in Perth-Peel is reused. Every year the Water Corporation discharges over 100 billion litres of treated wastewater from its treatment plants in the Perth-Peel area into the ocean.
- Mandate water sensitive urban design (WSUD) principles for all new buildings and residential developments and retrofit existing areas to capture stormwater for re-use or replenish aquifers and reduce the volume being treated and discharged into the sea. More than 100 billion litres of water is discharged into the Swan-Canning system and ocean annually via Water-Corporation owned Mains drains in the Perth-Peel region.
- Mandate dual plumbing systems supplying greywater in all new homes and incentivise retrofits in existing homes. Greywater reuse (wastewater from all indoor household uses apart from toilets) can enable 10–40% of a home's scheme water to be used.

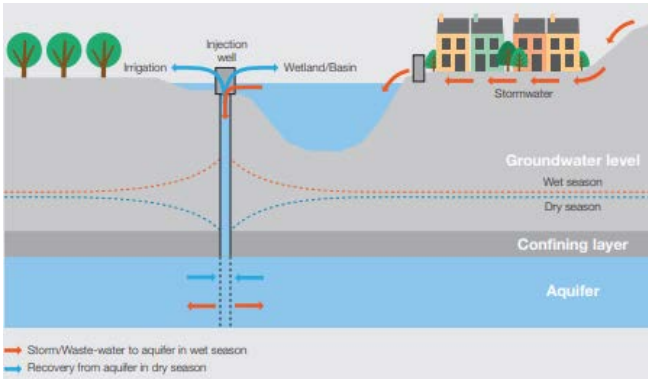
Measures to increase water efficiency will have several flow-on benefits for WA. A significant amount of energy is consumed in the capture, treatment and delivery of potable water. Investment in water efficiency reduces household energy and bills, reduces energy costs for water utilities (due to reduced need to pump water and wastewater) and reduces emissions from the energy-intensive, over-supply of water. Responsibility lies with individuals and industry to use water more efficiently, as well as with the State Government to implement policies and infrastructure to better capture and re-use water.

The WA Council of Social Service (WACOSS) also emphasises the rising energy intensity of water treatment and supply will drive rising water costs, potentially increasing the burden of cost recovery placed onto lower income households. Low income households spend a greater proportion of their weekly budgets on utilities and so are disproportionately impacted by rising prices and at increased risk of water hardship. Further, they are less likely to have access to water efficient appliances and more likely to be living in poor quality housing with leaky water supplies. State government water and concessions policy needs to ensure the supply of water as an essential service needed for drinking, cooking, bathing and cleaning is fair and affordable for all.

Box 17: Salisbury urban storm water harvesting case study

The City of Salisbury, SA offers a world-class example of urban storm water harvesting, with considerable environmental, social and economic co-benefits. Commencing in 1990, a 260ha area of low-lying degraded agricultural land was converted into an engineered wetland. 1,300ML of storm water is harvested from a 1,500ha residential and industrial catchment area each year.

The water is stored underground in an aquifer, treated and then recovered as water suitable for a continuous and sustainable supply at potable water quality. The harnessed, treated stormwater is sold to local industry and other users. The wetlands also eliminate the flow of polluted water into the sensitive Barker Inlet, a nursery for a majority of the State's fish population, and provides habitat for 160 species of birds, 20 species of water plants, fish, frogs, macro-invertebrates, long-neck tortoises, snakes and lizards.



Source: Arup UrbanLife: Water Resilience for Cities, 2010

Water efficiency as a jobs stimulus

International studies have shown that for every $1 million invested in water use efficiency and re-use projects (including water conservation, recycling, storm and rainwater harvesting and groundwater replenishment) 12–22 direct jobs are created.[69] Most jobs in water efficiency and recycling are construction and professional services. As well as these direct jobs, water conservation projects are known to have a high multiplier effect for indirect job creation, especially in local manufacturing and professional services.

'Reforestation for water production'

Forests play a role in influencing regional rainfall. A 2013 UWA study found up to 62% decline in rainfall in the southwest could be attributed to clearing.[123] There has been a significant amount of work on how rainfall can diminish after clearance of large areas of vegetation. In a recent comprehensive analysis of the depletion of rainfall in Western Australia, Andrich and Imberger found[124]:

- the reduction of native vegetation from 60% to 30% of the land area in the wheatbelt between 1950 and 1970 coincided with an average 21% reduction in inland rainfall relative to coastal rainfall; and
- for the forested coastal strip region south of Perth, land clearing that removed 50% of the native forests between 1960 and 1980 coincided with a 16% reduction in rainfall relative to stationary coastal rainfall.

There is a pressing need to undertake large scale reforestation to mitigate the long-term changes in climate, leading the authors to coin the term 'reforestation for water production.' Investment is needed to support further research to demonstrate how rainfall might be enhanced by strategic planting schemes in order to add to the rainfall totals where they are needed.

This presents a significant opportunity for the Water Corporation to gain additional rainfall and prevent another desalination plant being built. The opportunity is to return 300 GL per year into dams over around 10 years and is expected save up to $700 million by working with them on where to plant and participating in offsets. This also creates the potential for government to partner with regional communities to develop carbon offset markets and devise appropriate, strategic areas to reforest.[126]

CCWA also emphasise there should be no logging or clearing in water catchments, particularly those that are being used to supply towns if the goal is to maintain water for communities. Regrowth forests use up to 50% more water than mature forests[127] and the dewatering and change in hydrology that result from bauxite mining for example is having massive impacts on stream flow in the northern South West jarrah forests.

3.7.2 Are there policies adopted in other jurisdictions we should consider for WA?

Smart meter trials

In WA, a trial of smart water meters in Kalgoorlie/Pilbara in 2013 saved nearly 1 billion liters of water, using technology that only cost roughly $4 million.[67]

Based on this trial, it's been estimated that providing smart water meters to all WA households could provide annual savings in the vicinity of 70 billion litres a year – equivalent to 1.5 times the annual capacity of the Kwinana desal plant, for less than half the cost.

In South Australia, a new water testing technology has detected over half of all water main breaks and leaks in the Adelaide CBD since SA Water began trialing it in 2017. By using over 300 acoustic detention sensors, the Internet-of-Things network enables cracked or leaking pipes to be proactively detected and repaired, minimizing water inefficiency.

Harvesting urban stormwater

The economic and environmental benefits of preventing as much water from being treated as stormwater are well covered in the literature.

A policy program in North Rhine Westphalia, Germany's most heavily populated state, has made marked improvements to water and wastewater management. Under the Initiative for Ecological and Sustainable Water Management, generous tailored subsidies encourage the construction of green roof spaces, filtration systems and rainwater systems, which help to reduce the negative effects of stormwater in urban areas. The program has contributed to rehabilitating nearby rivers and water bodies made barren by decades of industrial pollution, by helping to absorb and filter pollutants from rainwater run-off.

Recommendations: Water Security

1. Develop a roadmap to decarbonise WA's water sector by 2050. WA's water system is a significant source of carbon pollution. Desalination and pumping stations, as well as leaks along the network make our system inefficient and a large carbon polluter.
2. Urgently prioritise investment and long-term planning to guarantee reliable and safe water supplies to First National communities across the state. Very few remote communities in Western Australia have access to treated drinking water, and cost-effective water treatment systems are required to provide potable water at the local scale. Existing infrastructure also needs to be adapted to cope with severe weather events such as flooding and extreme temperatures.
3. Develop a comprehensive and ambitious water efficiency program which has the potential to save the equivalent volume of a desalination plant
4. Invest in Urban stormwater harvesting opportunities to increase opportunities to harvest and reuse urban stormwater which increases the efficiency of treatment plants and has significant environmental and climate adaptation benefits
5. Update Water sensitive urban design guidelines for new communities and provide funding to retrofit existing communities
6. Incentivise greywater reuse
7. Investigate a Reforestation for water program
8. Replenish goundwater through forest preservation.
9. Protect forests in water catchments from logging and clearing.
10. Adopt a deep retrofit program for water efficiency targeting lower income and rental homes.

3.8 Livable towns and cities

The built environment account for 18% of WA's greenhouse gas emissions, and by international standards our housing and building stock is extremely inefficient. Improving energy efficiency and sustainability of our buildings and increasing green space in our communities will dramatically reduce emissions, improve our quality of life and resilience to climate change.

Housing

Designing homes and other buildings to better suit our current and future climate can reduce demand for electricity, save money, keep comfortable through all seasons, and be more resilient to climate change impacts such as heatwaves and more intense storms.[128]

Sustainable homes require less energy to heat and cool, enhance health and comfort and are more resilient to climate and weather extremes. Here in WA, energy efficiency upgrades in the home can lead to heating and cooling energy savings of up to 80% for the oldest and least efficient homes.

Box 17: Benefits to Collie of Energy Efficiency

Beyond Zero Emissions has modelled the impact of energy efficiency upgrades to homes in a town like Collie, which is cooler than much of WA, and found that energy savings for locals could be significant.

There are 4000 homes in the Collie region, and assuming each household saves around $900 per year and 30% of homes were retrofitted, annual savings would total over $1 million, which could be spend in the local economy, further boosting local businesses and reducing the cost of living for low income earners.

Source: BZE *'Collie at the Crossroads report'* (2019)

Rental and social housing

About 40% Western Australians live in rental housing, and lack choice and control to improve the energy efficiency of their homes. Rental homes tend to be the state's poorest performing homes, which lead to high energy bills. **(Box 18)**

Poor energy efficiency ratings means houses are hot in summer and cold in winter, driving up energy bills and creating poor health outcomes. People on low incomes can't afford to invest in energy efficiency upgrades, and renters have no choice. Research by the Australian Council of Social Services (ACOSS) and the Brotherhood of St Laurence found rooftop solar could reduce energy bills by more than $1000 a year, and a one off investment of $5,000 could have ongoing annual savings of $929.

Commercial Buildings

Improving the thermal performance of buildings will improve their energy efficiency performance and make them more comfortable places to live and work.[129]

New York City requires buildings over 25,000 square feet to reduce their emissions by 40% by 2030 and 80% by 2050. This will reduce annual emissions by 3.9 million tonnes by 2020.

Vancouver will require that all new buildings are carbon neutral from 2020. Emissions per square meter in new buildings fell by 43% between 2007–2017.[130]

3.8.2 What are the key barriers to improved energy efficiency for our built environment?

Solutions currently exist to rapidly reduce carbon footprints for buildings by more than 50% by 2030. These include strong requirements for energy efficiency, retrofitting, low carbon heating and cooling (including heat pumps and district heating systems based on renewables), incentives for using building space more efficiently and by incentivizing and enforcing low-carbon construction and strong energy and greenhouse gas requirements in procurement.[131]

A report commissioned by the Energy Efficiency Council found an ambitious strategy to improve the energy efficiency of Australian homes, commercial buildings and industry would cut household and businesses' energy bills by $7.7 billion a year, reduce gas use by 940 million gigajoules over a decade (equivalent to a large, untapped gas field), and create 120,000 job-years.[132]

On 1 February 2019 Energy Ministers agreed the Trajectory for Low Energy Buildings, a national plan that sets a trajectory towards zero energy (and carbon) ready buildings for Australia.[133]

Energy efficiency plays an important role in lowering energy bills for households and businesses; improving occupant comfort, health and productivity; saving energy (reducing wastage) for the wider economy; improving resilience to extreme weather and blackouts (peak demand); and reducing emissions.

Barriers identified in the COAG 'Trajectory for low energy buildings' released in December 2018 include:

- The market does not incentive cost effective energy efficiency improvements to buildings where the higher operating costs are borne by occupants (particularly building to rent/lease constructions);
- The current National construction Code (NCC) does not have optimal energy efficiency requirements.

Box 18: CLIMATE CODE RED: THE UNFAIR CLIMATE BURDEN ON WA's RENTERS

About 750,000 people rent in WA, in either private rentals or public and community housing.

Rental housing is typically less likely to have insluation, energy or water efficiency features, or solar power.

In Perth more than 80% of owner-occupier homes have inslulation, compared with just 37% of rented houses.

Across Australia less than 3% of rental housing has solar power or solar hot water systems compared to over 20% for owner-occupiers.

The lack of minimum standards in WA's rental properties means renters bear the cost of energy and water use without being able to make changes to key efficiency features such as insulation, window coverings, and efficient heating, cooling and cooking appliances. This places the health and wellbeing of renters at risk, and fear of eviction deters tenants from seeking repairs or asking for upgrades.

A national *Rental Health Survey in 2016* found:

- 61% of people said that their rental property was not cool in summer and warm in winter
- Only 6% of rentals have solar hot water and 4% have solar panels
- Only 8% have energy efficient appliances, almost 70% do not have insulation; and 35% have windows that don't have fly screens

The 'Make Renting Fair' alliance of WA's key community organistions found 50% of WA renters siad their homes are in need of repair, 49% are concerned making a request for repairs will mean a rent increase, and 27% fear eviction if they ask for repairs.

There are currently no enforcable standards relating to energy efficiency or climate appropriateness of rental housing in WA.

Other states have introduced programs that have improved energy efficiency for those with low incomes including the Victorian Healthy Homes program and the NSW Climate Change Fund.

In the UK the *Housing Health and Safety* rating system and a *Decent Homes Standard* sets out minimum standards and ensures housing is warm and weatherproof, with modern facilities. The government also provides financial incentives for landlords to upgrade rental properties of vulnerable households

A new minimum standard for all rental housing, coupled with a schedule of minimum requirements and a mechanism for enforcing them should be introduced. The standard could include requirements for retrofitting in rental properties, and would cover energy and water efficiency, minimum heating and cooling, insulation, ventilation, and efficiency of fixed appliances.

The State government could provide funding to assist private landlords meet the standard and encourage the installation of solar PV. This would also provide a significant co-benefit of a stimulus to WA businesses working in areas of energy efficiency, renewable energy and retrofitting areas.

Sources: WACOSS Submission the Climate Issues Paper (2019), Bankewest Curtin Economics Centre Energy Poverty in WA survey (2016); Australian Greens Rental Health Survey (2016); Make Renting Fair alliance (2019)

Improvements could deliver bill savings to new home buyers and renters of over $650 a year in colder or tropical parts of WA, and $170 each year in more temperate areas; and

- A key driver of peak electricity demand especially on hot summer afternoons is the growth in household air conditioning, which has been a significant driver in investment in generation and network capacity.[134]

Most new buildings in Australia are built to the minimum energy efficiency requirements in the National Construction Code (NCC). This misses cost effective opportunities for consumers, as new energy efficient technology costs have been falling considerably in recent years, while energy prices have been rising.

The National Energy Productivity Plan agreed by the Council of Australian Governments (COAG) Energy Council in 2015 aims to improve Australia's energy productivity by 40 per cent between 2015 and 2030. Energy efficiency requirements in the current building code are not adequate, and not enforced.

Box 19: Zero Carbon Ready Building Code

The *Built to Perform* report by the Australian Built Environment Council (ASBEC) and ClimateWorks released in 2018 calls on governments to commit to an urgent upgrade of energy standards in Australia's National Construction Code if new buildings are to be fit for a zero-carbon future.

The report shows that setting strong energy standards for new buildings in the Code could, between now and 2050, reduce energy bills by up to $27 billion, cut energy network costs by up to $12.6 billion, deliver at least 78 million tonnes of cumulative emissions savings, and can also be a driver for economic growth.

Box 20: 'ClimateClever' WA Schools Pilot Program

The Australian Sustainable Built Environment Council (ASBEC) has identified the education sector as offering some of the most cost-effective carbon abatement opportunities within the built environment.

In January 2016, a two-year Low Carbon School Pilot Program was developed and launched in Perth, with the aim to enable, empower and facilitate schools to reduce their greenhouse gas emissions, utility usage, and costs overall while educating and upskilling the next generation to be more efficient with resources.

A total of 13 schools participated in the pilot and over two years:

- Carbon emissions were reduced by an average of 20 per cent per student;
- Utility costs were reduced overall and schools recorded average savings of $16 per student, with 70% of schools saving $31 per student;
- A tree planting program was initiated and delivered by a parent at one of the participating schools, with all schools participating and planting over 50,000 trees in 2017, which led to the baseline carbon emissions of all schools being completely offset – enabling all schools to become carbon neutral.

The per student financial savings, together with the fact that more than 70% of the 625 identified actions were considered low (under $150) or no cost, demonstrates the significant potential for schools to reduce emissions on a cost neutral (or positive) basis, and supports reports identifying the education sector as offering some of the most cost effective emissions reductions opportunities in the built environment.

Source: Climate Clever Initiative / Low Carbon Living CRC Report at https://bit.ly/2PM9xwb

Beyond energy efficiency to a more holistic code

CCWA emphasises though that energy efficiency and low energy buildings are not enough. We strongly advocate for the adoption of more comprehensive building codes, such as the Green Star or LEED performance codes.

The Green Star rating is an internationally recognised system that assesses the sustainability of projects at all stages of the built environment life cycle. Ratings have been developed for Communities (precinct-scale development), during the design, construction or fit out phase of buildings, or during the ongoing operational phase; and measure nine categories including energy, transport, water, materials, land use and ecology, emissions, indoor environment quality, and innovation.[135]

The Green Building Council of Australia found that compared to average existing education buildings, Green Star-rated schools, TAFEs and universities had

- 59% less in greenhouse gas emissions
- 35% less potable water consumption
- 70% less electricity usage
- 54% reduction of construction and demolition waste sent to landfill.[136]

In addition to environmental benefits, low carbon schools provide long-term financial savings, deliver improved educational and health outcomes, such as reduced instances of asthma, flu and respiratory problems; better academic performance, and improved teacher retention rates.[137]

Communities

The climate and livability benefits of sustainable, well-designed infill development at the precinct scale can no longer be ignored.

CCWA strongly welcomes *Design WA*, the new design codes for apartments, and looks forward to the development of the next stages which will include Precinct Design and Medium Density developments. We strongly advocate for these design codes to be developed with climate change as the number one priority.

In an Adelaide case study which compared the difference between an 'optimal' sustainable development[138] with 'business as usual' scenario using a 9-hectare city block, precinct scale sustainable medium density mixed-use development, identified 23 separate benefits including

- 75% less carbon emissions over the whole precinct
- 88% energy generated on site
- Two thirds less energy consumption
- 33% reduction in the cost of living
- 27% less waste to landfill
- 10 times more public transport travel
- 32% less residential water use
- 7 times more cycling infrastructure ; and
- 27% more open space and 150% more active streetscape frontage.[139]

CCWA strongly advocates for sustainable, well designed infill developments along high frequency mass transit routes as a priority, over the current pattern of low density, single dwelling housing that has seen our city expand to almost 170km along the Swan Coastal Plain. A groundbreaking study released in 2016 studied the impact and true cost of Perth's urban sprawl **(Box 21)** and illustrated more sustainable, well designed alternatives.

3.8.3 How can we improve the retention of vegetation, particularly tree canopy, in our cities and suburbs?

CCWA emphatically emphasises that the primary cause of loss of vegetation and tree canopy in our cities and suburbs is due directly to uncontrolled clearing to facilitate poorly planned urban development, overseen by successive State governments.

A CCWA investigation has established WA has lost 1.1 million hectares of forest, and 10.1 million hectares of bushland and woodlands since 1990. This is covered in more detail in Section 3.10. **(Box 24)**

Tree canopy cover is an important defense against the heat impacts of climate change, with green suburbs up to 4–6 degrees cooler than treeless suburbs[140]. **However, canopy cover and urban forests must also be recognised as an essential source of carbon sequestration**.

CCWA also notes WALGA's draft submission which found tree canopy inequity exists across suburbs, with the least canopy often in the most socially disadvantaged areas.[141]

Over the last 60 years there's been 16 different planning and mapping projects for greenways in Perth. It's time to deliver.

Box 21: CODE RED: The true cost of Perth's urban sprawl

A groundbreaking report measuring the true cost of urban sprawl and the potential economic benefits that can be achieved through well-designed infill development in Perth was released in 2016.

It found it costs the State government $150,000 per lot to provide infrastructure such as roads, water, sewage, communications, power and new schools and health services in new Greenfields developments. This compares just $55,000 per lot in infill developments, a difference of $95,000 per lot.

This means:

- For every 1000 dwellings developed in infill sites, a saving up to $94.5 million could be achieved
- Lifting Perth's infill target from 47% to 60% would save $23 billion by 2050
- This would be enough to pay for the entire 'MAX' Perth Light Rail network as originally proposed 12 times over, or 9 new hospitals the size of Fiona Stanley
- A 100% infill target would save $53 billion by 2050.

CCWA believes these savings should be formally investigated and used to finance decarbonisation efforts across our transport, electricity and public sectors.

Source: #DesignPerth (2016) report by Curtin University, The Property Council, CODA Architecture, and The Australian Greens.

Recommendations: Livable towns and cities

Housing

1. Develop a Better Building code for new homes which embeds renewable energy and storage and aim for 10 star energy efficiency in all new homes, which are homes so efficient they require no heating or cooling
2. Introduce mandatory energy efficiency and climate performance standards for rental properties with incentives to landlords to retrofit and upgrade properties
3. Develop a program with local councils, energy retailers and local suppliers to install rooftop solar, energy efficiency measures and retrofits across WA's 40,000 social housing properties
4. Establish a Clean Energy for First Nations Communities Fund to invest in clean energy and energy efficiency improvements for remote First Nations communities
5. A 'Deep Retrofit' program for WA's existing housing stock, with incentives for every WA home to be retrofitted with insulation, energy efficiency measures
6. Like the ACT, WA should actively look to develop suburbs wit all-electric households, and exploring alternative gas such as biogas and hydrogen to inject into its existing gas network.

Built environment

7. Develop a roadmap to decarbonise WA's built environment sector by 2050, including a target to halve emissions from the built environment by 2030
8. Continue to support the trajectory for low-energy buildings being developed through COAG.
9. The focus on energy efficiency must shift to a more comprehensive and climate change appropriate building code. A new High Performance Zero Carbon Building code is needed that covers life cycle carbon emissions, energy, water, building materials, waste and landscape is needed, that is appropriate to our regions and climate.
10. The Precinct Design code and Medium Density Design code currently being developed by the WA Department of Planning must consider climate change and sustainable urban design as a priority.
11. Investigation of the true cost of greenfield development with the view to using savings made by increasing infill development being used to fund decarbonisation and adaptation efforts in our transport, housing and energy sectors.
12. Consideration of the benefits of establishing an Urban Renewal Commission and independent State Infrastructure Authority to drive 21st century planning and transport solutions and remove the cycle of politically motivated and short-sighted or never delivered infrastructure should be considered.

Urban Forest

13. End urban bushland clearing as an urgent priority.
14. Introduce as priority a funded, long term Urban Forest Plan to increase tree canopy and biodiversity as an adaptive measure to cool our cities and a mitigative measure to act as a carbon sink. The Urban Forest plan would
    - Provide protection for all existing Bush Forever sites and link them using urban forests across the entire metropolitan area, prioritizing areas with the least canopy and most disadvantage
    - Provide funding to support local governments plan and deliver urban forests
    - Protect trees and vegetation in new developments
    - Provide policy consistency to protect remaining urban bushland, significant trees and cultural sites, and
    - Introduce an "Urban National Park' category that can be added to the National Reserve system.
15. Provide funding for Local Governments to implement programs to increase tree canopy as part of their sustainability plans.

3.9 Resilient infrastructure and business

3.9.1 What are the key climate risks for the primary industry or resources sectors?

- A significant rising trend in Climate litigation against governments and corporations in relation to climate change
- Banks, Investors and Insurers are now recognising the risk of supporting projects that pose a risk to the climate. Six global development banks have committed to ending funding for fossil fuel extraction[142], and Sweden's central bank recently selling off bonds from Alberta, Western Australia and Queensland due to greenhouse gas emissions being too high[143],
- Stranded assets. As the world implements its Paris Target commitments it is inevitable that our fossil fuel exports will decline. Recent research has identified $1.3 trillion global investment in new LNG infrastructure, which is at risk of becoming a stranded asset as investor support and demand wanes for the next wave of oil and gas projects in Australia.[144]
- Frequency and severity of storms and cyclones with particular risk to remote mining operations

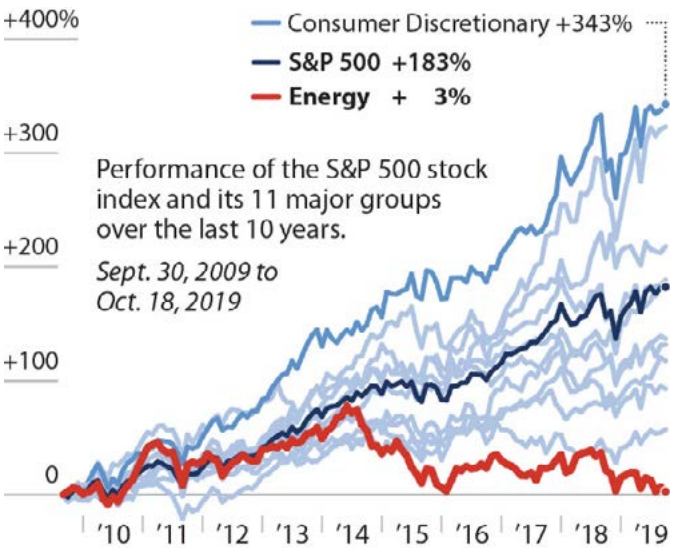
The decline of fossil fuels and vulnerability of WA's economy and industry sector

The world has reached a tipping point, with the global weighed average cost of new renewables now within the costs range of fossil-fuels and still falling.[145] Fossil fuel companies are dropping out of the top ten most valuable companies. Once a market leader, the fossil fuel sector has been a poor investment for a decade.

The energy sector, which does not include renewable energy, finished dead last among sectors in the Standard & Poor's 500 in 2018, in the wake of years of underperformance **(Fig 8)**. In 1980, seven of the top 10-ranked companies in the Standard & Poor's index were oil and gas companies. Today, there are none. In 1980, energy companies comprised 28% the S&P 500. Today, it is closer to 4%. The outlook for oil and gas companies is weak, at best.[146]

With the economics for renewables changing so rapidly the real risk to WA's fossil-fuel based export market and heavily fossil-fuel dependent economy is the pace at which other sectors innovate and electrify away from petroleum. Current policies which support LNG production without controls on greenhouse gas emissions, and which subsidise production via generous tax, exploration and royalties arrangements are unfairly and artificially propping up businesses that soon may no longer able to compete with renewables and zero carbon alternatives.

Fig 8: Energy is the worst performer over 10 years (S&P figures).



Source: S&P Dow Jones Indices

3.9.2 What are the best ways to enhance the resilience of public and private infrastructure?

The State government has estimated the financial impact of climate change to infrastructure including

- Impacts to land use with buildings at risk from sea level rise estimated to be worth $5–$8 billion
- Losses at Rockingham to Dunsborough estimated at $1.2 billion, and
- Impacts to infrastructure including sea level rise impact on 9000km of main roads worth $11.3 billion.[147]

Public infrastructure

The WA Government spent $32.8 billion on infrastructure in the decade between 2009/10 – 2018/19.[148] This spend represents a massive opportunity to show leadership and encourage the use of lower carbon material use, and also establish new industries here in WA. By requiring the use of more sustainable materials such as low-carbon cement and steel, the WA government can support industry in the state and significantly lower emissions in its own operations.

Construction accounts for 18% of Australian and global emissions, with almost two thirds of construction emissions coming from road, bridge, civil and other heavy engineering projects.[149] This is an area were the State government has significant influence. Meanwhile, the green building materials market which includes low emission concrete and steel, sustainable wood products, and use of recycled materials such as demolition waste for road surfaces,

is predicted to increase by 700% by 2022.[150] WA has an amazing opportunity to harness a share in the green construction boom, but research shows markets alone will not drive the scale of change needed, but that regulations and incentives will be essential. This is where the WA government can show leadership.

Infrastructure Sutainability Rating Tool

Much like the housing and building industry, there is a comprehensvie rating system for evaluating sustainability across the panning, desing, constructon and operational phases of infrastructure pograms, projects, networks and assets. The Infrastrucutre Sustainability Council of Ausralia's Infrastructure Sustainability Rating scheme assess a wide range of factors that contribute to the overall sustainability of a project, includign the quadruple bottom line and lifecycle environmental impact of materials.

The WA Government should require all State Government infrastructure projects over $10 million to be formally assessed using the IS Rating tool, and require private infrastructure projects such as rail lines, ports and energy infrastructure valued at over $100 million to undertake formal IS Rating as part of environmental assessments.[151]

In the EU, climate change adaptation and mitigation considerations are integrated in the preparation and approval of major projects. Adaptation seeks to ensure adequate resilience of major projects to the adverse impacts of climate change, for example flooding and is based on a vulnerability and risk assessment. Mitigation seeks to reduce the emission of greenhouse gases, for example in the selection of low-carbon options. This is addressed through the quantification of greenhouse gas emissions and integration in the cost-benefit analysis.

Recommendations: Resilient infrastructure and business

1. Develop a roadmap to decarbonise WA's infrastructure and business sector by 2050.
2. Increase funding for Local Governments to address coastal hazards (including erosion and inundation) to be commensurate with the risks being faced along our coastline, and consider establishing a Western Australian Coastal Council to provide independent expert advice on coastal policy and practice, and introduce coastal management legislation.
3. Adopt a low carbon Public Infrastructure policy requiring use of sustainable and low carbon materials in publicly-funded infrastructure.
4. Investigate and Incentivise a Green Construction industry here in WA specializing in manufacture and use of low emission concrete and steel, sustainable wood products and recycled building/ road materials.
5. Enact a moratorium on wetlands, mangroves and estuary clearing and coastal development which act as natural buffers to storm surges and are huge carbon sinks
6. Planning for climate proof communities, by ensuring climate change considerations (both mitigation and adaptation) is embedded in Government programs, policies and regulations. The State planning regime must be reviewed urgently to include climate change in its planning policies, including related issues such as urban forestry, preserving biodiversity, water security and emergency management. (WALGA)
7. Prepare a Living Infrastructure Strategy similar to that of the ACT government, and prioritise 'living infrastructure' in new developments such as trees for summer shade, permeable pavements, use of storm water in urban design, open spaces with low-water vegetation, and open water in lakes and wetlands we can keep our communities cool during hot weather and reduce the damage of high intensity rain storms.
8. Provide small grants for small businesses to perform sustainability or efficiency upgrades, including solar installations, refrigeration or equipment upgrades lighting or insulation improvements. Funding of $10 million, up to 1000–5000 grants could be provided.
9. As described in Section 3.2, subsidies for fossil fuel extraction and production must be urgently reviewed and diverted to businesses in Western Australia specializing in low or zero carbon technologies, research and development, and innovation.

3.10 Protecting biodiversity

Climate change is exacerbating the existing pressures on Western Australia's unique biodiversity.

Globally, more than one million species are at risk of extinction[152(2)]. In Australia conservative estimates show that 1800 native plant and animal species and woodlands, forests and wetlands are at risk of extinction. Australia has the highest rate of mammalian extinction in the world over the last 200 years and has already lost 50 animal and 60 plant species.[153]

Since 1989, a 309,805 km^2 area of WA's southwest has been internationally recognised as one of the world's 36 Biodiversity Hotspots. The listing of this area reflects both the international conservational imperative of protecting the exceptional concentration of endemic species that live here and also the exceptional loss of habitat that has occurred in a relatively brief period of time.[154(2)]

By 2000, ~90% of the Hotspot's 310,000km^2 area of primary vegetation had been cleared.[155,156,157]

Clearing, fragmentation and declining quality of habitat are interconnected, and consistently identified as major pressures on biodiversity. These and other pressures, including grazing, changed fire regimes, invasive species and changed hydrology, are a product of policy gaps and poor enforcement at both state and federal level.

The development of a climate change policy for WA is an unmissable opportunity to cease the trend of declining biodiversity in Western Australia, and the associated impacts on our human development and well-being. Additionally, strong regulatory protections for native vegetation will perform a substantial climate mitigation function.

In Western Australia, we have the solutions to reverse the trend of biodiversity loss right now.

The powerful combination of Indigenous leadership and knowledge, scientific research and supportive government policy holds the key to preserving one of the most biodiverse regions on earth. But instead of utilizing the solutions, the policies of successive WA governments have rapidly exacerbated the problem; through sustained cuts to environmental protections and funding and increasing rates of land clearing, marine damage and subsidised, unabated pollution. The design of a new climate policy for Western Australia is an unmissable opportunity to protect our native flora and fauna, by using localised knowledge to create jobs and provide a best-practice example for other states and nations to follow.

CLIMATE CODE RED: WA's BIODIVERSITY CRISIS

In 2009 the Western Australian Auditor General's report, Rich and Rare: Conservation of Threatened Species found that in many areas threatened species were not being effectively protected and recovered and that the number of threatened species was rising with only a few species improving.

It also reported that native vegetation has been cleared beyond safe ecological limits in some parts of WA (especially in the Wheatbelt and parts of the Swan Coastal Plain).

In 2017 the Auditor General's damning follow up, 'Rich and Rare: Conservation of Threatened Species Follow up Audit' found;

- The number of threatened species has increased to 672 (up 12%) and the number of listed threatened ecological communities remained at 66
- Conservation services were operating with less funding and staffing than 2009 levels despite the worsening situation
- 91% of critically endangered species and ecological communities and 55% of all threatened species and ecological communities had a recovery plan or interim recovery plans but these plans were not always resourced, so do not guarantee activity or improved outcomes, and
- There's been little progress since 2009 in reserving land for conservation.

CCWA notes only 4 of 10 recommendations of the Auditor General's report had been fully implemented at 2017.

Forests

WA's forests are found nowhere else on earth. The Issue Paper provides a woefully inadequate description of the role our forests play in preventing catastrophic climate change, their vulnerability to the impacts of a warming planet, and the cumulative effect of logging in Western Australia's old growth and high conservation value forests to date.

CCWA notes the Issues paper completely misses the point of the value of forests as one of the most effective and valuable carbon sinks. We are also strongly concerned that the Issues Paper looks to bioenergy as a new industry. The use of forestry 'waste' as a fuel source for bioenergy is strongly opposed to by CCWA and is not compatible with a modern climate strategy.

According to the IPCC, reducing deforestation and forest degradation is one of the most effective options for climate change mitigation.[158]

Forests, especially ancient forests, are the best hope we have of pulling carbon from the atmosphere and returning it to the soils.

The most recent (August 2019) IPCC Report concluded with 'high confidence' that the mitigation potential of reduced deforestation equals about one-third of the total global emissions. Further, "reducing deforestation and forest degradation rates represents one of the most effective and robust options for climate change mitigation".[159]

Native forests, especially ancient forests store carbon longer and more securely compared to logged and plantation forests[160] and Australian eucalyptus forests are among the most carbon dense in the world. Mature, biodiverse, ecologically intact forests capture and store the most carbon, and they are the most resilient and reliable carbon sinks.[161]

Old trees draw down more carbon than young trees[162] and it takes at least 150 years for a clear-felled forest to reach 90 per cent of the carbon carrying capacity of an old forest.[163]

At a local climate level, forests make and attract rain and reduce temperatures. Even as global warming accelerates, forest protection and restoration can bring local climate back to more manageable limits. Land-clearing in south-western Australia has caused up to 62 per cent of the region's rainfall decline.[164] Protection and restoration of forests offers the best promise of rain.

Forests also suffer from the effects of a changing climate.[165] Increased temperatures and reduced rainfall are increasingly putting tall forests under stress.

Western Australia can play a significant role in reducing global warming by protecting and restoring our extraordinarily carbon dense and biodiverse forests.[166]

WA's forests, especially our wet eucalypts store more carbon than the Amazon or Congo. It's estimated the Great Western Woodlands store about 50 tonnes of carbon per hectare, and about 950 million tonnes of carbon in total across their vegetation and soil.

Indicative modelling by Professor Brendan Mackay on the capacity of WA's south west forests sink, over a total area of 8.4 million hectares, is estimated to be 0.66 gigatonnes.

A study in 2012 by ANU reported if we stopped logging in our south west forests, we could turn the forests from a source of carbon emissions to a sink, with an estimated 5 million tonnes per year of sequestration. This in turn would generate revenue of between $16million–$438 million.

Unfortunately, at the time the Forest Products Commission refused to treat carbon credits as a forest product. The Forest Products Commission has been operating at a significant loss and is responsible for overseeing the conversion of our south west forests into low value products including woodchips and charcoal.

CCWA emphasises forest conservation is critical in our work to prevent catastrophic climate change.

Even if we stopped burning fossil fuels today, the lag between emissions and temperature increases will cause the globe to warm for at least another 30 years. This will almost certainly lead to average global temperature increases of more than 1.5˚C unless we protect and restore forests and other significant natural carbon sinks.

Box 23: The Gondwana Link

The Gondwana Link is a word leading ecological restoration project which coordinates the work of a number of NGOs.

Building on decades of conservation work and traditional expertise, the project seeks to reconnect 1,000 km of continuous habitat from the karri forests of the far south west to the woodland and mallee bordering the Nullarbor, to ensure that ecosystem function and biodiversity are restored and maintained. The program aims to play a significant role in building a post-colonial Australia, where Traditional Owners lead significant conservation programs and are beneficiaries of those programs.

3.10.1 Can existing land use and biodiversity management practices be modified to reduce vulnerability and improve resilience?

Comprehensive, structural reform of land use and management policies, rather than modification of existing ones, will be necessary to achieve better biodiversity outcomes. There are also a number of amazing land management and biodiversity initiatives that will benefit from extra funding and policy support.

Deforestation and land clearing must stop

Deforestation and forest degradation currently accounts for 13 per cent of global carbon emissions: the third largest source of carbon pollution.[167]

Native forests remove carbon dioxide from the air more effectively than anything else on land; they make and 'catch' rain and they moderate temperature. Logging and land clearing are a major driver of climate change, by releasing substantial amounts of greenhouse gas emissions and destroying critical carbon sinks.[168]

Both state and federal governments administer the inadequate regulatory framework of deforestation and land clearing in Western Australia. In practice, the EPBC Act and the Environmental Protection Act are not effectively performing their role of protecting biological diversity[169].

Protections under the EPA Act and other state policy instruments are failing to provide adequate regulatory protection for native vegetation and endangered species:

- According to the National Greenhouse Accounts, Western Australia now has the second highest rate of primary deforestation in the country.[170]
- Ancient, high conservation value native forests continue to be logged in the South West of the State, with poor compliance and enforcement of logging regulations for forest dependent threatened species. The definition of 'old growth forests' results in terrible biodiversity outcomes.
- Western Australian Native Vegetation Regulations were relaxed in 2013, to allow up to five hectares of clearing at a time without a permit and clearing of re-growing forests up to 20 years old.
- Large amounts of land clearing are frequently approved (233,082 hectares between 2005–2015), yet there is no reporting by the Western Australian government showing deforestation or emissions trends.
- The Department of Environment and Energy has also been found to have reported emissions attributable to land clearing at 5 times lower than actual volumes, distorting the contribution of land clearing to WA's emissions totals.

These problems highlight the desperate need for an overhaul of WA's regulatory framework for land clearing to address severe biodiversity decline and to capture the carbon cycle benefits of remaining native vegetation.

Habitat fragmentation

Fragmentation of landscapes places significant pressure on biodiversity, by inhibiting the ability of flora and fauna to adapt to climate change by migrating to more suitable environments.[171]

Box 24: CLIMATE CODE RED. The underreported and devastating scale and impact of forest clearing in WA

Forest clearing

Native vegetation has already been cleared below safe ecological limits on some areas of WA, especially the Wheatbelt and parts of the Swan Coastal Plan and South Coast[1]. By 1968, many of these iconic landscapes had been fundamentally and irreparably transformed. Yet, alarmingly, Western Australia continues today to have one of the highest rates of land clearing in the country.

Research compiled by CCWA shows that over **1.1 million hectares of forest has been cleared in WA since 1990–2017**, and another 10.1 million hectares of woodland and bushland has been cleared over the same time. (Source Table 6.L.10 UNFCCC Forest Conversions – WA Annual Areas and related GHG emissions, from the National Inventory Report 2017 Volume 2)

It's estimated that a significant additional area of native vegetation has been cleared for logging and other land uses, though this is not separately reported.

Research by CCWA has also uncovered that emissions data in Western Australia has been underreported in the State and Territory inventories.

WA's forests are one of the most important carbon stores. The impact of deforestation on our emissions has also been investigated by CCWA. We have found **between 1990–2017, deforestation in WA was responsible for 239 million tonnes of greenhouse gas emissions** – over 500% more than the Department of Environment and Energy published figure of 42,745,000 tonnes.

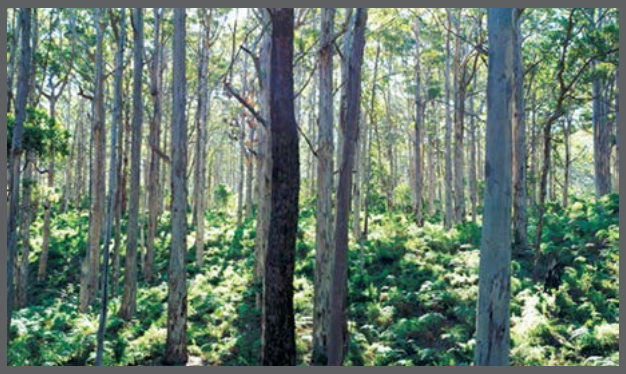


Image credit: WA Forest Alliance

Due to extensive history of land clearing, Western Australia has the second lowest proportion of native forest in patches of over 100,000 hectares. This has significant repercussions for biodiversity loss, with half of all EPBC Act–listed species at risk from habitat fragmentation.[172]

WA's current framework for environmental regulation, and the way it continues to be enforced, is consistently failing to impose adequate conditions on infrastructure projects and urban developments which have damaging environmental impacts and further fragment precious remaining habitat. Despite our grossly inadequate regulatory protections for land clearing, Western Australian organizations such as Gondwana Link, WA Forest Alliance and the Urban Bushland Council do incredible work to address habitat fragmentation, through ecological restoration programs.

Increased funding for Natural Resource Management (NRM) needed

State NRM funding was $7.75 million per year in 2018, after a once-off boost of $26 million in 2015 due to the Royalties for Regions program. Applications are significantly oversubscribed, with only 20% of large grants being funded in any one round, according to a Department representative.

CCWA advocates for a funding boost to match demand, and acknowledge significant cuts to nationally funded NRM programs have also occurred. This must be reversed as a matter of urgent priority and the State government must do more to advocate for and fund NRM activities as a climate policy priority.

Land clearing and urban bushland

The single biggest threat to biodiversity loss along the Swan Coastal Plain has been from land clearing for urban development which has occurred in an unsustainable, ad hoc, low density pattern.

Improved planning and use of existing urban areas through quality urban infill for example, reduces the pressure to expand Perth's urban footprint and remove precious urban bushland, banksia woodlands, grasslands, wetlands, and coastal ecosystems.

CCWA has strongly advocated for the permanent protection of the *Bush Forever* sites along the Swan Coastal Plain.

Introduced in December 2000, Bush Forever is the whole of government strategic plan to protect some 51,200 hectares of regionally significant bushland in 287 Bush Forever sites on the Swan Coastal Plain.

Bush Forever is a comprehensive, world class plan for the protection of our unique biodiversity on the Swan Coastal Plain. However, its implementation is incomplete. This unfinished business puts our irreplaceable natural assets of unique flora, fauna and vegetation systems at risk. **Now is the time to complete it**.

Box 25: WA's Aboriginal Ranger Program

The WA Government announced funding of $20m over five-years for the Aboriginal Ranger Program in 2017. To date it's provided funding to 42 Aboriginal organisations, creating more than 85 new jobs and 80 training opportunities across the state from the Kimberely to Esperance. Land and sea management activities include biodiversity monitoring and research, traditional knowledge transfer, fire management, cultural site management, feral animal and weed management, cultural awareness and immersion experiences for visitors, and guided tours and talks for visitors.

Noongar Ranger Program

The South West Land and Sea Council (SWALC) secured $2.5m over two rounds of funding and has employed 12 Noongar men and women as trainee rangers working on country in each of the six Noongar regions for 16 months.

Kimberley Ranger Program – Women on Country

In the Kimberley, women ranger teams have doubled in two years to 2019, with 50 now employed across all parts of the Kimberley. However, women ranger teams face major challenges including funding shortfalls and short-term contracts. Ngurarra Ranger Coordinator Chantelle Murray was the first female ranger coordinator in the Kimberley, and said:

> *"When it comes to conversations about land management women play a very important role in looking after country through both cultural and western ways. There are a lot of opportunities arising for women rangers but not as much funding as we have expected. We all need to work together across different levels to tell our stories to accomplish our vision of more women rangers as this is very important to us and our future generations."*

Sources: Department of Blodiveristy, Conservation and Attractions; Noongar Ranger Program; Kimberley Land Council

Increasing the conservation estate
The State Governments target for increasing Western Australia's conservation estate by 5 million hectares, or 20 per cent, by 2023–24 is supported by CCWA. However we advocate for a more substantial increase to the target (40%) and for this target to be codified into legislation.

CCWA supports the target to increase WA's conservation estate by 5 million hectares (20%) by 2023–24. However this is mostly in the north west region. It is strongly recommended to expand this to the south west forests, and to Perth's future urban forest and existing Bush Forever estate.

3.10.2 Can existing land use and biodiversity management practices be modified to reduce vulnerability and improve resilience?

Prescribed burning
WA's prescribed burning regime must be urgently reviewed and modified. The method is strongly criticised due to the target of 200,000 hectares per year being too high, and the locations being arbitrary and inappropriate.

Professor Brendan Mackay, amongst other experts, have stated **prescribed burning is no longer an appropriate fire prevention strategy in the age of 'fire weather'**, that is, extreme temperatures, high winds, a drying climate, and much longer, more intense fire seasons.[173]

CCWA strongly advocates for an urgent review of current prescribed burning practices.

Invasive Species
Large numbers of introduced animals, both in terms of species and population densities, are present in WA. Attempts to prevent incursions and eradicate these animals have met with limited success.[174] Failure to control introduced animals, for both terrestrial and aquatic species, adds an additional pressure to the impact of climate change, and is likely to result in further decline or extinction of native species or ecosystems. Introduced animals have been implicated in the extinction of 10 native mammal species in WA and the decline in population and range of many others.[175] Phytophthora dieback can cause the complete collapse of some ecosystems as it removes the structural layers of vegetation, directly affecting 50 percent of all flora species in the Southwest.

CCWA recommends as a priority, additional funding for research and programs t better manage and eradicate invasive species, prioritizing areas particularly vulnerable to the impacts of climate change, where interventions to remove other land use pressures are key.

3.10.3 Are there opportunities for new collaborations with landholders or communities to address climate risks and improve biodiversity outcomes?

CCWA welcomes the Issues Paper's encouragement of leadership by First Nations people relating to on land management and fire practices. CCWA emphasises genuine leadership must be allowed.

CCWA has strongly advocated for the introduction of a WA-based offsets program to offset the emissions of the WA LNG industry (roughly one third of our state's emissions). This is described in detail in Section 3.

First Nations-led land management programs
WA's biodiversity has been best cared for and nurtured under First Nations management for thousands of years. Today, we see a growing recognition among West Australians of the importance of maintaining strong connection to country for First Nations peoples.

Indigenous-led initiatives, such as the national Indigenous Protected Area (IPA) program and the WA Aboriginal Ranger program, provide hundreds of examples of how phenomenal biodiversity and environmental outcomes can be achieved through community leadership and many, many generations of intimate knowledge of country.

Such initiatives also achieve a huge host of co-benefits, including creating exciting employment opportunities, supporting the right to self-determination and bringing additional support and funding to remote communities. This has also been linked to improving health and wellbeing inequalities for First Nations people.[176] CCWA strongly supports significant increases in funding and support for these programs.

Recommendations: Protecting Biodiversity

Biodiversity Strategy

1. Enact best practice legislation to protect wildlife and biodiversity across the state, including the requirement for a statutory Biodiversity Strategy and an independent Science Committee to oversee and advise on listings.
2. Provide adequate funding for a State Biodiversity Strategy including a plan for effective ecological linkages in priority bioregions.
3. Review and increase funding to other key biodiversity programs including community education, research, water and land management.

Indigenous-led land management programs

4. Significantly increase funding for First-Nations-led management programs which are permanent and community driven, including increased funding for the Aboriginal Ranger Program to $100m over 20 years (an increase of 5×).

Forests and Conservation estate

5. Protect native forests as biodiverse carbon stores.
6. Restore cleared and degraded areas to native forest ecosystems.
7. End logging and transition the timber industry through a fair transition to sustainably managed plantations and farm forestry.
8. Change the definition of Old growth to capture all high conservation forests and permanently protect them in national parks.
9. Develop sustainable plantation and farm forestry sectors with a focus on ecologically beneficial timber production and carbon storage.
10. Develop a strategic approach to prescribed burning and protect native forests from inappropriate burning by replacing the annual controlled burning target in favour of small, strategic areas close to town-sites and infrastructure to keep fuel levels low; and allowing low-fuel level, long unburnt ecosystems to develop. No prescribed burning on the Swan Coastal Plain, and in the event of summer wildfire, ensure fast attack to stop fires immediately.
11. Rule out native forest bioenergy.
12. Increase funding for regional-scale land care and re-vegetation projects such as the Gondwana Link and Great Western Woodlands.
13. Review and prioritise ‘no clearing methodologies’ for mining in forested areas where possible, for example lithium mining can be conducted underground.
14. Introduce interventions to build resilience and reduce the impacts of climate change on forests by removing other land use pressures including clearing and burning.
15. Increase the target for increasing conservation estate by a further 20%. Seek for this target to be codified.

Clearing

16. Declare and implement a moratorium on clearing in both the south west IBRA region and in the Wheatbelt. These biodiverse regions are already over-cleared. Clearing reduces the carbon sink. This includes (but not limited to) stop clearing all TEC’s and PEC’s (both State and federally listed) such as Banksia Woodlands of the Swan Coastal Plain, Tuart Woodlands of the Swan Coastal Plain, and also stop clearing habitat of endangered species.
17. Undertake a comprehensive audit of all remaining critical habitat across the state and place an immediate moratorium on further clearing of WA’s 69 Threatened Ecological Communities.

Urban Bushland

18. Immediately complete Bush Forever as planned with all Bush Forever sites protected, restored and managed, AND with all their associated potential and existing ecological linkages protected and enhanced with extensive planting of appropriate local species, AND with all local bushland reserves protected and maintained.
19. Immediately and permanently protect 287 Bush Forever sites and lock away 51,000 hectares of biodiverse bushland as an urban carbon store.
20. Procure additional land for afforestation and reforestation projects in Perth’s metropolitan area, including ‘buying back’ land zoned as urban deferred on the Metropolitan Region Scheme and protecting it under a new Urban National Park strategy.

Continued over the page

Recommendations: Protecting Biodiversity *continued*

Funding and Governance

21. Increase State NRM funding to $20 million per year, paid for by the Offsets Fund we have described in Section 3.4.
22. Enact best practice legislation to protect wildlife and biodiversity across the state, including the requirement for a statutory Biodiversity Strategy and an independent Science Committee to oversee and advise on listings
23. Fully implement the recovery plans for the states most endangered species
24. Restore and increase funding to other key biodiversity programs including community education, research, climate adaption, water and land management, invasive species and feral animal control through the Western Shield Program.
25. Reform the states land clearing laws to protect wildlife habitat across the state, and place an immediate moratorium on further clearing of Threatened Ecological Communities.
26. 25. Undertake a comprehensive independent audit of all remaining critical habitat for endangered species and initiate measures to ensure the permanent protection and management of the areas identified.
27. Reinstate State of Environment reporting and ensure key recommendations are implemented.
28. Dramatically increase funding to DEWR, the EPA, DFES and DBCA to ensure environmental regulation and management of WA's parks, forests and reserves is effective
29. Increase funding for community groups to actively care for natural areas, to protect, repair and maintain local conservation areas
30. Greatly increased staff and resources for DBCA (Parks & Wildlife) is needed.
31. Funding for Local Government Authorities need to allocate much more staff and resources to protection and management of their local bushland and linkages.
32. Complete all Regional Park recommendations and generously fund their conservation management.

Wetlands

33. Protect all remaining wetlands of the Swan Coastal Plain and their buffer zones.

3.11 Strengthening adaptive capacity

3.11.1 Are there gaps in the availability of adaptation knowledge and information?

WA currently lacks comprehensive, effective adaptation planning. Adaption planning must span across our entire legislative framework, in order to improve resilience to a complex spread of direct and indirect impacts.

The West Australian Climate and Sustainability Forum Working Group Report in 2018 offers an insightful view of the extent of public health risks from an increasing frequency and intensity of extreme weather-related events such as extreme heatwaves, drought, heavy rains, tropical storms and bushfires in West Australia.[177]

The National Climate Change Adaptation Research Facility (NCCARF) Adaption Library provides a useful tool for WA policymakers to build on a wealth of localised research to guide climate adaption community consultation and policy.[178]

The development of a state climate policy presents an excellent opportunity to realise the benefits of a suite of proactive policies which perform not only an adaptive function, but a long-term mitigation function as well, such as carbon sequestration initiatives and ecological restoration programs.

This section of the Issues Paper demonstrates a short-sighted construction of the state governments obligation to strengthen adaptive capacity, as simply "providing tools, guidance and accurate information about the impacts of climate change and adaptation options". Adaptation actions need to take a long-term view to be effective.[179] In the Australian experience, government and communities have tended to favor short-term and responsive approaches, such as drought payouts, which can make adaptation more difficult to initiate and more expensive.[180]

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. The Intergovernmental Panel on Climate Change (IPCC) defines mitigation as the human intervention to reduce the sources or enhance the sinks of greenhouse gases[181] and adaptation as the process of adjustment to actual or expected climate and its effects.

WA-specific climate projections show a significant risk that extreme weather events will become more frequent and intense, adversely affecting life and property. Therefore, for future generations to enjoy the quality of life we enjoy now, actions are needed to increase our resilience to the effects of a changing climate.

Box 26: ACT's Adaptation Strategy

ACT's Adaptation strategy, released in 2016 is based on predicted climate hazards and risks includes a suite of 27 actions to increase reslience and reduce risks in ACT's community, city and environment.

The Strategy recognizes that twice as many fire an days and extended periods of hot weather by 2030, heat-related deaths could double and in some locations up to half the species present may be different by 2050, and the energy required to cool the family home may be at least double by 2070.

The Adaptation Strategy uses a sectoral assessment approach to identify climate change risks and consider adaptation actions across five sectors, including Disaster and Emergency management, Community health and wellbeing, settlements and infrastructure, water, natural resources and ecosystems, Innovation and Integration, and Monitoring and Evaluation.

Specific examples of actions that were to be completed by the end of 2017 included:

- Considering whether current regulatory settings of bushfire prone areas were adequately reflecting bushfire risk
- Updating the Flood Management framework
- Identify publicly accessible buildings as heat refuges
- Developing region-specific climate wise guides for buildings and estate planning
- Introducing a program of shade tree planting for walking and cycling routes; and
- Trials to innovate in climate adaptation innovation including new materials maximizing the capture and re-use of stormwater

Heatwaves

Heatwaves are the leading cause of death among natural disasters in Australia.[182] In Perth, there has been a 50% recorded increase in heatwaves between 1981–2011.14 CSIRO predicts that heatwaves will be increasingly common by the end of the century, suggesting temperatures will soar over 35°C for more than two months out of a given year. Heatwave conditions have been clearly linked to excess strain on health system resources, with emergency department presentations during heatwaves shown to increase by up to 18%.[183]

A NCAARF report has identified that non-English speaking homes are at higher risk and has emphasised the need to provide culturally appropriate information systems to help migrant communities manage the heat during Australian summers. Without substantial action to tackle climate change and cope with a more extreme climate, heatwaves could cause hundreds of additional deaths annually in Australia by 2050.[184]

Drought

Droughts can have wide ranging implications for health, including impacts on nutrition, an increased risk of infectious diseases and air contamination.[185] Agricultural drought months (defined as a month of extremely low soil moisture) are projected to increase by up to 20% over most of Australia by 2030 and up to 80% in the south-west by 2070.[186]

Decreased agricultural production in 2002/2003 resulted in a 1% reduction in GDP, which is equivalent to half of Australia's decline in annual GDP following the global financial crisis in 2009.[187] This can have a devastating influence on drought affected populations, with a recent NSW study having found that the relative risk of suicide can increase by up to 15% for rural males aged 30-49 as the severity of drought increases.[188]

Flooding

Regions of north west and southern Western Australia have proven to be flood-prone, thereby vulnerable to major health risks from extreme weather events. These risks include contamination of drinking water and food, as well as difficulties in accessing health services and treatment. Large quantities of standing water can lead to the explosion of mosquito populations, which are known to transmit diseases such as dengue fever.[189] The Queensland floods earlier this year highlighted the extent of repercussions, with 'tangible cost' of damage to infrastructure and communities amounting to $6.9 billion.

Bushfires

The influence of climate change on the amount and condition of the fuel is complex, however fire risk, fire weather and the length of fire seasons in Western Australia have increased since the 1970s. Bushfires are devastating to communities and have lasting impacts. In 2016, Yarloop experienced one of Australia's worst bushfires, in which two people lost their lives and 181 homes were destroyed. The trauma and stress of experiencing a bushfire can increase depression, anxiety and other mental health issues, both in the immediate aftermath of the trauma and for months or years afterwards.[190]

Exemplars in Adaptation

CCWA notes the exemplar approach of Victoria's comprehensive Climate Adaptation Plan 2017–20 , which commits the government over the life of the plan to:

- Encourage adaptation action across all policy areas and sectors of the economy,
- Help the community to understand and manage the risks and impacts of climate change, and
- More effectively manage risks to the Government's own assets and services from climate change by assessing the Government's current capabilities and practices and addressing whole-of-government risks and impacts in a more coordinated way.

Another approach to strengthening adaptive capacity, is through community-based adaption (CBA). CBA is a community-led planning process that uses facilitated engagement and capacity building programs to harness community priorities, needs, knowledge and capacity to empower affected communities to plan for and adapt to climate impacts.[192] This approach ensures that the interests of groups are paramount to the design of policies and programs which affect them,[193] and notes that communities who experience a sense of connectedness are often more resilient to the impacts of climate change.

Community-led processes

CCWA advocates for the implementation of community-based adaption elements into West Australia's climate adaption policies.

CCWA strongly advocates for supporting communities to develop local climate change adaptation and resilience plans.

Vulnerability

Vulnerability (be that biophysical or socioeconomic) a crucial consideration in any discussion on resiliency and adaptive capacity.[194]

The IPCC WG2 (2007) defines vulnerability as

> *"the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes."* [195]

CCWA acknowledges that adaptive capacities will differ between sectors, systems and communities, and this must be researched and incorporated as part of the Climate policy.

3.11.2 What are the main barriers to the adoption of effective climate change adaptation

Inequity in climate risks and adaptive capacity
CCWA notes the Issues Paper acknowledges that climate risks are generally not spread evenly across the community but are greater for vulnerable groups including Aboriginal communities, the elderly, people experiencing poverty, and the homeless.

CCWA emphasise that climate change hits people living on low-incomes or experiencing disadvantage first and hardest.

The WA Council of Social Service (WACOSS) has articulated this powerfully.

WACOSS states poverty significantly increases peoples' susceptibility to poor health and wellbeing outcomes resulting from climate hazards such as heatwaves, droughts, floods, cyclones and wildfires. The increasing risk of at-risk households by the increasing prevalence of extreme heat, especially in our northern tropical regions has been highlighted by research conducted by the Centre for Urban Research at RMIT. They found that nearly 88% of surveyed service providers were aware of people considered 'at risk' from climate-related hazards reporting that they often opted to avoid using air conditioners or fans due to electricity costs. Many also reported people experiencing adverse health impacts or declining mental health as a result of these conditions.[196]

They have the fewest protections from climate change impacts and live in the most affected places. They're more likely to be:

- Living in inefficient or poorly resilient homes
- Susceptible to heatwaves – elderly people, people with medical conditions or disabilities
- Socially isolated with less support in extreme event
- Less likely to be insured to recover

WACOSS also note people with fewer resources and capabilities have less money, choice, power and social connections to cope, adapt or recover.

Failing to halt climate change will cause greater poverty and inequality in the future.[197]

The Community sector plays a critical role in supporting vulnerable people before, during and after extreme weather events, but are themselves not resilient. According to ACOSS, 25% of community sector organisations think they would close for good after an extreme weather event. Lack of resources, capacity and engagement are key barriers.

People who experience poverty and disadvantage are also worse off if the transition to a clean economy is poorly managed and inequitable, because they pay disproportionately more of their incomes on essential services and have less choice and control to reduce costs.

WA's response to climate change must support a more just, inclusive, equitable and sustainable state.

Distributive energy inequity
The shift to a decentralised distributive clean energy system can create efficiency and create opportunities and benefits for consumers. A challenge we have for WA in decarbonising our electricity supply is in ensuring we have an equitable transition to renewable energy. Without targeted and systematic policies that prioritise vulnerable communities, the shift to decentralised distributive energy could become new poverty divide.[198]

2.1 million Australian households have installed rooftop solar, saving the average household $414.00 a year. This is a benefit that not all households are sharing.

People particularly vulnerable to missing out are people on Newstart, single parent households, households where someone is living with a disability or health issue; First Nations people and communities, migrants and refugees, pensioners, the working poor, renters and people living in housing stress (paying over 30% of their income on housing).

Affordable access to climate appropriate homes
As discussed in Section 3.8, people living in poor quality housing with inefficient appliances have limited capacity to reduce their exposure to extreme temperatures and older households often underestimate their vulnerability to associated health impacts.[199]

Poor quality housing, which typically includes lack of insulation, inefficient or faulty heating and cooling, and structural issues exposing the dwelling to weather, is one of the most significant drivers of people's experience of energy poverty and utility stress that significantly undermines households' capacity to be climate resilient.[200]

Coastal Planning
Western Australia currently has no specific coastal planning laws, statutes for coastal hazard management, nor an independent advisory body to consider coastal developments which threaten marine ecosystems and biodiversity or are threatened by rising sea levels and storm surges.

Coastal Planning in the face of Climate Change

Western Australia currently has no specific statute for coastal hazard management, nor an independent advisory body to consider coastal developments which threaten marine ecosystems and biodiversity. Other states in Australia have achieved much better legislative protections for their coasts. For example, NSW has overhauled its legislative framework, strengthening coastal governance through the development of a Coastal Management Act and associated support mechanisms (including guidelines, expert panel, and $81 million in funding). Also, in Victoria; the Marine and Coastal Act 2018 has been introduced to support integration across the marine, coastal and land-use planning systems.

Western Australia is in urgent need of stronger marine and coastal hazard management laws, to protect our coastal regions from unsustainable development and address coastal erosion.

Recommendations: Strengthening adaptive capacity

1. Adaptation plans for Western Australia are a core part of Zero Carbon legislation and should be prepared every five years and embed consideration of climate change across all levels of government decision making.
2. Climate adaptation planning and legislated climate adaptation requirements, including state-wide climate risk assessment and increased emergency services funding.
3. WA's response to climate change should support a more just, inclusive, equitable and sustainable state.
4. Climate policies must be implemented in a way that ensures a just transition and protect vulnerable communities. Programs which directly target and assist vulnerable groups to adapt to Western Australia's changing climate are recommended, including
   - Social housing retrofits
   - Investment into new housing and facilities for people experiencing homeless to ensure they are not exposed to harsher and harsher elements
   - Investment into essential infrastructure and facilities that are climate and culturally appropriate in remote First Nations communities
5. Invest in low income households first.
   - Invest in 'deep retrofits' including energy efficiency & clean energy for rental housing (including private rentals, community and public housing) Introduce mandatory energy efficiency and climate comfort standards for rental properties and phase in rooftop solar
   - Work cooperatively with federal and local together to co-fund ongoing programs for low-income and disadvantage households to provide access to energy efficient knowledge, products & solar PV.
   - Pilot new technologies with low-income and disadvantaged households; and
   - Fund the production of a West Australian social vulnerability map to enable development of local climate change adaptation and resilience plans
6. Prioritise funding and support for adaptation programs and partnerships with Aboriginal people and communities. This would include;
   a. Funding a genuine engagement process with remote indigenous communities on adaptation plans for their community and country.
   b. Investment in renewable energy and storage systems, and other essential infrastructure to increase resilience and provide stable utilities such as power and water for remote First Nations communities.
7. Provide funding and development of adaptation programs with farmers, local governments, businesses and other sectors.
8. Funding for community-led genuine engagement processes.
9. Coastal Planning reform, including independent advisory body and stronger marine and coastal hazard management laws, to protect our coastal regions from unsustainable development and coastal erosion.

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CLIMATE ANALYTICS

A 1.5°C COMPATIBLE CARBON BUDGET FOR WESTERN AUSTRALIA

WA's role in implementing the Paris Agreement and capturing opportunities in a decarbonising global economy

NOVEMBER 2019

CLIMATE ANALYTICS

CONTENTS

Cover photo: Darkydoors
Ningaloo Reef and Cape Range national park, a World Heritage area near Exmouth, Western Australia.

EXECUTIVE SUMMARY

This study analyses what actions Western Australia needs to take to play its role in global and national efforts to limit warming to 1.5°C.

Western Australia is on the frontline of climate impacts and has a vital interest in the world, and Australia as a whole, taking sufficient action fast enough to keep global warming within the Paris Agreement's 1.5°C temperature limit to protect its unique and iconic ecosystems, coastal and agricultural regions, and the health and well-being of its population.

WA's iconic ecosystems and World Heritage sites such as Ningaloo are threatened by warming above 1.5°C and are already showing substantial damage with global mean warming of 1°C. Marine heatwaves are already damaging fisheries and causing massive seagrass loss at Shark Bay.

Declining rainfall and rising temperatures in the southwest are placing escalating pressure on agriculture, water resources and there are early indications of agricultural productivity failing to keep up due to the impacts of a warming and drying climate. These changes are also threating WA's unique biodiversity-rich land ecosystems.

Sea level rise is causing escalating problems on the coast, with accelerating beach erosion and retreat threatening infrastructure, homes and lifestyles and are the first signs of the consequences of the accelerating global sea level rise now being observed in many towns and coastal parts of Western Australia. As the Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C (IPCC SR15) has established, every increment of global warming will rapidly escalate damages, impacts and risks. WA's coral reefs, such as at Ningaloo, face losses of 70-90% with 1.5°C of warming, and virtually complete losses of more than 99% with 2°C of global mean warming above pre-industrial levels.

This study aims to provides key Paris Agreement compatible carbon budget benchmarks and greenhouse gas reduction pathways for Western Australia consistent with the state playing its role in global efforts to limit warming to 1.5°C. The results include state wide emission reduction goals needed for 2030, options for WA to meet its aspirational net zero greenhouse gas (GHG) emissions goal for 2050, and the broad policy changes needed to meet this budget.

WA and the National context

The Australian national reduction target for 2030 of a 26-28% reduction compared to 2005 emission levels is inadequate. National reductions in the range of 44-61% by 2030 are needed to be consistent with the level of action Australia needs to take in global efforts to limit warming to 1.5°C and to meet the Paris Agreement's long-term temperature goal. These emission reductions are needed by 2030 to put the country on a cost-efficient pathway to achieve zero net GHG emissions by around 2050.

The 1.5°C compatible state level greenhouse gas target for Western Australia estimated in this report is a reduction of 49% by 2030 (from 2005 levels). Whilst this is within the Paris Agreement compatible national emissions reductions range for Australia as whole it should be noted that the reductions by 2030 for Western Australia are likely to be slightly less than the total national reductions that Australia will need to achieve, due to the particularly energy intensive character of the Western Australian economy, and in particular its very large liquified natural gas (LNG) sector.

In the national context, when Australia begins to deal seriously with the question of national emission reductions, it cannot be assumed that the other states will accept Western Australia doing less than them. We have not examined these issues in this report, but it is clear that policymakers in Western Australia need to be cognisant of the relative levels of action between the states. The experience with the European Union has shown that each state will have its own set of arguments on what is a fair and economically effective division of mitigation responsibilities.

Although, in August 2019, Western Australia adopted an 'aspirational goal' of achieving net zero GHG emissions by 2050, as of yet it does not have any targets for renewable energy nor does it have a specific 2030 reduction target. Western Australia and New South Wales are now the only states or territories without a renewable energy target. Several other states are moving ahead with more ambitious action and there are appears to be little or no coordination between the states on this, and it cannot be assumed that these states are contemplating Western Australia taking a lesser share of the emissions reduction burden than themselves.

Western Australia has unique opportunities to develop its own vision and strategy and reap the benefits of being a global leader in implementing the Paris Agreement. It is highly independent from the federal level, with its own independent energy system, as well as prime renewable energy and mineral resources. It is therefore well-placed to demonstrate its independence from the failings on climate action at federal level.

WA has the opportunity to develop new added-value manufacturing industries and create employment opportunities while moving away from being an exporter of carbon to becoming an exporter of zero emission energy carriers (green hydrogen, ammonia, or electricity) and products, in particular to neighbouring South East Asian countries. It also has unique challenges, with the physical scale of the LNG industry, and the extensive and deep links this industry has with the political parties and government of Western Australia raise important public policy issues in relation to long-term public interest and climate governance in the state. Nevertheless, the abundance of capacity, renewable energy resources and links to important Asian markets mean that there is a transition strategy open to the state to explore, which would allow it to decarbonise the LNG industry and transform into a major exporter of renewable energy, either directly via electricity or through green hydrogen exports.

A significant part of the study focuses on a Paris Agreement compatible carbon budget for the energy and industry sectors in Western Australia as the largest source of greenhouse gas emissions in the state is carbon dioxide emitted from fossil fuel combustion and use. Globally, carbon dioxide (CO_2) is the main driver of human induced climate change and ocean acidification, and CO_2 from fossil fuels is the largest source, accounting for about 66% of total GHG emissions globally.

In Western Australia, energy and industry emissions are the largest source of greenhouse gases, with CO_2 and methane (CH_4) emissions from fossil fuel use for energy and industry accounting for 89% of total GHG emissions from the state (excluding LULUCF). The most rapidly growing source of greenhouse gases in Western Australia is the LNG sector, with a more than threefold increase (318%) since 2005, with the sector doubling in size over the last five years and set to increase by nearly 50% by the late 2020s.

We know from the IPCC Special Report on 1.5°C (SR15) that to meet the 1.5°C limit in the Paris Agreement, CO_2 emissions from all sources need to peak around 2020, fall by 45% by 2030 compared to 2010 levels, and reach net zero around 2060. This report also shows that the energy transformations required to achieve this are technically and economically feasible and can have large sustainable development benefits. To develop a carbon budget for Western Australia, we draw upon the modelling framework that gives these global results and apply it within the West Australian context so that the

CO_2 emissions budget as well as the energy system transformation dynamics are consistent with the global results.

Carbon budget for Western Australia energy and industry sectors: Key conclusions

The carbon budget for Western Australia's fossil fuel CO_2 emissions for the period 2018-2050 is estimated at around 950 $MtCO_2$. This is about 0.17% of the remaining global carbon budget. **If Western Australia maintains its current emissions rate, it would consume this budget within 12 years**.

With the right policies and modern technologies, Western Australia can spread this budget over the next 30 years, so that it achieves zero CO_2 emissions by 2050, but the pathway to stay within this budget is critical: CO_2 emission reductions of about 37% by 2030, 81% by 2040 (all compared to 2005) and zero emissions by 2050 are needed.

Delays in reducing emissions will imply faster reductions later to stay within the carbon budget, implying higher costs and disruption, and a risk of locking in further fossil fuel infrastructure.

Carbon budgets (emission pathways) for each sector and for all energy/industry emissions are shown below in Table 1 (Figure 1) as well as necessary reductions pathway 2030 and 2040 compared to 2005, so that all sectors reduce emissions to zero by or before 2050.

Table 1: Paris Agreement compatible energy and industry carbon budget for Western Australia 2018-2050 by sector and total, with sectoral and total reductions by 2030 and 2040. Source for historical data: AGEIS (2019). LNG sector emissions include emissions from venting/fugitive emissions (own estimate). Note that the increase in emissions in the LNG sector by 170% in 2030 compares to an increase of 630% in the reference (business as usual) case. Electricity generation reaches zero before 2040, all other sectors by 2050.

Sector	Paris Agreement compatible carbon budget 2018-2050 $MtCO_2$	Remaining years at 2017 emissions rates	2005 Baseline $MtCO_2$	Share of current emissions (2017)	2030 reduction (compared to 2005 baseline) CO_2 only	2040 reduction (compared to 2005 baseline) CO_2 only
Electricity generation	160	6	17.5	31%	-95%	--100%
Transport	207	15	8.8	18%	-16%	-54%
Industry: LNG Sector	208	16	3.6	17%	+170%	-73%
Fugitive emissions (excl. LNG)	25	6	1.6	5%	-55%	-90%
Industry: other	328	15	18.1	28%	-30%	-77%
Buildings	22	12	1.2	2%	-41%	-70%
Total energy/industry emissions	**949**	**12**	**50.8**	**100%**	**-37%**	**-81%**
Total energy/industry excluding LNG sector	**716**	**11**	**45.6**	**79%**	**-53%**	**-79%**

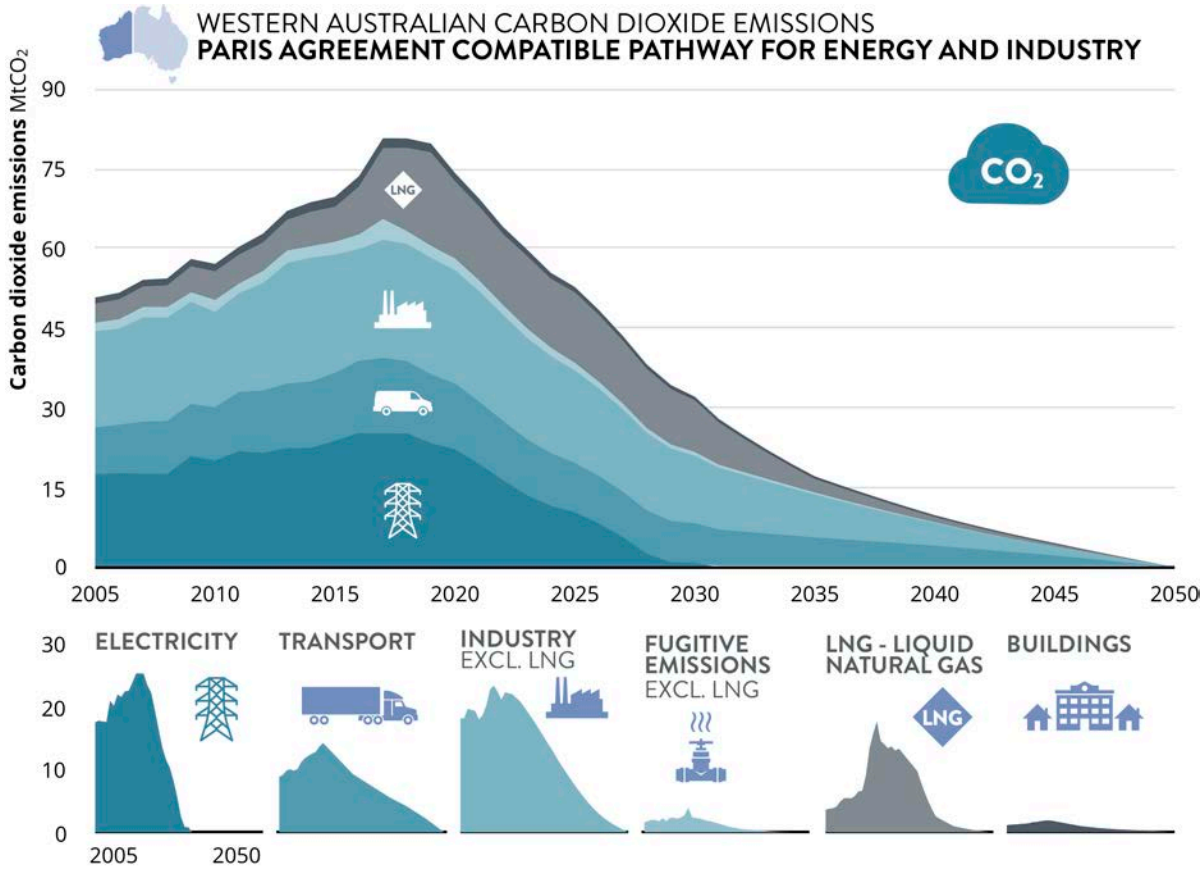

Figure 1: CO_2 emissions pathway for each of the sectors and energy and industry following transformation is consistent with the Paris agreement in each of those sectors. Total CO_2 emissions peak around 2020 and decline to about 37% below 2005 levels in 2030, for total budget of around 950 $MtCO_2$. Excluding the LNG industry, energy and industry CO_2 emissions would reduce by about 53% by 2030 below 2005 levels, for a total budget of 716 $MtCO_2$.

Achieving zero greenhouse gas emissions by 2050 – need for fast reductions by 2030

Total GHG emissions (including LULUCF) would need to peak as soon as possible and fall by 49% below 2005 levels by 2030. This translates into a reduction by 52% in 2030 compared to 2010. This is a key milestone for Western Australia – and Australia – to do their part to keep the Paris Agreement long-term temperature goal within reach and avoid the risks of escalating costs and institutional and economic lock-ins of carbon-intensive infrastructure, which will then be costly or more difficult to phase out later.

Unlike the other sectors, agriculture and waste emissions are difficult, if not impossible, to reduce to zero. Even with all the other transformational measures described in this report, remaining missions from these sectors would need to be compensated with negative emissions from the LULUCF sector.

In the LULUCF sector, native vegetation clearing and deforestation essentially need to stop by 2025. Non-CO_2 GHG emissions from the LULUCF sector would need to continue to decline slowly consistent with recent trends. A large sink in the land use sector would need to be maintained over the next decades.

With these assumptions, WA could achieve net zero emissions around 2050. Significant research is needed to evaluate trade-offs and ensure that a focus on carbon storage does not lead to unintended consequences for the agricultural economy, biodiversity, water and other elements of environmental value.

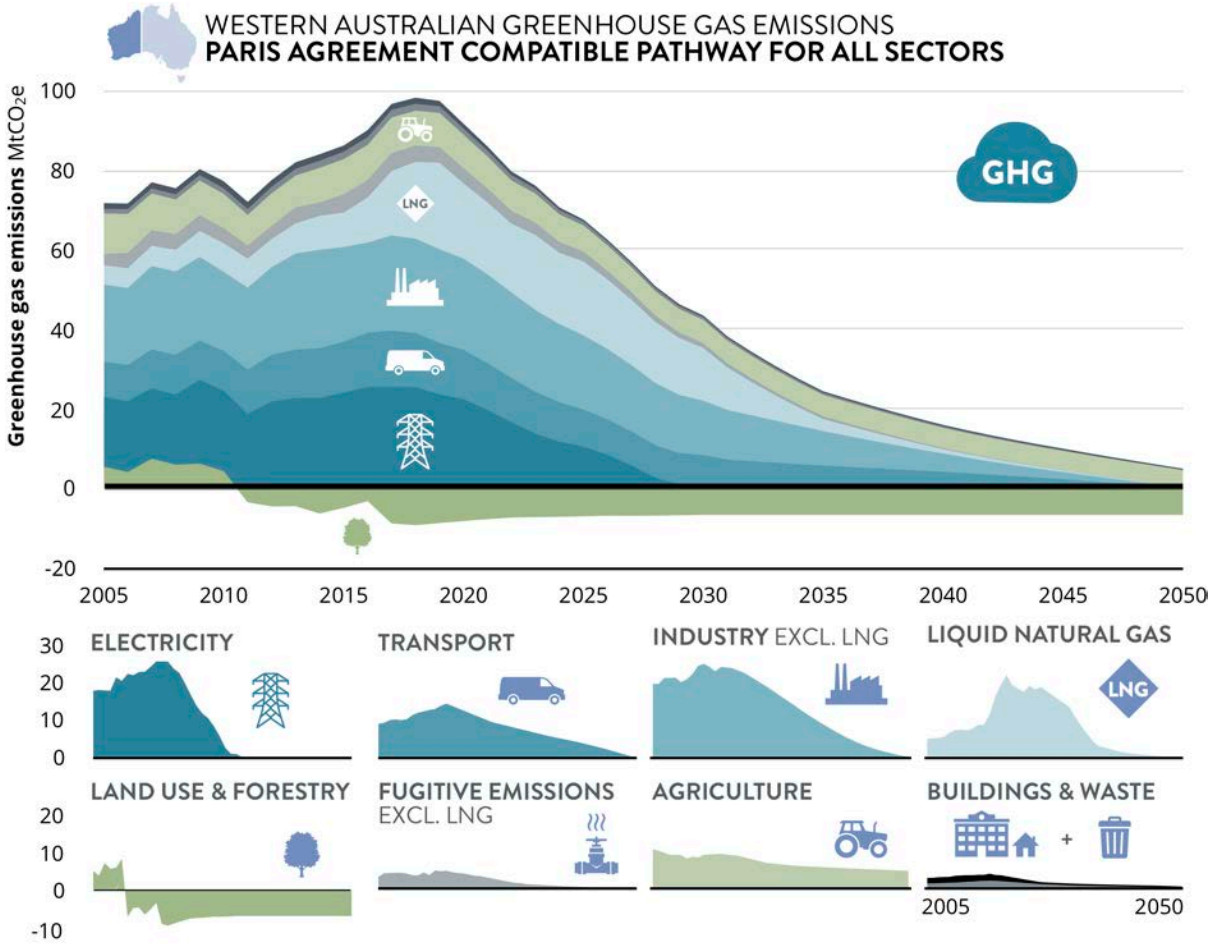

Figure 2: GHG emissions pathway for each of the sectors following a transformation consistent with the Paris Agreement in each of those sectors. Total GHG emissions peak around 2020 and decline to about 49% below 2005 levels in 2030, reaching net zero around 2050 contingent upon maintaining a large sink in the LULUCF sector. Consistent with national projections, the LULUCF sink is expected to slowly decline from recent high levels due to saturation of reforestation and other activities. It also assumes vegetation conversion (deforestation in broad terms) leading to emissions is effectively halted by 2025, which would require policy intervention. National projections assume ongoing deforestation losses.

Staying within the budget: A unique set of opportunities for Western Australia

Western Australia has prime resources that are needed to implement the Paris Agreement including first class wind and solar resources, minerals and critical materials for batteries and other technologies. Technologies associated with renewable energy, such as batteries and electric vehicles require natural resources available in Western Australia and the state is already the world leader in lithium production.

Green hydrogen offers Western Australia an option to transition the LNG industry into a renewable energy export industry as the state has a number of advantages:

- Ability to offer lower landed costs of hydrogen,
- Proximity to markets,
- Well established energy trading relationships,
- Experience in large scale energy infrastructure construction,
- Possibility of supplying hydrogen from a range of sources

Western Australia has a lot to gain from such a strategy, if such a transition is planned well, given it can move away from relying on exporting fossil fuels (LNG) towards exporting zero emissions energy

carriers (direct electricity or green hydrogen) or zero emissions energy intensive products such as zero emissions steel – with opportunities for additional manufacturing employment.

One of the key comparative advantages that Western Australia has is its geopolitical proximity to Asian energy markets, its relationship through the LNG industry with these markets, and through the export of mineral commodities. It is these advantages that have led, amongst other things, to the rise of the export on a global scale of iron ore, other minerals and LNG, but it is also this context that gives rise to a unique opportunity to effect a transition away from carbon intensive fuels to zero carbon industries.

The transition to a zero-carbon economy in Asia will require large amounts of energy, hence the market for energy carriers similar to LNG will not disappear. A number of Asian economies have - or are - developing hydrogen strategies, for a variety of different reasons, including energy security and climate change. A Paris Agreement driven decline in Asian demand for LNG would be matched by a corresponding increase in demand for clean energy carriers, in particular green hydrogen.

The key elements of the zero-carbon transition outlined here for the LNG industry involve developing new markets for green hydrogen, which requires a major ramping up of renewable energy generation capacity in regions near to the present LNG facilities. This fundamental transition in the energy market driven by Paris Agreement needs to be fully anticipated by the government based on independent scientific and objective analysis of likely market developments, rather than selective application of scenarios by industry. Unless the government has available to it independent and scientifically rigorous analyses, rather than those put forward by sectoral interests, there is a serious risk that it will fail to anticipate and miss the transition opportunities available to it, and large disruptions could occur that otherwise it would have avoided. Other Australian states appear to be moving ahead with elements of this transition strategy, which Western Australia probably should have led.

LNG sector in Western Australia: Need to transition

Emissions from the LNG industry that occur in Western Australia are estimated here to be around 22 Mt of carbon dioxide equivalent (CO_2e) per annum in 2019, about 22-25% of the state's emissions, and can be expected to approach 35 Mt CO_2e/year (30-33% of 2005 state emissions) or higher by the late 2020s if all present plans go ahead and the plants operate close to full capacity.[1]

The reference case for LNG cumulative emissions for 2018-2050, if not abated, are likely to be in the range of 1 $GtCO_2$, of the same order as the entire carbon budget for Western Australia – or equivalent to about 14 times the state's entire emissions in 2005. When the LNG is burnt offshore in power stations significantly greater missions occur but these are not counted domestically in Australia or in Western Australia. Under the agreed international greenhouse gas accounting systems used in the UNFCCC, Kyoto Protocol and the Paris Agreement, emissions are accounted for in the country in which the LNG is consumed.[2]

LNG manufacturing is an emissions intensive process and in Western Australia is estimated to have a total greenhouse gas intensity in the range of 0.39-0.74 tonnes of CO_2 equivalent per tonne of LNG (tCO_2e/tLNG) produced depending upon the plant, the gas reservoir being exploited and the timeframe.

1 These emissions are sometimes referred to as Scope 1 emissions.

2 These emissions are sometimes referred to as Scope 3 emissions.

The average intensity over the last 20 years is about 0.4 tCO_2/tLNG produced, with this intensity projected to increase over the next decade to close to 0.6 tCO_2e/tLNG.

There are three or four main sources of emissions: venting of CO_2 that naturally occurs in the gas reservoir which has to be extracted in the LNG manufacturing process, and is normally vented into the atmosphere; the energy used in converting the natural gas stream into its liquefied form is substantial - requiring about 9% of the energy content embedded per unit of LNG – and leads to significant CO_2 emissions; fugitive emissions from the liquefaction process plant are also significant; finally, in some cases in Western Australia natural gas is used to power pumping systems that move the gas onshore.

Apart from planned capture of CO_2 and storage in geological formations at the Gorgon plant, very few greenhouse gas mitigation measures have been announced or planned at any scale in Western Australian LNG facilities.

Under the Paris Agreement, demand for unabated natural gas in the power sector in Asia, a major source of Western Australian LNG demand, is likely to peak by around 2030 and then decline to close to zero between 2050 and 2060. This is a robust result of an analysis of 1.5°C compatible mitigation pathways assessed by the IPCC to be consistent with the Paris Agreement Long-term Temperature goal, and taking into account that Carbon Capture and Storage (CCS) is increasingly unlikely to be able to compete with renewable energy and storage. Renewable energy and storage provide a more cost-effective solution and additional benefits for sustainable development, with costs continuing to fall, while there are no observed cost improvements for CCS in power generation and incomplete capture would need to be compensated with additional, and likely expensive, efforts to remove carbon dioxide from the atmosphere. These pathways show that Paris Agreement implementation is likely to result in a substantial reduction in natural gas demand in the power sector in Asia without CCS, reducing from peak levels in 2030 to close to zero by 2050.

Irrespective of whether or not the demand reductions implicit in the Paris Agreement Asian power demand scenario above occur, the cumulative emissions of the LNG industry need to be reduced substantially and the basic options examined here - through carbon capture and storage of reservoir CO_2 and by introducing renewable energy quickly into the LNG manufacturing process - would need to be deployed in either case. In the reference case, the scale of the emission reductions would be substantially larger than in the Paris Agreement Asian power demand case.

An essential option for abatement in the LNG sector is to ensure that reservoir CO_2 is captured and stored, rather than released into the atmosphere. In Western Australia this is a very significant component of the overall emissions from LNG production. CO_2 in the natural gas reservoir has to be captured from the gas stream in any event to produce LNG, and its storage and transport to an appropriate geological storage reservoir should be well within the means of the industry to achieve. The broad approaches assumed here is that the level of CCS planned for the Gorgon plant of 80% from 2019 is phased in to all LNG plants from around 2023. This would avoid around 171 $MtCO_2e$ of emission in the Paris Agreement Asian power demand scenario and 304 $MtCO_2e$ of emissions in the reference case.

Processes in the LNG plant themselves require electricity and energy for refrigeration and these can mostly be electrified with clean renewable energy. About 9% of the energy content of LNG is used, in the form of natural gas, to manufacture the product. The corresponding CO_2 emissions can be avoided by using renewables in the LNG manufacturing process, which in large part is essentially driven by aeroderivative gas turbines. Phasing in of renewable energy so that by 2030 50% of natural gas uses in LNG manufacturing are replaced by renewable energy and 90% by 2035 and ultimately 100% by 2050 would directly avoid around 123 $MtCO_2e$ of emissions in the Paris Agreement Asian power demand

scenario and close to 395 $MtCO_2e$ of emissions in the reference case. Taking into account the likely co-reduction of other liquefaction process related emissions the GHG reductions induced by introducing renewable energy in this way could be up to 184 and 441 $MtCO_2e$ respectively.

Applying the options described above to the reference case to LNG production would reduce the peak emissions from Western Australia LNG manufacturing to around 300% above 2005 levels from a projected 600% increase by the mid 2020s in the case of no policy action. This would bring emissions back to about 176% above 2005 levels in 2030, 16% below 2005 levels in 2040 and 46% below in 2050. Zero CO_2 emissions would be needed by 2050 to be Paris Agreement compatible.

Under the Paris Agreement Asian power demand scenario the decline in natural gas demand from 2030 combined with the mitigation options discussed (carbon capture and storage, electrification), LNG related emissions in 2030 would be about 175% above 2005 levels, around 80% below by 2040 and approach zero by 2050.

To achieve these emissions reductions in the absence of a carbon pricing system would require the state government to introduce binding regulatory requirements on the LNG industry to meet or exceed greenhouse gas intensity benchmarks consistent with these emission reductions or conditions, or more specific technology standard based requirements that would apply to both existing and planned facilities.

Key conclusions for climate policy in Western Australia

It is critically important to take a whole of economy approach to a climate strategy and take into account the role of the power sector in decarbonising end use sectors. Our study confirms the importance of fast reductions in the short and medium term.

It is key to decarbonise the power sector via a fast transition to renewable energy, taking advantage of the vast potential and low and falling costs of renewable energy and storage technologies and the opportunities for a range of sectors. Every sector will need to contribute to reducing emissions. This would also contribute to achieving other objectives, such as reduced air pollution, protection of biodiversity, sustainable economic development and high-quality employment including in rural Western Australia. Building agricultural resilience to climate change through changes to management practices and regenerative agriculture approaches will help farming communities to adapt to climate change. This would also contribute to mitigation by increasing the storage of carbon in agricultural landscapes, whilst minimising adverse unintended side effects.

The following are conclusions relevant for policy in Western Australia:

- The need to develop a whole of the economy roadmap and strategy and detailed sectoral roadmaps and strategies in line with Paris Agreement. This strategy needs to be based on the Paris Agreement Long Term Temperature goal and the importance of limiting warming to 1.5°C and the urgent need to peak emissions and reduce them by around half by 2030.
- Strategies and roadmaps need to be based on Paris Agreement scenarios and analysis, that should be developed in a process with the broad participation of all stakeholders – industry and trade unions, civil society, as well as regional and local governments. Use of non-Paris Agreement compatible energy scenarios in government planning and economic projections risks blinding government to the inevitable policy transitions that need to be made.

- The pathway to zero is critical and it is dangerous to focus only on an endpoint of net zero emissions by 2050. The path to get there matters – both in terms of the cumulative emissions and their impact on temperature, as well as in terms of the technical and economic transition pathways and policy implications for the near future.
- Energy and industry are the key sectors that need to be addressed for full decarbonisation.
- Overall and sectoral strategies and roadmaps need to take into account the critical role of electricity generation transitioning to renewable energy and becoming fully decarbonised by the 2030s, to contribute to the decarbonisation of end use sectors through direct or indirect electrification.
- There will be a large increase in electricity demand and therefore a massive ramping up of renewable energy capacity – solar and wind – and this needs to be factored in when planning the transition in electricity generation, with clear targets and management of grid development, distribution systems and market regulation, as well as infrastructure for microgrids and off-grid solutions.
- Strategy of "sector coupling"[3] not only helps other sectors such as transport and industry reduce emissions and decarbonise, but also helps to provide grid stability with variable renewable energy – wind and solar – through battery or other storage and demand side management. Sector coupling helps, for example, people to integrate successfully their electric vehicle (transport sector) and charging via home-based photovoltaics (PV) and battery storage systems (buildings) with the power grid as a whole (energy and industry) whilst boosting the reliability and efficiency of the entire electricity distribution system (whole of economy).
- Sectoral strategies and roadmaps need to lead to the development of clear mid-term sectoral targets and policies to create incentives and develop the necessary infrastructure that are consistent with a Paris Agreement sectoral pathway, for example:
    - Electricity generation: one third renewable share by 2025, 90% renewable by 2030 and 100% in the early 2030s. This means phasing out coal before 2030 and gas shortly afterwards.
    - Industry: increase efficiency, reduce emissions by 30% in 2030 and 100% in 2050
    - Transport: prepare for rapid roll out of electric vehicles and trucks based on batteries and renewable hydrogen powered fuel cells (FCEV) by developing infrastructure such as charging stations for electric vehicles or hydrogen fuel cell trucks, and through government procurement and supply policies, establish targets for modal shift to public transport and support more cycling and walking, and replace bus fleets with electric and/or FCEV buses.
    - Forestry: halt deforestation as soon as possible and but not later than 2025, develop and secure biological sinks while preserving biodiversity, taking into account climate change.

It is important to address open research questions in a targeted way, ensuring knowledge is developed and shared broadly with stakeholders, and draw upon, and mobilise, the extensive capabilities of the West Australian research community through the establishment of innovative research funding and coordination centres and/or mechanisms. This is important for example for research on the role of the land-use sector and how it can contribute to CO_2 uptake and negative emissions either through the sustainable use of biomass and carbon capture and storage or through enhancing and sustaining sinks in forests and ecosystems.

3 Integrating a renewable energy system, connecting energy using sectors such as buildings, transport and industry with the power sector. See for example the discussion at https://www.irena.org/energytransition/Power-Sector-Transformation/Sector-Coupling

The necessity to transform the state's economy from its present energy and carbon intensive configuration to a renewable, zero carbon one poses unique challenges (and provides unique opportunities). To meet this challenge, a number of countries have introduced, or are planning to introduce comprehensive climate change legislation, including mechanisms for establishing legally binding carbon budgets for a period such as five years that are ratcheted up based on scientific and technical assessments. They are also planning to provide appropriate legislative powers and capacity to manage the transition.

The Western Australian government should seriously consider introducing comprehensive climate change legislation, such as a "zero carbon" law. There are many things that the state can do to advance the policy agenda needed to halt the growth of emissions and begin the transition towards zero that is required to protect the state from the worst effects of climate change. Introducing legislation specially designed for this purpose appears to be of critical importance.

INTRODUCTION

This report provides key carbon budget and emissions pathway benchmarks for the energy and industry sectors for Western Australia that are consistent with the state playing its role in national and global efforts to limit global mean warming to 1.5°C above pre-industrial levels. The Paris Agreement's long-term temperature goal (LTTG) aims to limit global average warming to 1.5°C above pre-industrial levels[4]. With the present level of warming at about 1°C above preindustrial levels, limiting warming to 1.5°C will require urgent and rapid action globally. The IPCC Special Report on 1.5°C (SR15) has shown that this remains feasible provided action is initiated very soon. Main messages from the IPCC (2018a) SR15 include:

- Climate Change poses a severe threat, with impacts and risks being significantly lower at 1.5°C compares to 2°C or higher temperature increases above pre-industrial levels.
- Avoiding these severe risks is still feasible, but requires cutting global greenhouse gas (GHG) emissions by 45% -about half - by 2030 compared to 2010 levels, and reaching zero CO_2 emissions from all sources by 2050 globally, and net zero GHG emissions globally by 2070.

Whilst these global reductions levels are not applicable exactly to each national and sub-national context they do provide a basic orientation for policy and the emission pathways needed to meet the Paris Agreement: a 45% reduction in energy and industry CO_2 emission or GHG emissions by 2030 compared to 2010 corresponds to about a 40% and 45% reduction compared to 2005 levels for Western Australia respectively.

Because of the key role of energy and industry CO_2 emissions to achieve the Paris Agreement temperature goal, the carbon budget for Western Australia will focus on what the state's fossil (energy and industry) CO_2 emission limits need to be across all sectors of the economy and energy system, in order to be compatible with its contribution to meeting the Paris Agreement's 1.5°C limit. In addition, the study looks at implications for the overall greenhouse gas pathway to achieve net zero emissions by 2050, in line with Paris Agreement and the WA State Government's 'aspirational' objective, including necessary reductions in non-energy sectors (agriculture and waste), and the role of the land use sector to compensate for remaining GHG emissions, in particular from agriculture. The study will provide key conclusions regarding necessary CO_2 and total GHG reductions by 2030 and key sectoral strategies and policies across all sectors, taking into account Western Australia's unique situation, responsibility and opportunities.

To estimate a carbon budget and emissions pathways for Western Australia consistent with necessary global and national efforts to limit warming to 1.5°C, we use multiple lines of evidence from the scientific and technical literature, making use of state-of-the-art analysis and modelling of technically and economically feasible and plausible emissions pathways and technologies. We also consider sustainability constraints (for example limits to the use of biomass and negative emissions technologies) and economic considerations (we aim to minimise costs).

The requirement for deep carbon dioxide reductions and zero emissions means that all emitters - both large and small - will need to take part. It is argued by some in Australia that because it is a small global emitter - about 1.1% to 1.4% of global emissions - then its actions are irrelevant and not necessary.

4 Article 2.1 of the Paris Agreement (PA) defines its long-term temperature goal (LTTG) as "[h]olding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change" (UNFCCC 2015).

However, small emitters, under 2% of global emissions of CO_2, added up to close to 30% of global CO_2 emissions in 2017, showing that achieving zero CO_2 emissions, or even very deep reductions, cannot be achieved without comparable action by all smaller emitters. Western Australia, with an independent energy system and unique opportunities and resources, as well as interest in achieving the 1.5°C limit to protect its unique natural resources, has a special responsibility to act in line with what these necessary efforts.

The **focus of the study is on domestic emissions**, and analyse specifically how much the **growing LNG sector** is contributing to these emissions, but also how it has to and can also contribute to necessary emissions reduction. We will provide an **outlook on the current large carbon footprint and the opportunities for Western Australia** to instead contribute to global emissions reductions through exporting zero emissions energy carriers and products.

PARIS AGREEMENT LONG TERM TEMPERATURE GOAL AND 1.5°C WARMING LIMIT

The long-term temperature goal (LTTG) of the Paris Agreement (PA) is

> *"[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change"* (UNFCCC 2015, Art. 2.1 PA).

The legally binding long-term temperature goal is, by design, both a substantive and legal strengthening of the previous international goal of holding warming below 2°C, agreed in Cancun at UNFCCC COP16 in 2010[5]. This goal is to be operationalized through the Agreement's different enabling elements, in particular Article 4.1 which establishes a timetable for peaking global GHG emissions as soon as possible, rapidly reducing these, with zero GHG emissions to be achieved globally in the second half of this century. The timetable for these global reductions and timing of achieving zero GHG emissions is to be based on the best available science.

The Paris Agreement LTTG requires a substantially lower level of warming be achieved than the former 2°C Cancun goal, which is still often referred to in Australia. Scientifically, the 2°C Cancun goal is interpreted as emission pathways that have a likely (66% or higher) probability of holding warming below 2°C. Peak 21st century warming in the published mitigation pathways consistent with the 2°C Cancun goal is 1.7-1.8°C and generally these pathways have less than a 50% probability of warming below 1.5°C by 2100[6].

The specific language of the Paris Agreement LTTG means warming should not rise above a level well below 2°C – which means peak 21st century warming needs to be lower than 1.7-1.8°C achieved in

5 UNFCCC 1/CP.16 The Cancun Agreements, Paragraph 4: "Further recognizes that deep cuts in global greenhouse gas emissions are required according to science, and as documented in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, with a view to reducing global greenhouse gas emissions so as to hold the increase in global average temperature below 2 °C above preindustrial levels, and that Parties should take urgent action to meet this long-term goal, consistent with science and on the basis of equity; also recognizes the need to consider, in the context of the first review, as referred to in paragraph 138 below, strengthening the long-term global goal on the basis of the best available scientific knowledge, including in relation to a global average temperature rise of 1.5 °C"

6 Note that in the underlying scientific literature, probabilities of holding warming below a certain level for a particular emissions pathway consider uncertainties in the global carbon cycle and climate system. In this context, for example a "median" warming level associated with a particular global emissions pathway means that 50% of a large collection of climate/carbon-cycle models shows warming above, and 50% shows warming below, the specified warming level, for that particular emissions pathway.

pathways consistent with the 2°C Cancun goal with a likely probability (66% or higher probability). The Paris Agreement LTTG excludes interpretations that would have warming rise above a level well below 2°C before declining to a level well below 2°C by, for example, 2100. The latter appears to be a common misunderstanding in the Australian policy debate. In addition, it is important to note that the only temperature limit referred to in the Paris Agreement is 1.5°C above preindustrial levels.

The IPCC (2018a) Special Report on Global Warming of 1.5°C (IPCC SR15) has assessed the impacts of global mean temperature increase of 1.5°C above pre-industrial levels, as well as the impacts avoided compared to higher levels of warming including 2°C. The report details the extent of global warming so far and the risks and impacts for both natural and human systems.

The projected risks on human and natural systems are vast, and the risk levels take a massive leap between 1.5°C to 2°C warming above pre-industrial levels (Climate Analytics 2019a). One example, is that limiting warming to 1.5°C degrees could mean 420 million fewer people would be exposed to exceptional heatwaves in contrast to 2°C global warming (IPCC 2018a). Risks of species losses and extinction are less likely in 1.5°C scenario compared to a warmer climate of 2°C (IPCC 2018a). Keeping warming well below 1.5°C is essential to prevent these adverse impacts.

The impacts of climate change are already being experienced in Western Australia, and the south-west is particularly vulnerable to climate change impacts. The latest data shows average annual temperatures will increase and annual rainfall is declining in the southwest, the intensity and duration of hot spells are projected to rise and increase in frequency (Dept Primary Industries and Regional Development 2019). Modelling suggests the drying trend will continue, with higher risks of droughts and bushfires (Dept Primary Industries and Regional Development 2019). Changes in climate has negative repercussions on the agricultural sector and water supply. Western Australia has experienced sea level rise twice the rate of the global average (Climate Commission 2011). Rising sea levels has created severe risks of coastal erosion in Western Australia (Seashore Engineering 2019).

Western Australia is an internationally recognised biodiversity hotspot. Iconic flora and fauna, such as the quokka, Carnaby's cockatoo and tingle trees, in addition to the Ningaloo reef are at risk from climate change (Climate Commission 2011). The erosion and decline of our native animals, reef, and beaches, also erodes at the identity and culture of the Western Australian. It impacts the quality of life and the drivers of Western Australian tourism. Western Australia has reached a critical crossroad and needs to play its part in climate change mitigation.

Already today marine heatwaves are being observed, such as the record marine heatwave of 2011, with unprecedented sea temperature levels and warming anomalies of 2-4°C persistent for more than 10 weeks, which led to massive coral bleaching in the Ningaloo and Shark Bay region and possibly permanent impacts on algae and marine seagrass of and around Shark Bay (around 36% of the bay's seagrass meadows died off) as well as further negative impacts on other species along the food chain.

Global mitigation pathways for the 1.5°C limit – it matters how we get to net zero

Given the strengthening of the long-term temperature goal in the Paris Agreement, compared to the Cancun Agreements, emissions pathways compatible with the PA must increase substantially both the margin and likelihood by which warming is held below 2°C, and simultaneously satisfy the 1.5°C limit.

The IPCC (2018a) Special Report on 1.5°C (SR15) adopted and published in October 2018 has assessed a new generation of mitigation pathways based on Integrated Assessment Models that examine the technical and economic feasibility of holding warming below 2°C and in particular limiting warming to 1.5°C, simultaneously considering many dimensions of sustainable development. The IPCC (2018a)

SR15 currently provides the "best available science" for operationalising the LTTG and defining key elements of the emission pathway in Article 4.1, because it provides the most comprehensive and up-to-date assessment of mitigation.

The IPCC (2018c) SR15 Summary for Policymakers (SPM) defined 1.5°C compatible mitigation pathways as those with no- or limited overshoot above 1.5°C warming:

- "no- overshoot"- limit median global warming to 1.5°C throughout the 21st century without exceeding that level
- "low-overshoot" - a brief and limited overshoot (<0.1°C) with median peak warming below 1.6°C around the 2060s and drop below 1.5°C by the end of the century (around 1.3°C warming by 2100).

The IPCC (2018a) SR15 is very clear about the increases in climate risks between 1.5°C and 2°C, which reinforces the clause of the LTTG that limiting warming to 1.5°C "would significantly reduce the risks and impacts of climate change". It is important to note that the 2°C Cancun goal ("hold below 2°C") pathways discussed in much of the literature and in the IPCC reports predating the Paris Agreement do not provide a perspective on limiting the temperature increase to 1.5°C.

In policy terms, if the 2°C goal were to be used as a guide, the resulting 2030 emissions levels would be far above those in 1.5°C-compatible pathways, as shown in IPCC SR15, so that the 1.5°C limit would be out of reach, unless extreme carbon dioxide removal levels are achieved by 2050, which the Special Report does not deem feasible for technical, economic and sustainability reasons (Wachsmuth, Schaeffer, and Hare 2018).

The IPCC (2018a) SR15 clearly shows that rapidly reducing global GHG emissions by 2030 – by around 45% compared to 2010 (see Figure 3) – is a key milestone towards limiting warming to 1.5°C and avoiding the risks of escalating costs and institutional and economic lock-ins with carbon intensive infrastructure, which will then be costly or more difficult to phase out later. Delaying emissions reductions would reduce the flexibility of future response options and increase the reliance on negative CO_2 emissions - taking CO_2 from the atmosphere – using Carbon Dioxide Removal (CDR) technologies. All pathways require a rapid decarbonisation of energy systems by 2050, with global anthropogenic CO_2 emissions at net zero by around 2050, and total GHG emissions zero globally by around 2070. Figure 3 below provides an illustration of these pathways.

A 45% reduction in global GHG emissions by 2030 compared to 2010 corresponds to an emissions level of 25-30 $GtCO_2eq$/year by 2030. Excluding pathways that exceed the CDR sustainability limits identified in the IPCC SR15 implies faster reduction of greenhouse gas emissions by 2030 – to a level of 25-28 $GtCO_2eq$/year (Climate Analytics 2019e).

Full implementation of the current Nationally Determined Contributions (NDCs) corresponds to an emissions level of 52-58 Gt CO_2eq/year, nearly twice as much as the 1.5°C compatible pathways imply. The IPCC (2018a) SR15 therefore concludes that the ambition level of the current Paris Agreement national emission commitments – NDCs - are not consistent with limiting global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030. The Climate Action Tracker (2018b) shows this pathway reflecting the ambition level of current NDCs leads to warming reaching 3°C by 2100. It should also be noted, the Climate Action Tracker estimates that with current policies (as of December 2018), the median warming is projected to result in a rise of 3.3°C by 2100 (Climate Action Tracker 2018b). Whilst 3°C warming is itself likely to be

extremely damaging, and catastrophic to many systems, there is at least a one in 10 chance (10%) that the current policy pathway could lead to global warming reaching, or exceeding, 4.5°C by 2100 (Climate Action Tracker 2018b).

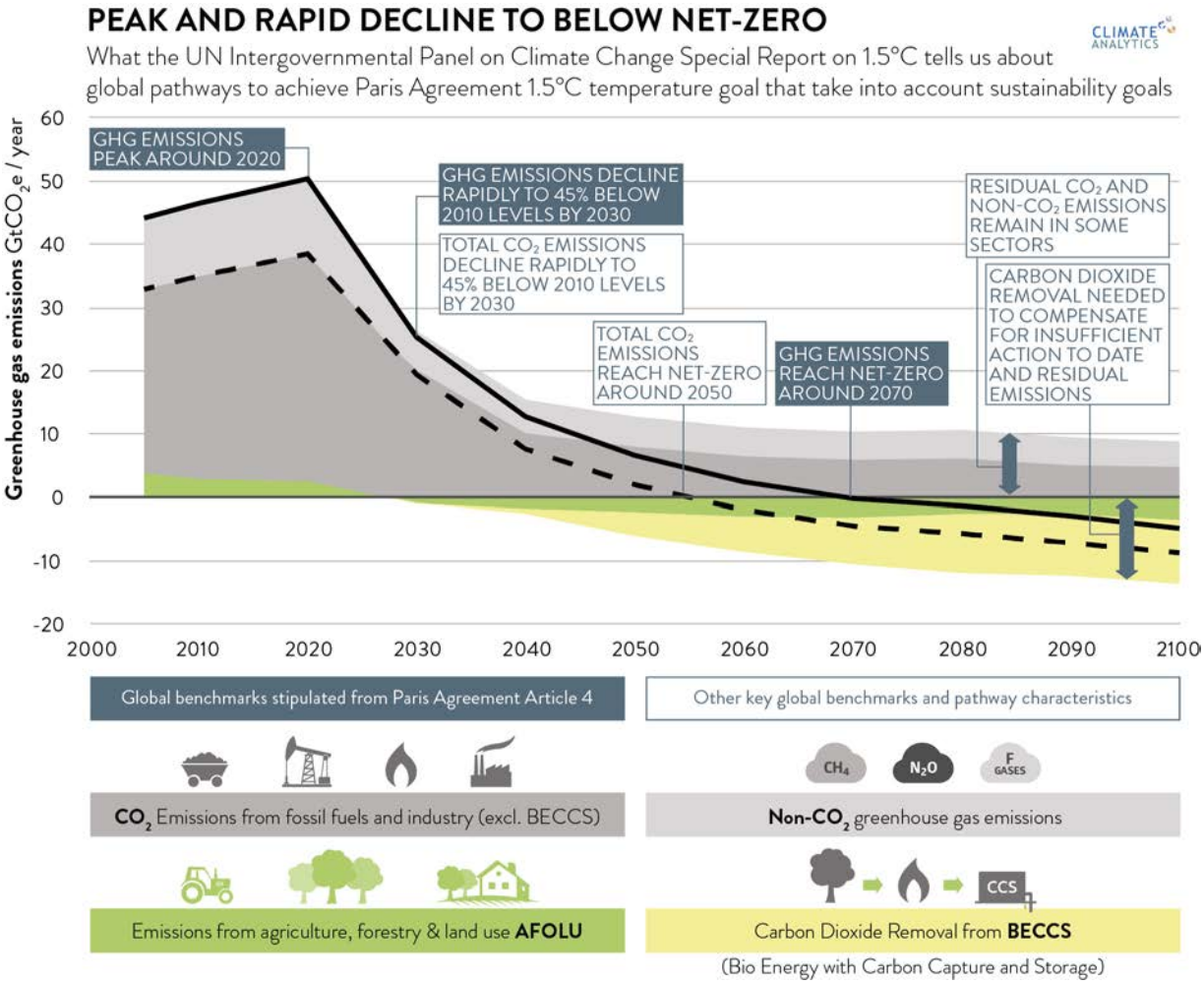

Figure 3: Illustration of the three benchmarks in Paris Agreement Article 4.1 for operationalisation of Article 2.1 (dark blue boxes) and global decarbonisation benchmarks (white box). This representative pathway is the median across all 1.5°C-compatible pathways from the IPCC (2018a) SR15 that reach levels of Carbon Dioxide Removal (CDR) below the upper end of estimates for sustainable, technical and economic potential around 2050 from SR15 in the sector of Agriculture, Forestry and Land-Use (AFOLU), as well as via Bioenergy combined with Carbon Capture and Storage (BECCS)[7]. Source: (Climate Analytics 2019e).

Whole of Economy Approach to net zero emissions – Transformations across all sectors

The IPCC SR15 outlines the range of mitigation strategies that can achieve the emissions reductions required to follow the pathways consistent with the PA LTTG described above. All pathways require a rapid decarbonisation of energy systems, with global net anthropogenic CO_2 emissions declining by about 45% from 2010 levels by 2030 and reaching net zero around 2050. In addition, substantial reductions of emissions of non-CO_2 greenhouse gases such as methane and nitrous oxide from agriculture, industry and other sectors are needed, and as well as a phase-out of HFCs (Climate Analytics 2019e).

7 All emissions and removals where calculated from the median emissions levels across the 46 pathways in the SR15 scenario database that are 1.5°C compatible, that satisfied the limits to CDR mentioned, and that reported data for all variables included here Source: SR15 scenario database (IIASA 2018) https://data.ene.iiasa.ac.at/iamc-1.5c-explorer

Achieving the Paris Agreement Long-term Temperature Goal requires transformative systemic change across the whole economy and society that is integrated with sustainable development to achieve the required deep cuts in GHG, and in particular CO_2 emissions. Carbon dioxide emissions from energy and industry need to reach net zero across all sectors of the economy by around 2060 globally and by around 2050 for a highly developed country like Australia. In addition, steep reductions in deforestation are needed.

The key characteristics of 1.5°C consistent global sectoral transformations based on the scenarios assessed by the IPCC are the following (Climate Analytics 2019e).

- Fully decarbonised primary energy supply by mid-century;
- Large energy demand reductions across all end-use sectors by 2030;
- Large reductions of fossil fuel use, in particular coal (-64% by 2030, -75% by 2050) and oil (- 11% by 2030, -60% by 2050);
- For natural gas, scenarios show a large range of changes by 2030, up to 20% increase and a 25% decrease, and up to a 55% reduction by 2050 with some models showing about the present levels (5% above 2010).
- Lower reductions in coal and natural gas correspond to those scenarios where it is assumed there is a high level of carbon capture and storage (CCS) deployment, which at present seems unlikely given the reducing costs of renewable energy and storage technologies.
- Rapid increase in the use of renewable energy;
- Bioenergy is used in many 1.5°C pathways, both with CCS (BECCS) and without, with uncertainties regarding limits to sustainable use
- Full decarbonisation of electricity generation by 2050, mainly through increased use of renewable energy reaching shares of over 50% by 2030 and over three-quarters by 2050 globally, and phase-out of coal by 2040 globally.
- Electrification of end-use sectors (transport, buildings, and some industry processes) and decarbonisation of final energy other than electricity, for example through the use of biofuels, hydrogen or other zero emissions energy carriers (aviation, shipping, and some industry processes)
- Net-zero land-use emissions between 2025 and 2040, requiring a steep reduction in deforestation and the adoption of policies to conserve and restore land carbon stocks and protect natural ecosystems.
- By 2050, negative emissions will already need to be on a multi-Gigatonne per year scale.

It is important to understand that all these sectoral transformations are needed – it is not a choice of one or the other and there is no room for offsetting one against the other.

Main energy transformation features of 1.5°C compatible pathways

Rapid reductions in energy demand across all sectors are fundamental for 1.5°C compatible pathways that also limit negative emissions through carbon capture technologies. The 1.5°C compatible transformation will require significant additional investment worldwide in low-emission infrastructure as well as redirection of financial resources from carbon-intensive investments toward low-emissions infrastructure.

A rapid and almost complete global phase-out of coal by 2040 in the power sector is a universal message from the new scenario results with many regions in particular OECD phasing out coal much earlier (around 2030/31). The share of coal for electricity generation (without CCS) shows a steep reduction in 1.5°C compatible pathways to 80% below 2010 levels by 2030 (Climate Analytics 2019d).

Substantial reductions in oil use by 2050 are also projected, coming in at around 30-80% lower than 2010 levels. By 2030, oil would need to decline by up to 35% below 2010 levels, but some models show an *increase* of up to 5%, reflecting assumptions about a lower and slower uptake of electric vehicles and transport than in other models.

For natural gas globally, 1.5°C compatible scenarios in line with the Paris Agreement long-term temperature goal assessed by the IPCC show a large range of changes by 2030, but have a median reduction of about 13% below 2010 levels, and by 2050 a 58% reduction compared to 2010 levels for those pathways that do not deploy carbon capture and storage (CCS). A high level of carbon capture and storage (CCS) deployment is very unlikely given the rapidly reducing costs of renewable energy and storage technologies. The use of CCS as a mitigation option in many scenarios is assessed on the basis of capacity factors in the order of 80–90%, which is not likely to be achieved in combination with a high penetration of variable renewables. Due to the high marginal cost of electricity production, CCS plant would be pushed out of operation first (Brouwer, 2015).

Figure 4 shows the projected demand for natural gas for electricity generation without CCS in the Asian region for 1.5°C compatible scenarios, which are assessed by the IPCC to be in line with the Paris Agreement long-term temperature goal. Demand for gas in the power sector will likely peak around 2030 and go down dramatically. These 1.5°C compatible pathways are compared to the IEA B2DS (below 2°C scenario) from 2016 which is not fully Paris Agreement compatible. This pathway peaks higher in 2030 but still drops quickly afterwards. A more recent scenario published by the IEA, the Sustainable Development Scenario (SDS) is also far from Paris Agreement compatible and has an even higher level of natural gas use after 2030 than the B2DS scenario. The SDS scenario substantially exaggerates the amount of natural gas used in the power sector and is an outlier compared to model assessments of limiting warming to 1.5°C. The SDS natural gas use in the Asian region is still rising in 2040 unlike any other of the published 1.5° compatible scenarios. The inconsistency between the IEA SDS scenario and the Paris agreement's 1.5°C temperature limit has been acknowledged by the IEA in its recent 2019 World Energy Outlook. The agency has signalled it will do further the work on the subject8. Whilst industry has chosen to emphasise the IEA SDS scenario this is the obvious reasons as the continued growth of natural gas aligns very well with their interests. Government, stakeholders, financial institutions and others however need to look carefully at scenarios which are fully Paris compatible to understand where the world may head as well as where it needs to go and therefore to be better able to understand and confront the transition challenges ahead.

[8] See WEO 2019, page 30: "The trajectory for emissions in the Sustainable Development Scenario is consistent with reaching global "net zero" carbon dioxide (CO_2) emissions in 2070. If net emissions stay at zero after this point, this would mean a 66% chance of limiting the global average temperature rise to 1.8 degrees Celsius (°C) above pre-industrial levels (or a 50% chance of a 1.65 °C stabilisation). In the light of the Intergovernmental Panel on Climate Change Special Report on 1.5 °C, we also explore what even more ambitious pathways might look like for the energy sector, either via "net negative" emissions post-2070 or by reaching the "net zero" point even earlier" at https://www.iea.org/weo2019/

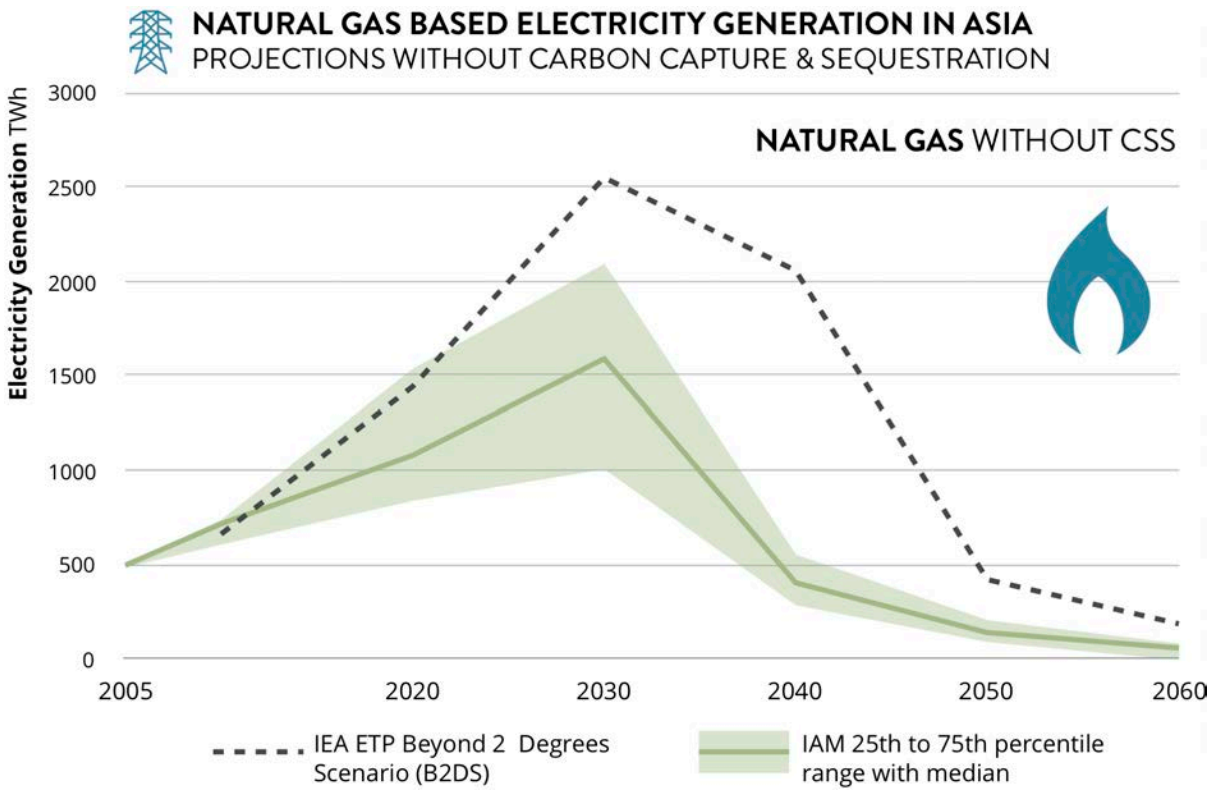

Figure 4: Electricity generation from natural gas without CCS. Shown are the median for PA-compatible Integrated Assessment Models (IAM), as well as the results from the IEA ETP B2DS used in the current study for some of the underlying pathways, both for the Asia region. Source:(Climate Analytics 2019c). The relative cost of CCS makes deployment of this technology unlikely in our assessment. The earlier IEA B2DS scenario shows a much higher natural gas demand than more recent fully Paris compatible scenarios.

The IPCC assessment of mitigation pathways clearly shows (Climate Analytics 2019e). that the continued use of natural gas would only be consistent with the Paris Agreement temperature goal if used with carbon capture and storage (CCS). Even then it would play only a small role in electricity generation by 2050 at around 8% of global electricity generation. Due to incomplete CO_2 capture rates, the use of gas with CCS would have to be balanced out with additional carbon dioxide removal (CDR). While the political, economic, social and technical feasibility of solar energy, wind energy, and electricity storage technologies has improved dramatically over the past few years, with costs dropping rapidly over the last few decades with corresponding growth trajectories much faster over the last years than expected (IRENA 2019b), CCS in the electricity sector has not shown similar improvements, with costs of CCS not coming down over the last decade. Together with more limited co-benefits than renewable energy, this cost trend makes these technologies increasingly unlikely to be able to compete with renewable energy, which is not yet reflected in many energy-economy models (Climate Analytics 2019e).

An important conclusion from this analysis is that sooner or later Western Australia will have to transition away from exporting natural gas, given CCS is increasingly unlikely to be able to compete with renewable energy and storage due to incomplete capture rates, no observed cost improvements in contrast to continuing cost improvements for renewable energy and storage technologies, as well as large additional benefits of renewable energy for sustainable development.

In all scenarios that limit warming to 1.5°C, renewable energy (excl. biomass) has to be ramped up quickly to supply 50-65% of total primary energy by 2050[9], displacing fossil fuels from traditional markets for power generation, mobility and heating. Renewables reach a particularly high share in electricity supply of 45-65% in 2030 and 70-85% in 2050. The political, economic, social and technical feasibility of solar energy, wind energy, and electricity storage technologies has improved dramatically over the past few years, with costs dropping rapidly over the last few decades with corresponding growth trajectories much faster than expected (IRENA 2019b). These fast developments enable more stringent near-term mitigation than currently planned.

The decrease in use of fossil-fuels and increase in renewables is associated with a major shift in investments, where global annual investments in low-carbon energy technologies overtake fossil investments by around 2025 in 1.5°C pathways (IPCC 2018b). The IPCC (2018a) Special Report shows that annual investment in low-carbon energy technologies and energy efficiency increase rapidly by a factor of 4-5 by 2050 compared to 2015. Compared to 2°C pathways, total energy-related investments in both supply and demand side increase by 12%.

9 Information on this was included by IPCC authors in the final draft of the SPM , but was not included in the final government-approved SPM. This data can however be extracted from the publicly available scenario data in IPCC's online scenario database: (IIASA 2018) https://data.ene.iiasa.ac.at/iamc-1.5c-explorer/

ROLE OF LAND SECTOR IN 1.5°C PATHWAYS

Limiting warming to 1.5°C will require global-scale transitions in global and regional land use, and in agricultural practices. In the near term, a focused effort will be needed to rapidly reduce and then reverse CO_2 emissions from land use. The majority of 1.5°C-compatible pathways achieve net zero land use emissions between 2025 and 2040, requiring a steep reduction in deforestation and the adoption of policies to conserve and restore land carbon stocks and protect natural ecosystems. By 2050, negative emissions will already need to be on a multi-Gigaton scale. This will likely require the deployment of bioenergy with carbon capture and storage in addition to reforestation, afforestation, and other land-based activities for sequestering carbon, such as land restoration and improved soil management (Climate Analytics 2019e).

Limiting warming to 1.5°C will require marked reductions in non-CO_2 emissions in the agriculture sector, even though these cannot be reduced to zero. Substantial reductions can be achieved through enhanced agricultural management and best practice farming on the supply side (for example, manure management, improved livestock feeding practices, and more efficient fertiliser use), as well as through demand side mitigation opportunities such as dietary shifts to healthier, more sustainable diets and measures to reduce food waste (Climate Action Tracker 2018c, 2019c).

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WA ECONOMY AND ITS CONTRIBUTION TO 1.5°C – CHALLENGES AND OPPORTUNITIES

Economy and Emissions profile

Western Australia's economy relies heavily on the mining of minerals and petroleum/gas, producing a significant proportion of the world's minerals and petroleum commodities. Mining currently generates 30% of Gross State Product (GSP) (in 2017-2018) and about 8% of employment (in 2018-2019). In terms of employment, the largest sectors are services industries (including retail, trade, healthcare, social assistance, and tourism) (72%), followed by construction (9%) in 2018-2019 (Government of Western Australia 2019a).

By far the biggest component of the mining industry is the mining and export of iron ore with AU$ 78.2 billion sales in 2018-2019 (share of 54% of minerals and petroleum sales), followed by LNG with AU$ 29 billions of sales (share of 20%). Both sectors have grown strongly over the past years, with Western Australia now being the source of 14% of global LNG exports (Government of Western Australia 2019b).

The heavy dependence on the resource extraction and export is reflected in the sectoral composition of GHG emissions: In 2017, more than 30% of all greenhouse gas emissions came from the mining sector (including gas extraction and processing, in particular LNG processing) – a bit more than the electricity supply (29%), and followed by manufacturing with 17% of greenhouse gas emissions, and agriculture with a share of 11%. The mining sector emissions have increased sharply since 2015, mostly due to the sharp increase in LNG processing and related emissions.

In 2017, Western Australia contributed 16.6% to Australia's total national emissions (all GHG, with LULUCF) and emissions have increased by 23.5% since 2005 (DEE 2019)[10], despite a reported decrease in emissions in the land use sector (LULUCF) from being a source of 5.3 Mt to being a sink of 8.8 Mt in

10 AGEIS trend data result in different share and increase, due to different LULUCF data – KP categories.

2007[11]. **Without the highly fluctuating and uncertain LULUCF emissions, Western Australia's GHG emissions contribute 17.6% to national emissions and have increased by 47% since 2005.**

Energy and industry (fossil fuel) CO_2 emissions are by far the most important current source of emissions and are the largest source of emissions increases. CO_2 emissions account for 83% of all WA GHG emissions excluding LULUCF, with almost all of these from fossil fuel combustion (which is 84% of total CO_2 emissions without LULUCF). The second largest source of CO_2 emissions are fugitive CO_2 emissions mostly from venting during gas extraction and processing (contributing 11% to total CO_2 emissions), and a smaller share of 4% from industrial processes (for example cement production). In addition, fugitive methane emissions are also related to extracting and use of fossil fuels with a share of 5% of total GHG emissions without LULUCF. **Together, fossil fuel energy and industry related CO_2 and methane (CH_4) emissions add up to a share of 89% of total GHG emissions (without LULUCF).**

Because of the large share of emissions from energy and industry, in particular energy industry (mainly LNG processing), **Western Australia contributes 20% to the national energy and industry (fossil) CO_2 emissions and these have increased even more than overall GHG - by 60% since 2005. (See** Table 2**).**

As discussed earlier, decarbonising energy and industry sectors and reaching net zero carbon emissions from fossil fuel and industry across all sectors of the economy by around 2060 globally and by around 2050 for a highly developed country like Australia is a key strategy to achieve the Paris Agreement temperature goal. This will be achieved through eventually phasing out all fossil fuels not only for power generation but for all other industry processes. This is why this study focuses on the carbon budget and emission pathways for fossil fuel and industry related CO_2 emissions.

The largest emitting sector in Western Australia is industry with a share of 48% of CO_2 emissions (excluding LULUCF) in 2017 (see Figure 5 and Figure 6). It is also the sector with the highest increase since 2005 - by 74% since 2005. Here we follow the sectoral definition used in greenhouse gas accounting (see Annex I for further details) and include the following categories under the Industry sector:

- direct combustion in manufacturing and other industry sectors, including mining,
- direct combustion in energy industry (in particular LNG processing),
- fugitive emissions (CO_2 and Methane) from energy industry (that is from coal mining, as well as extraction, production and processing of gas), and
- industrial processes (mostly CO_2 emissions from cement and ammonia production) and product use (non-CO_2 emissions).

Within industry, it is the fast ramping up of LNG processing that has contributed most to the increase of emissions. It alone has a share of 18%, and CO2 emissions have tripled since 2005.

Electricity use in industry is not accounted for under the industry sector, but under the electricity generation sector, which is the second largest sector (31% share, increase of 44% since 2005), followed by transport (17% share, increase of 61% since 2005). The buildings sector contributes 2% of direct CO_2 emissions, and these have increased by 62% since 2005. Indirect emissions from the building sector due to electricity use are accounted for under the electricity generation sector.

11 This is based on the published state inventory. However, there are uncertainties around LULUCF data. Here we look at the emissions profile without LULUCF.

Other, non-energy or industry related emissions – mainly from agriculture – need to be reduced as well, but are not expected to be reduced to zero. In Western Australia, about half (51%) of the other emissions (not fossil fuel and industry related CO_2 emissions) are from agriculture (methane and nitrous oxide emissions) which makes up 10% of total WA GHG emissions. This is the only sector where emissions have actually decreased (by 12% since 2005). Industrial processes and product use contribute 8% to other GHG emissions, through emissions from use of F-gases, which can largely be phased out.

Table 2 shows emissions from these sectors in the past as well as their current share. The LNG sector is shown separately because of its large contribution to emissions and emissions growth.

Table 2 Western Australia energy and industry sector carbon dioxide emissions ($MtCO_2$) and total Western Australia greenhouse gas emissions ($MtCO_2e$). Industry emissions include manufacturing and mining, energy industries excluding electricity, fugitive emissions, and process emissions and product use. The LNG Sector is shown separately because of its large contribution to emissions and emissions growth. Source: AGEIS (2019), own estimates (for LNG). Fugitive emissions outside the LNG sector are also shown separately because of the different nature of mitigation options. See discussion of emissions pathways for economic sectors, and Annex I for details regarding the categorisation of sectors.

Sector	2005	2010	2017	Share of 2017 emissions (excl. LULUCF)	Increase 2017 Since 2005 in %
Carbon dioxide – $MtCO_2$					
Electricity generation	17.5	20.1	25.2	31%	44%
Transport	8.8	10.0	14.2	17%	61%
Industry (excluding LNG)	18.1	17.9	22.2	27%	23%
LNG (including CO^2 venting/fugitives)	3.5	5.2	14.5	18%	318%
Fugitives - other	1.2	2.5	2.5	3%	110%
Buildings	1.2	1.4	1.9	2%	62%
Total energy and industry	50.3	57.1	80.6	99%	60%
Agriculture	0.7	0.7	0.9	1%	39%
Waste	0.0	0.00	0.00	0%	29%
Total WA emissions w/o LULUCF	**50.9**	**57.8**	**81.5**	**100%**	**60%**
LULUCF	12.3	6.5	-10.8		-188%
Greenhouse gases – $MtCO_2e$					
Electricity generation	17.6	20.2	25.4	27%	44%
Transport	9.1	10.3	14.6	15%	60%
Industry (excluding LNG)	19.5	19.9	23.9	25%	23%
LNG (including CO^2 venting/fugitives)	5.0	7.5	17.8	19%	256%
Fugitives - other	0.6	0.3	0.6	1%	10%
Buildings	1.3	1.5	2.0	2%	54%
Total energy and industry	**53.0**	**59.8**	**84.3**	89%	59%
Agriculture	10.2	8.7	9.0	10%	-12%
Waste	1.4	1.8	1.5	2%	5%
Total WA emissions w/o LULUCF	64.7	70.2	94.8	100%	47%
LULUCF	15.9	10.1	-7.8		-149%

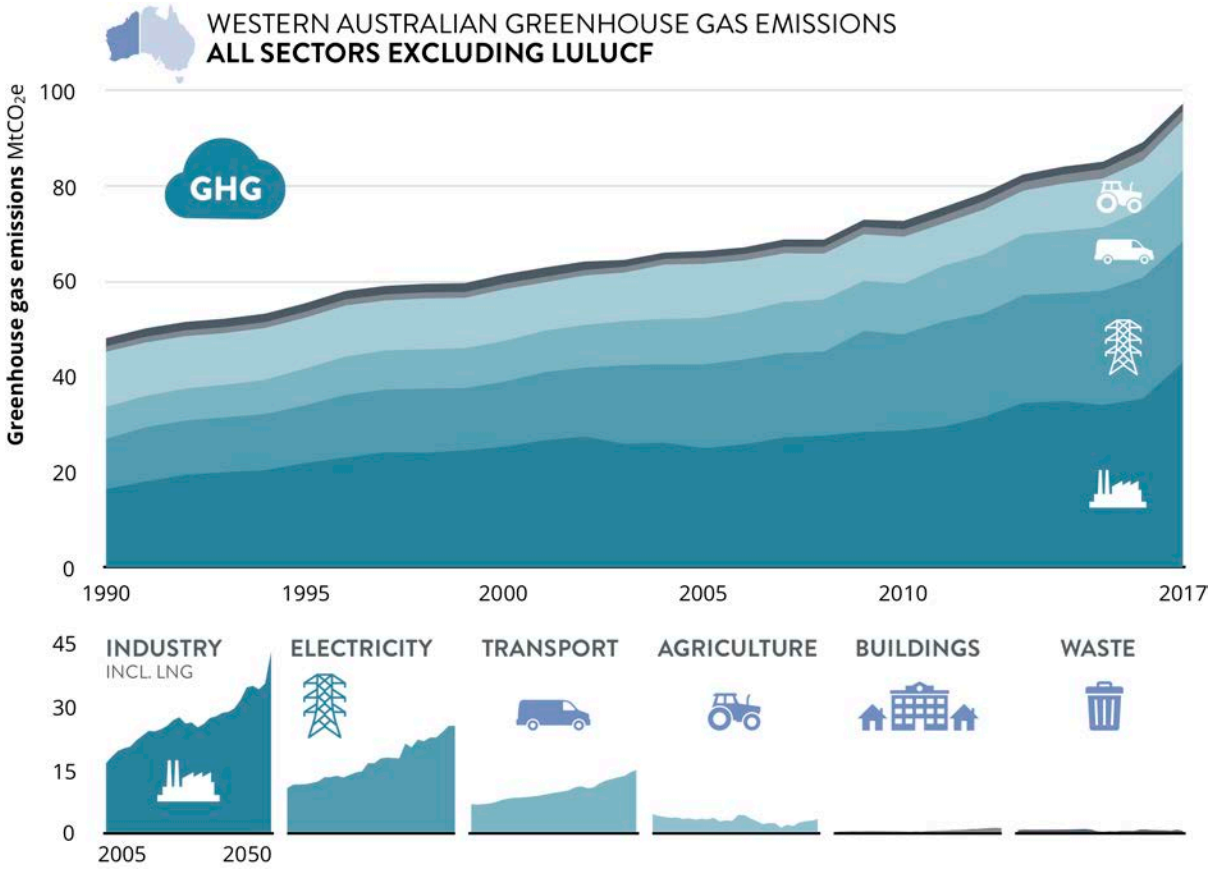

Figure 5: Historical emissions in Western Australia by sector, based on national greenhouse gas accounting. See also Table 2 and annex II for explanation of sectors. Emissions and removals from land use, land-use change and forestry are not shown. Source: AGEIS (2019).

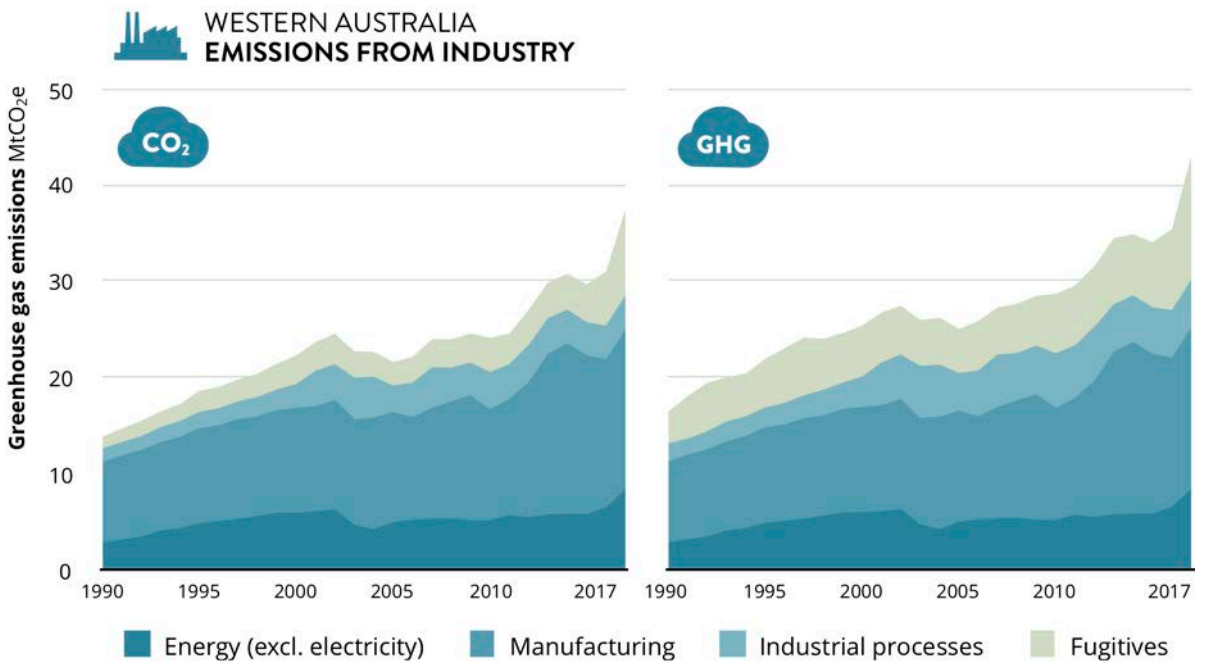

Figure 6 : Historical emissions in Western Australia in the industry sector – CO_2 (left) and all Greenhouse gases (right), with subsectors based on national greenhouse gas accounting. Most of industry emissions are CO_2 emissions, see also Table 2 and see Annex II for explanation of sectors. Source: AGEIS (2019).

Electricity generation and distribution in WEstern Australia– ready for the future?

Electricity generation in Western Australia is the second largest source of emissions (after industry) and contributes almost a third (31% share in 2017) to energy and industry carbon emissions, and these have increases by 44% since 2005. Despite having an independent electricity system and market[12], Western Australia and New South Wales are the only states that do not have a renewable energy target. Nor does Western Australia have an energy efficiency scheme. The state is lagging behind other states and territories with renewable energy despite having prime resources for solar and wind. Similarly, Western Australia does not have energy saving schemes, despite Victoria, New South Wales, South Australia and the ACT having schemes in place (ESIA 2018). In 2018 Western Australia had a low renewable energy share of only 8% of power generation, well below the national share of 19% (Department of the Environment and Energy 2019, Table O). However 27% of WA households have installed rooftop solar (Climate Council 2018) – the third highest proportion of all states and territories behind Queensland and South Australia.

2018 – a boom year for investment in Renewable energy in Australia – only saw two projects completed in WA with a total of 30 MW capacity (two solar farms, Emu Downs and Northam). A further 395 MW are under construction or financially committed (Clean Energy Council 2019), and a further eight projects with a total of 1GW of capacity have been approved for connection in December 2018, including a 210MW wind farm in the Mid-West. By October 2020, a total of 515 MW is expected to connect, including a 100 MW solar farm (Merredin) (RenewEconomy 2019e).

While uptake of large-scale renewable energy is still slow compared to other states, solar PV has become the largest source of generation capacity in the South West Interconnected System (SWIS) (WA Government. 2019) with households and businesses increasingly switching to rooftop solar and batteries, leading to a lower peak demand and challenging the management of the "most isolated grid of its size in the world" (RenewEconomy 2019e), with rooftop solar possibly tripling over the next ten years, forcing operational demand below a level of 700 MW, seen as a threshold below which system security becomes challenging to secure (RenewEconomy 2019d).

The WA government expects the share of renewable energy in the SWIS to double from around 16% to a share of over a third by 2030. It has reacted to the challenge for the isolated SWIS with the development of an Energy Transformation Strategy (WA Government. 2019). A number of innovative stand-alone power systems, distributed energy resources and microgrid trials are currently operating in Western Australia, in particular in regional and remote areas (WA Parliament 2019).

Given the prime resources for solar and wind and availability of infrastructure and skilled workforce, there is an increasing interest in large scale projects to generate power from renewable energy and store it in hydrogen for export into neighbouring Asian countries: A large scale combined wind and solar 15 GW project (twice the current capacity of installed large-scale wind and solar) is in development in the Pilbara, focusing on green hydrogen production for domestic and export markets, targeting mainly Japan and South Korea and expecting a very large market for green hydrogen over time (RenewEconomy 2019b). Another project is planned near Kalbarri, proposed by Hydrogen Renewables Australia with plans for up to 5 GW combined solar and wind to supply production of low-cost hydrogen (RenewEconomy 2019c). ARENA is looking into options for starting to use hydrogen domestically, before the export market develops, by injecting it into gas networks, or using it in transport or in industry, for example for the production of ammonia (instead of using natural gas, with

12 The electricity market is not part of the NEM and the gas market is not part of the eastern Australian gas market.

a potential of a sevenfold increase in electricity generation from renewable energy in order to produce hydrogen in addition to meeting the direct electricity demand (RenewEconomy 2019a).

There is an increasing recognition including with the WA Government's Green Hydrogen strategy, of the opportunities through the large potential for renewable energy, in particular solar and wind, combined with available infrastructure and skilled workforce in the energy industry – and the proximity of energy hungry Asian countries, some of them currently main importers of Western Australian natural gas.

WA needs to develop its own strategy and targets

Western Australia, with its own, independent energy system and unique resources and opportunities, needs to do its fair share to contribute to achieve the Paris Agreement temperature goal. Western Australia has an important role to play in reducing national emissions, given it is currently largely responsible for national emissions increasing, in particular because of the increase in emissions from LNG processing.

Given it is well known that the current federal emission reduction target of 26-28% reduction compared to 2005 levels that the government has committed to in its Nationally Determined Contribution (NDC) to the Paris Agreement is not consistent with the Paris Agreement (Climate Action Tracker 2019; Climate Analytics 2019b) and given the failure of the federal government to recognise this and even to develop any policies that would ensure achieving the insufficient current target for 2030, there is no reason for Western Australia to align with the federal target and its inadequate policies. To the contrary, as we can see in other countries, there is a responsibility and opportunities for subnational states to show leadership and move ahead with emissions reductions and an energy transition to renewable energy, and energy efficiency that benefits the state's economy, as can be seen in South Australia, or in California in the USA.

As we have outlined above, Western Australia has an own vital interest in achieving the Paris Agreement 1.5°C temperature limit, to protect its unique and iconic ecosystems and the services these provide, including the economic value through tourism, its agricultural regions, and the health well-being of its population.

Western Australia also has globally prime resources that are needed for the Paris Agreement consistent transition to renewable energy, not only with globally first-class wind and solar resources, but also with minerals and critical materials needed for batteries and other technologies.

Again, Western Australia has a lot to gain from such a strategy, if such a transition is planned well, given it can move away from relying on exporting fossil fuels (LNG) towards exporting zero emissions energy carriers (direct electricity or green hydrogen) or zero emissions energy intensive products such as zero emissions steel – with opportunities for additional manufacturing employment.

A fair share contribution

In addition to Australia's own domestic emission reductions to meet the Paris Agreement, Australia also needs to make a contribution to assisting other countries and reducing their emissions, which gives rise to what is called a "fair share" contribution to global emission reductions. This general fairness principle is one of the underpinning elements of the Paris Agreement. For wealthier countries, such as Australia, this almost always means that a "fair share" contribution when expressed in terms of national emission

reductions by a certain date is greater than the least-cost domestic emission reductions consistent with meeting the global temperature goal of the Agreement.
It is easy to confuse a "fair share" contribution of a country or region with the actual domestic reductions a country needs to make. In this study we have focused on the budget for the actual domestic reductions that Western Australia needs to make and the least cost emission pathway to achieve this.

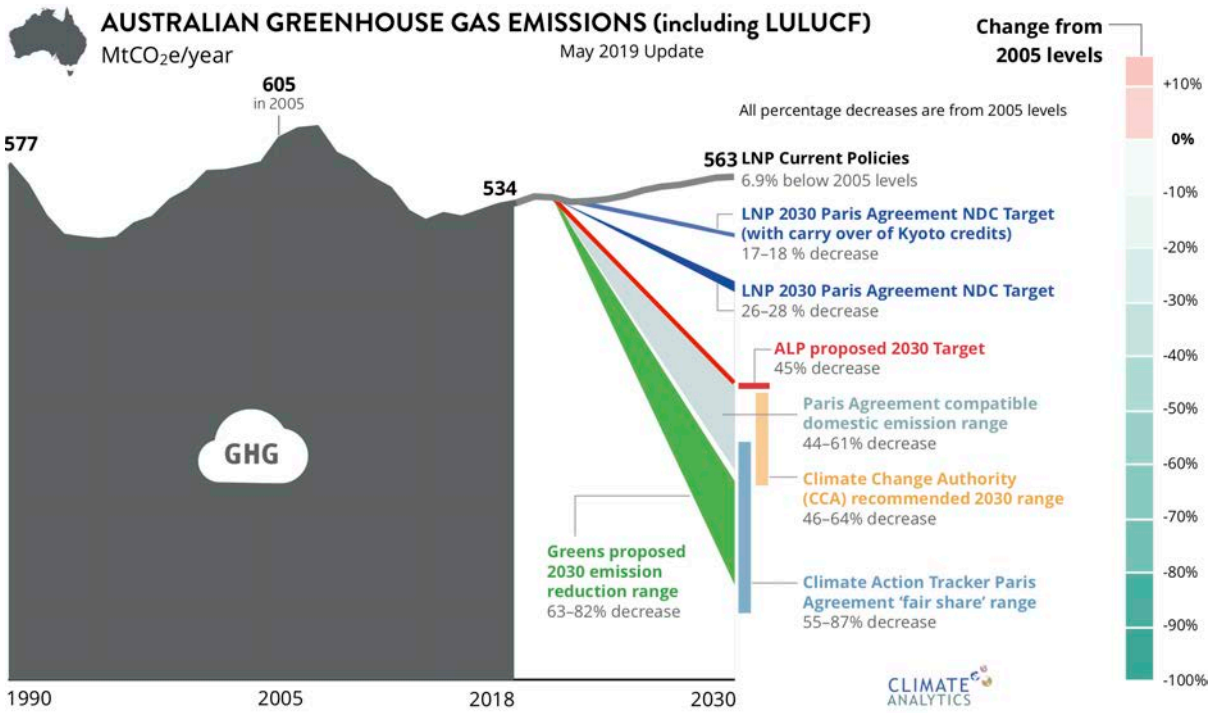

Figure 7: Schematic overview of national emission targets proposed by political parties on the May 2019 Australian Federal election compared to Paris Agreement compatible domestic emission pathways, Climate Action Tracker estimated fair share emission reduction ranges, and the 2015 recommended 2030 range of the Climate Change Authority. This figure shows the emission reductions with respect to emissions including land use, land use change and forestry

Australia, being a developed country, needs to make both domestic emission reductions and contributions to assisting poorer countries in order to move the Paris Agreement in reducing theirs. An estimation of what reasonable domestic emission reductions need to meet global climate goals such as the Paris Agreement to be made by Australia can be derived from examining what global, integrated assessment and energy models are telling us about the kind of energy transformations, and other actions, are needed in different regions, including Australia's own. For this evaluation we have applied one set of models, that provides a good perspective on the least-cost domestic emission reductions for Australia[13]. Given the reductions in renewable energy costs and storage, ongoing reductions in electric vehicle costs and other technological developments these emission reductions may indeed be conservative.

A Paris Agreement compatible 2030 domestic emission commitment target would be in the range of 44-61% emission reduction by 2030 below 2005 emissions, including land use change and forestry sources. Excluding land use change and forestry sources a Paris Agreement compatible domestic emission commitment target would be in the 35-55% reduction by 2030 from 2005 emission levels. There is a large range of least cost domestic emission reductions for Australia deriving from Paris

13 The pathway is derived from results from IAMs (Integrated Assessment Models) results under RCP 1.9 scenarios of (Rogelj et al. 2018) and methods of (Sferra et al. 2019)

Agreement global emission pathways due in part to the range of model results in the scientific literature.

If Australia's Paris Agreement 2030 NDC were to be expressed as a fair share target and be consistent with the range of scientific assessments of this it would be in the range of a 55-87% reduction below 2005 emission levels[14], including land use change and forestry sources (48-85% reduction below 2005 emission levels, excluding land use change and forestry sources). A fair share target represents a country's contribution to meeting the Paris Agreement globally, which includes domestic emission reductions plus contributions to reductions elsewhere, the NDC goal. There is a large range because of the wide range of fairness viewpoints in the scientific literature, with the range here drawn from the Climate Action Tracker (2019).

What this would mean in practice is that the total sum of domestic reductions + emission reductions overseas (from climate finance or acquisition of emission units) would need to add up to the total NDC "fair share" target. In general, this means that in addition to domestic emission reduction targets, the fair share contribution requires further effort abroad. If, for example, the fair share NDC was for a 70% reduction by 2030 then it could mean that domestic reductions of about 50% were achieved and emission units equivalent to 20% of the 2005 base year were supported by Australia internationally.

WA Climate policy in national and international context

Currently, there is no coherent climate or energy transition policy in Western Australia. Western Australia and New South Wales are the only states or territories without any renewable energy target. While WA has recently, in August, finally joined other states adopting an aspirational goal of achieving net zero greenhouse gas emissions by 2050, it does not have any targets for renewable energy nor does it have a specific 2030 reduction target, which Victoria and Queensland have adopted, and Victoria has also legislated. A discussion about the development of a State Government policy and roadmap was initiated with the Issues paper in September this year (WA Government 2019b).

There are elements of policies in energy and resources sector that are relevant for the development of the overall climate strategy, such as the Energy Transition Strategy and the Renewable Hydrogen Strategy. However, none of these are using the relevant Paris Agreement benchmarks outlined in the previous section, with the only exception of the issue paper referring to "well below 2°C" (but omitting the Paris Agreement's 1.5°C limit) and the 'aspirational' 2050 net zero greenhouse gas emissions target. In order to keep the 1.5°C limit within reach achieving key short-term benchmarks to peak emissions by around 2020 and reduce emissions by around 45% below 2010 levels by 2030 are essential.

Opportunities from transition to Renewable energy

Several studies have found that WA's transition to renewable energy is technically and financially feasible. Lu, Blakers and Stocks found that 90% to 100% renewable electricity is technically and financially feasible for SWIS of WA (Lu, Blakers, and Stocks 2017). They modelled several high renewable penetration scenarios and found renewables can be deployed and balance the grid, with different options available from solar PV, wind, and pumped hydro energy storage (Lu et al. 2017).

14 The higher limit (55%) is the boundary between 1.5°C Paris Agreement Compatible and 2°C Compatible and the lower limit (87%) the bottom of fair share range between Role Model and 1.5°C Paris Agreement Compatible (Climate Action Tracker 2019).

An analysis (Rose et al. 2016)[15] of different options for an 85% or even complete decarbonisation of electricity supply by 2030 for Western Australian South West Interconnected System (SWIS), focuses on ensuring reliability and grid stability, including a combination of energy efficiency measures and currently available technologies such as residential and commercial roof top photovoltaic systems, solar thermal power stations with heat storage, wind power and distributed battery storage systems. Laslett et al. (2017) also looks at a new technology option for longer-term storage of excess electricity by producing gas - so called "Power-to-Gas" technology, which can build on the gas infrastructure in Western Australia, using the ample solar and wind resources for electricity. Other options studied are wave power (presently in development stage) and biomass (from oil Mallee) to replace natural gas, as well as pumped hydro storage. These studies also assume an increased electricity demand due to an increased uptake of electric vehicles. They confirm what has been shown for other parts of Australia or other countries and globally: gas can play a limited role in a transition phase to 100% renewable energy, but with a declining share in electricity generation, given gas capacity would be mostly used to cover periods of low variable renewable energy power. Current development and falling costs of storage technologies would reduce this transition role even further.

WA is in close proximity to Asian countries with huge energy demand and global pressure to decarbonise their economies from the Paris Agreement. WA can offer renewable sources of energy, to help meet energy demand in Asia without the emissions of conventional energy sources. Furthermore, the natural resources needed in renewable energy related technologies create opportunities for the WA industry sector.

Technologies associated with renewable energy, such as batteries and electric vehicles require natural resources available in WA. The global demand for battery-based energy storage and electric vehicles requires resources that are mined in WA, and the state is informally dubbed "Lithium Valley". WA has huge reserves of battery materials such as lithium, nickel, cobalt, manganese and alumina (Dept. of Jobs Tourism Science and Innovation. 2019). WA is already the world leader in lithium production, and has rare earth minerals used for electric motors (Dept. of Jobs Tourism Science and Innovation. 2019).

The government has realised WA is in a position to benefit from the renewables boom, and published the "Future Battery Industry Strategy Western Australia", detailing the supportive government approach to create the industry, including attracting investment, facilitating projects, research and technology for sector development and new opportunities for domestic uptake in battery technology (WA Government n.d.). The state aims to have a future battery industry by 2025, and so far, the state has set up a Funding Assistance Register to support the battery sector including research groups, mining and processing companies, renewable energy companies and enterprises in the battery value chain (PV Magazine 2019). This is an approach that could also be followed for other opportunities to develop manufacturing value chains in Western Australia.

Green hydrogen offers WA an option to transition the LNG industry in renewable energy export industry (Climate Analytics 2018b). A report commissioned by the Australian Renewable Energy Agency (ARENA) found that prospective markets for Australian hydrogen were China, Japan, Republic of Korea, and Singapore (ACIL Allen Consulting 2018). The report lists the competitive position for Australia in the hydrogen market, which applies to WA. The factors mentioned include Australia's ability to offer lower landed costs of hydrogen, proximity to the market, having well established energy trading relationships and experience in large scale energy infrastructure construction, and the possibility of supplying hydrogen from a range of sources (ACIL Allen Consulting 2018). The report modelled 3 scenarios of different levels of demand for hydrogen (ACIL Allen Consulting 2018). The direct economic contribution

15 See also (Climate Analytics 2018b; Laslett et al. 2017)

in hydrogen production for export is estimated at A$201 million in the low demand scenario, $417 million in the medium scenario and $903 million in the high scenario for 2030 (ACIL Allen Consulting 2018). Although, these estimates are for Australia in general, WA has the opportunity to take the lead role in Australia's hydrogen development, considering its close proximity to Asia and renewable resource potential in its sparsely populated huge landmass.

In addition, a scheme involving energy efficiency can tackle pressing issues within Australia to help deal with escalating energy prices and the need for network upgrades to meet peak demands (ESIA 2018). The Energy Saving Industry Association (ESIA) has developed a policy setting guide serving as a case for introducing energy saving schemes in WA from 2019 to 2030 (ESIA 2018).

The widespread adoption of renewable energy technologies would create employment opportunities along the supply chain. Sustainable Energy Now (SEN) found that the development of new renewable energy infrastructure in WA could create 37,000 job years in construction, 6,000 job years in manufacturing and 1,400 job years for operations and maintenance (SEN 2017). The Climate Institute assessed the impacts of a clean energy boom in WA, finding that the large untapped resources of renewables offers opportunities for state-wide employment of over 4,700 new jobs in the electricity sector by 2030 (The Climate Institute 2011).

The Asia Renewable Energy Hub (2019a) is a wind and solar project proposed in the Pilbara in WA, with 15GW of wind and solar to be developed over 6,500 square kilometres. The project can power local industry and export to the Asia market using green hydrogen. The project has secured land, it has been granted Lead Agency Status by the WA government, and construction is scheduled to commence in 2022/3, and the first electricity generation is expected 2023/4 (The Asian Renewable Energy Hub 2019a). The Hub claims the $21 billion project would create 3,000 construction jobs over 10 years and 400 jobs for maintenance and operations, and the employment of a further 11,500 for indirect jobs (The Asian Renewable Energy Hub 2019b).

WESTERN AUSTRALIA'S ECONOMIC SECTOR PATHWAYS

In this section, the core of this study, we outline results of the energy system scenario analysis across all sectors of WA economy. We provide, for each sector, a **Paris Agreement compatible emissions pathway that is based on underlying least-cost emissions pathways**, and cost optimal pathways for the electricity sector. We also look at implications for fuel mix, key technologies, and sectoral transformations and key sectoral strategies and policies at state level.

Building Sector – Decarbonising through Efficiency and Electrification

The buildings sector (including both residential and commercial buildings) contributes 2% of direct CO_2 emissions, and these have increased by 62% since 2005, rising until 2016 and declining slightly in 2017. Indirect emissions from the building sector due to electricity use are accounted for under the electricity generation sector.

While the building sector is already largely (56%) using electricity and therefore is already decarbonised with power generation shifting to renewable energy, electrification is a key strategy to accelerate this decarbonisation either directly or indirectly through replacing fossil fuel combustion with biomass or (not included in the underlying model but likely a more sustainable option) "green" hydrogen (generated from renewable electricity). Full decarbonisation of this sector by 2050 leads to a **carbon budget for 2018-2050 of about 22 $MtCO_2$, and a reduction by 41% in 2030 compared to 2005. At current emissions rates, this budget would be used up in 12 years.**

Despite an increase in efficiency and resulting lower energy demand, electricity demand would increase slightly, by 23% from 2014 to 2050 due to electrification. Gas demand would go down both in absolute terms as well as in terms of the share of overall demand for buildings, and oil demand would decrease even faster, essentially phased out by 2040.

Key policies to support this development at state level are incentive schemes to refurbish existing buildings, as well as additional regulation and incentives to reduce energy demand, aiming for near net zero energy (fossil fuel free) new buildings from 2020 onwards, support programmes and information campaigns (working with local councils and appliances retailers) to install heat pumps and electric appliances to replace natural gas, as well as developing supporting regulation and research and development to support blending (green) hydrogen into the gas grid and eventually replacing natural gas with hydrogen in the grid, building on lessons learned from the ARENA (2018) pilot project with ATCO and on international experiences.

An essential further policy would be ambitious renewable energy targets and planning for ramping up renewable energy, taking into account additional electricity demand through decarbonisation of buildings and other end-use sectors.

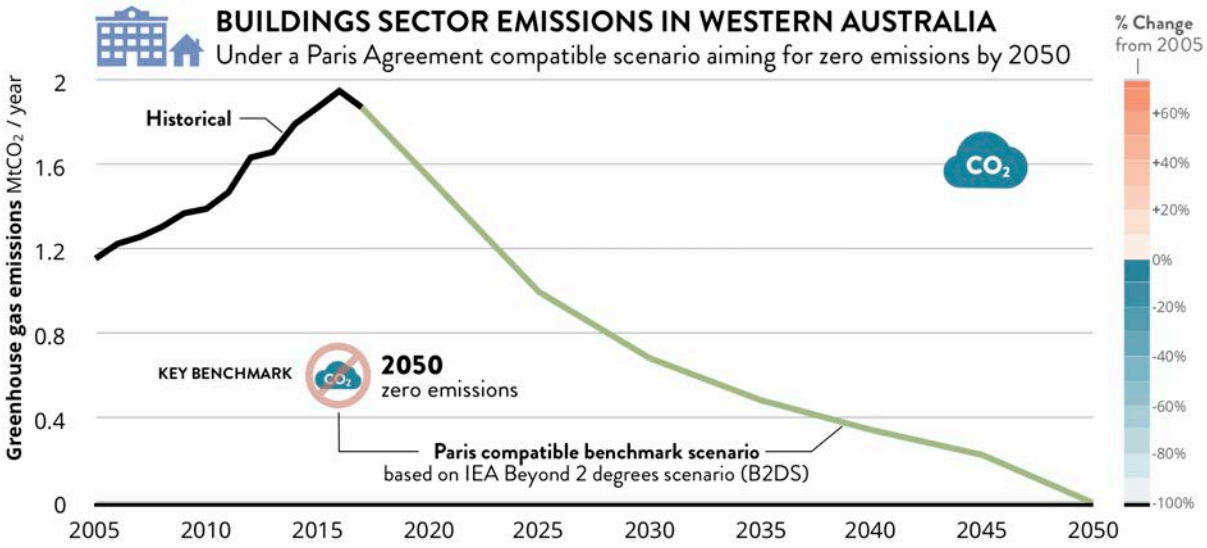

Figure 8: Carbon emissions from the buildings sector (residential and commercial) in Western Australia, for Paris Agreement benchmark scenarios based on the IEA "Beyond 2 Degrees" Scenario (B2DS) downscaled to Western Australia, with the benchmark of full decarbonisation by 2050, used to calculate the sectoral carbon budget) and adjusted to take into account historical emissions until 2017 Delayed mitigation leads to the need for more reductions to keep within the same budget (cumulative emissions).

Table 3: Fuel mix for WA building sector under a Paris Agreement compatible pathway based on technology assumptions in IEA (2017) ETP B2DS and benchmark of full decarbonisation by 2050, (delayed pathway). 2014: Historical data, Source Australian Energy Statistics.. Natural gas could be replaced with hydrogen in the gas grid (the underlying model did not assume availability of green hydrogen infrastructure)

		PARIS COMPATIBLE BENCHMARK SCENARIO		
	2014	2030	2040	2050
Oil	15%	3%	1%	0%
Natural gas	18%	14%	9%	0%
Electricity	56%	68%	75%	85%
Biomass	11%	15%	15%	15%
All fuels	**100%**	**100%**	**100%**	**100%**

Transport sector – Decarbonising with shift to electric mobility and green hydrogen

Transport is the third largest contributor to emissions, after industry and electricity generation. Emissions have increased by 61% since 2005, and it contributes 17% to energy and industry carbon emissions. Western Australia gas one of the highest rates of car use per person in the world and emissions intensity of vehicles is very high compared to international standards (WA Government 2019b). The WA state government has a goal to increase the number of homes in the Perth and Peel region to close proximity to public transport nodes by 45% from 2018 to 2031 (WA Government 2019a). Plans involve a new METRONET infrastructure, and 18 new train stations, and new precincts (WA Government 2019a). The Western Australian Electric Vehicles Working Group was created in 2018 to coordinate government action in delivering EV outcomes in the state (Dept. of Water and Environmental Regulation 2019). The group was established after the WA Minister for Water; Innovation and ICT; and Science, Hon. Dave Kelly MLA signed the Memorandum of Understanding on Electric Vehicles. The MOU was signed by several parties in Australia, to identify opportunities to accelerate the transition to EVs, with current uptake of EV in Western Australia well behind global average.

This section focuses on the energy transformation that needs to happen in Western Australia's transport sector in line with the Paris Agreement long term goal: full decarbonisation by 2050, in line with previous analysis on Paris Agreement benchmarks for achieving a fully decarbonised passenger and freight land transport by 2050 (Climate Action Tracker 2016, 2018c). This is supported by recent technological developments and opportunities through electrification and introduction of renewable hydrogen or synthetic fuels generated with electricity from renewable energy, as outlined in a national energy system scenario analysed earlier by Climate Analytics, where the transport sector (like other energy sectors) is fully decarbonised by 2050 (Climate Analytics 2018b; Teske et al. 2016).

Oil consumption is expected to decline sharply over time and phased out by 2050, mainly due to increasing reliance on clean electricity generation powering electric vehicles but also due to increased use of hydrogen fuel cell trucks for freight transportation.

For the Paris compatible benchmark scenario, **we get a total carbon budget of about 207 $MtCO_2$ and a reduction by 16% in 2030 compared to 2005. At current (2017) emissions, this budget would be used up after 15 years.**

The reduction by 2030 compared to 2050 is slower than in other sectors, given the high increase of emissions. However, and important benchmark is that **last fossil fuel combustion engine car should be sold before 2035** in order to achieve full decarbonisation of passenger transport by 2050. Similarly, infrastructure needs to be addressed now to achieve full decarbonisation of freight transport by 2050.

For aviation, technologies are also emerging zero emissions fuels and/or propulsion systems. The International Renewable Energy Agency (IRENA) (2018) has reported on a variety of pathways to produce renewable jet fuel, short range electric aircraft, and hybrid electric propulsion systems. Here we assume full decarbonisation by 2050, which in the case of aviation might imply the need for negative CO_2 emissions to compensate for remaining fossil fuel use if decarbonisation is not achieved by 2050.

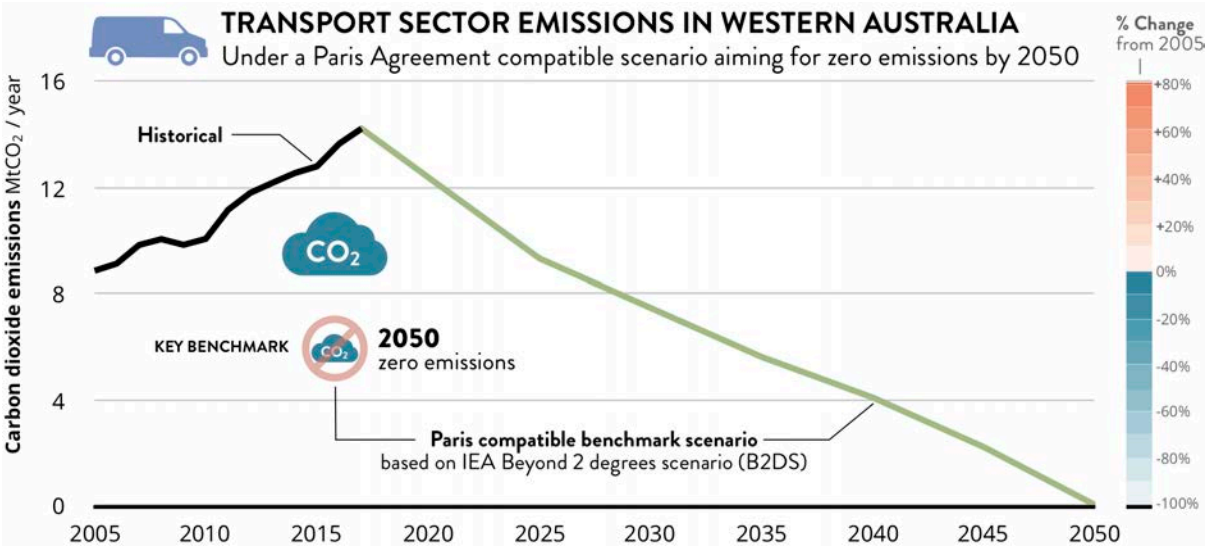

Figure 9: Carbon emissions from the transport sector in a Paris Agreement compatible pathway for Western Australia based on an IEA Technology scenario (IEA B2DS scenario) and the benchmark of full decarbonisation by 2050. We show the original pathway starting decarbonisation in 2014, and an adjusted pathway taking into account the sharp increase in real emissions from 2014 to 2017, keeping within the same carbon budget.

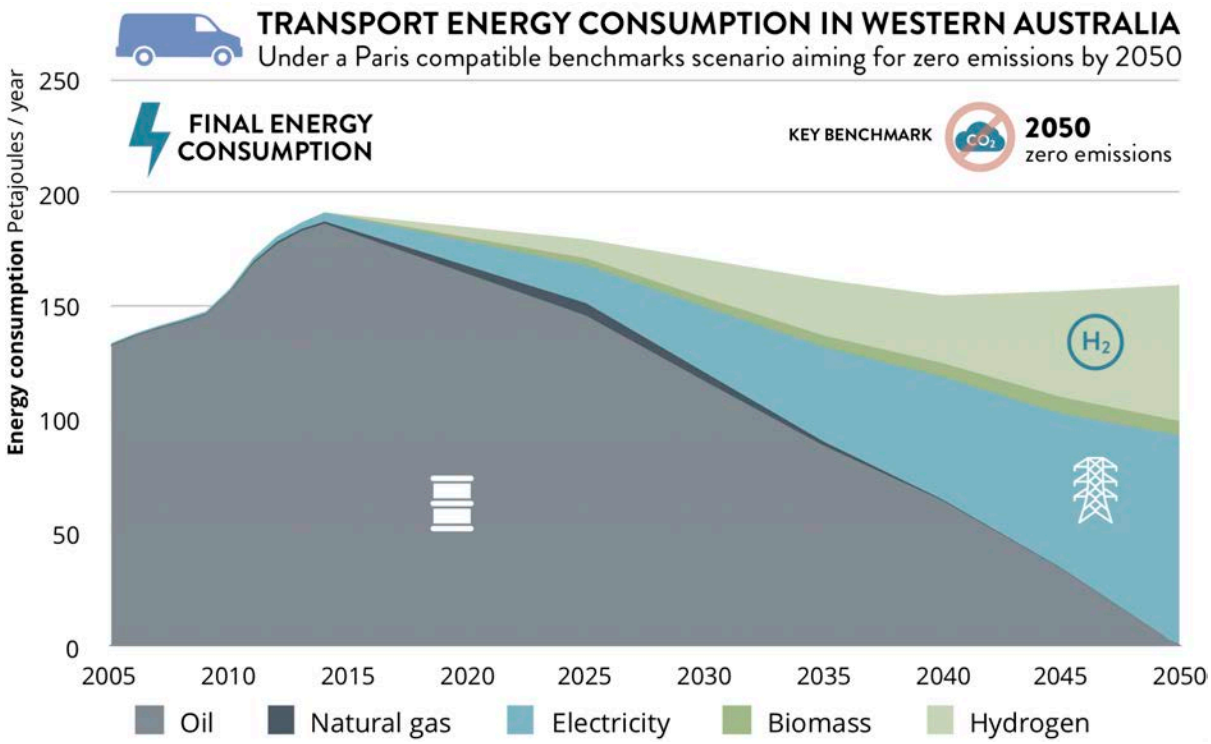

Figure 10 : Energy demand and fuel mix for the transport sector in a Paris Agreement compatible pathway for Western Australia based on an IEA Technology scenario (IEA B2DS scenario) and the benchmark of full decarbonisation by 2050. This pathway starts decarbonisation in 2014, and an adjusted pathway taking into account the sharp increase in real emissions from 2014 to 2017, keeping within the same carbon budget, has been developed to create the Paris Agreement pathway in Figure 8 and Table 4.

Table 4: Fuel mix for WA transport sector under a Paris Agreement compatible pathway based on technology assumptions in IEA (2017) ETP B2DS and benchmark for decarbonisation by 2050.

		PARIS COMPATIBLE BENCHMARK SCENARIO		
	2014	2030	2040	2050
Oil	97%	63%	39%	0%
Natural gas	1%	2%	0%	0%
Electricity	2%	23%	38%	58%
Biomass	0%	2%	4%	4%
Hydrogen	0%	10%	19%	38%
All fuels	**100%**	**100%**	**100%**	**100%**

Electric car sales are increasing worldwide, especially in countries like Norway or sub national states like California. Those countries and states have successfully introduced incentives and policies to accelerate the adoption of electric vehicles and other e-mobility options including metros, trams etc. An increasing number of countries are introducing targets to ban internal combustion cars, ending the sale of fossil-fuel dependent internal-combustion engines. For example, the UK plans to stop the production of petrol and diesel cars by 2040, Scotland stepped up this target to phase out combustion cars by 2032, France by 2040, and Netherlands by 2030 (World Economic Forum 2017).

Key State policy implications include:

- The need to support modal split away from individual passenger car transport to public transport, cycling, and walking, including through urban and regional planning
- Develop a roadmap and strategy to roll out charging infrastructure and hydrogen fuelling infrastructure with industry
- Work with local councils to support procurement towards electric mobility, including shifting to replace bus fleet with EV buses, building on international examples.

Industry: Manufacturing, Energy Industry –zero emissions through electrification, zero emission fuels, process innovation, energy and material efficiency

As outlined above, industry is the largest emitting sector in Western Australia with a total share of 48% of CO_2 emissions in 2017 – higher than the contribution from electricity generation. It is also the sector with the highest increase since 2005 - by 74% since 2005.

Here we consider direct combustion emissions in manufacturing and mining, excluding the LNG sector (analysed separately in the next section, given the importance of the LNG sector both for WA industry and its emissions[16].), as well as fugitive emissions because of the different nature of mitigation options. We also take into account process emissions (for example from cement or ammonia production) and emissions from product use.

These emissions from direct combustion in manufacturing and mining (excluding LNG sector) and from industrial processes and product use together comprise a share of 28% of energy and industry carbon emissions and have increased by 23% compared to 2005 (see table 2).

We analyse this part of the industry sector based on the analysis of international and national scenarios and research on option for electrification of industrial processes (BZE 2018) and international best practice examples (see Annex for details) and taking into account the specific Western Australia economic profile and structure and show how the Western Australian industry sector can achieve zero CO_2 emissions by 2050, discussing implications for key sectors: manufacturing and mining.

In some industry sectors, greenhouse gas emissions originate not only from fuel combustion to generate heat or electricity, but also from fuel combustion needed to start certain chemical reactions in particular for steel, cement, and ammonia production. Apart from increasing efficiency and

16 Fugitive emissions for production of natural gas for domestic use (factoring out gas used in producing LNG), oil production and coal production are calculated with respect to the published inventory of these sources and government energy balance and/or data. These calculations are done in such a way that they are consistent with the federal Government's December 2018 greenhouse gas projections and related historical emissions time series. This means that where our approach results in fugitives exceeding the results are scaled to the government inventory and/or starting point for greenhouse gas projections in 2018. For the purposes of calculating LNG emissions in this report a bottom-up, plant by plant, approach has been taken which reconciles quite closely with Clean Energy Regulator reports and other data sources. The domestic gas fugitives for Western Australia are inferred as the difference between the total gas fugitives and LNG estimates based on our approach over the historical period. Projections of domestic gas fugitives going forward are based on domestic gas demand arising from the modelling results in this work multiplied by the recent historical fugitive emissions intensity ($MtCO_2e/PJ$) of domestic gas production. Whilst this does not capture the decreasing intensity of fugitives estimated for domestic natural gas industry in Australia and evident in government inventories, because natural gas is phased out in the Paris agreement scenario there is no real benefit to modelling more complicated assumptions. Fugitives from West Australian coal production is calculated with respect to national emission factors historically, and projected forward based upon the projected coal demand in the Paris agreement scenario modelled in this report, with the recent average fugitive emissions intensity ($MtCO_2e/PJ$) of coal production applied. Fugitives from domestic oil production in Western Australia are calculated in a similar way. Overall, the estimate of fugitives based on the methods used here are quite close to the published government inventories. Nevertheless, there are significant differences and the scaling down of inventories could make small but significant (2.5-5%) difference to the future carbon budget calculated for Western Australia. Under the reference pathway where it could be assumed that oil production (e.g. condensates and other natural gas liquids) tracks LNG production this could amount to 50 Mt CO_2e cumulative extra emissions in the period 2018 to 2050, and for the Paris Agreement Asian demand scenario, could amount 250 Mt CO_2e cumulative extra emissions for the same period.

decarbonising energy supply, decarbonisation of these sectors (cement and ammonia production are currently relevant for Western Australia) requires a shift in production methods (including more circular production routes) or in product use (Climate Analytics 2018a). Steel and cement manufacturing are among the most carbon intensive industries involving process emissions. While Western Australia does not have steel production at present, it does have the potential to introduce zero emissions steel production based on its iron ore and renewable energy resources. Process emissions contribute a share of 9% to industry greenhouse gas emissions in Western Australia, mainly from cement production. The largest share of CO_2 emissions is from direct combustion for heat demand in industry.

Full decarbonisation of the industry sector by 2050 implies eventually replacing coal, oil, and gas with renewable energy not only for power generation but also for heat demand in industry, with hydrogen as a renewable fuel option for high-temperature applications in the industry sector, together with biomass. Gas can also be replaced by renewably-produced hydrogen as feedstock for ammonia production. While cement production is often considered a difficult to abate sector, recent research shows the possibility for full decarbonisation, mainly driven by replacing conventional production methods with new, low-carbon alternatives such as geopolymer cement instead of carbon-intensive process of producing Portland Cement from limestone. It can also include the need to take up remaining carbon emissions. While often the need for Carbon Capture and Storage (CCS) is assumed for decarbonising cement production, other technologies are available such as mineral carbonation that can be implemented at lower cost (BZE 2018).

Renewable energy alternatives exist for all applications of industrial natural gas use, not only for power generation but also for lower output temperatures and high temperature thermal processes as well as chemical feedstock, as studied by ARENA (2015). Recent interest internationally (IRENA 2019a) and nationally (ACIL Allen Consulting 2018, CSIRO 2018) in the development of strategies for (renewable) hydrogen including at national and state level offer opportunities for a faster decarbonisation of industry sectors in Western Australia.

More recent cost estimates, with CSIRO (2018) in the National Hydrogen Roadmap estimating that in or around 2025, clean hydrogen could be cost-competitive with existing industrial feedstocks such as natural gas, and energy carriers such as batteries in many applications[17], making it much more likely for these to become least cost options in particular with adequate policies in place at federal and state level.

Recent estimates show that hydrogen technology can be competitive with coal-based plants for steel production by 2030, with the cost of renewable hydrogen falling below $2.20 a kilogram (Bloomberg 2019).

While Western Australia does not have steel production at present, this opens opportunities for developing a new manufacturing industry.

An important strategy across all industry (and other end use) sectors is an increase in energy efficiency. Australia is lagging behind most other developed and even many developing countries with policies to incentivise energy efficiency. Such policies can and have to also be introduced at state level. However, energy efficiency cannot be the only focus for decarbonisation of industry, and needs to be complementary to decarbonisation in particular through electrification, which in itself also increases energy efficiency.

17 See also (Bloomberg 2019)

In our scenario, emissions start reducing more slowly than in other sectors – by 30% in 2030 compared to 2005, mainly due to efficiency gains, but also with industry processes starting to get electrified and fossil fuels starting to get replaced by biomass or green hydrogen. Direct electrification of processes increases to 80% by 2050, with replacement of coal with gas or biofuels for remaining heating processes over the next ten years, and replacement of fossil fuels by green hydrogen and fossil fuels phased out completely by 2050, coal faster (by 2040). Natural gas demand increases only slightly reaching a peak before 2030 and then declining. Electrification, including the use of green hydrogen, leads to an increase in demand for electricity which needs to be decarbonised ramping up renewable energy power generation.

Based on this scenario, we calculate a carbon budget for the industry sector excluding LNG production and processing for 2018-2050 of **328 Mt CO_2 and emissions would have to be reduced by 30% in 2030 compared to 2005. At current emission level, the budget would be used up within 15 years.** Emissions from electricity generation are not included in this budget, but in the budget for power generation.

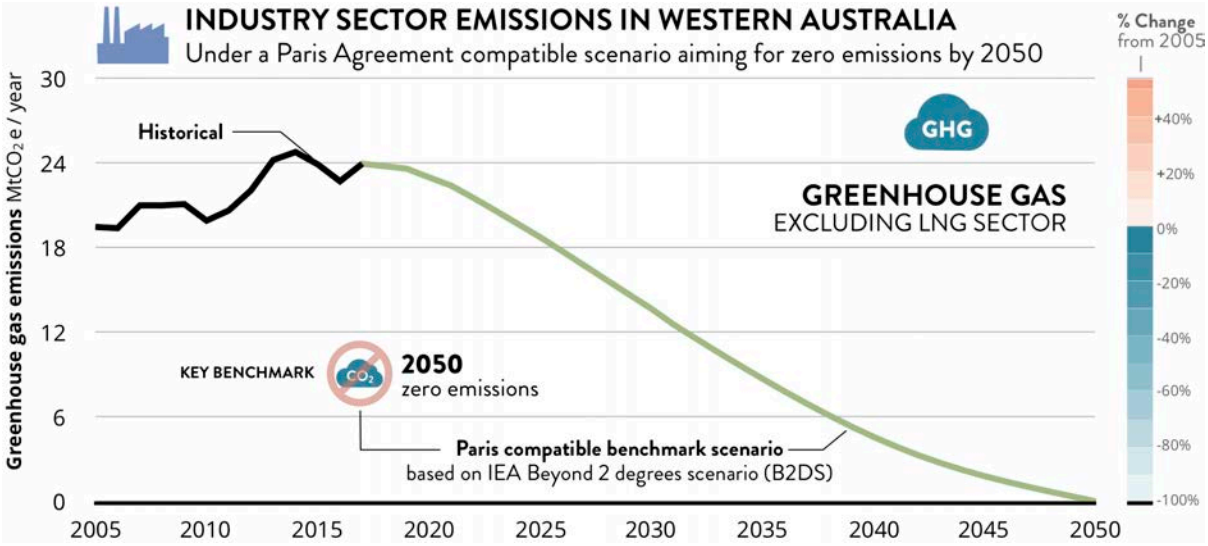

Figure 11: Carbon emissions from the industry sector (excluding LNG sector) in a Paris Agreement compatible pathway for Western Australia based on analysis of national and international scenarios and indicators with the PROSPECTS tool (Climate Action Tracker 2018a) and the benchmark of full decarbonisation by 2050. We show historical data until 2017 (Source AGEIS 2019).

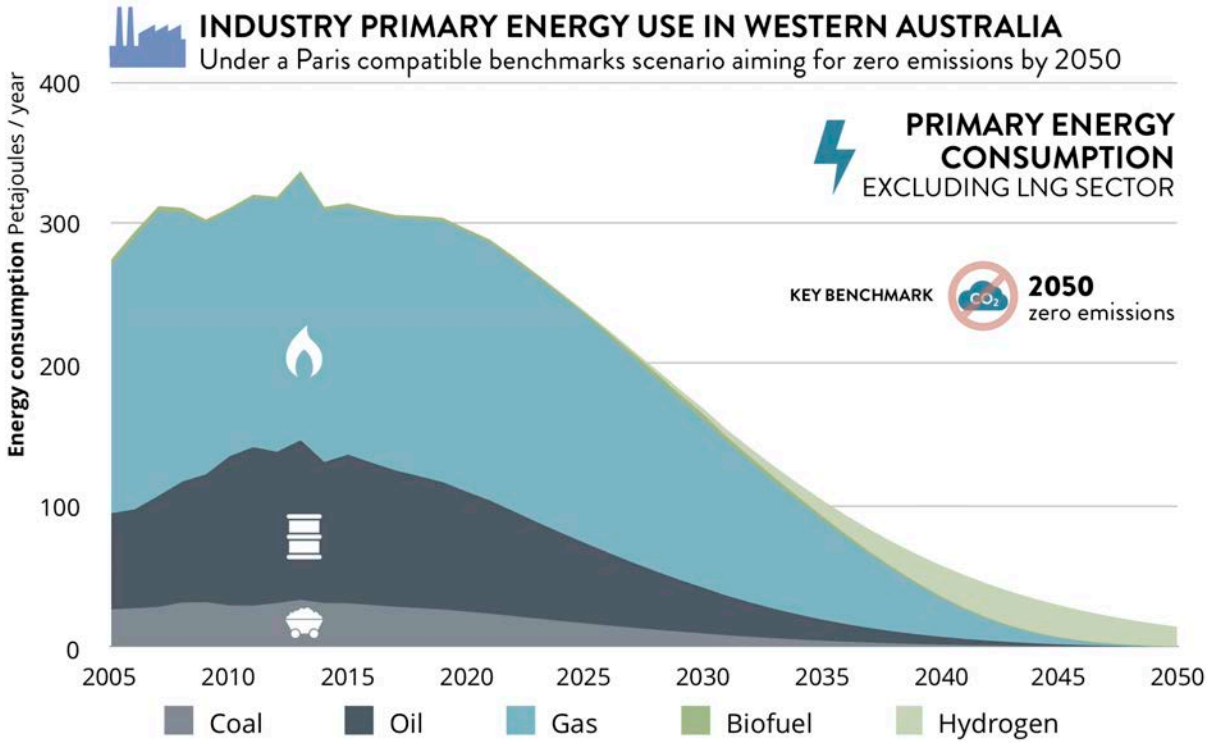

Figure 12: Primary Energy demand and fuel mix for direct combustion in the industry sector (excluding LNG sector) in a Paris Agreement compatible pathway for Western Australia based on analysis of national and international scenarios and indicators with the PROSPECTS tool (Climate Action Tracker 2018a) and the benchmark of full decarbonisation by 2050. We show historical data until 2017 (Source AGEIS 2019). It is important to note that this does not include electricity demand, as emissions from power generation are included in the power sector. The scenario assumes electrification of industry processes reaching 80% in 2050, and fossil fuels being gradually replaced by biomass and, increasingly, green hydrogen. This leads to increased electricity demand taken into account in the mitigation pathway for the power sector.

Table 5: Fuel mix for WA industry sector (excluding LNG sector) under a Paris Agreement compatible pathway based on technology assumptions from a range of scenarios, as analysed with the PROSPECTS tool (Climate Action Tracker 2018a) and benchmark for decarbonisation by 2050. Source: Own calculations, 2014 historical value: Australian Energy statistics.

		PARIS COMPATIBLE BENCHMARK SCENARIO		
	2014	2030	2040	2050
Oil	32%	19%	10%	0%
Natural gas	57%	70%	47%	0%
Coal	10%	6%	3%	0%
Biomass	1%	3%	3%	3%
Hydrogen/Solar Thermal	0%	2%	38%	95%
All fuels	**100%**	**100%**	**100%**	**100%**

This scenario is an indicative Paris Agreement compatible benchmark scenario, based on existing international scenarios and analysis of mitigation options and least cost mitigation pathways, applied to the Western Australia context and structure of the industry sector. It is outside of the scope of this report to look at new manufacturing and export opportunities, for example for zero emissions steel, aluminium, cement production or for export of green hydrogen or other energy carriers.

Given the complexity and diversity of the industry sector, there is a need to develop detailed industry specific scenarios involving stakeholders from industry, trade unions, and civil society, in order to derive roadmaps for research, development, and deployment. This can be the basis to develop a transition strategy, bringing all stakeholders on board, and including roadmaps to take advantage of unique opportunities and competitive advantage of Western Australia.

An important element of a decarbonisation strategy for the industry sector is to include an assessment of macroeconomic impacts and impacts for employment in regions, as well as developing a transition strategy for regions affected by phasing out production and use of coal as well as extraction, processing and use and export of gas, developing roadmaps for new manufacturing industries in specific regions.

Western Australia also needs to introduce an energy savings scheme, as it is one of the states without any such scheme (ESIA 2018).

Power sector – decarbonising fast and delivering zero emissions power for electrified end use sectors

As discussed above, electricity generation in Western Australia is the second largest source of emissions (after industry) and contributes almost a third (31% share in 2017) to energy and industry carbon emissions, and these have increases by 44% since 2005.

This section provides a pathway for Western Australia's power sector, under a Paris Agreement cost optimal compatible emissions pathway, considering key technology and market trends, the state context (see above) and previously analysed international, national and sectoral scenarios for fossil fuel and renewable energy benchmarks (coal phase out, only short transition role for gas, move towards 100% renewable energy with storage and transmission).

In all 1.5°C compatible pathways fast decarbonisation of the power sector paves the way for deeper emissions reduction in other sectors by means of increasing electrification. This implies a very fast ramp up of renewable energy generation, to take into account a fast growth in electricity demand in the 2030s when electrification kicks in considerably across end use sectors, reaching an almost fourfold demand in 2050 compared to the reference case.

While even in the reference case, renewable energy quickly becomes the dominant source of electricity generation, reaching 50% ahead of 2030, 70% in 2040, and 95% in 2050, driven by the cost-competitiveness of renewable energy technology, the Paris Agreement benchmark pathways reaches a third in the mid 2020s, and around 90% in 2030, with a fully renewable energy based and fully decarbonised electricity generation by 2035– but with much higher absolute generation given the higher electricity demand (see Figure 13 and Figure 14).

We take into account the announcement by the WA government (Booth 2019) for a staged shut down of two of the remaining four coal units in 2022, as well as the projections by the AEMO (2019) and available information about already approved connections for 2019-2021 (RenewEconomy 2019e) for expected increase in rooftop solar and large-scale wind and solar projects, with half a gigawatt scale growth in utility scale PV over the next few years and a share of 65% of Variable Renewable Energy (VRE) supply expected by 2024 AEMO (2019).

The assumed growth of rooftop solar at 25% per year until it reaches an assumed maximum share of 80% from present 27%, and the continued growth in large-scale renewable energy projects leads to lowering demand for gas, being phased out in the early 2030s, and coal being phased out before 2030 already, with wind and solar becoming the main power sources from the early 2020s onwards (See

Figure 15). While some of this development is already occurring due to market forces, it will need a careful management as well as clear policy direction, given the crucial role of the power sector to address additional demand from electrification of end-use sectors.

The carbon budget we calculate for power sector is 160 Mt CO_2, requiring emissions reductions of 95% by 2030 from 2005 levels, and reaching zero emissions in the early 2030s. At current level of emissions, this budget would be used up after only 6 years.

Key benchmarks for the electricity generation pathway for Western Australia are:

- Coal is phased out before 2030, and gas shortly after
- Renewable energy share needs to grow from 8% now to a third in the mid 2020s and 90% in the early 2030s.
- Renewable energy capacity needs to ramp up very fast to take into account an expected increase in demand from electrification of end-use sectors.

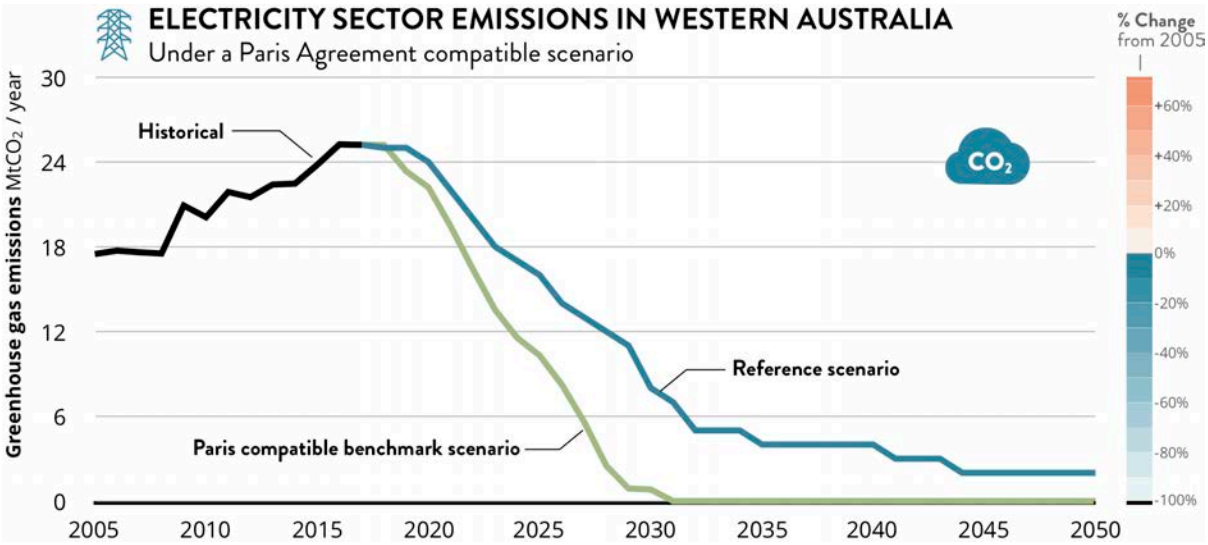

Figure 13: Emissions from power generation in Western Australia - Reference and Paris Agreement Pathways. The power sector needs to and can decarbonise by the early 2030s.

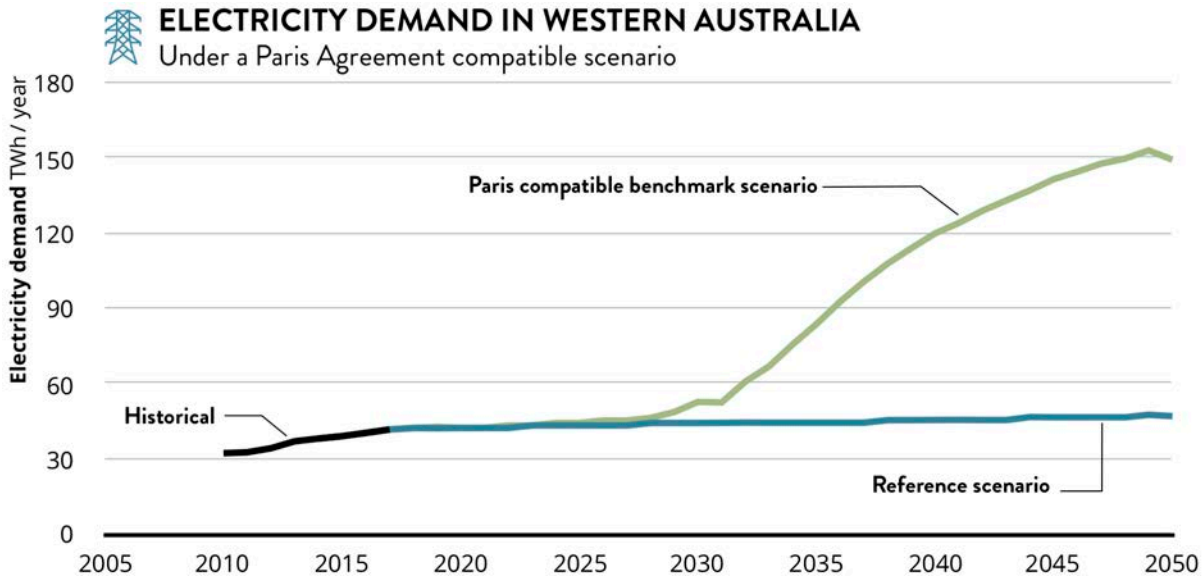

Figure 14: Electricity demand in Western Australia - Reference and Paris Agreement Pathways. With electricity demand increasing due to electrification of end-use sectors (transport, buildings, industry), electricity demand increases by a factor of 3.7 by 2050 compared to current levels, despite increased energy efficiency in end-use sectors.

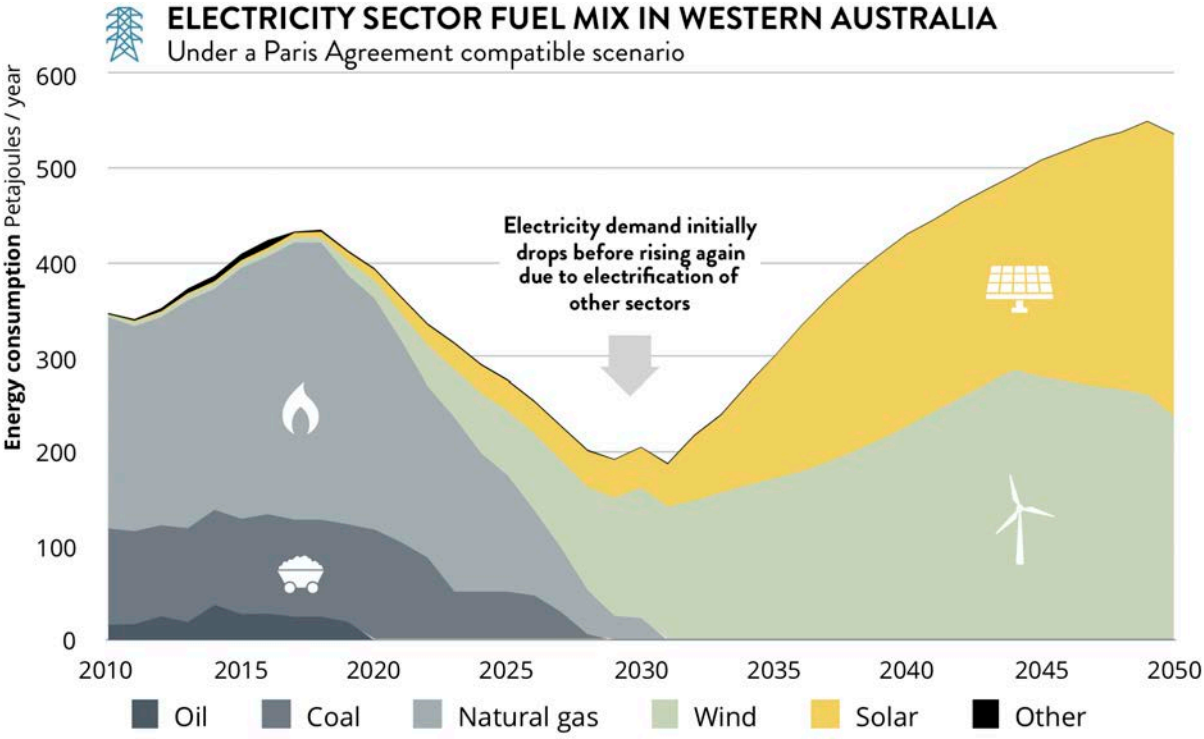

Figure 15: Western Australia's Fuel Mix for the Paris Agreement Pathway. Solar and Wind energy become dominant sources from the early 2020s. Coal is phased out before 2030, and gas shortly after 2030.

The analysis of a Paris Agreement compatible benchmark scenario shows the critical importance of a whole of economy approach to a climate strategy, and the need to take into account the role of the power sector in decarbonising end use sectors.

The WA government has developed an Energy Transition Strategy (WA Government. 2019), as a reaction to the current developments in the market, including the increased share of distributed energy resources, battery systems, and microgrids. This can be developed further to integrate a roadmap with clear midterm targets, taking into account the increased electricity demand and the need for a fast decarbonisation, including phasing out coal before 2030 and gas by the early 2030s. This needs to provide planning certainty for legislation and market design, transmission and storage investments and fast ramping up of large scale solar and wind projects.

LNG Sector: preparing for transition to zero carbon, green hydrogen

The LNG sector is analysed with more detail and granularity, given its importance for WA economy and emissions profile, as well as its contributions to international emissions. We show:

- A mitigation pathway in comparison to a business as usual pathway
- Implications of reduced gas demand globally/in Asia in a Paris Agreement pathway
- Options for decarbonisation of LNG processing through electrification.

The liquefied natural gas (LNG) sector has grown rapidly in Western Australia over the last decades, doubling in size over the last five years to about 45 million tonnes of LNG (MtLNG) per annum production in 2018[18] capacity, and is set to increase by about 35% to 60 MtLNG p.a. by, or shortly after, 2025 (Figure 16). The primary energy demand for gas in the LNG processing sector has increased correspondingly and now approaches 240 PJ per year.

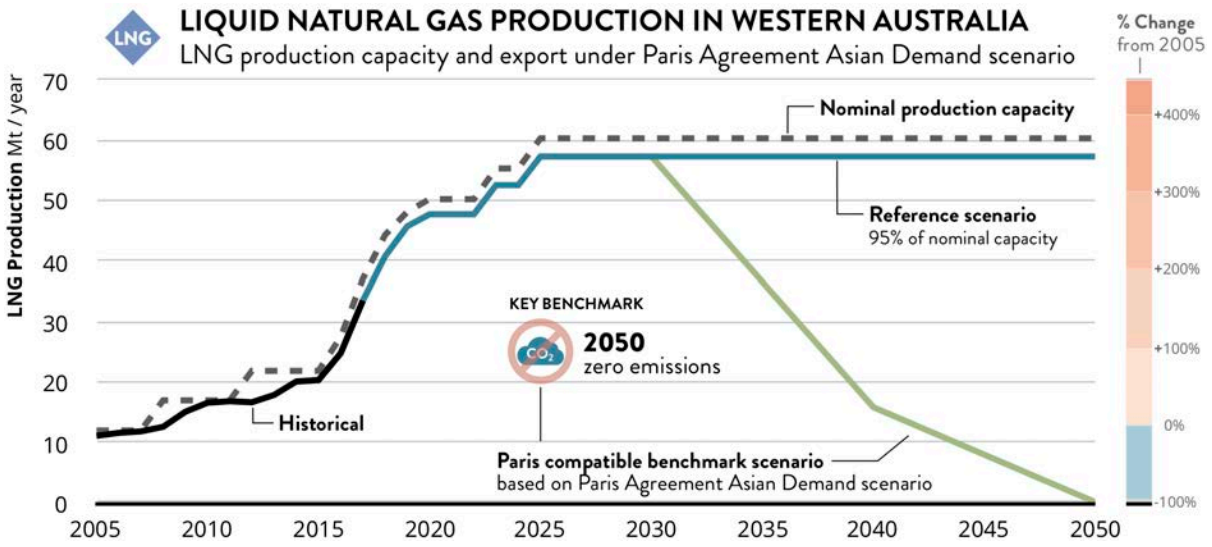

Figure 16 Growth of LNG production capacity and exports until 2019, with projections until 2030 based upon projected changes/increases in LNG production capacity and assuming 95% of nominal capacity is produced and exported. LNG exports in the reference case are limited to 95% of nominal LNG production capacity.

[18] See https://www.jtsi.wa.gov.au/docs/default-source/default-document-library/wa-lng-profile---september-2019.pdf?sfvrsn=413f701c_6

Along with the rapid growth of CO_2 emissions from the natural gas used to produce LNG[19], fugitive emissions from LNG processing and related activities and venting of the CO_2 from the natural gas reservoirs, have also increased rapidly. Emissions from the LNG industry in WA are estimated here to be approaching 22 Mt CO_2e per annum and can be expected to approach 35 Mt CO_2e per annum by the late 2020s[20].

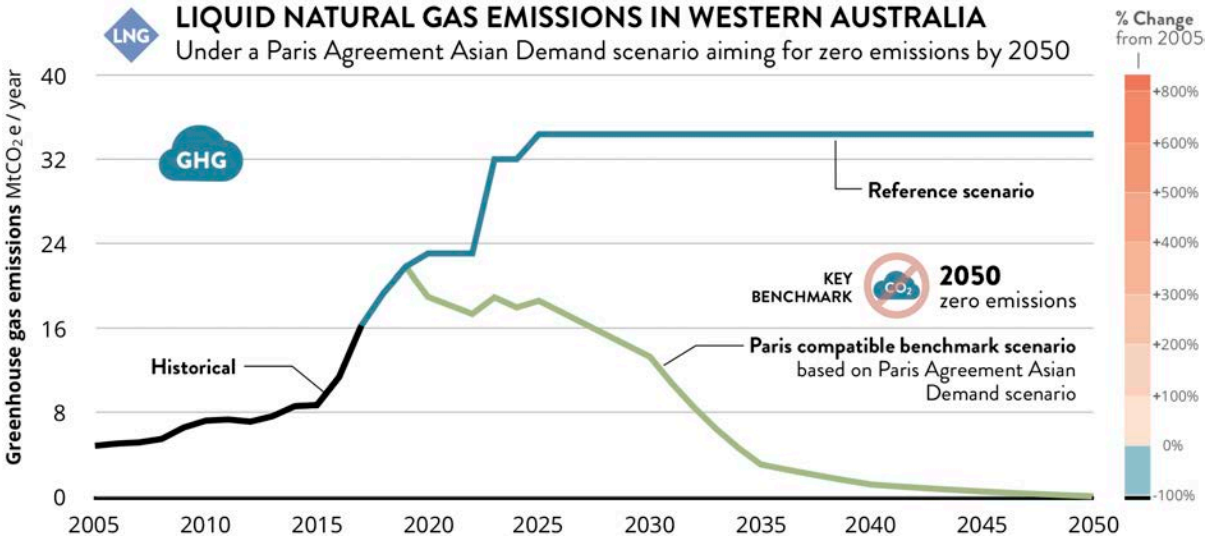

Figure 17 Growth of LNG processing emissions in Western Australia from natural gas used in liquefaction, CO_2 from natural gas reservoirs and fugitive emissions from the LNG manufacturing process until 2019 with projections to 2030. Whilst the intensity of CO_2 emissions from direct energy use and liquefaction have remained fairly stable, in terms of tonnes of CO_2 per tonne of LNG produced, there has been an increase in CO_2 vented from natural gas reservoirs due to the concentration of CO_2 in more recently exploited natural gas reservoirs. The reference case projection does not include CO_2 CCS at the Gorgon LNG plant, however this is included in the Paris Agreement case and explains the drop of total emissions from 2019 to 2020, when it is assumed that the Gorgon CO_2 CCS is capturing 80% of the reservoir CO_2 and storing it in a secure geological formation.

Apart from planned capture of CO_2 and storage in geological formations at the Gorgon plant very few greenhouse gas mitigation measures have been announced or planned at any scale in Western Australian LNG facilities.

With the reference case emissions of the natural gas industry of at least 1 billion tonnes of CO_2 equivalent greenhouse gas emissions between 2018 and 2050 it is clear that there has to be substantial mitigation if the sector is to become Paris Agreement compatible. The projected cumulative emissions from the present trajectory of the LNG industry in Western Australia equal or exceed a Paris Agreement compatible carbon budget for the state.

Global implementation of the Paris Agreement means that the recent growth in the use of natural gas cannot continue, whether for the power sector or in other applications. Scenarios vary, however a common denominator is that in the next decade natural gas demand would have to peak and began to decline, and in central case estimates fairly rapidly. A critical variable in this equation is the likely role of carbon capture and storage. We view that deployment of CCS technology particular in the context

[19] For every tonne of LNG produced it is assumed that natural gas equivalent to 9% of the energy content of the LNG is required for the manufacturing process.

[20] Emissions from LNG production facilities are estimated here based on standard emission factors, energy balance, physical estimates of CO_2 losses from natural gas reservoirs and plant specific emission intensity based on environmental impact statements and other studies. These estimates are approximately 5% lower than the Clean Energy Regulator Scope 1 plant specific reports for the NWS Karratha, Pluto and Gorgon operations in Western Australia in 2017/18. The estimated Wheatstone emissions are only 45% of the CER Scope 1 reports for 2017/18, however this may be do higher than normal emissions associated with the scaling up of operations at this plant. In general LNG operations also supply domestic gas and data in respective EIS documents emissions associated with this are of order of 5% of the LNG related emissions.

of gas turbines used in the power sector as being very unlikely due to high cost and the fact that this technology cannot eliminate 100% of emissions.

As shown above, the analysis of global mitigation pathways in line with the Paris Agreement as assessed by the IPCC shows that under the Paris Agreement demand for natural gas in the power sector in Asia, a major source of LNG demand, is likely to peak by around 2030 and then decline to close to zero between 2050 and 2060 (Figure 4). One scenario therefore for the LNG industry in Western Australia under Paris Agreement implementation would be to more or less follow the modelled trajectory for natural gas demand in the power sector in Asia for the period 2030 to 2060 which would result in a substantial reduction in LNG demand, reducing from peak levels in 2030 to close to zero by 2050.

Of course, the transition to a zero-carbon economy in Asia will require large amounts of energy, hence the market for energy carriers similar to LNG will not disappear, and this is where the potential for renewable hydrogen exports from Western Australia becomes much more visible. A number of East Asian economies have, or are developing hydrogen strategies, for a variety of different reasons, including energy security and climate change. A Paris Agreement driven decline in Asian demand for liquefied natural gas would be matched by a corresponding increase in demand for clean energy carriers, in particular Green Hydrogen. Hence the key elements of the zero-carbon transition outlined here for the LNG industry involved building up new markets for green hydrogen, which needs a major ramp up in renewable energy generation capacity in regions near to the present LNG facilities.

A decline in demand for LNG industry consistent with the Paris Agreement reaching close to zero by 2050 would reduce all LNG related emissions very substantially. Nevertheless, in order to meet the commitments of the Paris Agreement, and stay within the carbon budget and minimise the need for negative emissions, significant additional abatement measures would need to be introduced. These would include extending carbon capture and storage for reservoir CO_2 losses to all LNG plant in Western Australia as well as replacing a significant fraction of natural gas used in LNG processing by renewable electricity. The broad approaches assumed here is that the level of CCS planned for the Gorgon plant of 80% from 2020 (which would capture approximately 60% of present total CO_2 reservoir emissions for LNG operations in WA) extended to all plant from 2023, combined with the phasing in of renewable energy so that by 2030, 50% of LNG manufacturing natural gas use is replaced by renewable energy, 90% by 2035 and by 2050, 100%.

Irrespective of whether or not the demand reductions implicit in the scenario above occur, the cumulative emissions of the LNG industry need to be reduced substantially in the basic options examined here would need to be deployed in either case. In the reference case, the scale of the emission reductions to be achieved through carbon capture and storage of reservoir CO2 and by introducing renewable energy quickly into the LNG manufacturing process would be substantially larger than in the Paris Agreement Asian power demand case. For completeness we show both scenarios which achieve similar levels of cumulative reductions by 2050.

Applying the options described above to the reference case LNG production, as is shown in Figure 19 would reduce the peak emissions from Western Australia LNG manufacturing to around 300% above 2005 levels from a projected 600% increase by the mid 2020's in the case with no policy action. This would bring emissions back to about 176% above 2005 levels in 2030, 16% below 2005 levels in 2040 and 46% below in 2050. Zero CO_2 emissions would be needed to be Paris Agreement compatible.

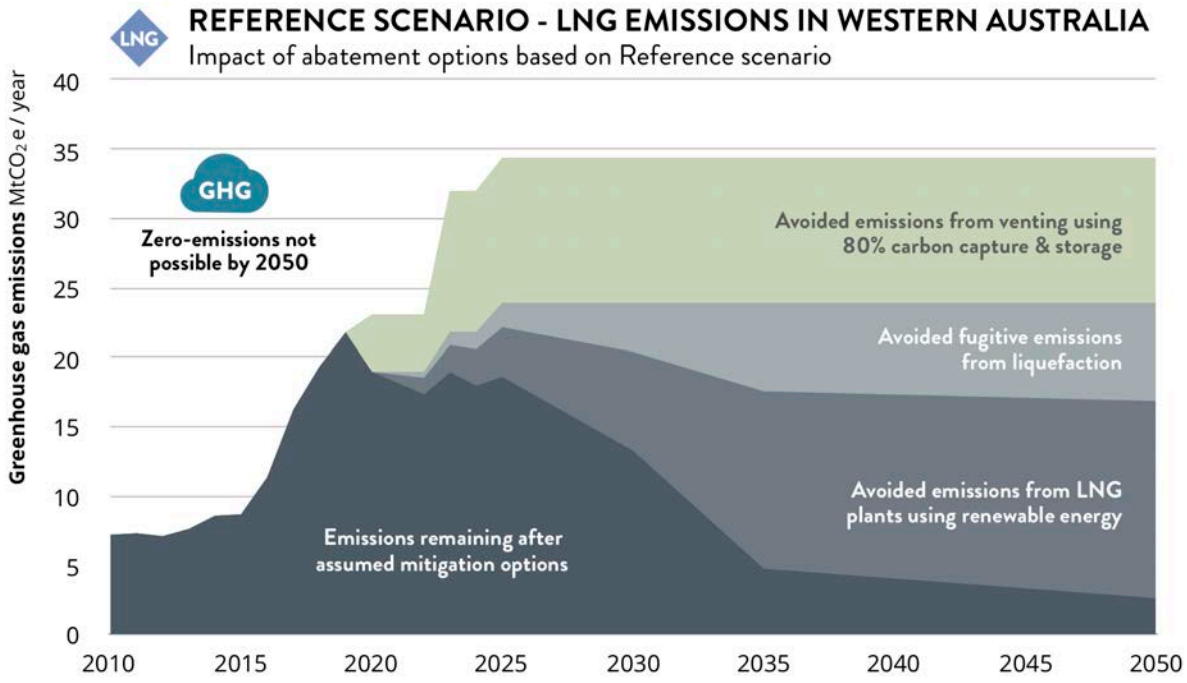

Figure 18 Relative role of the abatement options described in the text for reference case LNG demand and see Table 6. Zero emissions are not achieved by 2050. The cumulative emissions remaining between 2018 and 2050 after the assumed mitigation options are applied in this reference scenario is 323 MtCO2e. This amounts to approximately one third of the Western Australian Paris agreement compatible carbon budget for the energy system. There could be more or less emissions left depending upon the rate and scale of the actual mitigation options deployed.

Under a Paris Agreement induced decline in demand from 2030 combined with the mitigation options discussed (carbon capture and storage, electrification), this would lead to LNG related emissions in 2030 being about 175% above 2005, around 80% below 2005 levels by 2040 and approach zero by 2050 (Figure 19).

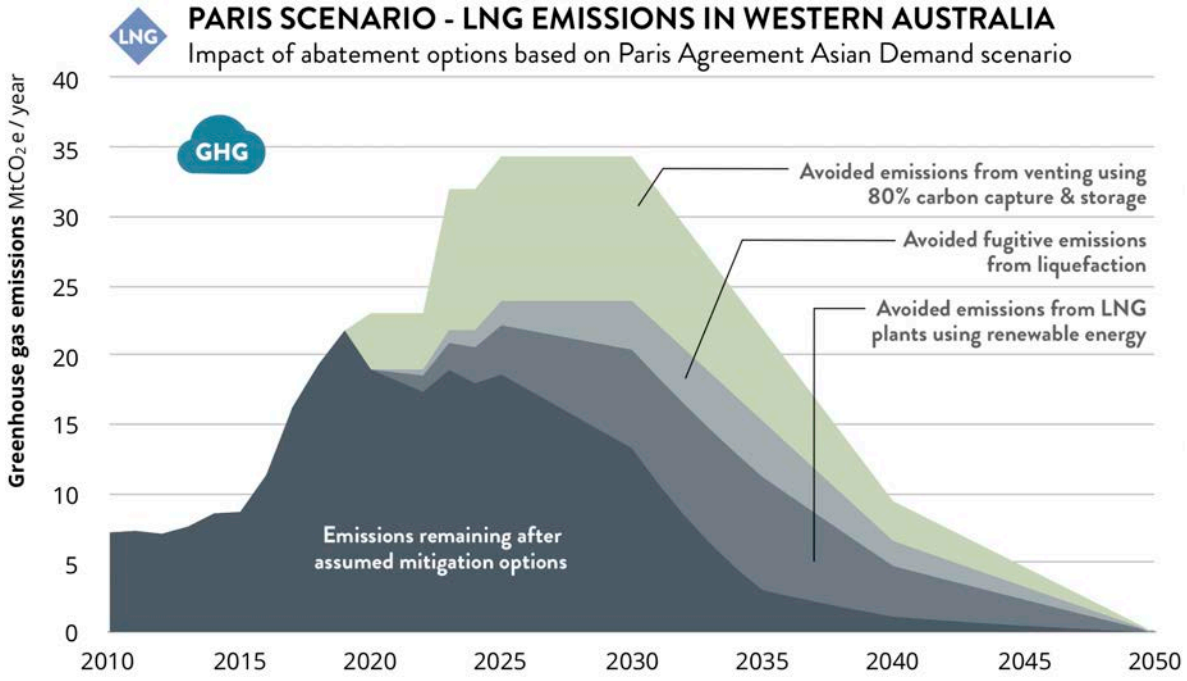

Figure 19 Relative role of different elements of a Paris Agreement LNG demand reduction scenario and mitigation options in reducing emissions from the reference case to close to zero emissions by 2050. The cumulative emissions remaining between 2018 and 2050 after the assumed mitigation options are applied un this Paris Agreement LNG demand scenario is 274 $MtCO_2e$. This amounts to approximately about 29% of the Western Australian Paris agreement compatible carbon budget for the energy system. There could be more or less emissions left depending upon the rate and scale of the actual mitigation options deployed.

Table 6 below compares the reference case and Paris Agreement LNG demand reduction scenario. In the reference case, with no abatement, cumulative emissions in the period 2018-2050 are likely to be in the range of 1 $GtCO_2$, of the same order as the entire carbon budget for WA. A Paris Agreement Asian demand reduction scenario would reduce this by over 60% to around 438 $MtCO_2e$ without abatement options. Cumulative emissions can be reduced much further to around 274 $MtCO_2e$ through CCS and renewable energy replacing natural gas in the LNG manufacturing process. With this the LNG industry would take up about a quarter of the WA carbon budget for this period. The cumulative emissions from the reference case with all mitigation options is about 20% higher at about 320 $MtCO_2e$, and zero emissions would not be reached. This would imply the need for the LNG industry to generate negative CO_2 emissions elsewhere to compensate.

Table 6 Cumulative emissions from LNG Reference and Paris Agreement scenarios

Cumulative emissions 2018-2050 $MtCO_2e$	Paris Asian Natural Gas power demand	Contribution to avoided emissions (%)	Reference case – production at 2030 levels	Contribution to avoided emissions (%) [21]
Reference case cumulative emissions 2018-2050	1,067		1,074	
Cumulative Paris carbon budget emissions	274		323	
Where do avoided Emissions come from?				
Demand decline	438	56%	0	9%
Avoided CO_2 from renewabilizing LNG plant	123	16%	395	40%
Avoided CO_2 from venting with 80% CCS	171	20%	304	41%
Avoided liquefaction fugitives	61	8%	146	20%
Total avoided emissions	**793**		**745**	

The WA government provides strong support to the LNG industry, epitomized in the new LNG Futures Facility. The Premier Mark McGowan announce $10 million to support the facility, aiming for WA to be a global leader in developing and testing LNG technology (WA Government 2019c). It has been argued that the facility will "future-proof" the state's LNG industry (WA Government 2019c) to ensure the industry persists into the future, however there is little sign that this has taken of the fundamental energy transitions required to meet the Paris Agreement goals globally. A further large LNG project, Browse is proposed by Woodside that could scale up the LNG industry in WA, if approved, with start-up likely around 2026 (Toscano 2019). The Scarborough gas field is proposed also for development which would extend the life of the North West Shelf Project (Reputex 2018).

To ensure the transition outlined here, in particular the need to extend the level of CCS planned for the Gorgon plant of 80% capture and storage of reservoir CO_2 from 2020 to all LNG operations from 2026, combined with the phasing in of renewable energy for liquefaction, the government would have to likely introduce regulation given there is no carbon pricing at federal level.

If there is less demand reduction than assumed here, the same emissions pathway needs to be reached. This would imply a higher abatement to be reached with CCS and renewabilisation of the LNG manufacturing process.

21 May not add to 100% due to rounding errors.

Requesting offsetting emissions would not be a viable option to achieve this mitigation pathway, as the mitigation achieved outside of the LNG sector (for example as noted in the (Reputex 2018) report would need to be implemented in any case, and not to compensate for no, or insufficient, mitigation in the LNG sector. A requirement for offsetting would only be viable for any mitigation below the pathway outlined here. This would imply, de facto, a pricing mechanism that would allow raising funds for some of the mitigation outlined for other sectors, which can be justified given the high cumulative emissions in the LNG sector since 2005.

Carbon budgets for Western Australia energy and Industry sectors

Table 7 summarises the results the preceding analysis to produce a Western Australian Paris Agreement compatible budget and pathway and related sectoral carbon budgets and pathways for the period 2018-2050, as well as benchmarks for emission reductions for 2030 compared to 2005 levels to establish both the state and its key sectors on 1.5°C compatible pathways.

We calculate the carbon budget for Western Australia's fossil fuel (energy and industry) CO_2 emissions for the period 2018-2050 to be a bit below 1 $GtCO_2$, which is about 0.17% of the remaining global carbon budget until zero emissions.

Table 7: Paris Agreement compatible energy and industry carbon budget for Western Australia 2018-2050. Source for historical data: AGEIS 2019. LNG sector emissions include emissions from venting/fugitive emissions (own estimate).

Sector	Paris Agreement compatible carbon budget 2018-2050 $MtCO_2$	2030 reduction (compared to 2005 baseline) CO2 only	2005 Baseline $MtCO_2$	Remaining years at 2017 emissions rates
Electricity generation	160	-95%	17.5	6
Transport	207	-16%	8.8	15
Industry: LNG Sector	208	+170%	3.6	16
Fugitive emissions (excl. LNG)	25	-55%	1.6	6
Industry: other	328	-30%	18.1	15
Buildings	22	-41%	1.2	12
Total energy/industry emissions	**949**	**-37%**	**50.8**	**12**
Total energy/industry excluding LNG sector	**716**	**-53%**	**45.6**	**11**

Figure 20 shows the pathway for CO_2 emissions from energy and industry towards zero emissions that is consistent with this budget.

An overall CO_2 emission reduction of about 37% by 2030 from 2005 levels, 81% by 2040 and zero emissions by 2050 is needed to limit cumulative emissions to the carbon budget to its 950 million tonne carbon budget.

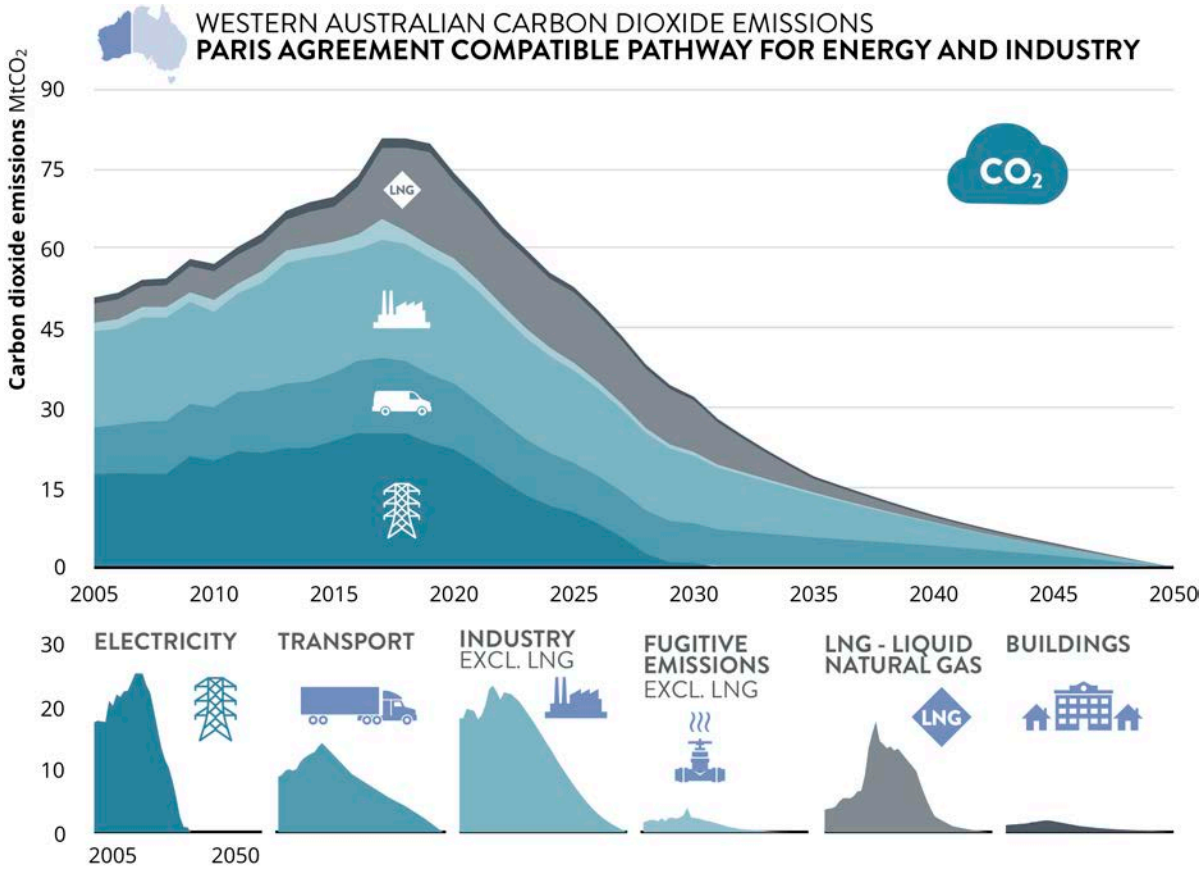

Figure 20. CO_2 emissions pathway for each of the sectors and energy and industry following transformation is consistent with the Paris agreement in each of those sectors. Total CO_2 emissions peak around 2020 and decline to about 37% below 2005 levels in 2030, for total budget of around 950 Million Tonnes CO_2. Excluding the LNG industry, energy and industry CO_2 emissions would reduce by about 53% by 2030 below 2005 levels, for a total budget of 716 $MtCO_2$.

A key conclusion is the need to **reduce emissions in the immediate term** given the current growth in emissions – every delay in reducing emissions will imply faster reductions later to stay within carbon budget, implying higher costs and disruption, and risks locking further into fossil fuel infrastructure.

If current (2017) emission rates were to be continued, the overall energy and industry carbon budget of about 950 Mt CO_2 would be consumed within 12 years.

Another key conclusion is that the electricity sector needs to and can reduce emissions faster than any other sector, by 95% in 2030 compared to 2005 (and zero by 2035). All sectors except for LNG and transport would have to be reduced faster than the Australian reduction target of 26-28% by 2030. The transport sector would need to reduce emissions by about 16% by 2030 compared to 2005 levels. On the other hand, the peculiarities of the LNG industry mean that its increase would be limited to about 170% increase above its 2005 levels (compared to a reference case increase of 630%), however it would be reaching reductions of about 73% below 2005 levels by 2040 and 100% by 2050.
We compare our findings and estimated carbon budget for Western Australia's energy and industry sectors for plausibility against other methodologies used to generate national or state carbon budgets, to confirm our estimate is a robust estimate for a Paris Agreement, compatible energy and industry carbon budget for Western Australia:

- If we apply Australia's share of current global emissions of about 1.1% of global fossil fuel (energy and industry) emissions in 2017 (C. Le Quéré et al.2018) to the global carbon budget of 610 $GtCO_2$ (range 555 to 730 Gt) until the year of zero emissions estimated earlier (Climate Analytics 2019a), this results in a budget for Australia of 6.7 $GtCO_2$ (range 6.1-8.0 $GtCO_2$). With the current Australian share of 20% for Western Australia of fossil energy and industry CO_2 emissions the Western Australia budget would be **1.3 $GtCO_2$ (range 1.2- 1.6 $GtCO_2$).**
- Total **global carbon budget until 2100 is considerably lower** than until net zero emissions, implying the need for negative emissions after reaching net zero. Australia's share of this budget until 2100 would be, based on the current 1.1% share of global emissions, 5.2 GtCO2 (range 3.5-7.7 GtCO2), and **WA's share** would be **1.0 GtCO2** (range 0.7 – 1.5 GtCO2) based on a 20% share.
- As a cross check for consistency against the global carbon budget derived from Integrated Assessment Modelling results outlined above, we have produced an estimated budget for Australian energy related CO_2 emissions over 2018-2050 in the range of 4.8-6.6 $GtCO_2$. A 20% share for Western Australia would correspond to **1.0 to 1.3 $GtCO_2$**.
- Based on a national scenario for decarbonising the entire energy system, we have, earlier, estimated a national budget for Australia of about 5.5 Gt CO_2. Assuming a share of 20% of this national budget for Western Australia, corresponding to the share of energy CO_2 emissions in 2017, this would result in a budget of **about 1 $GtCO_2$ and is confirmed with this study.**

ACHIEVING ZERO GREENHOUSE GAS EMISSIONS BY 2050

In order to assess how Western Australia gets to net zero GHG emissions by 2050, we have analysed Paris Agreement consistent mitigation pathways in sectors outside of energy and industry, and also take into account emissions apart from carbon in energy and industry – mainly industrial emissions from product use (so called F-Gases) that can be phased out, as well as fugitive emissions that will be phased out with the phasing out of fossil fuel extraction.

The key remaining sectors are agriculture (10% of WA emissions) and waste (small share of 2% of WA emissions). While there are cost effective options to considerably reduce emissions from waste, that are already being implemented in other countries, agriculture is a more challenging sector, and emission cannot be reduced to zero.

Remaining emissions will have to be compensated by negative emissions from the land-use sector.
It is also important to look at how Western Australia will contribute to negative emissions beyond reaching net zero, consistent with the Paris Agreement.

The carbon budget derived in this report for energy and industry is focused on the budget up to the point in time of net zero emissions. While this study aims at providing guidance on a budget that would limit the need for negative emissions, this does not mean that the need for negative emissions after achieving net zero emissions can be ignored. The timing, scale and opportunities for net negative emissions needs to also be analysed in the Western Australian context in future work. The need for negative emission technologies and their deployment on a sustainable basis would need to be considered for the energy system transformation and land-use sector strategies in Western Australia, and is beyond the scope of this study. However, by developing sector specific mitigation pathways, we are providing a benchmark pathway for overall greenhouse gas emissions in Western Australia.

Agriculture Sector

The agriculture sector is responsible for 10% of emissions in WA (Figure 2) and the sector's emissions have been on an upward trajectory since 2008 (DEE 2019). Agriculture is a sector that is highly vulnerable to climate change, especially, temperature changes, hot spells, frost, rainfall intensity, drought and water supply, cyclones, and fire risk (Dept. Primary Industries and Regional Development 2019a). Despite these risks, there is not a state specific climate policy under the list of current initiatives on the WA Department of Primary Industries and Regional Development website (Dept. Primary Industries and Regional Development 2019b). There is also a lack of specific mitigation analysis and scenarios, with national scenarios published in the past focusing on offsetting emissions from agriculture with sequestration in forests.

Emissions from agriculture cover emissions from enteric fermentation, manure management, manure applied to soils and left on pasture, rice cultivation, and other land-related emissions from synthetic fertilisers, crop residues and cultivation of organic soils. Thus, here we do not cover emissions from electricity use or fuel combustion from operating equipment, which are included in the energy-related emissions covered in pervious subsections. The bulk of agriculture greenhouse gas emissions we cover in this part are methane and nitrous oxide.

To derive the projections of non-energy emissions from the Agriculture sector for the "Paris Agreement Compatible Scenarios", we applied the growth rate of non-CO_2 emissions from the agriculture sector for the OECD region over 2016-2050 based on the 1.5°C pathways assessed in the Special Report on Global Warming of 1.5°C by the Intergovernmental Panel on Climate Change (IPCC 2018a). The subset of scenarios excludes those that exceed the sustainability limits for carbon-dioxide removal options identified in the SR 1.5 and the underlying literature. The higher ambition level of the "Paris Agreement Compatible Scenarios" is based on the most ambitious end of the ranges given by the selected scenarios from IPCC (2018a), projecting an annual average rate of -1.9 % p.a. reduction of non-CO_2 emissions from agriculture sector in the OECD region over 2016-2050.

Applied to Western Australia, this implies a potential reduction by 43% in 2030 and 56% in 2050 compared to 2005.

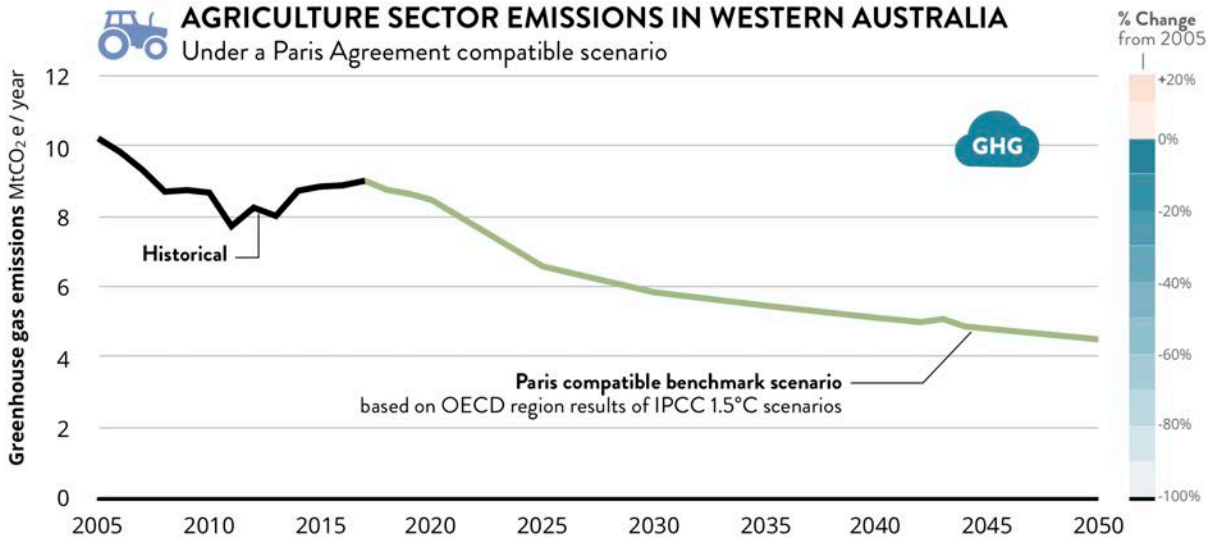

Figure 21: Western Australia Paris Agreement benchmark scenario for the agriculture sector, based on OECD region resutls of global scenarios analysed by the IPCC that are consistent with the Paris Agreement Temperature goal. See text for details. Emissions are reduced by about half towards the end of the century.

In the underlying scenarios, key mitigation options are enhanced agricultural management (e.g. manure management, improved livestock feeding practices, and more efficient fertiliser use), as well as demand side measures such as dietary shifts to healthier, more sustainable, low-meat diets and measures to reduce food waste. The underlying scenarios do not, however, offer a complete assessment of mitigation options and do not generally cover e.g. large-scale replacement of meat by plant-based proteins and cultured meat, novel technologies such as methanogen inhibitors and vaccines, nor synthetic and biological nitrification inhibitors (see IPCC 2018a).

There are no national scenarios published that lead to reductions in emissions from agriculture. The Deep Decarbonisation Pathway Scenario (ClimateWorks Australia 2014) leads to an increase in emissions by 2050 by 20%. A recently published study (FABLE Consortium 2019) also assumes agriculture emissions to stay at a level of 80 Mt CO2eq in 2050.

Waste Sector

The waste sector accounts for 2% of the state's emissions (Figure 2) and the emissions in the waste sector have increased 5% since 2005 (DEE 2019). Western Australian had the highest rates of waste kilograms per capita compared to Australia's other states and territories (all waste excluding fly ash) (Waste Authority WA 2019). In the same year, WA had the second to highest rates in amount of waste to landfill, and came joint second to worst for lowest rate of resource recovery (at 48%) (Waste Authority WA 2019). The state government has a target of 75% of waste generated in WA to be reused or recycled by 2030, through the State Waste Strategy (WA Government 2019a; Waste Authority WA 2019).

Emissions from waste are primarily due to the release of landfill gas from anaerobic decomposition of waste material in landfills as well as due to waste water treatment. These would mainly include methane and nitrous oxide emissions. To derive the projections of emissions from waste sector for the Paris Agreement Compatible Benchmark Scenario, similar to the agriculture sector, we applied annualized growth rates for the OECD region over 2018-2050 based on the regional pathways assessed in the Special Report on Global Warming of 1.5°C by the Intergovernmental Panel on Climate Change (IPCC 2018b). Under the '1.5°C Paris Agreement compatible' pathway, the emissions from waste sector shows a reduction by 69% in 2030 and about 77% in 2050. Mitigation in the waste sector has been identified as highly cost effective and could even return a net profit (IPCC 2018b).

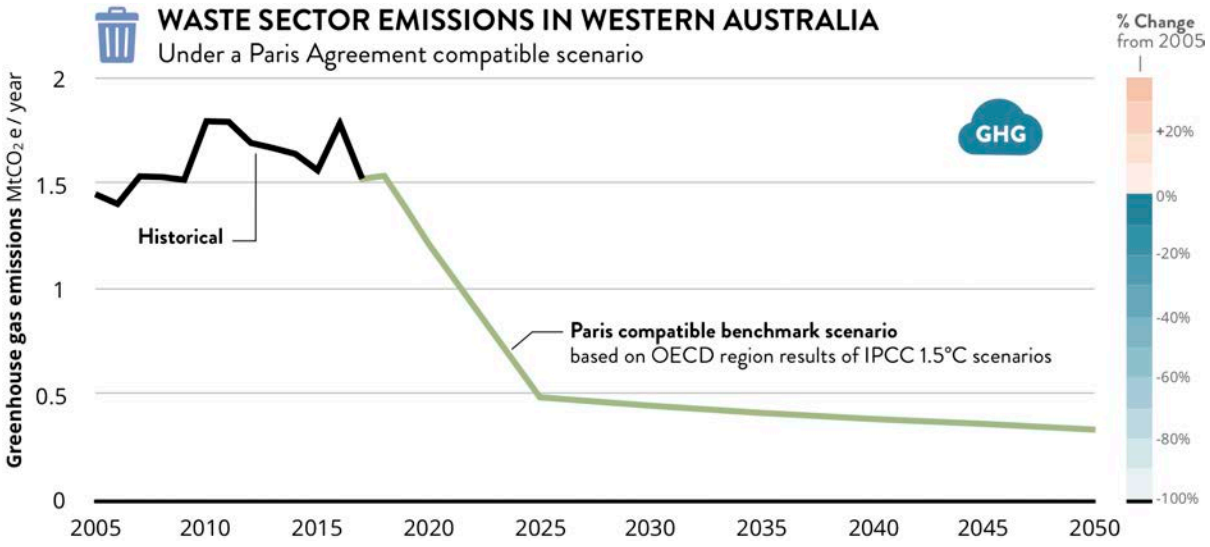

Figure 22: WA Waste Emissions PA Scenario $MtCO_2e$ (historical data 1990 to 2017, from AGEIS). The PA benchmark scenario is based on the results for the OECD region of a PA 1.5 scenario assessed by the IPCC.

Western Australia would need to reduce organic waste levels, creating a smaller task in also diverting the rest of organic waste from landfill. Current organic material in landfill areas will continue to emit GHG emissions until fully decomposed, making it imperative to begin plans to divert all organic matter. Western Australia's waste policy needs to be more ambitious and focus on organic material waste, with specific emissions targets for an emissions reduction pathway for this sector. Local government policy needs to align with state level policy and targets to tackle waste at the source.

LULUCF Sector

The land use, land use change and forestry (LULUCF) sector has a history of high fluctuations in emissions in WA. The LULUCF has transitioned between being an emissions source to an emissions sink in 1999, back to an emissions source in 2003, and then an emissions sink from 2011 to current (AGEIS 2019). The WA government plans to create five million hectares of new national, parks, marine parks, and other conservation reserves, which converts to a 20% increase in the WA conservation estate (WA Government n.d.). The plan is under development and the WA government is in consultation with stakeholders such as local governments, conservation groups and Traditional Owners (WA Government n.d.).

It is beyond the scope of this study to examine scenarios for land use, land use change and forestry however to enable a total greenhouse gas pathway for Australia it is important to make some simple stylised assumptions about the likely future trajectory of the carbon sink in this sector. In recent years the LULUCF sector has become a significant sink, storing carbon in forests, vegetation and soils. A number of projections indicate that the recent sink will reduce gradually over the next decade without substantial incentives to maintain and increase it. In this scenario we assume that the vegetation deforestation essentially stops by 2025, and that the non-CO_2 GHG emissions from the LULUCF sector decline slowly consistent with recent trends. Absent a detailed assessment we have assumed that the sink would reduce following the December 2018 Federal Government projections (Department of the Environment and Energy 2018) so that by 2030 it is about 30 percent below 2017 levels. For the purpose of this stylised scenario we maintain the sink at a constant level after that time until 2050.

A CSIRO assessment of potential for land sector carbon sequestration by Bryan et al (2015) indicated substantial potential for additional storage of carbon from a variety of different activities in agricultural land in Australia. Whilst the results were not specifically reported for Western Australia, this region was modelled, and a number of conclusions are relevant.

Firstly, policies that focus on carbon storage alone do not generate significant benefits for biodiversity, and policies that favour environment and biodiversity values will result in lower levels of carbon storage. Secondly, even with large incentives, the inertia in agricultural systems and in the terrestrial biosphere means that there will be low amounts of additional carbon storage by 2030. Thirdly there is a significant trade-off between a focus on carbon uptake and water values, with a high focus on carbon reducing available water significantly.

These factors indicate a significant research need to evaluate trade-offs and ensure that a focus on carbon storage does not lead to unintended consequences for the agricultural economy, biodiversity water and other environmental values. Figure 24 shows the relative scale of the increase land sink required to offset ongoing LNG sector emissions if there is no abatement at source.

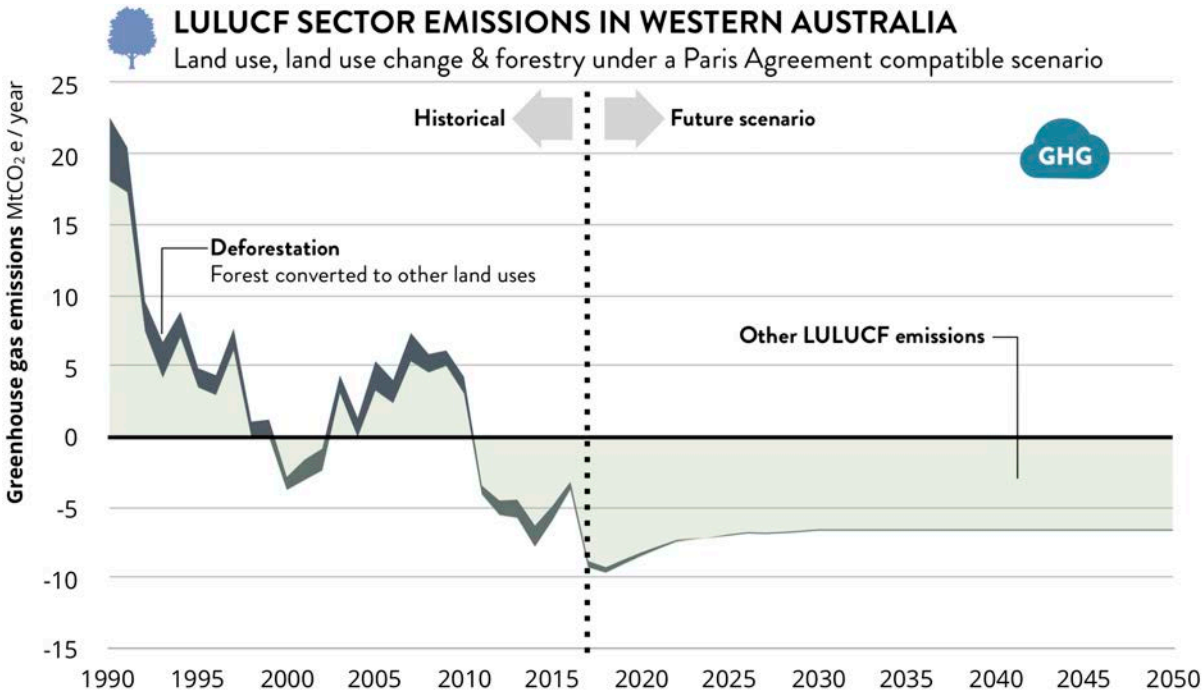

Figure 23 This figure shows the historical trajectory of land use, land use change and forestry (LULUCF) drawn from the June 2019 "State and Territory Greenhouse Gas Inventories 2017" for total LULUCF for all greenhouse gases (mainly carbon dioxide) and deforestation (defined as Forest converted to other land uses). A stylised scenario for the future development of the sector is shown assuming deforestation ending by 2025 and the recent uptake of CO_2 due to afforestation reforestation and other processes gradually reduces without further policies, essentially following the relative pathway from the December 2018 national greenhouse gas projections for the Australia wide LULUCF sink, maintained at 2030 levels until 2050.

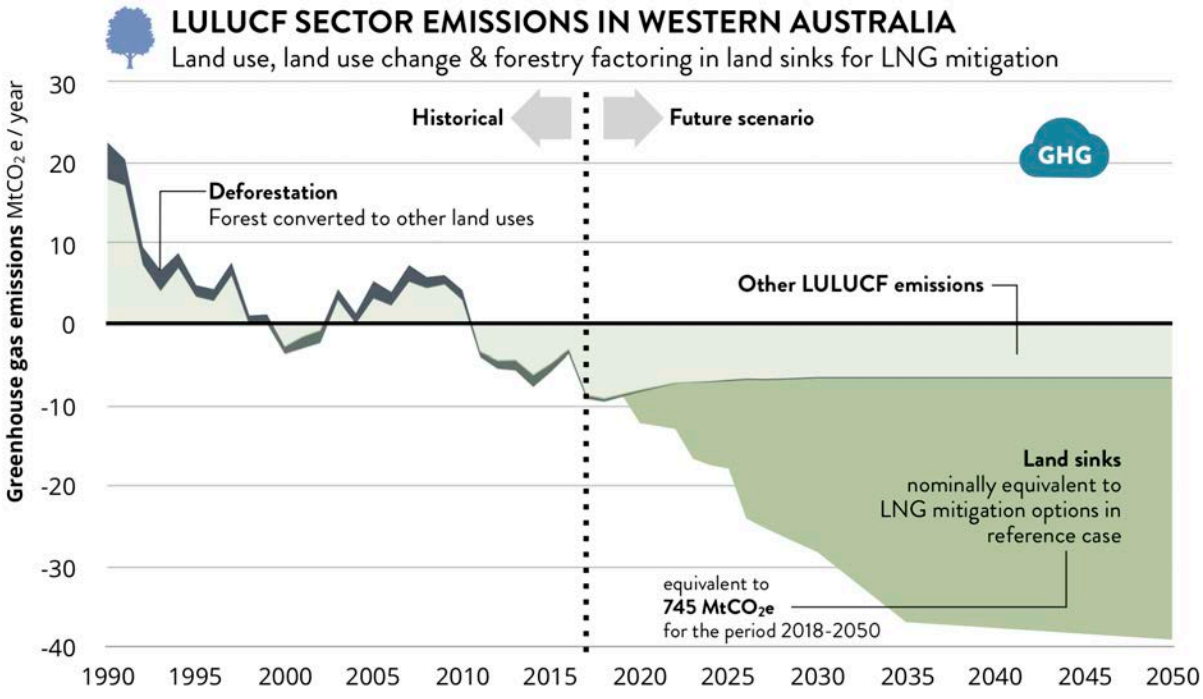

Figure 24 As in Figure 23 but showing the additional annual land sink nominally equivalent to the LNG mitigation options in reference case and shown in Table 6 and which total around 745 $MtCO_2e$ for the period 2018-2015.

Overall pathway

Figure 25 shows the overall greenhouse gas emissions in the Paris Agreement Benchmark Pathway for Western Australia. The only remaining emissions in 2050 would be from the agriculture and waste sector. They would need to be compensated with negative emissions from the Land-use sector.

GHG emissions would need to peak as soon as possible and then reduced steeply, **overall by 49% in 2030 compared to 2005 (35% without LULUCF)**. This is a much stronger reduction than the national federal target and confirms the inadequacy of that target and of assuming it as a benchmark for Western Australia. It is within albeit at the lower end of the range estimated for a domestic federal emissions reduction target for 2030 in line with the Paris Agreement.

This pathway achieves net zero emissions around 2050, if the size of the sink in the Land-use sector is maintained at high levels. Not shown is the pathway after 2050, where emissions would need to continue to be negative, leading to a net uptake of CO_2.

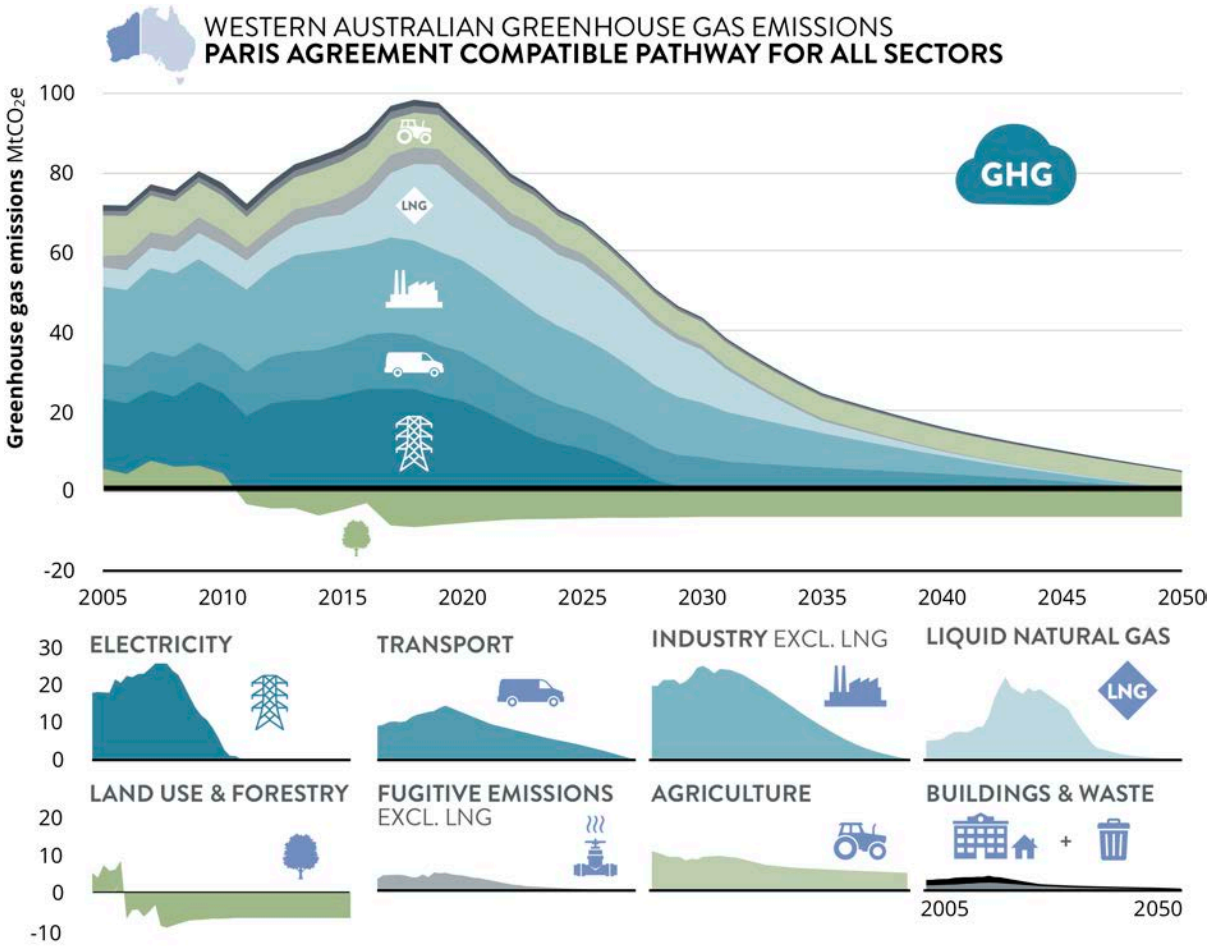

Figure 25 GHG emissions pathway for each of the sectors following transformation consistent with the Paris Agreement in each of those sectors. Total GHG emissions peak around 2020 and decline to about 63% below 2005 levels in 2030, reaching net zero in the 2040s contingent upon maintaining the recent large sink in the LULUCF sector.

CONCLUSIONS AND OUTLOOK

Policy Implications

This analysis has produced an energy and industry Paris Agreement compatible carbon budget for Western Australia that is consistent with the global carbon budget and the necessary global and national energy transformation across different regions required to limit warming to 1.5°C.

It shows how the **Western Australia carbon budget relates to the global carbon budget** and also provides information on the **emissions pathway** by which the budget needs to be met in order to ensure the Paris Agreement goal to limit warming to 1.5°C does not get out of reach.

It shows how this needs to be complemented with reductions in the **sectors outside of energy** and industry, in particular agriculture and waste, and the **role of land use and forestry to compensate** for **remaining emissions in particular from agriculture** that cannot be fully decarbonised.

It confirms the importance of **fast reductions in the short and medium term**, and the key strategy to decarbonise the power sector by a fast transition to renewable energy, taking advantage of the **vast potentials and low and falling costs of renewable energy and storage technologies** and the opportunities for a range of sectors.

Key conclusions for climate policy in Western Australia:

- Need to develop a **whole of the economy roadmap and strategy** and **detailed sectoral roadmaps and strategies** in line with Paris Agreement. This strategy needs to be based on the Paris Agreement Long Term Temperature goal and the importance of **limiting warming to 1.5°C** and the urgent need to **peak emissions and reduce them by 2030**.
- Such strategies and roadmaps need to be based on **robust scenarios and analysis**, that should be developed in a process with **broad participation of all stakeholders** – industry and trade unions, civil society, regional and local governments.
- It is **dangerous to focus only on an endpoint of net zero emissions by 2050.** The pathway there matters – both in terms of the cumulative emissions and their impact on temperature, as well as in terms of the technical and economic transition pathways and policy implications for the near future.
- **Energy and industry** are the **key sectors** that need to be addressed for full decarbonisation.
- The overall and sectoral strategies and roadmaps need to take into account the critical role of **electricity generation transitioning to renewable energy and fully decarbonised by the 2030s,** to contribute to the decarbonisation of end use sectors through direct or indirect electrification.
- Such a strategy involves a large increase in electricity demand and therefore a **massive ramping up renewable energy capacity – solar and wind** - that takes this into account and needs to be factored in when planning the transition of electricity generation, with clear targets and management of grid development and market regulation, as well as infrastructure for microgrids and off grid solutions.
- This strategy of "**sector coupling**" not only helps other sectors such as transport and industry reduce emissions and decarbonise, but also helps providing stability of the grid with variable renewable energy – wind and solar - through battery or other storage and demand side management.

- Sectoral strategies and roadmaps need to lead to the development of clear mid-term **sectoral targets** that are consistent with a Paris Agreement sectoral pathway, such as targets for expansion of renewable energy capacity that take sector coupling into account, and targets for electrification of transport and a shift to public transport and more cycling and walking, as well as targets for efficiency and shift to zero emissions fuels in industry, as well as a target to stop deforestation and develop and secure biological sinks while preserving biodiversity, taking into account climate change.
- In addition to roadmaps and targets, sectoral strategies need to include necessary near term transformational **policies to create incentives and develop the necessary infrastructure** to allow for a timely transition, such as charging stations for electric vehicles or hydrogen fuel cell trucks, or expanded public transport. This can also include **state-level legislation** to ensure sectoral targets are met despite the lack of action at federal level.
- **Every sector will have to contribute** to reducing emissions, and **linking it to other objectives** such as reduced air pollution, protection of biodiversity, sustainable economic development and high quality employment including in regional Western Australia.
- It is important to **address open research questions** in a targeted approach, and ensuring knowledge is developed and shared broadly with stakeholders. This is important for example for the **role of the land-use sector** and how it can contribute to uptake of CO_2 and **negative emissions** either through the sustainable use of biomass and carbon capture and storage or through enhancing and sustaining sinks in forests and ecosystems.

Western Australia has unique opportunities to develop its own vision and strategy and reap benefits of being a global leader in implementing the Paris Agreement, independent of the current failure at the federal level: with its own independent energy system, unique opportunities, prime renewable energy but also minerals resources, it has the opportunity to develop new manufacturing industries with added value and employment creation and moving away from being an exporter of carbon to becoming an exporter of zero emissions energy carriers (green hydrogen, ammonia, or electricity to neighbouring South East Asian countries) and products.

ANNEX I: METHODOLOGY AND MODELLING APPROACH

We have used as the starting point for developing the 1.5°C compatible energy and industry pathway for Western Australia global and regional data from the "Beyond 2°C Scenario" (B2DS) in the "Energy Technology Perspective" (ETP 2017) report of the International Energy Agency (IEA 2017). The ETP model enables a technology-rich, bottom-up analysis of the global energy system. We recently analysed the B2DS and this analysis (Climate Action Tracker 2018b) is reproduced in the next paragraphs.

The IEA (2017) estimated that the B2DS pathway has a peak global warming of 1.75°C above pre-industrial with a 50% likelihood meaning that its warming exceeds that of a 1.5°C compatible scenario. In its estimation of the peak warming level associated with the B2DS scenario, the IEA assumed that non-CO2 GHG would add about 0.35°C to the CO2-only warming. We however have evaluated the IEA B2DS pathway applying the same climate model approach to warming levels as was used in the IPCC Special Report on 1.5°C and earlier IPCC Fifth Assessment Report, enabling a comparison of "like with like" with the IPCC 1.5°C compatible scenario set. As the IEA provides only energy-related CO2 emissions, land-use and non-CO2 GHG emissions need to be estimated. When we assume comparable non-CO2 GHG emissions pathways to the ones analysed by the IPCC, and allow for negative emissions also comparable to the IPCC 1.5 pathways, we find that the B2DS scenario until 2050 is a close analogue climatically to the more recent 1.5°C compatible pathways.

There are however significant caveats, some related to the limitations of downscaling (see below) and others to the faster than expected cost reductions in key technologies for decarbonisation in particular renewable energy, storage (battery and pumped storage), electric vehicles and renewable hydrogen.

Since the IEA (and in general scenarios in the scientific literature) does not provide scenario data at sub-national state levels, nor at national level for Australia, in this report we first downscale the results of the B2DS scenario for the OECD region to Queensland, by using a model-based approach: SIAMESE (Simplified Integrated Assessment Model with Energy System Emulator) (Sferra et al. 2019).

SIAMESE is a reduced complexity IAM (Integrated Assessment Model), which provides cost-optimal emission pathways at the country, or state level, taking into account the complex interactions between economic growth, energy consumption and carbon emissions. While downscaling the energy-sector results from a given model (e.g. the IEA/ETP 2017), SIAMESE takes into account a coherent set of assumptions in line with a "middle of the road" socio-economic storyline (Dellink et al. 2017; Fricko et al. 2017). This storyline relies on a continuation of historical trends regarding technological developments and GDP growth at the country (or state) level. At the same time, SIAMESE has a cost optimisation perspective when allocating how much a country or a region would need to contribute to global emissions reductions in line with the Paris Agreement long term goal.

The SIAMESE downscaling approach can be applied to the overall economy (e.g. scaling down the overall primary energy consumption and emissions), or to individual sectors (e.g. transport, power and others). SIAMESE takes as input the original IEA B2DS (pathways for the OECD region, which start in 2014 in this scenario) and the observed energy consumption and emissions data for Western Australia. Based on the SIAMESE simulation we calculate the B2DS compatible carbon budget for Western Australia' transport and building sectors as the cumulative emissions remaining from 2018 to 2050 considering historical emissions until 2017.

Limitations of the downscaling are embedded in the driving scenario, which in this case is weak in several areas including decarbonization in industry, electrification of transport, and costs of renewable hydrogen as an energy carrier. We therefore use the SIAMESE simulation and estimate of a B2DS compatible carbon budget as an initial estimate which provides an upper bound on the carbon budget

for the transport and building sector to evaluate against the Paris Agreement benchmark of achieving zero CO2 emissions by around 2050 for developed economies. These leads to Paris Agreement benchmark budgets for transport and building sectors, as well as fuel mix and demand estimates, in particular electricity demand. Given electrification is an important strategy for decarbonisation of transport and building sectors, the paris Agreement benchmark pathways for these sectors imply an increased electricity demand.

To determine the pathway and carbon budget for the electricity sector, given its important role for decarbonising end use sectors, but also to make sure it is consistent with global cost-optimal mitigation pathways consistent with the Paris Agreement temperature goal.

We compare the IEA B2DS results for the OECD region with the 1.5°C pathways assessed in the Special Report on Global Warming of 1.5°C by the Intergovernmental panel on Climate Change (IPCC SR 1.5, 2019). These pathways lead to peak warming to at most 1.6°C and subsequently return warming to below 1.5°C by 2100 with at least 50% probability. The subset of scenarios we consider here excludes those that exceed the sustainability limits for carbon-dioxide removal options identified in the literature. Fuss et al. (2018) identify a sustainability limit of 0-3.6 GtCO2 (removal)/yr for Agriculture, Forestry and Other Land Use (AFOLU), and 0.1 – 5 GtCO2/yr for Bioenergy with Carbon Capture and Storage (BECCS) in 2050, as also reflected in the IPCC SR1.5. We apply these limits to the average of each of the corresponding pathway values between 2040-2060 to filter out pathways which exceed them. The cumulative CO2 emissions from the electricity sector in OECD of the IEA ETP B2DS scenario over its time horizon (2014-2060) are on the high side compared to the range of the IPCC 1.5 scenarios (applying the 25th to 75th percentile range, as is commonly used in IPCC SR1.5, i.e. the range covers half of the pathways, while a quarter of pathways has cumulative emissions below this range, and the final quarter of pathways lie above this range). Staying on the more ambitious end of the range of CO2 budgets would minimise the amount of negative emissions needed for Paris Agreement compatibility over the second half of the century. The lower end of the range of IPCC SR1.5 pathways assessed here exceeds the cumulative CO2 emissions from IEA ETP B2DS by about 30%. Detailed assumptions will be published in (Climate Action Tracker 2019 b – AUS SU report).

As the downscaling model SIAMESE does not resolve technologies within either the fossil-fuel or renewable energy sectors, as well as for scenario analysis of the electricity supply sector, we apply the Australian electricity system optimisation model AUSeMOSYS, developed by Climate Analytics based on the current version of the Open Source energy Modelling SYStem (OSeMOSYS). The model provides a cost-optimised energy system pathway to meet the given demand for electricity, and taking into account the limit to cumulative emission derived as described, as well as taking into account increased electricity demand in industry, transport, and buildings from decarbonisation through electrification. The AUSeMOSYS model is multi-regional, dividing Australia into seven regions including New South Wales (NSW), Queensland (QLD), Victoria (VIC), Tasmania (TAS), South Australia (SA), Western Australia (WA), and Northern Territory (NT). The model time horizon covers the period from 2010 until 2050 in 1-year-steps, while each year is split into six time slices. Here we analyse the results for the Western Australia region. For a detailed description of the modelling framework and assumptions we refer to (Climate Action Tracker 2019 b – AUS SU report). Specific assumptions for Western Australia based on available projections for renewable energy uptake are explained in the main text.

Given the importance contribution and very region-specific economic profile of the industry sector in Western Australia, we determine the electricity demand and fuel mix as well as related emissions for the industry sector, by analysing a range of scenarios and literature related to key benchmarks for selected indicators, and applying them to the specific Australian and Western Australia context with the scenarios analysis tool PROSPECTS developed by the Climate Action Tracker consortium (Climate Action Tracker 2019 – Methodology annex), applied for an analysis of scaling up mitigation action

options for Australia (Climate Action Tracker 2019b – Australia scaling up report, forthcoming), and downscaling this to Western Australia specific economic and energy system as well as emissions input data.

Assumptions for other sectors (LNG, agriculture, waste, land-use), not directly modelled, are explained in the main report.

ANNEX II: SCOPE OF EMISSIONS BY SECTOR FROM THE AUSTRALIAN GREENHOUSE EMISSIONS INFORMATION SYSTEM (AGEIS).

Energy and Industry Emissions

Electricity generation emissions are from fuel combustion for public electricity and heat production (AGEIS 1.A.1.a).

Transport sector includes fuel combustion emissions from domestic aviation (AGEIS 1.A.3.a), road transportation (AGEIS 1.A.3.b) (cars, light commercial vehicles, heavy duty trucks and buses, motorcycles, and other), railways (AGEIS 1.a.3.c), domestic navigation (AGEIS 1.A.3.d) (pleasurecraft and domestic marine). It does not include other transportation (AGEIS 1.A.3.e) which is included in the industry sector (consistent with the sector definition in the IEA ETP).

LNG Production includes emissions from fuel combustion for LNG processing (included in AGEIS 1.A1) and emissions from fugitives related to LNG (as a subsector of Industry) (own estimates).

Industry other emissions include:

- Energy industries (AGEIS 1.A.1) minus public electricity and heat production (AGESIS 1.a.1.a). This includes fuel combustion from petroleum refining, manufacture of solid fuels industries (i.e. coal mining, gas production and distribution minus fuel combustion for LNG processing) and other energy industries.
- Manufacturing industries and construction (AGEIS 1.A.2) includes fuel combustion emissions from iron and steel; non-ferrous metals; chemicals pulp, paper and print; food processing, beverages, and tobacco; non-metallic minerals; and other, as well as agriculture, forestry and fisheries energy sector emissions (AGEIS 1.A.4.c).
- Fugitive emissions from fuels (AGEIS 1.B) including from coal mining (underground and surface mines); oil (exploration, crude oil production, transport, refining and storage, and distribution); natural gas (exploration, production, transmission and storage, distribution and other); and venting and flaring. (Fugitives (AGEIS 1.B) data is categorized as confidential on AGESIS. We calculate it here by deducting fuel combustion (AGEIS 1.A.) from energy (AGEIS 1.) and based on own estimates.
- Industrial Processes (AGEIS 2) which includes the mineral, chemical, metal and electronic industries; plus non-energy products from fuels and solvent use; product uses as substitutes for ozone depleting substances, and other.

Building sector emissions include fuel combustion from commercial/ institutional (AGEIS 1.A.4.a) and residential buildings (AGEIS 1.A.4.b).

Other sectors (non-energy and industry related emissions)

Agriculture emissions (AGEIS 3) from enteric fermentation, manure management, rice cultivation, agricultural soils, prescribed burning of savannas, field burning of agricultural residues, liming, urea application and other carbon-containing fertilisers.

Waste emissions (AGEIS 5) include solid waste disposal, biological treatment of solid waste, incineration and open burning of waste, wastewater treatment and discharge, other.

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Climate Analytics is a non-profit climate science and policy institute based in Berlin, Germany with offices in New York, USA, Lomé, Togo and Perth, Australia, which brings together interdisciplinary expertise in the scientific and policy aspects of climate change. Our mission is to synthesise and advance scientific knowledge in the area of climate change and on this basis provide support and capacity building to stakeholders. By linking scientific and policy analysis, we provide state-of-the-art solutions to global and national climate change policy challenges.

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RUNAWAY TRAIN: The impact of WA's LNG industry on meeting our Paris targets and national efforts to tackle climate change

CCWA & Clean State Report: October 2019

Clean State

Conservation Council of Western Australia
ccwa
Look forward

The Conservation Council of WA is proud to present this report as the state's foremost non-profit, non-government conservation organization, representing almost 150,000 supporters and 105 member groups.

CCWA has been an advocate for conservation and a sustainable Western Australia for more than 50 years, working directly with the government, media, industry, community groups, and political parties to promote a more sustainable WA and to protect our natural environment.

We acknowledge that we meet and work on the land of the Nyoongar people. We pay respect to their Elders – past, present, and future – and acknowledge the important role all Aboriginal and Torres Strait Islander people continue to play in advancing a more sustainable Western Australia.

This report is printed on 100% recycled paper.

Contents

Key Findings

This is the first time a report has investigated the full impact of greenhouse gas emissions from WA Liquefied Natural Gas (LNG). It investigates the domestic pollution generated here in WA from mining and export of LNG (scope 1 emissions), and found just two companies, Chevron and Woodside responsible for the overwhelming majority of runaway pollution that places our Paris commitments in jeopardy.

1. WA LNG pollution is breaching the Paris Agreement

LNG production in WA is the fastest growing pollution source in Australia and has been the primary driver of recent national emissions growth.

Australia's international commitment under the Paris Agreement requires pollution to be reduced by 26-28% from the 2005 baseline year. **But current and proposed LNG projects coming online since 2005 will add 41.6 million tonnes of pollution a year, equivalent to a 61% increase on WA's 2005 emissions baseline, and an 8% increase above Australia's 2005 baseline.**

2. Gas is WA's biggest polluter, dwarfing all other pollution sources

The rapid expansion in LNG production in Western Australia in combination with inadequate carbon pollution controls has had a dramatic impact on the state's total emissions: while all other states' emissions are falling, WA's have **risen by 23% since 2005.**

Emissions from current WA LNG facilities make up 36% of WA's total annual emissions. If the proposed Woodside Burrup Hub expansion is approved, opening up the Browse and Scarborough gas fields, emissions from WA's current and proposed LNG facilities will account for 47% of WA's annual emissions.

Carbon pollution from Chevron's Wheatstone and Gorgon projects is almost three times more than WA's Muja power station - WA's oldest and dirtiest coal fired power station.

Pollution from WA's five currently operating LNG facilities is so high that Chevron and Woodside are in the Top 10 list of Australia's highest emitters.

Pollution from WA's current and proposed LNG facilities combined will be as high as the total annual emissions from countries including Ireland, Sweden, Hong Kong and New Zealand.

3. Chevron and Woodside are responsible for most of this pollution and there are no effective controls on their operations

Current controls on carbon pollution from WA LNG projects were found to be completely inadequate. Where conditions have been imposed, they vary, and have either not been met or the license condition has been removed.

4. WA LNG pollution cancels out Australia's national efforts to reduce emissions

Gas vs Emissions Reduction Fund (ERF)

Over the next twelve years, the total cumulative emissions from WA's five current LNG facilities (384Mt) will cancel out the entire amount of abatement expected to be delivered under the ERF (375Mt).

At a total cost of $4.55 billion the ERF is effectively an Australian taxpayer-funded offset program for Chevron and Woodside's operations to 2031.

Gas vs Renewable Energy Target (RET)

Annual carbon pollution from WA's current LNG projects cancels out the entire pollution savings from all of Australia's renewable energy every year.

The Renewable Energy Target (RET) of 20% by 2020 covers every solar panel, large solar farm and all wind power installed in Australia since 2001. It's been described as Australia's largest and most effective carbon abatement policy and is helping us avoid about 26 million tonnes of pollution each year.

Yet the level of pollution from WA LNG is 1.2 times the amount we are saving every year with renewable energy in Australia

Gas vs Rooftop Solar PV

Annual carbon pollution from WA's five LNG plants (32Mt) is almost five times greater than the savings made by every single solar panel across 2.1 million Australian rooftops every year.

20% of Australian homes now have solar on their rooftops, with over 2.1 million solar PV systems installed nationwide. Australia's fleet of solar rooftops are generating about 8.5GWh of electricity which in turn avoids about 6.6 million tonnes of pollution. These savings are dwarfed by the annual emissions from WA LNG.

5. Offsetting LNG pollution in WA would create 4000 jobs

A study commissioned by CCWA investigated the abatement potential and economic benefit to WA of offsetting direct emissions generated by the LNG industry within the state.

It found the potential for 80 million tonnes of emissions offsets per year here in WA. Offsetting 30 million tonnes per year – an amount just short of the total emissions from WA LNG - would create around 4,000 jobs.

These new jobs would include tree plantings, large scale renewable energy, and rangeland regeneration and savannah burning activities, and would also have significant benefits to WA's natural environment.

6. There is no such thing as clean gas

This report looked at the seven most common myths about gas and found:

- Gas is still a fossil fuel and breaks the carbon budget.
- Elevated methane levels negate any 'advantage' over coal.
- A major international review of LNG infrastructure found that the threat to the climate from LNG is 'as large or larger than coal'.
- There is no evidence for Australian gas 'reducing emissions overseas' and the concept of burning more fossil fuels to reduce emissions is perverse
- New gas projects will only lock in another 40-60 years of carbon pollution and are highly risky projects that will risk billions of dollars into stranded assets
- Large-scale, low cost renewables can now displace both coal and gas, and
- Complying with the IPCC and Paris Agreement goals means reducing gas, not increasing it.

Executive Summary

A precedent study

This report presents the first thorough investigation of direct carbon emissions from Western Australia's Liquefied Natural Gas (LNG) industry, revealing alarming growth in pollution that is placing Australia's Paris Agreement targets in jeopardy and undermining Australia's national efforts on climate change.

The scale of pollution

Chevron and Woodside are two of Australia's largest carbon polluters. Five currently operating WA LNG facilities are in the Top 10 list of WA's highest polluters and produce more than double the emissions of WA's three coal-fired power stations. Yet WA Government measures to control and regulate carbon pollution from LNG have been and remain totally ineffective at constraining pollution growth from the sector. Where conditions to control pollution have been imposed on some LNG projects, they are inconsistent, inadequate, unenforceable, and in some cases have been removed altogether.

This report found WA LNG pollution will account for 36% of WA's total emissions and 6% of national emissions at full production. If Woodside's proposed Burrup Hub expansion is approved and the Browse and Scarborough fields are exploited, the WA LNG sector will be responsible for almost half of Western Australia's total pollution (47%) and almost 8% of Australia's annual emissions.

This report also compared emissions from LNG production in WA to other major emissions sources. Factoring in further expansions proposed by Woodside, WA LNG emissions will be more than one quarter (28%) of that from Australia's existing fleet of coal fired power stations, and almost equivalent (96%) to the pollution from every single passenger vehicle in Australia. At full production, WA LNG pollution is comparable to the annual emissions of Ireland, Switzerland, New Zealand and Hong Kong.

The impact on the Paris Agreement targets

A focus of this research has been investigating the impact of emissions from WA LNG projects on our ability to reach the Paris Agreement targets. Under the Paris Treaty, Australia has committed to reducing total national greenhouse gas emissions by 26-28% below its 2005 level by 2030. Immediate action to undertake rapid reductions is specified in the Paris Agreement and all signatory countries have been asked to outline their plans to achieve net zero emissions in 2050.

This report investigated WA LNG projects that have commenced operations since Australia's 2005 Paris baseline year and found current facilities together with proposed expansions will add 41.6Mt CO_2-e pollution every year, which represents a 61% increase relative to WA's 2005 baseline and an 8% increase relative to Australia's 2005 baseline.

This growth in pollution from WA LNG operations since 2005 effectively adds 8% to Australia's current emissions reduction target, increasing it to 33-35% by 2030, forcing all other states and sectors of the economy to compensate for WA's runaway growth in LNG pollution.

This report also found the impact of WA LNG pollution on WA's 'carbon budget'. To achieve the modest target of 26-28% emissions decrease on 2005 levels by 2030, WA's total annual emissions will need to drop to 49Mt - however without any controls, emissions from current and proposed LNG facilities will be 41.6Mt – or 85% of this amount.

These significant increases in WA LNG pollution are found to be in breach of the Paris Agreement and actions necessary to keep global warming within the long-term global temperature goal.

Clean State LNG Report 2019

The impact on national efforts to reduce emissions

WA LNG emissions were also found to be fundamentally undermining Australia's national efforts to tackle carbon pollution. Specifically:

- Just 12 years' of WA LNG emissions will cancel out the entire abatement expected to be delivered by the $4.5 billion Emissions Reductions Fund (ERF)
- Annual WA LNG pollution is 1.2 times greater than the annual carbon savings delivered by all installed renewable energy capacity under the Renewable Energy Target (RET)
- Annual WA LNG emissions are almost five times greater than the annual carbon savings delivered by Australia's 2.1 million solar rooftops.

The danger of the 'clean gas' myth

The report also investigated commonly made claims about gas contributing to global efforts to tackle climate change, through claimed displacement of other dirtier fuels. Such claims were found to be misleading and dangerous. Considered across its entire lifecycle, elevated methane levels as well as emissions from gas production negate any 'advantage' over coal. Gas is a polluting fossil fuel that is competing with renewable energy in global efforts to phase out the use of coal.

A major international review of LNG infrastructure found that the threat to the climate from LNG is 'as large or larger than coal' and the IPCC has said that global gas use must decline, not increase in order to meet global climate targets. New gas projects will lock in another 40-60 years of carbon pollution and are at high risk of becoming stranded assets given that large-scale, low cost renewables and storage can now displace both coal and gas.

The opportunity to control emissions from WA LNG

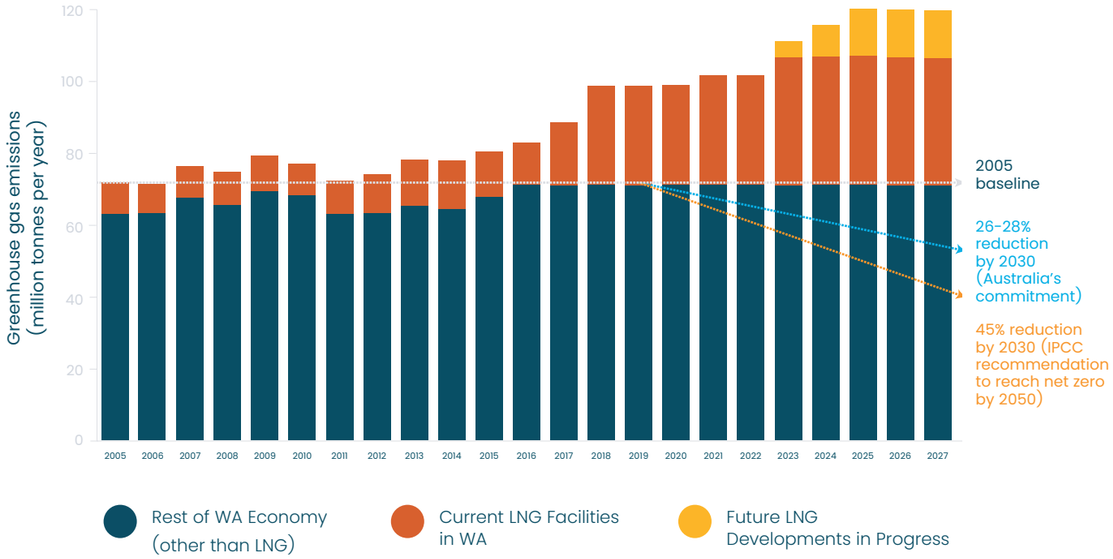
Despite the alarming size and scale of Western Australia's LNG pollution problem, solutions have been proposed that would prevent this pollution burden from being transferred to the Australian community and other businesses. For example, the WA Environmental Protection Authority has recommended that conditions be reinstated and strengthened to require that WA LNG companies offset emissions through investments in activities such as tree planting, carbon farming and renewable energy.

Previous analysis has identified the potential to deliver 80 million tonnes of emissions offsets per year here in Western Australia, and that offsetting current WA LNG emissions would create over 4,000 jobs in the state. These carbon pollution offset activities would not only deliver economic benefits to regional Western Australia, but could also provide significant benefits to WA's natural environment.

The runaway emissions of WA's LNG industry have gone largely unnoticed in Australia's national debate on climate change, but they can no longer be ignored.

This report strengthens the case for immediate action to update Western Australia's policy approach for assessing and controlling pollution by WA's LNG industry.

Figure 1: Trajectory of emissions from WA LNG facilities from 2005, compared with the rest of the economy



1. Introduction

Background and scope of this report

Liquefied Natural Gas (LNG) developments in Western Australia have been identified by the Australian Government as the fastest-growing carbon pollution source in Australia, and the primary driver of recent increases in Australia's overall emissions. However, until now there has been no comprehensive analysis of how much carbon pollution will result from WA's LNG sector, including the impacts of this pollution on state and national efforts to meet Australia's targets under the Paris Agreement.

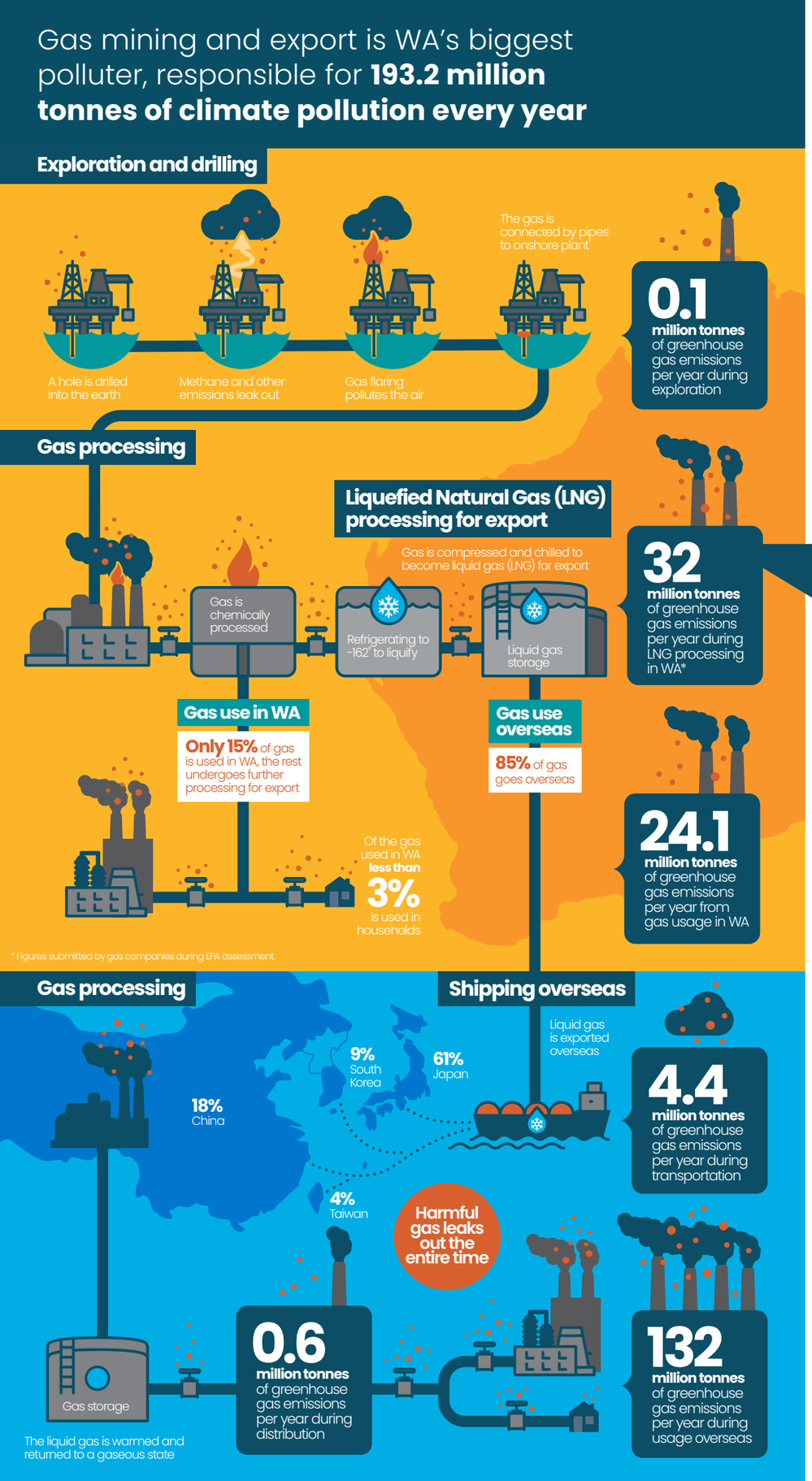
Australia has recently overtaken Qatar as the world's largest net exporter of LNG [1], with the greatest share produced by new facilities in the North West of WA.

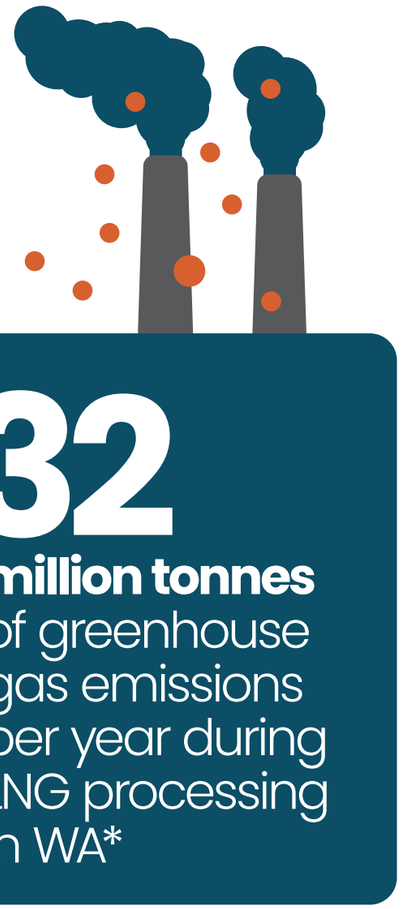
This growth in production is occurring at a time when there is an increasing focus on LNG as a major threat to the global climate. The International Panel on Climate Change (IPCC) has said that near-term reductions in natural gas production will be required to meet international carbon pollution reduction goals. Other climate and energy analysts are calling for a moratorium on LNG development globally. A major international review of LNG infrastructure released in July 2019 found that the threat to the climate from LNG is 'as large or larger than coal'. [2]

Emissions data for WA LNG projects has been notoriously difficult to find due to time lags in reporting and aggregation of data, making it difficult to assess the true impact of greenhouse gas emissions generated by WA LNG facilities.

Data collected in this report

The data used in this report is direct emissions data sourced from the LNG industry itself. Figures are quoted from public documents released by LNG companies as part of the Environmental Impact Assessment from each of these projects. It is likely that these figures are significant underestimates of the true pollution from these facilities, as the gas industry consistently relies on highly conservative estimates of fugitive emissions (methane), which can have a very significant impact on overall pollution. No real-time monitoring data for fugitive emissions from WA LNG production is available.





* This figure is the direct emissions for five currently operating WA LNG facilities at full production and is the focus of this report.

Sources of pollution in the LNG production process

In 2018 CCWA investigated the impact of the full life cycle emissions (direct + indirect) of the WA LNG industry and found gas mining and export responsible for 193.2 million tonnes of climate pollution every year.

The production of LNG is extremely energy intensive and is one of the most polluting forms of energy production. Both direct (scope 1) and indirect (scope 3) carbon pollution results from the LNG production process.

Direct carbon pollution results from almost every stage in the in the LNG production system, including:

- energy used to process the gas;
- venting large volumes of 'reservoir gas' or CO2 occurring naturally in the gas reservoirs;
- fugitive methane emissions at all stages in production;
- flaring; and
- energy used to extract and pump the gas to processing facilities.

Indirect carbon pollution resulting from transporting and burning the LNG overseas is much greater than the direct pollution.

For the purposes of this study indirect emissions have not been included as they are not accounted for in Australia and are not included in the Paris targets. However, the impact of the full lifecycle emissions of WA's LNG industry on global emissions will be the subject of future investigation by CCWA.

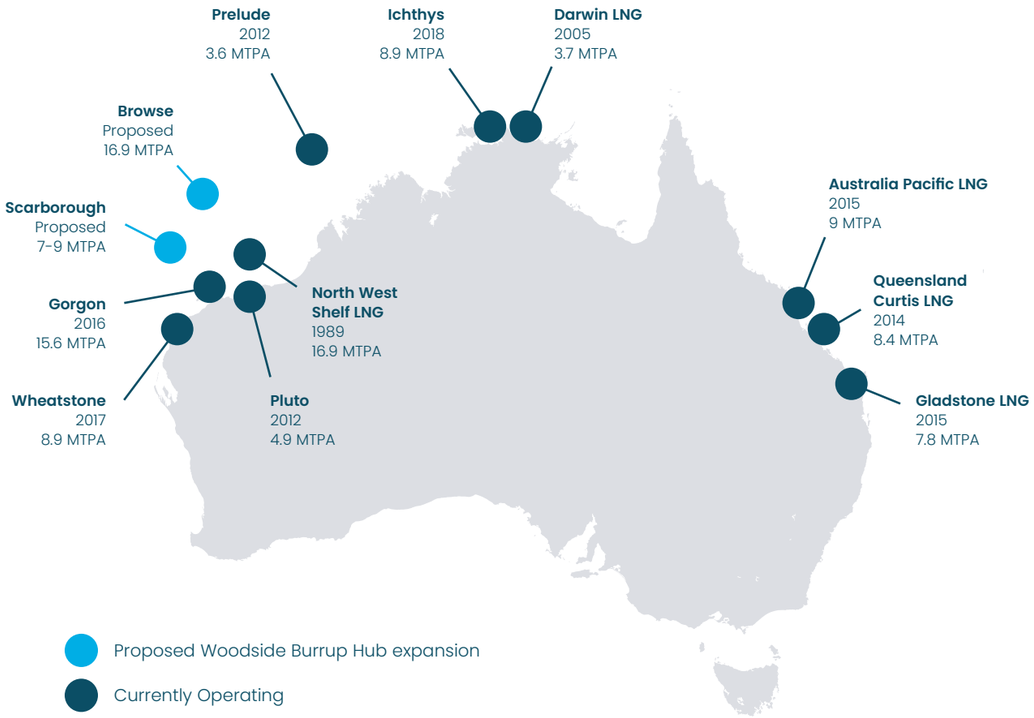
This study also examines, for the first time, the impact of the proposed expansion to the Burrup Hub. The Burrup Hub and its cumulative impact on emissions is the subject of a separate Clean State/CCWA briefing paper.

2. Overview of WA's LNG industry

In recent years, Western Australia has been at the epicenter of a dramatic expansion in Liquefied Natural Gas (LNG) production capacity. Over half of this production capacity has come online in just the last three years.

Of the ten currently operating LNG facilities in Australia, five very large plants are located off Western Australia's North West coast (Figure 2) and account for 56% of the total Australian LNG capacity. Three LNG facilities are located onshore on the Pilbara coast, one on Barrow Island, and one is a floating facility (the largest floating LNG plant in the world). Further expansion is proposed with the development of the Browse Basin and Scarborough gas fields as part of Woodside's Burrup Hub expansion.

Figure 2: Australian LNG Projects and annual capacity - current and proposed



WA's LNG industry – current and proposed facilities

A summary of currently operating and proposed LNG plants, their capacity and GHG emissions are shown in the table below. **Note full references have been provided in a more detailed version of this table at the Appendix.**

Table 1: Currently operating and proposed LNG facilities in WA

	Project	Operator	Start	End date	Production capacity (Mt)	GHG emissions per year (MtCO2-e)
Current	North West Shelf	Woodside joint venture (JV) inc. BHP, BP, Chevron, Japan Australia LNG, Shell	1989	Mid 2020s	16.9	**7.6**
	Pluto	Woodside JV inc. Kansai Electric, Tokyo Gas	2012	40 years	4.9	**2**
	Gorgon	Chevron JV inc. ExxonMobil, Shell, Osaka Gas, Tokyo Gas, JERA	2016	50 years	15.6	**9.74***
	Wheatstone	Chevron JV inc. KUFPEC, Woodside, Kyushu Electric, JERA	2018	30 years	8.9	**10**
	Prelude	Shell JV inc. Inpex, CPC, KOGAS	2018	25 years	3.6	**2.3-2.7**
Proposed Burrup Hub expansion#	Browse Basin	Woodside JV inc. Shell, BP, Japan Australia LNG, PetroChina)	2026	2070	16.9	**14.6**
	Scarborough	Woodside/BHP	2023	2055	12	**2.6**

* Chevron announced commencement of its geosequestration project on 8th August 2019 with the target to capture 80% of its reservoir gas, bringing emissions down to 5.1-6Mt with CCS. Given the technology is unproven and the condition is not enforceable — and considering the time it will take to sequester a significant amount of carbon pollution — we have not included the claimed emission reduction as part of this report.

The Burrup Hub and proposed expansion is the subject of a separate Clean State/CCWA briefing paper.

WA LNG project size

The charts below show how the projects compare to each other in terms of their total emissions. They show:

- For current projects, Chevron's Gorgon and Wheatstone projects account for more than half of all WA LNG emissions.
- For all projects (proposed and combined), Woodside's Burrup Hub complex will dwarf all others and be one of the most emissions intensive projects in Australia.

Figure 3:
Current WA LNG

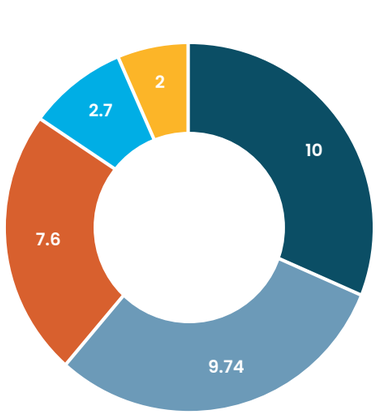
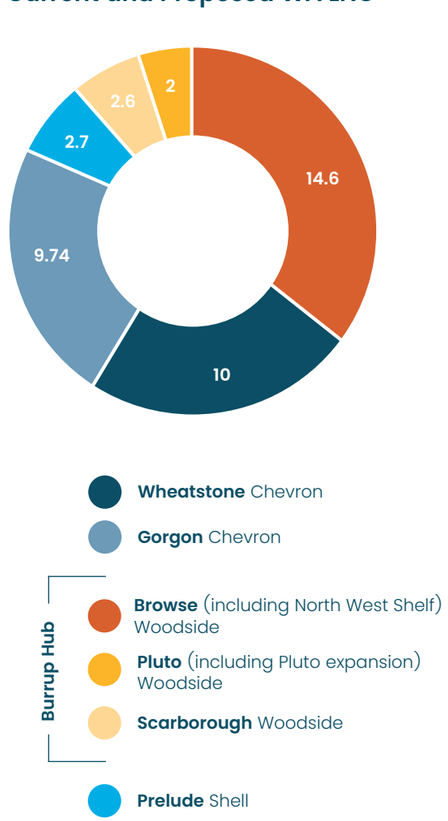


Figure 4:
Current and Proposed WA LNG



Emissions by operator

The following charts show the proportion of emissions generated by different operators. It shows Chevron is by far the biggest polluter, accounting for more than 60% of all LNG pollution in WA.

If the proposed Browse Burrup Hub expansion is allowed, Woodside will account for 46% of all WA LNG pollution in WA.

Figure 5: Share of current WA LNG emissions by operator.

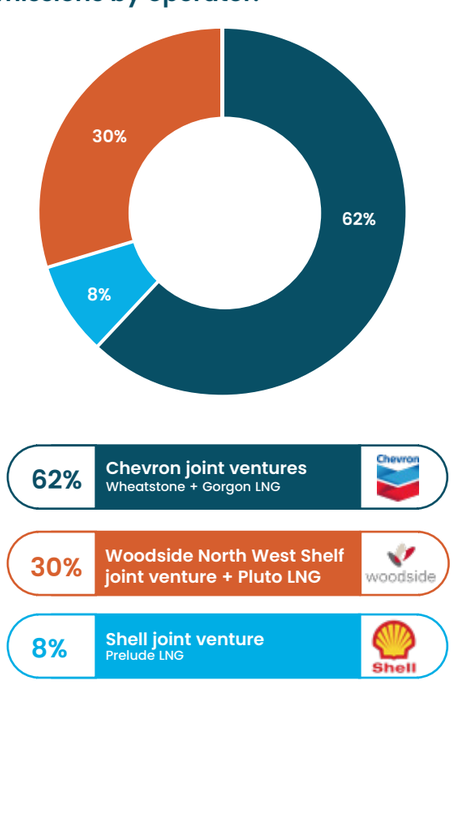
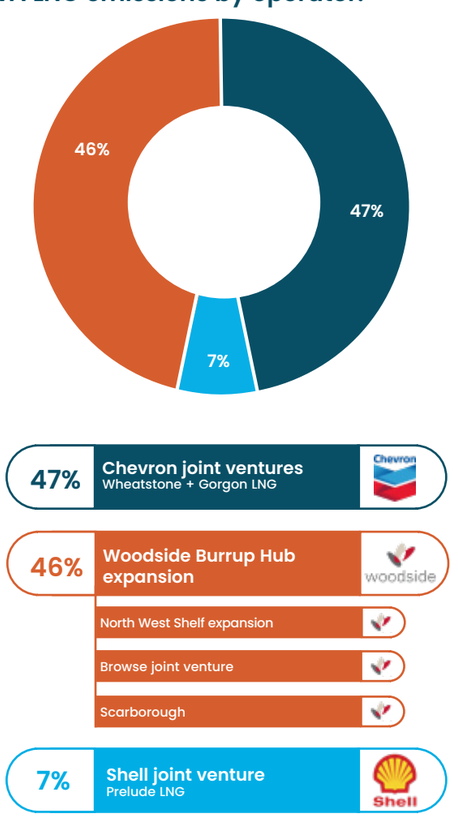


Figure 6: Share of current and proposed WA LNG emissions by operator.



Australia's biggest polluters

Chevron and Woodside are in the Top 10 list of Australia's highest emitters[3], and are the only entities in that list that aren't from the electricity sector (Table 2). Just ten companies are responsible for over half of Australia's direct greenhouse gas emissions. And just two companies — Chevron and Woodside — are responsible for 14% of Australia's scope 1 emissions (and growing).

Table 2: Australia's 10 highest greenhouse gas emitters scope 1

(Source: Clean Energy Regulator 2019)

AGL Energy	43.1 million tonnes
Energy Australia Holdings	21.7 million tonnes
Stanwell Corporation	17.4 million tonnes
Origin Energy Ltd	17.2 million tonnes
CS Energy Ltd	14.7 million tonnes
Chevron Australia	12.0 million tonnes
Pioneer Sail Holdings	11.3 million tonnes
OzGen Holdings Australia	11.0 million tonnes
Woodside Petroleum Ltd	10 million tonnes
NRG Victoria Pty Ltd	8.5 million tonnes
	152.2 million tonnes (50.2% scope 1 emissions reported)

Key finding

Just two companies — Chevron and Woodside — are responsible for 14% of Australia's scope 1 emissions (and growing).

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Western Australia's biggest polluters

All five currently operating WA LNG facilities are in the Top 10 list of WA's highest emitters (Table 3). In fact they're in the first, second, third, seventh and eighth position. **The table shows 70% of pollution from WA's 10 biggest emitters is from LNG.**

Emissions from Chevron's Wheatstone and Gorgon projects are three times larger than WA's biggest coal fired power station (Figure 7–9).

Table 3: WA's 10 highest carbon polluters

Facility name	Operator	Emissions*
Wheatstone Operations	Chevron	10 million tonnes
Gorgon Operations	Chevron	9.74 million tonnes
North West Shelf Project	Woodside	7.65 million tonnes
Muja Power Station (black coal)	Synergy	3.98 million tonnes
Worsley Alumina Refinery/mine	South32	3.58 million tonnes
Bluewaters Power 1&2 (black coal)	Synergy	2.96 million tonnes
Prelude LNG	Shell	2.7 million tonnes
Pluto LNG	Woodside Burrup	1.93 million tonnes
Collie Power station (black coal)	Synergy	1.85 million tonnes
YPF Ammonia Plant	Yara Pilbara Fertilizers	1.51 million tonnes
		Total: 45.9 million tonnes
		Total LNG: 32 million tonnes (70% of total)

Source: Emissions for all non-LNG facilities were for 2017-18 from the Clean Energy Regulator (May 2019) and CCWA data[4]. Emissions for all LNG facilities use emissions anticipated at full production.

Figure 7: Share of pollution from WA's 10 biggest emitters

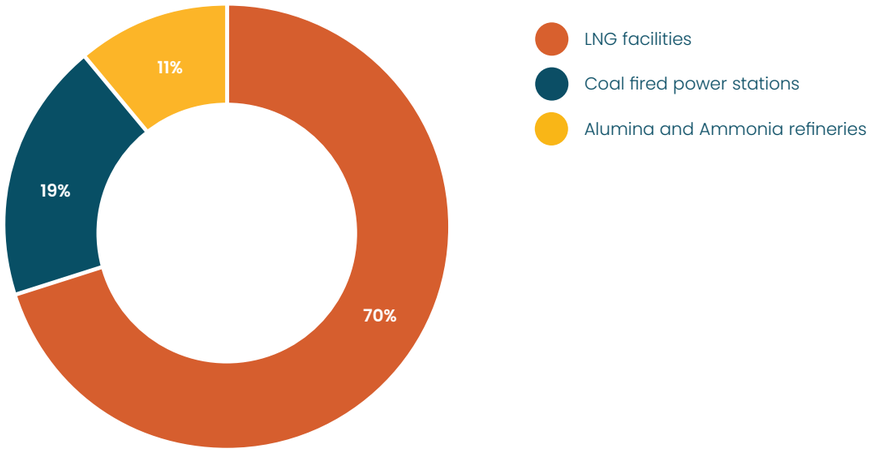
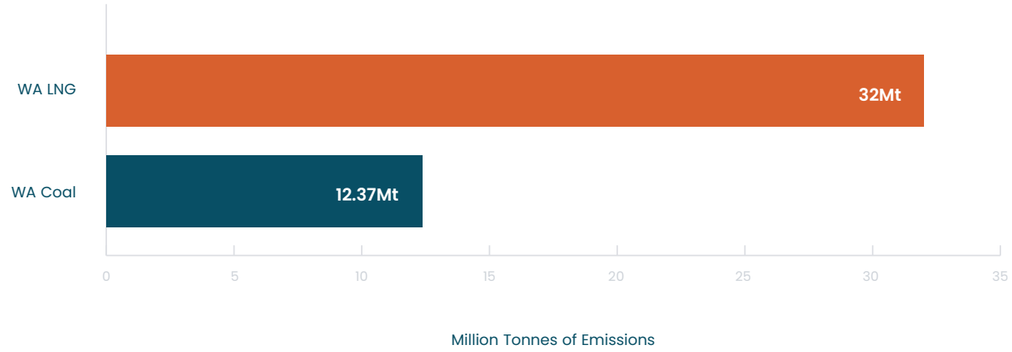


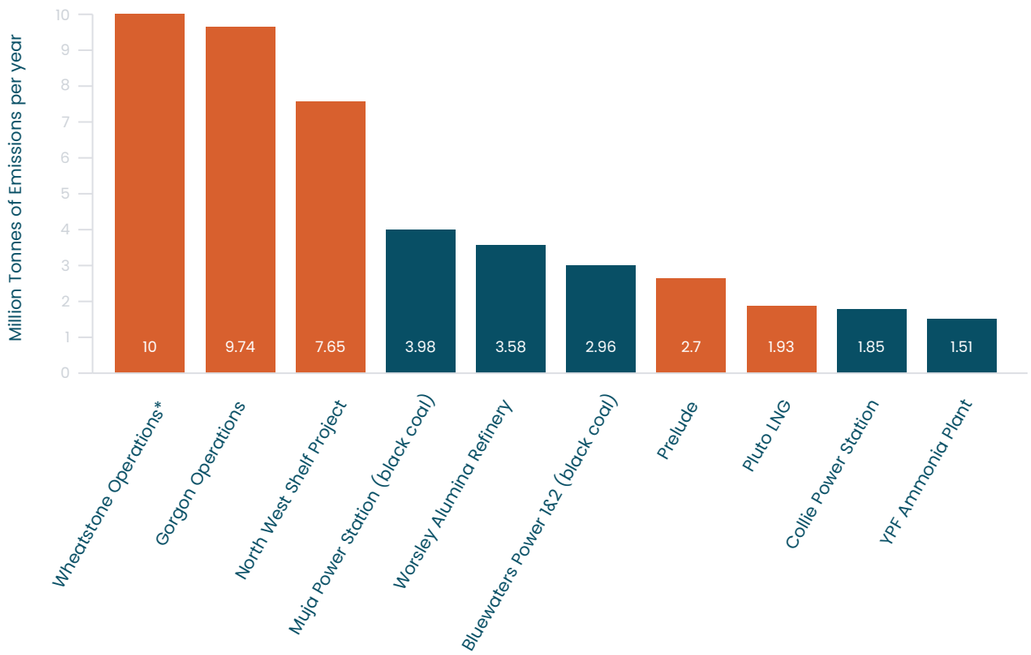
Figure 8: Comparison of pollution from coal and LNG in WA



Emissions from five operating WA LNG facilities produces 32Mt per annum, compared with emissions from WA coal fired power stations and the Alumina refinery of 12.37Mt. (Figure 9)

This means WA LNG produces 2.5 times the pollution from burning black coal in WA.

Figure 9: Western Australia's ten biggest CO_2 emitters



Source: Emissions for all non-LNG facilities were for 2017-18 from the Clean Energy Regulator (May 2019) and CCWA figures. Emissions for all LNG facilities use emissions anticipated at full production.

3. Current regulation and control of greenhouse gas emissions from WA LNG

With the exception of the Shell Prelude floating LNG facility (which is located in Australian Commonwealth waters), carbon pollution and other emissions from WA LNG projects are regulated by the West Australian Government under the Environmental Protection Act. State conditions are variable, usually requiring some level of offsetting of emissions, **however in most cases these conditions have either been removed or have not been implemented.**

Table 4 provides a summary of conditions regulating greenhouse gas emissions for current and proposed WA LNG facilities.

Table 4: Greenhouse gas conditions for current and proposed WA LNG facilities

Project	Operator	Start	Carbon pollution controls or offset conditions
North West Shelf	Woodside /NWS Joint venture	1989	**No controls on pollution.** No offsets are required, however the 1989 State approval required 'best available technologies' at the time. These conditions are currently under review by the WA EPA as part of the Browse / Burrup Hub proposal which would significantly extend the operating life of this facility.
Pluto	Woodside	2012	**Conditions to partially offset pollution however compliance in doubt.** Conditions required 'reservoir gas'(0.24Mtpa)[5] to be offset. Compliance with conditions is unclear due to questionable additionality of offsets and lack of surrendering or retirement of offset certificates, and a lack of enforcement to date.
Gorgon	Chevron	2016	**Conditions not complied with or enforced (currently under review).** State government approval conditions require 80% of 'reservoir gas' emissions (3.4-4 million tonnes each year)[6] from the Gorgon facility to be captured and pumped underground (geosequestration or CCS) delivering a 40% reduction in the project's total emissions. Chevron received $60m in federal funding for the geosequestration project. It announced geosequestration had begun on August 8th 2019, more than two years after production commenced. Delays were due to 'ongoing technical problems'[7] and Chevron has also been accused of deliberately mismanaging the geosequestration project.[8] No penalties were imposed by the WA government for emissions not sequestered over this period, and alternative offsets were not provided by Chevron despite state conditions requiring them in the event the geosequestration is not successful. A review is currently underway by the WA Environmental Protection Authority to examine and clarify the intended start-date for the geosequestration condition at the request of the WA Minister for the Environment. There is no federal requirement for sequestration and under the Commonwealth Safeguard Mechanism Chevron has set itself an emissions limit of 8.3MtCO2-e per year – which assumes CCS does not operate successfully.[9]
Wheatstone	Chevron	2018	**Conditions removed (currently under review).** Project was originally approved with conditions to offset reservoir emissions (2.6Mtpa) as a minimum. These conditions were removed[10] when a national price on carbon was introduced and have not been reinstated. The conditions are currently under review by the WA Environmental Protection Authority at the request of the WA Minister for the Environment.
Prelude	Shell	2018	**Conditions not implemented**. The Shell Prelude facility is regulated by the Commonwealth Government as it is located in Commonwealth waters. Original recommendation by the Commonwealth Department of Environment in 2009 was to offset 100% emissions from the facility.[11] It is unclear what level of emissions reduction is required for this facility, if any.
Browse Basin	Woodside led JBV	2026	**Currently under assessment.** No GHG controls have been proposed by Woodside. The Browse Basin project is currently under assessment by State and Commonwealth Governments. If it goes ahead the project will extend the life of the existing North West Shelf LNG facility for at least 25 years[12] and add a further 7MtCO2-e just through venting CO2 and pumping the feed gas, making Browse the most pollution intensive gas development in Australia. The final investment decision is expected in late 2020.[13]
Scarborough	Woodside /BHP	2023-30	**Currently under assessment. No GHG controls have been proposed by Woodside.** The final investment decision is due in 2020 and Woodside is targeting for development to be completed in 2023.[14]

It is clear from the above summary that the current controls on WA LNG projects are completely inadequate in controlling carbon pollution from these projects. Where conditions have been imposed, they vary. Conditions have either not been met or have been removed. The failure of current pollution controls on WA LNG can be put down to several factors, including:

- Inadequate and weak conditions (all projects)
- Non-compliance with conditions and lack of enforcement (Chevron Gorgon)
- Questionable provision of offsets (Woodside Pluto)
- Removal of conditions (Chevron Wheatstone)
- Government failure to implement recommended conditions (Shell Prelude)

While some conditions are being reviewed, it's startling to find these major polluters are operating without any controls in place at all.

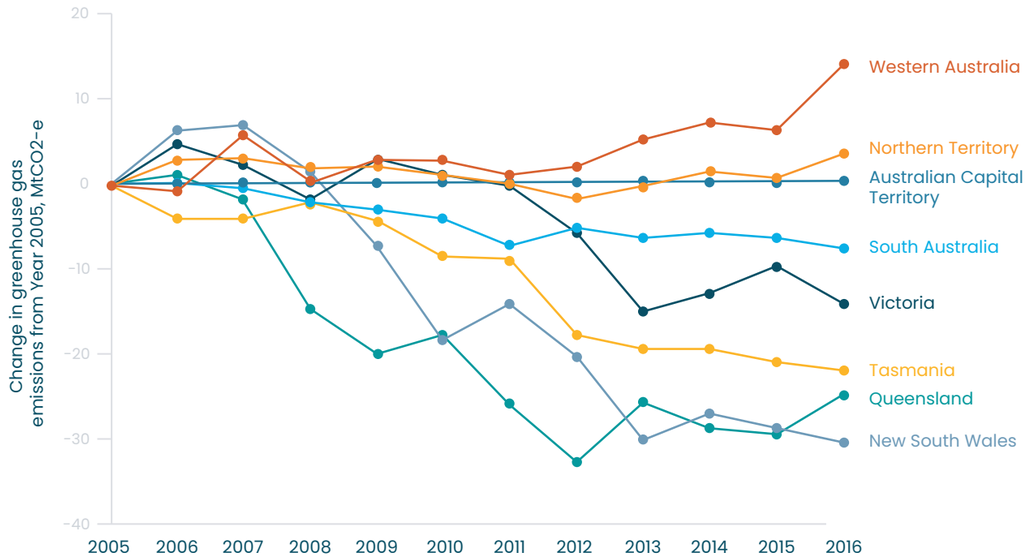
The WA EPA is currently reviewing its assessment guidelines on how it will consider greenhouse gas emissions in its future assessments of developments in WA.

4. Impact of WA LNG on Western Australian emissions

The rapid expansion in LNG production in Western Australia has had a dramatic impact on the state's total annual emissions (Figure 10). WA is the only state in Australia with emissions that have been rising since 2005, and this can be directly attributed to the LNG industry.

WA's emissions have risen significantly since 2005. The only states with recently rising emissions are those in which major LNG projects are operating: Queensland (Gladstone LNG), the NT (Inpex LNG) and WA. All rises in emissions are due to LNG production and development.

Figure 10: States and Territories greenhouse gas emissions trends, 2005-2016



Source: Government of Western Australia presentation April 18, 2019

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The impact of Western Australia's LNG industry on the state's annual greenhouse gas emissions is discussed below (Table 5).

Table 5: Current LNG facilities compared with Western Australia's annual emissions

Project	Operator	Start	LNG Production capacity (Mt)	GHG emissions (MtCO2-e)	GHG as % WA emissions
North West Shelf	Woodside/NWS Joint venture	1989	16.9	7.6	9%
Pluto	Woodside	2012	4.9	2	2%
Gorgon	Chevron	2016	15.6	9.74	11%
Wheatstone	Chevron	2018	8.9	10	11%
Prelude	Shell	2018	3.6	2.3-2.7	3%
			49.9	**32**	**36%**

GHG emissions from five currently operating WA LNG facilities amount to 32MtCO2-e at full production. WA's GHG emissions in 2017 were 88.5Mt. **The total annual GHG emissions from the five LNG plants are equivalent to over one third (36%) of WA's total annual GHG emissions.**

This means more than one third of WA's total pollution comes from just two companies.

Table 6: Proposed Woodside Burrup Hub Expansion compared with Western Australia's annual emissions

Project	Operator	Start	LNG Production capacity (Mt)	GHG emissions (MtCO2-e)	GHG as % WA emissions (88.5MtCO2-e)
Browse Basin + NWS	Woodside led JBV	2026	10	14.6	16.5%
Scarborough + Pluto expansion	Woodside/BHP	2023-30	12	2.6	3%
			22	**17.2**	**19.5%**

Emissions from two proposed LNG expansions currently being assessed (Woodside's Browse and Scarborough fields) will emit 17.2 million tonnes of GHG per year.

Compared with WA's current emissions of 88.5Mt, the total emissions from exploiting these two new fields will be equivalent to almost 20% of WA's total emissions.

Table 7: All emissions – current and proposed WA LNG facilities compared with WA's annual emissions

	Total
LNG Production capacity (Mt)	64.9
GHG emissions (MTCO2-e)	41.6
GHG as % WA emissions (88.5MtCO2-e)	**47%**

When combined, all current and proposed WA LNG projects would emit 41.6MtCO2-e per year, equivalent to more than half (47%) of WA's total annual GHG emissions.

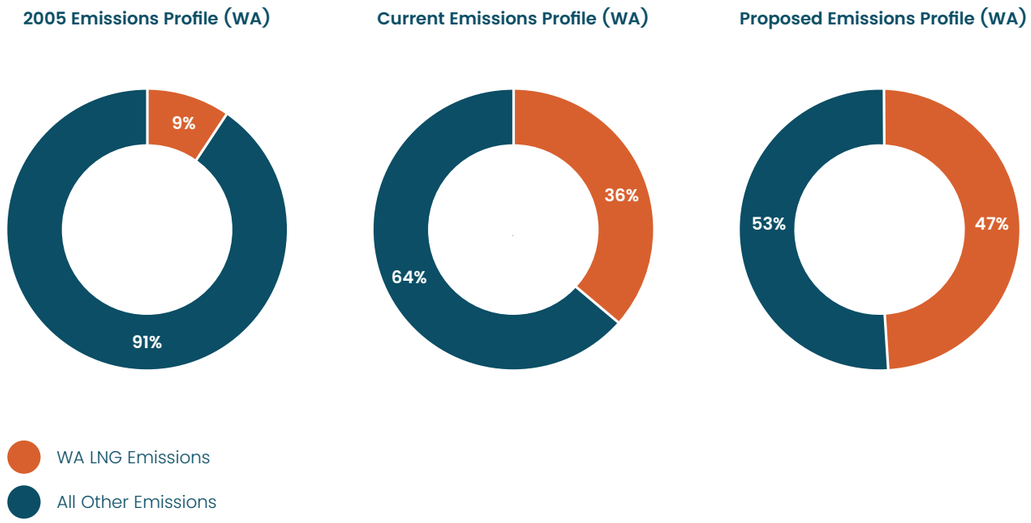
If the proposed Burrup Hub expansion is allowed to proceed, LNG production will contribute to almost half of WA's total annual emissions.

A growing proportion of WA's emissions over time

Over time, emissions from LNG have dramatically increased as a proportion of WA's total greenhouse gas pollution. In 2005, emissions from one LNG plant (North West Shelf) was 7.6Mt and equivalent to about 9% of WA's total emissions profile. By 2019, emissions from five operating plants was 32Mt at full production and equivalent to over one third of our total emissions (36%), as shown in the charts below.

If Woodside's proposed Burrup Hub expansion goes ahead, LNG pollution will amount to 41.6Mt, equivalent to almost half of WA's total emissions (47%). This means just two companies, Woodside and Chevron, along with their joint venture partners, will be responsible for almost half of WA's total emissions.

Figure 11: Proportion of WA's total annual emissions from LNG mining and export



5. Impact of WA LNG on Australian emissions

The rapid expansion in LNG production in Western Australia is the most significant industrial driver of carbon pollution increases in Australia. This was acknowledged by Australia's former Environment Minister, Melissa Price, in 2018:

'The...increase in emissions was largely driven by the LNG production for export, which the volumes increased by some 25.4 per cent.' - Melissa Price, 9 October 2018[16]

The role of LNG production was also described in the Quarterly Update of Australia's National Greenhouse Gas Inventory for March 2019, the Department of Environment and Energy states:

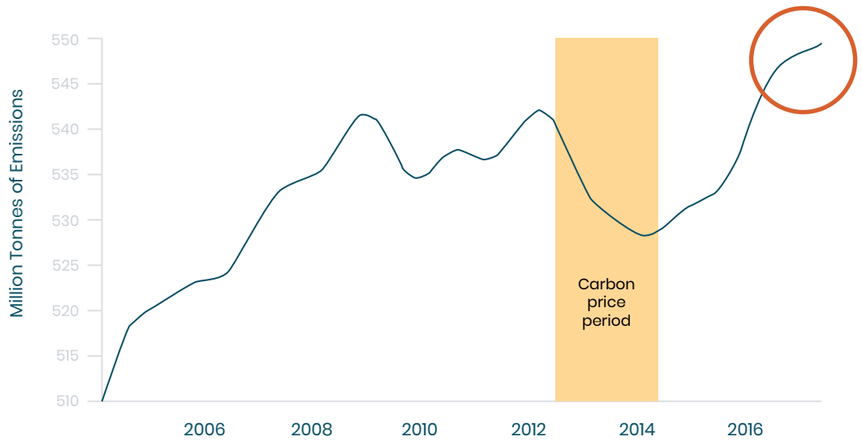
'Emissions for the year to March 2019 are estimated to be 538.9Mt CO2-e, up 0.6 per cent or 3.1Mt CO2-e, on the previous year, primarily due to increased LNG exports.'

The March 2019 figures also show Australia's fugitive emissions have increased by 60% since 2004 and now account for 11.1% of Australia's total emissions by sector.

The Western Australian LNG industry (WA LNG) is responsible for most of the increase in exports and pollution. The impact of the WA LNG industry on Australia's annual emissions is shown in the table below.

Figure 12: Total annual greenhouse gas emissions

Excluding land use, land use change and forestry



Source: Table adapted from Greg Jericho, 9 January 2019[17]

The impact of WA's LNG industry on Australia's annual greenhouse gas emissions is discussed below.

Table 8: Current WA LNG emissions compared with Australia's total emissions

Project	Operator	Start	LNG Production capacity (Mt)	GHG emissions (MtCO2-e)	GHG as % Australian emissions (538MtCO2-e)
North West Shelf	Woodside/NWS joint venture	1989	16.9	7.6	1.4%
Pluto	Woodside	2012	4.9	2	0.4%
Gorgon	Chevron	2016	15.6	9.74	2%
Wheatstone	Chevron	2018	8.9	10	2%
Prelude	Shell	2018	3.6	2.3-2.7	0.5%
			49.9	**32**	**6.3%**

Total GHG emissions from five currently operating LNG facilities amount to 32MtCO2-e at full production. Australia's GHG emissions in 2017 were 538Mt. Current production therefore accounts for over 6% (6.3%) of Australia's total annual emissions.

Table 9: Proposed Woodside Burrup Hub expansion emissions compared with Australia's total emissions

Project	Operator	Start	LNG Production capacity (Mt)	GHG emissions (MtCO2-e)	GHG as % Australian emissions (538MtCO2-e
Browse Basin + NWS	Woodside NWS joint venture and Browse joint venture	2026	16.9	14.6*	2.7%
Scarborough + Pluto expansion	Woodside/BHP	2023-30	12	2.6	0.5%
			28.69	**17.2**	**3.2%**

*Includes emissions from existing NWS facility which will be used to process gas from the Browse field

Emissions from Woodside's proposed Burrup Hub expansion (exploiting the Browse and Scarborough fields) will emit 17.2 million tonnes of GHG per year, which would be equivalent to 3.2% of Australia's annual emissions.

Table 10: All emissions – current and proposed WA LNG facilities compared with Australia's total emissions

	Total
LNG Production capacity (Mt)	58.9
GHG emissions (MTCO2-e)	41.6
GHG as % Australian emissions (88.5MtCO2-e)	**7.7%**

When combined, all current and proposed WA LNG projects would emit 41.6MtCO2-e per year, equivalent to almost 8% (7.7%) of Australia's annual GHG emissions.

It's important to note these figures are only for direct emissions, that is, pollution generated by extracting and processing for export (scope 1 emissions). When full lifecycle emissions are added (scope 2 and 3), including the pollution generated by shipping the gas overseas (4.4MtCO2-e), storage and distribution (0.6MtCO2-e) and eventual combustion (132MtCO2-e) WA's LNG industry is responsible for about 193 million tonnes of pollution every year.[18]

Key finding

When combined, all current and proposed WA LNG projects would emit 41.6MtCO2-e per year, equivalent to almost 8% (7.7%) of Australia's annual GHG emissions.

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6. Comparison with other major emitters

This report compares the emissions from WA LNG to other major emitters and sectors of the economy in Australia.

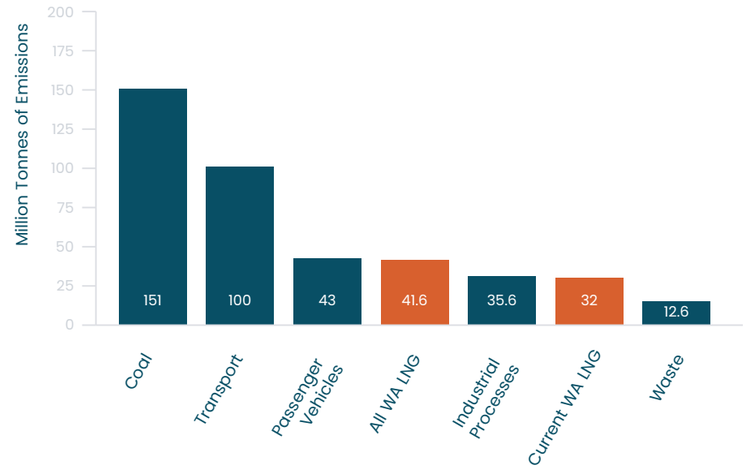
Electricity

Total GHG emissions from current LNG facilities (32Mt) are equivalent to about 17% of emissions from Australia's entire electricity sector. The electricity sector is the single largest source of greenhouse gas emissions in Australia (184Mt) and responsible for 33% of our total emissions (in the year to December 2017).

Coal-fired power stations

The Clean Energy Regulator (CER) maintains a register of all electricity generators in Australia, including the amount of electricity and GHG emissions produced by each per year. Based on the most recent year (2016-17) the amount of GHG emissions produced from all of Australia's coal-fired power stations was 151Mt. Emissions from five current LNG plants (32Mt) are equivalent to approximately 21% of the total annual emissions produced from Australia's coal-fired power stations. **Emissions from current and proposed LNG facilities combined (41.6Mt) would be equivalent to 28% of all coal-fired power stations.**

Figure 13: WA LNG pollution compared with major emitters in Australia



Transport

Emissions from all current and proposed LNG plants is equivalent to almost half (41.6%) of the total emissions from Australia's entire Transport sector. Transport is Australia's second largest source of greenhouse gas emissions, emitting 100Mt per year and responsible for 18% of Australia's emissions in the year to December 2017.[19]

Passenger vehicles

According to the ABS, passenger vehicles in Australia in 2015-16 travelled a total of 175,899 million km and used 18,606 ML of fuel, equivalent to about 43Mt CO2-e.[20] Emissions from the five LNG plants (32Mt) is equivalent to almost three quarters (74%) of the total annual emissions from every single passenger vehicle driven in Australia driven over a year. **Emissions from all current and proposed LNG facilities would be equivalent to 96% of Australia's entire passenger vehicle emissions over a year.**

Waste

If approved, GHG emissions from Woodside's Browse project (14.6MtCO2-e) will be significantly larger than Australia's entire waste sector (12.6Mt), which is the seventh largest source of greenhouse gas emissions in Australia and responsible for 2% of Australia's emissions.[21]

7. Comparison with other countries' emissions

Using figures from the Global Carbon Atlas[22] we compared the annual pollution from WA's currently operating LNG facilities (32Mt) to the total annual emissions of other countries. We found:

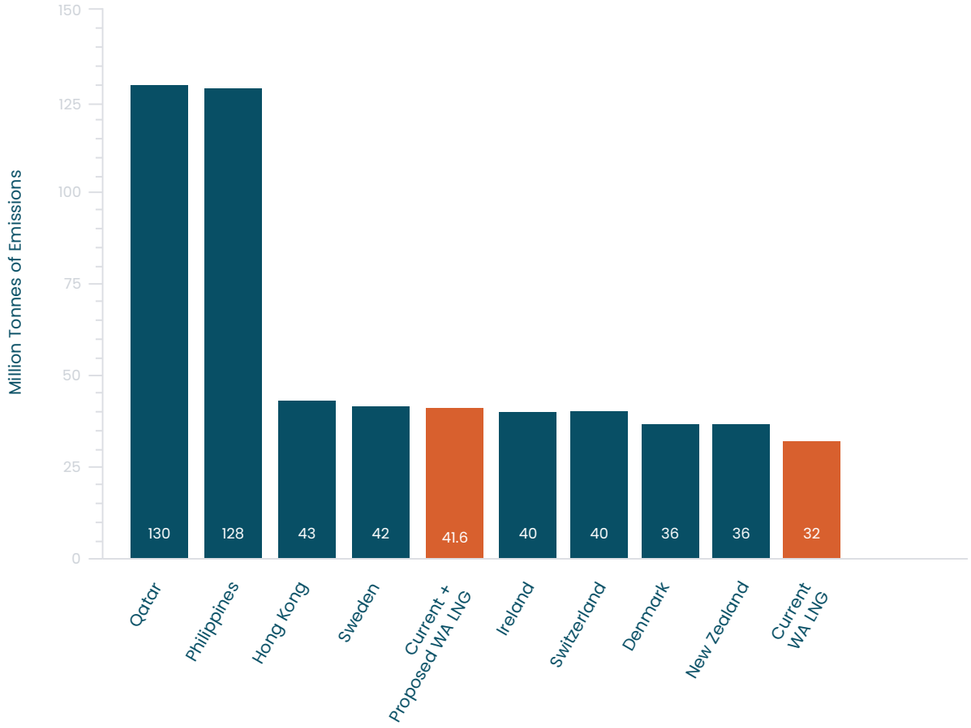
Emissions from current WA LNG facilities (32MtCO2e) are almost as high as the annual emissions of countries including Denmark (36Mt) and New Zealand (36Mt).

Emissions from current and proposed LNG facilities combined (41.6MtCO2-e) will be:

- Higher than the annual emissions of countries including Ireland (40Mt) and Switzerland (40Mt) and just under that of Sweden (42Mt) and Hong Kong (43Mt)
- One third of the annual emissions of Qatar (130Mt) and the Philippines (128Mt)

If approved, emissions from Woodside's Burrup Hub project (17.2Mt) will be significantly more than the annual emissions of Cambodia (7.9MtCO2-e), Zimbabwe (10MtCO2-e) and Afghanistan (13Mt).

Figure 14: WA LNG pollution compared with other countries



8. Our commitments under the Paris Agreement

Australia's responsibility under the Paris Agreement

Australia has committed to reducing total national greenhouse gas emissions by 26-28% below its 2005 level (532Mt) by 2030 under the Paris Treaty.
This means our greenhouse gas emissions will need to be down to about 450 million tonnes a year by 2030 to meet the current target– or down to 333 million tonnes to meet the IPCC's target of 45 per cent reductions by 2030.[23]

Article 4.1 of the Paris Agreement specifies that, in order to reach the temperature limit set under the Agreement, that countries should aim to reach a global peak emissions as soon as possible, undertake rapid reductions thereafter and reach zero emission sometime in the second half of the century in accordance with best available science.

The United Nations has asked all signatory countries to outline their plans to achieve net zero emissions by 2050 ahead of a climate action summit in New York in September 2019.[24]

Our emissions need to peak in 2020 and start falling rapidly soon after, and deep cuts across every sector will be needed in order to achieve the trajectory needed to reach net zero emissions by 2050.[25]

Increasing emissions of the gas industry are in breach of the Paris Agreement and contradict the best available science on what is needed to meet the Paris Agreement long-term temperature goal.

New research by Carbon Tracker shows how out of alignment the oil and gas industry is with the goals and aspirations of the Paris Agreement. It shows the oil and gas in projects that have already been approved will take the world past 1.5°C, assuming carbon capture and storage remains sub-scale. It also names the Gorgon stage 2 project as number three in the top 6 list of oil and gas projects globally that are non-compliant with the Paris Agreement.

Western Australia's responsibility under the Paris Agreement

The responsibility for meeting the Paris Agreement in Australia is a shared responsibility by the Australian government and the individual states.

As Environmental law expert Dr Hugh Finn explains:

The Paris Agreement imposes obligations on Australia – and while it's the executive (Commonwealth) that enters into treaties, the obligations of treaties rests in the states, so those obligations rest not only on the Commonwealth Government but on the states as well. The reality is with treaty obligations, states almost always legislate to implement those. ***Without state legislation or action those obligations would not be met.***[26]

According to Dr Finn, Australian states have an even stronger obligation under international treaties such as the Paris Agreement when action at the Commonwealth level is inadequate to deliver Australia's commitments:

My view is that Commonwealth legislation will not achieve our treaty obligations. ***The reality is the states have to step into that vacuum and help us meet our Paris commitments.***[27]

This therefore affirms the legal position that Western Australia is responsible for taking action to meet the Paris Agreement. At the time of writing this report the WA government announced an 'aspiration to net zero', however the new policy also allows big polluters to set their own emissions targets. The key test will be whether emissions will be reduced in the near term, and whether projects will be approved that significantly increase emissions. .

As outlined in FIgure 11 on the next page, all states have net zero emissions reduction targets by 2050, in line with the Paris Agreement. Three Australian States have enshrined these targets in legislation.

Figure 15: Australian states and territories emissions targets

Western Australia
Net zero by 2050

Aspirational net zero emissions target announced in late August, but it's unclear whether this will apply to the LNG sector or be enshrined in legislation. WA also lacks a renewable energy target and formal climate change strategy.

Northern Territory
Net zero by 2050

Targets set out in its Draft Climate Response, with a big focus on solar energy and export.

South Australia
Net zero by 2050

Target in South Australia's Climate Change Strategy 2015-2050, and will be enshrined in legislation in the future.

Queensland
Net zero by 2050

Target set out in the Queensland climate transition strategy, which also includes an interim target for at least a 30% reduction in emissions on 2005 levels by 2030.

New South Wales
Net zero by 2050

Target set out in the NSW Climate Change Policy Framework.

Victoria
Net zero by 2050

Legislated target in the Climate Change Act 2017 with five yearly interim emissions targets.

Australian Capital Territory
Net zero by 2045

Legislated target set out in section 6 of the Climate Change and Greenhouse Gas Reduction Act 2010.

Tasmania
Net zero by 2050

Target in Tasmania's Climate Change Action Plan 2017–2021, to be legislated under the Climate Change (State Action) Act 2008.

8.1 Impact of WA LNG emissions on WA's 2005 Paris baseline

Under the Paris Treaty, Australia has committed to reducing total national greenhouse gas emissions by 26-28% below 2005 levels. Yet the reality is that uncontrolled emissions from WA's LNG industry are increasing Australia's emissions and putting our ability to meet this target into jeopardy.

Emissions from current and proposed LNG projects (operating post 2005) have been investigated to determine their impact on Australia's Paris Agreement baseline and commitments.

Table 11: Impact of WA LNG on Western Australia's 2005 emissions baseline*

	Project	Operator	Start	GHG emissions (MtCO2-e)	% increase relative to WA's 2005 Baseline
Current	Pluto	Woodside	2012	2	2%
	Gorgon	Chevron	2016	9.74	15%
	Wheatstone	Chevron	2018	10	15%
	Prelude	Shell	2018	2.3-2.7	4%
Proposed Burrup Hub expansion	Browse Basin	Woodside JV	2026	14.6	21%
	Scarborough	Woodside /BHP	2023-30	2.6	4%
Total				**41.6**	**61% increase**

* To calculate the impact of Burrup Hub expansion facilities on the 2005 baseline we only counted emissions from projects commencing after 2005. Emissions from the North West Shelf project which came online in 1989 were therefore excluded.

Our research shows:

- **Emissions from four current LNG projects (operating after 2005) are emitting 24.4MtCO2-e at full production, which represents a 36% *increase* on WA's 2005 emissions baseline**
- Chevron's Gorgon and Wheatstone projects are the states single biggest polluters and emitting 19.74MtCO2-e at full production, which represents a 30% increase on WA's 2005 baseline
- Emissions from current and proposed projects combined will add 41.6MtCO2-e of pollution every year at full production, equivalent to a 61% increase relative to WA's 2005 emissions baseline

Key finding

Emissions from all current and proposed projects will add 41.6 million tonnes of greenhouse gas pollution every year at full production, equivalent to a 61% increase on WA's 2005 emissions baseline.

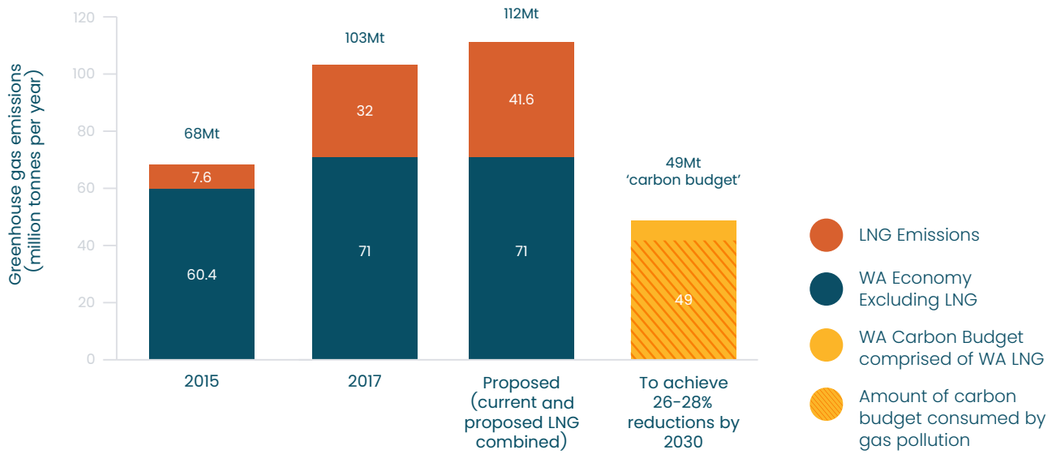
WA's Carbon budget

Another way to represent the impact of WA LNG emissions to WA is to look at the proportion of WA's 'carbon budget' that would be used by LNG emissions. **To achieve the modest target of a 26-28% decrease in emissions on 2005 levels by 2030, WA's annual emissions will need to drop to 49Mt, but emissions from current and proposed LNG facilities are 41.6Mt, which would be 85% of this amount (Figure 16).**

This means that without any controls on pollution, the rest of the WA economy needs to reduce its emissions from around 71 million tonnes per year to just 7.4 million tonnes by 2030 – or by 90%.

In other words, without any action by the LNG industry to curb its pollution WA will have an emissions reduction target of 90% by 2030 to reach the modest national target of 26-28% reduction by 2030. This is an impossible ask on the rest of the economy and community.

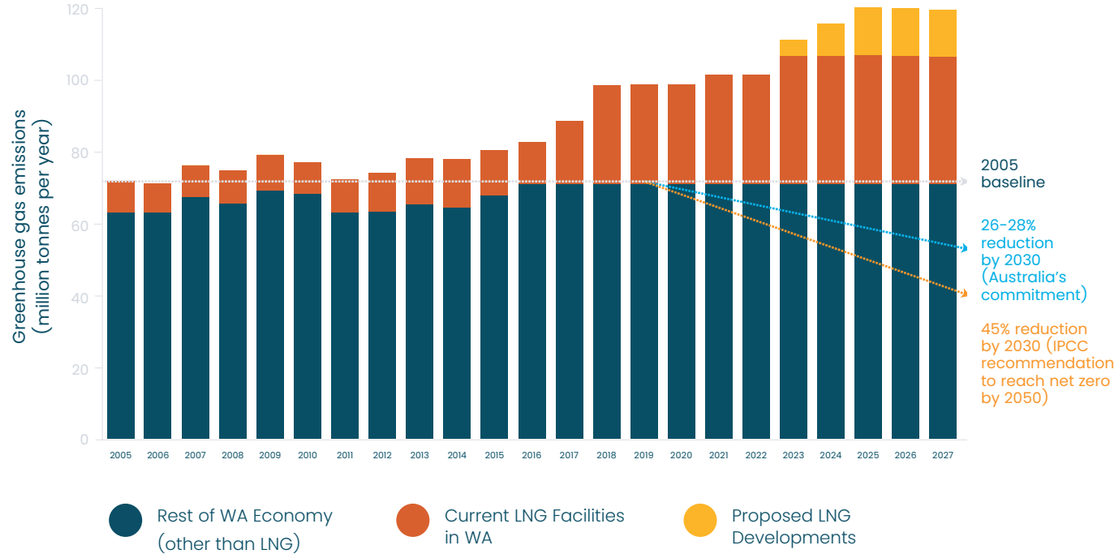
Figure 16: WA's Carbon Budget to 2030 versus WA LNG emissions



8.2 Cumulative impact of WA LNG emissions

The cumulative total of emissions from LNG facilities coming online since 2005 and their impact on the ability to achieve the Paris targets is shown below (Figure 17).

Figure 17: Trajectory of emissions from WA LNG facilities from 2005, compared with the rest of the economy



The graph shows that, compared to the emissions from the rest of the WA economy which have remained relatively stable since 2005, emissions from WA LNG are rising almost exponentially.

This increase is at odds with our international commitment made under the Paris Treaty to reduce emissions by 26-28% below our 2005 baseline.

It also shows the size of the abatement task to reach net zero emissions by 2050 given the trajectory of WA's rising emissions.

Immediate action to contribute to the peaking of global emissions by around 2020 is clearly indicated in the Paris Agreement and is supported by the recent IPCC 1.5° Special Report.

The increasing emissions of the LNG industry are in breach of the Paris Agreement and contradict the best available science on what is needed to meet the long-term temperature goals committed to under the Paris Agreement.

8.3 Impact of WA LNG emissions on Australia's 2005 Paris baseline

This section examines the impact of WA LNG on Australia's ability to reach the Paris targets.

Emissions from current and proposed projects (operating post-2005) were investigated to determine the impact on Australia's Paris commitments.

Table 12: Detailed impact of emissions by project on Australia's 2005 baseline emissions

	Project	Operator	Start	GHG emissions (MtCO2-e)	% increase relative to Australia's 2005 baseline (532MtCO2-e)[28]
Current	Pluto	Woodside	2012	2	0.4%
	Gorgon	Chevron	2016	9.74	1.8%
	Wheatstone	Chevron	2018	10	2%
	Prelude	Shell	2018	2.3-2.7	0.5%
Proposed Burrup Hub expansion	Browse Basin	Woodside JV	2026	14.6	2.7%
	Scarborough	Woodside/BHP	2023-30	2.6	0.5%
Total				**41.6**	**8% increase**

Australia has committed to a 5% reduction of GHG by 2020 and a 26-28% reduction of GHG on 2005 figures by 2030. But our findings show:

- Emissions from four current LNG projects that came online after 2005 represent a 4.7% increase to Australia's 2005 baseline.
- **Combined emissions from current and proposed WA LNG projects will increase Australia's emissions by 41.6MtCO2-e, equivalent to an 8% increase above 2005 levels.**
- This means, if unchecked, this pollution effectively adds another 8% to Australia's current emission reduction target, making it 33-35% by 2030.
- **The unchecked pollution from just 5 facilities owned by three corporations is forcing all other sectors of the Australian economy to do the heavy lifting to compensate for the runaway emissions.**

Key finding

Combined emissions from current and proposed LNG projects will increase Australia's emissions by 41.6 million tonnes, equivalent to an 8% increase on Australia's 2005 baseline.

Impact of the proposed Burrup Hub expansion on our 2005 Paris baseline

It's worth noting the impact of Woodside's proposed Burrup Hub expansion separately:

- **Emissions from Woodside's Browse and Scarborough projects would emit another 17.2MtCO2-e, representing a 25% increase on WA's 2005 baseline levels, and 3.2% increase on Australia's 2005 baseline.**
- The Browse project, if approved, will be the most emissions intensive development in Australia, adding an additional 7 million tonnes just through venting and pumping the gas 900km and about another 7.6 million tonnes from processing at the North West Shelf LNG facility. This project alone will emit pollution equivalent to 2.7% increase over Australia's total 2005 baseline.

Just two companies - Woodside and Chevron - are responsible for most of the runaway pollution that is in breach of the Paris Agreement and puts our national target in jeopardy.

9. Comparing WA LNG pollution with national emissions reduction efforts

To achieve a 26% reduction from 2005 levels by 2030, Australia will need to reduce its cumulative emissions between 2020 and 2030 by about 850Mt.[29]

The Department of Environment and Energy has estimated that this could be achieved by a reduction of approximately 375Mt through projects supported through the Emissions Reduction Fund, another 175Mt from energy efficiency measures implemented through the National Energy Productivity Plan, 120Mt from vehicle efficiency measures through the National Energy Productivity Plan, 85Mt from reduced ozone and HFCs and the remaining 205Mt from technological improvements and 'other sources of abatement'.[30]

In the same 10-year period, the five current LNG plants will produce about 320MtCO2-e, equivalent to almost half of the national reduction task.

This section compares WA LNG pollution with major Australian initiatives to reduce pollution:

- The Emissions Reduction Fund
- The Renewable Energy Target; and
- Solar rooftops

WA LNG pollution compared with abatement delivered by the Emissions Reduction Fund (ERF)

The Emissions Reduction Fund

In 2014 the Australian Government repealed the price on carbon. The carbon price generated about $13.8 billion in revenue and reduced emissions by 40 million tonnesin just two years of operation. It covered 60% of Australia's emissions and was paid by 348 businesses, including Woodside which had the highest liability outside the electricity sector and paid $171.9 million in its first year.

In its place the Government set up the Emissions Reduction Fund and provided $2.55 billion for activities to reduce emissions and 'help achieve Australia's 2020 emissions reduction target of five per cent below 2000 levels by 2020 and 26-28 per cent below 2005 emissions by 2030.'[31] In February 2019 the Emissions Reduction Fund was rebadged as the Climate Solutions Fund and provided with an additional $2 billion in funding, bringing total investment to $4.55 billion.

To date, 37.3 million tonnes of abatement has been achieved by the Emissions Reduction Fund.[32] (Table 13)

Table 13: Emissions Reduction Fund outcomes to date

	Eighth auction (December 2018)	Cumulative total
Abatement purchased	3.3 million tonnes	193 million tonnes
Abatement delivered		**37.3 million tonnes**
Average price per tonne	$13.82	$12
Total committed	$45 million	$2.29 billion
Total contracts	34	457
Contracts completed		**20**
Total projects	36	477

Source: Australian Government Department of the Environment and Energy (December 2018)

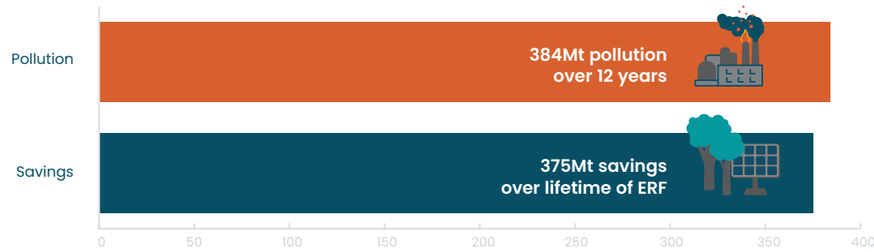
Key finding

It will take just 12 years for current LNG facilities to cancel out the entire abatement expected to be delivered over the lifetime of the $4.5 billion Emissions Reduction Fund.

Comparing WA's LNG emissions to abatement purchased under the Emissions Reduction Fund we found:

- The Emissions Reduction Fund has delivered a total of 37.3 million tonnes of abatement to date, which is only slightly larger than the amount WA's five current LNG facilities emit each year without any controls (32MtCO2-e).
- At the most recent auction 34 carbon abatement contracts were awarded to deliver 3.3 million tonnes of abatement, but this is almost ten times smaller than the annual emissions of WA's five current LNG facilities.
- Annual emissions from Chevron's Gorgon facility (9.74MtCO2-e) are three times higher than the total abatement purchased in the most recent auction (3.3Mt).
- **The Australian government has invested $4.55 billion into the Emissions Reduction Fund, meaning 100% of this funding is effectively being provided by taxpayers to offset the operations of Woodside, Chevron, Shell and BHP's five WA LNG facilities over the next twelve years.**

Figure 18: 12 years of WA LNG pollution will cancel out all savings made by the $4.5 billion Emissions Reduction Fund



WA LNG pollution compared with abatement delivered by the Renewable Energy Target

The Renewable Energy Target (RET)

The Renewable Energy Target (RET) is a target for at least 33,000 gigawatt-hours (GWh) of Australia's electricity to be produced from new renewable sources by 2020.

The RET has been described as 'Australia's largest and most effective carbon abatement policy, as well as being a very cost-effective policy for stimulating investment in new generation capacity' by the Clean Energy Council.

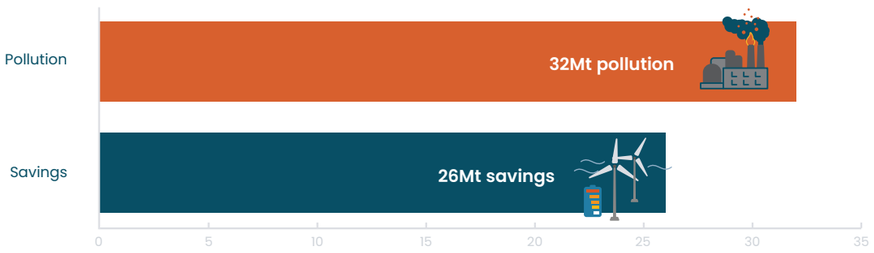
To date it's delivered 8400 megawatts of renewable energy[33] and is expected to deliver about 360 million tonnes of carbon abatement over its lifetime.[34] This includes:

- 58Mt over 2015–2020 — about the same as annual emissions from all of Australia's passenger cars and light commercial vehicles
- 299Mt over 2015–2030 — more than half of Australia's current total annual emissions.[35]

Using an average emission factor of 0.796t CO2-e/MWh, we calculated the annual emissions avoided by the renewable energy generation installed under the RET to be 26.3Mt CO2 per year.

This means the annual emissions of WA's five LNG plants (32Mt) are 1.2 times the annual savings being made through the RET (26.3Mt).[36]

Figure 19: WA LNG pollution is canceling out all savings made annually by the RET



Key finding

The annual emissions of WA's five currently operating LNG plants (32Mt) are 1.2 times more than the emissions saved every year through the Renewable Energy Target.

This means that emissions from Chevron and Woodside WA LNG operations are larger than the annual savings being made from every single renewable energy installation across Australia under the RET.

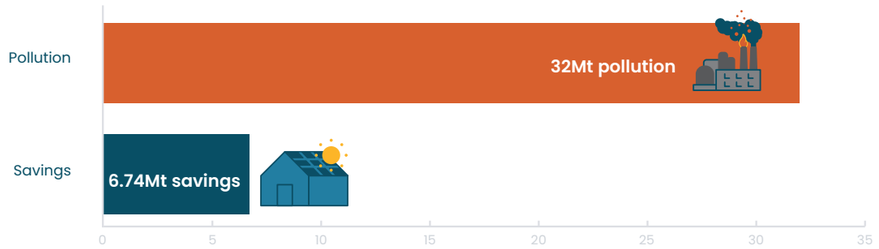
WA LNG pollution compared with abatement delivered by Rooftop Solar PV

Solar PV

Australians love rooftop solar power. The Solar Council estimate Australians are installing 6 solar panels every minute. 20% of Australian homes now have solar on their rooftops, with over 2.1 million solar PV systems installed nationwide (at June 2019).[37] Australia's total installed rooftop solar was generating about 8.56GWh of electricity to June 2019, which in turn saved about 6.67Mt CO2.[38]

This means the annual emissions of WA's five LNG plants (32Mt CO2 generated) are almost five times greater than the total emissions saved each year by Australia's entire fleet of rooftop solar panels across 2.1 million homes (6.74Mt CO2 saved).

Figure 20: WA's LNG pollution is 5 times larger than the savings being made by Australia's 2.1 million solar rooftops



10. The opportunity for offsets and job creation here in WA

The opportunity to reinstate and strengthen pollution controls on LNG projects in WA has the potential to address Western Australia's largest source of carbon pollution, while creating a substantial new driver for jobs growth and investment in the WA economy.

While offsets can currently be purchased from throughout Australia and internationally, there is an untapped opportunity for WA to capture significant employment and other benefits by requiring offsets for LNG emissions that are sourced from within Western Australia.

A recent study by Reputex investigated the abatement potential and economic benefit to WA of offsetting direct emissions generated by the LNG industry within the state.[39] **It found there are approximately 80 million tonnes of emissions offsets available per year** identified across agriculture, renewable energy, carbon farming, and vegetation management activities including rangeland regeneration and savannah burning; (Figure 21). **The same report also found offsetting 30 million tonnes per year would create around 4000 jobs, with the largest portion in the South-West and Southern Rangelands (Figure 22).**

The largest source of new job creation would be in reforestation plantings (1,190 new jobs), followed by large scale renewable energy (614), rangeland regeneration (249) and savannah burning (186); with all remaining jobs attributed to other land-sector projects (1,694). Not only would this be of direct benefit to the WA economy and community by creating long term careers in sunrise industries, but would have significant benefits to WA's natural environment and biodiversity.

This compares to an estimated 2340 direct and indirect jobs in WA created by the Gorgon, Wheatstone and North West Shelf projects – the three largest facilities currently operating in WA and the only projects for which jobs data is publicly available.[40]

This approach would be in line with the NT government which is currently developing a 'buy NT-first' policy for offsets for emissions generated by its onshore gas industry. It was reported that this would generate a fund of between $880 million to $3.4billion per year by 2022.[41]

Currently there is little incentive for LNG companies to make investments that would reduce their pollution. Requirements to offset all carbon pollution to a net zero target would also create a market incentive for the LNG sector to invest in measures to mitigate GHGe, including installing renewables and battery storage at production plants, as Conoco Phillips announced recently for its Darwin LNG facility.

Figure 21: Projected GHG offset potential in WA across three scenarios

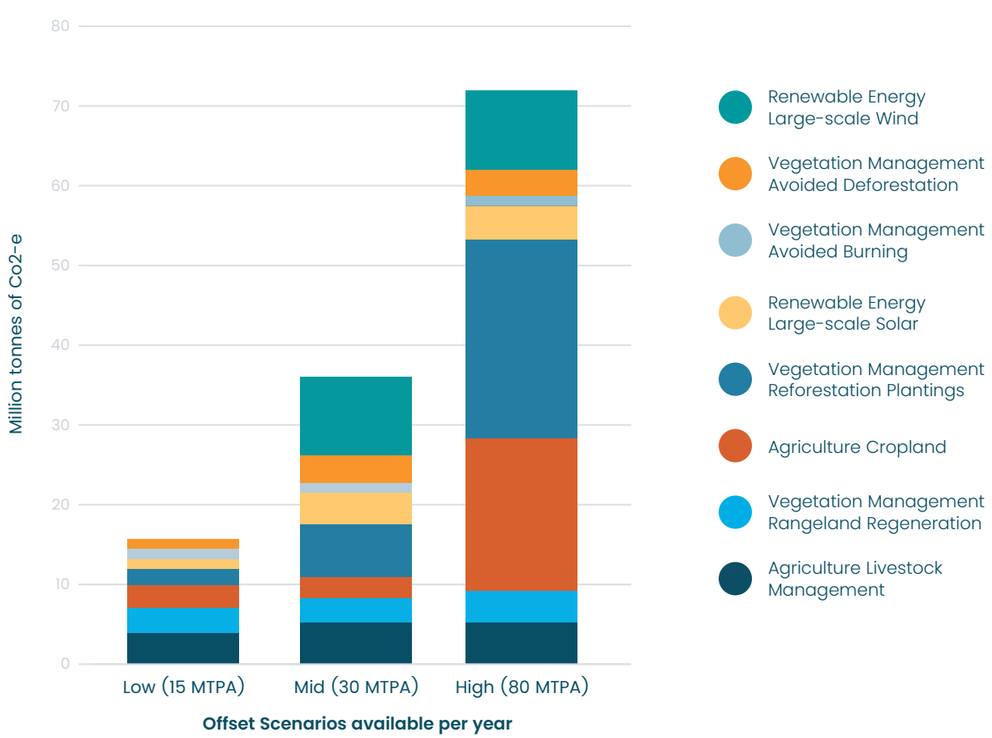
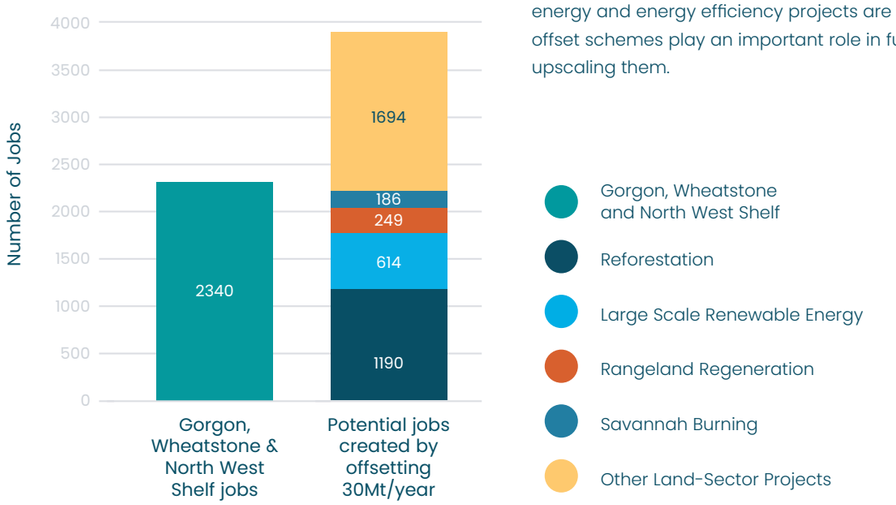


Figure 22: 4000 jobs created by offsetting LNG emissions compared with existing jobs in WA LNG



Offsetting is not a silver bullet

While offsets can play a role as a partial solution to emissions from existing LNG operations, the availability of offsets is limited. Offsets should not be used as a default measure to allow fossil fuel expansion which in turn forecloses opportunities to offset emissions in other parts of the economy where reduction is more difficult, expensive, or not an option. Offsets should only be used once LNG companies have exhausted all possible efforts to reduce their emissions first.

In the words of UN Environment Program:

'Offsets are only part of the answer... If we are serious about averting catastrophic planetary changes, we need to reduce emissions by 45% by 2030. Trees planted today can't grow fast enough to achieve this goal... What we must look at is how these actions sum up to reflect the true cost of emissions and the urgency of their reduction. It cannot simply be a one-for-one model. If one tonne of sequestered CO2 is the price of one carbon credit, we still need to deliver the missing 45 per cent emissions' reduction, as well as the future projected increase.'

The UN Environment Program supports carbon offsets as a temporary measure leading up to 2030, and a tool for speeding up climate action. It also argues renewable energy and energy efficiency projects are critical and offset schemes play an important role in funding and upscaling them.

Clean State LNG Report 2019

Clean State LNG Report 2019

11. The ‘Clean Gas’ Myth

Claims are often made by the gas industry that LNG is ‘cleaner’ than coal and it’s needed for a ‘transition’ to a low carbon future. Federal Minister for Emissions Reduction Angus Taylor has even made the claim that Australia’s gas exports are good for the climate by reducing emissions overseas. These statements have been found to be unsubstantiated and misleading at a time when the global task of reducing global emissions to zero is more urgent than ever. In this final section we look at the most dangerous myths about gas, and the realities for each.

1. Gas is still a fossil fuel that breaks the carbon budget

Even if global coal use was eliminated overnight, burning the oil and gas we’re already digging up would blow the 1.5 degree carbon budget.

There is a strong and clear scientific consensus that there is too much carbon in the atmosphere. We have surpassed the ‘safe’ level of 350 parts per million (ppm) and have reached one degree of warming. The world is now approaching 415ppm which will make keeping within 1.5 degrees of warming almost impossible.

The implications are simple: there is no room for new fossil fuel development — gas included — within the Paris Agreement goals.

At the most fundamental level, burning more fossil fuels won’t save the climate.

2. Gas is not ‘cleaner’ than coal

Perhaps the most common myth is the claim that gas is ‘50 percent cleaner than coal’. But this doesn’t take into account the emissions across the **full life cycle** of gas, including extraction, processing, transport, and storage in addition to those emitted when it is burned to create energy.

Over a full life cycle analysis research has shown gas does not have much advantage over coal in terms of C02 emissions, and a major international review of LNG infrastructure released in July 2019 found the threat to the climate from LNG is ‘as large or larger than coal’.

Achieving **net-zero emissions** by 2050 is essential to limit global warming to 1.5 degrees. Research by Carbon Tracker shows that even if global coal use was eliminated overnight, burning the oil and gas reserves already being exploited will take the world past 1.5ºC. [42]

Key finding

Requirements for Chevron, Shell and Woodside to offset their pollution would create around 4000 jobs in WA.

3. The methane problem

When we consider methane, a far more potent greenhouse gas than CO2, elevated methane levels negate any ‘advantage’ over coal.

Carbon dioxide emissions are only one part of the picture. Gas is mostly methane, an extremely potent greenhouse gas that traps 86 times more heat than CO2 over a 20-year period. Methane is responsible for 25% of global warming to date.

When the gas industry claims that gas is ‘cleaner’ than coal, it’s ignoring the huge amounts of methane released into the atmosphere at all stages of its lifetime, known as ‘fugitive emissions’. These emissions escape during drilling and extraction, transportation in pipelines and storage, and eventual combustion. It’s estimated to be as much as 9% of the entire volume of the gas resource.

The IPCC Special Report modelled pathways that limit global warming to 1.5ºC – all involved deep reductions to methane and gas emissions. Yet Australia’s fugitive emissions have increased by 60% since 2004.43
Fugitive emissions are now the fifth largest source of greenhouse gas emissions in Australia and growing.

A series of reports including a recent study in *Science* has shown that gas’s lifecycle methane emissions are much higher than previously estimated, which only further undermines the notion of any climate advantage over coal. [44] [45]

4. Australian gas is not reducing emissions overseas

The gas industry and Australian Government has claimed LNG has the potential to lower emissions in import countries by around 148Mt per year. [46] [47] This report finds this claim to be unfounded and misleading.

According to the IEA report The Role of Gas in Today’s Energy Transitions, most of the push for coal-to-gas switching in China is occurring in areas to replace coal-fired boilers in residential and industrial settings (which are a major contributor to poor air quality), not power plants. This report found no evidence of gas replacing coal in any power stations overseas to date.

The truth is, Australia is now the world’s largest exporter of coal,[48a] which means our gas is being burnt overseas in addition to coal not instead of! And for every tonne of LNG produced in Australia around 2.8 tonnes of greenhouse gas pollution is emitted when combusted in a second country.[48b] Australia exported 70 million tonnes of LNG in 2018, which will emit 197 million tonnes of CO2 when burned. That’s additional emissions. Not ‘savings’.

The only thing that would genuinely reduce emissions overseas is to export or encourage the adoption of renewable energy.

The reality is our gas is being burnt in addition to – not instead of – coal, and our exports are significantly increasing global emissions.

5. Large-scale, low-cost renewables can now displace both coal and gas

In most markets bulk renewables – utility scale wind and solar power plants - are now the cheapest form of power and are already able to compete with new coal or gas plants on a levelized cost of energy (LCOE) [49] basis in Germany, the United Kingdom, China, Australia, and the United States. [50]

Even the CEO of Australia's largest energy company AGL has stated the transition from a coal-power-dominated grid to low-carbon generation will largely bypass or leapfrog 'baseload' gas, and instead shift straight to large-scale wind and solar. [51]

Wind and solar plants coupled with battery storage are also getting cheaper. The price of dispatchable, storable renewable energy, unlike the volatile gas market, is tied only to technology costs that are going down almost exponentially. Recent forecasts suggest it may be cheaper to build new renewables plus storage than to continue operating natural gas plants by 2035. [52]

Even if we ignored the climate problems, based just on the economics the time is up on gas.

6. New gas projects will only lock in another 40–60 years of pollution

Gas is a 'transition fuel' to a cleaner economy. The reality is that building new gas infrastructure requires **massive** multibillion-dollar investments and **decades** of operation to becoming profitable.

No investors today expect to retire their asset earlier than 30 years into its lifetime at a minimum, meaning gas plants being built or expanded today could still be operating beyond 2050, when we know emissions must be net zero. **Woodside wants to continue producing LNG from its proposed $44 billion Burrup Hub expansion until 2070!**

The IPCC Special Report shows that gas use for energy and methane emissions need to reduce significantly and immediately in order to have any hope of meeting Paris Agreement. The report modelled pathways that limit global warming to 1.5ºC which required a reduction in primary energy produced by gas of 25% in 2030 and 74% in 2050, with renewables projected to supply up to 85% of electricity by 2050.

Global gas demand will peak and decline within the next 10-15 years as the world implements the Paris Agreement. The inevitable phase out of gas combined with the falling cost of renewable alternatives will make new LNG projects untenable and unprofitable in the long term and throw into question their financial viability. A recent report found at least 202 LNG terminals worth $1.3 trillion are in development worldwide and called for a moratorium on new gas infrastructure given the high risk of these investments becoming stranded assets. [53]

By locking in decades of carbon pollution, any new LNG expansion is on a collision course with the Paris Agreement and is at a very real risk of becoming a stranded asset.

7. To achieve the Paris goals and stay within the IPCC carbon budget, gas use needs to reduce not increase.

The IPCC has said the world needs to be half decarbonized by 2030, and fully decarbonized by 2050 to keep within 1.5 degrees of warming.

To achieve this it has calculated a 'carbon budget' (below) which shows it is crucial for emissions to begin falling after 2020. Any delay to this will make the trajectory to net zero emissions technologically and economically impossible to follow.

While the gas industry claims that gas is 'helping' us transition to a safe climate, the reality is time is running out to make the deep cuts necessary to meet the Paris targets.

This is why energy and climate analysts are calling for a moratorium on LNG development globally. The increasing and uncontrolled emissions of the LNG industry are in breach of the Paris Agreement and the best available science.

The truth is, if emissions continue to rise beyond 2020 or even remain level, the IPCC temperature goals set in Paris become almost unattainable.

Figure 23: Trajectories to reach net zero by 2050 based on international carbon budget

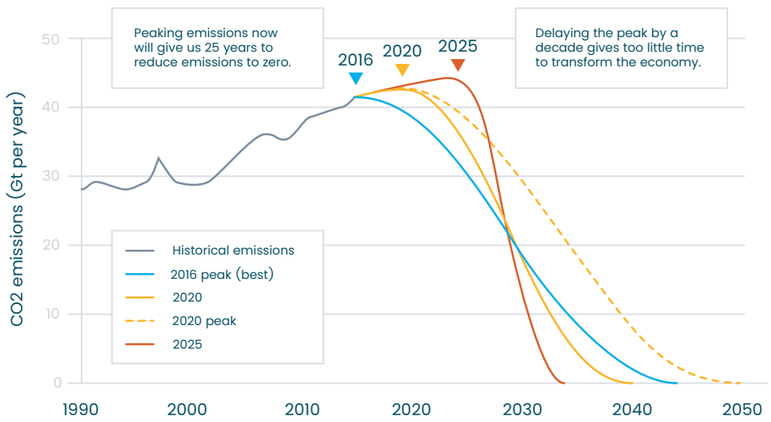


Figure adapted from the IPCC and Global Carbon Project.

Conclusion

This report presents the first thorough investigation of direct carbon emissions from Western Australia's LNG industry, revealing alarming growth in pollution that is placing Australia's Paris Agreement targets in jeopardy and undermining Australia's national efforts on climate change.

While other states have achieved emissions reductions since the 2005 Paris baseline year, rapid growth in WA LNG pollution has effectively canceled out these benefits - instead causing Australia's overall carbon pollution to rise significantly over this time.

The report considers only direct emissions from extracting and processing gas, and does not consider even greater pollution from the combustion of the gas overseas. Despite this, **uncontrolled direct pollution from just two companies – Chevron and Woodside – is already cancelling out the gains made by all solar and wind energy across the entire continent.** If further proposed WA LNG expansions go ahead, the WA LNG sector will be responsible for almost half of Western Australia's total pollution from all sources.

This report shows that WA Government measures to control and regulate carbon pollution from LNG have been, and remain totally ineffective at constraining pollution growth from the sector. Where conditions to control pollution have been imposed on some LNG projects, they are inconsistent, inadequate, unenforceable, and in some cases have been removed altogether.

As a result, runaway pollution growth from the WA LNG sector has had a dramatic impact on total emissions for WA and Australia and is undermining progress being made on climate change in other states. WA LNG pollution already accounts for 36% of WA's total emissions and 6% of national emissions. If Woodside's proposed Burrup Hub expansion is approved and the Browse and Scarborough fields are exploited, LNG emissions will account for almost half of WA's total annual emissions, and almost 8% of Australia's annual emissions.

Emissions from LNG production in WA was also compared to other major emissions sources. Factoring in further expansions proposed by Woodside, WA LNG emissions were found to be more than one quarter (28%) of total pollution from Australia's existing fleet of coal fired power stations, and 96% of the pollution from every single passenger vehicle in Australia. WA LNG pollution is comparable to the total annual emissions of Ireland and Switzerland, Sweden and Hong Kong.

Under the Paris Treaty, Australia has committed to reducing total national greenhouse gas emissions by 26-28% below its 2005 level by 2030. Immediate action to reduce emissions is necessary under the Paris Agreement, and is supported by the IPCC 1.5° special report. **This report finds that increases in WA LNG pollution are in breach of the carbon budgets and science underpinning the Paris Agreement and are fundamentally at odds with what is needed to meet the Paris Agreement long-term global temperature goal.**

A focus of this research has been investigating the impact of emissions from WA LNG projects that have commenced operations since Australia's 2005 Paris baseline year, to determine the impact on our state and national emissions baseline, and our ability to reach the Paris emissions reduction targets. **Emissions from WA LNG projects that have commenced operation since 2005 together with proposed expansions will add 41.6Mt C02e pollution every year, which represents a 61% increase relative to WA's 2005 baseline and an 8% increase relative to Australia's 2005 baseline.**

Growth in pollution from WA LNG operations since 2005 effectively adds 8% to Australia's current emissions reduction target, increasing it to 33-35% by 2030, forcing all other sectors of the economy to compensate for WA's runaway growth in LNG pollution. To achieve the modest target of 26-28% emissions decrease on 2005 levels by 2030, WA's total annual emissions will need to drop to 49Mt - however without any controls, emissions from current and proposed LNG facilities will be 41.6Mt – or 85% of this amount.

WA LNG emissions were also found to be fundamentally undermining Australia's national efforts to tackle carbon pollution:

- Just 12 years' of WA LNG emissions will cancel out the entire abatement expected to be delivered by the $4.5 billion Emissions Reductions Fund (ERF)
- Annual WA LNG pollution is 1.2 times greater than the annual carbon savings delivered by all installed renewable energy capacity under the Renewable Energy Target (RET)
- Annual WA LNG emissions are almost five times greater than the annual carbon savings delivered by Australia's 2.1 million solar rooftops.

The report also investigated commonly heard claims made about gas contributing to global efforts to tackle climate change, through claimed displacement of other dirtier fuels. Such claims were found to be misleading and dangerous. Gas is a polluting fossil fuel that is competing with renewable energy in global efforts to phase out the use of coal. Considered across its entire lifecycle, elevated methane levels as well as emissions from gas production negate any 'advantage' over coal.

A major international review of LNG infrastructure found that the threat to the climate from LNG is 'as large or larger than coal' and the IPCC has said that global gas use must decline, not increase in order to meet global climate targets. New gas projects will lock in another 40-60 years of carbon pollution and are at high risk of becoming stranded assets given that large-scale, low cost renewables and storage can now displace both coal and gas.

Despite the alarming size and scale of Western Australia's LNG pollution problem, solutions have been proposed that have the potential to prevent this pollution burden from being transferred to Australian taxpayers or businesses. For example, the WA Environmental Protection Authority has recommended that WA Government conditions be reinstated and strengthened, to require that WA LNG companies offset emissions through investments in activities such as tree planting, carbon farming and renewable energy.

Previous analysis has identified the potential to deliver 80 million tonnes of emissions offsets per year here in Western Australia, and that offsetting current WA LNG emissions would create 4,000 jobs in the state. These carbon pollution offset activities would not only deliver economic benefits to regional Western Australia, but could also provide very significant benefits to WA's natural environment.

The runaway emissions of WA's LNG industry have gone largely unnoticed in Australia's national debate on climate change, but they can no longer be ignored. Carbon pollution from a handful of very large LNG projects dominated by Woodside and Chevron is already cancelling out the entire savings of all installed renewable energy under the nation's Renewable Energy Target (RET) and cancelling out the emissions reductions being achieved in other Australian states.

This report strengthens the case for immediate action to update Western Australia's policy approach for assessing and controlling pollution by WA's LNG industry.

Failure to implement effective controls will inevitably result in an extremely large carbon pollution reduction burden and associated cost being transferred to Australian households and businesses. Another abatement program at the same size and scale of the Emissions Reduction Fund or Renewable Energy Target will be required to counter just the existing and future pollution growth from the WA LNG industry.

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[10] Under Ministerial statement 873 a condition of approval by the WA government was to 'prepare a GHG abatement program that demonstrates the proposal is designed and operated in a manner which minimizes GHG emissions as far as practicable' and Condition 19.9 specifically required an offset package to offset the reservoir CO2 released into the atmosphere from the proposal at a minimum. Under the Safeguard mechanism Chevron has a calculated emissions baseline of 4.09mta.

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[31] http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/about

[32] http://www.cleanenergyregulator.gov.au/ERF/Auctions-results/december-2018

[33] The Clean Energy Regulator expects about 4000 megawatts of Large-scale capacity will be accredited in 2019, taking the total to around 8400 megawatts generating since 2017. 2018 was a record-breaking year for new Large-scale renewable energy power stations and Small-scale solar PV installations for households and businesses. Total renewable capacity installed under the Renewable Energy Target more than doubled from 2.2 gigawatts in 2017 to 5 gigawatts in 2018. At http://www.cleanenergyregulator.gov.au/About/Pages/Events/Smart%20Energy%20Conference%20and%20Exhibition%202018/Developments-and-trends-in-the-renewable-energy-target.aspx and http://www.cleanenergyregulator.gov.au/DocumentAssets/Documents/The%20Renewable%20Energy%20Target%202018%20Administrative%20Report.pdf

[34] Climate Change Authority (2014) Renewable Energy Target Review Report. December 2014. Chapter 2p20. Modelling for the Warburton review (2014, p. 41) by the Climate Change Authority showed the RET would reduce emissions by this amount relative to a scenario in which the RET was repealed. (CCA 2014a, ***Targets and Progress Review—Final Report***, Melbourne, and CCA 2014b, ***Light Vehicle Emissions Standards for Australia—Research Report***, Melbourne cited in https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Direct_Action_Plan/Report/c07

[35] Climate Change Authority (2014) Renewable Energy Target Review Report. December 2014. Chapter 2p20. Modelling for the Warburton review (2014, p. 41) by the Climate Change Authority showed the RET would reduce emissions by this amount relative to a scenario in which the RET was repealed. (CCA 2014a, ***Targets and Progress Review—Final Report***, Melbourne, and CCA 2014b, ***Light Vehicle Emissions Standards for Australia—Research Report***, Melbourne cited in https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/Direct_Action_Plan/Report/c07

[36] Harries (2018). WA LNG industry and GHG Emissions: A Report Prepared for the Conservation Council of Western Australia. Tyto Energy and Environmental Consulting, Wembley, WA.

[37] Clean Energy Regulator publishes monthly installation figures at http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations#Smallscale-installations-by-installation-year

[38] State/territory PV electricity generation data can be multiplied by the specific state and territory GHG emission factors (tonnes CO2e/MWH) obtained from the National Greenhouse Accounts Factor for electricity generation in each state or territory and used to calculate the reduction in GHG emissions achieved by the solar PV systems in each state or territory. The annual figures of solar PV production for 1 May 2017–30 April 2018 of 8099297Kwh were disaggregated by state and multiplied by an emission factor for each state, arriving at a total of 6.37Mt CO2-e GHG emissions avoided. To update the figure for 2019 we simply extrapolated the average amount of GHG avoided per GW (8.1Gw total generated/6.369 GHG emissions avoided = 1.27Mt avoided per GW. Therefore 8.56Gwh generated / 1.27 = 6.74Mt GHG avoided). We based our calculations on those used by Harries (2018) WA LNG industry and GHG Emissions: A Report Prepared for the Conservation Council of Western Australia. Tyto Energy and Environmental Consulting, Wembley, WA

[39] Reputex Energy (2018) 'Offsetting Emissions from Liquified Natural Gas Projects in Western Australia, November 2018

[40] ACIL Allen Consulting. 2018. ***Economic contribution of Chevron in Australia.*** At https://australia.chevron.com/-/media/australia/publications/documents/acil-allen-report-snapshot.pdf

[41] Reported in The Australian, 22/10/18

[42] https://www.carbontracker.org/reports/breaking-the-habit/

Clean State LNG Report 2019

[43] Quarterly Update of Australia's National Greenhouse Gas Inventory for the March Quarter 2019 at http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/quarterly-update-australias-nggi-mar-2019

[44] http://science.sciencemag.org/content/early/2018/06/20/science.aar7204

[45] https://www.vox.com/energy-and-environment/2018/7/13/17551878/natural-gas-markets-renewable-energy

[46] https://theconversation.com/australias-energy-exports-increase-global-greenhouse-emissions-not-decrease-them-118990

[47] In a clarifying statement, the Department compared the emissions that would be produced from the combustion of Australia's LNG exports for the year to December 2018 against the emissions generated from the combustion of an equivalent amount of energy of black coal. Under this comparison, the combustion of LNG exports would generate 197.1Mt CO2-e, which is around 148Mt CO2-e less than the emissions generated by the combustion of the same amount of energy of black coal (345.1Mt CO2-e).' at https://www.theguardian.com/environment/2019/jun/07/angus-taylors-claim-lng-exports-reduce-global-emissions-likely-wrong-climate-expert

[48a] http://www.worldstopexports.com/coal-exports-country/

[48b] According to then Federal Department of Climate Change in 2011, these figures are a rule of thumb estimate, supported by evidence found in a number of Australian LNG project Environmental Impact Statement documents, Answers to Questions on Notice Department of Climate Change and Energy Efficiency, ***Program 1.1*** Question on Notice No.17 at https://greensmps.org.au/articles/worley-parsons-lng-emissions-report

[49] LCOE is a measure of a power source that allows comparison of different methods of electricity generation on a consistent basis

[50] OCI cited in https://www.vox.com/energy-and-environment/2019/5/30/18643819/climate-change-natural-gas-middle-ground

[51] https://reneweconomy.com.au/agl-kills-idea-of-gas-as-transition-fuel-wind-solar-storage-cheaper-63013/

[52] https://www.vox.com/energy-and-environment/2018/7/13/17551878/natural-gas-markets-renewable-energy

[53] The New Gas Boom (2019) at https://globalenergymonitor.org/new-gas-boom/

[54] Australia's emissions in 2005 were 532MtCO2-e : https://www.abc.net.au/news/2015-08-11/clay-how-does-australias-emissions-target-stack-up/6688942 citing National Greenhouse Gas Inventory at http://ageis.climatechange.gov.au/

[55] North West Shelf. Approved for 7.7-9.4MtCO2-e http://www.epa.wa.gov.au/sites/default/files/EPA_Report/924_B962.pdf Woodside's North West Shelf project's emissions of 7.6 million tonnes a year will rise substantially next decade if it processes gas as planned from the Browse project. Due to the high CO2 content of the gas and the energy required to pump it 900km to the NWS plant, Browse's offshore operations would emit an average of four million tonnes of CO2 a year for 50 years, according to a company environmental submission in November, but this estimate did not include the liquefaction of the gas onshore that is usually the dominant source of emissions for an LNG project.

[56] https://www.australianmining.com.au/oil-gas/woodside-to-create-thousands-of-jobs-at-burrup-hub/

[57] https://www.woodside.com.au/our-business/pluto-lng

[58] Currently Pluto is emitting approximately 2MtCO2-e and the total approved emissions is 4.1MtCO2-e under EPBC 2006/2968. (Pluto is currently one LNG processing train producing 6Mt of LNG. After 5 years, when the second LNG train comes online, and the total LNG production reaches 12Mt , this would increase to approximately 4.1MtCO2-e of CO2-e. Carbon pollution from Woodside's Pluto project will rise from the to 4.1MtCO2-e if a second LNG train is added to process gas from the new Scarborough field). Sources: Page 342 of Scarborough Offshore Project Proposal Submission June 2019 to NOPSEMA at https://www.nopsema.gov.au/assets/epdocuments/A679881.pdf p. 23 of the report, Pluto LNG Development, Burrup Peninsula: Woodside Energy Ltd, Report and recommendations of the Environmental Protection Authority (Environmental Protection Authority Perth, Western Australia, Report 1259) http://www.epa.wa.gov.au/sites/default/files/EPA_Report/2533_Bull1259.pdf

[59] Gorgon, Chevron. NOPSEMA Decision Notification 15th August 2016.

[60] Gorgon: Calculations based on proponent information released in documents as part of several Environmental Impact Assessment processes, including EPA reports 1221, 1323, 1394 and 1539. The Australia Institute estimate the average or peak total CO2 emissions before CCS are 8.5 to 10Mt per year and 5.1 to 6Mt after CCS per year. Source: Gorgon-tuan Problem. Tom Swann. November 2018 at https://www.tai.org.au/sites/default/files/P635%20Gorgon-tuan%20Problem%20%5BWeb%5D.pdf. It has been reported that the Gorgon LNG plant had all its three trains in production for just a third of the 2019 year and emitted nine million tonnes to be the State's biggest carbon polluter. Under the Federal Government's safeguard mechanism, Gorgon must limit its average annual emissions to less than 8.35 million tonnes over the three years to mid-2020. Source: https://thewest.com.au/business/energy/future-emissions-shock-for-was-major-lng-players-ng-b881143493z.

[61] https://australia.chevron.com/our-businesses/wheatstone-project

[62] Wheatstone. Chevron state the Project will emit 10.4 million tonnes per year , Page 97 Final Environmental Impact Statement/ Response to Submissions on the Environmental Review and management Program for the Proposed Wheatstone Project. February 2011 at https://australia.chevron.com/-/media/australia/our-businesses/documents/volume-1-final-environmental-impact-statement-response.pdf

[63] Shell Australia Prelude FLNG Environment Plan Summary p9 https://www.nopsema.gov.au/assets/epdocuments/A535000.pdf

[64] Prelude: Shell Australia Prelude FLNG Environment Plan Summary page 9 at https://www.nopsema.gov.au/assets/epdocuments/A535000.pdf
Source: Page169 of Prelude Floating LNG Project: Draft Environmental Impact Statement (Shell Development (Australia) Proprietary Limited, EPBC 2008/4146) and confirmed by the Minister for Climate Change and Energy Efficiency stating the Department Question No 339 answered 6 December 2010, https://www.shell.com.au/promos/sustainability/prelude-eis/_jcr_content.stream/1475632907147/15a771833defe107c1336c8a4854a95607408b1d/prelude-eis.pdf

See also https://greensmps.org.au/articles/greenhouse-gas-emissions-projected-lng-projects

See also reports it is permitted to emit 2.7MtCO2-e when in production. Prelude emitted more than 250,000 tonnes during a year without production, at https://thewest.com.au/business/energy/future-emissions-shock-for-was-major-lng-players-ng-b881143493z and see also http://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/North%20West%20Shelf%20Project%20Extension%20Proposal%20Section%2038%20Referral%20Supporting%20Information.pdf

[65] http://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/North%20West%20Shelf%20Project%20Extension%20Proposal%20Section%2038%20Referral%20Supporting%20Information.pdf

[66] As part of the Burrup Hub expansion it's proposed the Browse gas field will be exploited to replace the gas feeding the North West Shelf which is expected to run dry in the 2020s, and will emit an additional maximum annual emissions of 7MtCO2 just from flaring and pumping gas 900km to the NWS plant inclusive of all vented reservoir gas over 50 years of operation, according to page 29 at http://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/Browse%20to%20NWS%20Development%20Supporting%20Document.pdf

Liquification onshore at the North West Shelf facility is not included in that estimate and we estimate to be 7.6Mt CO2-e the same as the current North West Shelf operations. Browse is being approved by stealth, by carving it up into 7 separate components. Our calculations therefore include emissions from continued operation of the North West Shelf LNG facility.
Source: Page 4 EPBC Act referral. Submission #3836 - Scarborough Development nearshore component. Scarborough Development nearshore component at http://epbcnotices.environment.gov.au/_entity/annotation/b0d328fd-f906-e911-931a-00505684324c/a71d58ad-4cba-48b6-8dab-f3091fc31cd5?t=1545800733411 and https://www.woodside.com.au/our-business/burrup-hub/scarborough-to-pluto

[67] EPBC Act referral. Submission #3836 - Scarborough Development nearshore component Title of Proposal - Scarborough Development nearshore component P4. http://epbcnotices.environment.gov.au/_entity/annotation/b0d328fd-f906-e911-931a-00505684324c/a71d58ad-4cba-48b6-8dab-f3091fc31cd5?t=1545800733411

[68] The Pluto project site has environmental approval for a total production capacity of 12 mmtpa, which includes 4-5 mmtpa at the Pluto Expansion (Train 2) liquefaction train, proposed to be developed as a brownfield expansion of the existing plant, and 4.9mmtpa at the existing Pluto facility (Train 1) Source: Pluto LNG Expansion - Commercial Overview 24 July 2019 at https://www.woodmac.com/reports/lng-pluto-lng-expansion-commercial-overview-55967718

[69] The $11 billion Scarborough project will deliver an additional 4-5Mtpa via a 340km pipeline to the existing Pluto facility, and a second train is proposed for processing this gas. The estimated direct emissions for the Pluto LNG Development are in the order of 1.9 Mtpa of CO2e (carbon dioxide equivalent) increasing to approximately 4.1 Mtpa of CO2e when LNG production increases to 12 Mtpa (the greenhouse gas emissions are based on 95% plant utilisation).

Greenhouse gas emissions associated with the two trains at the Pluto Gas Plant were assessed and approved under the Western Australian Environment Protection Act 1986 and Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC 2006/2968 and Ministerial Statement 757). The total approved greenhouse gas emissions were 4.1 MMtCO2e/yr. The Pluto Gas Plant currently emits approximately 2 MM tCO2e/yr. Additional emissions attributed to expansion will fall within the remaining 2.1 MMtCO2e/yr.

Offshore and marine construction emissions are anticipated to be in the order of 470 000 tonnes of CO2e and drilling will contribute a further 50 000 tonnes of CO2e. As with onshore construction emissions, these should be considered as order of magnitude estimates as the facility design process is ongoing and details of construction activities are still under development. Source: Page 61-63

Public Environmental Review EPBC Referral 2006/2968 Assessment No. 1632 December 2006 at http://www.epa.wa.gov.au/sites/default/files/PER_documentation/1632-PER-PLUTO%20LNG%20PER.pdf and Page 342 of Scarborough Offshore Project Proposal Draft for Public Comment – June 2019 Page 342 at https://www.nopsema.gov.au/environmental-management/offshore-project-proposals/offshore-project-proposals-public-comment/scarborough/.

Appendix

Details of currently operating and proposed LNG facilities in Western Australian and Commonwealth Waters at full capacity

		Project	Operator	Start	End date	LNG production Capacity (Mt)	Greenhouse Gas Emissions (MtCO2-e)	% above WA 2005 levels (68MtCO2-e)	% above Australian 2005 levels (532MtCO2-e)[54]
Current projects	Pre 2005	**North West Shelf (NWS) Project**	Woodside NWS joint venture (JV) (inc. BHP, BP, Chevron, Japan Australia LNG, Shell)	1989	Mid 2020s	(16.9)	(7.6)[55]	-	-
	Post 2005	**Pluto LNG**	Woodside JV (inc. Kansai Electric and Tokyo Gas)	2012	40 years[56]	4.9[57]	2[58]	2%	0.4%
		Gorgon LNG+	Chevron JV (inc. ExxonMobil, Shell, Osaka Gas, Tokyo Gas and JERA)	2016	50 years[59]	15.6	9.74[60]	15%	1.8%
		Wheatstone LNG	Chevron JV (inc. KUFPEC, Woodside, Kyushu Electric, JERA)	2018	30 years[61]	8.9	10[62]	15%	2%
		Prelude LNG^	Shell JV (inc. Inpex, CPC, KOGAS)	2018	25 years[63]	3.6	2.3-2.7[64]	4%	0.5%
		Total current				**33**	**24.4**	**36%**	**4.7%**
Burrup Hub including proposed expansion[#]		**Browse Basin ^*** (Offshore emissions)	Woodside JV (inc. Shell, BP, PetroChina, Mitsui-Mitsubishi)	2021-2	2070	n/a	7[66]	10%	1.3%
		NWS Project Extension (Onshore processing)	Woodside NWS JV (inc. BHP, BP, Cevron, Japan Australia LNG, Shell)	2026	2070[65]	16.9[##]	7.6[66]	11%	1.4%
		Scarborough ^** (Offshore emissions)	Woodside/BHP	2023-30	2055	n/a	0.5[69]	0.7%	0.1%
		Pluto (Existing Train 1)	Woodside JV (inc. Tokyo Gas, Kansai Electric)	2012	40 years	(4.9)	(2)	(2%)	(0.4%)
		Pluto Expansion (Proposed Train 2)	Woodside JV (inc. Tokyo Gas, Kansai Electric)		2055[67]	12[68]	2.1[69]	3%	0.4%
		Total proposed				**28.9**	**17.2**	**25%**	**3.2%**
		(Total Burrup Hub)				**(28.9)**	**(19.2)**	**(28%)**	**(3.6%)**
		Total post 2005 (current and proposed projects)				**61.9Mt**	**41.6MtCO2-e**	**61%**	**7.9%**

Note: The Burrup Hub and proposed expansion is the subject of a separate Clean State/CCWA briefing paper.

Note: Emissions from Ichthys (8.9MtCO2-e) and Crux (3MtCO2-e) located off WA but processed in NT not included but total a further 11.9MtCO2-e.

+ Chevron announced commencement of its geosequestration project on 8th August 2019 with the target to capture 80% of its reservoir gas, bringing emissions down to 5.1-6Mt with CCS. However for the purposes of this report, given the technology is unproven, the condition is not enforceable, and the time it will take to sequester a significant amount of carbon pollution, we have not included the claimed emission reduction as part of this report.

^ LNG fields located in commonwealth waters but counted against WA emissions for the purpose of this study and as listed by the Office of the Chief Economist.

[#] The Burrup Hub Expansion includes a number of activities currently being advanced simultaneously: Scarborough; Pluto Train 2; Browse to NWS Project; NWS Project Extension and Pluto-NWS Interconnector. (Source: Woodside September 2019 Scarborough Overview)

*The Browse project ($24bn) is the largest untapped conventional gas resource in Australia. If approved, gas from the Browse basin will replace that of the North West Shelf, which is expected to run dry in the 2020s, and become the most emissions-intensive LNG development in Australia. It will emit an additional 7MtCo2e just from venting and pumping gas 900km to the NWS facility. It is being approved by stealth, and has been carved up into 7 separate components to conceal the true impact of its total emissions. Browse is being approved by stealth, by carving it up into 7 separate components.

**The Scarborough project ($11bn) will deliver an additional 4-5Mt to the existing Pluto facility onshore via a 340km pipeline and adding a second train onshore for processing. In total, the Pluto facility will process 12Mtpa onshore according to Woodside, and according to the project proposal just submitted to NOPSEMA, has been approved to emit a total of 4MtCO2-e combined.

[##] based on production capacity of the North West Shelf

Clean State

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info@cleanstate.org.au

November 2019

renewWA

Reliable Jobs, Renewable Energy and a Safe Future for All - A Joint Call for Climate Action in WA

Doctors for the Environment Australia

Uniting Church in Australia Western Australia

Conservation Council of Western Australia ccwa Look forward

Citizens' Climate Lobby

UNIONSWA

FCA

Catholic Earthcare Australia

WA Landcare Network

Wilderness Society Life. Support.

350 Perth

Public Health Association Australia

Anglican EcoCare Diocese of Perth

CJU Climate Justice Union

Curtin University Sustainability Policy (CUSP) Institute

Curtin University

wacoss wa council of social service

renew.

Sustainable Energy Now www.sen.asn.au

ShelterWA

TENANCYWA Community Legal Centre for Tenants

Ethical Advisers' Co-op

Quakers Australia

ICWA The Islamic Council of Perth Western Australia

Save Beeliar Wetlands

Catholic Archdiocese of Perth

Caritas Australia

JEDO

PBM

CENTRECARE "People Making Time for People"

Ban Uranium Mining Permanen

Buddhist Council of Western Australia

ARRCC Australian Religious Response to Climate Change

Nuclear Free WA

Reliable Jobs, Renewable Energy and a Safe Future for All – A Joint Call for Climate Action in WA

RenewWA signatories make the below statement and call for climate action in WA:

Western Australia has enormous potential to benefit from the transition to a clean, renewable energy powered economy. Climate action, including requirements for WA's largest polluters to offset greenhouse gas emissions, has the potential to deliver thousands of new jobs across regional Western Australia and Aboriginal communities in carbon farming, tree planting, Indigenous Ranger programs, renewable energy and other industries. With rich renewable energy resources, abundant supplies of battery metals and potential to generate renewable-derived Hydrogen for export, WA has a bright future ahead if the benefits of a clean energy economy are supported by strong government action on climate change.

This is our opportunity to transition to a renewable energy economy with reliable, quality jobs for Western Australian workers and maintain a safe climate for all.

Despite these opportunities, WA remains one of only two states in Australia with no renewable energy target, and the only state with significant growth in carbon pollution. The failure to control pollution from the WA Liquefied Natural Gas (LNG) industry is responsible for Australia's national emissions growth and is putting Australia's commitments under the Paris Agreement on climate change at risk.

RenewWA welcomes the State Government's recent announcement committing to net zero emissions by 2050. To ensure that this target is achieved and aligns with the guidance of the Intergovernmental Panel on Climate Change (IPCC), interim targets are also required.

It is clear that the Australian Government is not providing effective or comprehensive climate change policy solutions at a national level and WA is missing out on the renewables boom while its LNG resources continue to be extracted with minimal benefit back to the community.

RenewWA organisations believe it is essential that the State Government lead action to control WA's rising carbon pollution through a whole of government, whole of economy and whole of community approach.

The members of RenewWA call for immediate action on climate change by the State Government for the sake of workers, communities and future generations, which must include the following essential elements:

- **Just Transition:** Support for workers and communities to transition from fossil fuel industries so that we leave nobody behind. Greater investment is needed in alternative industries to provide paid training and skills development for workers to move without disadvantage into reliable, quality local jobs and to take advantage of our abundant renewable energy resources and high-skilled workforce.

- **Immediate reduction of carbon pollution:** The Paris Agreement demands an immediate reduction in carbon pollution, and this is a critical goal that must be reflected in WA Government climate change policy.

- **Science-based targets for WA:** Science-based carbon pollution reduction targets must be adopted for WA in order to ensure that our state makes a fair and equitable contribution to global climate change efforts, consistent with the Paris Agreement. Interim targets must be adopted to achieve the global need to reduce carbon pollution to net zero emissions by 2050.

- **Controls on LNG pollution:** Requiring existing LNG projects to reduce and offset emissions is an essential first step in controlling WA's emissions growth and delivering new jobs in clean industries in regional WA communities. LNG developments must be required to offset all pollution as recommended by WA's independent Environmental Protection Authority and offsets must be made with local projects.

- **A Just Transition away from gas extraction:** Gas as a fossil fuel contributes significantly to climate change and a just transition away from gas extraction is needed. Recent reports[1] have identified that the threat to the climate from LNG expansion is as great as, or greater than coal. The IPCC has identified the median near-term reduction for natural gas use as 15% by 2030 and 43% by 2050 in order to meet the temperature goals established under the Paris Agreement.

- **Protecting and increasing natural carbon stores:** Action is needed to rapidly reduce logging and land clearing to protect natural carbon stores and support natural carbon sequestration and habitat including revegetation, ecosystem restoration and tree-farming. Support is required for regenerative agriculture and community driven land care and natural resource management.

- **Supporting vulnerable households and communities:** Low-income households, older people and people with poorer health are particularly vulnerable to the health impacts of heatwaves and rising temperatures. Access to low-cost energy from residential solar, batteries or energy-efficient appliances is currently out of reach for many, especially if they don't own their own home. Investment in schemes to provide access to affordable renewable energy and energy efficiency measures needs to be prioritised, including in regional and remote areas.

350.org
Anglican EcoCare Commission, Anglican Diocese of Perth
Alternative Technology Association, *trading as Renew Australia*
Australian Religious Response to Climate Change
Buddhist Council WA
BUMP (Ban Uranium Mining Permanently)
Caritas Australia
Catholic Archdiocese of Perth
CentreCare
Catholic EarthCare Australia
Citizens' Climate Lobby
Climate Justice Union
Conservation Council WA
Curtin University Sustainability Policy (CUSP) Institute
Doctors for Environment Australia (DEA)
Ethical Advisors Co-op
Farmers for Climate Action
Islamic Council WA
Justice, Ecology & Development Office, Catholic Archdiocese Perth
Nuclear Free WA
Presentation Sisters
Public Health Association of Australia
Religious Society of Friends (Quakers) in Australia
Save Beeliar Wetlands
Shelter WA
Sustainable Energy Now
Tenancy WA
The Wilderness Society
Uniting Church in Western Australia
UnionsWA
WA Council of Social Services
WA Landcare Network

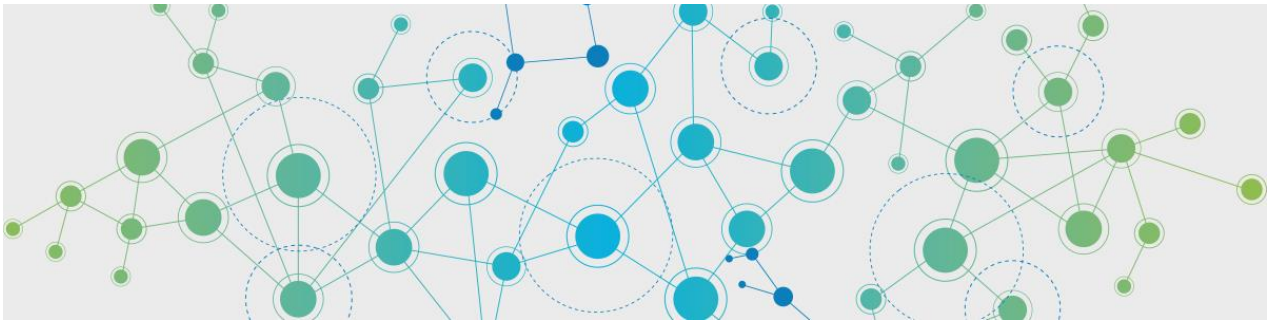
[1] https://globalenergymonitor.org/wp-content/uploads/2019/06/NewGasBoomEmbargo.pdf

RepuTex ENERGY

OFFSETTING EMISSIONS FROM LIQUIFIED NATURAL GAS PROJECTS IN WESTERN AUSTRALIA

For the Conservation Council of Western Australia (CCWA)

November 2018



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Australia

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26 November 2018

Piers Verstegen
Executive Director
Conservation Council of Western Australia
City West Lotteries House, 2 Delhi St,
West Perth, Western Australia

Dear Piers,

OFFSETTING EMISSIONS FROM LIQUIFIED NATURAL GAS (LNG) PROJECTS IN WESTERN AUSTRALIA

In accordance with the Agreement for the Provision of Services dated 20 June 2018 ('Agreement'), RepuTex has been engaged by the Conservation Council of Western Australia (CCWA) for the provision of analysis on the offsetting of LNG emissions in Western Australia.

The enclosed report sets out the outcomes of our work. The scope of our work, including the grounds for any opinion, modelling assumptions and exclusions, are detailed within this Report.

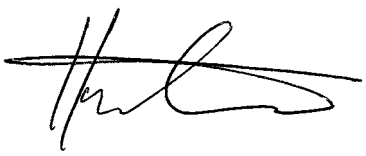
The Report has been prepared for the sole use of the customer, for a specific purpose as stated in the document. Parts of this Report may include assumptions on future policy or market conditions that have been reasonably made based on our professional experience. These assumptions are stated within the Report. As with any analysis that considers future circumstances, caution should be taken when relying on outcomes, with future market dynamics potentially different to actual results.

The Report is structured as follows:

- Sections 1 and 2 provide a summary and background to the engagement;
- Section 3 describes the scope of our analysis and modelled scenarios;
- Section 4 contains our modelling results, including outcomes for offset availability in Western Australia; offset supply and price scenarios to meet modelled demand; implied economic value and offset investment; and regional job creation in Western Australia;
- Section 5 provides two case studies for the co-benefits of implementing different offset projects - a rangelands restoration project, and a renewable energy project in Collie;
- Appendices provide further information on our research models and methodologies.

Should you have any questions please contact me on (03) 9600 0990 or hugh.grossman@reputex.com

Yours Sincerely,



Hugh Grossman
Executive Director
Energy and Carbon Markets

ABOUT REPUTEX

RepuTex is a leading provider of independent analysis and pricing insights for the Australian renewable energy, power and emissions markets.

We have worked with over 150 customers across Australia and the Asia-Pacific, including large energy users and emitters, offtakers and project developers, financials and government departments & agencies.

Since 1999, our insights have become a key reference point for the market, providing our customers with an advanced perspective on the impact of new forces – such as renewable penetration, new energy storage technology and emissions contracting – on price formation and market development.

Our focus is on data-driven insights: In doing so, we draw on our proprietary advanced analytics models to provide our customers with a deeper perspective on evolving market risk and pricing patterns.

We have offices in Melbourne and Hong Kong, supported by a team of analysts with backgrounds in econometrics, statistics, commodities & policy. The company is a winner of the China Light and Power-Australia China Business Award for research across Asia-Pacific.

To learn more, please visit www.reputex.com

CONTENTS

1. EXECUTIVE SUMMARY

Project background

- RepuTex has been engaged by the Conservation Council of Western Australia (CCWA) to analyse the economic benefits of reinstating greenhouse gas (GHG) conditions on Liquified Natural Gas (LNG) projects in Western Australia, specifically the requirement for proponents to offset emissions from LNG developments.
- This Report presents the modelling outcomes of a series of illustrative scenarios, which seek to understand the type and price of carbon offsets that could be available within Western Australia should an offset industry be developed, and the economic benefits of local investment.
- Modelling aligns offset supply with illustrative annual offset demand at three reference levels:
    - **Low Scenario** - Demand for offsets equivalent to 15 million tonne of carbon dioxide per annum (Mtpa), reflecting approximately half of domestic emissions from current LNG facilities;
    - **Medium Scenario** - Demand for 30 Mtpa, reflecting approximately all direct domestic emissions from current LNG facilities;
    - **High Scenario** - Demand for 60 Mtpa, a doubling of the medium scenario, reflecting illustrative demand to offset direct emissions from current and proposed LNG developments.
- In determining the potential availability, cost, and co-benefits of abatement needed meet the above demand reference levels, we draw on our Marginal Abatement Cost (MAC) model to identify potential emissions reduction activities in Western Australia and quantify the total volume and cost of undertaking identified activities. Analysis then considers investment and employment opportunities for Western Australia that are likely to develop as a result of a local carbon offset industry.

Availability of Western Australian abatement

- Issuance of Australian Carbon Credit Units (ACCUs) in Western Australia is currently about 700,000 per annum (p.a.) - derived largely from landfill gas and savannah fire management activities – and represents approximately 10 per cent of the Commonwealth's Emissions Reduction Fund (ERF).
- Considering legal barriers to carbon rights on Western Australian rangelands is now being addressed, we anticipate a quick expansion in 'Human Induced Regeneration' (HIR) projects, doubling Western Australia ACCU issuance in less than two years. The total potential supply of offsets from Western Australia's rangelands, however, is much larger still. Though a combination of expanded methodologies, greater certainty, and higher prices, we estimate Western Australia rangelands alone could generate around 4.5 million ACCUs p.a. by 2030.
- There is a similar potential to create tens of millions of additional offsets per annum though a wider diversity of renewable energy, agriculture and vegetation management activities in Western Australia. In total, Western Australia has the potential to supply in excess of 80 Mt of abatement per annum.

Investment necessary to drive new offset supply in Western Australia

- Should LNG production facilities be required to offset their direct emissions, analysis suggests that Western Australia has ample abatement potential to meet offset demand within the state.
- For the Low Scenario for 15 Mtpa of abatement, modelling suggests a carbon offset price could settle at around $15 per tonne – about the same as the current value of ACCUs. Notably, findings indicate that a considerable supply of around 5 to 6 Mtpa of abatement is available at little to no net-cost to farmers. These offsets could be issued for agricultural (crop and livestock) efficiencies that can both increase yields and reduce agricultural emissions. Such activities would therefore be of a higher value than business-as-usual (BAU) and result in little to no net-cost for the farmer.
- While the market price of offsets from these activities will ultimately be determined by the balance of supply and demand (rather than the underlying net-costs of a project), findings indicate that

Western Australia has ample 'low cost' offset opportunities, should policy be designed to overcome market inefficiencies and unlock this supply.

- A Medium Scenario for 30 Mtpa of emissions reductions would approximately triple investment in offset projects, with carbon offset prices modelled to grow to more than $50 per tonne as 'low-hanging' abatement is contracted, and demand for offsets 'buys its way up the cost curve'. This demonstrates that as prices rise, a greater supply of offsets could become available. Under this scenario, investment in renewable energy sector could play a complementary role to ACCU methodologies, supplying around one third of all offsets.
- Under the High Scenario for 60 Mtpa, forest and rangeland sectors are modelled to supply a large volume of offsets though large-scale and long-term sequestration activities, that may begin to transform land-use practices in the state. This would see carbon offset prices grow to around $100 per tonne, underpinned by the need to unlock higher cost abatement projects.
- The midpoint of the Marginal Abatement Cost Curve for Western Australian abatement is modelled to be about $40 per tonne. While this is higher than current ACCU prices underpinned by the ERF, this should still be competitive against forecast international carbon price benchmarks. For example, in Europe, carbon prices are projected to grow from about A$30 per tonne today to more than A$60 per tonne by 2023 as policy ambition increases.

Economic and employment benefits for Western Australia

- The development of a carbon offset market in Western Australia has the potential to provide significant benefits beyond GHG emissions abatement. These include large economic opportunities for investment and job creation across the state, particularly in regional communities, as well as co-benefits to biodiversity, landscape protection and water quality.
- Should enough demand be realised to create a carbon offset market in Western Australia, analysis indicates that value of the offset industry may range between $81 million (low scenario) to $2.9 billion (high scenario) per annum.
- On an employment per million dollars of investment basis, Savana Burning projects are found to create the largest number of jobs per dollar invested, with 12 jobs per million dollars ($m), followed by Reforestation Plantings (10 jobs/$m), Rangeland Regeneration (9 jobs/$m) and Renewable Energy (5 jobs/$m)
- In total employment terms, these activities are modelled to create around 4,000 jobs under the Medium Scenario. Five out of six jobs of these jobs are expected to be created in the land sector, with the largest portion of jobs in the South West and Southern Rangelands areas.
- Jobs attributed to Reforestation Plantings are expected to be the largest source of new job creation (1,190), reflecting larger investment in that activity, followed by Renewable Energy (614), Rangeland Regeneration (249) and Savanah Burning (186); with all remaining jobs attributed to other land-sector projects (1,694).
- Abatement from the land sector is expected to generate permanent job creation, such as aboriginal rangers, bee keepers, carbon foresters, land managers, stockmen and tree planting contractors, along with indirect employment, such as the service and tourism industries in regional areas.
- Abatement from the renewable energy projects could assist with substituting the coal mining and coal-fired power facility jobs that are declining in the Collie region as generators age and coal plants are not anticipated to be replaced.
- Comparably, large-scale renewable energy projects are expected to create both a net gain int employment and higher paying jobs, which are needed to build not only the solar and wind facilities, but also the new electricity infrastructure needed to access these resources and carry them to electricity consumers. New jobs are also created to operate and maintain large-scale solar and wind energy facilities.

2. BACKGROUND

2.1 LNG project development in Western Australia

Western Australia currently has four operating liquefied natural gas (LNG) projects: Woodside's North West Shelf and Pluto facilities; and Chevron's Gorgon and Wheatstone projects. Including Shell's Prelude floating LNG (FLNG) plant, which is expected to commence shipping in late 2018, LNG exports from these projects are expected to grow to a total capacity of around 50 million tonnes of LNG per annum.[1] This places Western Australia second to Qatar (77 million tonnes of LNG per annum) as the world's largest LNG exporting centre, with Australia's total export capacity of 88 million tonnes of LNG per annum projected to surpass Qatar in 2018.[2]

Woodside's North West Shelf Venture began exporting LNG in 1989, growing to current production of up to 16.9 million tonnes of LNG per annum from five trains. In 2005, Woodside began construction on the Pluto gas field, which now produces approximately 4.7 million tonnes of LNG per annum. Chevron's Gorgon project began exporting from its first LNG train in March 2016. With all trains at full production, the project has a total capacity of up to 15.6 million tonnes of LNG per annum. In 2017, Chevron commenced production at its nearby Wheatstone project, with a combined capacity of up to 8.9 million tonnes of LNG per annum. In parallel, Shell's Prelude (FLNG) facility is being commissioned and is expected to produce around 3.6 million tonnes of LNG per annum from the fourth quarter of 2018.

In addition to operating and commissioning facilities, Woodside's proposed Browse LNG project remains in progress, potentially developed to feed an expansion at the North West Shelf plant when its current gas source runs dry in the 2020s.[3] A final investment decision is expected around 2020-21, with gas production of approximately 10–12 million tonnes of LNG per annum.[4] Woodside is also proposing to develop the Scarborough gas resource, estimated to produce around 4-9 million tonnes of LNG per annum,[5] with a final investment decision expected in 2020 ahead of start-up in 2023-24. Between 58 and 70 million tonnes of LNG per annum of capacity is projected to be available through all WA facilities.

Table 1: Current and major proposed LNG projects in Western Australia.

Project	Operating Company	Status	Start	Current Capacity (Mtpa LNG)[6]	Projected Gas Feedstock for LNG exports (Mtpa LNG)[7]
North West Shelf Venture	Woodside	Operating	1989	16.9	16.9
Pluto	Woodside	Operating	2012	4.7	5.3
Gorgon LNG	Chevron	Operating	2016	15.6	15.6 - 20.8
Wheatstone LNG	Chevron	Operating	2017	8.9	13.35
Prelude Floating LNG	Shell	Commissioning	2018	3.6	3.6
Browse^	Woodside	Proposed	2026-30	-	10 - 12
Scarborough*	Woodside	Proposed	2023-30	-	4 - 9

^ Gas production expected to be sent via the NW Shelf facility

* Gas production expected to be sent via the Pluto facility

[1] Government of Western Australia, August 2018. *WA Liquified Natural Gas Industry* Profile, Available here. This does not include gas from wells processed on the Ichthys Explorer offshore platform (processed in Darwin).
[2] Government of Western Australia, Department of Jobs, Tourism, Science and Innovation, WA Liquefied Natural Gas Industry Profile, August 2017
[3] Reuters, Woodside sees new momentum on long-delayed Browse gas project, 18/4/18
[4] Woodside, Browse project webpage: here. Accessed 17 Sep. 2018
[5] Woodside, Scarborough project webpage, here. Accessed 17 Sep. 2018
[6] Office of the Chief Economist, Resources and Energy Quarterly, June 2018.
[7] Nominal production capacity inferred from Table 10 in AEMO, 2017. *Gas Statement of Opportunities for Western Australia*, Available here. Scarborough's proposed downstream development will require an additional train at Pluto LNG with a targeted capacity of 4–5 Mtpa.

2.2 Greenhouse gas emissions from LNG projects

The conversion of natural gas into LNG by cooling it for transport is a highly energy and emissions intensive process, however GHG emissions from LNG plants are, in practice, no longer limited by any federal regulation. Limited federal regulation has led to increasing pressure for and gas developers operating in Australia to take a proactive approach to reduce their emissions, and for states to strengthen environmental approval and oversight processes.

GHG emissions for LNG developments are considered as part of each project's environmental approval process, with emissions performance and reporting requirements able to be implemented under Ministerial Statements (MS). Conditions vary by project and are subject to review by the Minister.[8] For example, MS 873 (2011) gave approval for Chevron to construct and operate the Wheatstone LNG development subject to appropriate actions to 'minimise emissions to levels as low as practicable', including measures to report performance against an emissions benchmark and offset reservoir GHG emissions.[9] Following the implementation of the *Clean Energy Act 2011* (Carbon Pricing Mechanism or 'CPM') these conditions were lifted,[10] with regulations not reinstated following the repeal of the CPM.

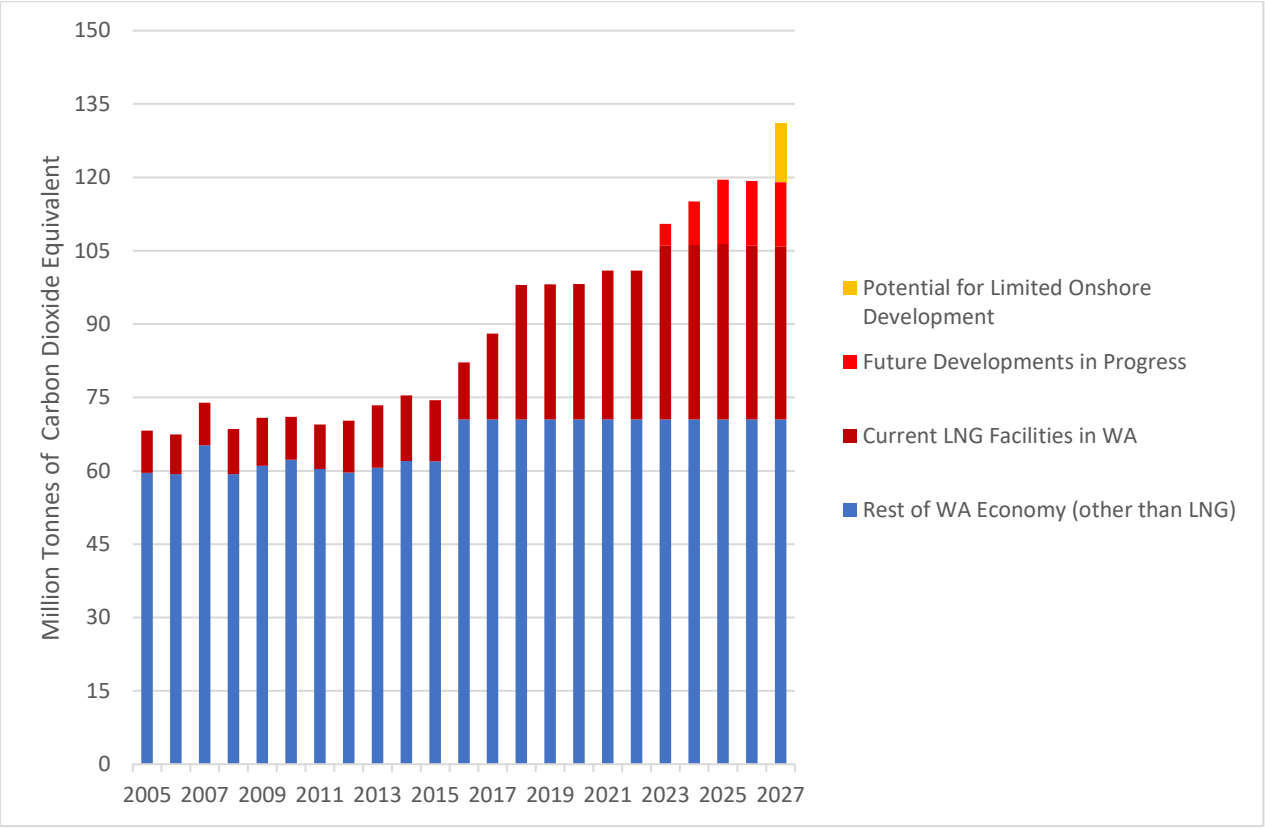
The Western Australian Environmental Protection Authority (EPA) is currently reviewing the adequacy of conditions implemented for Chevron's Wheatstone project[11], along with conditions applied to the Gorgon development to investigate the likelihood of success and adequacy of geo-sequestration or reservoir gas on Barrow island.[12] This has potential to result in stricter operating conditions for these projects, particularly should requirements to offset GHG emissions be reinstated for proponents.

As shown in Figure 1, Western Australian greenhouse gas (GHG) emissions from LNG production at current LNG facilities are projected to grow to around 30 Mtpa of CO_2e13 - an increase of approximately 300 percent on 2005 LNG emission levels when there was only a single operating LNG production facility in Western Australia. These LNG projects will increase Western Australia's total state emissions about 44 per cent above 2005 levels.[14]

Including the potential for limited onshore development in the Canning basin, GHG emissions from LNG production in Western Australia could easily grow to 60 Mt CO_2e per annum or more, with future developments already progressing in the Scarborough and Browse[15] fields. As a signatory to the Paris Agreement on climate change, Australia has committed to reduce its total emissions to 26-28 per cent below 2005 levels by 2030 and reach net zero emissions by 2050.[16]

[8] Under Section 46 of the Environmental Protection Act 1986 the Minister may request the EPA to inquire into and report on the matter of changing implementation conditions relating to proposals.
[9] Ministerial Statement 873, Conditions 19-1 to 19-8 (August 2011)
[10] Ministerial Statement 922
[11] http://www.epa.wa.gov.au/proposals/wheatstone-development-%E2%80%93-gas-processing-export-facilities-and-infrastructure-s46-2143
[12] http://www.epa.wa.gov.au/proposals/gorgon-gas-development-revised-and-expanded-proposal-s46-2161
[13] The 30 Mtpa figure is net of floating LNG located in international waters.
[14] Total CO_2 emissions in Western Australia were about 68 Mt in 2005.
[15] Torosa, Brecknock, and Calliance fields.
[16] Australia ratified the Paris Agreement on 10 November 2016. Our Nationally Determined Contribution ('NDC'), dated August 2015, sets an economy-wide target to reduce GHG emissions by 26 to 28 per cent below 2005 levels by 2030. This target has been rated as 'insufficient, and with a level of ambition that, if followed by all other countries, would lead to global warming of over 2°C and up to 3°C'.

Figure 1: Western Australia's past, projected and potential GHG emissions.



Source: LNG emissions projection data from RepuTex. 'Rest of WA Economy' data from State and Territory Greenhouse Gas Inventories 2016, Commonwealth of Australia 2018.

2.2.1 Total 'lifecycle' emissions

While analysis is limited to emissions that occur in Western Australia, there is a much larger volume of 'downstream' GHG emissions from the shipping, distribution, and end use of LNG. Should entire lifecycle emissions be considered, GHG emissions from all operating and proposed LNG projects are projected to be approximately 5 times those from manufacturing LNG,[17] largely attributed to emissions from the distribution and end use of gas. A more complete calculation of 'life cycle GHG emissions' from Western Australia LNG production would therefore extend total emissions from current operating and commissioned facilities to almost 200 Mtpa.

Table 2: Emissions from gas mining and export of LNG from Western Australia (million tonnes of carbon dioxide equivalent every year).

LIFECYCLE TOTAL	197.2
Exploration and drilling	0.1
Gas processing	36
Gas use in WA	24.1
Domestic Subtotal	**60.2**
Shipping overseas	4.4
Distribution	0.6
Usage overseas	132

[17] Hardisty, P., Clarke, T., Hynes, R. (2012), *Life Cycle Greenhouse Gas Emissions from Electricity Generation: A Comparative Analysis of Australian Energy Sources* – Energies.

International Subtotal	**137.0**

Source: Clean State.

2.2.2 Future development of unconventional gas emissions in Western Australia

At present LNG developments in Western Australia focus on 'conventional' natural gas resources, however, some companies are exploring the development of 'unconventional' resources, including exploiting shale gas in the Canning Basin using hydraulic fracturing (fracking). Fracking is the process of injecting liquid at high pressure into subterranean rocks, boreholes, etc. to force open existing fissures and extract oil and gas. This extraction method requires many wells and is an inherently leaky process.

Based on analysis undertaken by Climate Analytics on unconventional gas in Western Australia,[18] unconventional gas resources from even relatively small basins - such as Carnarvon - could extend total emissions by a further 3.4 to 3.9 Gt CO_2-e. Combining this with other larger gas basins - like Canning - could see Western Australia emissions rise by approximately 13.4 to 20.8 Gt CO_2-e.[19] Developing and using these resources would therefore entail a large increase in GHG emissions for Western Australia.

[18] Hare, Roming, Hutfilter, Schaeffer, & Beer (2018), *Western Australia's Gas Gamble: Implications for exploiting Canning Basin and other unconventional gas resources for achieving climate targets* – Climate Analytics; Table 1.
[19] Assuming 6.5% CH_4 leakage. These figures are only for domestic emissions. The lifecycle emissions of unconventional gas development would be much more.

3. ABOUT THIS ENGAGEMENT

3.1 Scope of engagement

RepuTex has been engaged by the Conservation Council of Western Australia (CCWA) to analyse the economic benefits of reinstating greenhouse gas (GHG) conditions on LNG projects in Western Australia, specifically the requirement for proponents to offset emissions from LNG developments.

This Report presents the modelling outcomes of a series of questions, which seek to understand the type and nature of carbon pollution offsets that could potentially be available within Western Australia should offset conditions be reinstated, and the economic benefits of developing a local carbon offset industry.

Key modelling questions include:

- Identify the type and nature of carbon pollution offsets that would potentially be available in Western Australia to offset carbon emissions at various reference levels;
- Quantify the number, type and spread of jobs that could be created in WA, if emissions from LNG projects were required to be 100 per cent offset through the acquisition and retirement of carbon credits generated in Western Australia;
- Understand, on a regional basis, the economic, investment, employment and business development opportunities that would be created in WA through generation of carbon offsets at the reference levels;
- Understand the benefits of developing a carbon sequestration industry in WA's rangelands by focusing on this industry as a delivery vehicle for offsets; and
- Understand opportunities to provide new employment and diversify regional economies in transition (such as the Collie region) through the development of new offset industries;

Sections one and two of this report provide a summary and background to the engagement; section three describes the scope of our analysis and modelled scenarios; section four contains our modelling results, including outcomes for offset availability in Western Australia, the annual value of offset investment in Western Australia, and regional job creation; section five details illustrative case studies for the co-benefits of offset projects in regional Western Australia.

3.2 Scope of analysis

To understand the type and volume of GHG emissions offsets that may be available in Western Australia, and subsequent economic investment and job creation opportunities, we establish three reference levels for emissions offset requirements that could be reinstated on LNG developments.

Modelling aligns offset supply with illustrative annual offset demand at thee reference levels, reflecting 'low', 'medium' and 'high' scenarios for the acquisition and retirement of offsets:

- **Low Scenario** - Demand for offsets equivalent to 15 million tonne of carbon dioxide per annum (Mtpa), reflecting approximately half of domestic emissions from current LNG facilities;
- **Medium Scenario** - Demand for 30 Mtpa, reflecting approximately all direct domestic emissions from current LNG facilities;
- **High Scenario** - Demand for 60 Mtpa, a doubling of the medium scenario, reflecting illustrative demand to offset direct emissions from current and proposed LNG developments.

The scope of this Report does not consider offsetting lifecycle emission scenario, however, using a more complete approach to emissions liability would be more consistent with Ecological Sustainable

Development (ESD) principles[20]. These principles require that LNG developments share responsibility for ensuring there is no net increase in life cycle GHG emissions, even if this results in emissions transported overseas being offset overseas, as recommended by a recent Australian gas development inquiry.[21] A condition for 100 per cent of life cycle GHG emissions to be offset would create significant demand for CO_2-e offsets, which may present a challenge for an economy the size of Western Australia. Although outside the scope of this analysis, international offsets may need to be considered for emissions that occur outside of Australia.

The scope of this report also does not include the full potential for higher GHG emissions associated with unconventional gas resources. Although not expressly modelled, the cost of offsetting these emissions would be higher than our High Scenario. The future development of these resources would also put significant upward pressure on the cost of offsets, which may become prohibitively expensive unless offsets could be accessed from outside of Western Australia.

3.3 Summary of modelling process

In determining the potential availability, cost, and co-benefits of abatement offsets available in Western Australia to meet the above demand reference levels, we draw on our Marginal Abatement Cost (MAC) model to identify potential emissions reduction activities in Western Australia and quantify the total volume and cost of undertaking identified activities.

For the purposes of this report, analysis focuses on GHG abatement activities related to emissions removals from the land-sector, along with a broader set of activities that are likely to deliver large-scale emissions reductions, while creating significant economic and environmental benefits for Western Australia. For example, investment in GHG abatement activities that assists with the task of replacing coal-fired generation with renewable energy may be favourable given the potential for this investment to support the transition of the Western Australian economy, particularly in the Collie region, through the development of new industries that generate GHG offsets.

Abatement activities are classified into the following categories: “Renewable Energy”, “Agriculture” and “Vegetation Management”, described in Table 3:

[20] Chapter 4: Evidence and Risk Assessment Methodology, Principles of ESD - Scientific Inquiry into Hydraulic Fracturing in the Northern Territory.
[21] Chapter 9: Greenhouse Gas Emissions, Recommendation 9.8 – That the Northern Territory and Australian governments seek to ensure that there is not net increase in the life cycle GHG emissions emitted in Australia from any onshore shale gas produced in the Northern Territory (Scientific Inquiry into Hydraulic Fracturing in the Northern Territory).

Table 3 – Summary of GHG abatement activities by category.

Category	Major Activities	Summary
Agriculture	Livestock Management	Abatement is delivered because livestock produce emissions for fewer days, and fewer animals are required for a given level of output. Managers can reduce emissions by establishing higher quality pasture, providing a feed supplement all year round, improving weaning percentage by culling unproductive cows, installing fences to control heard movements and improve joining practices, and expanding watering points to allow cattle to graze more widely and make better use of available pasture.
Renewable Energy	Lage-scale Solar	Abatement is delivered by the annual electricity generation of a >1 MW solar energy project displacing the emissions intensity of fossil fuels in the South West Interconnected System (SWIS).
	Large-scale Wind	Abatement is delivered by the annual electricity generation of a >1 MW wind energy project displacing the emissions intensity of fossil fuels in the SWIS.
Vegetation management	Avoided Deforestation	Abatement is mainly generated by stopping all harvesting in the public native forests, and thereby avoiding the emissions that clearing would have produced.
	Rangeland Regeneration	Projects capture carbon by changing rangeland management practices to facilitate regeneration of native vegetation. Landholders can assist regeneration through activities such as excluding livestock from the project area, managing the timing and extent of grazing, managing feral animals and non-native plants in the project area, and stopping activities such as mechanical destruction of natural regrowth.
	Reforestation Plantings	Projects capture carbon by permanently planting native trees or mallees to establish forest cover. This includes 'integrated carbon farming' that in addition to biodiverse tree plantings could also include other complementary activities like some farm forestry – e.g. sandalwood – sheep grazing and bee keeping.
	Savannah Burning	Participants undertake appropriate fire management in their projects, so carbon dioxide is removed from the atmosphere by sequestering carbon in dead organic matter and to avoiding emissions of methane and nitrous oxide from the late dry season burning of grasslands.

Projected costs and abatement volumes are derived from bottom-up examination of different project types in line with our in-house MAC curve for the Australian economy. Given there is often a wide range of abatement costs associated with different individual projects, we apply average marginal abatement costs, which are calculated to represent the typical cost of undertaking each activity in Western Australia.

Estimated offset supply volumes are aligned with assumed offset demand levels described in Section 3.2. This establishes whether there is likely to be enough abatement within Western Australia to cover the demand scenarios, while enabling the analysis of what types of projects are likely to supply the bulk of emissions offsets, and the price at which offset supply and demand may be balanced.

3.4 Key assumptions

A MAC curve is a dynamic tool which needs to be regularly updated due to changes in emissions baselines, fuel and technology costs, technological developments and process improvements. Subsequently, in developing our MAC model for the Australian economy, we draw on regular consultation with market stakeholders. In undertaking analysis in this Report, we specifically consider feedback from Western Australian carbon farmers, pastoralists, and renewable energy developers, including Emissions Reduction Fund (ERF) project proponents, aggregators, financial institutions, academic researchers and policymakers. Input on investment, job creation, project costs, abatement volumes, timing and transaction cost assumptions are incorporated into our modelling assumptions and our proprietary cost databases, which we present within this study.

Modelled projects are scaled to a state-wide activity level based on available land area, appropriate vegetation, timing and location, to provide a cumulative estimate of abatement in Western Australia. To compare abatement costs across such a wide range of activities, a marginal abatement cost is estimated by dividing the net present value of a project by its total abatement.

Modelling assumes the below settings:

- GHG abatement activities are assumed to be undertaken in Western Australia;
- Proponents are required to offset their emissions in line with the emissions reference scenarios above (e.g. 50-100 per cent of emissions);
- Prices are reported in 2018 Australian dollars unless otherwise noted. No pricing interaction with any future changes in federal policy is considered;
- Modelled MAC outcomes depict the technological potential of abatement measures, based on the maximum estimated abatement potential of each activity, exclusive of behavioural aspects and policy implementation barriers;
- While some abatement measures may result in cost savings relative to business as usual (BAU), in practice, savings are only realised once market inefficiencies are overcome (for example by policy). These inefficiencies may be in the form of split incentives, information gaps, policy uncertainty and/or significant upfront payment barriers;
- Transaction costs may be included when estimating potential abatement prices, referred to as 'offset prices', or the price that an offset may receive in the market. Transaction costs are an overlay on abatement costs, varying by project type, size, and location. These reflect administrative costs of development, such as project sourcing, measurement of abatement and legal costs;
- Where relevant, abatement activities are consistent with Australian Carbon Credit Unit (ACCU) methodologies and may therefore be considered fungible with any future compliance scheme. Total abatement estimates included forecast changes and expansions of Emissions Reduction Fund methodologies.
- Direct and indirect employment is included in job multipliers;

For further information on our research process and methodology refer to Appendix A.

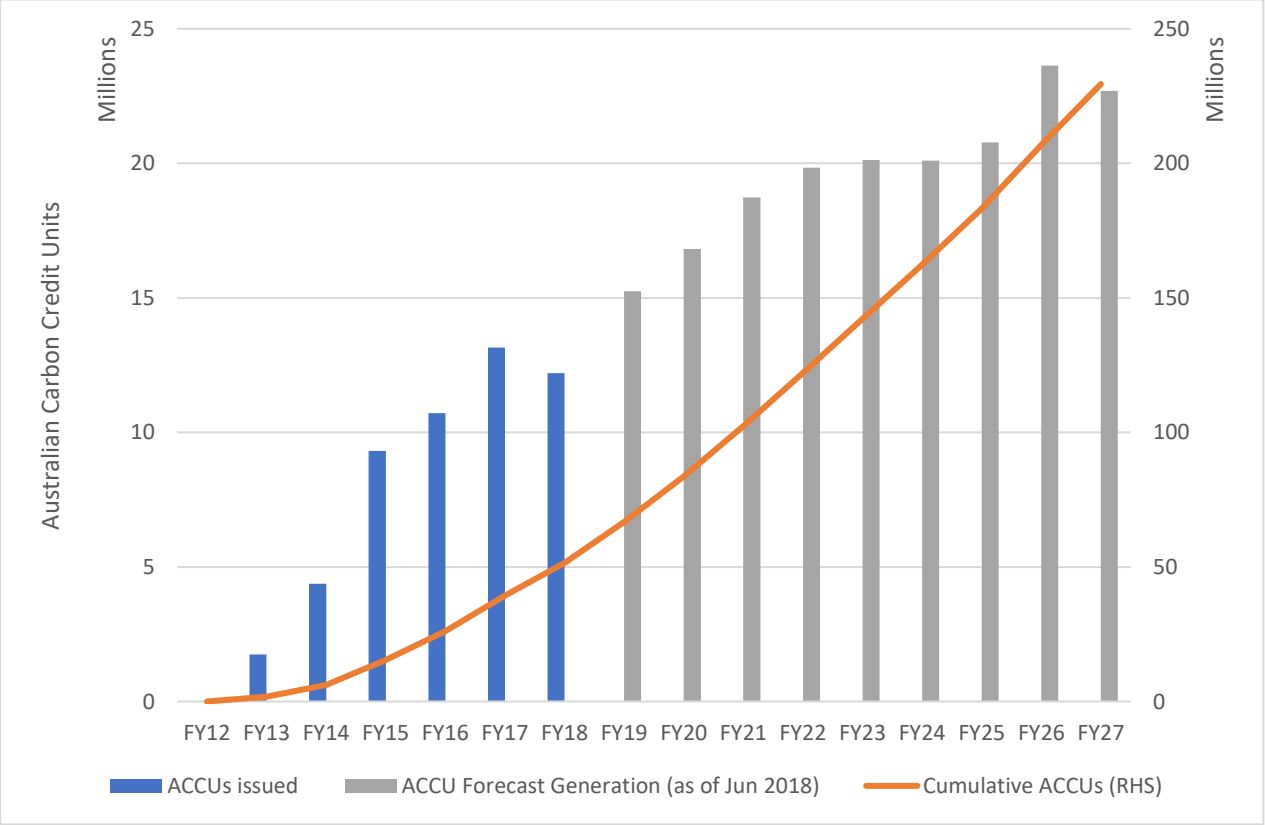
4. CURRENT OFFSET AVAILABILITY

4.1 Current offset supply in Western Australia

To date, most GHG abatement offsets issued in Australia are in the form of ACCUs, with issuance overseen by the Clean Energy Regulator (the Regulator). Following the conclusion of the Carbon Price Mechanism at the end of June 2014, the Commonwealth's Emissions Reduction Fund (ERF) has formed the primary market for ACCUs, with the Regulator entering into contracts to purchase offsets from developers active in land, waste and now industrial sector projects[22]. More recently, activity in a 'secondary' market has developed, underpinned by large facilities offsetting excess emissions over their safeguard mechanism baselines.

As shown in Figure 3, the ERF has contracted to purchase approximately 192 million ACCUs though 429 contracts,[23] with offsets to be issued and delivered over the next two to ten years. Around 12.2 million ACCUs have been issued in financial year 2017-18. National ACCU issuance over the next decade is anticipated to be over 15 million per annum, with growth in both the number of ACCUs issued per project and the total number of projects.

Figure 3: Forecast issuance of ACCUs in Australia under the Emissions Reduction Fund (Sep 2018).



Source: RepuTex Energy 2018

In Western Australia, annual ACCU issuance under the ERF has grown from around 500 thousand in 2016-17 to more than 700 thousand per annum in 2017-18. Of this, approximately 400 thousand ACCUs per annum have been issued to reforestation and savannah burning projects (55 per cent). Western

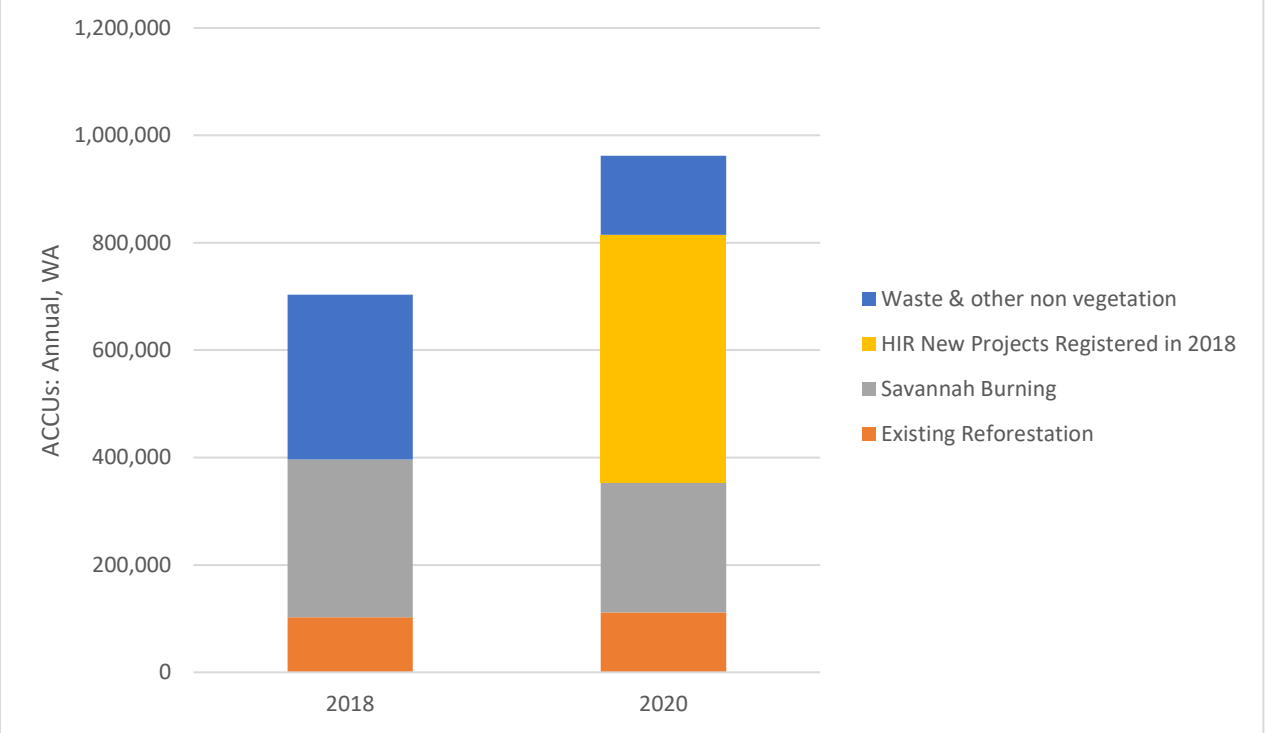
[22] In September 2018 a method for industrial equipment upgrades method came into effect, providing an alternative method for upgrades to existing industrial equipment including compressed air systems, boiler systems or pumps to improve the energy efficiency of the upgraded system.
[23] As of 16 August 2018: Clean Energy Regulator, http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/carbon-abatement-contract-register

Australia therefore contributes less than 10 per cent per cent of national ACCU supply. This is largely because of historic supply constraints in the land sector, due to uncertainty around carbon rights on leasehold land[24], resulting in the state missing out on much of the available ERF funding.

The Western Australian government has recently clarified long-standing questions in relation to carbon sequestration projects on Crown land. Consequently, a sharp increase in ACCUs is forecast for projects utilising the ERF's Human Induced Regeneration (HIR) methodology, which is popular in the eastern states. In April 2018, the Western Australian government gave approvals for pastoralists to participate in the ERF, with a 12-month pilot program established as a first step towards creating an accessible carbon farming industry. However, further reform to land tenure will be required for carbon farming to reach its full potential by addressing the term of pastoral leases and native title implications.[25]

As shown in Figure 4, should carbon rights on lease-hold lands be resolved favourably, we estimate an additional 500,000 ACCUs could eventually be issued annually. Almost all these offsets are expected to be derived from sequestration activities undertaken on rangelands (yellow bar), however this growth is likely to be offset by reduced ACCU generation from the waste sector (blue bar), such as landfill gas.[26] This could see average supply from all activity types in Western Australia increase from 700,000 in 2018 (left hand column) to approximately 900,000 offsets per annum (right hand column). Assuming enough demand, we estimate these ACCUs could be made available at current secondary market prices[27].

Figure 4: Projected ACCU issuance in Western Australia with newly registered HIR projects



Source: Clean Energy Regulator and RepuTex, 2018.

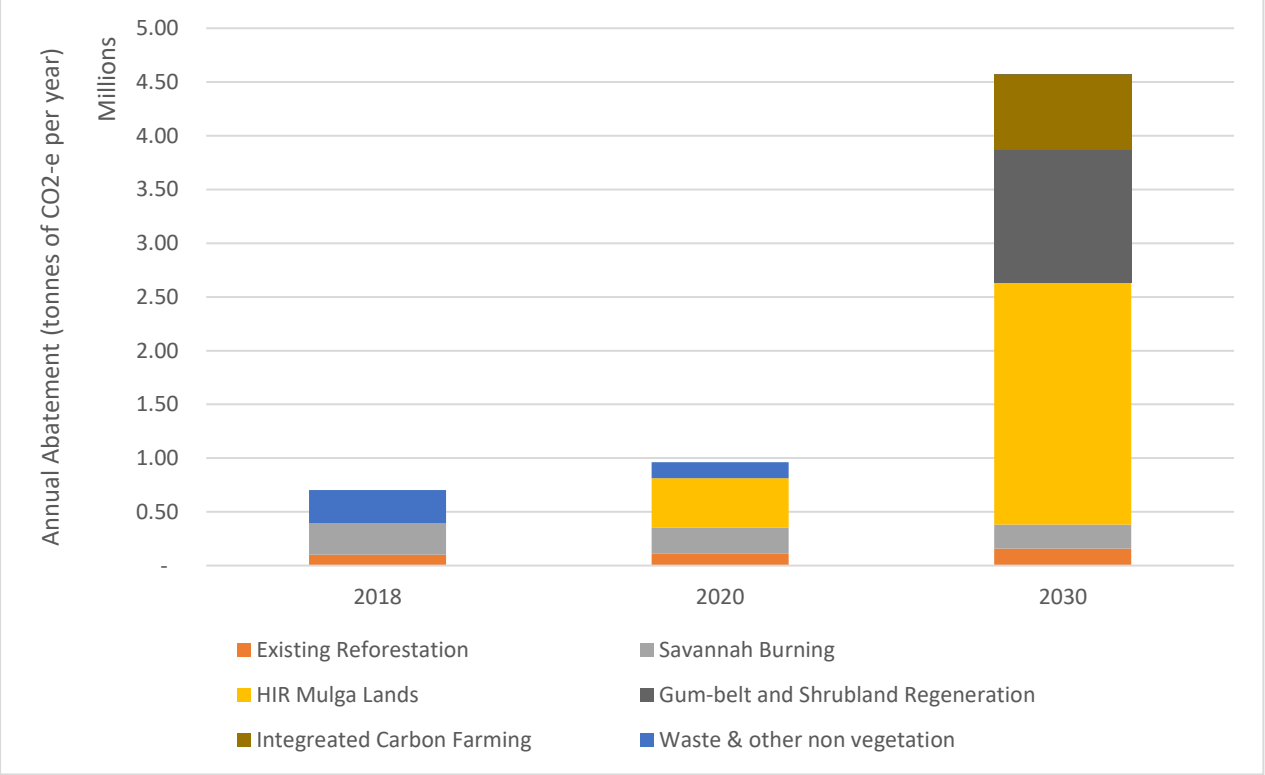
[24] ABC News: Courtney Fowler, Michelle Stanley, Tara de Landgrafft, Multi-billion-dollar potential for Western Australia's carbon farming industry - 20 April 018 (WA Country Hour); http://www.abc.net.au/news/rural/2018-04-20/carbon-farming-approval-for-western-australian-pastoralists/9672784
[25] ABC News, Multi-billion-dollar potential for Western Australia's carbon farming industry 20/4/18
[26] May – June 2018: Offset price survey, RepuTex.
[27] Current ACCU 'spot' prices are approximately $17.

4.2 Potential to expand current ACCU supply

Should current ERF methodologies be revised, and potentially extended, further increases to rangeland ACCU issuance are expected by 2020, beyond current registered projects. For example, should the current HIR methodology be revised to account for all above-ground carbon pools, and incorporate advancements in low-cost drone measurement technology, a 30-50 per cent increase in ACCUs generated from rangelands crediting areas may be achievable.[28] This would subsequently result in increased rangelands abatement, particularly within the Southern Rangelands[29], which has the greatest potential for carbon sequestration due to land degradation (as a result of overgrazing and other pressures).

In this region, the greatest potential for carbon sequestration is via mulga shrublands, which occupy 50 million hectares of the rangelands, or about 20 per cent of Western Australia. Using the current HIR method, around 40 Mt of CO2-e may be sequestered over 25 years[30], or 1.6 Mt per annum. A rate of 1.6 Mtpa is around 2.5 times the projected ACCU issuance to HIR projects by 2020, suggesting there is significantly more abatement potential that has not yet been registered under the ERF. Assuming a further increase of 40 per cent on this total potential, abatement may grow on average to over 2.25 Mt per annum, as shown in Figure 5. Of this, around 1.1 Mt, or half of this abatement, is expected to be derived from new mulga shrublands potential, and 600,000 from a new rangeland method, as shown in Figure 6.

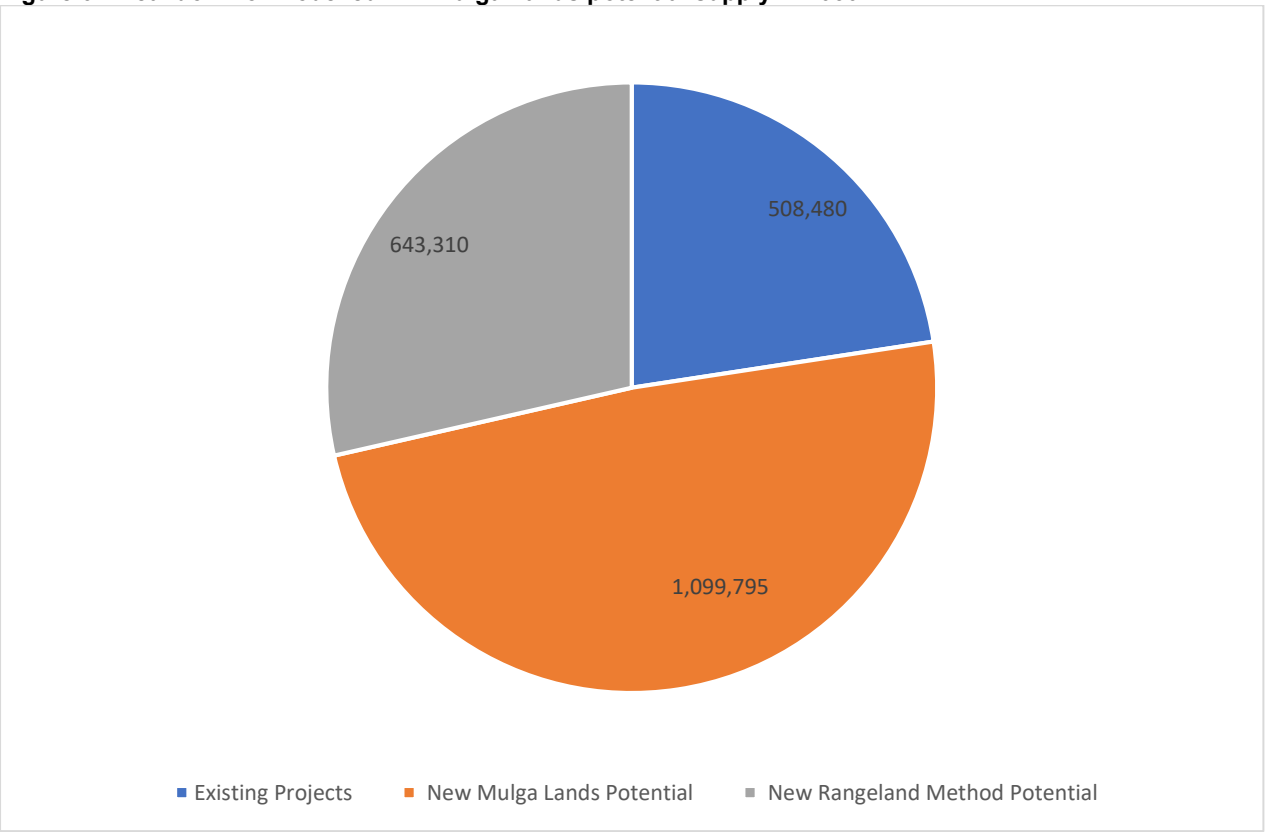
Figure 5: Current supply of ACCUs in 2018 versus extended potential supply in 2020 and 2030.



Source: RepuTex Energy 2018

[28] Correspondence with Dr Peter Russell estimates that there would be a 30-50% increase in ACCUs generated within the existing and potential HIR project Carbon Estimation Areas if a 'rangelands method' was developed.
[29] All WA rangelands south of the middle of the Pilbara.
[30] Estimate from Select Carbon Ltd.

Figure 6: Breakdown of modelled HIR Mulga Lands potential supply in 2030.



Source: RepuTex Energy 2018

Beyond expanded abatement from mulga lands, other areas with carbon sequestration potential include the gum-belt of Eucalypt woodlands in the Goldfields and salt bush and blue bush in the southern rangelands. These areas do not have vegetation that would meet the current HIR criteria, however if this criterion is expanded, the potential sequestration in these areas is projected to grow an additional 40 Mt.[31] We estimate this may contribute around 1.5 Mt per annum.

Potential also remains for additional supply from integrated carbon farming projects in Western Australia, which have combined diverse plantings with alternative, non-carbon revenue streams to recoup investments at lower prices than traditional environmental planting projects[32].

In aggregate, outcomes suggest the rangelands could generate a total potential supply of around 4.5 million tonnes per annum in Western Australia under new methodologies, should existing and planned methods be expanded and fully captured in Western Australia. This is a five-fold increase on the current projected baseline of 900,000 ACCUs per annum (should newly registered HIR projects be successful) but suggests that a considerable scale up of supply beyond the potential of Western Australia's rangelands will be required to meet the three demand reference levels identified in Section 3.2.

[31] Correspondence with Dr Peter Russell via Mr. David Mackenzie.
[32] Developers estimate that increased contract prices, and acceptable escalating forward contracts, could result in plantings of around 5,000 hectares p.a. within two to three years. This may grow to around 30,000 hectares p.a. across multiple developers, delivering 120,000 to 210,000 ACCUs p.a. This assumes a ten-year payback period and 20 to 30 per cent up-front capital is available to assist with covering planting costs. Australian banks currently finance these types of projects in New Zealand on the basis of bi-partisan support for their Emissions Trading Scheme.

5. AVAILABILITY OF OFFSETS TO MEET DEMAND

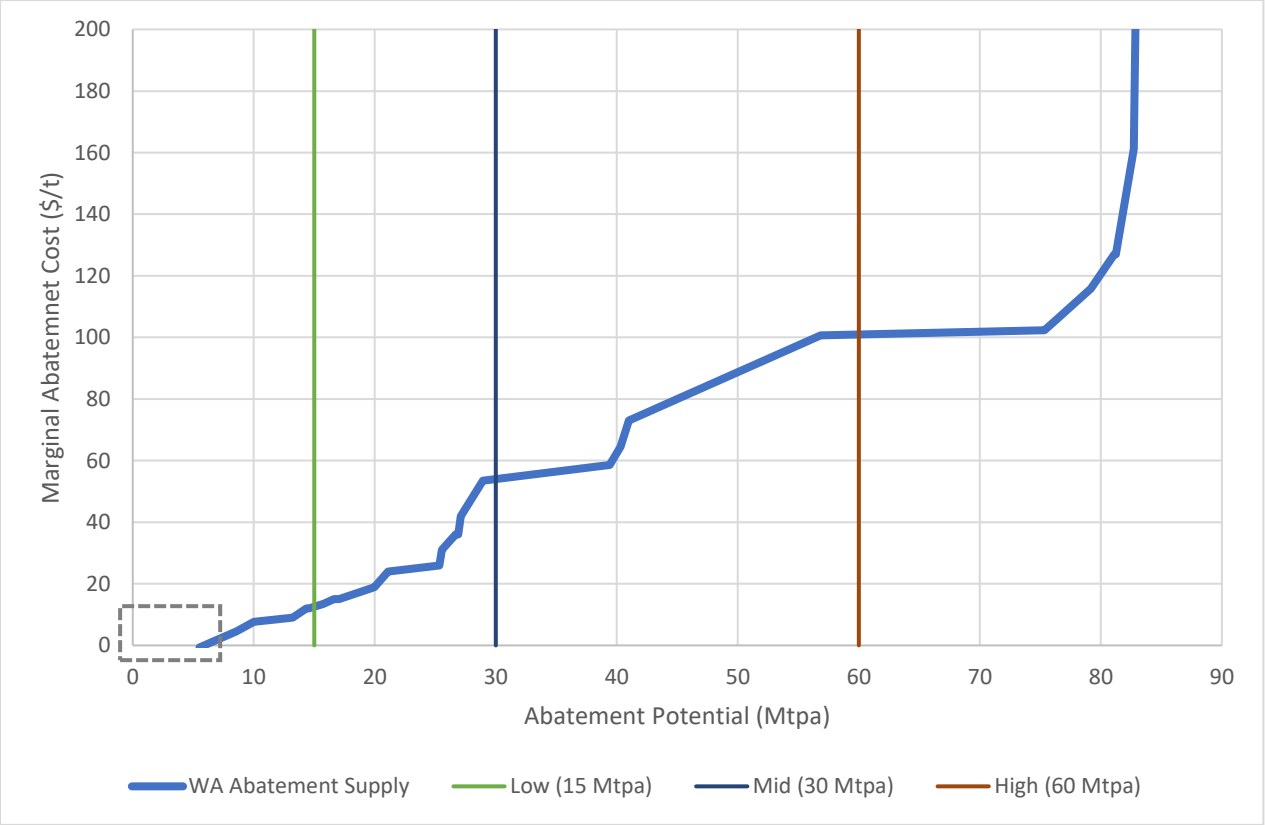
5.1 Offset supply and price scenarios in Western Australia

To understand the type and volume of GHG emissions offsets that may be available in Western Australia to meet modelled demand levels, below, we apply marginal abatement cost analysis to align estimated supply volumes with assumed demand for 15 Mt, 30 Mt and 60 Mt of abatement demand, outlined in Section 3.2. This enables a deeper understanding of what types of projects are likely to supply the bulk of emissions offsets in Western Australia, and the price at which offset supply and demand may be balanced.

Given West Australia's ACCU issuance of around 400,000 from the land sector in 2018, potentially growing to 900,000 per annum should newly registered HIR projects be successful, each demand scenario would require a considerable increase in offset supply from current levels. This reflects the large potential growth opportunity for the carbon offset industry in Western Australia, with a robust source of demand likely to trigger considerable large-scale investment to generate new offset supply.

As shown in Figure 6, should emissions conditions be tightened for Western Australian LNG production facilities, requiring projects to offset their direct emissions, analysis suggests that Western Australia has ample abatement potential to meet demand within the state. Findings indicate that approximately 80 Mt of emissions reductions are available across all identified activities (blue line), equivalent to Western Australian state-wide emissions in 2017. Western Australia therefore has considerable local abatement available to meet modelled demand scenarios, or to meet any future net-zero emissions reduction target.

Figure 7: Marginal cost of abatement in WA versus assumed offset demand reference levels.



Source: RepuTex Energy 2018.

The marginal cost of meeting modelled demand is shown via the intersection of each demand scenario (vertical lines) with supply (blue line). Although marginal abatement costs can be negative (shown via grey box in Figure 7), such as when the low carbon option is cheaper than the business-as-usual option, marginal abatement costs often rise steeply as more pollution is reduced. As more demand for offsets

develops in line with the modelled scenarios, the price for offsets in Western Australia is therefore projected to increase, encouraging more supply to come become available to the market.

As shown in Figure 7, demand for 15 Mtpa of emissions reductions is expected to be fulfilled up to $15 per tonne, with the doubling of annual demand to 30 Mtpa likely to approximately triple marginal abatement costs, as the marginal cost of abatement grows to $50 per tonne. Under a high demand scenario of 60 Mtpa, abatements costs are projected to grow to $100 per tonne, underpinned by the need to unlock higher cost abatement at the far end of the supply curve.

Notably, findings indicate that Western Australia is well placed to supply a large quantity of low-cost offsets, with considerable supply of around 5 to 6 Mtpa available under $1 per tonne (grey box). This is mostly associated with agricultural efficiencies that increase yields, while also reducing cropland emissions. Even more significant is the availability of up to 15 Mtpa of supply (18 per cent of total abatement) under $15 per tonne, largely attributed to optimising grazing patterns and regenerating rangelands, potentially at the same time. This suggests Western Australia ample 'low cost' offset opportunities should policy be designed to capture these activities (refer to breakout box below).

Beyond the low scenario, the assumed price of offsets increases with each demand scenario as 'low-hanging' abatement is contracted and demand for offsets 'buys its way up the cost curve'. At the higher demand scenarios, we see two clear price plateaus become evident, a level encompassing large-scale renewable energy projects around $50 per tonne, and a large plateau at approximately $100 per tonne attributed to reforestation on higher value lands. Around half of all abatement is therefore available above $40 per tonne. Despite this, all scenarios reflect well against international carbon price benchmarks, with carbon prices in Europe projected to grow from about A$30 per tonne today to approximately A$60 per tonne by 2023, driven by the higher ambition of policy in these markets[33].

Interpreting marginal abatement cost (MAC) analysis, and 'negative costs'

Marginal abatement cost analysis is regularly used to measure the cost and emissions reduction potential of implementing activities to reduce greenhouse gas (GHG) emissions across an economy, or within a sector. Abatement costs and volumes are plotted in order from lowest to highest cost, forming a 'greenhouse gas abatement cost curve'. Market stakeholders may then compare relative abatement volumes and costs from different activities and technologies, and the potential for emissions reductions to be derived from different sectors. This can inform cost-efficient policy design and abatement planning, helping to identify the potential sources and costs of achieving specific emission reduction objectives.

Modelled MAC outcomes in this Report depict the technological potential of abatement measures, based on the maximum abatement potential of each activity, exclusive of behavioural aspects and institutional implementation barriers, often created by the design of policy. The exclusion of 'market imperfections' results in the representation of negative abatement costs - abatement measures that have a positive return over the lifetime of an investment. While these measures may be result in cost savings, in practice, savings can only be realised once market inefficiencies (such as split incentives, information gaps, policy design or upfront payments barriers) are overcome.

These inefficiencies are particularly important for carbon farming abatement activities, where physical abatement can take a long time to manifest and payback periods can be long. For example, integrated carbon farming activities have a 25-year project life, that typically experiences the highest carbon sequestration rate on the backend of the project (years 6 though 25), well after capital costs have been invested. The high cost and long payback period of these projects generally creates a large barrier for investment, often resulting in entities choosing to implement higher cost abatement projects that may offer greater certainty, such as projects with non-carbon revenue streams (such as electricity or gas sales).

The design of efficient policy can help to overcome these barriers. In doing so, policy could help unlock low-cost abatement in a sector or across an economy. For example, legislating an emissions reduction compliance obligation (such as an emissions reduction target, cap or baseline, or offset regulation), can provide certainty for investors that demand for abatement will still exist by the time that offsets are issued (i.e. in 6+ years for land-sector projects). This can make projects, such as integrated carbon farming

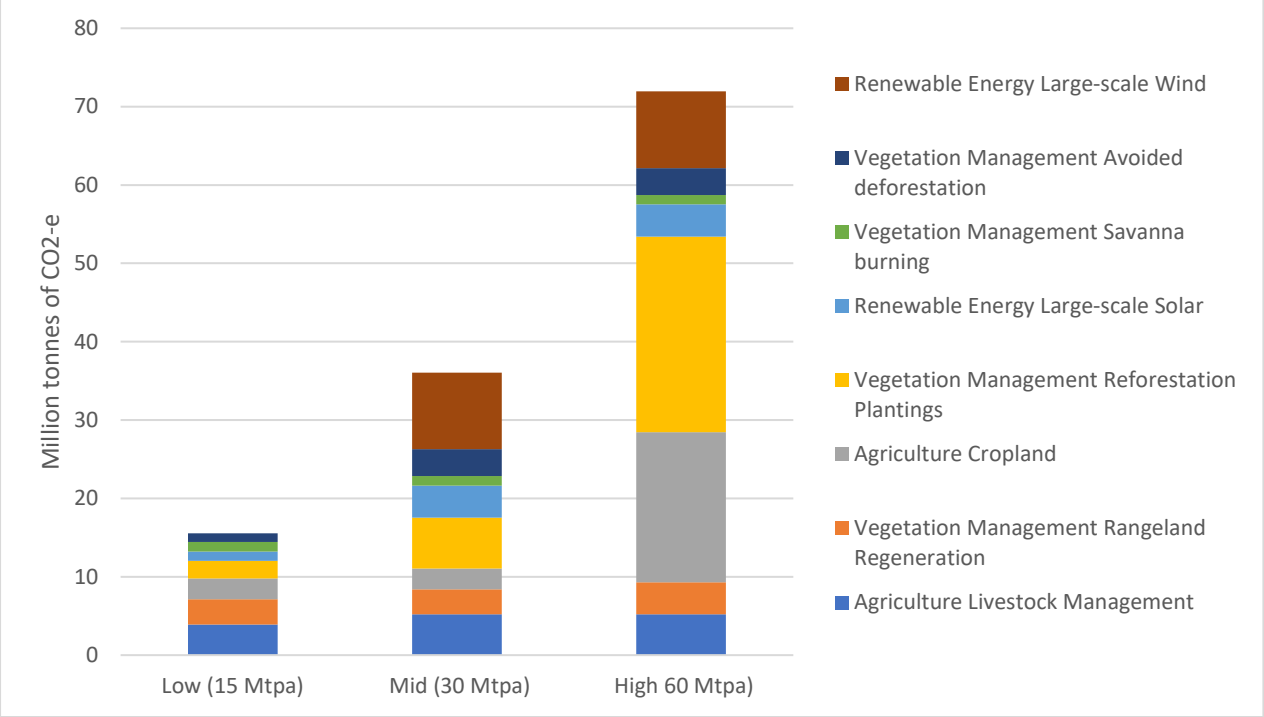
[33] Assumes exchange rate of 0.7 Euro to AUD. Carbon Price Outlook: December 2018, RepuTex Energy.

activities, more attractive for investment. Aside from setting a robust source of demand, policy must be clear and transparent, ensuring participants understand how any mechanism operates, while building certainty by ensuring access to information, such as levels of demand (individual facility emissions and targets), availability of supply, and the price paid to offset a liability. These parameters are not addressed under the Commonwealth ERF, limiting the effectiveness of the scheme[34].

For the purposes of analysing the abatement potential of offset activities within the Western Australian economy, modelled estimates in this Report assume that emissions reduction investments are made in an optimal market setting (low transaction costs and no barriers to implementing projects), underpinned by policy certainty and transparency. This ensures all potential abatement in the market is 'unlocked'. Large abatement volumes are therefore shown to be achievable, at the marginal costs identified, subject to the design of policy that can incentivise the identified emissions reduction opportunities.

5.2 Projected offset supply by type

Figure 8: Supply of GHG abatement offsets from Western Australia to meet demand reference levels.



Source: RepuTex Energy 2018.

As shown in Figure 8, the source of abatement - and consequently the price of offsets - changes based on modelled demand assumptions. Under a 'Low demand' scenario (15 Mtpa), emissions reductions are modelled to be achieved from a balance of low-cost renewable, vegetation and agricultural project types. Of these, pastoralists are expected to supply the largest portion of abatement, attributed to low-cost

[34] To date, the effectiveness of the Commonwealth's ERF scheme has been constrained by low transparency, structural inefficiency and uncertainty over the continued source of demand. Rather than set a traditional demand obligation (such as an emissions reduction objective), the ERF operates as a voluntary reverse-tender process, with deferred payment of contract obligations (until delivery of abatement), and no transparent market price. While the Clean Energy Regulator discloses an 'average price of abatement' this does not reflect the true market price of abatement, i.e. the last or "highest" contract price accepted by the Regulator. Modelling suggests that a large spread of contract prices occurs within ERF auctions. As a result, the average price is not a robust signal for the true value of abatement in the Australian market. For example, RepuTex analysis of ERF auctions 1-3 suggested a lowest contract price of around $9 while highest clearing prices reached over $16, reflecting a significant premium over both the lowest contract price, and the reported average price ($11.83). Report link. Together, the voluntary nature of the scheme, combined with low investor certainty and transparency has subsequently limited the scheme's effectiveness.

livestock management (4 Mt), rangeland regeneration projects (3 Mt), cropland projects (3 Mt) and reforestation planting (2 Mt). Examples of activities with low marginal abatement costs include:

- **Livestock management**: establishing higher quality pasture, providing a feed supplement all year round, improving weaning percentage by culling unproductive cows, installing fences to control heard movements and improve joining practices, and expanding watering points to allow cattle to graze more widely and make better use of available pasture. This may generate offsets though more efficient cattle production reducing livestock emissions of methane associated with digesting feed and nitrous oxide from the dung and urine though shorter average lifetimes.[35]
- **Rangeland regeneration**: activities such as excluding livestock form the regeneration area, managing the timing and extent of grazing, manage feral animals and non-native plants and stopping clearing activities such as mechanical re-clearing of vegetation. This could generate offsets though the regeneration of native forest.[36]
- **Cropland**: activities that reducing cropland soil emissions like avoiding the burning of crop residues in favour of retaining them in the field, converting crops to pasture to reduce tillage, and increasing biomass yields through optimising fertiliser application.[37]
- **Reforestation plantings**: farm forestry activities that derive revenue from the regular harvesting of wood or provide shelter for agricultural activities. Other integrated carbon farming projects capture revenue from farm forestry to support additional pursuits including biodiverse tree plantings.

In addition, abatement from low-cost, non-ACCU generating activities could occur, including 'behind-the-meter' solar PV projects in the agriculture industry, particularly for common, large energy consuming processes such as irrigation and pumping, washing, processing, packing processes, cooling refrigeration and vacuum coolers in a factory.

For many of these activities, even relatively low-cost, small improvements in farming operations could result in a large volume of abatement. As noted, the challenge for policymakers to capture low-cost abetment is therefore not to just create demand for offsets, but to lower barriers for small livestock operations to quantity their abatement and receive payment for their credits. Should policy be designed to minimise transition costs, offset prices may reasonably be expected to remain in line with today's levels yet incentivise much larger supply volumes to do improved market efficiency.

While emissions reductions from livestock activities dominate low-cost opportunities in the 'low demand' scenario, under a 'medium demand' scenario, investment in renewable energy sector is projected to play a complementary role to the ACCU market, supplying around one third of all offsets. Around 14 Mtpa (39 percent) of all abatement is modelled to be supplied by allowing large-scale construction of solar and wind energy projects to create carbon offsets. In doing so, such investment can transition the Western Australian electricity sector, and change the way that the economy is fuelled, from legacy coal and gas-burning facilities into a clean-energy economy, underpinned by local renewable energy jobs and resources.

Examples of renewable energy abatement modelled here include large-scale (multi-MW) solar PV and wind projects on grasslands and degraded agricultural lands, underpinned by falling costs for solar PV. Significant projects of tens - or even hundreds - of MWs can combine to export electricity to the grid, potentially displacing GHG emissions from fossil-fuelled electricity generation earlier than currently forecast. These types of projects are now more economically feasible with only minimal carbon payments necessary, however, certainty afforded by small offset payments could help to maintain or accelerate the pace of renewable energy development as current renewable energy targets end.

Under a 'high demand' scenario, forest and rangeland sectors are modelled to supply a large volume of offsets though large-scale, long-term sequestration activities, that may begin to transform land-use practices. Notably, Western Australia has a significant amount of reforestation potential, with up to 25 Mtpa of emissions reductions available.

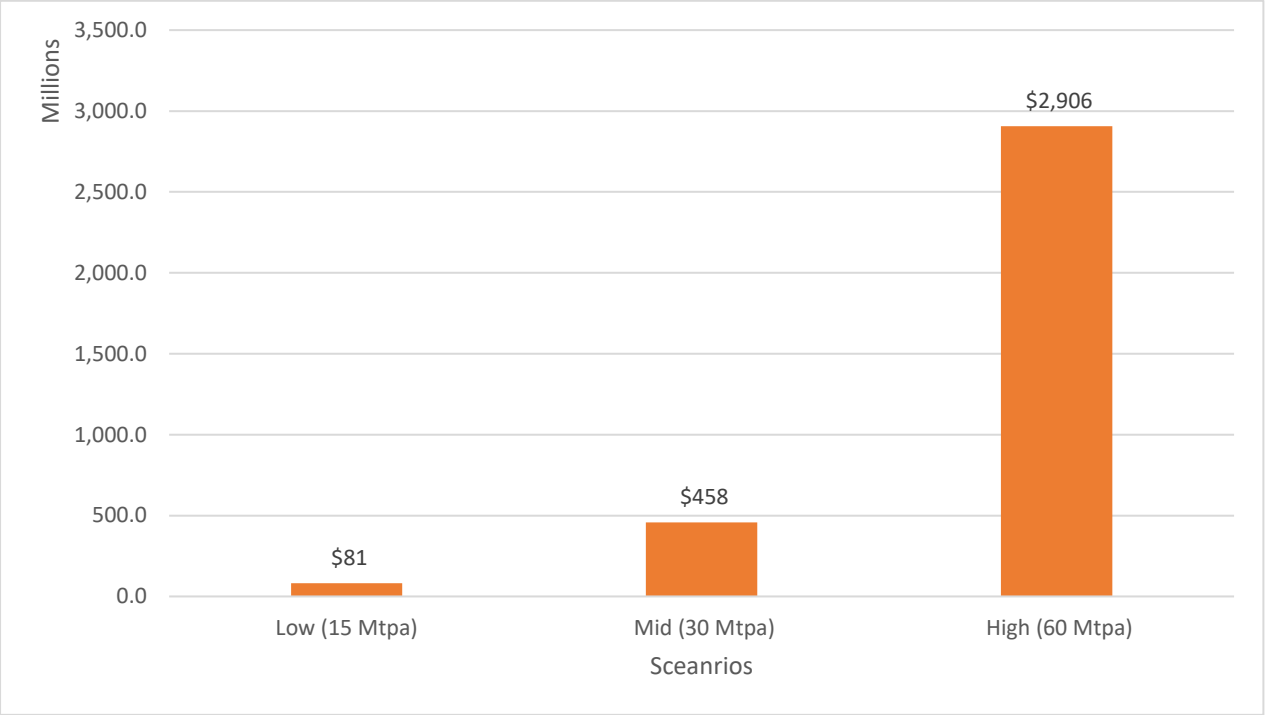
[35] See Australian Department of the Environment: Beef cattle herd management method.
[36] See Australian Department of the Environment: Human-Induced regeneration permanent native forest method.
[37] See Australian Department of the Environment: Estimating sequestration of carbon in soil using default values.

6. INVESTMENT AND ECONOMIC BENEFITS

6.1 Implied value of Western Australian offset industry

Should the above demand levels be realised, analysis indicates that value of the West Australian carbon offset industry may range between $81 million to $2.9 billion per annum, in line with the modelled price paths for abatement in Section 3.2.

Figure 9: Annualised Value of Western Australian Offset Market by Scenario.



Source: RepuTex 2018

As shown in Table 4, emissions reduction opportunities associated with carbon farming projects are estimated to receive the greatest share of investment, reflecting the larger potential of the land sector in each of the modelled scenarios. Should demand increase in line with a high scenario, this investment may grow to more than $2.9 billion annually, with the land sector capturing around $2.3 billion in offset investment. This suggests considerable opportunity for carbon farming proponents, with investment potentially flowing from large-scale LNG projects through to proponents on a long-term per annum basis, creating a basis for new and sustainable economic growth and job creation across the state, rather than more concentrated economic development in the coastal Pilbara and Kimberly offshore regions.

Table 4: Million dollars of annualised investment by category and demand scenario.

Category	Scenario		
	Low (15 Mtpa)	Mid (30 Mtpa)	High (60 Mtpa)
Agriculture	$20m	$26m	$1,660m
Renewable Energy	$1m	$18m	$627m
Vegetation Management	$60m	$414m	$619m
Total	**$81m**	**$458m**	**$2,906m**

Source: RepuTex 2018

6.2 Regional job creation from carbon offset industry

The development of a carbon offset market in Western Australia has the potential to provide significant benefits beyond GHG emissions abatement. These include large economic opportunities for investment and job creation across the state, particularly in regional communities, as well as co-benefits to biodiversity, landscape protection and water quality.

Increased economic activity is modelled to have considerable implications for both construction and long-term employment creation in Western Australia's regional economies. This may be in the form of direct construction jobs, needed to build new electricity infrastructure, and employment to operate and maintain large-scale solar and wind energy facilities. Investment is also able to spur permanent job creation associated with 'carbon farming' projects, such as aboriginal rangers, bee keepers, carbon foresters, land managers, stockmen and tree planting contractors, along with indirect employment that occurs along the value chain, such as the manufacturing of component parts, service industries, and so on.

To understand the impacts of increased investment in carbon farming on job creation, we identify employment multipliers from a range of primary and secondary sources for different activity types. Multipliers are aligned with operational and capital expenditure for each project type to derive a total employment figure per million dollars of investment.

Table 5: Job creation per million dollars of investment.

Project	Jobs/$M	Capital to labor spend ratio ($/person-yr)	Job Mix			Primary Investment Region
			Low skilled	Skilled	Professional	
Savanna Burning	12	90,000	5	4	4	Kimberley
Reforestation Plantings	10	100,000	3	2	5	Southern Rangelands
Rangeland Regeneration	9	120,000	3	4	3	Southern Rangelands
Renewable Energy	5	190,000	1	3	2	South West

Sourced from data provided by project developers. Multipliers consider direct job creation only.

As shown in Table 5, on an employment per million dollars of investment basis, abatement from the land sector is expected to generate more labour-intensive projects than the electricity sector. Savana burning was found to have the highest number of jobs, averaging around 12 jobs per million dollars. Other land-sector projects were also found to create approximately double the number of jobs per dollar invested compared to renewable energy projects. This is because a larger portion of every dollar invested goes toward labour in the land sector, relative to the capital-intensive electricity sector.

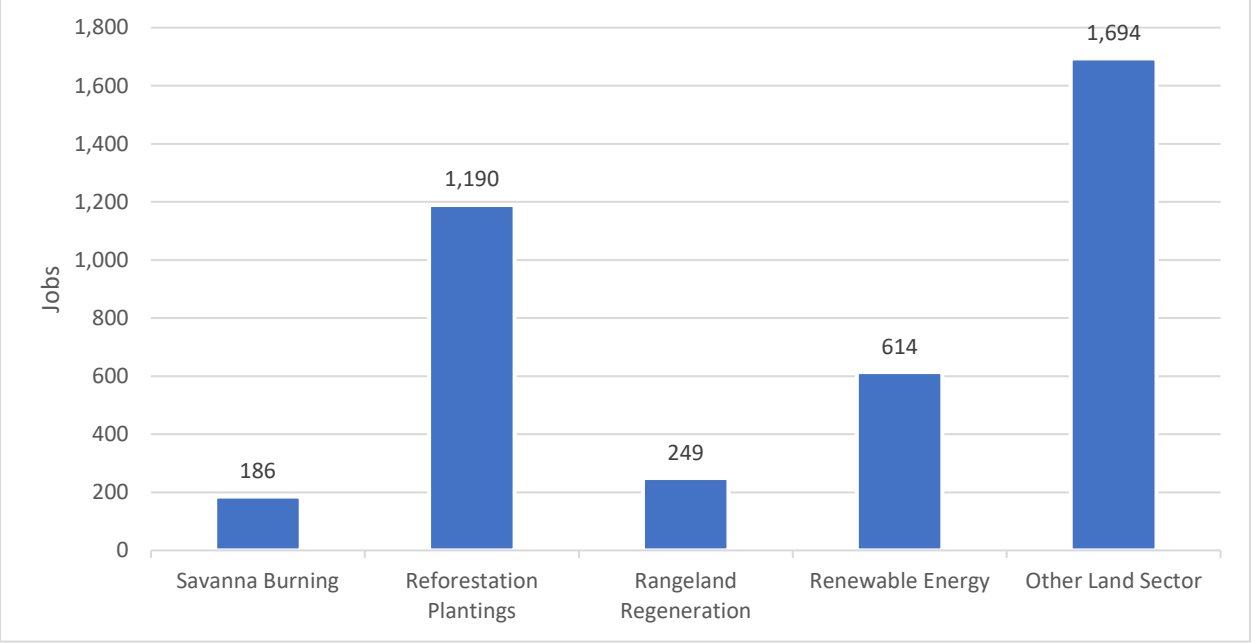
Consequently, the land sector creates a wide differentiation of jobs across all skill levels. These jobs are concentrated in the Western Australian rangelands, with 'growing' projects in the Southern Rangelands and fire-management projects in the far north.

Renewable energy projects provide a larger proportion of skilled and professional construction jobs and can result in faster and larger emissions reductions than tend to occur in the land sector. Accordingly, renewable energy projects tend to create higher paying jobs - averaging over $70k per annum. These projects can also directly mitigate the negative economic effects of a transition to a clean energy economy, which tend to be concentrated in specific areas, e.g. the South West regions of the state.

Although categories such as renewable energy can create many jobs, the sheer size of potential land-sector investment and project types results in the forest planning projects having the larger job creation potential. As shown in Figure 10, other land-sector projects, such as forest management, are also labour intensive and have a high total employment potential, with 5 out of 6 jobs ultimately expected to be created in the land sector. While savanna burning has the highest jobs per dollar invested, below we see that job creation potential is larger for other project types, in line with absolute investment levels. Using the medium demand scenario for illustrative purposes, modelling finds that only 186 jobs could be created though

savanna burning projects, whereas 1,190 may be associated with reforestation plantings, 249 with rangeland regeneration, 614 with renewable energy, and up to 1,694 in all remaining land sector projects.

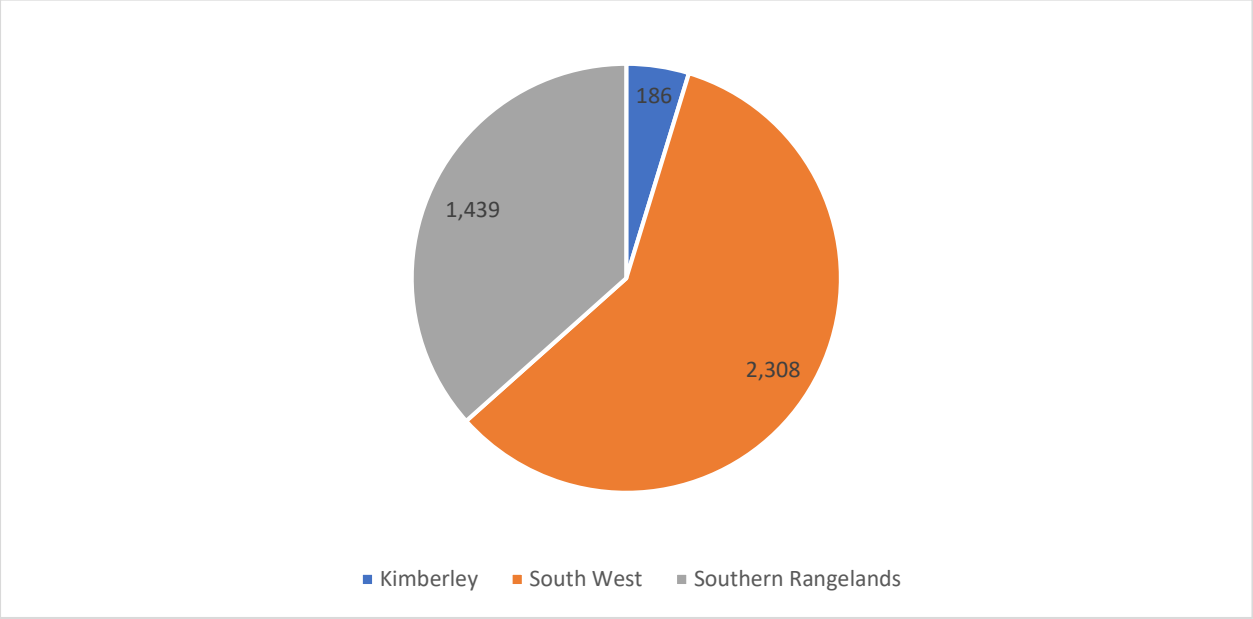
Figure 10: Job creation by category based on modelling of medium demand scenario.



Source: RepuTex 2018

Despite most jobs being associated with land-sector projects, job creation is modelled to be highest in the South West (non-rangeland) region of the state. This is because many of the largest opportunities for jobs associated with labour-intensive renewable energy, reforestation and forest management, are in the southwestern areas which contain both wetter agricultural areas and infrastructure associated with the more built-up parts of the state. Despite this, employment and regional development benefits are spread across the state, particularly in non-urban, regional areas that have in the past been overlooked and/or where job creation is traditionally in decline.

Figure 11: Illustrative job creation by primary investment region in the Medium scenario.



Source: RepuTex 2018

7. CASE STUDIES: ECONOMIC BENEFITS OF OFFSET INDUSTRY DEVELOPMENT

To understand specific economic, investment and employment opportunities created in Western Australia through the development of a carbon offset industry, we provide two case studies, detailing local opportunities associated with rangeland regeneration and renewable energy project development.

7.1 Bulga Downs Rangelands Restoration Project

Summary

- Bulga Downs is a 780,000 hectare (ha) pastoral lease, around 340 kilometres north of Kalgoorlie in Western Australia.
- In June 2018, the Bulga Downs rangelands restoration project was successful in the Emissions Reduction Fund (ERF) reverse auction, which will enable Bulga Downs to generate carbon offsets from revegetation activities on the land using the Human Induced Regeneration (HIR) method.
- The project is expected to generate an average of 80,000 metric tonnes of carbon offsets per year over 25 years.
- The project will bring substantial investment into the local economy, with the potential to generate three to four new full-time roles - a 50 per cent increase from current staff levels - and contract additional services from the local community. Further growth of similar projects also has potential for the increased contracting of specialists within the community for carbon measurement activities, such as contracting local pilots for flyover work monitoring forest canopy growth.

About Bulga Downs

Bulga Downs is a 780,000 hectare (ha) pastoral lease in Western Australia, around 340 kilometres north of Kalgoorlie. David McQuie has owned the lease since 1984, shifting from herding sheep to cattle on the property, in part as result of the impact from dingoes. Since the shift livestock, dingos are now recognised to have some benefit in controlling kangaroo and wild goat populations while having a much more limited impact to his own cattle herd.

Bulga Downs takes a holistic approach to land management on the property, allowing for certain tracts of land to regenerate while the herd is moved onto other parts. At any point in time, around 25 to 30 per cent of the property is under spell, meaning that the land is destocked for a period to enable vegetation to regenerate. The spelling period for any tract of land ranges from one to ten years depending on the condition of the land and how much time it needs to regenerate.

Fencing at Bulga Downs

Cattle are moved to different areas of the property based on several indicators, including the level of grazing and ground cover, rainfall patterns, and distribution of plants. Although this approach restricts cattle from grazing certain tracts of land for years, the size of the herd has increased over the long term as the land has regenerated.

Project Description

Western Australian rangeland projects have historically been precluded from participating in the Commonwealth Emission Reduction Fund (ERF) due to uncertainty over the carbon rights on leasehold land. In April 2018 the Western Australian government gave in-principle support for pilot carbon sequestration projects, enabling landholders to earn carbon credits for their practices. A decision will be

made by the end of the year that may potentially pave the way for pastoralists to permanently exercise their carbon rights to the land.[38]

In June, the Bulga Downs rangelands restoration project was successful in the ERF reverse auction, enabling Bulga Downs to generate carbon offsets from revegetation activities on the land using the Human Induced Regeneration (HIR) method.[39] Through this project, current land management practices will be extended to encourage revegetation in the following ways:

- **Additional fencing -** Additional fencing will be built on the property to allow more precise livestock management across the property.

- **Water point placement -** Even within fenced-off tracts of land, cattle can graze the land unevenly if water sources are concentrated in certain areas, since cattle tend to stay near water sources. To encourage grazing to be spread more evenly across paddocks, more water points will be placed on the land and they will be placed more strategically to optimise grazing patterns.

- **Livestock management -** Livestock numbers per watering point will be managed to avoid overgrazing. While some tracts of land will be free of livestock, much of the land will be managed to promote carbon sequestration while also allowing limited grazing. While certain tracts of land will need to be livestock free for the first few years to establish themselves as forests, livestock integration with the forested land is ultimately viewed as key to the success of the forests. Without livestock grazing in these areas, the land runs the risk of woody weed invasions, higher risk of fire, and misses added nitrogen levels from cow manure as well as nutrients being compacted into the ground. The key is to monitor the land properly to balance the livestock levels.

Not all the property will be set aside for carbon sequestration. Out of the 780,000 hectares on the property, only 100,000 hectares are being targeted for reforestation, which is expected to sequester on average about 80,000 tonnes of carbon dioxide (CO_2) per year over 25 years. This sequestration rate also accounts for land already being reforested due to past land management practices and will not be eligible for generating offsets. Only land that will become reforested after the project has been accepted will be credited. While this will lower the potential for generating carbon offsets, it does mean there is good carbon sequestration potential for other rangeland properties in Western Australia that have degraded land and are considering similar land management practices.

Project Methodology

To measure the amount of carbon sequestered from this project, the HIR methodology was used for the Bulga Dows project. This methodology relies on the Full Carbon Accounting Model (FullCAM) software to model the carbon sequestration from changing land management practices to enable the regeneration of native forest. Forest cover that can be counted towards this methodology is defined as:

1. Land that has an area of at least 0.2 hectares; and
2. Land that has trees that:
    a. are 2 metres or more in height; and
    b. provides crown cover of at least 20 per cent of the land.[40]

Australian Integrated Carbon (AIC) is the project proponent, managing the monitoring, verification, and creation of carbon offsets for Bulga Downs. To create the Australian Carbon Credit Units (ACCUs), AIC establishes a baseline greenhouse gas inventory using remote sensing and airplane flyovers, which are then validated with on the ground field surveys. This survey also identifies which tracts of land are most suitable for sequestering carbon under the project. Follow-up measurements will then be taken throughout the 25-year crediting period to verify that carbon is being sequestered at the expected rates.

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[38] Government of Western Australia, 2018. *Rangeland regeneration to sequester carbon.* https://www.agric.wa.gov.au/climate-change/rangeland-regeneration-sequester-carbon
[39] Australian Government, 2018. *Human-Induced regeneration of a permanent even-aged native forest.* http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/methods/human-induced-regeneration-native-forest
[40] Ibid.

Project Impacts

The Bulga Downs rangeland restoration project is expected to directly sequester about 80,000 tonnes of CO_2 per year over 25 years. Carbon sequestration is expected to be minimal in the first 3 to 5 years, then ramp up significantly from years 5 to 15 before tapering off from years 15 to 25. These sequestration activities can generate ACCUs for up to 25 years. In addition to direct carbon sequestration benefits, there are several co-benefits to the project:

- **Revenue generated from selling ACCUs:** ACCUs generated from the project will be split into three pools:
    - 20 per cent of the ACCUs will be sold through the ERF market
    - 50 per cent of the ACCUs will be sold on the open voluntary market
    - 30 per cent of the ACCUs will be set aside as a contingency fund in the case of fire or another 'reverse' event that could release carbon back into the atmosphere

  Annual ACCUs generated are projected to be valued at between $1.1 and $1.9 million, applied for employing on-site staff, infrastructure improvements (e.g., fencing, water point placements), and project monitoring.

- **Local employment:** Supported by the income stream from selling ACCUs to the market, Bulga Downs is expecting to hire a three to four new low-skilled staff, a 50 per cent increase from current staff levels (seven staff members). As most infrastructure is towards the end of its life, there is a backlog of work on fencing, replacement of yards, and water points, along with livestock management and mechanical maintenance.

- **Indirect economic impacts:** Given that the buyers of ACCUs from Bulga Downs are expected to come from outside the rangelands, ACCU revenues will create a net benefit for the regional economy and local community industries. In addition, project materials will be locally sourced for additional infrastructure improvements, and local specialists contracted. Further growth of similar projects also has potential for the increased contracting of professional and skilled specialists within the community for carbon measurement activities, such as contracting local pilots for flyover work monitoring forest canopy growth.

- **Land and soil benefits:** Given land spelling routing for livestock has been used, increased pasture has been observed in paddocks, along with greater soil stability and fertility, and less erosion during heavy rains. These trends are expected to continue with the implementation of the carbon offset project.

- **Biodiversity benefits:** When the landholder moved onto the property 34 years ago, there were five bird species present. The most recent bird survey showed a dramatic increase to 89 bird species, with these trends expecting to continue with the implementation of the offset project.

Additional carbon offset opportunities from more detailed methods

While the HIR method has been used on projects for a few years, the method covers only 'trees', i.e. vegetation above – or capable of growing above - two metres, with a canopy cover of at least 20 per cent. Management practices being used for rangeland restoration projects, however, are also increasing the carbon stock closer to ground level, e.g. non-tree vegetation (and below ground in the soil). Obtaining accurate measurements of all above-ground vegetation carbon stocks is more resource intensive and costly than monitoring and verification requirements of the HIR method, however, a more complete accounting methodology has the potential to significantly increase carbon offset generation potential. Current estimates suggest that a new rangeland method, that counts all above-ground carbon, could generate an additional 30 to 50 per cent more offsets in the crediting areas than just using the current HIR method, while using a method that measures all above-ground and below-ground carbon could generate an additional 30-90 per cent more.[41]

[41] Correspondence with Dr Peter Russell estimates that there would be a 30-50% increase in ACCUs generated within the existing and potential HIR project Carbon Estimation Areas under an improved rangelands method.

In the case of Bulga Downs, a more comprehensive above-ground methodology could increase average annual carbon offsets from 80,000 tonnes per year to between 104,000 and 120,000 tonnes. At a price of $15 per tonne, that would equate to an annual increase from $1.2 million revenue to between $1.56 and $1.8 million. This could result in the creation of five new jobs, up from three to four under the current methodology. The development of a more comprehensive and cost-effective rangeland method is anticipated to be two years away, while a above- and below-ground method could take another five years.

7.2 Renewable Energy Investment in Collie

Summary

- Supporting the growth of renewable energy in Collie will help drive a just transition for the region by providing investment, a net increase in jobs, and preventing premature deaths through cleaner air.
- The development of 200 MW of solar farms and 300 MW of wind farms in the Collie region is estimated to reduce greenhouse gas (GHG) emissions by 1 million tonnes CO_2e annually, provide $628 million of investment, 478 construction job-years, and 112 to 132 direct permanent jobs for operation and maintenance.
- The Collie region is seeking out the development of the renewable energy among others to diversify their economy, and they are well placed as an established energy hub in the state with the infrastructure and renewable resource potential in the region to support this development.

Background on Collie

The Collie region sits about 200 kilometres south of Perth and is an electricity generation hub for Western Australia. The region is host to three coal-fired power plant complexes (Muja, Collie, and Bluewaters) totalling 1,778 megawatts (MW). In 2017, generation from these plants made up about 50 per cent of all generation in the South West Interconnected System (SWIS), the electricity grid that handles 80 per cent of the electricity needs of Western Australia. All these plants are fed from two coal mines in Collie, which provide around 600 jobs for the region to complement around 400 jobs at the coal plants.[42]

As these coal plants age, however, Collie is looking for ways to diversify the economy and create a viable job replacement plan. Currently, 75 per cent of coal capacity in the Collie region is nearing retirement age, with the Muja AB component of the Muja power plant recently shut down.[43] Meanwhile, investing in renewable energy can result in a net gain in employment relative to the coal industry. Considering there is unlikely to be any commercial appetite for financing new coal-fired replacement capacity, the state government is promoting a few initiatives, including:

- **The $20 million Collie Futures Fund** – This fund was set up to diversify Collie's economy and provide long-term employment security. Currently up to $2 million is available through the Collie Futures Small Grants program.[44]
- **$30 million to support solar power** – The current state government made an election commitment in 2017 to commit $30 million to support the establishment of a solar farm in Collie.
- **$30 million to support biomass energy** - The current state government made an election commitment in 2017 to commit $30 million to support the building of a biomass energy plant in Collie and the planting of timber plantations in the region to support the plant.
- **$100,000 for pumped hydro demonstration plant -** The current state government made an election commitment in 2017 to commit $100,000 for an engineering pre-feasibility study for the deployment of a pumped hydro facility to be built on mine voids around Collie.

[42] The West Australian, 2018, *Collie Councillors Bin Solar Panels Savings Plan for Fear of Rocking Coal Town's Confidence.* Accessed 20 September, 2018: Link.
[43] Government of Western Australia, 2017. *Synergy to Reduce Electricity Generation Cap by 2018.* Accessed 20 September, 2018: Link.
[44] Government of Western Australia. *New Group to Power Collie into the Future.* Accessed 20 September, 2018. Link

Collie has the potential to support substantial renewable energy resources to support a Just Transition[45] away from coal as the industry faces increasing economic and environmental pressures. A 2017 report from Sustainable Energy Now (SEN) highlights the potential for 200 MW of solar generation, 1,000 MW of wind generation, and 400 MW from a biomass facility in the southwest region of Western Australia to displace the retirement of coal generators.[46]

While the potential for renewable resources in the Collie region are available, deploying these resources is also in line with providing clean, reliable electricity at a reasonable cost. A 2017 study found that transitioning as far as 90 to 100 per cent renewable energy grid in the SWIS grid could be nearly cost competitive with fossil fuel alternatives, even without a carbon price, while meeting reliability standards and security requirements. This relied on a mix of rooftop solar, solar farms, wind farms, biogas, and pumped hydro energy storage to achieve 90 to 100 per cent renewable energy penetration. While battery storage was considered, it was not incorporated into the assessment due to its early stages of deployment in Australia and was flagged as another technology that could provide complementary reliability resources at a lower cost if battery prices continue to fall.[47]

Collie has already started transitioning to renewable energy, as a 20 MW solar farm in an industrial area of Collie was approved in May 2018.[48] This project is expected to bring in 40 to 80 construction jobs to go along with four ongoing full-time jobs for the local community.[49]

Representative solar farm for Collie

Drawing on the size of recently approved projects and state government commitments, this case study will look at the potential costs and impacts of a 30 MW solar farm.

Total Investment

Solar installation costs have been dropping significantly in recent years, with ARENA noting that costs have gone down from about $1.60 per watt in 2015 to an expectation of $1 per watt over the coming year, or somewhere between $50 to $60 per MWh.[50] If prices drop as expected, the cost of building a 30 MW solar farm is expected to be around $30 million.

Electricity Generation and Displaced Emissions

To estimate electricity generation from the solar farm, we use a capacity factor of 18.4 per cent which assumes the solar modules use a polar type single-axis tracking system and the average irradiation for the region of 4.69 kWh per square metre per day. Based on a 30 MW solar farm, annual generation would be 48,355 MWh.

To calculate the annual emissions displaced by the solar farm, we took the weighted average emission intensity factor for the SWIS region from fossil fuel electricity since this form of electricity would be most likely to be displaced. The fossil GHG emission factor for the SWIS region for the 2017 financial year is

[45] Just Transition is a framework that has been developed by the trade union movement to encompass a range of social interventions needed to secure workers' jobs and livelihoods when economies are shifting to sustainable production, including avoiding climate change and protecting biodiversity, among other challenges.
[46] Sustainable Energy Now, 2017. *Transition from Coal to Renewable Energy on the SWIS by 2021.* Accessed 20 September, 2018: https://d3n8a8pro7vhmx.cloudfront.net/sen/pages/185/attachments/original/1488364425/SWIS_Transition_from_Coal_to_RE_2021_presentation_edited_28-2-2017.pdf?1488364425
[47] Lu, Bin, Blakers, Andrew, Stocks, Matthew, 2017. *90–100% renewable electricity for the South West Interconnected System of Western Australia. Energy.* Accessed 20 September, 2018: https://www.sciencedirect.com/science/article/pii/S0360544217300774
[48] Government of Western Australia, 2018. *Southern Joint Development Assessment Panel Agenda*. Accessed 20 September, 2018: https://www.collie.wa.gov.au/wp-content/uploads/2018/04/20180424-Agenda-No-33-Shire-of-Collie.pdf
[49] Collie Mail, 2018. *Solar Farm to Mine Cryptocurrencies*. Accessed 20 September, 2018. https://www.colliemail.com.au/story/5461419/solar-farm-to-mine-cryptocurrencies/
[50] Renew Economy, 2018. *Australia Solar Costs Hit "Extraordinary" New Lows – $50s/MWh.* Accessed 20 September, 2018. https://reneweconomy.com.au/australia-solar-costs-hit-extraordinary-new-lows-50s-mwh-27007/

0.75 tonnes CO_2e / MWh, resulting in annual displaced emissions of 36,159 tonnes CO_2e which is equivalent to about 0.2 per cent of all power sector emissions in Western Australia, or 0.3 per cent of the SWIS region.[51]

Job Creation

There are a range of estimates regarding the potential for job creation from solar farm construction and operation. On the lower end, the developer of the solar farm in Collie is expecting to hire 40 to 80 workers for six months for construction of a 20 MW solar farm, with 4 ongoing roles for operations and maintenance (O&M) afterwards. On the higher end, SEN estimates 2.5 job-years per MW for construction and installation (C&I)[52] and 0.3 permanent O&M roles per MW of solar generation in the region. Table 6 summarises the range of different estimates of job creation for solar projects in Western Australia which are scaled up or down by capacity for a representative 30 MW project.[53]

Table 6: Job Creation Potential for a representative 30 MW Project

Project/Report	C&I (Job-Years)	Manufacturing (Job-Years)	O&M (Permanent Jobs)
Collie Solar Farm[54]	45		6
SEN Solar Potential – SWIS Region[55]	75	66	9
Emu Downs[56]	61		
Northam Solar Farm[57]	45		
Job Range	**45 to 75**	**66**	**6 to 9**

Note: Projects have been linearly scaled to normalise data at a 30 MW basis. C&I jobs have been converted to job-years where available.

Other Co-benefits

Solar farm development has the potential to bring in additional co-benefits to the region, including:

- **International industries seeking clean energy sources** – Many major corporations are committed to being powered completely by renewable energy in order to meet their corporate social responsibility and carbon neutrality goals, providing an opportunity for the Collie region to

[51] Australian Government Clean Energy Regulator, 2018. *Electricity Sector Emissions and Generation Data 2016–17*. Accessed 20 September, 2018: http://www.cleanenergyregulator.gov.au/NGER/National%20greenhouse%20and%20energy%20reporting%20data/electricity-sector-emissions-and-generation-data/electricity-sector-emissions-and-generation-data-2016-17

[52] Job-years represent the equivalent number of years that 1 worker would take to complete a job. So, for instance 10 job-years can represent 1 worker working 10 years full time to complete a job, or 10 workers working 1-year full time to complete a job.

[53] On average, jobs in renewable energy industries are more intensive per unit of energy produced than in the coal industry. A Climate Council report on renewable energy jobs estimated that in 2030, a scenario that moved Australia's electricity system to 50 per cent renewables would provide a net increase of about 28,000 construction and operation jobs in the electricity sector compared to 2014, while a business-as-usual scenario would only provide a net increase of 14,000 jobs compared to 2014. Source: Climate Council, 2016. *Renewable Energy Jobs: Future Growth in Australia.* Accessed on 25 September, 2018: https://www.climatecouncil.org.au/uploads/7b40d7bbefbdd94979ce4de2fad52414.pdf

[54] 40 to 80 construction jobs over 6 months and 4 ongoing jobs for a 20 MW project, scaled up to 30 MW. Source: Collie Mail, 2018. *Solar Farm to Mine Cryptocurrencies*. Accessed on 21 September, 2018: https://www.colliemail.com.au/story/5461419/solar-farm-to-mine-cryptocurrencies/

[55] 2.5 job-years/MW for C&I, 6.7 job-years/MW for manufacturing assuming 33 per cent of non-module parts manufacturing is in WA, 0.3 jobs/MW for O&M. Source: Personal Communication with Alastair Leith, Sustainable Energy Now, 25 September, 2018.

[56] 70,000 man-hours went into construction. Assuming 1,710 working hours per year, this comes to 41 job-years for a 20 MW solar farm, scaled up to 30 MW. Source: APA, 2018. *Emu Downs Solar Farm Official Opening.* Accessed 21 September, 2018: https://www.apa.com.au/news/media-statements/2018/emu-downs-solar-farm-official-opening/

[57] 30 construction jobs, assuming over a 6 months construction period for a 10 MW solar farm, scaled up to 30 MW. Source: Clean Energy Council, 2018. *Jobs and Investment in Large-scale Renewables.* Accessed 21 September, 2018: https://www.cleanenergycouncil.org.au/policy-advocacy/jobs-and-investment.html

host renewable energy projects with purchase power agreements for major companies, and to build data centres powered by renewable energy.[58,59]

- **Increased air quality and human health** – The addition of renewable energy to the region will improve the air quality and human health conditions the Collie region and elsewhere in Western Australia by displacing more polluting forms of electricity generation.[60] Four of the pollutants from coal power plants that most directly impact human health are coarse particles (PM_{10}), fine particles ($PM_{2.5}$), sulphur dioxide (SO_2), and nitrogen oxides (NO_x). These pollutants contribute to an increased rate of asthma, respiratory problems, stroke, heart attacks, and cancer. Studies have shown that residents that live within 50 kilometres of a coal plant are three to four times as likely to die prematurely, and in the Latrobe Valley in Victoria, the Hazelwood power station has been estimated to cause 18 deaths per year. Throughout Australia, the health impacts from coal-fired power stations are estimated to be $2.6 billion annually.[61]

Implications for Expanded Renewable Energy Presence in Collie Region

While utility-scale solar power development is not eligible to create offsets under the Emissions Reduction Fund (ERF), investment in this sector by the LNG sector could provide a significant opportunity to drive a Just Transition for the community of Collie, shift all of the south Western Australia to a clean energy economy, attract international investment to the state, and contribute to major emissions reductions toward Australia's pledge to keep global warming to less than 2°C.

Sustainable Energy Now estimates the potential for about 200 MW of utility-scale solar development within an 80-kilometre radius of Collie, which could be complemented by up to 300 MW of wind power development.[62] An investment from the LNG sector to help drive a combined 500 MW of renewable energy generation is estimated to have the following direct impacts:

- $628 million of investment into the Collie region
- 468 construction job years for building out the renewable energy generators
- 112 to 132 permanent jobs created to operate and maintain the renewable energy generators
- 1 million tonnes CO_2e reduced annually[63]

Development of the renewable energy industry in Collie will support a Just Transition for the community as coal generation declines in the long run. The Collie community recognises that there is a transition underway and they are generally supportive of this transition if it is done in a way that is fair to the 1 in 9 people in the community that are directly employed in the coal sector. To help in this transition, the Collie-Bunbury Economic Plan is currently being drawn up which will identify major industries to target for investing in the region. Running in parallel to this effort, the state Public Utility Office is developing a retirement schedule for the coal generators in the region that is due out at the end of 2018. Once this schedule is released, more clarity is also expected regarding the status of the state government's solar and biomass commitments for the region.

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[58] Data Center Knowledge, 2018. *Special Report: Data Centers & Renewable Energy.* Accessed 20 September, 2018: https://www.datacenterknowledge.com/special-report-data-centers-renewable-energy

[59] Deloitte, 2017. *Serious Business: Corporate Procurement Rivals Policy in Driving Growth of Renewable Energy.* Accessed 24 September, 2018*: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-corporate-procurement-renewable-energy-report.pdf*

[60] Government of Western Australia Environmental Protection Authority, 2017. *EPA Urges Tighter Environmental Controls in Collie Report 1607*. Accessed 20 September, 2018: http://www.epa.wa.gov.au/media-statements/epa-urges-tighter-environmental-controls-collie-report-1607

[61] Environmental Justice Australia, 2017. *Toxic and Terminal: How the Regulation of Coal-Fired Power Stations Fails Australian Communities.* Accessed 24, September, 2018: https://www.envirojustice.org.au/sites/default/files/files/EJA_CoalHealth_final.pdf

[62] Sustainable Energy Now, 2017. *Transition from Coal to Renewable Energy on the SWIS by 2021.* Accessed 20 September, 2018: https://d3n8a8pro7vhmx.cloudfront.net/sen/pages/185/attachments/original/1488364425/SWIS_Transition_from_Coal_to_RE_2021_presentation_edited_28-2-2017.pdf?1488364425
Personal Communication with Ian Porter of Sustainable Energy Now on 21 September, 2018.

[63] These impacts are limited to direct impacts for building out and operating renewable energy generation and does not account for the potential for increased manufacturing for renewable energy generation parts, establishing local biomass feedstocks, and indirect job creation in the community from increased economic activity.

8. APPENDIX A

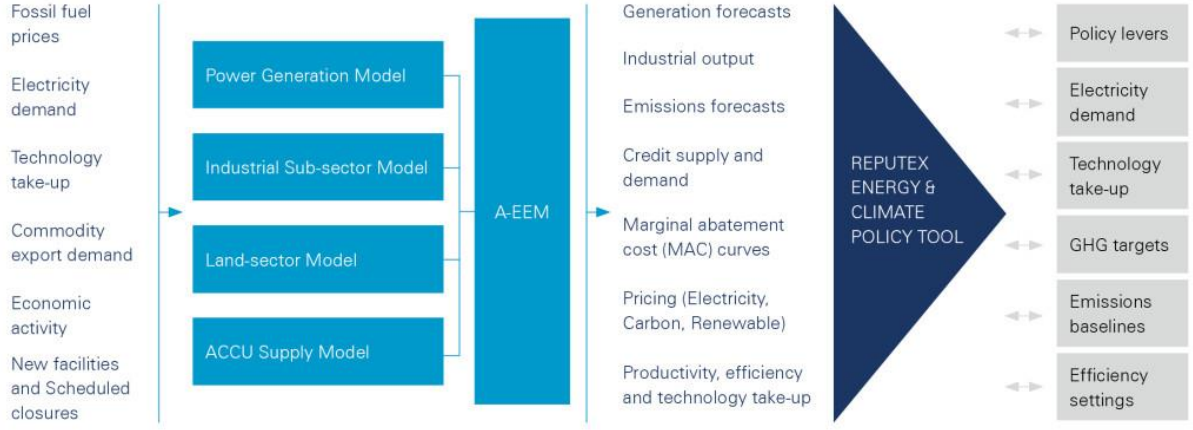
8.1 Australian Energy and Emissions Model (A-EEM)

Project cost and volume analysis is derived from our Australian Energy and Emissions Market (A-EEM) model. This model references current ACCU issuance and contracted obligations under the Emissions Reduction Fund, along with our ERF Auction Simulation Tool, which maps project cost and volumes, transaction costs and bidding behaviour to establish upper and lower price estimates for the competitive reverse auction scheme.

Our A-EEM model is comprised of three sub-sector models for the power, industrial, and land-use sectors, producing output and emissions forecasts for the Australian market through to 2050. A-EEM produces a range of outputs including:

- GHG emissions projections;
- Energy generation, consumption, and pricing projections;
- Industrial production projections;
- Supply and demand for carbon credits;
- Credit export and import dynamics; and
- Marginal abatement cost (MAC) curves.

Figure 12: RepuTex Australian Energy and Emissions Model (A-EEM) schematic



Our marginal abatement cost (MAC) resource, contained within our A-EEM model, was originally developed in 2012 and is subject to regular review. Review and output benchmarking is supported by consultation with around 50 industry participants, providing feedback on technology readiness, cost assumptions and barriers to investment for emissions reduction activities across the Australian economy.

Analysis covers all GHG emissions sectors of the Australian economy, with selected activity types filtered for the purpose of this project. A baseline of Australia's 2017 'business as usual' emissions projections is created, with emissions projected to 2030. Emissions reduction opportunities are then identified, and combined, to form our Australian abatement cost curve, with available abatement volumes benchmarked against our reference case emissions baseline.

8.2 Marginal Abatement Cost (MAC) methodology

A MAC curve depicts the emissions reduction potential and corresponding cost for abatement activities relative to a reference case in a specified year. The width of each bar represents the potential to reduce emissions in the stated year. The height of each bar reflects the annualised net cost of reducing one tonne of GHG emissions. The full MAC curve reflects the potential emissions reduction from all activities within the assumed scenario.

Analysis covers all GHG emissions sectors of the Australian economy, with a baseline of Australia's 2017 emissions projections. Emissions are projected to 2030, with the cost curve analysing the year 2030

specifically. In determining the readiness of a technology, analysis considers whether technologies currently at the pilot stage, or later, and whether there is consensus for a technology to be in place prior to the stated timeline. The modelling process is summarised below:

- The emissions baseline originates with the Government's 2017 emissions projections for Australia.
- Emissions reduction activities and technologies are based on opportunities identified through extensive consultation with industry.
- Abatement potential is defined as the annual reduction between the baseline emissions in 2030 and the emissions projection after the activity has been implemented.
- Abatement costs are defined as the annualised cost of reducing GHG emission by one tonne of carbon dioxide equivalent.
- Abatement costs assume an 'investor' approach, including annualized repayments for capital expenditure and operating expenditure, along with the project cost of implementing or installing a given activity or technology.
- Costs and opportunities therefore reflect the marginal cost per tonne faced by an investor to implement an emissions reduction opportunity, including the typical private costs of capital. Investment barriers faced by the market are considered, taking account of market constraints such as the availability of technology, along with energy demand forecasts, new and expanded facility production rates, power capacity forecasts, and expected learning curves.
- Transaction costs, institutional barriers and non-monetary costs (e.g. investment appraisal, procurement and legal costs, and regulatory compliance costs, administrative costs of finance, etc.) are not included.
- To calculate the total abatement potential and cost of abatement activities, a few measures which fall within a defined activity may be grouped together, with an average marginal abatement cost and quantity of emissions reductions calculated based on bottom-up analysis of different technical and economic potentials.
- Emissions reduction activities and technologies are ordered in terms of least marginal cost of abetment, with the maximum possible volume of emissions reductions determined from an assumed scenario analysis.

Key Assumptions

A MAC curve is a dynamic tool which needs to be regularly updated due to changes in emissions baselines, fuel and technology costs and technological developments. Subsequently, there are many uncertainties contained within MAC curves, including:

- Accuracy of current emissions data and projections,
- Changes to business-as-usual projection,
- Changes to energy prices for gas and oil,
- Development of new technologies, and
- Investment risk created by climate policy uncertainty.

Modelling assumes the following:

Behavioural change	No adjustments were made for opportunities involving lifestyle or behavioural changes (e.g. driving less) not because they are undesirable, but because their costs or benefits are largely non-financial and thus difficult to quantity.
Carbon Capture and geologic Storage (CCS)	CCS is not assumed to play a major role in Australian abatement before 2025. After 2025, CCS could be considered on a large scale, with the Power sector showing the largest CCS potential (55 percent of the total) due to large point sources, availability of cheap fuel/electricity and suitable infrastructure. There is high uncertainty on the cost side, as CCS technology has not yet been deployed on such a large scale successfully. Costs are assumed to decrease with development stages; we assume $224/tonne from a "cost to investor" perspective (i.e. 15 percent interest rate). Base capex for new-build coal-fired power plants equipped with CCS is $11,200/kW (assuming a 40-year lifespan). Storage availability is not assumed to be a significant bottleneck for long-term CCS-equipped plants that can sell CO2 for enhanced oil recovery (EOR) with additional revenue stream.
Discount rates	About four per cent depending on sector.

Distributed generation	Electricity costs continue to rise while solar PV persistently fall, positioning distributed generation as a dominant abatement technology from 2018 onwards.
Electricity consumption	Australian Energy Market Operator's 2017 neutral electricity consumption. In this projection increased electricity demand is largely offset by projected solar PV growth.
Electricity emissions	Electricity emissions are not expected to reach peak levels seen in 2009 due to a combination of relatively flat electricity demand and a decrease in the emissions intensity of the electricity sector.
Emissions projections	Baseline emissions resulting in 551 Mt of total domestic emissions in 2020 and 570 Mt in 2030. Note that figures are based on Australia's Emission Projections 2017.
Energy prices	Energy prices are critical to the calculation of the marginal abatement costs of each activity. These include the price of electricity and gas, which reflect our estimates at the beginning of 2018. Analysing in-scope measures involved a wide range of assumptions, including barriers to development, energy demand forecasts, new and expanded facility production rates, power capacity forecasts, expected learning curves, and initial generation costs.
Energy security	Cost of new power development favours demand-side management and energy storage.
Gas price	Average gas price of $10/GJ between 2018 and 2030.
Land clearing	Government projection (2017) for land clearing emissions;
Levelised cost of energy	Cost of new energy development favours renewables with wind and solar PV remaining the cheapest. The levelised cost for each generation technology is calculated based on a 20- to 40-year cost recovery period, using a real after tax weighted average cost of capital of 7.7 percent for comparison purposes. The actual cost of capital may vary by technology, e.g. the cost of capital for coal-fired facilities are likely higher than this, whereas the cost for solar PV expect around 7 per cent equity return for contracted plants.
Livestock activity	Increased herd numbers in agricultural linked to international demand.
Nuclear energy	Assumed no nuclear power development.
Oil price	Projected to average $80 a barrel (expressed in real 2018 dollars) over the projections period.
Renewable Energy Target	33 Terawatt-hour (TWh) Large-scale Renewable Energy Target for eligible production after 2020.
Solar PV	Engineering, Procurement, and Construction (EPC) costs of $1.15 per Watt and capacity factor dependent of mounting fixed tilt (lower end of range) or tracking (higher end of range).
Technology	All activities analysed are technologically feasible, meaning that in a projected year, greenhouse gas emissions reduction is projected to be possible with the technology.
Wind	EPC costs about $2,000 per kW, with an average capacity factor of 34 per cent.

9. REPUTEX CONTACTS

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