Collie at the Crossroads

Planning a future beyond coal

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Beyond Zero Emissions acknowledges that we work on Aboriginal land. We pay our respects to their Elders past, present and emerging.

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Repower our Regions

Beyond Zero Emissions (BZE) is an internationally recognised climate change think tank, providing independent and ambitious climate change solutions for Australia.

Our flagship research program shows how all sectors of the Australian economy can decarbonise, repower and benefit from the transition to zero emissions.

These Zero Carbon Australia plans cover renewable energy and electricity; energy efficient buildings; sustainable transport; agriculture, farming and land use; and industry.

Through volunteer-powered research we show that a thriving, equitable zero emissions society is achievable and affordable now, and that Australia can become a renewable energy superpower.

Beyond Zero Emissions is using this research to develop reports for repowering fossil dependent regions with renewable energy, zero carbon industries, agriculture and land use.

Collie at the Crossroads is part of our Repowering our Regions program. We have already published reports for the Northern Territory and Port Augusta in South Australia. Plans for the Hunter Valley in New South Wales, rural Victoria and elsewhere in regional Australia are to follow.

The Noongar people are the Traditional Custodians of southwest Australia. Collie is located on the land of the Wilman tribe, known as the fresh water people. Collie and surrounds are part of the Gnaala Karla Booja region. We recognise that the Noongar people's sovereignty over their land was never ceded and the impact of this ongoing dispossession continues to this day. Beyond Zero Emissions stands in solidarity with First Nations people in calling for the establishment of a First Nations Voice in the Constitution, as described in the Uluru Statement from the Heart. We further support calls for the establishment of a Makarrata Commission on agreement-making and truth-telling between Aboriginal and Torres Strait Islander peoples and governments.

Our reports will support regional communities to identify zero-carbon opportunities and empower them to act. Each report draws from our award-winning body of research. They are:

- led by our world-class researchers and community of local experts
- tailored to the unique character and needs of each region
- practical and deliverable
- bold, energising and inspiring
- empowering, giving communities the information they need to build support for rapid decarbonisation and to inspire people to act.

Collectively, these reports will show how Australia can be a renewable energy superpower in the zero-carbon global economy.

Support our work

Donate

Your support will enable our community of climate experts to continue delivering climate solutions that inspire hope and action. We make your dollars work hard to produce high-impact solutions by pairing our world-class research team with enthusiastic and capable volunteers from academia, business and government. With your tax-deductible donation we can deliver more successes like these:

Electrifying Industry: a global first report showing how manufacturing can fuel switch to renewable electricity. The report was launched at a one-day seminar attended by more than 200 leaders in industry and renewable energy.

Rethinking Cement: the world's first report showing how cement can be decarbonised. This has generated international and national interest and support across the construction and infrastructure sector.

Stationary Energy Plan: this pioneering report changed the conversation on renewables in Australia, showing governments, businesses and communities that 100% renewable electricity is possible.

Electric Vehicle Report: shows how Australia can easily and affordably match and even top the UK's lead on electric vehicles. The report has been endorsed by the ACT and Queensland governments.

Renewable Energy Superpower: a report that has become the spoken ambition of Australian climate leaders.

Zero Carbon Communities Guide: a guide to inspire confidence and action at the local level.

Volunteer

Beyond Zero Emissions is powered by volunteers: engineers, scientists, economists and communicators all contributing their time and expertise to develop and promote climate solutions that support a rapid transition to zero emissions.

You can support our bold vision for a Zero Carbon Australia by donating your time with us. Opportunities exist for motivated and capable volunteers across cities and regions. Many of our volunteers make new friends, expand their professional network and learn new skills while doing interesting and impactful work with us.

Partner

We have successfully translated findings from our research into commercial projects for a select group of clients who share our values and ambition. We can deliver these solo or in partnership with other organisations. Selective commercial work provides an important opportunity for us to translate our visionary research into direct outcomes.

Contact us via our website to find out more about how you can support our work by making a donation, volunteering or partnering with us.

www.bze.org.au

Endorsements

'BZE have for years been the pathfinder, mapping the possibilities for our rapid, and inevitable, transition to a low-carbon society. The Zero Carbon Australia Electric Vehicles Plan [2016] is another vital piece of the jigsaw we must complete to make that transition, but particularly important given the need to move away from our social and economic reliance on ICE technology in a large continent with a widely dispersed population.'

Ian Dunlop, Member of the Club of Rome

'[BZE's Buildings Plan, 2013] comprehensively proves how we can reduce our buildings emissions, and demonstrates how individuals can contribute. The leadership shown by Beyond Zero Emissions is what the world needs, effective communication of practical applications to solve our current climate crisis.'

Jigar Shah, Clean energy entrepreneur and author of "Creating Climate Wealth: Unlocking the Impact Economy"

'[BZE's Stationary Energy Plan, 2010] is a timely and aspirational report that deserves the widest attention and debate, particularly by political and industrial decision makers.'

General Peter Gration, AC, OBE, FTSE, Former Australian Chief of Defense

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The Climate Justice Union works in communities across Western Australia to accelerate the transition to zero emissions and prepare for climate change impacts, while taking care of people and place.

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Key Messages

1. Western Australia is endowed with a wealth of renewable energy resources. **There is ample sun and wind to power the state's electricity needs; domestic, commercial and industrial.** Well developed technology exists to provide reliable and affordable renewable electricity to consumers.

2. Renewable electricity is cheaper than new or existing coal or gas fired power stations. This reality is becoming clearer as the global transition to renewables accelerates. In this context, the closure of Collie's coal industry is inevitable. **Immediate action is needed to secure the livelihoods of coal workers, their families, and the town they support.**

3. **Collie's economy can be re-tooled for a low-carbon future, creating 1,750 long term, secure jobs in renewable manufacturing, green building materials and recycling.** Many of these new jobs are made possible by a rapid rollout of renewable energy.

4. **A 100% renewable electricity target would spur on over $13 billion in new investment on the grid and 5,000 jobs in construction and maintenance.**

5. **The energy transition can pay social dividends.** Working conditions can be improved and economic benefits can be shared through programs for home energy efficiency upgrades, small business sustainability and direct community investment.

Contents

Executive Summary

What does Collie look like in 2030? This simple question has profound implications for the 9,000 people who call the town home. For Collie to prosper, a grand coalition must be formed, which works to secure the town's future in the interests of the community, workers and the planet.

The climate is changing quickly. Western Australia is getting hotter and drier. A rapid transition to renewable energy is needed to avert the worst of these changes.

The future is uncertain for workers in Collie's coal industry, long the town's economic mainstay. **The recent announcement of plans to close Muja units 5&6, as well as jobs losses at Griffin Coal, highlights the urgent need for long-term, funded transition planning.**

Staring down the end of the industry that built the town, Collie faces a challenge dozens of communities around Australia, and thousands worldwide, will confront in coming decades.

Despite these challenges, the future for Collie and fossil-fuel communities all over Australia is bright, if they can seize the opportunities coming decades will present. **The global move to a low-carbon economy presents a once-in-a-generation opportunity for Collie's workers.** A local workforce geared towards sustainable industry and manufacturing can underpin the next century of prosperity for Collie's people.

The opportunities outlined in this report are made possible by a broader transition on WA's main electricity grid. The looming closure of Muja power station is the perfect opportunity for WA to fully harness the state's renewable energy abundance. A renewable transition and creating a circular economy can lower costs, diversify WA's economy and create healthier, more sustainable regions.

Benefits for community in the Gnaala Karla Boodja region need to be planned at the outset. **This work to secure a social licence for change can begin immediately.** Existing workers can be looked after, conditions can be maintained. Local communities must also be supported through the transition, including programs to assist small businesses and low-income earners.

Collie can retain its role at the heart of the energy system by supplying and supporting the rollout of renewable energy in WA. Existing skills and infrastructure in the Collie-Bunbury region can be put to use developing new, high-value products for use in WA and abroad.

Opportunities

This report describes a range of industries set to grow rapidly in coming years, and highlights the secure, well-paid jobs they can create in Collie.

Taken together the opportunities listed below have the potential to create over 1,750 jobs in Collie, more than offsetting 1,250 positions in the coal industry. The transition described in this report would avert more than 14 million tonnes of CO_2-e per year by 2030.

Renewable Energy Transition: Hundreds of new jobs in the South West supporting a grid powered 100% by renewable energy. Collie's role at the heart of the network maintained.

Sustainable Building Materials: Collie supplies Western Australia with valuable sustainable construction materials, and helps to decarbonise the state's buildings and infrastructure.

Recycling Renewable Technology: Western Australia leads the world in battery and PV recycling, processing and reuse.

Table 1: Summary of economic opportunities

Employment in Collie & Bunbury		Investment (2019 dollars)
Renewable energy transition	1,245	$13+ billion statewide
Sustainable building materials	330	$330 million
Recycling renewable products	175	$82.5 million
Total	**1,750**	**$13.4+ billion**

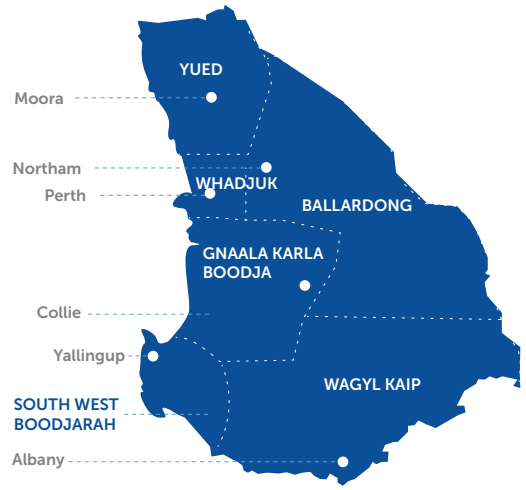
Recommendations

Long-term policy direction and programs will drive the economic transition described in this report. To create conditions for change, this report recommends:

1. **Secure social licence for the transition through support for workers and the community.**
2. Legislate for a **100% Western Australian Renewable Energy Target (WA-RET) by 2030.**
3. **Maximise local industry participation** by designating all WA-RET developments as "strategic projects" under the Western Australian Industry Participation Strategy.
4. Implement **low-carbon building material requirements** for all state and local government infrastructure spends over $20 million.
5. Develop a **Renewable WA Common User Facility** to supply the transition to 100% renewable electricity and position WA as a world leader in clean technology.
6. Create a **Western Australian Sustainable Industry Investment Fund** to drive the transition to clean manufacturing and industry with $2.5 billion in investments over ten years.
7. **Review and redirect existing industry support** away from fossil fuel and boom/bust mineral developments towards emerging clean industries.

The Gnaala Kaala Boodja region

Figure 1: Noongar language divisions



The Gnaala Karla Boodja region refers to the Noongar language or dialectical groups of the Binjareb/Pinjarup, Wilman and Ganeang peoples. The Gnaala Karla Boodja region encompasses the region south of Perth to Donnybrook and from the coast inland to past Narrogin.

Collie is located on the lands of the Wilman tribe of the fresh water people. The Wilman people acknowledge the Ngarngungudditj Waugal as the creation spirit of the Collie River. To demonstrate respect, each visit to the river begins with the tossing of a handful of dirt into the water. This act "lets the river know we are present".[1]

The Wilman people have preserved and protected their boodja (land) and moort (family) since time immemorial, sustaining cultural practices for thousands of generations. Despite two centuries of colonisation, the Wilman have maintained traditions which care for the land and waters of Collie and surrounds.[2] The Collie region is home to a lasting testament to this history of dislocation and cultural revival in Roelands Village, a former mission which now runs healing and cultural programs.[3]

The environment movement, Governments and mainstream Australia have much to learn from Traditional Owners in how to live sustainably on Noongar boodja.

Noongar ownership of land - *koorah, nitja, boordahwan*

All of the projects proposed in this report fall within Noongar boodja, and will impact, shape and change the land. In recognition of ongoing Noongar sovereignty over Noongar boodja, it falls to project developers and Government to ensure Traditional Owners are both active participants in the planning process and beneficiaries of the economic opportunities created.

The principle of Free, Prior and Informed Consent (FPIC) should be a cornerstone of engaging with Traditional Owners about their land. FPIC ensures that Traditional Owners have 'equal opportunity' to engage with any proposed project on their land or which impacts their land. Equal opportunity means equal access to financial, human, linguistic and material resources in order for communities to fully and meaningfully engage in the process.[4]

Benefits to Indigenous communities must be planned at the outset, and not dependent on hopes of prosperity "trickling down". Canada and New Zealand already have successful track records of renewable energy projects facilitating Indigenous benefit, including part-ownership of renewable energy resources. This First Nations experience can guide the participation of Traditional Owner groups in the coming energy revolution.[5]

Designing a transition for Collie that also contributes to righting the wrongs of colonisation will depend on the commitment of all participants to listening to Traditional Owner voices.

Noongar seasons - *Birak, Bunuru, Djeran, Makuru, Djilba and Kambarang*

Noongar people recognise six seasons, based on the unique climate of Noongar boodja. These seasons, determined by weather patterns, are called:

- Birak, December & January, the first summer.
- Bunuru, February & March, the second summer
- Djeran, April & May, the autumn
- Makuru, June & July, the first rains
- Djilba, August & September, the second rains
- Kambarang, October & November, the wildflower season

Knowledge of these seasons helps Noongar people know which animals and plants are available for hunting or harvesting. Taking only what is needed from the land is a core component of Noongar custom. By studying changes in nature, Noongar people know when certain foods or medicines are plentiful, and when they should be left to recover.

Through working in concert with natural patterns, Noongar people avoid depleting the resources they rely on. These customs allowed Noongar culture to flourish for tens of thousands of years. The knowledge of how to live on boodja was given to Noongar people by the Waugal and has been passed down by Elders ever since.[6]

1. Introduction

Western Collieries Ltd workers C.1960s[7]

Collie sits in the *Gnaala Karla Boodja* region, home for tens of thousands of years to the *Pinjarup*, *Wilman* and *Ganeang* people.[8] *Noongar* people maintain strong cultural links to the Collie region, and to particular sites, such as the Collie River.[9] In 2015 this ongoing connection was recognised in a landmark native title determination encompassing Collie and the South West, the South West Native Title Settlement.[10]

Since the 1880s, Western Australia (WA) has been powered by coal mined from Collie and its surrounds. Collie's prosperity, and much of its identity, was borne of this industrial history.

Collie is located 200 kms from Perth, in the heart of the South West Interconnected System (SWIS). The town's coal industry is made up of two coal mines and the three power stations they supply.[11] The mines and power stations combined employ around 1,250 workers and contractors.[12]

As a result of changes in the energy system, there is growing uncertainty over the viability of Collie's coal industry, and a strong push from the community for rapid economic diversification. The stark reality of a warming climate, the economics of a renewable grid and the design limitations of coal generators mean Collie's coal industry faces a perfect storm.

Figure 2: Collie and surrounds

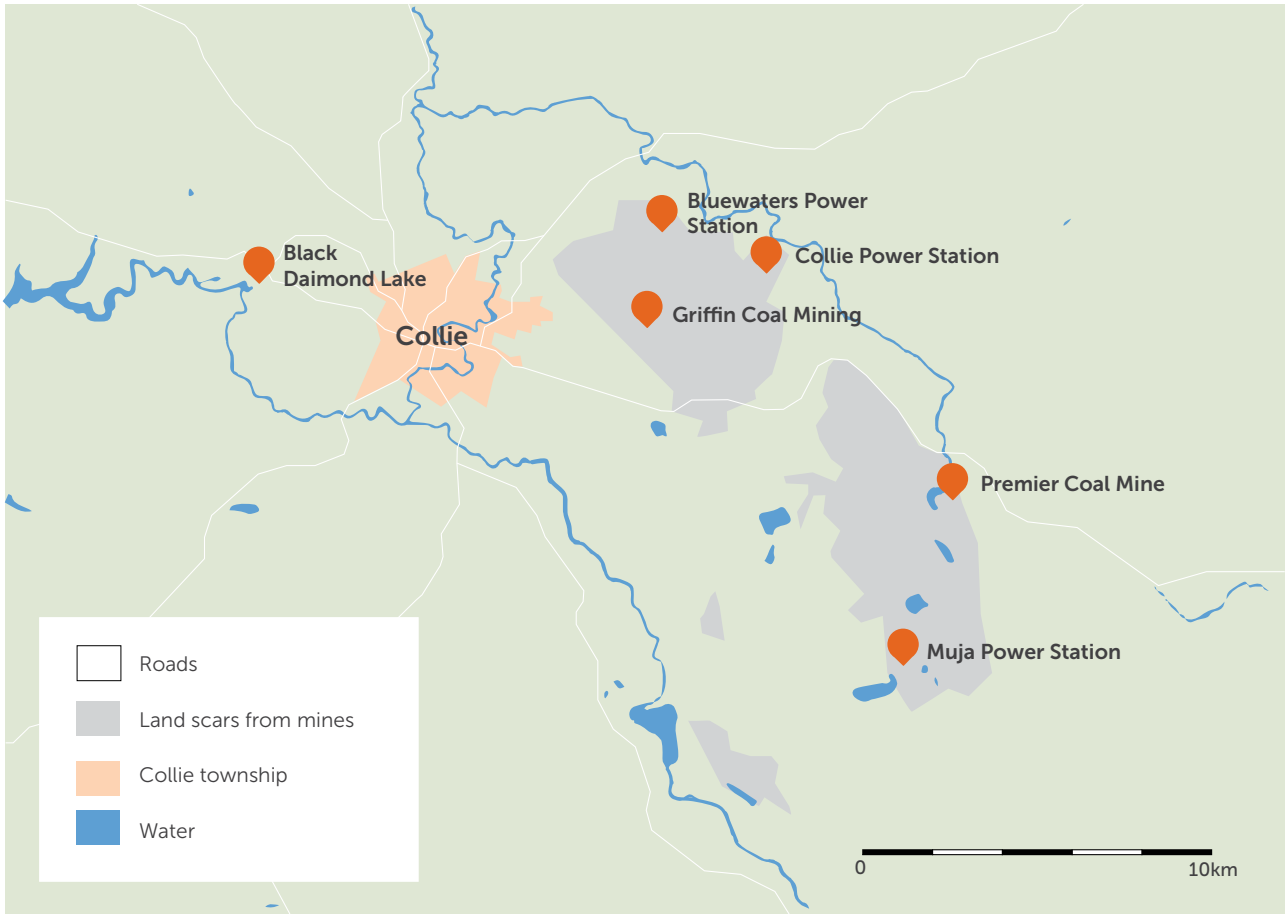
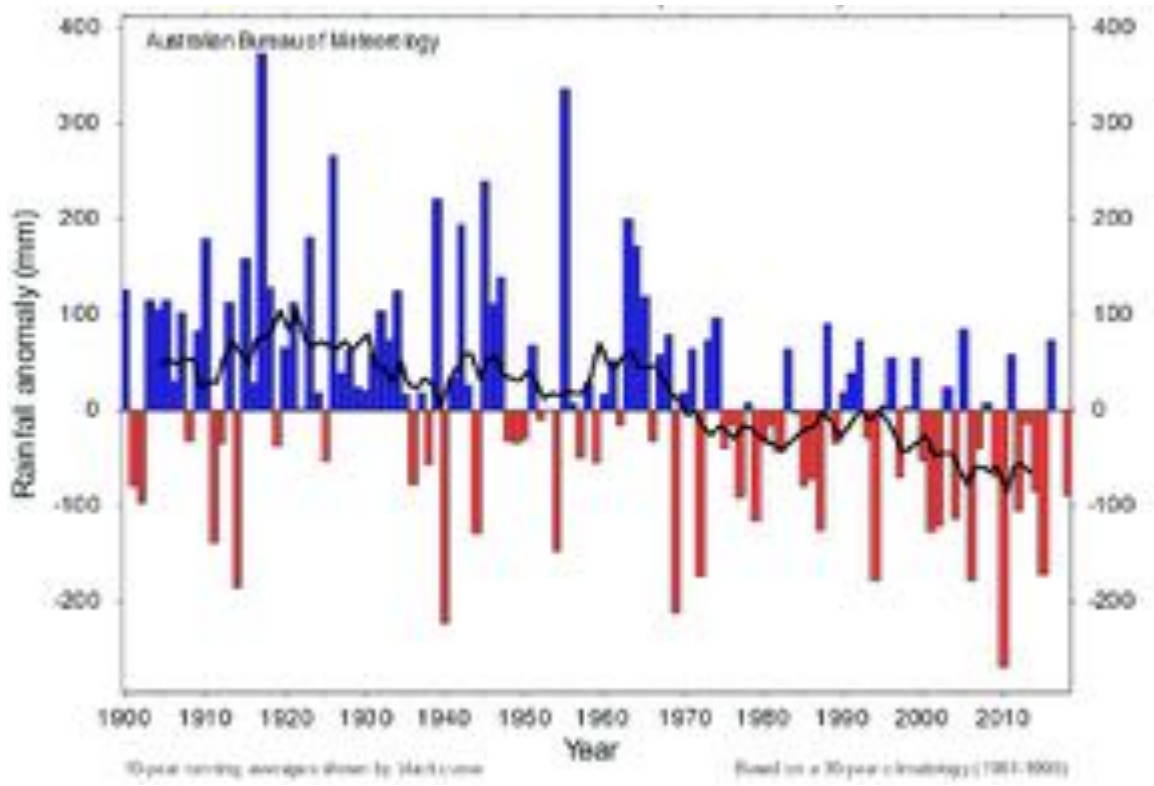


Figure 3: Annual rainfall anomaly - South Western Australia (1900 - 2018)



Collie, and the South West more broadly, are particularly exposed to the risks of climate change. South West WA has been called a "canary in the coal mine for climate change" due to a stark decline in rainfall over recent decades.[13] Rainfall has declined 20% in the lower South West since 1970 and predictions are for this trend to continue.[14] Worst case projections by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BoM) indicate rainfall could decline by an additional 35% on current levels by 2090 if greenhouse gas emissions are not brought under control.[15] [16]

The end of coal presents WA with a choice about the type of economic transition that Collie will face. Regional transitions away from fossil fuels can be an opportunity for economic diversification and growth, or stagnation and decline.[17]

Much existing work has focused on the opportunities in tourism and agriculture to replace jobs lost in Collie's mines. Developing these sectors is to be encouraged; however, to provide a sufficiently secure economic future on which the town can rely for its lifeblood, the strengths of the existing workforce must be harnessed.[18]

This report describes a range of well-paid and secure jobs in new industries that can support Collie's future development.

The clean energy revolution will see US$10.3 trillion dollars invested worldwide by 2050, and hundreds of billions more spent on investment in low-carbon manufacturing.[19]

Collie and the South West are ideally located to lead the state and nation in transitioning local economies to sustainable industry. A prosperous future for Collie can be built on the back of WA's strong renewable resources and the region's established energy and transport infrastructure, skilled workforce and existing heavy industry.

Collie at the Crossroads maps out a vision for a prosperous, low-carbon Collie in 2030. This report shows how the energy transition can pay economic and social dividends to communities moving away from coal, while establishing sustainable new industries that will set them up for decades to come.

2. Global renewable energy transition

A powerful combination of governments, investors and business action is driving our global economy towards a zero-carbon future. Renewable energy investment now outperforms most fossil fuel investments, a trend that is accelerating.

This transition will have a profound effect across the economy. Sectors such as manufacturing, mining and transport will be transformed in perhaps the biggest wave of change since the industrial revolution. Clear planning and decisive action can support regions most impacted to build new renewable industries and provide attractive jobs for workers.

Governments, business and communities will all play a part in securing a position for Western Australia as a leader of the global clean energy economy.

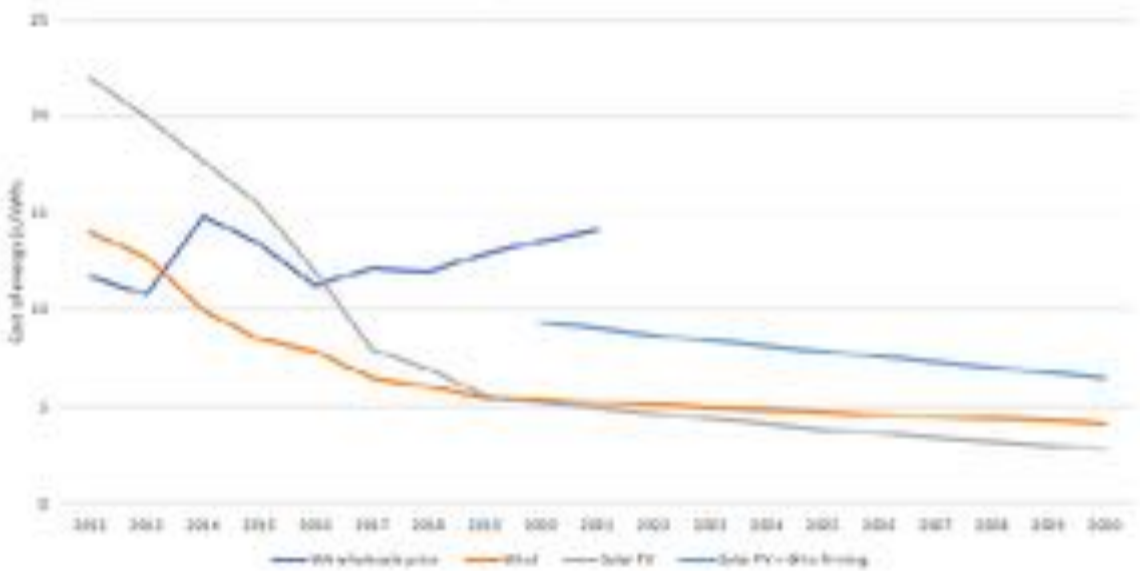
Renewables are now cheaper than fossil fuels

Fossil fuels will be trapped in a pincer movement, with economics on one side and climate action on the other. The cost of renewable energy has been falling steeply for decades, and solar power is now 80% cheaper than only 10 years ago.[20]

In Australia, large scale wind and solar power are now often cheaper than existing coal and gas power plants – even when the cost of building those plants has been paid off.[21] Electricity from large-scale solar can now be produced for as little as 5-6 cents per kilowatt hour (c/kWh) in Australia, well below the average market price.[22] This compares to Western Australia's average wholesale price of around 13 c/kWh.[23]

Solar PV and battery costs are set to continue their steep decline. By 2030, solar PV could fall by another 50% and solar PV firmed with two hours of battery storage will be far cheaper than current forecasts for Western Australia's wholesale energy (Figure 4).[24] Renewable electricity at this price will completely rewrite energy economics.

Figure 4: The cost of renewable energy in Australia has plummeted and will continue to fall.



Government policy supports climate action

To achieve the Paris Climate Agreement's aim of keeping warming to "well below two degrees", most of our fossil fuel reserves must remain in the ground, and new fossil fuel developments are out of the question.[25] Australia's key trading partners, such as China and India, are ramping up their climate policies and setting ambitious renewable energy targets.[26] We must decarbonise our exports to maintain strong demand for our goods and services in a renewable energy economy.

> *"...now is not the time for a medium-sized economy to test global tolerance for free riders."* [27]
>
> *Innes Willox, CEO of the Australian Industry Group*

As more countries impose costs on carbon pollution, Australia will come under increasing political pressure to put a price on carbon. China now runs the world's largest emissions trading scheme [28] and the European Union is already discussing carbon tariffs.[29]

Investors are divesting from fossil fuels

The Investor Group on Climate Change has called the Paris Agreement an unambiguous market signal of the end of fossil fuels.[30] Responding to this, institutional investors have divested more than $US6 trillion of fossil fuel investments.[31] Institutional investors are now joining forces to demand more ambitious climate action.

The Investor Agenda, a group of 415 investors representing over US$32 trillion in assets, has called on governments to put a price on carbon, abolish fossil fuel subsidies and phase out thermal coal power.[32] Advocacy from the Task Force on Climate-related Financial Disclosures and investor groups like Climate Action 100+ has persuaded many of the world's largest corporate emitters, including significant WA operator Rio Tinto, to commit to ambitious targets for decarbonising their operations. [33] [34]

Fossil fuels also face increasing legal challenges.[35] A court case early in 2019 saw the first Australian decision against a new coal mine on climate grounds. A NSW court dismissed an appeal against the initial rejection, basing part of its reasoning on the increased greenhouse gas emissions a new mine would cause.[36]

Business initiatives

Many large businesses are surpassing governments in their level of climate ambition. Some of the world's leading companies aim to source 100% of their electricity from renewable sources. Apple, Google and Microsoft have already achieved this goal.[37]

More than 500 global corporations have joined the Science Based Targets initiative, which requires them to set emissions reduction targets in line with the Paris Agreement. Signatories include many household names such as Coca-Cola, Gap, IKEA, L'Oreal, Nestlé, Sony and Walmart. Some corporations, such as Mars and Sony, have gone further, committing to eliminating their indirect (Scope 3) emissions.

In WA, even large emitters like Woodside, Westfarmers and South32 are using internal carbon pricing to guide business decisions and quantify climate risk.[38]

3. A 100% renewable grid

Powering Western Australia with 100% renewable energy by 2030 is affordable and achievable.[39] [40] [41] [42] The economics of renewable generation have improved to the point of consistently beating traditional thermal generators on price.[43] [44] [45]There is a growing consensus among Australia's experts in energy policy, economics and engineering that moving the energy system to 100% renewable generation is a necessary change. [46]

While the bulk of Australian energy modelling demonstrating pathways to 100% renewable energy has focused on the east coast National Electricity Market (NEM), the same factors work in Western Australia's favour. Western Australia has excellent access to wind and solar resources and plenty of suitable locations for pumped hydro energy storage.[47] [48]

The first step in transitioning Collie's economy from coal to clean energy and industry is a rapid, managed transition of Western Australia's main grid (the South West Interconnected System) to 100% renewable energy. By committing to a wholesale renewable rollout on the SWIS, WA can raise its profile as an energy innovator, lower power prices and create a thriving local industry in low-carbon manufacturing and clean technology. A 100% renewable energy SWIS is the foundation of securing Collie's future without coal while delivering broader social and economic benefits to all Western Australians.

Individual modelling done by Sustainable Energy Now (SEN) and researchers at the Australian National University (ANU) shows a 100% renewable SWIS is achievable by 2030.[49] [50] Table 2 below summarises the technology mix each set of modelling suggests would be sufficient to reach 100% renewable energy.

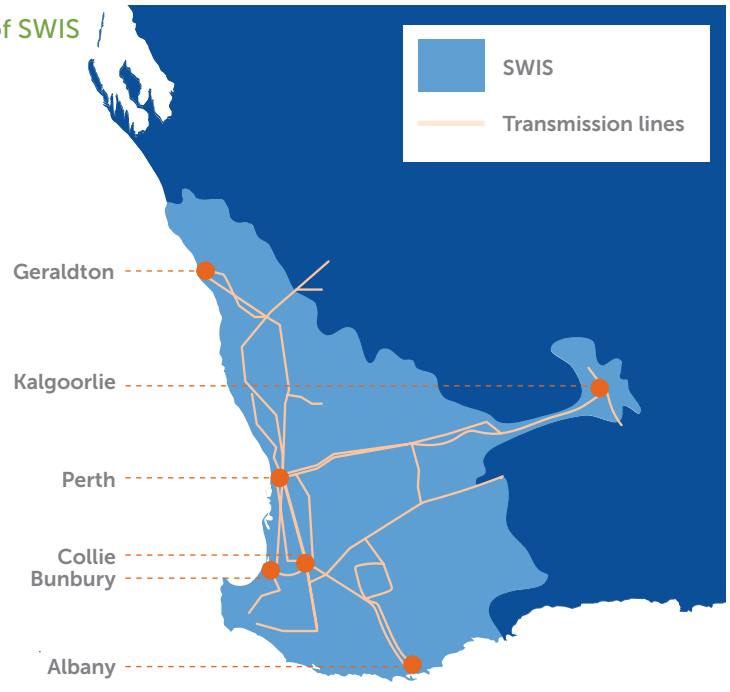
Table 2: Technology mix for a 100% renewable SWIS

	SEN	ANU
Wind	6,000 MW	4,000 MW
Solar	3,000 MW	4,300 MW
Dispatchable renewable	3,300 MW	3,000 MW
Total	**12,300 MW**	**11,300 MW**

This report has based its findings on SEN's higher figure of 12,300 MW of renewable capacity. The SWIS already contains 650 MW of wind and utility solar generation, as well as 1,100+ MW of rooftop solar PV.[51] [52] Taking this existing capacity into account, reaching 100% renewable electricity requires a buildout of under 1,000 MW of new capacity per year to 2030.

There is currently 4,900 MW of renewable capacity committed or under construction in Queensland alone and three times this amount nationwide. Despite a shambolic national policy environment,

Figure 5: Collie at the heart of SWIS



Australia built almost 12,000 MW of renewable capacity between January 2017 and December 2018.[53] Given these figures, building 1,000 MW per year in WA is a readily achievable goal.

The price of renewable energy has declined rapidly in recent years. The Levelised Cost of Energy (the cost per unit of output) for solar projects in the NEM has declined by more than 60% since 2015.[54] The CSIRO projects the cost of solar generation will fall another 35-40% and wind generation will drop by over 15% by 2030.[55] Alinta Energy CEO, Jeff Dimery, recently announced Yandin Wind Farm, 200km north of Perth, was likely to produce electricity at under $50/MWh when completed in 2020.[56]

Table 3: Current and future cost of renewable energy

	Solar	Wind
NEM LCOE in 2019	$50-60/MWh[57]	>$60/MWh[58]
CSIRO 2030 projections[59]	$30-40/MWh	$50/MWh

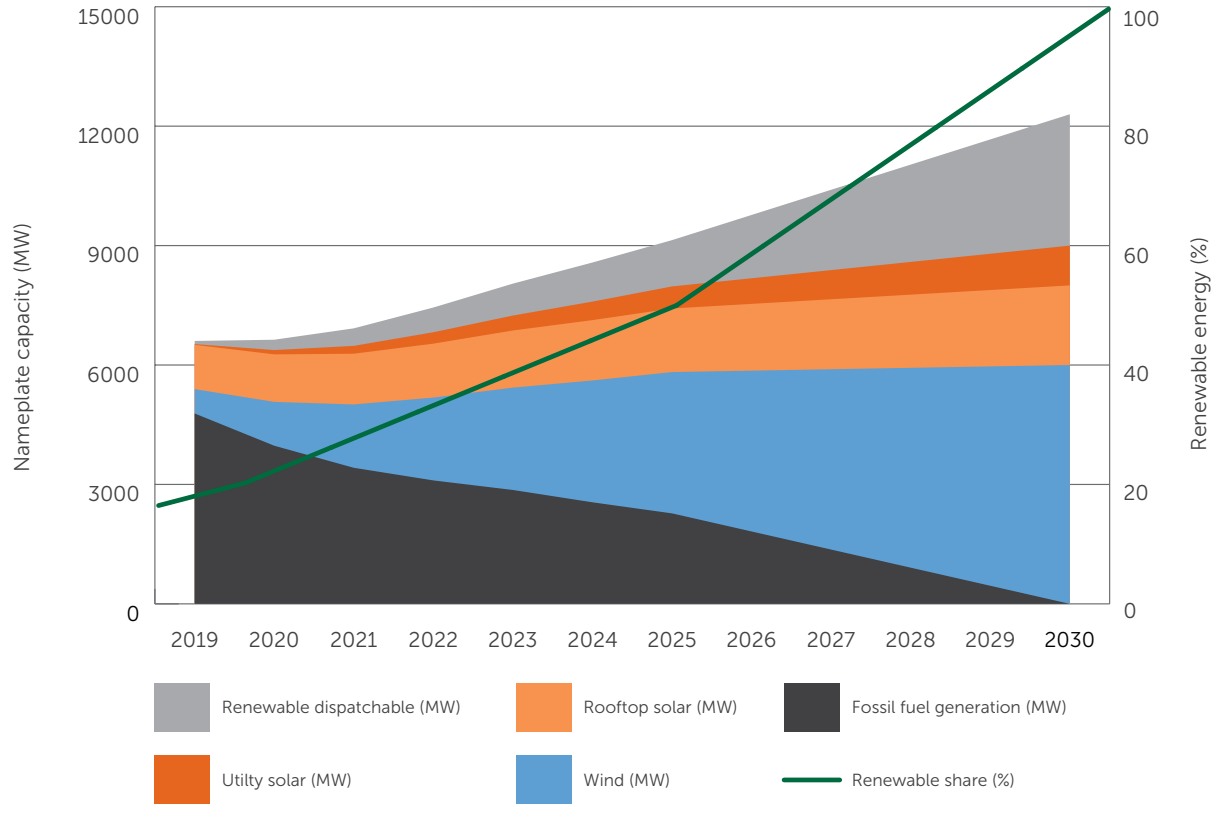
Extra costs will be incurred to ensure that renewable energy can be dispatched at any time it is needed. These "firming" costs include storage and grid services such as inertia and frequency control (to keep the whole network stable and running safely).

The cost of firming these intermittent generation sources is estimated to be an additional $5/MWh up to 50% renewable energy penetration, and $25/MWh at 100%.[60] [61]

The CSIRO estimates the cost of solar energy firmed with six hours of storage will be $70 by 2030 - cheaper than any competing technology.[62] For comparison, the Australian Energy Market Commission (AEMC) gives a WA wholesale price of $129/MWh, with projected price increases of >4% through to 2022 due to rising coal and gas prices.[63]

Exposing WA energy consumers to the full cost of their supply has been an ongoing issue for WA State Governments. Hundreds of millions of dollars of subsidies have been paid out of consolidated revenue to shield consumers from the full cost of running the energy system.[64] [65] To reduce this burden on the budget, households were hit with a 7% increase in the cost of electricity in 2018-19. An ambitious renewable energy rollout is the best option to protect consumers from inevitable price hikes as these subsidies are withdrawn. [66]

Figure 6: Indicative 100% renewable energy pathway



4. The future of industry in Collie

The statewide rollout of renewable energy will create thousands of jobs in regional areas around Western Australia. Meanwhile, the loss of jobs resulting from the closure of Collie's coal plants and mines will be highly localised. Sustainable new industries need to be established to ensure Collie's workers do not face significant financial hardship as the coal industry winds down.

WA's abundant renewable resources create a massive opportunity to boost the state's industrial base and capture far more value from its mineral resources.

Collie is well placed to ride this wave of reindustrialisation as the new hub of sustainable manufacturing in WA.

> *"Renewable energy is the way that Australia can once again become a cheap energy superpower and industries like aluminium smelting will relocate onshore."*[67]
>
> *-Kobad Bhavngri, Head of Bloomberg New Energy Finance Australia*

Manufacturers that adapt will remain competitive in a low-carbon future. Current fossil fuel reliant industrial processes are simply incompatible with the emissions reductions required of nations to achieve the aims of the Paris Agreement.[68]

4.1 Low-carbon manufacturing

The move to low-carbon manufacturing and processing presents a once in a generation opportunity to reduce costs and achieve a competitive advantage in a carbon-constrained world. WA has huge potential to drive a wave of industrialisation using new technology and affordable, renewable energy.

The Collie-Bunbury region, at the heart of the SWIS, has a skilled workforce, strong transport links and existing industrial infrastructure. These factors make the region the ideal location for these new industries to develop.

At the same time as cheap renewables are reshaping the economics of energy intensive industries, demand for low-carbon materials and products is set to boom.

- The value of the global green building materials market is predicted to increase from US $46 billion in 2014 to US $364 billion in 2022.[69]
- In response to customer demand, metal producers such as Rio Tinto and Alcoa now charge a premium for low-carbon products.[70]
- Many of the technological barriers to producing sustainable industrial products such as green steel have been overcome.[71]
- Private firms and Governments are increasingly required to account for embodied emissions in products and infrastructure.[72]

Companies and jurisdictions that seize this potential will prosper, those that don't will be left behind.

The growing market for low-carbon materials is also creating exciting opportunities for new industries focused on reusing and recycling post-consumer and post-industrial materials.[73] Creating circular industries, which capture the value in waste to produce new sustainable materials and products, is an opportunity worth up to $4.5 trillion worldwide by 2030. [74]

The opportunities below are only a few of the many available to Collie and Western Australia. Strategic investment, forward thinking and long-term vision can underpin decades of sustainable economic growth for the Collie-Bunbury region.

Box 1: Skills for the future

For Collie to prosper as a sustainable manufacturing hub, time and money will need to be spent reskilling Collie's coal workers. Although local workers will have a wealth of transferable knowledge, additional sector specific training will be a vital first step in helping coal workers to transition to new roles.

Assisting workers to complete training while still employed can help to minimise the disruption experienced and ensure a steady supply of skilled staff for growing new industries.[75] Workers should be supported to identify their existing skills and the jobs they hope to transition into. Tailored training plans backed with funding from employers and government can then be developed to help fulfil these ambitions and overcome barriers to retraining.[76] Priority must be given to ensuring local educational facilities are equipped to deliver the necessary programs. Consideration should also be given to co-locating educational facilities in Collie with business entrepreneurship and innovation programs.

The University of NSW's Industrial Relations Research Centre attributes substantial investment in training and innovation programs for much of the success in transitioning Germany's Ruhr Valley away from coal mining.[77] The centre's report, *The Ruhr or Appalachia? Deciding the future of Australia's coal power workers and communities*, found:

"Retraining—especially when used as a preventative measure rather than a reactive response to plant closure—is the most effective method for preventing unemployment and long-term unemployment. This training needs to occur well before retrenchment to be most effective in the transition to decent work. It should also be provided without cost to those workers."

4.2 Protecting workplace conditions

The end of Collie's coal industry will inevitably have a profound effect on the town. This report shows how sound planning can make this a smoother process, leading to economic renewal and the creation of thousands of high-quality jobs. Putting workers and community at the heart of this planning will help to secure the best possible outcome for the town.

The International Labour Organisation (ILO) argues the energy transitions can contribute to greater prosperity both for the affected workers and the community more broadly:

> *"Greening all enterprises and jobs by introducing more energy and resource efficient practices, avoiding pollution and managing natural resources sustainably leads to innovation, enhances resilience and generates savings which drive new investment and employment."* [78]

The energy transition presents an opportunity to rethink the kind of economy we want. In recent years, work in Australia has become less secure, wages have stagnated and the interests of employers dominate industrial relations.[79] [80] As old industries close and new industries open, we have a choice in the kind of economic transition we create.

Workers in Collie's coal mines and power stations have benefited from a long history of strong union representation. Despite challenges created by the declining viability of Collie's coal mines, unions have continued to play a central role in protecting the conditions and entitlements of local workers.[81] [82] To gain the support of coal workers and their representatives, new jobs must be high quality.

WA union members protest outside Albemarle lithium processing plant site in April 2019 (credit: AMWU)

Maintaining high-quality working conditions will be an ongoing challenge as new employers enter the region. Government can play a leading role in promoting fair and democratic workplaces by ensuring that all government-funded projects in Collie-Bunbury adhere to agreed workplace standards. Minimising the use of contract labour, protecting collective bargaining rights and guaranteeing a central role for worker's representatives in all negotiations are important and achievable proposals.

By stepping up to the challenge and providing a hands-on approach to coal transition, WA's State Government can help to create well-paid, secure, and sustainable jobs in Collie.

5. Creating new, real jobs for Collie

Collie has over 1,250 coal industry jobs. By harnessing the skills of the existing workforce, South West Western Australia can rapidly transition to a renewable grid. Achieving a 100% renewable SWIS can help to create 1,750 new jobs in Collie-Bunbury.

The decarbonisation of the SWIS is the foundation for the future of Collie and is achievable, with clear mandates and policy support, within 10 years. Not only will a 100% renewable energy SWIS deliver jobs and economic gains in the Collie-Bunbury region, the initiatives required to deliver the renewable energy technology in this timeframe will also be supporting ongoing renewable energy development for other regions.

Over 1,750 new jobs are spread across a range of industries, with a more diverse employment base providing greater security to the region (see Figure 7).

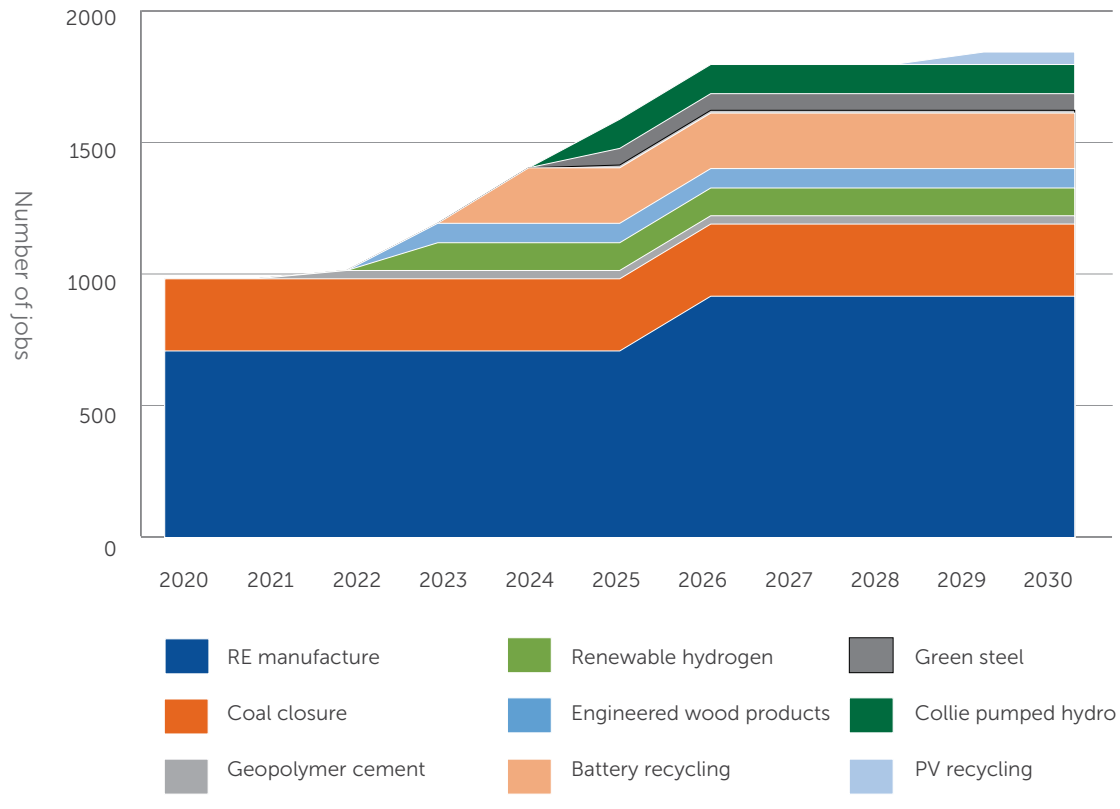
Renewable Energy: Hundreds of new jobs in the South West supporting a grid powered 100% by renewable energy. Collie's role at the heart of the network maintained.

Sustainable building materials: Collie supplies Western Australia's construction and infrastructure sector with low-carbon cement, wood products and recycled steel.

Recycling renewable technology: West Australia leads the world in battery and PV recycling, processing and reuse.

The chart below shows the build up of jobs from 2020-2030 in the Collie-Bunbury region. Over this period, all current coal industry jobs are replaced with high quality equivalent jobs in renewable energy powered sectors.

Figure 7: Employment impacts of *Collie at the Crossroads* proposals 2020-30



Explainer: What is a job?

The jobs which will underpin Collie's ongoing economic wellbeing are those in secure, long-term and well paid workplaces. Therefore, jobs listed in this report are all ongoing operational jobs lasting 10 years or more. Although no construction jobs are counted in the section below, there will likely be an average of 100 additional construction jobs per year required to build facilities for making new building materials and recycling plants.[83]

A job year = 1 Full Time Equivalent (FTE) worker for 1 year. Jobs are not equal to workers; this terminology is not interchangeable.

E.g. Coal plant decommissioning creates 260 jobs for ten years.

- Theoretically, this could be done in 5 years by creating 520 jobs (doubling the resources allocated), or over 20 years by halving resources to 130 jobs.
- Not all jobs will be filled by 1 person. Many Australians are choosing to work a 0.8 FTE workload, meaning 1 'job' might be shared among the workforce. If half of the 260 jobs created were filled by full-time workers, and the rest were filled by people working 0.8 FTE, this would create employment for an additional 30 people working at 0.8 FTE for ten years.

5.1 Making renewable energy

Transitioning to 100% renewable energy will create 5,000 jobs in construction and maintenance across WA between 2020 and 2030.[84] These energy generation jobs will be created in the windiest, or sunniest locations in the SWIS.[85]

In addition to these jobs in the installation and maintenance of renewable energy infrastructure, a great many more will be created designing and manufacturing the equipment and components necessary to build wind and solar farms.[86]

Figure 8: Renewable resources on the SWIS

There are huge opportunities for jurisdictions with strong renewable resources and an established industrial base, such as Western Australia, to create ongoing employment along the whole renewable value chain (see Table 4). The Collie-Bunbury region can be the location for much of the supporting industry and innovation upon which a statewide rollout of renewable energy will rely. Using a mix of existing and new infrastructure, access to transport and a skilled workforce, Collie can capture a large share of the investment value, and resulting employment, a large scale renewable rollout will entail.

Table 4: Summary of renewable opportunities

	Jobs	Investment
Manufacturing	870	$13+ billion statewide[87]
Pumped hydro (200MW)	60	Included above
Coal Plant Decommissioning	260	$75 – 125 Million[88]
Green hydrogen peaking plant	45	Included above
System stability	10	Included above
Total	**1,245**	**$13+ billion statewide**

Renewable energy manufacturing

At present, the vast bulk of Australia's wind energy manufacturing is done offshore, due in large part to an uncertain policy environment. Consistent energy policy is needed to provide incentive for offshore manufacturers to establish Australian operations (see Box 2). Our modelling shows that with the right policies in place, building a 100% renewable SWIS would create up to 870 high-value manufacturing jobs for the duration of the 2020-30 rollout.[89] [90] [91]

The Collie-Bunbury region can be home to much of the supporting industry and innovation upon which a statewide rollout of renewable energy will rely. Using a mix of existing and new infrastructure, access to transport and a skilled workforce, Collie can capture much of the investment value, and resulting employment, a large scale renewable rollout creates. A centralised facility for the manufacture and development of renewable technology will ensure the maximum possible share of the required infrastructure could be captured by WA firms (for more information see Section 7.3).

Not modelled were the ongoing opportunities in supplying the repowering of the North West Interconnected System (NWIS), remote mine sites and industrial users, as well as in developing energy export industries. Given the vast scale of WA's energy resources, and rapid energy demand growth in the wider region, there will be a substantial market for renewable manufacturers well beyond 2030. Projects such as the Asian Renewable Energy Hub highlight the significant, ongoing revenue streams emerging as the region decarbonises.[92]

Box 2: Keeping jobs local

The first major wind manufacturing announcement in recent years, Vestas' commitment to produce turbine hubs and drive trains in Geelong, came about as a result of local content requirements imposed on developers under the Victorian Renewable Energy Target (VRET).[93] Australian renewable manufacturing mainstay, Keppel Price, has doubled its wind tower fabrication workforce, predicting strong future growth under state clean energy targets.[94]

Targeted industry support and policy stability can significantly boost the share of domestically sourced materials in renewable energy projects. The share of domestic production in the United States wind industry almost tripled in five years from 25% in 2008 to 72% in 2012.[95] This growth has been attributed to consistent tax policy and local industry support.[96]

WA has existing industry capacity in the manufacture components for large projects, with many local firms contributing materials and know-how to massive mineral and fossil fuel developments. The skills and capabilities required to produce fibreglass turbine blades are similar to those already found in the state's marine services and construction industry. Likewise, steel fabrication businesses working with the oil and gas sector could readily transition to producing turbine towers and solar panel mountings. More complex components would likely require industry capability building but investing in this area would set WA manufacturers up to ride a wave of renewable energy development in Australia and throughout South East Asia.

Coal plant decommissioning

Coal plant and mine closures are often associated with job losses. Yet closures also create jobs in the decommissioning and rehabilitation processes they necessitate. The progressive closure of Collie's coal industry could create over 260 jobs per year over ten years.

The closure of Victoria's Hazelwood Power Station, and South Australia's Northern Power Station, provide a guide for the jobs created in the progressive closure of Collie, Bluewaters and Muja Power Stations.[97] These examples both indicate that 1.7 job years is created for every 1MW of generation capacity closed. The total generation capacity of Collie's power stations is around 1,600MW, indicating around 100 jobs for ten years will be required to decommission these plants.

Coal mines also create work in remediating and repairing the landscape. Roughly one worker is required to rehabilitate 2.4 hectares of disused coal mine in a single year.[98] Based on this, to rehabilitate Collie's 4,000 hectares of coal mines, 165 jobs will be created for 10 years.[99]

Unions and employers can work together to create an additional safety-net for workers vulnerable to long-term unemployment by ensuring they are prioritised for roles in rehabilitation and decommissioning.

Creating a workforce skilled in mine rehabilitation has the potential to create an ongoing pipeline of work for Collie locals. The South West has a number of large mines that will require partial or wholesale rehabilitation in coming decades, including in nearby Boddington and Greenbushes (see Box 3).

To ensure the remediation of Collie's mines leads to ongoing work, opportunities for co-locating training facilities should be investigated. Re-tooling Collie TAFE as a specialist facility in mine remediation, land management and heavy machinery operations would equip Collie's workers with the skills they will need to 2030 and beyond.

Box 3: The challenges of mine rehabilitation

Mine rehabilitation is a complex and expensive process. As BZE highlighted in *The 10GW Vision*, many closed mines leave a legacy of heavy metal contamination and groundwater pollution.[100] This point has recently been reinforced by news the Balla Balla river system in northern WA has been contaminated by runoff from the shuttered Whim Creek Copper Mine.[101]

Of particular concern is the practice of non-productive mines being put into indefinite "care and maintenance". In discussing WA's gold mines, researchers from Edith Cowan University found "Sites in care and maintenance are often neglected and minimal rehabilitation is undertaken resulting in massive environmental liabilities and social issues." [102]

The WA State Government, Premier Coal and Griffin Coal must start planning now for the full and ongoing rehabilitation of Collie's coal mines. A mine closure which protects the health of Collie's residents and the surrounding environment will require a great deal of money and strict regulations in place to ensure rehabilitation is completed to a high standard. Ongoing monitoring to ensure compliance with stringent environmental standards will also be necessary to maintain community confidence.

Engaging Traditional Owners in the remediation of Collie's mines presents an opportunity to reaffirm Noongar connection to country and improve rehabilitation outcomes.

The closure of Collie's coal mines can set a new standard for mine rehabilitation in WA. Given the scale of the challenge facing the state, with 1,137 mines in various condition listed as "shut", developing a comprehensive model for the closure of aged mines should be a priority.[103] [104]

Hydroelectric energy generation

Hydro energy generation is a very mature technology with a long track record of efficient operation. Hydroelectric power stations make energy by gravity feeding water through a turbine and can generate large volumes of consistent electricity. Hydroelectric power stations are also very flexible, able to quickly follow changes in demand and are well suited to providing grid stability. [105] [106]

Pumped hydro energy storage (PHES) uses the same principle as a traditional hydroelectric power station, with the additional benefit of being able to pump water back uphill when electricity is cheap. As Figure 9 describes, when there is insufficient generation on the grid, stored water is released back downhill to generate electricity. This process converts around 80% of input energy into valuable supply at times of low generation.[107]

The retired coal pits in the Collie region are potentially an excellent location for pumped hydro, given their size and proximity to transmission infrastructure.[108] Other surrounding bodies of water or suitable combinations of potential reservoirs could also serve as upper or lower storage ponds, depending on practical, amenity and environmental concerns.

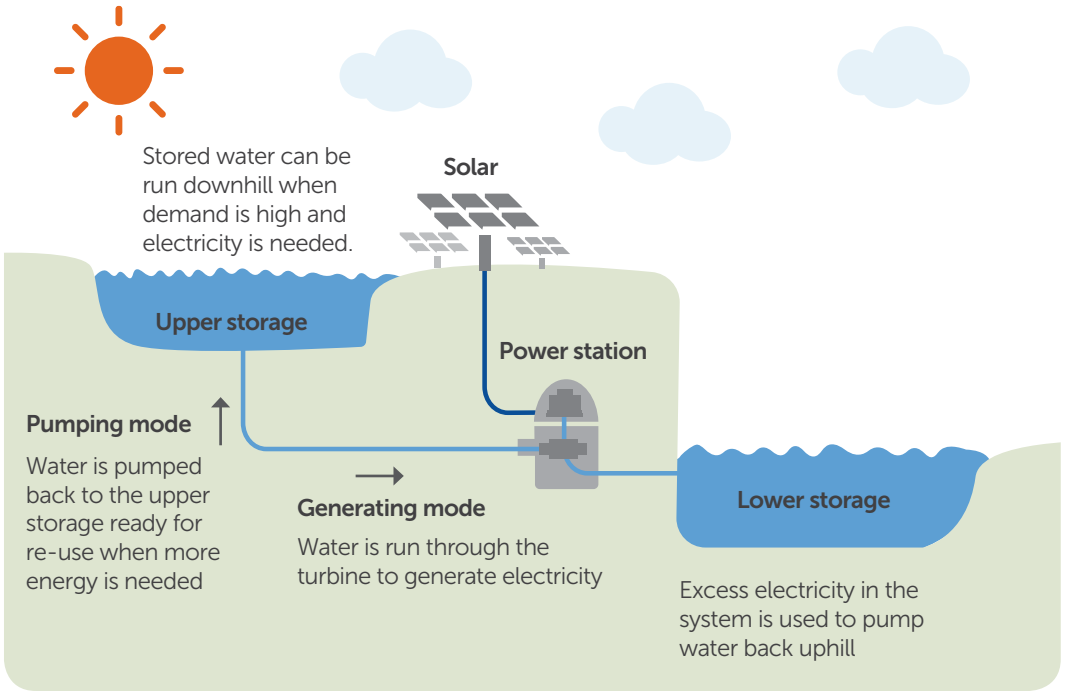
Box 4: Pumped hydro in former mine

The Kidston Clean Energy Hub is an integrated solar and pumped hydro project in northern Queensland. Located on the site of a former gold mine, the Kidston project combines 320MW of solar PV with a 250MW/2,000MWh pumped hydro system run out of an abandoned gold mine. The project, due to commence construction in 2019, will produce enough renewable electricity to power 260,000 homes. The project received financing from both the Clean Energy Finance Corporation (CEFC) and the Northern Australia Infrastructure Facility.[109]

Subject to a detailed site feasibility study, it is possible that Western Australia could store a significant portion of its overnight energy needs in a Collie Pumped Hydro Energy Storage Plant. A 200MW/1,600MWh plant could provide up to 12% of average overnight demand.[110]

Operating a 200MW Pumped Hydro plant in Collie would likely create 60 jobs.[111]

Figure 9: Pumped hydro energy storage (PHES) system



Green hydrogen peaking plant

Hydrogen will be an essential global commodity in the 21st century. Hydrogen's high energy density, versatility and ability to be transported over long distances make it a useful way to move and store renewable energy around the world. The gas is also used in several important industrial processes, such as the manufacture of green steel, fertilisers, glass, electronics and organic chemicals.

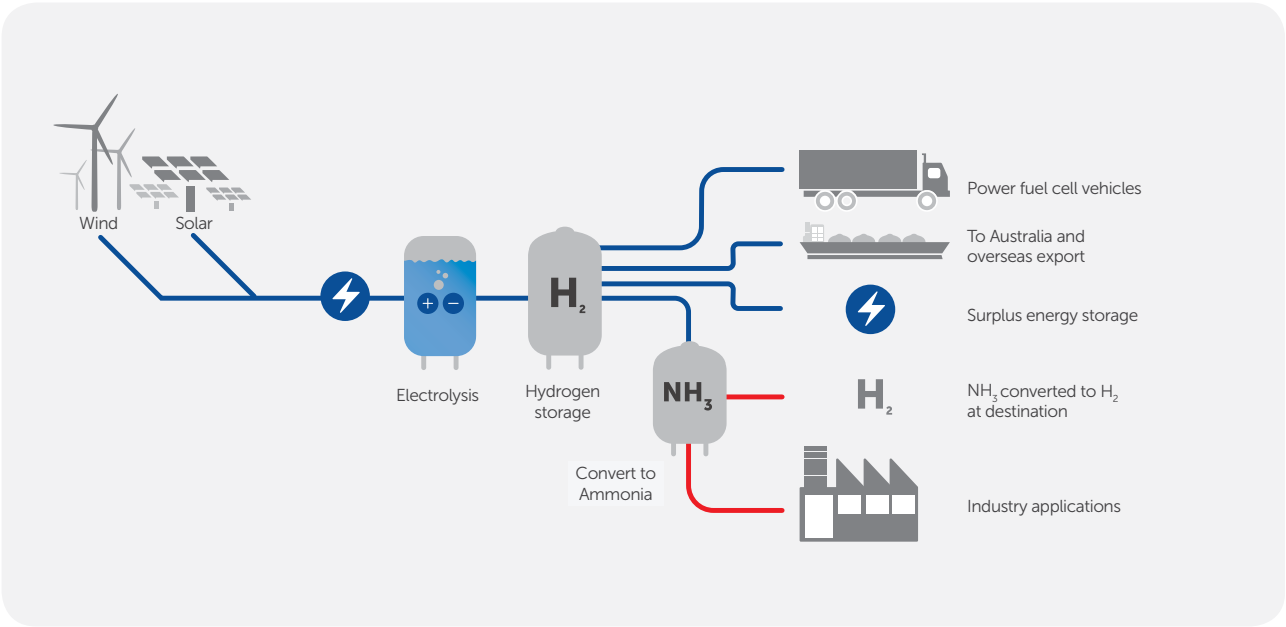
Several countries, most notably Japan and Korea, have mapped out ambitious plans to create a "hydrogen economy", for everything from electricity and heat to cars, buses, boats and trucks.[112] There are currently more than 45 renewable energy to hydrogen projects in the European Union alone.[113]

The Hydrogen Council estimates that by 2050, the global annual market for hydrogen, for all uses, will total $1.25 trillion.[114] The Australian Renewable Energy Agency estimates Australia can create an export market for green hydrogen worth $12.4 billion by 2040.[115]

The most promising route to green hydrogen is through electrolysis.[116] This involves passing an electric current through water, causing it to split into oxygen and hydrogen. Australia has a huge competitive advantage in the production of green hydrogen, with some of the world's best renewable resources, expertise in renewable energy construction, gas handling and sustainable finance, as well as a stable investment climate.[117]

Figure 10 shows the potential opportunities for WA in green hydrogen production, including energy exports, industries such as low-carbon steel production, heavy vehicles, shipping, peaking services and energy storage. The Hydrogen Council envisages that by 2030, 250–300 TWh of surplus solar and wind energy could be converted to hydrogen.[118]

Figure 10: Application for hydrogen in renewable energy powered SWIS



One potential domestic use for hydrogen is storing renewable electricity for use during periods of low wind or solar output. As the share of renewable electricity on the grid nears 100%, there will be significant periods where there is more renewable energy being generated than batteries and pumped hydro can absorb. Some 100% renewable models suggest this surplus generation could constitute up to 23% of all energy generated.[119] Electrolysis for hydrogen storage is one possible use for this surplus electricity.

Collie is a prime location for a hydrogen plant due to its excellent grid connections, existing skill base, proximity to potential alternative gas users (such as heavy transport and an electric arc furnace), and access to desalinated water (avoiding the need to desalinate onsite). Building a plant in the final few years of the renewable rollout would ensure there is sufficient surplus energy and would benefit from projected capital cost declines for hydrogen production.[120]

A Collie hydrogen plant could include a 120MW electrolyser capable of producing between 17,600 and 20,800 normal cubic meters (Nm^3) of hydrogen per hour at peak capacity.[121] Ten hours of supply (960MWh) could be stored onsite for later use in a 96MW gas turbine specially designed for burning hydrogen. The plant would store energy when prices are low, and produce energy when prices are high, providing valuable peaking and grid stabilisation services. A Collie hydrogen plant would employ 45 people and could provide 6% of WA's overnight demand during low wind and solar periods.[122]

System stability

The principal requirement of an electricity grid is that demand and supply are in balance at all times. Aside from balancing supply and demand, networks also require additional services such as frequency control; reactive power and inertia to function smoothly and safely.

Large thermal power stations currently provide these grid services. As thermal power stations are retired, grid regulators are having to find new ways to make sure the electricity delivered to consumers still meets all the requirements of the existing system.

One way to provide a range of grid services is to use a piece of machinery called a synchronous condenser. A synchronous condenser is essentially a large spinning mass which is connected to the electricity network to provide many of the services thermal power stations currently do.

Around the world, some utility companies are repurposing generators from retired coal power stations as synchronous condensers. This repurposed machinery is then put to use providing the same grid services it performed in its former life, without burning any coal.[123] It is possible the retired equipment from Muja and Collie Power Stations could be retrofitted to fulfil this role too.

Grid scale batteries can also provide some system stabilising services. The Hornsdale Power Reserve in South Australia has shown itself to be adept at responding to events which risk the stable operation of the grid, such as unplanned outages at coal power stations.[124]

Collie would be an excellent place to locate grid stabilising infrastructure because of the town's extensive connections to the transmission network. Synchronous condensers and grid scale batteries would ensure Collie could continue to play a central role in ensuring a stable, safe supply of electricity to the SWIS.

5.2 Sustainable building materials

Industry organisations, such as the Green Building Council of Australia and Infrastructure Sustainability Council of Australia, are increasingly incentivising large projects to minimise embodied carbon in their building projects. This includes the use of low-carbon concrete mixes, mass timber construction and low-carbon steel. These are all emerging industries in Australia.[125] [126] Currently, many of our greenest building projects use imported products, despite our capacity to design and produce world leading materials on shore.

Australia has a huge opportunity to expand the sustainable building material industry in locations where access to raw inputs are already plentiful and can be sustainably managed (see Table 5). Collie is one of these well-resourced locations, with access to large reserves of fly ash for low-carbon cement, plantation forests for engineered wood products and an untapped local supply of scrap steel for recycling.

Table 5: Summary of sustainable material opportunities

	Jobs	Investment
Low-carbon cement	30	$50 million[127]
Engineered timber	100	$60 million[128]
Recycled steel	200	$220 million[129]
Total	**330**	**$330 million**

Low-carbon cement

Fly ash is an alkaline powder produced as a by-product of coal combustion in power stations. The ash often contains elevated levels of a range of heavy metals, including arsenic, mercury, cobalt and lead. Fly ash can also be used as a key ingredient in low-carbon cement. [130]

Cement manufacture accounts for 8% of global CO_2-e emissions, a number that is likely to increase as other sectors of the economy transition to low-carbon energy and processes.[131] Traditional cement production is emissions intensive as a result of both the large volume of energy required to heat material during the process, and the CO_2 released during the calcination of limestone ($CaCo_3$+heat–>$CaO+CO_2$). Cement produced using fly ash instead of limestone avoids a large portion of energy used in heating, as reactions occur at room temperature, and avoids entirely any emissions produced during calcination.[132]

Stockpiles of fly ash are a persistent environmental and health hazard and requires ongoing management in large storage ponds near coal power stations.[133] Over the past fifty years, Collie's coal plants have produced vast quantities of fly ash that will need to be managed as the plants close. Using Collie's fly ash to produce low-carbon cement is one way to ensure stockpiles continue to be actively monitored and safely managed in coming decades.

Australian firms are now using low-carbon cement to build some of the greenest infrastructure in the world, including Toowoomba's Wellcamp Airport (see Box 5). Transurban recently commissioned Beyond Zero Emissions to do a detailed study of the potential for decarbonising cement in their projects. This study demonstrates that including fly ash in cement mixes, along with other sensible methods, can achieve almost 80% reduction in emissions by 2030 and come close to eliminating the emissions from cement in a range of large infrastructure projects by 2040.[134]

Box 5: The largest geopolymer cement project in the world

In 2014, Toowoomba's Wellcamp Airport became the world's largest geopolymer concrete project using 50,000 m^3 of Wagners' Earth Friendly Concrete to construct everything from the terminal, to the runways and supporting infrastructure.[135] [136] The project was completed in 19 months and is designed to cater for large jets up to 747 size.

Passenger jet at Toowomba's Wellcamp airport

With a total national stockpile of fly ash exceeding 225 million tonnes, and only 20% of annual production put to economic use, Australia's fly ash represents a massive untapped resource.[137] Combined annual production of fly ash from all three power stations in Collie is likely to be around 300,000 tonnes per annum.[138] [139] [140] Working backwards, stores of fly ash since 1990 exceed six million tonnes. While most of Australia's productively used fly ash is "fresh", mining ash storage ponds is both technically feasible and the focus of growing interest from market participants.[141] [142]

Australia's six alumina refineries are also home to half a billion tonnes of untreated red mud; four of these refineries are located between Collie and Perth.[143] Like fly ash, red mud can be used in the production of low-carbon cement.[144] Potential exists to use Collie's vast red mud stores for cement production, although this technology is less well developed.

A medium sized low-carbon cement plant processing 200,000 tonnes of fly ash per year could be built near Collie. Current stores could supply at least 30 years of production and would employ between 30-40 people.[145] This number could increase significantly if a productive and cost-effective use can be found for WA's red mud stockpile.

Box 6: Sustainable forestry supporting business and protecting biodiversity

South West WA has a long, and often tumultuous, association with the timber industry. The jarah, karri, tuart and tingle forests of the South West have been a source of wood products since long before colonisation. Following the arrival of Europeans in the 19th century, the rate of land clearing for both forestry and agriculture increased dramatically, with 70% of the South West's original vegetation cleared. The South West is a recognised global biodiversity hotspot, home to more than 2,700 endemic plant species.[146] Declining rainfalls and longer, hotter summers pose a growing risk to remaining native forests and grasslands.[147]

Forests for Life aims to reverse the trend of native forest loss in the South West, while providing sustainable employment in farm forestry and land care. Their Farm Forestry and Landcare Program aims to plant 40,000 ha of plantation timber, producing between 450,000 and 600,000 m3 of timber each year within 25 to 35 years. The program also aims to repair 4,000 ha of degraded habitat in ecologically valuable areas. These new plantations would make ideal feedstock for high-value timber processing facilities as current plantation stocks are consumed.

The species earmarked for planting in the Forests for Life financial assessment include hardwoods such as blue gums, sugar gums, spotted gums and ironbark. Opportunities also exist for engaging Traditional Owners in planning the species and land care practices employed in the proposed plantations and reserve areas. While most engineered wood products are currently made using exotic softwood species such as radiata pine, juvenile Australian hardwoods are also likely suitable for large-scale production of products such as CLT.[148] [149]

If the Farm Forestry and Landcare Program is implemented as currently imagined, Forests for Life estimates the plan can create 860-940 new jobs in the region in planting, harvesting, land care, transport and high value processing.[150]

Engineered timber

Timber is a versatile, affordable and lightweight building material.[151] Modern timber engineering processes such as cross laminated timber (CLT), laminated veneer lumber (LVL) and glulam, have further expanded its use in commercial buildings. In May 2019, updates to the National Construction Code now support large timber building systems across all building types.[152]

Timber products have the lowest embodied energy out of all common building materials, while also absorbing and storing atmospheric carbon.[153] When a tree is harvested from a plantation and turned into a timber product, the carbon remains stored. When the next trees grow, then carbon is stored in both the product and the tree. In the Zero Carbon Industry Plan, Rethinking Cement, BZE demonstrated shifting 15% of Australia's cement use to alternative materials such as Engineered Wood Products (EWP) could avert 0.9 million tonnes of CO_2-e production per annum, while sequestering an additional 1.4 million tonnes each year.[154]

Cross-laminated timber (CLT) is a processed building material that can replace carbon-intensive materials such as concrete and steel in a wide range of building applications.

CLT is made by gluing multiple layers of timber together at 90 degree angles to one another, resulting in superior strength. As prefabricated timber, CLT is fast to assemble on-site.[155]

Right now, there is only one operational large-scale CLT plant in Australia, although more are proposed to meet growing demand for sustainable building materials.[156] In 2018, New Zealand company XLam opened Australia's first CLT plant in Victoria. Once fully operational, this facility will produce 60,000m^3 of CLT each year, or enough 'pre-cast timber' to build more than 50 projects the size of Lendlease's Forte Apartments every year[157] (refer to Box 7 for the latest CLT projects in Australia).

Collie is an ideal location for a state-of-the-art CLT plant given its strong transport links, excellent energy infrastructure and access to many of the proposed new forested areas. If built to similar specifications as the XLam facility in Victoria, a 120,000 m^3 CLT plant in the Collie region, fed with sustainable plantation hardwood timber, could create approximately 100 local jobs.[158]

Box 7: Engineered timber in Australia

Lendlease has pioneered mass timber construction in Australia, with six major projects completed since 2012, and a commitment to using wood products in all the firm's development precincts.[159] [160] Lendlease is yet to use timber products from a local manufacturer, with all projects being supplied with prefabricated timber from overseas.

Notable Australian engineered wood buildings completed by Lendlease in recent years include:

Melbourne's Forte apartment building, built in 2012 using 485 tonnes of timber products. At 32.2m, Forte is the world's tallest timber residential building.[161]

Melbourne's Library at the Dock, built in 2014 using 1,000 tonnes of timber products. Library at the Dock was Australia's first community building built using CLT, as well as the first public building to achieve a six star Green Star rating.[162]

Brisbane's 25 King St, completed in 2018. Dubbed the "plyscraper", at 52m, 25 King St is the tallest timber building in Australia.[163]

Recycled steel

Western Australia is in a strong position to pioneer low-carbon recycled steel making, taking advantage of the state's abundant renewable energy resources to process domestic scrap (see Box 8).

Steel is an endlessly recyclable material, which can be melted and reused over and over again without losing its properties.[164] It is this ability which underpins the worldwide use of small electric arc furnaces (EAF) to locally process steel and iron scrap into products which can then be turned back into consumer or industrial goods. EAFs are steel recycling and manufacturing facilities that use huge amounts of electricity to heat and melt metal of various grades back into a usable form.

To generate the heat needed to melt steel — over 1500 degrees celsius — EAFs use between 350 and 500 kWh per tonne of steel produced. A 300 tonne batch of steel processed in an electric arc furnace takes between 105 and 150 MWh.[165] An arc furnace producing 400,000 tonnes of steel per year will use between 140-200GWh annually, depending on the efficiency of the process; this is equivalent to the output of a medium sized wind farm.

At present, Western Australia's steel scrap is exported to other states or overseas for recycling and reuse. Consumers in Western Australia then import finished steel products to meet demand. Australia's waste production has been increasing at a rapid rate for decades, and metal waste is no exception.[166] The majority of our metal waste is collected and exported. In 2011-12 the value of metal waste exports was almost $2 billion.[167] The value of these exports could instead be captured by local manufacturers to fulfil domestic demand for steel products. Given per-person steel consumption in Australia is 290kg per annum, WA requires roughly 725,000 tonnes of steel each year.[168]

A renewable buildout of the scale described in this report would also require huge amounts of steel. On average, large wind turbines are 79% steel by weight.[169] The widely used Vestas V90 3MW turbine weighs almost 400 tonnes; based on the 79% figure quoted above, the steel requirement for a single unit is around 316 tonnes.[170] Building sufficient wind capacity to reach 100% renewable energy in the SWIS using these turbines (5,350MW of additional capacity) would require in excess of 560,000 tonnes of steel. Large scale projects such as the Asian Renewable Energy Hub would more than double this potential steel requirement.[171]

The Collie-Bunbury region is ideally located to meet a portion of this need with a medium sized electric arc furnace processing domestic and imported scrap (see Box 9). With strong rail links, access to reliable electricity transmission infrastructure, a skilled workforce, and Bunbury Port nearby, the region has many of the necessary criteria to establish a facility. Sufficiently low electricity prices could be achieved with cheap renewable energy.

Plans for an EAF in the Collie region were floated in March 2019, with no subsequent announcement made concerning progress on the project.[172] Integrating a steel recycling facility with a centralised renewable fabrication facility (see section 7.3 for more details) may provide the ongoing demand necessary for the project to get off the ground.

Using Liberty OneSteel's Laverton steel mill, which employs 350 people and produces 710,000 of steel annually as a reference, we can estimate the jobs created from a medium scale low-carbon steel facility.[173] [174] Assuming a plant size of 400,000 tonnes per year, a Collie electric arc furnace would employ up to 200 people.

Box 8: Low-carbon steel making in Collie

Making steel can be a very carbon intensive process. Producing one tonne of new steel from iron ore can emit up to 1.82 tonnes of CO_2 if made using a blast furnace and oxygen furnace. By removing carbon-intensive ore smelting from the production process, steel's embodied CO_2 emissions can be lowered to near zero.[175] Use of fossil-fueled blast furnaces can be avoided by smelting recycled material or iron reduced using Circored technology in a renewable energy powered EAF. [176] [177]

Under a 100% WA-RET, the energy supply feeding an EAF in the Collie region would be entirely renewable and carbon neutral by 2030. In the interim, renewable energy certificates can be purchased for the energy used in low-carbon steel production, offsetting the emissions produced to generate the electricity.[178]

EAFs use some gas to provide additional heat to parts of the furnace, this gas can be replaced using renewable methane, or a mix of methane and hydrogen.[179] Depending on the grade of the input scrap, steel production in an EAF also requires the addition of carbon to strengthen the final product. Provided this carbon is sourced from sustainable biomass instead of coal, a renewable EAF in Collie could produce near carbon neutral steel.

Box 9: Shipbreaking

Ships that have reached the end of their useful life represent one possible source of scrap for recycling. HMAS Darwin is an Adelaide Class Frigate which entered service with the Australian Navy in 1984 and was decommissioned in 2017. The vessel was originally slated for deliberate scuttling off Tasmania's east coast to form an artificial reef. After the Tasmanian Government rejected this plan, HMAS Darwin was moved to the Australian Marine Complex at Henderson, where it remains.

As Australia commits to building its next generation of naval defence assets, a program slated to cost $90 billion, almost the entire existing Australian naval fleet will become obsolete.[180] The Department of Defence's 2017 Naval Shipbuilding Plan makes no reference to how, or where, the retired Collins, Adelaide, Armidale and Anzac class vessels will be broken down.

At present, 90% of global shipbreaking work is carried out in Bangladesh, China, India, Pakistan and Turkey. Lax environmental and labour laws mean shipbreaking is regarded by the International Labour Organisation as one of the most dangerous jobs in the world, with workers facing "unacceptably high levels of fatalities, injuries and work-related diseases."[181]

In recognition of the severe environmental and human toll the shipbreaking industry imposes on some of the world's poorest regions, the international community has taken a number of steps to improve shipbreaking practices. The European Union's 2013 Ship Recycling Regulation lays out clear standards for the disposal of EU flagged vessels at approved shipyards.[182] [183] The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009 (the Hong Kong Convention) will be, when ratified, the first global agreement to set in place standards for the safe and environmentally sound recycling of ships.[184] These standards show the international support for the development of a high-quality shipbreaking industry, and also the market that will develop in tandem.

The HMAS Darwin's sister ship, the HMAS Sydney, along with the Fremantle class of patrol boats, were all scrapped in Australia by Birdon Engineering.[185] By committing to recycling all Australian Navy ships domestically, the Australian Government can help to establish a sizeable shipbreaking industry in Western Australia. Recycling this steady stream of retired naval vessels will develop the skills and infrastructure necessary for the industry to flourish as the market for high-quality ship recycling grows.

Scrapping the outgoing naval ships listed above could provide more than 70,000 tonnes of steel for domestic recycling in Collie. The civilian market will expand as the skills and capacities of the local industry develops.

5.3 Recycling renewable products

The energy transition in Western Australia and around the world, will require huge volumes of minerals.[186] The silver in solar panels, steel in wind turbines, lithium and cobalt in batteries and copper in electric cars has to come from somewhere.[187] Researchers have predicted meeting the International Energy Agency's conservative 70% by 2050 renewable pathway will require an increase of between 200% and 900% in energy sector mineral inputs.[188]

To avoid a disastrous increase in environmentally and socially harmful mining, effective use of recycled materials must be built into the foundations of the energy transition.[189] WA can get on the front foot in this effort by establishing the facilities required to embed circular economy principles in the renewable rollout. Recycling and reusing these valuable materials will maximise their onshore productive value.

Table 6: Summary of recycling opportunities

	Jobs	Investment
Lithium battery recyling	70	$32.5 million [190]
Solar PV recycling	105	~$50 million [191]
Total	**175**	**$82.5 million**

Lithium-ion batteries

A large volume of lithium-ion batteries will reach the end of their lives in the next ten years. As an integral component of modern electric cars and a solution for renewable electricity storage, the use of these batteries is rapidly increasing. While the recycling of lead acid batteries is now well understood, large scale lithium-ion recycling is still in its infancy. Current practices at home and overseas cause environmental harm, human health risks and leave a vast amount of valuable resources unrecovered. The growing market for high-quality, large-scale battery recycling remains largely untapped, with a single, small plant operating in Victoria. [192]

An opportunity awaits WA to lead the world in lithium-ion battery recycling and create 70 jobs with a facility at Kemerton Strategic Industrial Area (SIA).[193] Materials recycled from batteries will provide a value-added input to WA's expanding lithium mining and processing industries. Up to 95% of a lithium-ion battery is recyclable and some of the recoverable raw materials are not naturally present in Australia. Recycling lithium battery waste rather than letting it go offshore or to landfill could provide Australia an estimated $813 million to $3 billion worth of resources per annum by 2036.[194]

The growth in lithium-ion battery use is going to bring a great increase in the volume of end-of-life batteries (see Box 10). The Global Battery Alliance forecasts over 11 million tonnes of spent lithium-ion batteries will be discarded worldwide by 2030.[195] According to Regional Development Australia's *Lithium Valley* report, currently more than 95% of lithium-ion batteries are deposited in landfill.[196]

Box 10: Opportunity for onshore battery recycling facilities

As Australian consumers recycle only 2% of lithium-ion batteries, CSIRO estimates Australians create 3,300 tonnes of lithium-ion battery waste a year, a figure set to grow by 20% every year.[197] Australia has no battery collection or transfer infrastructure specific to lithium-ion batteries, meaning they are typically collected among other "e-waste".

A limited amount of material recovery processing is performed on the spent batteries or they are simply exported to plants in Asia for recycling. A recent report from the Chamber of Commerce and Industry of Western Australia suggests the first significant wave of domestic battery waste in Australia will emerge in the early 2020s.[198] CSIRO research suggests this approaching wave of waste and the dangers associated with the transportation of used lithium-ion batteries mean that shipping offshore is not a sustainable solution. Australia must instead increase its on-shore recycling capability.[199]

WA is responsible for mining the majority of the world's lithium, along with other minerals necessary to domestically manufacture batteries.[200] This existing market participation provides an opening for a world-leading battery recycling facility to be integrated into this battery material supply chain.

Recycled materials could be reused in new lithium-ion batteries to reduce production costs. Building

up WA's waste battery processing capacity with a specialist recycling facility would give Australia first-mover advantage as the glut of battery waste arrives. It will develop WA's place in existing lithium supply chains by offering recycled materials that can be combined with virgin materials to produce high value-added products. Additionally, retaining these battery metals in Australia will lower the energy and resource needs of WA's burgeoning lithium-ion battery industry.[201]

Given the environmental and safety concerns surrounding lithium battery waste, WA can promote itself to the world as providing an ethical and environmentally robust recycling solution under Australia's strong regulatory structure. The Kemerton SIA would be an ideal location for a facility processing 3,300 tonnes of battery waste per annum (Australia's annual production in 2016), with room for significant expansion as global use skyrockets. Kemerton's proximity to Bunbury Port and planned rail access to the Perth-Bunbury railway makes it well suited for receiving both domestic and international battery waste and exporting recycled materials.

Kemerton can be at the heart of WA's endeavour to develop a lithium processing and battery development hub, as new industries join the soon to be built Albemarle lithium hydroxide plant.[202] Importing batteries and recovering minerals will support local industry and concentrate knowledge, bolstering WA's status as a world hub for the lithium industry.

Discarded batteries awaiting recycling

Solar PV

Reaching 100% renewable energy on the SWIS will require between 3GW and 4.3GW of solar PV capacity. Given an average solar panel rating of 300 watts, WA will need to have installed between 10 million and 14.4 million solar panels by 2030. Up to 4 million solar panels are already in place on Western Australian roofs.[203]

Solar panels generally last between 15 and 25 years, depending on their quality and the conditions to which they are exposed.[204] Many of the panels which have been installed in Australia over the past ten years still have long, productive lives ahead of them. The 20 year delay between installation and removal obscures the scale of the waste challenge facing Australia as ageing systems are removed from homes.[205] [206]

Assuming a very conservative failure rate of 0.05%, and an average panel lifespan of 20 years, WA will need to be able to recycle 37,000 solar panels per month by 2025. This number will grow to 64,000 per month by the end of 2030, with strong growth continuing to 2050. Given recent evidence in Australia of 2.7% of solar installations being deemed "unsafe" by the Clean Energy Regulator, it is likely these numbers could be higher.[207]

PV systems are currently a priority category for development of a product stewardship scheme.[208] Around 95% of the materials used in making a solar panel are recyclable.[209] Panels are primarily made up of glass and aluminium, as well as small volumes of valuable materials such as copper, zinc, nickel, gallium, tellurium, selenium and silver. Other valuable, and potentially hazardous, materials found in PV units include lead and cadmium.[210]

Proper recycling allows for PV components to be collected and either resold or reused while improper disposal in landfill is likely to lead to heavy metals leaching into the surrounding environment.[211] PV recycling also significantly reduces the environmental harms associated with the extraction of minerals and production of components for PV manufacturing.[212] While Australia has historically relied on exporting e-waste overseas for recycling, processing this waste locally is a massive opportunity for local business (see Box 11).

Box 11: Commercial scale solar panel recycling

Australian firm Reclaim PV have recently announced plans to establish the country's first commercial scale photovoltaic recycling facility. Reclaim PV have been recycling small numbers of panels since 2015 but aim to be processing 100,000 units each year by 2020.[213]

At present, PV units are collected from around the country and are processed in a central location. Reclaim PV aim to establish processing centres around the country as the volume of panels requiring recycling increases.[214]

Reclaim PV's new plant will be the first, and only, large scale recycling facility for solar panels in Australia. Facilities for PV recycling also exist in other parts of the world, with French firm Veolia an early leader in the field.[215]

Collie, as home to WA's renewable energy manufacturing hub, can also host the facilities required to ensure vast investments in renewable energy technology are not lost to landfills or overseas processors. The International Renewable Energy Agency estimates the value of materials in retired PV units will total $15 billion per annum by 2050.[216] Capturing this value for reuse domestically will ensure WA continues to reap the benefits of the renewable rollout even as assets are retired. High volume, low value materials such as recycled glass and aluminum can be reused in WA's clean manufacturing and renewable energy industries, while valuable metals can be reused or sold into international markets.

A local facility processing 200,000 solar panels per annum would employ roughly 105 people, with vast room for expansion as the need for recycling grows.[217] A smaller plant could be established in the very near-term to capture existing PV waste and iron out any logistical challenges associated with collection.

6. Social licence for change

The projects discussed above can create secure, well paid jobs in industries set to boom over coming decades. These opportunities more than replace all existing coal industry jobs and will bring new ideas and industries to Collie and surrounds. Collie's industry workers and their families, as well as local businesses, will be the primary beneficiaries of this growth.

Government, locals and industry must also ensure that this period of economic change pays broader social dividends for a range of community members, particularly Traditional Owners, low and fixed income households. This goal can be achieved by incorporating community-led local development initiatives into Collie's transition.

Establishing a range of local development projects would build resilience and connection in the community, save locals money, reinvest funds back into the town and improve amenity.

Coming up with a suite of community development projects, designed in close consultation with residents, is also an excellent way for Government to create social licence for change. The WA State Government can use Collie's transition as an opportunity to develop a model for supporting communities through significant economic disruption.

The ideas listed in this section are examples of possible community-led initiatives. Locals would need to be involved in a process to determine what kind of community projects would best suit the town's needs.

6.1 Energy efficiency retrofits for low-income households

Home energy efficiency achieves more than just affordable thermal comfort, there are also a range of positive well-being outcomes for occupants.[218] New blended finance models for achieving home energy efficiency upgrades have shown promising results in Victoria, and Collie's community is an excellent scale for early adoption of a retrofit program. Government, private finance and local business support will be essential to curating an effective home energy efficiency upgrade program for Collie and the region.

Home energy efficiency upgrades can lead to conditioning (heating and cooling) energy savings of up to 80% for the oldest and least efficient houses.[219] Collie is cooler than much of WA, meaning energy savings for locals could be significant. The procurement process can be streamlined through software tools, such as the 'BOOMPower' platform led by CHIAVic with Impact Investment Group and Bank Australia, which delivered over 1,000 community housing upgrades in 2018-19.[220] [221] These efficiencies can lower the cost and speed up the procurement process dramatically while ensuring local businesses provide products, equipment and services.

There are 4,000 dwellings in the Collie region. Assuming Collie households save around $900 per annum, and 30% of homes are retrofitted, annual household savings total over $1 million. This money will then be spent in the local area, further boosting local business while easing financial pressure for low-income earners.

6.2 Sustainability grants for local businesses

To assist local businesses during a period of economic change and uncertainty, small grants of between $2,000 and $10,000 could be provided to small businesses to perform sustainability or efficiency upgrades. Possible uses for the grants could include solar installations, refrigeration or equipment upgrades, insulation improvements or lighting upgrades.

Beyond improving the energy efficiency of local businesses, sustainability grants would have far reaching economic benefits for the Collie community. By utilising subsidised investments, businesses would be able to lower their operating costs far into the future with less upfront investment. The direct benefit of this would be more money kept in the pockets of small business owners, boosting the security and financial sustainability of the local economy. As costs fall, it will become more viable for businesses to hire additional staff, further adding to the economic health of the region.

State Government assistance of $500,000 would fund between 50 and 250 sustainability grants.

Box 12: NSW Bin Trim Rebates

The NSW State Government has a target of reducing litter by 40% between 2015 and 2020.[222] As part of a suite of programs to achieve this target, the NSW Environmental Protection Authority administers the Bin Trim grants program for small and medium businesses.[223] The program contributes up to 50% of the capital cost of procuring recycling equipment, with amounts between $1,000 and $50,000 available.

The grants have helped small businesses such as independent grocers cut their waste disposal cost by up to a third.

6.3 A clean industry community fund

It is increasingly common for best practice renewable energy projects to establish community funds in the regions in which they operate. A small portion of project profits are diverted to the fund to be spent as the community sees fit. Projects funded include sporting facility upgrades, apprenticeships, community buses, local festivals and community centre improvements. A similar model could be established for new low-carbon industries moving into Collie.

Box 13: Pacific Hydro Community Investment Program

Pacific Hydro is one of Australia's leading renewable energy developers. Pacific Hydro established the Community Investment Program in 2005 as part of the firm's community consultation and engagement commitments. The program returns a share of revenue from individual projects back into the communities in which they operate. Pacific Hydro has established a community fund in each region in which they have developed a wind or solar farm, with locals given the say over which community projects to fund.

The Community Investment Program has funded 700 projects worth a total of $3 million since 2005.[224]

Locals could decide on models for allocating funds, bringing people together and giving a broad range of community members a say in improving the town. A Collie Community Fund would increase social licence for new industries, improve amenity and build community resilience.

6.4 An energy co-operative

Community Renewable Energy is renewable energy development that involves the community in developing, owning, running and benefiting from the project. There are currently over 105 community energy projects of various sizes operating around Australia.[225] Projects range from small solar installations on local sports halls, to much larger wind projects.

Collie could play home to a locally owned community energy co-operative, with returns given back to locals in the form of dividends, reductions in power bills or as grants for community projects. Solar gardens are a model which could provide renters and low-income households with access to affordable renewable energy. A solar garden is a solar farm that offers locals the chance to purchase or lease solar panels. Members then have a credit applied to their electricity bill for the amount generated by their share of the solar garden.[226] Subsidies can be provided to ensure access is affordable for low-income earners.

Box 14: Denmark Community Windfarm

The Denmark Community Windfarm in South West WA is a locally owned facility made up of two 800 kW turbines. The wind farm was first proposed by residents in 2003 as a response to climate change and began generating in 2013. Funding for the project was raised via a share offering in the local community and supported by the Commonwealth Government.

The turbines supply around 54% of Denmark's annual energy demand and avert 6,000 tonnes of CO_2-e per year. The group which initiated the project, Denmark Community Windfarm Inc, is a shareholder in the operating company and returns all income, approximately $20,000 annually, back to the local community via sustainable enterprise grants.[227]

A 1MW community solar garden could be built for around $1.5 million, with funds coming from a mix of Government grants and community contributions.[228]

Denmark Community Wind Farm (credit: Peter Auer, Simon Neville & John Sampson)

7. Policy recommendations

The chapter below lists policy interventions designed to support an economically and environmentally sustainable transition away from coal towards new industries. The policy proposals below describe how Governments can provide clear industry incentives and market signals to help sustainable industries stand on their own feet. These recommendations avoid the short-sighted handouts that have undermined transitions elsewhere.

In summary, the recommendations are:

1. Secure social licence for the transition through support for workers and the community.
2. Legislate for a 100% Western Australian Renewable Energy Target (WA-RET) by 2030.
3. Maximise local industry participation by designating all WA-RET developments as "strategic projects" under the Western Australian Industry Participation Strategy.
4. Develop a Renewable WA Common User Facility to maximise local value capture in the transition to 100% clean energy and position WA as a world leader in renewable technologies.
5. Implement low-carbon building material requirements for all state and local government infrastructure spends over $20 million.
6. Create a Western Australian Sustainable Industry Investment Fund to drive the transition to clean manufacturing and industry with $2.5 billion in investments over ten years.
7. Review and redirect existing industry support away from fossil fuel and boom/bust mineral developments towards clean industries.

7.1 Secure social licence

Residents of regional towns can be understandably cautious of grand promises. The scale of the changes facing Collie, and the likely impact on the community, will require governments and industry to build trust before major work begins.

The prospect of jobs disappearing overnight, as occurred at Griffin Coal in June 2019, causes stress and anxiety for workers. As part of a legislative package to transition WA's energy system, the jobs of existing workers in Collie's coal mines and power stations must be secured.

A comprehensive workforce transition plan, with a focus on developing supported pathways into retirement, rehabilitation work or new industries, will allow workers to make informed decisions about their future.

A key component of planning for the managed transition for Collie's coal workers will be a thorough skills audit. An audit will identify both existing skill gaps in the community, which can then be addressed, as well as existing strengths, which can then feed into economic development planning.

Similarly, a process to understand and service the needs of the broader community will build support for the transition. The managed closure of the town's founding industry will be a difficult process for many people. Giving locals a substantive voice in the evolution of their community will give people a sense of control and create better long-term outcomes for the region (see Box 15).

Box 15: The Future Melbourne Strategy

In 2015, the City of Melbourne began the process of refreshing its ten year strategic plan. Instead of writing first and consulting the community later, the City decided to empower residents to design the plan themselves. After a broad consultation process involving over 2,000 people, a citizen's jury of 50 was selected to review and rewrite the Strategy, supported by subject matter experts. The resulting work was accepted by Council in 2016 and became the 2016-2016 Future Melbourne Strategy.[229]

A similar model to a citizen's jury could be used in Collie to meaningfully engage the community in planning for the town's future.[230]

Ensuring the voices of the Traditional Owners are also heard and acted on in the transition process is essential. Embedding the principle of Free, Prior and Informed Consent (as described earlier in this report) at the core of planning for Collie's transition is an important step in ensuring Noongar people's ongoing sovereignty over their land is recognised and respected.

Trust will be key to creating a fair and effective economic transition in Collie. The WA State Government can build this trust, while reducing anxiety in the community by:

1. Immediately developing and funding a comprehensive workforce transition plan to secure jobs for workers in Collie's coal mines and power stations.
2. Conducting a skills audit of existing workers in the town, with funding in place to address any gaps identified.
3. Engaging the broader Collie community in a meaningful and substantive consultation process on the future of their town.
4. Guarantee Free, Prior and Informed Consent will be sought from Noongar people for all projects on Noongar boodja.

7.2 Legislate for a 100% WA-RET

The first step in effecting the transition described above is to legislate for a 100% Western Australia Renewable Energy Target (WA-RET) by 2030. This ambitious but achievable target would send a clear message to industry, markets and civil society: WA is taking the transition seriously, and is the natural home for businesses, projects and people who take it seriously too.

The WA Government will have to ensure adequate new renewable supply is being developed as fossil fuel plants are closed. The exact means of encouraging the rapid deployment of renewable energy in WA will require careful planning.[231] Despite differences in the WEM's design, there are Australian case studies from which WA policymakers can take inspiration. Given the recent success of the reverse auction process employed by the ACT, Victoria and Queensland to meet renewable energy targets, this model could also serve WA's purpose.

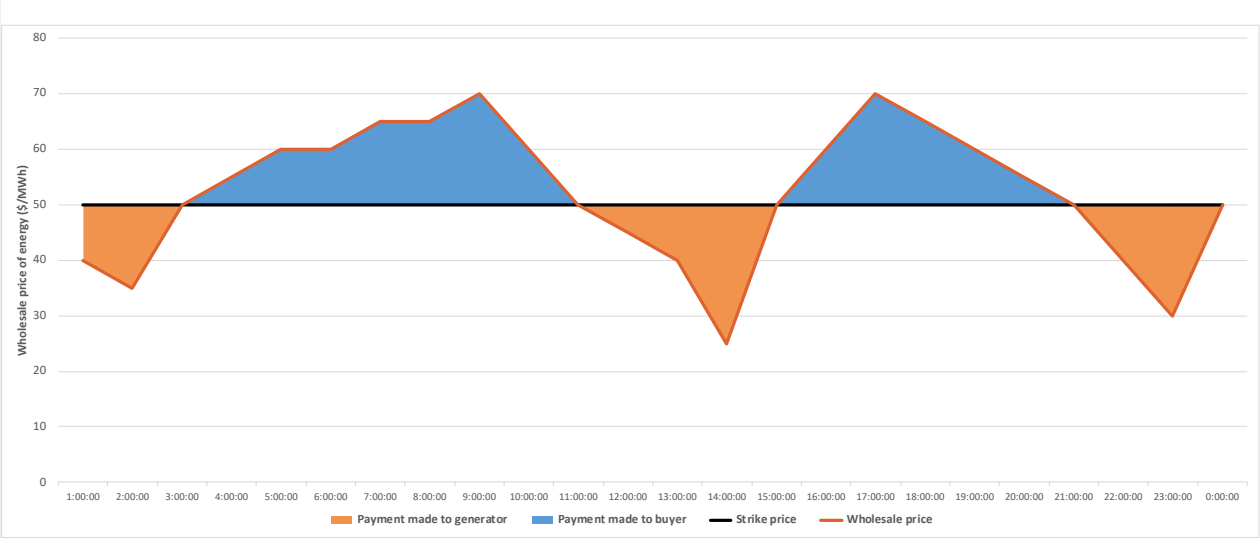
Box 16: How does a reverse auction work

A reverse auction flips the traditional auction process, in which buyers outbid each other to purchase a product from a seller. Instead sellers compete to secure the sale of a product to a buyer at lowest cost.

When contracting for the sale of energy, a reverse auction generally seeks bids on an agreed price per MWh of electricity. Once this price has been decided, the buyer and the seller enter into a contract in which the buyer agrees to make payments to the seller when the market price is below the contracted price, while the seller agrees to pay the buyer when prices are higher (see Figure 11). In this way, the developer has a guaranteed source of revenue for a portion, or all, of a project's output; providing sufficient certainty for a project developer to secure financing.[232] [233]

Other Australian renewable energy reverse auctions have included additional requirements for project developers covering local content requirements, community co-ownership and benefit sharing provisions. A reverse auction process is compatible with maintaining state ownership of generation, as is the case for Queensland's CleanCo.[234]

Figure 11: Example balance of payments in an energy Contract for Difference (CfD)



A well designed renewable energy reverse auction should not impose additional costs on government. The price agreed in the Victorian reverse auction was considerably below the average wholesale cost, suggesting the Victorian Government could even make money on the contracts.

Staged reverse auctions through to 2030 could underpin a 100% WA-RET, with an interim target of 50% by 2025. This model would help the WA Government achieve a number of otherwise competing policy priorities:

- Replace lost energy supply as a result of the closure of ageing generation assets.
- Allow for flexibility in the technology deployed as the needs of the energy system change. Reverse auction processes can be readily adapted for firming service .[235]
- Capture the benefits of price declines towards the end of the 2020s as the cost of technology falls.
- Lower wholesale prices while increasing competition in the WEM.[236]
- Create more than 5,000 jobs in construction and maintenance statewide.
- Ensure the $13+ billion investment required is spread fairly between private firms, Government, domestic and commercial solar owners and energy consumers.[237]
- Provide an ongoing pipeline of work for WA's advanced manufacturing sector.
- Avoid 86 MT CO_2-e by 2030 and 13 MT annually from 2030 on.[238]
- Propel WA from the back of the pack on renewable energy and climate targets to the front.[239]

The benefits of a comprehensive transition to renewable energy will extend to communities all over WA, as construction and maintenance jobs are spread across the regions. The benefits to Collie and surrounds are potentially far greater if policies are put in place to snare a significant share of the manufacturing and assembly work required for the rollout.

Bringing these elements together real will require leadership. WA can demonstrate this leadership by:

1. Legislating for a 100% WA-RET by 2030.
    a. Developing and enacting a policy framework to ensure the generation required to reach 100% by 2030 is built.

Explainer: A changing grid

This report has based its technology assumption on modelling which does not account for substantial changes in the nature of demand on the SWIS. Important changes which will influence the volume and timing of energy use include the uptake of electric vehicles, substantial energy efficiency improvements in buildings and large scale electrification of manufacturing processes.[260] [261] [262]

As the nature of energy use on the grid changes, the technology mix proposed above may also need to change. A 100% renewable energy target for WA will need to be flexible and adaptable enough to manage this uncertainty and take advantage of exciting new developments in the energy sector.

7.3 Renewable energy common user facilities

A Common User Facility (CUF), is a purpose-built site for fabrication, storage, logistics or any other economic activity, where the owner of the facility has designed it to be employed by a range of users. Once a facility is established, tenants can bid to use the CUF's assets as opportunities arise.

CUFs are useful for growing industries because the construction of large fabrication facilities involves high fixed costs which must be recouped over long periods. These costs are difficult to service, even for the largest operators.[240] CUF's overcome this barrier to investment by making appropriate facilities available to industry participants without requiring huge upfront expenditure.

A CUF can be particularly effective when the facilities involved are very expensive - as in high-tech manufacturing - or work is sporadic - as in shipbuilding (see Box 17). Having multiple participants using the same facility also ensures that infrastructure is in use most of the time, reducing unproductive downtime.

Box 17: Australian Maritime Complex

Australian Maritime Complex (AMC) is a Common User Facility for the manufacture, repair and maintenance of vessels for the naval, civilian and oil and gas industries. The AMC is located next to a large industrial precinct which is home to a cluster of more than 150 maritime businesses and technology providers. The AMC has a wide range of facilities available to users, including large fabrication halls, deep water berthing, ship lifts, project management offices, conference facilities, office space and training providers.

The AMC was built by the Western Australian Government at a cost of $180 million ($80 million of which was provided by the Commonwealth) with the vision of establishing "A world-class centre of excellence for manufacturing, fabrication, assembly, technology, repair and maintenance servicing activities in the defence, marine, oil and gas, and resource industries."[241] [242]

The Henderson CUF has played host to over 440 maritime projects since 2003 (almost 30 per year), including multi-billion dollar contracts for the long-term maintenance of Australia's submarine fleet. In its 15 years of operation, the AMC has generated over $2.5 billion for the local economy and created 40,000 direct and indirect jobs.[243]

Given Western Australia's successful experience with Common User Facilities and given the scale of the task in moving to 100% renewable energy on the SWIS, there is scope for additional facilities to be built to facilitate this transition.

A Renewable Energy Fabrication and Logistics Common User Facility located at the Kemerton Strategic Industrial Area would give WA businesses the best chance of successfully bidding for fabrication and assembly work in the state's renewable buildout. Kemerton is well located for a Renewable WA CUF because of existing access to rail and road transport, ports, energy infrastructure, a skilled workforce and a central location in the SWIS.

A Renewable WA CUF would ensure the maximum possible share of investment during the transition was spent in Western Australia, providing direct jobs for locals and creating a multiplier effect as locally invested funds circulate through other sectors of the economy.

Possible infrastructure a Renewable WA CUF might require includes fabrication sheds, heavy lift facilities, storage, site offices, a logistics hub, training facilities as well as specific equipment for the manufacture of larger components such as turbine blades. As in the case of the AMC, renewable energy businesses and contractors would likely move to the surrounding area to access the CUF, creating a clean-energy knowledge and jobs cluster. Competition between local providers would keep procurement prices down for renewable developers and for energy consumers.

1. Establish a Renewable WA Common User Facility on the site of the Kemerton Strategic Industrial Area funded by contributions from the Western Australian and Commonwealth Governments.
    a. Ensure necessary infrastructure, such as rail and port access, is available and has the capacity necessary to support a rapid renewable rollout.

7.4 Local content requirements

Moving the SWIS to 100% renewable energy will require a huge amount of cement, steel, labour and advanced technology. Western Australia is uniquely placed to take advantage of these opportunities, with massive mineral resources and an established manufacturing and industrial base. To maximise this opportunity, State Government policies should be aligned to ensure the greatest possible local value is created during the transition.

The West Australian Government has recognised the value in helping local suppliers secure contracts for a larger share of the $27 billion the State Government spends on procurement each year.[244] Fulfilling an election commitment to pass a comprehensive WA Jobs Act, the current Labor Government has designed a series of policy responses to encourage growth in local industries and diversification of the state's economy (see Box 18).[245]

Box 18: The Western Australian Industry Participation Strategy

The Western Australia Industry Participation Strategy (WAIPS) is a core element of the State Government's industry and jobs strategy. The WAIPS lays out requirements for tenderers for State Government contracts to identify commitments to participation by local industry.[246]

WAIPS participation plans vary in the level of commitment required depending on spend and location of the contract. Projects worth $5 million and up are generally required to submit a detailed participation plan, while projects with a contract value of $25 million or more can be declared a strategic project by the Jobs Minister. Strategic projects require a participation plan with additional local commitments.

The procurement of 246 railcars for Perth's public transport network is an example of the WAIPS process creating opportunities for local industries. The 50% target for local content work will ensure a substantial portion of the $1.6 billion spend remains in WA providing work for local firms.[247] The WAIPS process is similarly well suited to ensuring local suppliers extract maximum value from the rollout of renewable energy in Western Australia.

The Western Australian Government can give local suppliers the best shot at success by:

1. Designing renewable capacity reverse auctions to ensure alignment with the WAIPS process.
2. Assigning all reverse auction rounds from 2020-2030 "Strategic Project" status under the terms of the WAIPS.
3. Embedding the Industry Link Advisory Service and a team of local content advisors in the Renewable WA Common User Facility to ensure tenderers are supported through the process.
4. Training Local Content Advisors employed by Regional Development Commissions in renewable energy technologies and industry requirements.

7.5 Low-carbon building material requirements

Construction accounts for 18% of both global and Australian greenhouse gas emissions. Around 63% of Australia's construction emissions come from road, bridge, civil and other heavy engineering projects.[248] This is an area over which State Governments have significant influence.

The value of the green building materials market is predicted to increase from US $46 billion in 2014 to US $364 billion in 2022, a 700% jump.[249] Western Australia has an opportunity to carve out a share of this booming market, but it will require industry planning and government intervention. Market research shows government regulations and incentives are a crucial driver in the uptake of green materials. Markets alone will not create the scale of change needed to trigger WA's clean industry boom.[250]

The Western Australian Government spent $32.8 billion on infrastructure between 2009/10 and 2018/19.[251] This spend represents a massive opportunity to encourage more sustainable and efficient material use, while establishing new industries in Western Australia. By requiring the use of sustainable alternatives, such as low-carbon cement and steel, the Western Australian Government can support industry in the state while achieving significant emissions savings in its own operations (see Box 19).

Box 19: Infrastructure Sustainability Rating Tool

The Infrastructure Sustainability Council of Australia (ISCA) is a member-based not-for-profit working across Australia and New Zealand to improve sustainability outcomes in infrastructure development. ISCA is best known for their influential Infrastructure Sustainability (IS) Rating Tool and associated training and support programs.

"The IS Rating Scheme (IS) is Australia and New Zealand's only comprehensive rating system for evaluating sustainability across the planning, design, construction and operational phases of infrastructure programs, projects, networks and assets. IS evaluates the sustainability performance of the quadruple bottom line (Governance, Economic, Environmental and Social) of infrastructure development."[252]

The IS Rating Tool assesses a wide range of factors that contribute to the overall sustainability of a project. The rating assesses projects across the quadruple bottom line, with 10 out of 100 points available for projects able to demonstrate low lifecycle environmental impact of materials.

The table below shows the CO_2-e savings achieved by projects assessed using ISCA's IS Rating Tool when compared to a BAU reference design. Data is given for both a wide range of ISCA rated projects, as well as an average of seven ISCA rated Western Australian projects. The data shows emissions savings of up to 40% are achievable by swapping to more sustainable materials and construction techniques.[253]

Table 7: Major infrastructure projects emission savings

	Asset value	Reference design/ business as usual (tonnes CO_2-e)	ISCA rated projects (tonnes CO_2-e)	% Reduction
Range of ISCA rated projects	$15m - $2b	3,035 to 261,433	2,644 to 235,903	-1.99% to -40.55%
Average of 7 WA projects	$607m	117,188	102,767	-11.36%

Main Roads Western Australia already requires that all projects worth over $100 million are formally assessed using the IS Rating Tool. Projects between $20 million and $100 million are required to make use of the tool, but not undergo formal assessment.[254]

This leadership from Main Roads is to be congratulated, and ought to be extended to other areas of infrastructure investment. The WA State Government can both boost local opportunities to enter the booming global market for low-carbon materials, while dramatically reducing the negative impacts of its own operations by:

1. Requiring all State Government infrastructure projects over $20 million to be formally assessed using the IS Rating Tool.
2. Requiring all State Government projects over $50 million to receive a level 3 in the Resource Strategy Development (Rso-1), Adaptability (Rso-5), Material Lifecycle Impact Measure and Management (Rso-6) and Environmentally Labelled (Rso-7) credits of the IS Rating.
3. Requiring private infrastructure projects (such as ports, rail lines and energy infrastructure) valued at more than $100 million to undertake a formal IS Rating as part of environmental assessments.

7.6 Sustainable industry investment fund

A Green Investment Fund is a finance mechanism established to support clean energy, industry and manufacturing. Green funds can be set up as dedicated institutions, like Australia's Clean Energy Finance Corporation (CEFC) or the UK's Green Investment Bank (later sold to Macquarie Group), or they can be administered from within government.[255] [256] Green Investment Funds are designed to leverage private sector investment in clean technologies, often supported by taxpayer funds, levies or the issuing of bonds.[257] Funds are often required to provide shareholders (in most cases the Treasury) with a positive return on investment.

Box 20: Clean Energy Finance Corporation

The Commonwealth Government's Clean Energy Finance Corporation was established in 2012 with the goal of investing $10 billion in clean energy and energy efficiency programs. The stated aim of the fund is to lower Australia's greenhouse gas emissions and accelerate the transition to a clean economy powered by renewable energy.

The CEFC has invested $6.6 billion in clean technology projects since inception, leveraging a further $12.3 billion in investment from the private sector - or $1.80 for every $1 invested. The CEFC was established to run as a risk-taking, profit-making fund, with a target return of 3-4% above Commonwealth bond rates.

With investments in clean energy, smart cities, innovative new technology, transport, energy efficiency and waste management, the CEFC has played a central role in Australia's accelerating energy and economic transition. The fund has tracked abatement from projects since its inception, recording over 190 MT of CO_2-e abatement.[258]

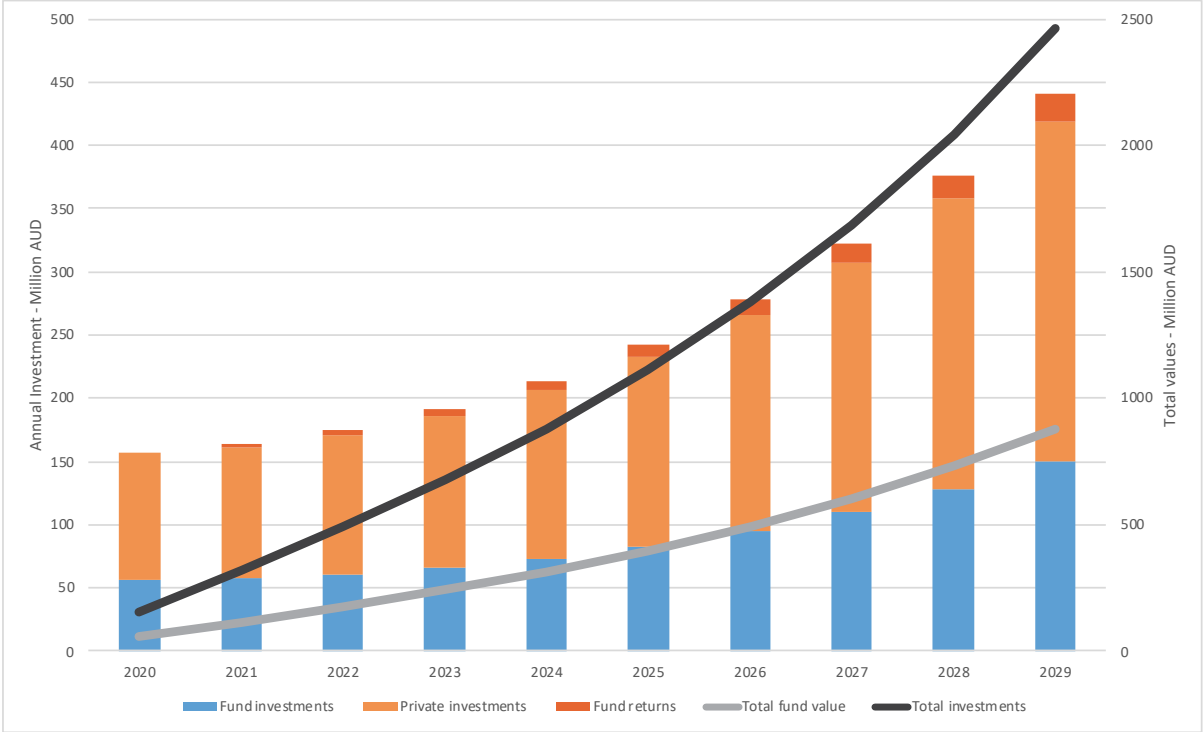
A Western Australian Sustainable Industry Fund could play a pivotal role in positioning the state as a world leader in clean industry and manufacturing. Instead of investing in renewable energy projects, the Western Australian Sustainable Industry Fund could identify and fund projects like those described in this report. Once innovative new industries are up and running, returns on funds invested can be reinvested in the next wave of low-emissions technology, creating a diverse clean manufacturing and industry ecosystem.

Money for the fund's initial investment pool could be sourced from a levy on Western Australian gas users, who pay the lowest average cost in the country.[259] A $0.10/GJ levy on gas would raise $56 million each year, to be invested back into clean industry. A levy on gas would capture some of the costs associated with ongoing use of fossil fuels and would divert funds to industries and technologies that will underpin the next century of economic growth.

If the Western Australian Clean Industry Fund can replicate the CEFC success in leveraging private sector investment, total additional investment would total $156 million per annum (see Box 20). A Western Australian Sustainable Industry Fund could facilitate investments of up to $2.5 billion by 2029 (see Figure 12). Investment on this scale would be a powerful regional development and climate mitigation tool, particularly for areas, like Collie, facing an uncertain future in a carbon constrained world.

1. Establish a Western Australian Clean Energy Fund, resourced by a $0.10/GJ levy on domestic gas consumption.
    a. Target CPI+3% investment performance, ensure returns are reinvested back into industry.
    b. Target $1.80 private sector investment for each dollar of fund investment.

Figure 12: Western Australian Green Industry Fund (2019 dollars)



7.7 Review and redirect existing industry support

Every year, state governments around Australia spend billions of dollars supporting the mining industry. In the years between 2008 and 2014, the WA State Government spent roughly $1 billion annually—via direct expenses or concessions—supporting the mining and fossil fuel industry.[263]

There is still substantial spending on mining industry assistance across a range of government portfolios, from the $10 million spent every year on the fossil fuel Exploration Incentive Scheme, to repairing roads damaged by mining vehicles.[264] [265]

A significant share of government expenditure on mining industry assistance, particularly on infrastructure benefiting a small number of users, should be shouldered by the companies profiting from extractive projects. Nascent green industries do not have the same access to capital as Woodside, Chevron, BHP or Rio Tinto and industry assistance should reflect this reality.

Although administered Federally, the treatment of tax credits in calculating Petroleum Resource Rent Tax (PRRT) is perhaps the most egregious example of government largess for fossil fuel projects.

Overly generous treatment of capital and exploration spending have seen fossil fuel producers accrue $324 billion in tax credits to offset future revenues when calculating PRRT receipts. Only six of 138 eligible projects paid any PRRT in 2017-18, with a total tax take of $1.16 billion on $29.7 billion dollars of revenue (an effective 3.9% tax rate on the industry).[266] Multinational fossil fuel producers are being gifted billions of dollars in averted tax take while state governments are losing out on vital revenue to fund public services.

To ensure scarce government industry and infrastructure investments are being used to support fledgling industries, and not to pad the profitability of established firms, the WA State Government should:

1. Conduct a review of the WA Government's direct and indirect funding of the mineral and fossil fuel industries, with a focus on redirecting spending to clean energy and industry.
2. Rapidly move away from providing any direct or indirect development assistance for fossil fuel projects.
3. Lobby the Commonwealth Government to change treatment of tax credits for calculating Petroleum Resource Rent Tax and push for the introduction of set royalty rates.
    a. Lobby for a greater share of revenues to be returned to state governments.

9. Conclusion

Coal's reign as the fuel of Australia's prosperity is over. The share of coal in Australia's energy mix has fallen 18% since 2008-09, with ongoing planned coal plant closures pointing to continued decline. [267] The energy market is changing. Low cost renewables have undermined the business case of traditional coal plants. As the share of Western Australia's energy provided by wind and solar increases, coal power stations are struggling to keep up.

Happily, there is a readily available alternative for the SWIS. The plunging cost of renewable energy, coupled with a range of storage options, means WA can decarbonise its energy system and lower costs for consumers. A well planned and rapid transition away from fossil fuels would create thousands of construction and maintenance jobs statewide and a corresponding boom in clean-tech innovation and manufacturing.

WA should lead the nation in the energy transition, instead the state has fallen behind the east. By providing a consistent policy environment, shared facilities and targeted industry investment, the WA State and Commonwealth Governments can set local firms up to capture the lion's share of $13+ billion in renewable investment.

The opportunities described in this report will create up to 1,750 jobs in the Collie-Bunbury region, more than replacing the roughly 1,250 jobs lost in the closure of mines and power stations.

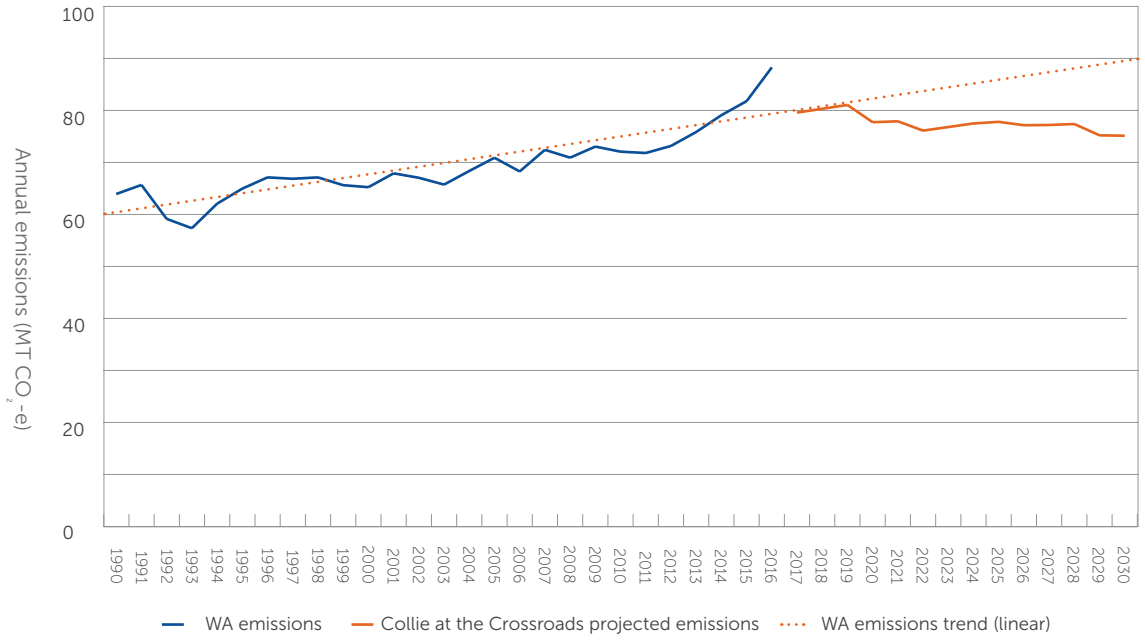
Well paid jobs in clean industry and manufacturing, combined with efforts to increase employment in tourism, agriculture and service provision, can underpin a sustainable economic future for Collie. A more diverse regional economy, in which risk and opportunity is spread across multiple sectors and enterprises, will create a more resilient community.

Collie's transition also presents an opportunity to put social justice and workers' rights at the heart of a regional development strategy. This report outlined a range of community-led local development projects aimed at small businesses and low-income earners. These projects, combined with requirements for recipients of WA State Government funding to adhere to agreed workplace standards, can create a fairer transition for a broader range of community members.

On a final, but vital note, the actions described in this report would lower WA's CO_2-e emissions by around 92 MT tonnes by 2030, and 14 MT tonnes per annum from 2030, a 16% reduction on 2030 projections.[268]

Collie at the Crossroads shows an alternative future for Collie is possible, but technical feasibility and economic opportunity are only half the challenge. It is up to the community to demand ambitious action from unions, Government and business to see the vision presented here become a reality.

Figure 13: *Collie at the Crossroads* emissions abatement (all projects)



Appendix 1 - The decline of coal in Collie

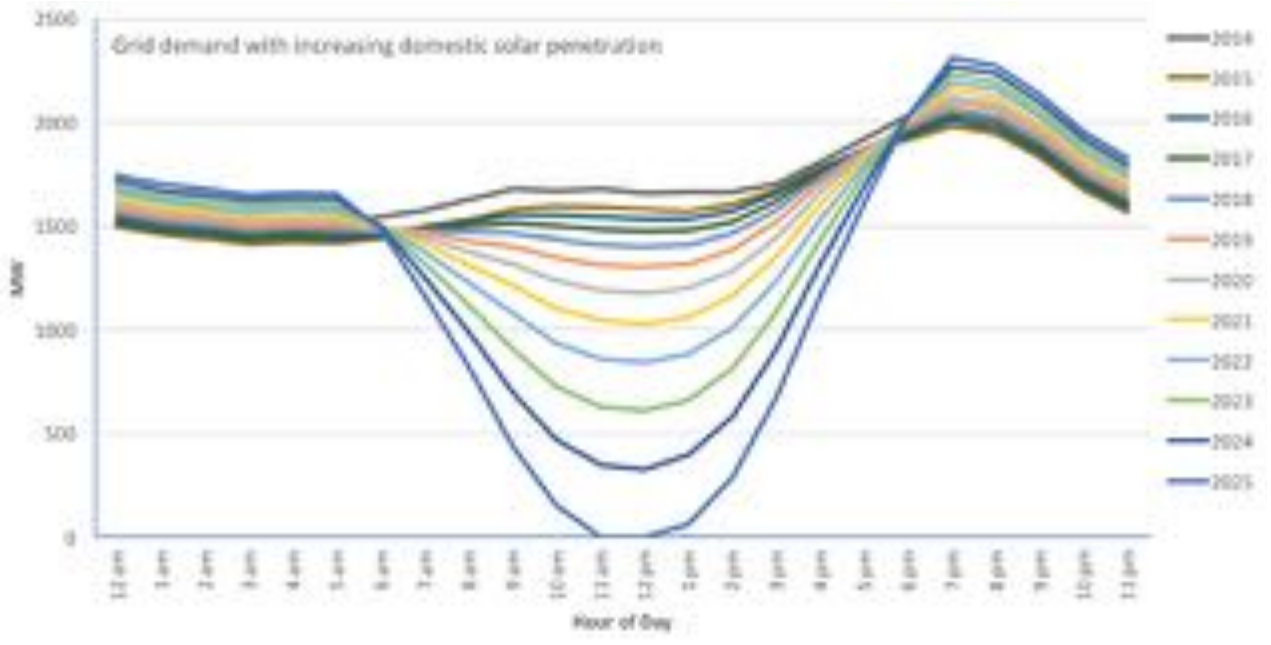
Western Australia's policymakers need to start planning now for a rapid transition to clean energy. More renewable energy is entering the system every day and existing plants are not suited to the demands of a 21st century grid. The reliability and financial sustainability of Collie's coal plants is in decline. Acknowledging and planning for these inevitable changes will lead to the most orderly, and lowest cost, energy transition.

Coal can't compete

WA's energy system is changing quickly. The rapid rise of distributed renewable generation has undermined the business model of coal generators and inflexible combined cycle gas turbines (CCGT). Wind and solar generators don't need fuel to operate and cost almost nothing to generate electricity once built. This difference means renewable generators can accept much lower prices than a coal or gas generator with higher generating costs.

Meanwhile, as a result of the enthusiastic uptake of rooftop PV in WA, daytime demand now falls quickly from the morning peak. As solar generation drops off in the afternoon, demand increases rapidly to peak around 18:00-19:00 (Figure 14). The Australian Energy Market Operator (AEMO) predicts that some locations in Australia will see negative minimum daytime demand by 2023-24.[269]

Figure 14: Grid demand with increasing domestic solar penetration (credit: SEN)



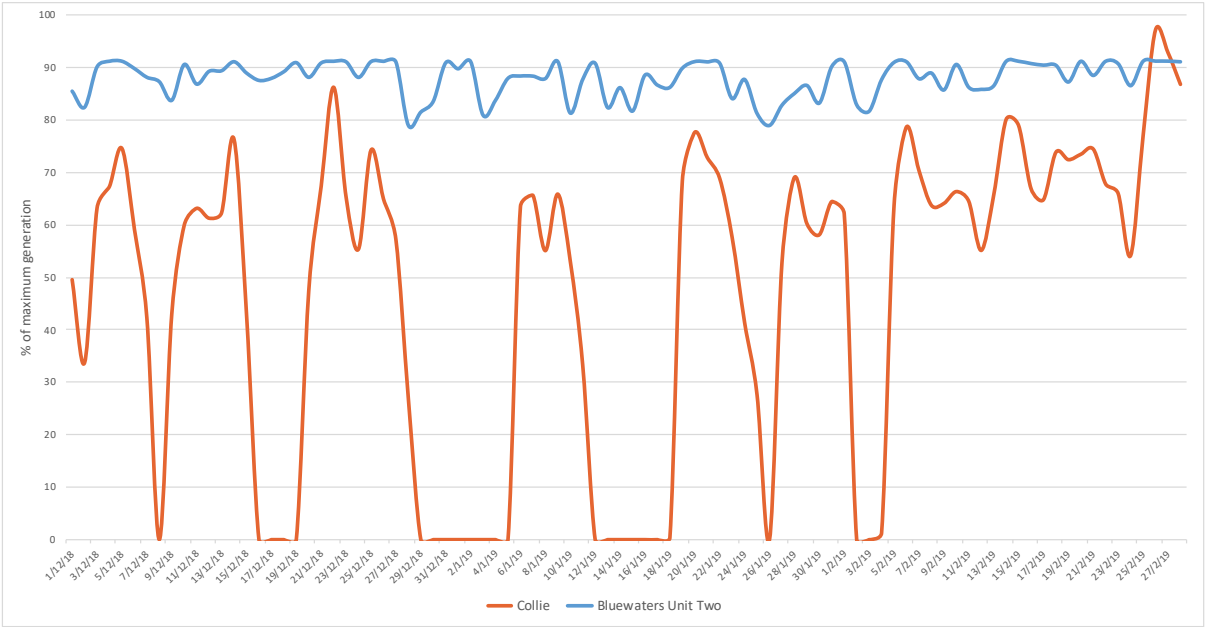
While flexible generators, like hydroelectric plants, can stop generating when it isn't economical, inflexible coal generators aren't designed to switch off at short notice or ramp up or down beyond constrained design limits. This can make it uneconomical for coal and gas generators to produce energy during certain periods.

During periods of low demand, high renewable supply and a high share of inflexible generation, prices on the Wholesale Electricity Market (the market operating on the SWIS) can even fall below $0. Some months these factors can come together to create negative prices for long periods - in November 2018 the WEM balancing market was in negative territory during 7% of all trading periods, and 6% of periods in January 2019.[270]

To avoid the oversupply problems caused by inflexible coal generation, some WA asset owners are running plants in a way which minimises exposure to low or negative pricing. By shutting down a coal unit, an owner can avoid incurring the expense of generating when prices will not cover costs. Where such 'cycling' does occur, the design life of the plant is impacted.

An example of a coal plant being run in a non-standard manner can be seen in Figure 15 below. The daily generation over summer is shown for both Collie Power Station and Bluewaters Power Station Unit Two. The difference in operation is clear, with Collie being repeatedly switched off while Bluewaters runs at a constant high output. Figure 15 makes clear the impact low demand, increasing renewable penetration and inflexible generation are already having on the viability of Collie's coal plants. Similar cycling is taking place in Muja's 38 year old Units Five and Six (now slated for closure). [271] [272]

Figure 15: Daily average generation 01/12/18 - 28/02/19



Old coal generators are unreliable

As coal power stations age, they become less reliable. The same is true of almost all complex mechanical systems.[273] As more and more components reach the end of their design lives, the overall effectiveness of the plant will decline, while maintenance costs will increase.

There are a range of reliability issues Collie's aging plants will face, including: corrosion, metal fatigue, high-temperature creep cracking and thermal shock. The very high pressures and temperatures involved in coal plants make exposed components particularly susceptible to failure as their age increases. While some of these issues can be dealt with through regular maintenance and repair, the increasing cost of doing so is often what forces the closure of ageing assets.[274] [275] Age-related maintenance issues are made worse by non-standard operation, as described above.

The risk ageing coal plants pose to system security is one AEMO has explicitly identified in the NEM:

> *"The forecast risk of load shedding in 2018-19 has increased since the 2017 ESOO, primarily because modelling has now factored in a reduction in thermal generation reliability observed in recent years,"* [276]

Coal plants also become less reliable as temperatures increase. Coal power stations rely on water to provide cooling for the condensers to convert steam from the turbine back to boiler feed water. As the ambient temperature increases, the ability of water cooling systems to perform this role is reduced. An inability to effectively cool the system can force plant operators to curtail generation, or worse, lead to plant failure.[277]

In 2017, the Australia Institute prepared a report titled *Can't Stand the Heat* which laid out the ongoing reliability risk ageing generators and extreme heat posed to the NEM. The report concluded:

> *"Climatic conditions in Australia are changing dramatically as a result of global warming. We are entering an era of more frequent, more intense and longer heat waves[...] Not only do these heat waves dramatically increase demand for electricity, but our electricity system is not designed to cope with these conditions. Coal and gas generators rely on cooling systems that make them significantly less efficient in hot weather, and increase the risk of breakdowns."* [278]

As South West WA continues to warm over coming decades, the incidence of extreme heat events will increase.[279] Increased extreme heat events will reduce coal plant reliability, which will further undermine the system stability of the SWIS.

The east-coast has seen firsthand the challenges unreliable coal plants can pose during extreme weather events. In January 2019, a heat wave hit Victoria and South Australia, leading to multiple days above 40 degrees across much of the region. The additional load on the system, caused in large part by air-conditioning and cooling, combined with 1,800 MW of brown coal capacity being offline, led to forced load-shedding across Victoria.[280]

West Australia also has experience with coal plants failing to deliver when needed. In January 2015, a run of hot weather coincided with the temporary closure of the Pinjar gas plant (due to bushfire risk) and the forced unavailability of Muja's Units Six and Eight.[281] Losing almost a quarter of capacity during a heat wave puts system stability at risk and poses a serious challenge to grid operators.

No future for coal plants in the SWIS

As more utility scale wind and solar are added to the SWIS, with 900MW recently cleared for grid access, the contribution of coal plants will continue to decline.[282] This new generation mix, paired with subdued daytime demand due to rooftop solar, will require steeper and more frequent ramping, duties to which Collie's coal plants are poorly suited. More renewable energy will also increase the likelihood of negative pricing through the day and in the early morning, undermining the economics of running inflexible coal generation.

Maintenance issues will become more pronounced as equipment is operated outside of its intended use, with a corresponding increase in costs and risk of unexpected forced outages. In the worst case, the age of the plant combined with the stresses inflicted by cycling and ramping leads to unscheduled plant failure. Unless plant closure has been planned in advance, this loss of capacity could put system security at risk.

Ignoring these risks will not make them go away. Planning for the inevitability of retirement will provide the best opportunity to create an orderly transition away from polluting, inflexible generation to clean energy backed up by flexible storage and demand response.

Box 21: Risks of sweating assets

Refurbishment of the remaining generating units at Muja (Five, Six, Seven & Eight) and the sole unit at Collie may seem an attractive prospect at face value.

Leaving aside the urgency of slashing emissions from energy generation, extending the life of ageing thermal generators is a reckless and unproductive use of money. As Western Australians are well aware, the botched refurbishment of Muja's generating units One, Two, Three & Four cost taxpayers in excess of $310 million, injured workers, was completed 18 months late and sent the project's engineering firm into bankruptcy - all to have the units closed in 2017.[283] Similarly, when AGL requested engineering firm Worley Parsons estimate the cost of extending the life of the 45 year old Liddell Power Station, the final assessment came back at $900 million.[284]

The strains to which coal plants are exposed over the course of their operational lives means delaying their closures will inevitably come at great expense. Keeping ageing plants open beyond their safe design life is not responsible or sensible. Funds can be more efficiently spent encouraging increased renewable energy uptake.

Appendix 2 - Keeping freight off roads

The industrial changes described in this report will affect the type and volume of material being moved around the region. While coal freight will decline as the industry closes, any capacity freed up will likely be offset by growth in new and existing industries. Ensuring access to the state road and rail networks, as well as export markets via the Port of Bunbury, will underpin the success of the proposals in this report.

In recognition of the negative environmental, amenity and health impacts of heavy road vehicle movements, freight generated by new industries in the Collie-Bunbury region should be transported by rail. Increased truck movements in and around Bunbury have become an issue as traffic associated with lithium mining has ramped-up.[285] While cleaner hydrogen or electric trucks are in development, rail remains the most efficient, least disruptive and safest means of transporting large volumes of freight.[286]

The South West Main Line is the primary existing rail freight route to the Port of Bunbury. The narrow gauge, single track line is not electrified and all trains on the line use diesel fuel. The line is primarily used for freight to and from Bunbury and Kwinana ports, although it also carries limited passenger services. The single track Collie/Premier line runs from the main line through Collie to the Scotts Strategic Industrial Area, with a branch connecting to the Worsely alumina refinery.[287] The South West Line below Brunswick Junction, where the Collie/Premier line joins the main line, is currently near capacity, with increases in freight tonnage up to 2030.[288]

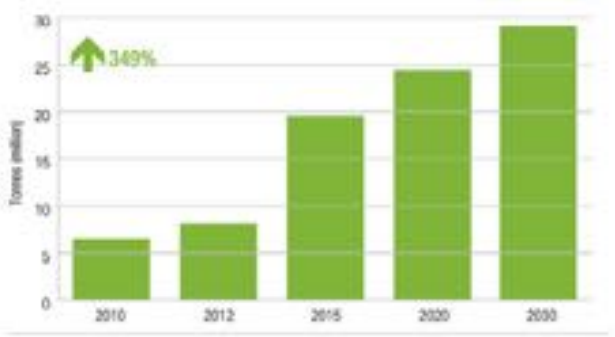
Investment in rail infrastructure upgrades is needed to facilitate the efficient movement of raw materials and finished goods in the Collie-Bunbury region, particularly given the new industries proposed in this report. The SWDC has identified duplication of the South West Main Line from Bunbury to Brunswick Junction, as well as a spur line from the Kemerton Strategic Industrial Area (KSIA), as priority projects.[289]

Moving freight by diesel fuelled rail produces between one quarter to one eighth the CO_2-e emissions of diesel trucks.[290] [291] These emissions, as well as the particulate pollution generated by burning diesel, can be eliminated entirely if trains are powered by renewable electricity.[292] Switching freight to electricity means procuring new locomotives and installing infrastructure along the line. Electric locomotives have a range of non-environmental benefits, including improved tractive efficiency, lower ongoing costs, quicker acceleration, quieter operation and lower upfront costs.[293]

Despite the benefits described above, electrification is an expensive process and may not be viable on infrequently used freight routes.[294] Renewable hydrogen is one alternative route to zero emissions rail freight, with the first hydrogen passenger train entering service in Germany in 2019.[295] Before hydrogen can replace diesel for freight applications, more work is required to develop fuel cells powerful enough to haul long cargo trains.[296] If developed, hydrogen freight trains would have access to a ready source of fuel in the Collie Green Hydrogen Plant.

Other low-carbon options include double stacking, biodiesels or using dual mode locomotives to take advantage of electrification along busy stretches, while reverting to diesel on standard track.[297]

Figure 16: Brunswick Junction–Collie line freight growth (credit: WA Dept of Transport)[300]



Box 22: Noongar people and WA's railways

As in many areas of Australia, the railways played an important part in the colonial history of WA's Indigenous peoples.[298] In the early years of the network's founding and expansion, many Noongar people found work as fettlers and gangers, building infrastructure still in use today.[299]

As upgrades are made to the South West's rail network, efforts should be made to both acknowledge and celebrate this history, and to identify opportunities for ongoing economic development for Noongar people.

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