Retirement of coal fired power stations

Submission to the Australian Senate Inquiry

Submitted by *Sustainable Energy Now*

10 November 2016

Sustainable Energy Now (SEN) is a voluntary group of some 200 members and associates, many of whom are professionals in the engineering, science, educational, business and IT fields.

SEN conducts regular talks and seminars, lobbies government, writes media articles and produces strategies to promote renewable energy in Western Australia. It also conducts research and modelling in regard to the technical and economic feasibility of renewable energy in Western Australia.

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Executive Summary

Australia's electricity generating fleet includes a large number of aging, inefficient and polluting intensive coal fired generators, which significantly contribute to Australia having one of the highest levels of greenhouse gas (GHG) emissions per capita in the world. Much of this plant has exceeded its design life, but continues to operate due to the low cost of their fuel. However, these units are facing challenges, in that:

- the lower than expected growth in electricity demand, and in many cases its decline, coupled with the growing deployment of zero marginal cost renewables, has depressed the wholesale power price and hence the margins for these units
- because of their age, they are facing the prospect of either increasing maintenance costs or becoming considerably less reliable

At the same time, electricity systems around the world, including in Australia, are being transformed through the deployment of increasingly cost-competitive renewable energy. Wind and solar photovoltaics (PV) already have a lower levelised cost than new coal or gas in many locations, and this trend will continue due to the:

- continued rapid fall in the cost of renewable energy
- increased viabilities of enablers of renewable energy
- take up of more energy efficient technologies and appliances, and electric vehicles
- elimination of fuel price volatility when using renewable generation sources

In December 2015 Australia committed itself to the Paris Agreement, from which Australia will contribute towards ensuring that the average global temperature rise will be kept to well below 2°C above pre-industrial levels with the aim of limiting the rise to 1.5°C.

The key principle underlying this submissions is that it is in Australia's national interest to achieve the objectives the Australian Government committed itself to in Paris in December 2015, and that Australia will face considerable costs if this objective is not achieved. This means there is great urgency in the need to decarbonise Australia's generating fleet such that if there is a risk that the current market arrangements do not deliver this outcome then measure need to be put in place so that it is achieve. Fortunately, the drivers of the transformation listed above enable this goal to be achieved with minimal cost although there will be some social and community disruption that needs to be planned for and addressed.

This submission has drawn on a review of closures of coal sectors in a range of countries and modelling of WA's South West Interconnected System (SWIS). A review of experience in a range of jurisdictions indicates the need for a co-ordinated and integrated approach that is well defined and communicated, to:

- create the market conditions that foster the rapid and efficient deployment of low carbon solutions, such as renewables, energy efficiency and demand side management, as well as dissuade the continuation of GHG emitting generation
- impose explicit constraints on high GHG emitting generating units

SEN's modelling and analysis of the SWIS indicates that with the existing RET scheme, existing coal-fired units can be replaced with wind and solar PV generation, providing stable, robust and secure energy with little or no increase in existing wholesale electricity prices.

This modelling considered the impact of the retirement of coal generation in the Collie region, and found that there is a variety of attractive prospects for regional re-development in this region.

Recommendations

General

Recommendation: Establish a timeframe for the decarbonisation of Australia's generating fleet that is consistent with the objectives of the Paris Agreement and so enables Australia to remain within a carbon budget that is tighter than the 10.1 $GtCO_2$-e recommended by the Climate Change Authority from 2013 and 2050

Recommendation: Prohibit the build of new coal-fired units

Recommendation: Limit construction of new gas plant to only that needed to support a high-penetration Renewable Energy supplied grid, and to have dual-fuel capability to enable the use of biofuels if/when available.

A Renewable Energy Industry Plan

Recommendation: Develop a Renewable Energy Industry Plan that fosters a positive investment climate for investors in renewable generation, including outlining long term objectives, targets and measures without the need for regular reviews that undermine investor confidence

Recommendation: The Renewable Energy Industry Plan should select from a range of options that support that rapid deployment of renewable generation, storage facilities and energy efficiency after taking account of:

- *recent innovations in funding renewables, such as reverse auctions used in a variety of jurisdictions including the Australian Capital Territory, and climate bonds*
- *prospects for revising electricity market rules that take account of the need for low marginal cost generators to recover their capital costs and the importance of valuing flexible options that enhance grid stability and provide balancing and other ancillary services*
- *the need to identify and remove barriers to entry and innovation in providing a cost efficient robust electricity system with a high penetration of renewables, considering options for storage providers and trading power between distributed generation sources*

Disincentives

Recommendation: Rapidly phase out fossil fuel incentives and subsidies

Recommendation: Provide disincentives for business to continue as usual through low cost mechanisms that:

- *force the retirement of the existing coal fleet, such as declining emission standards*
- *provide adequate notice to operators of how this mechanism will be implemented*
- *do not enable companies with unique information to derive unintended advantage, or **game** the system*

Energy Security

Recommendation: Ensure ongoing energy security through cost effective options including rapid response backup generation capability, storage and demand side management

Innovation

Recommendation: Promote and fund ongoing innovation to encourage particular technologies and business models through bodies such as ARENA and the CEFC, in order to bring Australian clean technology innovation right through to full commercial deployment and ready for export

Regulation

Recommendation: Remove regulatory barriers to uptake of renewable energy and energy storage in the commercial and household sectors

Recommendation: Investigate and support innovative 'time of use' electricity tariffs to balance peaks and troughs in demand.

Recommendation: Require residential, commercial and industrial developments to undertake a feasibility study into deploying a microgrid that incorporates renewable generation and storage

Social Benefits

Recommendation: Subsidise installation of solar PV in social housing as a matter of equity

Recommendation: Provide certainty to the public and business through a long term transition plan, which is responsive enough to adapt to changing circumstances

Workforce development

Recommendation: The Government tasks an entity, with the responsibility of:

- *identify regions and communities that may be adversely impacted through the transformation of the energy sector that includes the retirement of coal-fired units*
- *design and co-ordinate adjustment programs that identify appropriate long term sustainable goals in those regions and communities, and put in place strategies and measures for achieving those goals including retraining opportunities for affected workers*
- *liaise with relevant state and local governments, businesses, education facilities, and community groups*

1. Introduction

Sustainable Energy Now (SEN) is pleased to make this submission to the Senate inquiry into the retirement of coal fired power stations. While the terms of reference of this inquiry make reference to the policy mechanisms to encourage the retirement of coal-fired power stations from the National Electricity Market (NEM), SEN believes that this inquiry should take a broader perspective that includes the markets outside of the NEM, such as the South West Interconnected System (SWIS) in Western Australia, which includes significant aging coal fired units at Colie.

Australia's electricity generating fleet includes a large number of aging, inefficient and pollution-intensive coal fired generators, which significantly contribute to Australia having one of the highest levels of greenhouse gas (GHG) emissions per capita in the world. Much of this plant has exceeded its design life, but continues to operate due to the low cost of their fuel. However, these units are facing challenges, in that:

- the lower than expected growth in electricity demand, and in many cases its decline, coupled with the growing deployment of zero marginal cost renewables, has depressed the wholesale power price and hence the margins for these units
- because of their age, they are facing the prospect of either increasing maintenance costs or becoming considerably less reliable

At the same time, electricity systems around the world, including in Australia, are being transformed through the deployment of increasingly cost-competitive renewable energy. Wind and solar photovoltaics (PV) already have a lower levelised cost than new coal or gas in many locations, and this trend will continue due to the:

- continued rapid fall in the cost of renewable energy
- increased viability of enablers renewable energy such as:
    - the fall in the cost of storage
    - growing expertise in integrating renewables in to the energy system that results in reliable and stable supply
    - an increasing range of business and financing models that support renewables and storage technologies
- take up of more energy efficient technologies and appliances, and electric vehicles
- elimination of fuel price volatility when using renewable generation sources

In December 2015 Australia committed itself to the Paris Agreement, from which Australia will contribute towards ensuring that the average global temperature rise will be kept to within 2°C above pre-industrial levels with the aim of limiting the rise to 1.5°C.

This agreement requires that Australia urgently de-carbonises its economy, including the electricity sector. Fortunately, the drivers of the transformation listed above enable this goal to be achieved with minimal cost although there will be some social and community disruption that needs to be planned for and addressed.

The key challenges include:

- overcoming the barriers that GHG emission-intensive generating units face in exiting the market and effectively managing the this transition
- providing a stable and secure investment climate that will foster the rapid deployment of renewables and their efficient integration into the energy system
- minimising the social and regional disruption of this transformation and ensuring that those adversely impacted are able to continue productive lives

SEN has undertaken a review of relevant literature, see the list of references, taken account of the experience in a range of jurisdictions and undertaken its own modelling analysis.

A review of experience in a range of jurisdictions indicates the need for a co-ordinated and integrated approach that is well defined and communicated, to:

- create the market conditions that foster the rapid and efficient deployment of low carbon solutions, such as renewables, energy efficiency and demand side management, as well as dissuade the continuation of GHG emitting generation
- impose explicit constraints on high GHG emitting generating units
- develop appropriate transitional arrangements in relevant regions and locations that identify key strengths and opportunities and provide support in their redevelopment

SEN's modelling and analysis of the SWIS indicates that existing coal-fired units can be replaced with wind and solar PV generation, with no change to the existing gas generation plant, to provide stable and robust energy supply. With the RET target factored in, this transition (including the installation of new transmission infrastructure for the RE) can be achieved with little or no increase in existing wholesale electricity prices. (see page 15)

This modelling considered the impact of the retirement of coal generation in the Collie region, and found that there is a variety of attractive prospects for regional re-development in this region, and in other regions and communities that face some social disruption.

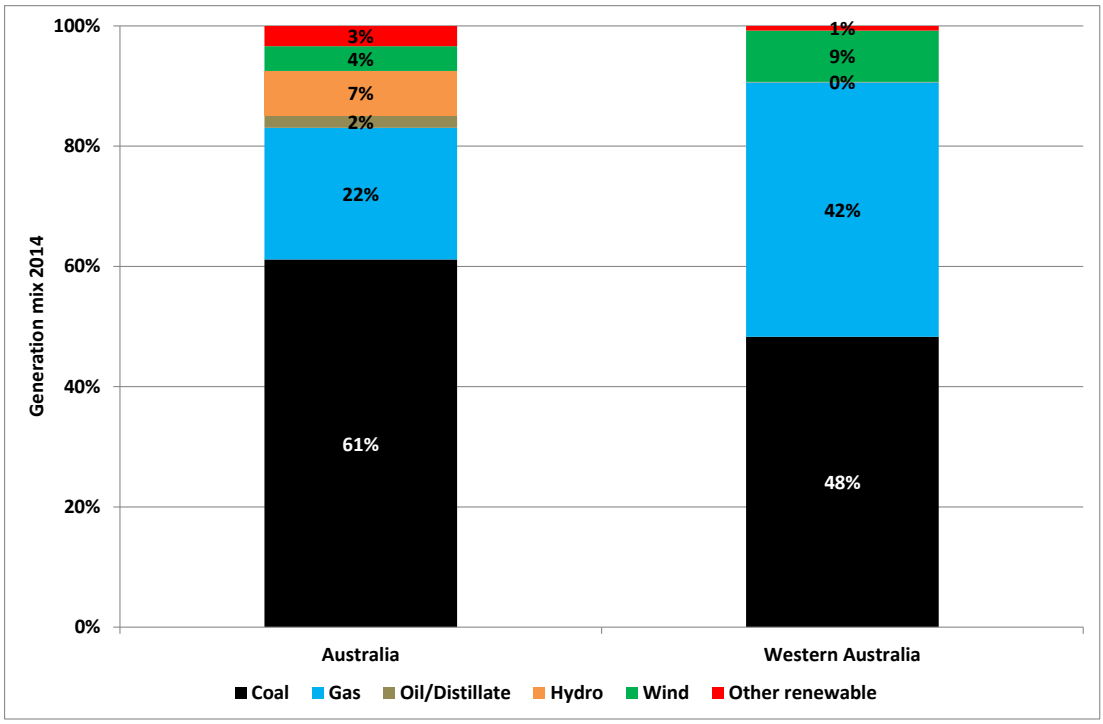
The structure of this submission is as follows:

- Section 2 outlines the principles SEN takes when considering the retirement of coal fired power plants
- Section 3 addresses the issues raised in the inquiry's Terms of Reference
- Section 4 lists references used in preparing this submission

2. Overview of guiding principles

Owing to its natural endowment of fossil fuels, Australia developed a predominantly coal and gas based electricity generating fleet. This is illustrated in the Australian and Western Australian fuels mix for 2014 shown in Figure 1, which also indicates that the share of gas is higher in Western Australia than the average for Australia.

Figure 1: Australia's and Western Australia's fuel mixes in 2014



Source: IEA for Australia's fuel mix and AEMO for WA's fuel mix

The high use of coal, and in particular the use of brown coal in Victoria, has resulted in Australia having a greenhouse gas (GHG) intensive energy mix, which is a key factor in Australia having one of the highest levels of GHG emissions per capita.

At the COP21 in Paris in December 2015 Australia committed itself to a process in which Australia will contribute to ensuring that the average global temperature rise will be kept to within 2°C above pre-industrial levels with the aim of limiting the rise to 1.5°C.

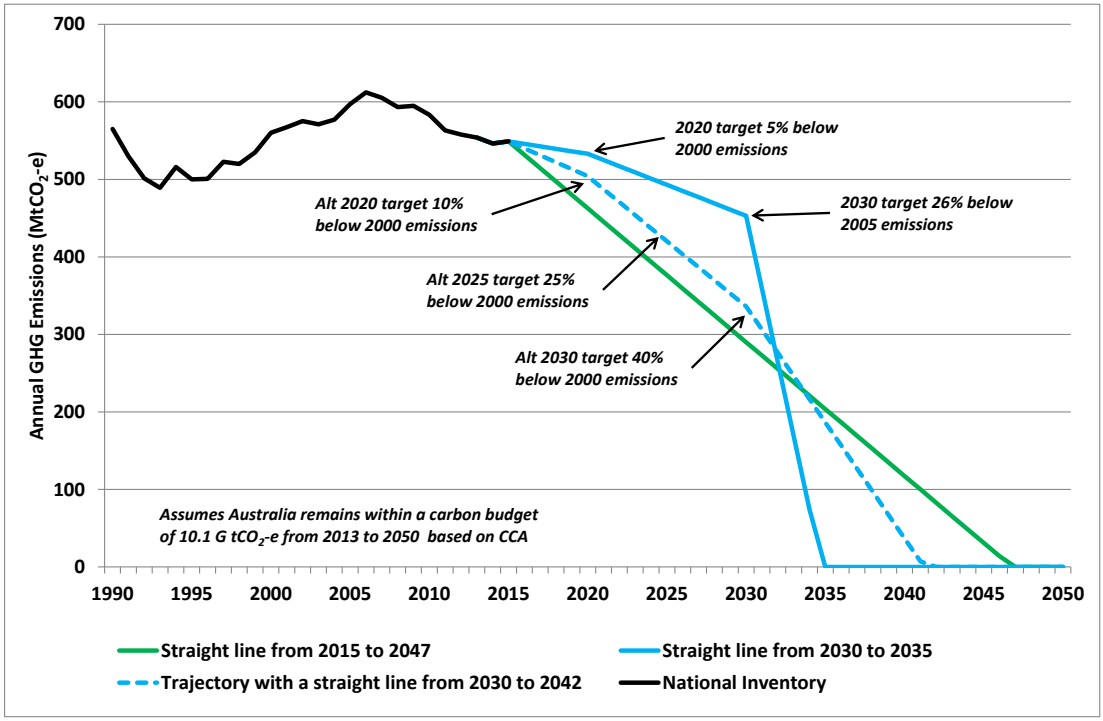
In February 2014 the Climate Change Authority (CCA) recommended that Australia's fair contribution towards a 67% probability of limiting the increase in global warming to 2°C would be to remain within a national carbon budget for the period of 2013 to 2050 of 10.1 $GtCO_2$-e[1]. Given the revised objective of keeping temperature rises well below 2°C, this carbon budget should be revised down.

[1] Climate Change Authority, *Reducing Australia's Greenhouse Gas Emissions — Targets and Progress Review Final Report*, February 2014

Figure 2 shows Australia's emissions until 2015 and three potential emissions trajectories that are consistent with the CCA's recommended carbon budget, in which:

- the solid blue line illustrates the trajectory required from the existing 2030 targets suggesting Australia will need to rapidly become net carbon zero between 2030 & 2035
- the solid green line reflects a linear trajectory between 2014 and 2047
- the dashed blue line reflects a trajectory with more ambitious targets to 2030, followed by an accelerated trajectory to net zero emissions from 2042

Figure 2: Australia's GHG emission trends and future targets



Source: Australian Emission Projections

While the Government is yet to accept the CCA's recommendation on a carbon budget, it cannot escape the fact that the sooner significant emissions reductions are achieved, the less difficult and less costly it will be to achieve the goal it committed itself to less than a year ago.

It is SEN's view that it is in Australia's national interest to achieve the objectives the Australian Government committed itself to in Paris in December 2015, and that Australia will face considerable costs if this objective is not achieved. This means there is great urgency in the need to decarbonise Australia's generating fleet such that if there is a risk that the current market arrangements do not deliver this outcome then measures need to be put in place so that it is achieve. Such measures should address not only ensuring prompt retirement of the existing coal units, but their efficient replacement with zero carbon sources in a way that provides a robust and reliable energy system and a fair and just transitional arrangements for effected stakeholders. These views shape the direction and recommendations of this submission.

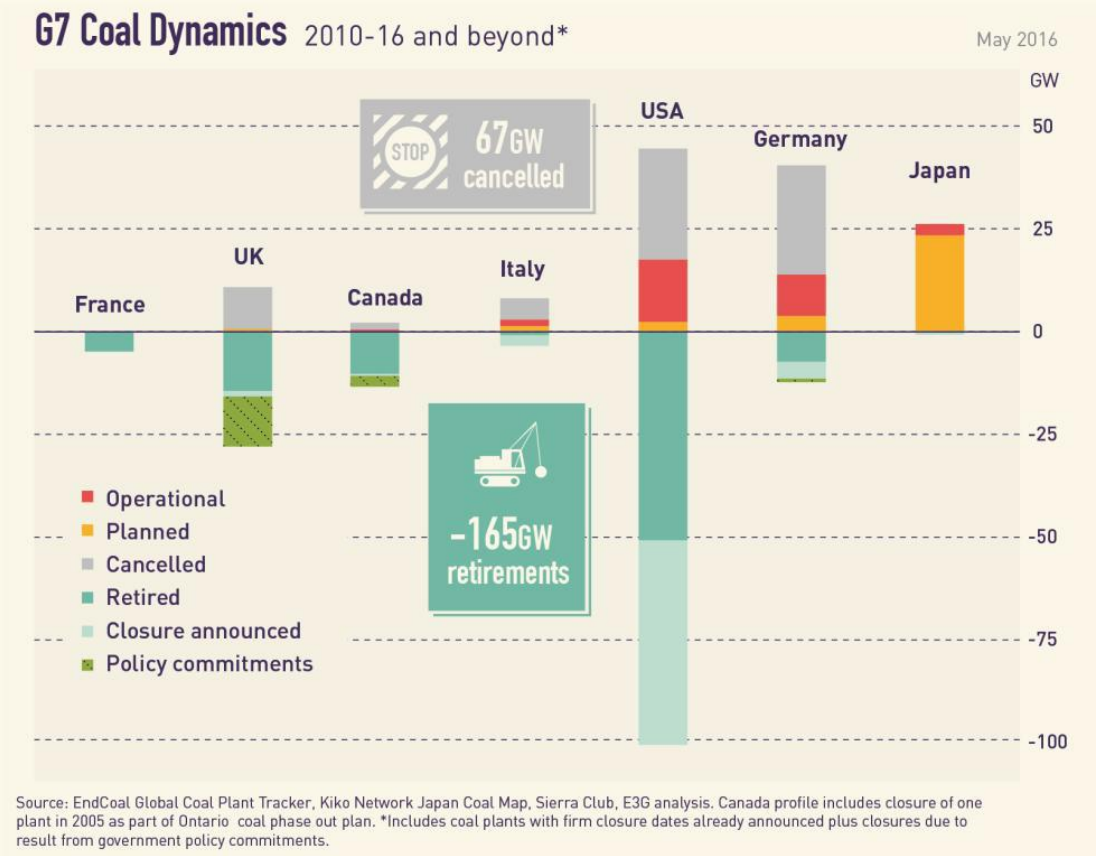
3. Issues raised in Terms of Reference

This section addresses the issues raised in the inquiry's Terms of Reference.

3a The experience of closures of electricity generators and other large industrial assets on workers and communities, both in Australia and overseas

In recent years, there has been a significant closure of existing, and cancellation of planned, coal fired power plants in a range of jurisdictions. For example, Figure 3 shows that, in the G7 countries since 2010, 67 GW of proposed coal fired plant has been cancelled and 165 GW of coal fired plant have been closed or are scheduled for closure.

Figure 3: Changes in coal-fired generating fleet in G7 countries since 2010



Source Littlecott C, *G7 Coal Scorecard Update Coal Phase Out Commitments and Power Plant Closures*

There is a vast literature on the social and economic impacts of the closure of important industries and many lessons are transferable across sectors, be they automotive and ship building or coal mining and coal-fired generation.

The UK House of Commons report into the closure of many coal mines during the 1980s and 1990s found that

> *The closures of the coalfields in the 1980s and early 1990s resulted in the loss of more than 250,000 jobs … left a legacy of high unemployment, social deprivation and environmental degradation*

Many of the support arrangement that had been put in place were poorly co-ordinated and short term and did not lead to stable employment. In response to many of these issues, many Regional Development Agencies were established in the UK to engage with local communities and coordinate programs and measures[2].

By contrast Germany had a profoundly different experience when transforming the coal dependent Ruhr region into a diversified economy with minimal social disruption[3]. This process involved:

- engagement between stakeholders in 2007 who agreed to the goals of ending Government subsidies for coal mining and ceasing coal mining by 2018
- creating the RAG Foundation to provide training to employees, information about job opportunities, financing ongoing management of the mine and rehabilitation of the land, and financing education, scientific and cultural projects
- successful retraining and redeployment of employees

Government support for communities undergoing significant economic transition is not unique to the European Union. For example, workers impacted by the declining coal industry in Kentucky, including coal miners, employees at coal-fired power plants, and those who had been employed in coal supply chain jobs, such as manufacturing or transportation received the following support:

- $11.3 m from the US Department of Labour in a National Emergency Grant to fund job training and job search assistance
- $35 m from the State of Kentucky in grants under a dedicated regional program, Partnerships for Opportunity and Workforce and Economic Revitalization (POWER) initiative

Australia is not immune from coal disruption. Coal-related jobs have been trending down for decades, having nothing to do with regulations that affect coal, but instead being related to ageing coal stations with outdated inefficient power generation modes. In the USA, the industry further moved to mechanise mountain top mining which required fewer workers by the thousands. Similar automation in Australia has dramatically reduced the need for labour in coal mining over the last 20 years. Other factors include the low cost of natural gas, a rise in energy efficiency, and a decrease in global demand for coal for power generation.

In November 2016 Engie announced that it would close the Hazelwood coal fired power station in the Latrobe Valley Victoria in March 2017[4], which currently employees 750 people. The Federal Government announced it would provide the following support:

- $20 million in support for local infrastructure
- $3 million to help employees
- $20 million Regional Jobs and Investment Package.

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2 See Shutt J, Henderson R and Kumi-Ampofo F, *Responding to a regional economic crisis: An impact and regeneration assessment of the Selby coalfield closure on the Yorkshire and Humber region*

3 See Taylor R, *A Review of Industrial Restructuring in the Ruhr Valley and Relevant Points for China*, and Schulz S & Schwartzkopff J, *Instruments for a managed coal phase-out German and international experiences with structural change*

4 www.engie.com/en/journalists/press-releases/hazelwood-power-station-australia/

The Victorian Government announced a $22 million package of support will be available for Hazelwood workers and affected businesses. This includes:

- a Worker Transition Centre established in Morwell in partnership with the Gippsland Trades and Labour Council – a one-stop-shop for individual support
- education, counselling, financial advice and subsidised job-seeker training for workers in transition
- tailored support for businesses to help them identify new opportunities and develop a transition plan
- an expansion of the Back to Work program to businesses that employ workers in the Latrobe Valley.
- a call centre and website will go live today to provide affected workers with access to information and support.

The Victorian Government will also provide an additional $20 million will fund the establishment of a dedicated Latrobe Valley Authority to lead its response and manage the transition and the future economic development of the Latrobe Valley.

The Latrobe Valley disruption is unlikely to be an isolated instance. The Hunter Valley and Collie was identified in our modelling, also face disruption to business as usual. Initiatives like those listed above need to be rolled out across Australia, implemented through a Renewable Energy Industry Plan and administered by an entity with the responsibility to:

- identify regions and communities that may be adversely impacted through the transformation of the energy sector that includes the retirement of coal-fired units;
- design and co-ordinate adjustment programs that identify appropriate long term sustainable goals those regions and communities, and put in place strategies and measures for achieving those goals;
- liaise with relevant state and local governments, businesses, education facilities, and community groups.

Development of the Renewable Industry Transition Plan should commence as soon as practicable, so that work on new renewable industries can be commenced before coal-fired power stations go out of business. It will be too late to start this after coal power workers are out of a job.

Section 3d provides practical examples of the type of industry transition which can be established in Collie and surrounding environs. Fortunately, many of the technical and managerial needs of the low-carbon energy sector are similar to those in traditional energy and power industries. However, a degree of reskilling will be required, so the government should start a retraining program for workers in the coal power industry, and part of the transition plan.

There is a positive outlook for such transition plans. According to EU trade union SustainLabour, the renewable sector in Europe alone could produce 6.1m new jobs by 2050. By the same token, they also state that divestment in coal, oil and gas, and other carbon-intensive sectors could lead to a massive shake-up elsewhere in the global labour market.

In Scotland, recent falls in fossil fuel commodity prices hit the oil and gas sector hard: more than 65,000 jobs were lost in the sector. However, Scotland has become a hub of clean energy generation, generating just under half of all the renewable electricity produced in the UK.

The Scots have introduced the Transition Training Fund aiming to help retain the wealth of skills and experience developed by the oil and gas industry and to redeploy it in other sectors. The training will be provided by a mix of higher education colleges and businesses. Under the scheme Danish conglomerate Maersk is offering training in the renewables sector, while Inverness College UHI will train people in developing skills for the electrical, solar, biomass or heat pump sectors.

3b The role that alternative mechanisms can play in alleviating and minimising the economic, social and community costs of large electricity generation and other industrial asset closures, drawing on experiences in Australia and overseas

Coal-fired generation is suited to relatively constant electrical power output, and therefore considered only economically viable for providing the lowest constant (baseload) demand for power over a typical daily cycle. However Western Australia's South-West Interconnected System (SWIS) power demand typically fluctuates from 'baseload' to about three times that, so the response limitation of coal is overcome by adding variable generation (such as gas turbines) to meet the shortfall and balance the system.

SEN was interested in the feasibility of renewable alternatives to this scenario. It developed the "SEN Integrated Renewable Energy Network" (SIREN) Toolkit software[5], in order to model commercially available renewable generation and storage technologies, in terms of technical, economic and environmental (CO_2e emissions) considerations. Historical temperature, wind and solar radiation data from NASA were used to underpin the model (from the US Department of Energy, "System Advisor Model"), which was overlaid onto Geographical Information System (GIS) data, and then tested in a variety of scenarios. Two detailed studies have been developed from this modelling:

- the longer term "Clean Electricity Western Australia (CEWA) 2030"[6] study, based on an assumption of a $30 carbon price), and
- the near-term transition plan "SWIS Coal Retirement 2021" (SCR 2021), based on a 20% Renewable Energy Target with $55 LGCs (large-scale generation certificates).

The rationale for these two reports was to firstly determine a long-term vision to ensure an optimised mix of Renewable Energy, and then to set the direction for an initial transition over the next 5 years. The reason for different assumptions is reflective of what SEN believes is relevant to that timeframe.

These studies demonstrate how an orderly transformation of the SWIS to a Renewable Energy dominant system can be achieved economically by 2030. Specifically, the present coal 'baseload' generation can be replaced by a combination of energy sources, such as commercially available renewables complemented with storage (battery, pumped-hydroelectric, molten salt) and

[5] http://www.sen.asn.au/modelling_overview
[6] "Clean Electricity Western Australia (CEWA) 2030", Rose et al, 2016
http://www.sen.asn.au/modelling_findings

dispatchable generators (gas/biofuel) which together provide a stable, reliable and responsive system (discussed further in section 3c(iv)).

SEN's modelling of the near-term for the SWIS (SCR 2021 report) shows that all coal generation can be replaced with an ambitious but feasible build of wind and solar PV with little or no increase in electricity prices depending on the RET target and the Large Generation Certificate (LGC) price.

The CEWA 2030 report demonstrates that the SWIS can transition to at least 85% Renewable Energy (RE) by 2030 for the same Levelised Cost of Electricity (LCoE[7]) as renewing the existing coal and gas generation. In reality, Renewable Energy is expected to be cheaper as the modelling in the report has used conservative cost data for Renewable Energy that is higher than current forecast costs.

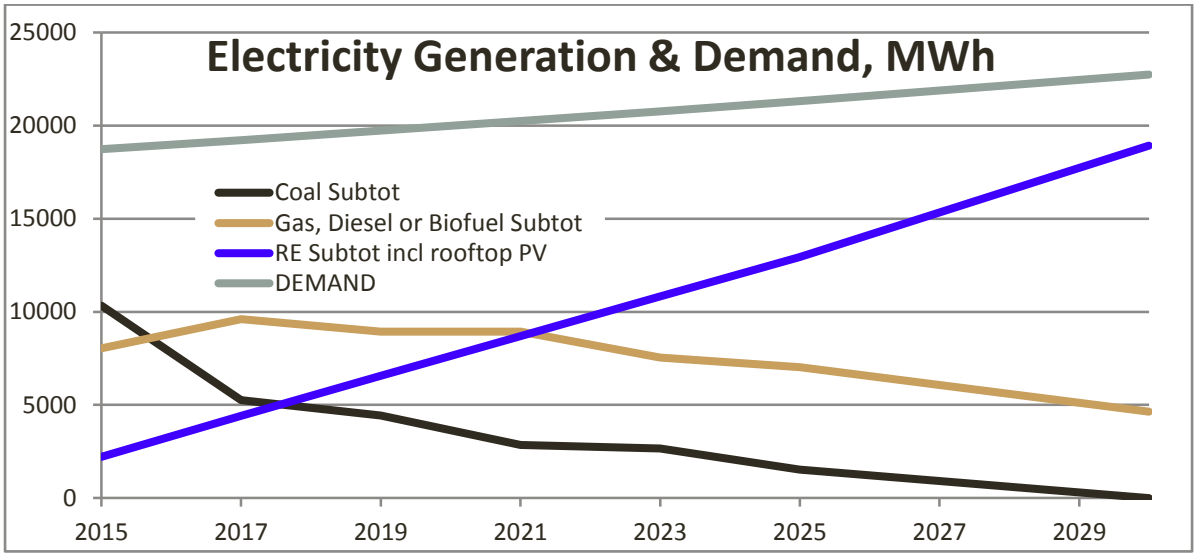
Modelling details

Contrary to conventional belief, 'baseload' generation is not needed. The modelling shows that a mix of renewable sources can meet expected demand for most of the year except for some periods in winter. In such cases, demand can be met by Rapid-response Open Cycle Gas Turbines (OCGT) running on gas/biofuel, which can be further reduced with the addition of some storage, discussed further below.

A graphical representation of this transition of generation is illustrated in Figure 4, from the CEWA 2030 report. Energy demand is assumed to grow, based on data from the Independent Market Operator of WA (IMOWA). Further, renewable energy installations are assumed to increase approximately linearly. However, many other trajectories are possible and feasible, as technology advances.

The transition scenario shows that as this transition occurs, existing combined cycle gas turbines (CCGT) be used temporarily at a higher utilisation rate to take up the loss of phased-out 'coal generation, until sufficient installation of renewables makes up the difference.

Figure 4: Electricity generation and demand modelling over study period



Source: SEN, *Clean Energy WA 2030 report*

[7] The Levelised Cost of Electricity (LCOE) amortises the cost of energy production as a combination of costs of capital expenditure, operations and maintenance and fuel over the lifetime of a generation source.

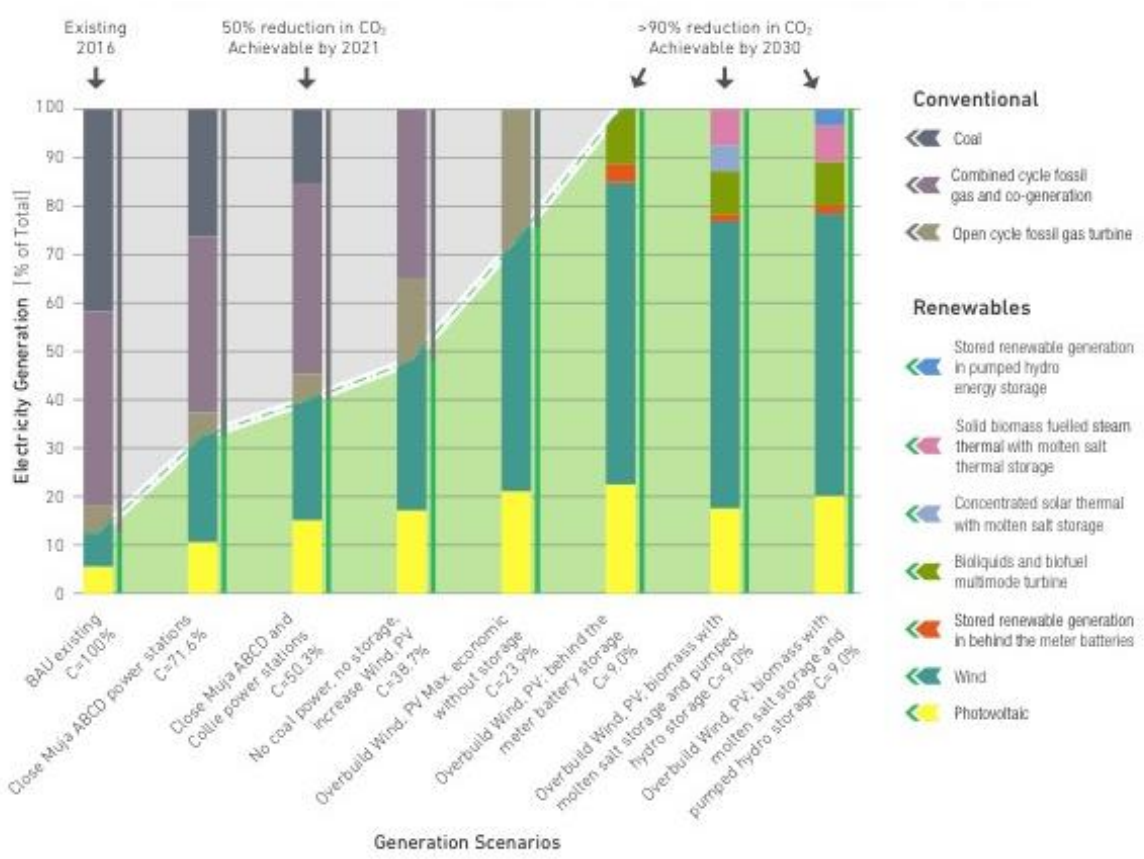
Figure 5 shows more specifically how the energy mix could change at different phases in the transition. Existing baseload gas generation (shown as combined cycle gas turbines (CCGT) remains fairly constant, while coal is replaced by renewables. In other words, the modelling shows gas is used as a transition fuel, but, importantly, no new gas generation capacity needs to be constructed to meet demand. Figure 5 also shows that OCGT remains important to balance load. In the modelling, OCGT increases in importance after coal is phased out, but this decreases as the remaining renewable energy capacity is installed.

In the longer term, rapid-response Open Cycle Gas Turbines (OCGT) running on gas/biofuel will be needed to balance the system and provide stored energy in periods of extended low solar and wind conditions. The amount of gas/biofuel used is relatively small (only enough to generate 10-15% of total electrical energy).

Some of the CCGT generation plant could be retained to provide dispatchable power for the short low-wind and solar periods through the year.

Figure 5 below shows that closure of all coal and increasing wind/PV generation from 14% to 46.5% (column 4) will decrease carbon emissions to 37.5% of current levels, ie a reduction of 63.5%.

Figure 5: SWIS Coal Retirement 2021 – Summary of modelled scenarios



Source: SEN, SWIS Coal Retirement 2021

The assumptions used in the analysis shown in Figure 5 are summarised below.

Table 1: Results of SEN's modelling of transitional scenarios

Scenario / Assumptions	BAU existing C=100%	Close Muja ABCD and Collie power stations C=71.6%	Close Muja ABCD and Collie power stations C=50.3%	No coal power, no storage, increase Wind, PV C=38.7%	Overbuild Wind, PV Max. economic without storage C=23.9%	Overbuild Wind, PV; behind the meter battery storage C=16.9%	Overbuild Wind, PV; CST and biomass with molten salt storage C=9%	Overbuild Wind, PV; biomass with molten salt storage and pumped hydro storage C=9%
Zero C price and zero RET	$91	$99	$109	$109	$117	$124	$137	$136
$30/t Carbon Price	$109	$112	$119	$116	$122	n/a	n/a	n/a
$55 LGC price, 20% RET target; excess LGC's sold	$98	$96	$100	$98	n/a	n/a	n/a	n/a
RET as above; Recent PPA's for wind, PV in Australia	$98	$94	$97	$94	n/a	n/a	n/a	n/a

SEN's SWIS transition modelling (Table 1 above) shows that if there were no RET or carbon price, closure of all coal and replacement with wind/ PV (column 4 row 1) would increase the LCOE by $18 per MWh (1.8c / kWh)

However, the table shows with the current RET target of 20% factored in, with an assumed average LGC price of $55/MWh, (compared to current LGC prices of > $80), and that excess LGC's are sold at that price, the LCOE is equal to or less than BAU in rows 3 and 4.

Actual electricity prices will of course depend on future RET targets and LGC prices. An alternative way of modelling this is to assume that the RET target increases to at least 46.5% post-2021 (equivalent to the 'no coal scenario in column 4 Figure 5) and that there are no excess LGC's to sell. Under this scenario, the existing and no-coal scenarios are at equal cost with a LGC price of $46.

Future LCOE's of wind and PV will also greatly affect LCOE. Row 4 of Table 1 assumes PPA prices that have been paid for generation on good wind and solar sites in Australia in 2016. These are significantly lower than the BREE (2014) costings assumed for rows 1 – 3. SEN considers this modelling to be conservative as wind and PV costs are projected to fall well below the recent PPA's.

Table 2: Cost assumptions used in SENs analysis of transitional scenarios

	LCOE, $/MWh		
	Conservative LCOE's	Reference	**Recent Power Purchase Agreement prices, Australia**
Wind	**$85**	2025	**$77**
PV, rooftop	**$65**	Solar Choice, 2016	
PV, fixed, utility	**$110**	BREE 2014 est. for 2025	**$100**
CST with 6 hrs storage	**$165**	BREE 2014 est. for 2025	
'Behind meter' Battery	**$40**	nominal subsidy = SRET	
Coal	**$100**	BREE 2014 est. for 2025	
Nuclear (SMR)	**$159**	BREE 2014 est. for 2025	

Transmission costs

SEN has also modelled the additional transmission required and this amounts to less than 800 km of 330 kV lines costing <$1 billion, which will add only $3/ MWh to the cost of electricity.

Carbon Capture and Storage (CCS)

As there are some proponents of CCS, SEN has modelled CCS retrofit against equivalent RE scenarios, the results of which are shown in Table 3.

Table 3: SEN's modelling of CCS vs RE scenarios for the SWIS

Scenario / Assumptions	Close Muja AB; CCS retrofit C=40.9%	Close Muja AB; New coal CCS C=40%	No coal, no storage, increase Wind, PV C=38.7%
LCOE with Zero C price and zero RET	$106	$132	$109
LCOE with $30 C price	$113	$140	$116
LCOE with 20% RET target; $55 LGC price, excess LGC's sold	$113	$140	$98
LCOE with RET as above; current PPA's for wind, PV in Australia	$113	$140	$94

Table 3 above shows that with no RET or carbon price, LCOE of carbon capture and storage (CCS) retrofit is similar to the RE scenario with similar carbon emissions. However, with existing RET conditions as for Table 1 above, CCS is $19 / MWh more expensive than RE. The reason is that coal power with CCS is not renewable energy and cannot claim LGC's. SEN's policy is that CCS should not be used with coal as it is not cost effective, even when retrofitted to old plant and the leakage risks and maintenance costs of the old coal plant are not factored in.

While SEN has analysed scenarios that include CCS for comparison purposes, SEN does not support nor believe that it is a viable option for coal-fired generation for numerous reasons including:

- Existing coal power generation is generally speaking the only practical application of the "conventional" approach: ie capture by amine solvent-based adsorption process from flue, sequestration in subsurface formations.
- Only the amine capture is mature technology while sequestration is immature
- Existing CCS examples are few (ie 3-4) and not in economic scenarios.
- Existing (brownfield) coal power is usually co-located close to coalfields to be economic at the development instigation stage. It is rare to find co-located suitable subsurface conditions to receive the concentrated CO_2 gas for sequestration and not practical to transport over distance due to cost.
- CCS is an overhead cost and even on "value written down" assets, cannot be justified unless new concepts to monetise the CO_2 can be developed. None have been to date. Timeframe to reach maturity is to too long to be relevant to comply with the COP21 objectives.
- CCS processes cannot provide any comfort that the storage reserves have significant storage security on a long or short term basis.

- The technical complexity and parasitic power requirements of CCS means the reliability and availability (capacity factor) of existing old and also new power plants must be significantly reduced
- Grid parity of RE (and continued cost reductions) means the "venture into the unknown" of CCS would never be cost competitive.
- CCS will approximately double the wholesale price of electricity based on its cost prior to transmission. Additionally, if the risks mentioned above are factored, this may be a low estimate.

SEN is aware that abatement is challenging in some commercial applications given existing technologies, such as cement production and mineral refining. Circumstances may exist in which CCS is the most viable abatement options for these applications. However, CCS will still face considerable challenges, as it is unproven commercially, the leakage risks are not understood and it will face community opposition, and other more effective and efficient abatement options may emerge.

The age of the SWIS coal generators and their predicted retirement ages is shown in Table 4. Four of these plants will reach the end of their design life in the next four years, at which time they should have been depreciated, which provides an opportunity to start the transition to renewable energy sources.

Table 4: Details of coal fired power plants connected to the SWIS

COAL-FUELLED GENERATORS	Owner	Yr built	Retire	Retmt age, yrs	MW capacity
MUJA AB (G1, G2, G3, G4)	Synergy	1965	2016	51	220
Muja C (G5, G6)	Synergy	1981	2017	36	385
Muja D G7, G8)	Synergy	1985	2019	34	422
Collie	Synergy	1990	2019	29	317
Bluewaters 1	Sumitomo	2009	2029	20	217
Bluewaters 2	Sumitomo	2009	2030	21	217

According to our modelling, a transition to renewable energy for Western Australia is both cost neutral and timely. However, the opportunity could be wasted unless commitment, planning and the transition begin immediately, because of the imminent retirement of the Muja coal-fired units.

Other studies into high penetration RE by the University of NSW[8] and the Australian Energy Market Operator[9] for the NEM further confirm that 100% RE can provide reliable cost-effective electricity.

[8] Elliston B, Riesz J and MacGill I, What cost for more renewables? The incremental cost of renewable generation - an Australian National Electricity market case study, Renewable Energy, Volume 95, September 2016, Pages 127–139

Collie coal community transition

SEN has considered the impact of the transition to renewables on the community of Collie, which will be directly impacted by the phase out of coal-fired generation. Depending on the approach taken to this disruption, there could be severe impacts on the Colie community, however, with sufficient planning, the disruption can be minimised, and potentially improved - see Section 3a.

Geographical factors (regions of high wind and solar radiation) in the general vicinity of Collie indicate that it is possible to:

- Install 1,000 – 1,400 MW of wind east and west of Collie (equivalent to 7 Collgar windfarms)
- Install up to 200 MW of utility scale PV
- Build new industries: based on RE, such as a sustainable biomass industry with other byproducts, manufacturing of RE components; and tourism.

Other benefits Australia-wide in moving to a low-carbon economy

SEN is not alone in considering the economics of renewable energy sources, and the issues involved in a just transition towards this goal. The Senate Inquiry Committee may be aware of these reports, which come to largely similar conclusions:

- Australian Conservation Foundation (ACF) report, Our Energy Future: A plan to transition Australia to clean energy[10]
- Australian Conservation Foundation (ACF) and Australian Council of Trade Unions (ACTU) report, Jobs in a Clean Energy Future[11]
- Beyond Zero Emissions, Zero Carbon Australia: Renewable Energy Superpower[12], October 2015
- Clean Energy Council (CEC) Powershift: A blueprint for a 21st century energy system[13]

3c Policy mechanisms to encourage the retirement of coal-fired power stations from the National Electricity Market

3c(i) the 'Paris Agreement' to keep global warming below 2 degrees Celsius, and ideally below 1.5 degrees Celsius

Australia has agreed to the COP21 *Paris Agreement* and has recently ratified it. This embodies a commitment for the Australian Government to ensure global temperature rises are well below 2°C, and aim for 1.5°C.

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[9] AEMO, "100 per cent renewables study - modelling outcomes," Australian Energy Market Operator, Melbourne, 2013. https://www.environment.gov.au/system/files/resources/d67797b7-d563-427f-84eb-c3bb69e34073/files/100-percent-renewables-study-modelling-outcomes-report.pdf

[10] ACF Our Energy Future. https://d3n8a8pro7vhmx.cloudfront.net/auscon/pages/1463/attachments/original/1478645824/Our_energy_future_A_plan_to_transition_Australia_to_clean_energy_WEB.pdf?1478645824

[11] Australian Conservation Foundation and Australian Council of Trade Unions, *Jobs in a Clean Energy Future*, https://d3n8a8pro7vhmx.cloudfront.net/auscon/pages/1435/attachments/original/1477355385/ACF_Jobs_in_a_clean_energy_future.Web.pdf)

[12] Beyond Zero Emissions, *Zero Carbon Australia: Renewable Energy Superpower*, October 2015

[13] Clean Energy Council, *Powershift: A blueprint for a 21st century energy system*, http://www.cleanenergycouncil.org.au/powershift

The Agreement means that no new coal-fired power stations should be built and existing coal-fired generation facilities should be retired (rather than refurbished). As discussed in section 3b, WA has the opportunity to take an early lead to retire all coal-fired stations on the SWIS without compromising security or cost of supply.

Australia has some history of discussing closing coal-fired units. In 2011 the Government indicated that it would negotiate an orderly closure of approximately 2,000 MW of some of Australia's most emissions-intensive generation capacity by 2020. After a change in government, in 2014 the COAG Energy Council had taken the following very different position

> *"… Nor does [the council] support assistance to generators to exit the market. The Council considers it is for the market to provide signals for investment and deinvestment for generation, and opposes the transferral of the costs of retiring assets onto consumers or taxpayers."*[14]

Under the current electricity market arrangements, Australia will eventually witness the retirement of all coal-fired generation. However, the barriers to exit and industry statements reported in Section 3c(ii) indicate that some form of government policy will be required if Australia is to decarbonise its economy at the rapid pace required to remain within a carbon budget consistent with its commitments made in Paris in December 2015.

Figure 3 illustrates that, internationally, there has been a substantial number of retirements and announced closures as well as cancellations of proposed projects. The two main drivers are:

- government policy and regulations; such as setting emission limits
- market conditions resulting in coal generation being displaced by other forms of generation, such as gas in the US and renewables in Europe

Some jurisdictions have indicated that further measures are required. Specifically:

- the UK has begun a consultation to phase out all of its coal fleet by 2025[15]
- Germany has considered options for phasing out coal-fired generation by 2050[16]

There have been some doubts about whether Germany and the UK will achieve these goals, but it is clear that many major developed economies are focusing on how to reduce their use of coal.

3c(ii) the stated and expected life span of Australia's coal-fired power plants

Retirement of coal-fired generating units, particularly the brown coal units in the Latrobe Valley, has already commenced. Facilitating retirement of coal-fired generating units, such as in Collie, would reduce the GHG intensity of Australia's generating fleet and materially contribute towards meeting one of the Australian Government's international commitments. Further, the sooner these units are closed, the greater the contribution will be towards Australia remaining within a carbon budget.

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14 COAG, *Council of Australian Governments Meeting Communique,* Adelaide, 11 December 2014

15 See www.gov.uk/government/consultations/coal-generation-in-great-britain-the-pathway-to-a-low-carbon-future

16 See http://uk.reuters.com/article/us-germany-environment-coal-idUKKCN0XU1R1

However, significant barriers to coal-fired unit exiting have been identified[17], including:

- the cost of coal is lower than gas so, for coal-fired units, the wholesale power price usually exceeds the operating costs
- older coal fired units have recovered their capital costs, such that when the wholesale price is above their operating costs, they enjoy material returns
- there are high site remediation costs
- there is a first mover disadvantage, as shutting a plant could lead to slightly higher wholesale prices, which benefit all the remaining units
- there has been significant uncertainty regarding climate and energy policy, which has stifled new investment in renewables, resulting in insufficient pressure on older generating units to close

These barriers to exit mean that while some old coal fired power plants will close, such as Northern in South Australia and Hazelwood in Victoria, those remaining are unlikely to do so at the rate necessary to enable Australia to meet its international commitments. For example, their closure is expected to raise the wholesale power price, increasing the commercial viability of all remaining power plants. This is corroborated in AGL's GHG policy, which states that it will not be until around 2050 that AGL will close all its existing coal-fired power stations.[18]

What exists here is what economists refer to as an externality, where those who incur the costs do not enjoy all of the benefits and those who enjoy the benefits do not incur all of the costs. In this case owners of power plants bear the cost of closure but do not experience the benefits and those who benefit from lower emissions do not pay the cost of the closure of the plants.

Externalities often lead to sub-optimal outcomes, as there can be either too:

- much of the undesirable outcomes, such as pollution, when those who benefit do not pay all of the costs
- little of the desirable outcomes, such as public health and education as well as research and development, as those who benefit do not pay all of the costs

Economic theory suggests that there should be some form of Government intervention to resolve this issue and lead to an optimal outcome.

Given that coal fired power in WA appears to have the lowest cost at present, it represents the first merit order for dispatch to the network. However, in addition to Government regulations constraining coal generation, a shift in market conditions has contributed to the closure of some units. An analysis of the US power market indicates that the margins for coal-fired units have been squeezed through a combination of an increase in the cost of coal and lower gas prices leading to lower wholesale electricity prices.

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[17] See Jotzo F & Mazouz S, *Brown coal exit: a market mechanism for regulated closure of highly emissions intensive power stations* and Nelson T, Reid C & McNeill J, *Energy-only markets and renewable energy targets: Complementary policy or policy collision?*

[18] See https://www.agl.com.au/~/media/AGL/About%20AGL/Documents/Media%20Center/Corporate%20Governance%20Policies%20Charter/1704015_GHG_Policy_Final.pdf

Tierney[19] compared the 2007 and 2010 merit orders in the Pennsylvania-New Jersey-Maryland (PJM) market[20], and found that the difference between coal costs and gas costs narrowed, reducing the market competitiveness of coal.

While gas may be pushing coal out in the US, renewables appear to be doing likewise in Germany and potentially South Australia. German energy majors Eon and RWE began suffering losses recently, Eon in 2014 and 2015[21], while RWE suffered its first loss since 1949 in 2013[22] and another loss in 2015[23].

Renewable generation has increased dramatically in Germany in recent years, from 6% in 2000 to 31.6% in 2015[24] resulting in a decline in the wholesale power price and squeezing the margins the coal fired generators receive for their power. Recent reports indicate that the difference between the wholesale price and the operating cost for coal units, referred to as the *dark spread*, has fallen to a third of the five-year average for this time of year, raising the likelihood of further closures[25].

Traditionally, the Australian Energy Market Operator (AEMO) has forecast maximum electricity demand to ensure that sufficient capacity is made available. However, the take up of rooftop solar PV is reducing the level of demand during the day time, meaning less conventional generation is required during these periods. To better understand this issue, AEMO has started forecasting minimum demand, and Figure 6 shows the most recent minimum demand projection for South Australia.

[19] Tierney S, Why Coal Plants Retire: Power Market Fundamentals as of 2012

[20] See www.analysisgroup.com/uploadedfiles/content/news_and_events/news/2012_tierney_whycoalplantsretire.pdf

[21] See http://www.rte.ie/news/business/2016/0309/773585-e-on-results/

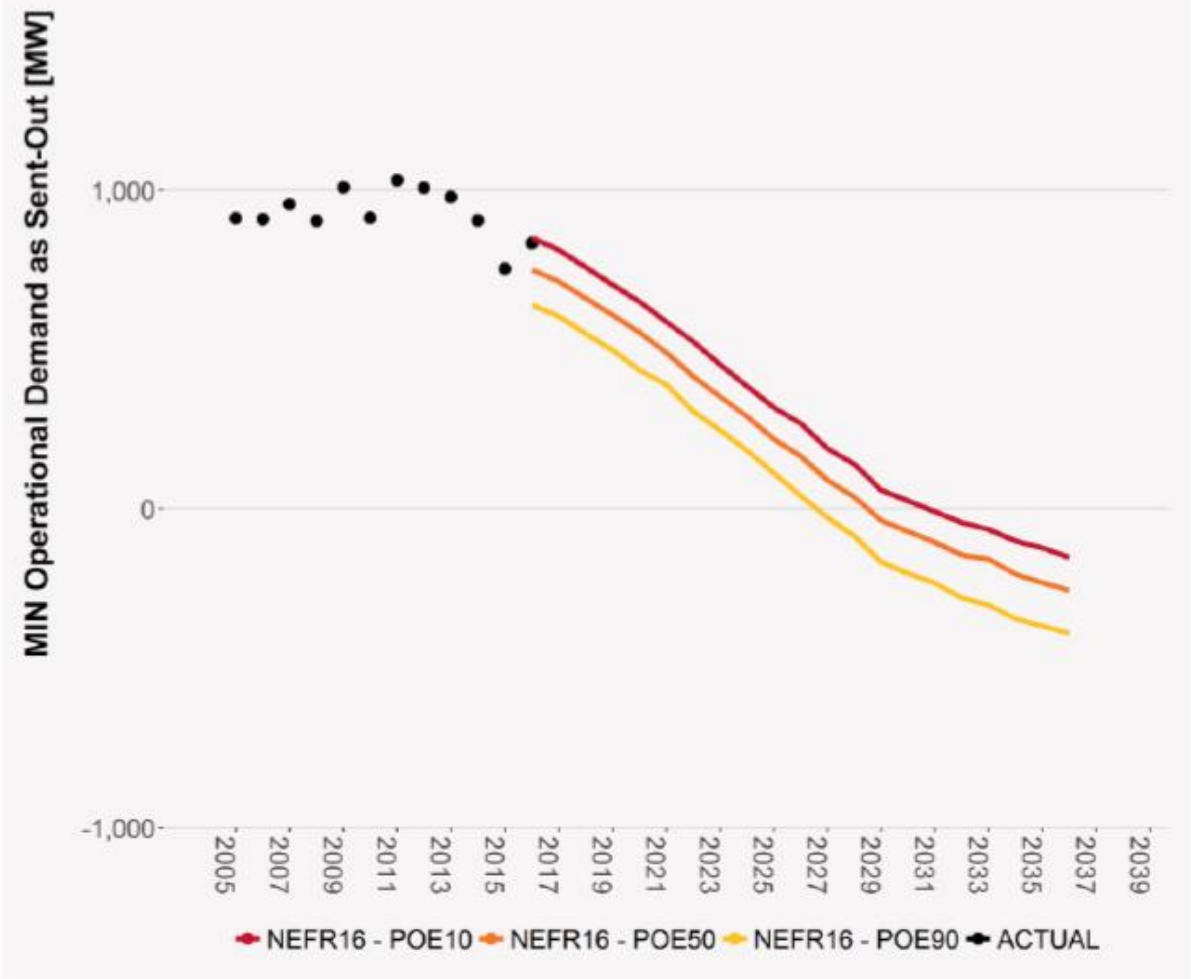
[22] See http://www.bloomberg.com/news/articles/2014-03-04/rwe-reports-first-loss-in-more-than-60-years

[23] See www.rwe.com/web/cms/mediablob/en/2974774/data/0/7/RWE-Annual-Report-2015.pdf

[24] See www.bmwi.de/EN/Topics/Energy/Renewable-Energy/renewable-energy-at-a-glance.html

[25] See www.bloomberg.com/news/articles/2016-09-30/more-german-coal-plants-face-early-retirement-as-profit-dwindles

Figure 6: Forecast minimum demand for South Australia



Source: AEMO 2016 National Electricity Forecasting Report

Figure 6 shows that AEMO expect that by 2027 there could be times of the day when there is more output from solar PV than load drawn from the grid, which effectively means that demand becomes negative in which this excess is exported to the other states. However, such a situation will prove difficult for inflexible plant, such as old coal fired units, that take time to ramp up and down. This suggests it will become difficult for plants that are suited to providing constant base load power to remain commercially viable.

From an economics perspective, if coal is removed from the dispatch merit order, there will be a corresponding increase in wholesale electricity prices *unless* economically competitive renewable energy is introduced in synchronous timing with coal fired generation retirement. This is consistent with SEN's modelling and our proposal for a Renewable Energy Transition Plan.

In addition to the economic incentive to retire coal-fired generation, the emissions and efficiency of these plants is arguably more important. CO_2 Emissions from coal fired plants is approximately *double* that of combined cycle gas turbine (CCGT) plants. In addition, coal plants emit other undesirable chemicals such as NOx, SOx and heavy metals.

3c(iii) the increasing amount of electricity generated by renewable energy and likely future electricity demand

This Term of Reference was addressed in detail in Section 3b. In summary, under the SEN modelling of the SWIS, up to 85% Renewable Energy can be installed with little or no effect on the LCOE, and without needing to install new gas generation capacity. Renewable Energy can supply any amount of demand with adequate back-up through rapid response Open-Cycle Gas Turbines and energy storage mechanisms.

Over recent years, electricity demand has been decreasing, with demand in the National Electricity Market declining or remaining flat for six consecutive years to 30 June 2015[26]. However, SEN's modelling is based on IMOWA's assumptions of increasing demand. Future demand and peak power management will be significantly affected by power efficiency gains, time-shifting, electric vehicles and electrified transport, and fuel-shifting from gas to electrical appliances. It will be difficult to predict whether demand will increase or decrease because of the competing nature of some of these factors.

3c(iv) maintenance of electricity supply, affordability and security

SEN believes that the key to an integrated, stable and optimal RE powered electricity grid is to plan and coordinate a transition to RE with an economic and complementary mix of generation and storage, supporting transmission infrastructure and environment in which innovative business models can develop.

The current SWIS generating system has a large amount of surplus generating capacity that is usually idle and in reserve in case of failure of one of the few large, more than 300 MW, generating units. This excess capacity incurs significant costs and SEN's modelling identified an optimal mix of RE generation and plant locations that minimise LCOE while providing grid security.

This surplus capacity is also used to provide for peak demand which occurs for very brief periods (hours) over the year. More efficient options for addressing periods of peak demand include embedding storage in the grid, migrating to "time of use" (real time) tariffs and smart metering and appliances, as well as greater use of demand side management

Microgrids are another, emerging approach to provide grid stability. Microgrids are usually connected to the overall grid but can disconnect if necessary and operate independently. They typically integrate some form of storage, demand management and distributed generation that enable them to deliver stable service to both the microgrid and larger grid as well as reduce losses.

The use of storage assists including renewable generation and reducing the need for spinning reserve required to respond to sudden changes in demand. Microgrids are often associated with fringe areas of a major grid, such as in mining sites, remote communities and farming areas, for example microgrids are being trialled in a variety of locations in Western Australia near

[26] https://www.aer.gov.au/wholesale-markets/wholesale-statistics/national-electricity-market-electricity-consumption
and
https://www.aer.gov.au/system/files/State%20of%20the%20energy%20market%202015%20%28A4%20format%29%20%E2%80%93%20last%20updated%204%20February%202016.pdf

Ravensthorpe to replace infrastructure destroyed in bush fires in late 2015, Onslow, Garden Island and Kalbarri.[27]

However, there are also opportunities to deployment in urban settings, and one is being trialled in the new northern Perth suburb of Alkimos. There is significant potential for new developments and re-development projects to deploy microgrids that integrate renewable generation and storage facilities[28].

In addition to the new technical solutions to constructing a renewables based electric system:

- There are a growing number of innovative technologies and business models that can enhance grid stability as well as assist decarbonising the electricity sector. These include: behind the metre storage, which enable end users to retain and use the power their distributed energy resources generate and in combination with time of use tariffs re-charge their batteries in periods of low demand/price and draw on this electricity in times of high demand/price
- *peer-2-peer* trading, enabling end users with distributed energy resources to trade between each other
- demand side management, where end users can be treated as an effective supplier through being paid to shed load during high demand periods
- third party storage providers who can help shift demand through time of day arbitrage as well as provide ancillary services such as balancing and frequency support

The recent shutdown of the South Australian grid during a storm event, which was inaccurately blamed on wind power, was related much more to the severe damage done to the transmission infrastructure and protection settings on generating assets than the variability of wind power.[29]

The recent storm damage in Florida and subsequent power loss to over 1 million households, where only 2.1% of the generation is from RE, illustrates that regardless of the form of generation, it is susceptible to shut down or fail during extreme weather events.

Forecasting wind and solar is increasingly accurate. The Australian Wind Energy Forecasting System (AWEFS) provides accurate forecasts of wind generation on the NEM grid at 5 minute intervals, 5 minutes in advance for individual wind farms and NEM regions. This accuracy of short term forecasting has proven in practice world-wide to allow adequate time for dispatch of stored or fuelled energy to compensate for falling RE generation. Cloud-predictive technology is also coming online. These factors contribute to more responsive demand management.

The year used the year used in the SEN modelling and scenario comparisons was 2014. Variability in weather conditions in 2014 did not impact of energy security, with the OCGTs providing adequate power during the worst wind/solar low periods.

[27] http://arena.gov.au/project/solar-and-storage-trial-at-alkimos-beach-residential-development/, www.energycouncil.com.au/analysis/going-off-grid-goes-west/ and http://sciencewa.net.au/topics/energy/item/4146-going-off-grid-easier-with-friends

[28] www.theurbandeveloper.com/micro-grids-give-new-meaning-community-empowerment/

[29] www.aemo.com.au/Media-Centre/-/media/BE174B1732CB4B3ABB74BD507664B270.ashx and www.aemo.com.au/Media-Centre/Update-to-report-into-SA-state-wide-power-outage

The effect of variability in wind and solar resources between years was another consideration. To test this, a typical RE scenario including 6,000 MW of wind and 3,000 MW of solar PV capacity was modelled for 6 years using SIREN's hourly wind and solar data. Data for 2007to 2011 and 2013 was modelled against actual load (IMOWA 2015) for those years, scaled up so that total energy demand for the year equalled total demand in 2014. The result was that renewables and 15% OCGT output met demand in all cases.

A risk analysis in the CEWA 2030 report showed that fuelled generation dominant scenarios modelled (coal/gas and nuclear/gas) carry much higher risks than any of the RE Scenarios. Nuclear had the highest risk profile, particularly in terms of safety and environment (radioactive waste), cost overruns and long project schedules and overruns particularly in recent experience. Coal and gas carry high environmental (carbon pollution) risks and are susceptible to fuel availability and price fluctuations.

A commonly-stated alternative of moving to 100% gas fuelled generation would achieve less than a 30% reduction in CO2 emissions, and be cost equivalent to renewables according to SEN modelling noted above, and which also shows that, in WA, no new gas generation capacity is needed.

Policy implications

It would be beneficial for the grid operator to be able to encourage/incentivise the installation of: energy storage (batteries or other), smart meters (with bi-directional power and control capabilities) and smart appliances, with incentive costs offset by the lower costs realised by reducing peak infrastructure costs.

As the SWIS grid is a monopoly infrastructure, it is critical that it is planned and operated in a way which benefits all users, which is a role more typical of government.

Benefits of Public ownership of critical monopolistic infrastructure:

- Public ownership of some generation assets will make it easier to offer cheaper electricity to industry and households
- Retailer access to a public network can be planned and controlled for the benefit of grid stability, security and sufficiency
- From a technical balance aspect, public ownership should be more transparent and secure
- Private ownership may compromise the network and blame may be placed upon RE for failures
- Scrutiny of network-related matters is more transparent if publicly owned

Since the WA government has substantial stakes in a large portion of coal generation assets, it would seem appropriate that the WA government would be the most appropriate entity to take action to retire coal-fired power stations.

3c(v) any other relevant matters

The preceding discussion indicate that both Government policy and market conditions can result in the closure of coal-fired units. In their discussion of this topic, Nelson et al. highlight the importance of a stable and efficient mechanism to encourage renewable generation to replace any exiting coal as well as the three types of Government measures aimed at closing coal-units, shown in Table 5.

Table 5: Types of policy instruments for facilitating phasing out of coal fired units

Policy instrument	Description	Bearer of costs
Government funding	Governments may pay generators to either close or reduce the level of operation of old GHG intensive units	Taxpayers
Market based solution	A levy is used to fund the closure of old GHG intensive units	End users directly through the levy and possibly indirectly through higher wholesale prices due to less low cost capacity being available
Direct regulation	The Government imposes regulations, say emission standards, that result in the closure of non-compliant units	Possibly end users indirectly through higher wholesale prices due to less low cost capacity being available

Source: Nelson T, Reid C & McNeill J, *Energy-only markets and renewable energy targets: Complementary policy or policy collision?*, Economic Analysis and Policy, 46, 25-42, 2015

In November 2015 Jotzo and Mazouz proposed a market mechanism in which aging generators could bid in a declining auction to determine the lowest payment necessary to overcome the barriers to exit, after which the *winning* generator would close the relevant units and receive payment from the other generators raised through a levy and slightly higher wholesale prices.[30] While this is an interesting proposal and may be successful in retiring initial coal units, there may be challenges in continuing this process to substantially decarbonise Australia's generating fleet within a timeframe necessary to meet the international commitments made in Paris. Specifically, as more units are retired, the market power of the remaining units to manipulate or take advantage of both the auction process and the wholesale power market will be increased.

It is therefore important to have the appropriate policy settings to ensure the transition occurs and meets the objectives of cost, security of supply and that the lowest possible emission levels are achieved.

While it is possible to recommend relevant policy settings to encourage retirement of coal-fired units, this is compromised by the 'commercial in-confidence' nature of such matters as:

- Power purchase agreements
- Gas and Coal purchase agreements
- Termination clauses
- Legislation or long term contracts protecting generator operating companies

3d Policy mechanisms to give effect to a just transition for affected workers and communities likely impacted by generator closures

3d(i) mechanisms to ensure minimal community and individual impact from closures

Section b) outlined a proposed replacement of four coal-fired power stations in Collie, and their replacement by 1,000 – 1,400 MW of Wind and 200 MW of utility scale PV.

[30] See Jotzo F & Mazouz S, *Brown coal exit: a market mechanism for regulated closure of highly emissions intensive power stations*, CCEP Working Paper 1510, November 2015

The livelihood of communities presently relying on coal fired generation can be maintained and potentially improved in the transition to a Renewable Energy SWIS by taking opportunities to utilise a high local-content of labour and resources utilised in the Renewable Energy industries.

An estimate of the relative jobs 'intensity' of renewables vs fossil fuelled generation is shown in the table below. Renewables generate 2-7 times the number of long-term jobs (25+ years) in Operations and Maintenance compared to coal or gas.

Table 6: Employment indicators by generation type

	Construction/ Installation Job years/MW	Manufacturing Job years/MW	Operations & Maintenance Jobs/ MW
Coal	11.2	5.4	0.14
Gas	1.3	0.93	0.14
Biomass	14	2.9	1.5
Wind	3.2	4.7	0.3
PV	13	6.7	0.7

Source: *Energy Revolution: A Sustainable World Energy Outlook 2015*. Greenpeace International

Policy settings can improve jobs transition through:-

- Diversification of economies by attracting new sources of job-creating investment
- Creation of jobs in new or existing industries resulting from diversification,
- New industries related to the RE economy: wind turbine generator towers, solar installers, biomass agriculture and related transport industries, battery or solar PV manufacturing
- Providing a range of workforce services and skills training, including work-based learning opportunities, resulting in industry-recognized credentials for high quality, in demand jobs.

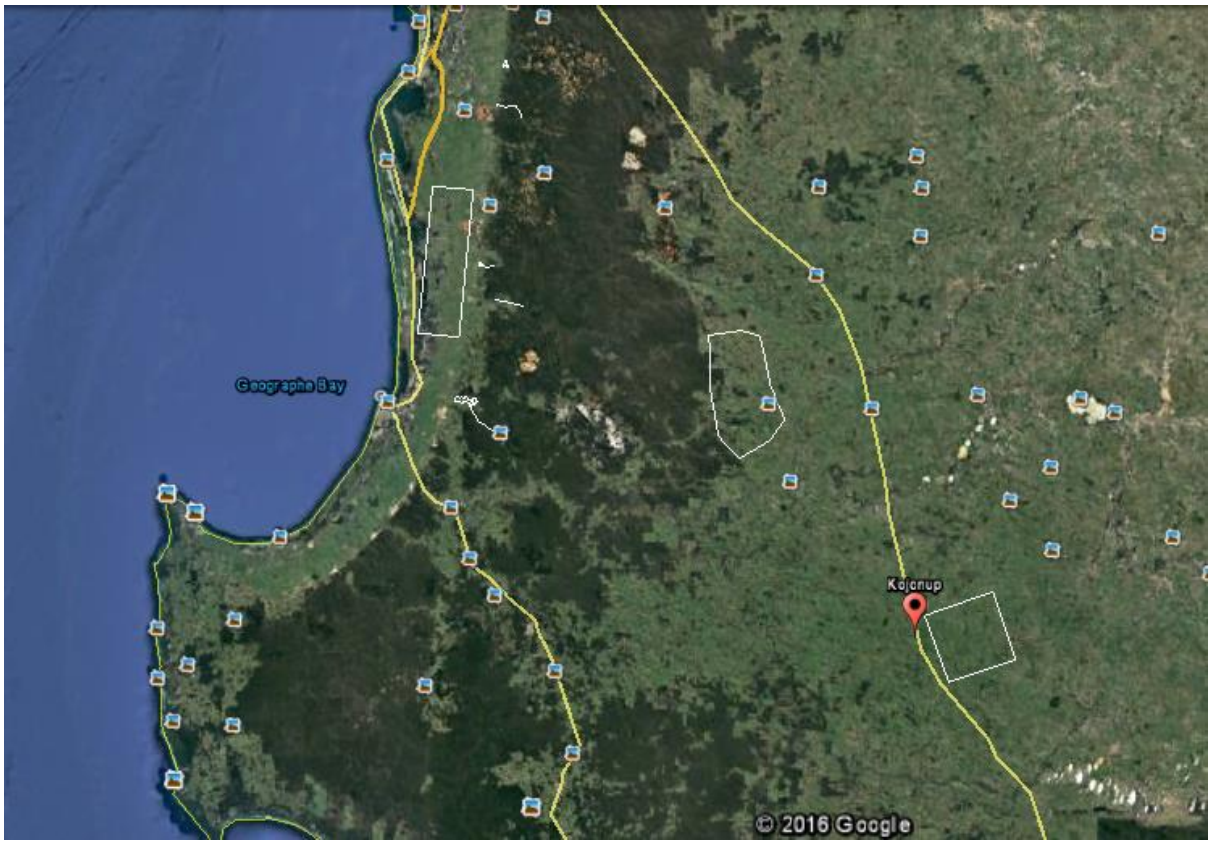
3d(ii) mechanisms to attract new investment and jobs in affected regions and communities

The following sections outline the opportunities for Collie and similarly-affected regions within the state. These are practical solutions, which need to be backed up by policy and government action.

Wind and solar plant installation, operation and maintenance

SEN modelling of 1,000-1,400MW of wind turbines and 200MW of solar PV utility-scale generation could be utilised within the Collie locality, creating a corresponding number of permanent jobs for the community, plus initial construction employment and other supporting roles for the local community.

Higher agricultural land east of Collie and Kojonup and coastal plain west of Harvey; 1500 MW of wind would easily fit in the three areas outlined in white on the map below.



Wind turbine and solar plant manufacturing

Local manufacturing opportunities exist for utility-scale wind turbine and solar plant component manufacture such as wind turbine pylons and blades, and solar panel support structures.

Manufacturing of solar PV panels is potentially competitive given WA's local mineral sands resources and that the highly-automated process of their manufacture means that labour costs are a relatively small component of their cost.

Mineral sands, Lithium mining

WA's mineral sands and Lithium resources are valuable inputs to the manufacture of solar PV panels and Lithium batteries needed to supply the rapidly growing global demand for stationary energy storage and electric vehicles.

Skill sets of coal mining and plant operation can be transferred to mining of these resources to provide employment opportunities in the area.

Biomass Power and Pellet Industry (sustainably cultivated):

Plantation timber waste, Oil Mallee and wheat stubble are local resources which can be used in biomass combustion plants or made into biofuel to run gas turbines for dispatchable electrical power during periods of low solar and wind activity.

Verve Energy's Integrated Wood Processing (IWP) 1MW biomass generation demonstration plant in Narrogin showed the potential for Oil Mallee (grown in windrows "Mallee Alleys" on wheatbelt farms) to be used for electricity generation, as well as other resulting products and benefits including; Eucalyptus oil (as industrial solvent), biochar (for activated carbon filtration) and potential to reduce groundwater salinity to enhance agricultural productivity.

Verve Energy's Integrated Wood Processing 1MW demonstration plant.

Oil Mallee trees grown in the in the southern agricultural region (with rainfall of 400- 600 mm) do not require supplemental water and would produce a reliable cash crop for farmers. To capture these biomass resources, rail transport to/from Wagin and Katanning could be utilised.

"Oil Mallee Alleys"

Wood waste (pine and blue gum plantations)

Apart from an initial construction phase of plant and support infrastructure, the biomass agricultural industry would offer a significant number of permanent jobs over the life of the plant (25-30 years).

A vision for Collie's involvement in the biomass industry is illustrated in Table 7 below.

Table 7: Potential vision for Collie biomass industry

Time period	Objective
2017 – 2025	Establish and expand mallee woodchip production on farms in the Great Southern region resulting in: • Hundreds of jobs growing harvesting and transporting woodchips • 120 km railway to Wagin / Narrogin – $360 m project • Construction and maintenance jobs based in Collie
2020-2022	Construct 400 MW biomass generator with molten salt storage (MS) at Collie resulting in: • 150 permanent jobs (ref: 50 MW biomass plant in Vermont employs 40) • 8,000 job-years in construction and manufacturing
2021-2025	Establish wood pellet manufacturing plant in Collie and export from Bunbury port

Ref: 85,000 tpa plant in NY State employs 16; another 100 in wood supply and support industries. $10 million in payroll, wood purchase and other expenditures annually. *http://biomassmagazine.com/articles/5579/production-begins-at-largest-wood-pellet-plant-in-northeast-u-s*

Pumped hydro storage construction, operation and maintenance

Part of the energy storage modelled in SEN's CEWA report includes the use of pumped-hydroelectricity (PHS). Relevant PHS examples are 'dam-to-dam' (Snowy Scheme), or 'cliff-ocean' (such as in Okinawa). PHS could be constructed at dams in the south-west of WA, such as at Wellington dam. Significant construction jobs and long-term plant operations employment would result.

Tourism & hospitality

Collie is a unique and beautiful area and has significant appeal for tourism, which it appears has not been developed. However, an effort to invigorate tourism to this area could provide a significant livelihood for the area and people.

3d(iii) State Policy Initiatives

Specific to Western Australia and resulting from SEN's modelling focus, are the following suggested policies which would assist in the rapid and steady growth of the renewable industry and livelihood of the local coal-affected economy and society, as well as for the state itself:

- Balancing generators (OCGT, biomass and grid storage) should all be owned by Govt. (Synergy) to prevent price gouging during shortfall periods by corporate power providers.
- Secure gas supply agreements and pipeline capacity to cover peak gas demand for electricity generation.
- Set up an Office of Renewable Energy answering directly to Dept. of Premier and Cabinet to plan RE transition, with Western Power and Synergy.
- Supply tariff and feed-in tariff incentives for behind the meter battery storage and rooftop solar.
- Reform electricity market - power purchase agreements with 'contracts for difference' enabling private industry to supply all wind, solar PV and solar CST generation at stable prices.
- Encourage the combined application of 'time of use' (ToU) tariffs, smart meters and smart appliances to assist in balancing supply as well as reducing overall electricity costs by load-shifting and peak demand reduction.
- Introduce incentives and assistance for sustainable-biomass production and renewable fuel industries.

- Legislate to ensure biomass for energy is harvested from plantation and other sustainable sources, not native forest.
- Initiate approvals for potential renewable energy and storage (ie. pumped-hydroelectric) development zones.

3e The appropriate role for the Federal Government

Change in the electricity generation and supply market is inevitable. The information presented in this submission, and in other reports (BZE, CEC, ACF/ACTU, Greens 2029), indicates that, over a 15 year time scale, renewable energy is currently cost competitive with fossil fuel energy sources, in LCoE terms. Ongoing technological advances and economies of scale will make renewable energy more and more economical, with minimal ongoing fuel costs.

SEN's analysis shows that a transition to renewable energy is economically justifiable, while also reducing carbon emissions and enabling Australia to meet and exceed its carbon pollution reduction targets.

> *Recommendation: Establish a timeframe for the decarbonisation of Australia's generating fleet that is consistent with the objectives of the Paris Agreement and so enables Australia to remain within a carbon budget that is tighter than the 10.1 $GtCO_2$-e recommended by the Climate Change Authority from 2013 and 2050*
>
> *Recommendation: Prohibit the build of new coal-fired units*
>
> *Recommendation: Limit construction of new gas plant to only that needed to support a high-penetration RE supplied grid, and to have dual-fuel capability to enable the use of biofuels if/when available.*

It is important that policy is not an impediment to this transition. However, many factors will impact on the broad uptake of renewables (e.g. advances in technologies, technologies which become market leaders through outperforming others, reduced demand through energy efficiency measures, increased demand from electric vehicle uptake, etc.). Most forms of disruptive technologies regardless of the industry result in cost savings. It is almost universal that the largest contribution to change is driven by economics. To keep up with disruptive technologies, policies must be forward looking, flexible and responsive, and monitored on an ongoing basis.

Both the Federal and State Governments have a role to play in a transition away from fossil-fuelled power generation, due to the likely impact on employment in the sector, with flow-on effects on the communities where these workers live, as is occurring in the Latrobe Valley. Continuing with 'business as usual', or leaving the change to the 'market' is likely to cause severe 'shocks' to communities, and cause political damage to the government of the day.

The measures outlined in sections 2b) & 2c), based on SEN's modelling and research, provide a roadmap to transition the Collie community away from coal mining and electricity production, while also increasing employment in construction, manufacturing, operations and maintenance. Some retraining will be needed, but within similar trade groupings. There are also economic opportunities for other regional centres, for example in oil mallee growing, processing and power industry

A Renewable Energy Industry Plan

This submission argues that it is currently, and completely, feasible to transition away from fossil-fuelled electricity generation towards a renewable energy generation future, starting with simple steps using commercially mature technologies.

The Federal Government must recognise this and establish a policy environment which will guide the transition to renewables.

> *Recommendation: Develop a Renewable Energy Industry Plan that fosters a positive investment climate for investors in renewable generation, including outlining long term objectives, targets and measures without the need for regular reviews that undermine investor confidence*
>
> *Recommendation: The Renewable Energy Industry Plan should select from a range of options that support that rapid deployment of renewable generation, storage facilities and energy efficiency after taking account of:*
>
> - *recent innovations in funding renewables, such as reverse auctions used in a variety of jurisdictions including the Australian Capital Territory, and climate bonds*
> - *prospects for revising electricity market rules that take account of the need for low marginal cost generators to recover their capital costs and the importance of valuing flexible options that enhance grid stability and provide balancing and other ancillary services*
> - *the need to identify and remove barriers to entry and innovation in providing a cost efficient robust electricity system with a high penetration of renewables, considering options for storage providers and trading power between distributed generation sources*

The following paragraphs build on the arguments presented earlier, and present a number of policy initiatives.

Disincentives

Any policy environment needs to provide disincentives for business to continue as usual, such as implementing an emissions trading scheme and phasing out fossil fuel subsidies. A further disincentive, as used during the Gillard government was to penalise generators not meeting minimum levels of emissions reduction, or to require them to purchase Renewable Energy Certificates (RECs)/LGCs to meet their obligations, and using the proceeds to incentivise renewables and compensate disadvantaged people or sectors. Ramping the limits increasingly over time should be considered.

> *Recommendation: Rapidly phase out fossil fuel incentives and subsidies*
>
> *Recommendation: Provide disincentives for business to continue as usual through low cost mechanisms that:*

- *force the retirement of the existing coal fleet, such as declining emission standards*
- *provide adequate notice to operators of how this mechanism will be implemented*
- *do not enable companies with unique information to derive unintended advantage, or **game** the system*

Energy Security

Renewable energy provides a high degree of energy security so a high-penetration of renewables provides significant benefits. When complemented with various forms of storage and rapid response backup generation capability, a reliable supply can be assured.

> *Recommendation: Ensure ongoing energy security through cost effective options including rapid response backup generation capability, storage and demand side management*

Innovation

Global markets are moving rapidly toward renewable energy and associated innovative enabling technologies. Australia has a history of developing world-leading technologies, including solar photovoltaics, wave energy and others. For Australia to remain competitive means that continued development of new technologies, and installation of commercially available technologies en masse to continue to drive down technology costs will give Australia a distinct advantage.

> *Recommendation: Promote and fund ongoing innovation to encourage particular technologies and market sectors through bodies such as ARENA and the CEFC, in order to bring Australian clean technology innovation right through to full commercial deployment and ready for export*

Regulation

The use of regulation to shape and guide the transition to a de-carbonised economy will help to ensure that a reliable, secure electricity supply will result. Within the regulation structure, private enterprise can be enabled to develop/operate in ways to minimise costs.

> *Recommendation: Remove regulatory barriers to uptake of renewable energy and energy storage in the commercial and household sectors*

> *Recommendation: Investigate and support innovative 'time of use' electricity tariffs to balance peaks and troughs in demand.*

> *Recommendation: Require residential, commercial and industrial developments to undertake a feasibility study into deploying a microgrid that incorporates renewable generation and storage*

Social Benefits

RE offers the potential of local benefits to most consumers in the form of reduction and limitation of electricity costs, as well as reduced health issues in areas affected by current fossil fuelled generation pollution. Following are some considerations:

Recommendation: Subsidise installation of solar PV in social housing as a matter of equity

Recommendation: Provide certainty to the public and business through a long term transition plan, which is responsive enough to adapt to changing circumstances

Workforce development

- A just transition to a clean energy future must include a for alternative employment, and to assist in this are the following suggestions:

- *identify regions and communities that may be adversely impacted through the transformation of the energy sector that includes the retirement of coal-fired units*

- *design and co-ordinate adjustment programs that identify appropriate long term sustainable goals in those regions and communities, and put in place strategies and measures for achieving those goals including retraining opportunities for affected workers*

- *liaise with relevant state and local governments, businesses, education facilities, and community groups*

3f Other relevant matters

The following items are ancillary to retirement of coal but important to ensure good outcomes economically and environmentally:

- Renewable Energy being pollution free means that there is no need to pay fossil-fuelled generators to reduce carbon emissions, or pay for other forms of carbon abatement.
- Costs of additional transmission infrastructure to support RE are insignificant in comparison to the wholesale costs of electricity.
- SEN does not support the use of 'unconventional gas' from fracturing, due to the issues with fugitive emissions of methane, and other effects on water and land[31].

[31] Ref: https://www.epa.gov/sites/production/files/2015-06/documents/final_nepa_fact_sheet_6_03_508_km_0.pdf and https://www.thenation.com/article/global-warming-terrifying-new-chemistry/

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