Submission to DWER on draft Policy on Climate Change in Western Australia

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About SEN

SEN (Sustainable Energy Now Inc.) is a non-profit association advocating for the utilization of sustainable energy sources within Western Australia. SEN brings together a mix of multidisciplinary knowledge and capability, providing impartial advice on renewable energy.

SEN's working teams consist of volunteers whose professional backgrounds include science, business, education and the environment. The teams have committed thousands of hours to developing evidence-based solutions towards transitioning WA's energy use from fossil fuels to renewables for the good of humanity, the economy and the environment, as a way for WA to play its part in the global transition to a more sustainable future.

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Introduction

The State government's decision to develop a climate policy is welcomed by SEN. The challenges facing the state from climate change are immense and demand a clear policy response.

In a time when human activity is causing the release of substantial volumes of greenhouse gases (GHGs) into the atmosphere, the consequences of those actions are becoming daily more evident.

The pre-industrial concentration of CO_2 in the atmosphere was 280ppm (temperaturerecord.org). The current concentration of CO_2 in the atmosphere is 410 ppm and the current global emissions trajectory will create warming of 3-4 degrees C, where a maximum of 1.5 degrees C was considered by the Paris climate agreement to be the upper limit for a relatively 'safe' climate, even though Climate Science warns of loss and damages with potentials to reach points of no return in climate and oceanic systems.

The implications of this global warming has been acknowledged by the Premier:

> *"The science of anthropogenic climate change has effectively been settled for two decades, and no serious government can ignore the policy implications."* - ***Premier Mark McGowan*** *12 Feb 2019*

Minister Johnston's media release about the State Climate Policy *"supports the Federal Government's target of reducing emissions by 28 per cent by 2030"*, and sets an aspiration of net zero greenhouse gas emissions by 2050.

SEN sees these targets as an important first step, but argues that much more is needed than is currently proposed. SEN will be advocating that the Policy commitment is deepened from the time it is published.

SEN's submission is based around the targets set by the Federal government. There is strong legal opinion to say that the state must legislate to achieve the 28% target within WA, given the commitments entered into on WA's behalf by the federal government.

The government has operated within the limits imposed on it by the economic and political situation of the times, reinforced by the fossil fuel lobby. However, that situation will change dramatically in the next few years, as the impact of climate change becomes increasingly evident.

SEN asserts that the concept of what is economically viable will change – what is now considered too expensive will soon be considered more than an acceptable price to pay to limit global temperature rise. It also must be considered against the fact that it is cheaper to take strong and rapid action to address the problem now, than to defer action.

In particular, the fossil fuel industry will need to include a price on their emissions in their business models (including paying to have their emissions removed and stored), or lose their social licence to operate.

SEN will argue that there is a large gap in the Climate Policy Consultation document. The Introduction acknowledges that *"WA contributes 17% of Australia's greenhouse gas emissions"*, but this is not explicitly addressed in the bulk of the consultation document. It is very clear that GHG emissions from the resources industry, particularly gas (LNG and 'unconventional'), need to be addressed.

In terms of meeting national greenhouse gas emission targets, electricity generation is one of three 'low-hanging fruit'. The others are electrification of transport and

energy efficiency. With appropriate policy settings, and relatively low investment, governments can make fast inroads into reducing GHG emissions.

However, other sectors should not be ignored, or have lower priority. Reductions need to be quickly made across the board in order to limit dangerous global warming. Actions across all sectors of the economy, from energy to transport, agriculture, and construction and manufacturing are needed.

SEN agrees with the consultation document that *"we have genuine opportunities to transform the way we live, how we commute and how our business and industries operate"* and our submission provides indications of many of the actions needed to be included in the Policy.

Where SEN lacks the expertise to comment, the submission references sources that can provide recommendations.

As we work to meet the challenge of climate change, SEN encourages the government to call the players together, to seek to find the solutions in a cooperative and united approach to overcoming the social and technological barriers for solutions.

The Climate Policy is a welcome first step of what must be an ongoing dynamic response to the challenge. SEN is looking forward to continuing making its contribution to the development of the Policy, not just on this occasion, but as the Policy and the strategy continues to evolve in the coming years.

The Challenge of Climate Change to Western Australia

SEN's climate change position is founded on the science of climate change, which shows:

- World average temperatures are warming continually;
- The warming is predominantly caused by anthropomorphic emissions of greenhouse gases (GHGs); mainly CO_2 and methane;
- For temperatures to cease rising, emissions of these gases must be reduced to the minimum possible, and then the remaining emissions must be balanced with the extraction or absorption of equivalent volumes of GHGs from the atmosphere (Net Zero Emissions); and
- Achieving Net Zero Emissions in itself will not limit global warming until a new climate equilibrium is established (if at all), with many processes in the climate system already deteriorating, there's considerable uncertainty and risk around these long-term feedbacks; and
- There will be a need to extract more GHGs than will be emitted so as to draw down the concentrations of the gases (namely CO_2 but potentially methane) in the atmosphere to pre-industrial levels.
- Subsequent extraction of GHGs from the atmosphere is not equivalent to mitigation of future emissions, damage to the climate occurs the longer anthropogenic GHG emissions remain in the atmosphere.

Whilst there is a degree of scientific consensus on these points, there is considerable concern that the rate of warming and the complex interactions that occur in the environment may mean the situation is far more dangerous than is currently predicted in global targets. As further research is carried out, more drastic action is likely to be needed to minimise the deleterious effects of climate change on humanity and terrestrial and marine ecosystems, all of which comprise our global life support systems.

In this submission, SEN has worked on the basis that the aim of the state government's climate change policy will be to support the federal government's Paris commitment of achieving a 26 to 28% reduction on 2005 emissions by 2030, and to aspiring to net zero emissions by 2050[1]. SEN has considered the implications of the targets and included actions that can contribute to achieving the outcomes sought.

While SEN understands the Western Australian government is not ruling out emissions reduction in other states contributing to achieving the reductions needed in Western Australian emissions, SEN has based its policy suggestions around achieving the targets in Western Australia. SEN also draws attention to the legal opinion in the CCWA Runaway Train report[2], that the Paris targets adopted by Australia must be reflected in Western Australian legislation, and must become binding on the state. Achieving the targets is therefore not optional.

The figures for 2017 show Western Australia contributed 16.7% of Australia's GHGs[3] so the task will be considerable, but, with leadership from the government, and cooperation and commitment from industry, particularly the oil and gas sector, and the community, it is achievable[4].

While the target of 26% to 28% is the focus of the government's approach and takes into account the political, economic and industrial issues of the current time it does not adequately reflect SEN's view of the serious and urgent nature of the action that needs to be undertaken. SEN advocates for the adoption of more ambitious targets and trajectory, consistent with Climate Science.

In this context, SEN is of the view there are two policy priorities for the government in addressing climate change:

- The first is reflected in the targets already set out; that is minimising emissions and achieving net zero.
- The second is the need to draw down additional GHGs from the atmosphere to reduce concentrations to pre-industrial levels. SEN understands this consultation is only framed to reach net zero but provides evidence here that more needs to be done to draw down additional GHGs from the atmosphere to achieve pre-industrial concentrations of CO_2. Discussion of the evidence supporting the need to return GHG concentrations to pre-industrial levels is contained in Appendix B.

SEN notes the actions needed to address the second policy priority are the same as the actions needed to minimise emissions and achieve net zero, so the second priority involves simply extending the actions beyond achieving net zero.

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[1] Media Statement Hon Bill Johnston MLA Minister for Mines and Petroleum; Energy; Industrial Relations: State Government details emissions policy for major projects Wednesday, 28 August 2019

[2] Conservation Council of WA and Clean State, *RUNAWAY TRAIN: The impact of WA's LNG industry on meeting our Paris targets and our national efforts to reduce emissions*. 2019.

[3] State and Territory Greenhouse Gas Inventories 2017 Department of Environment and Energy Australian Government June 2019. Page 3

[4] Reputex Energy, *Offsetting Emissions from Liquified Natural Gas Projects in Western Australia*. 2018, Available at https://www.cleanstate.org.au/wp-content/uploads/2018/11/REPUTEX-REPORT_Offsetting-LNG-emissions-in-Western-Australia.pdf.

As the government accepts the need to reach net zero emissions, the risks facing the economy from climate change are implicitly assumed. Further information on the risks can be found in these reports by Beyond Zero Emissions:

- "Carbon Crisis" https://bze.org.au/research/other/carbon-crisis-report/
- "Fossil Economy" https://bze.org.au/research/other/fossil-economy-report/
- "Laggard to Leader". (Ref BZE https://bze.org.au/research/other/laggard-to-leader/), which demonstrates opportunities to become a leader in decarbonising.

If minimal action is taken on climate change policy, there is a risk that major petrochemical and LNG projects could become stranded assets, and this is a major risk for the state economy.

Additional points of concern to SEN include:

- The Paris Agreement targets underestimate the extent of global warming the world faces given existing concentrations of GHGs in the atmosphere;
- Even so, the world is not on track to limit its emissions to the levels agreed in the Paris Climate Agreement;
- Australia is not on track to meet its current commitments under the Paris agreement;
- Western Australia is not on track to achieve the emission reduction targets, rather it is increasing emissions;
- Pollution from fossil fuels during extraction, processing and combustion cause problems other than warming, such as acidification of the oceans, contamination of water sources and health problems due to the particulates arising from the burning of carbon-based fuels; and
- Negative Emissions Technologies (NETs) will be required to address the crisis particularly given the demonstrated political barriers to rapid decarbonisation of our economy.

SEN advocates for:

- The rapid phasing out of the use of carbon-based fuels;
- The replacement of fossil-fuelled electricity with generation from renewables;
- The replacement of LNG exports with energy generated from renewables and exported either as electricity in cables or as hydrogen obtained from renewably-powered electrolysis (green hydrogen) perhaps in some modified form (for instance ammonia);
- The hierarchy of avoidance, minimisation and offsets (as established in the EPA GHG emissions guidelines discussion paper) being adopted to assess new development proposals;
- The adoption of the proposed EPA Guidelines on GHG pollution;
- The rapid development and installation of NETs (powered by renewable energy) in Western Australia to facilitate withdrawal of CO_2 and methane from the atmosphere in significant volumes. See below for further discussion; and
- The mitigation and extraction of methane from the atmosphere to begin as soon as possible[5].

[5] Methane has a Global Warming Potential (GWP) over 20 years (GWP20e) that is 86 times greater than CO_2. Extracting methane may have a significant immediate effect that will outweigh the warming effect of CO_2 in the short term, thus buying the world some time to establish CO_2 removal technologies at the scale required to impact on the temperature increases.

SEN notes there are significant opportunities for Western Australia to replace its carbon based energy export industries with non-carbon based energy carriers that derive their energy input from renewables, and to create new industries for the state, including carbon farming and to use its significant renewable energy resources to facilitate the drawdown and storage of CO_2.

Current and Future Emissions for Western Australia

Western Australia's GHG emissions have risen sharply in the last few years in contrast to the other states and territories, as shown in Figure 1. This is largely due to the large LNG production projects which started up in the state's Northwest (see Fig. 2), and if proposals for further production proceed, the state's emissions will climb much higher. The commencement of fracking activities in Western Australia may also substantially increase the volumes of gases being produced (see for instance the CCWA "Runaway Train" report[2]).

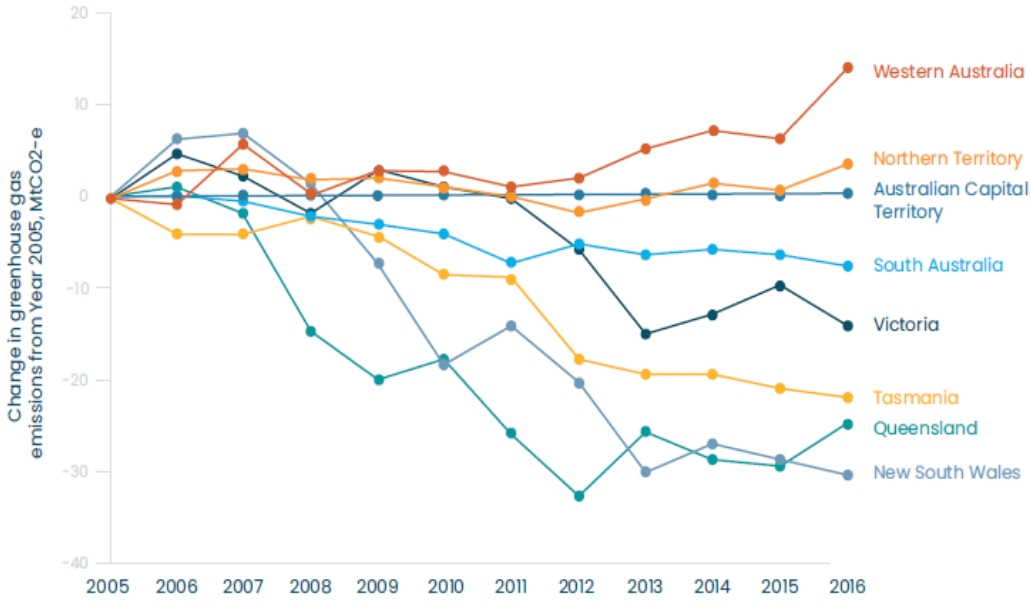

Figure 1. Greenhouse gas emissions by state. From the "CCWA Runaway Train Report 2019" Footnote 2.

Western Australia's annual emissions targets for 2030 and 2050 are significant. The latest figures[6] show Western Australia contributed 16.7% of Australia's GHGs in 2017 and emissions are projected to continue to grow due to further LNG developments proposed in Western Australia (see Fig. 2), and unconventional gas fracking.

[6] Department of Environment and Energy. *State and Territory Greenhouse Gas Inventories*. 2017 [cited 2019 3 December]; Available from: https://www.environment.gov.au/system/files/resources/917a98ab-85cd-45e4-ae7a-bcd1b914cfb2/files/state-territory-inventories-2017.pdf. Page 7.

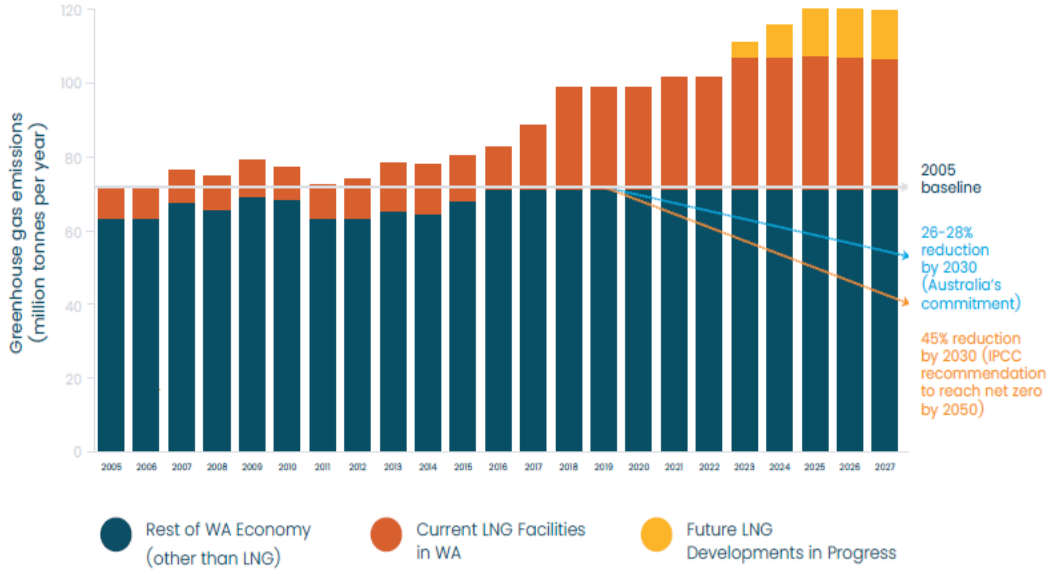

Fig 2: Trajectory of emissions in WA. From the "CCWA Runaway Train Report 2019" Footnote 2.

Table 1 breaks down the actual and projected emissions under various targets. Column 1 shows the categories of greenhouse sources and sinks. Columns 2 & 3 contain actual figures for 2005, and 2017[7]. These are 71.7 Mtpa CO_2e and 88 Mtpa CO_2e respectively. Column 4 shows the percentage change from 2005 to 2017.

Column 5 calculates the 2030 target, by multiplying the 2005 figures by the agreed Paris reduction (28%). This shows that total emissions by 2030 are required to decline to 51.6 Mtpa. Column 6 calculates the emissions reductions needed in each sector in comparison to the 2017 data (in the same ratio as for 2017). 35.4 Mtpa of total reductions are needed to move from the 2017 actual figure of 88.5 Mtpa to the 2030 target of 51.6 Mtpa.

These figures imply that total emissions should reduce by approximately 3.7 Mtpa CO_2e per year between 2020 and 2030 (based on 2017 emissions and assuming a linear trend, equating to a total reduction of 37 Mtpa).

SEN asserts that the trajectory of the reduction in emissions is critical, with an early reduction having much lower risk than leaving the task to the end of the target period.

[7] Department of Environment and Energy. *State and Territory Greenhouse Gas Inventories*. 2017 [cited 2019 3 December]; Available from: https://www.environment.gov.au/system/files/resources/917a98ab-85cd-45e4-ae7a-bcd1b914cfb2/files/state-territory-inventories-2017.pdf. Pages 53-56.

Table 1. Adapted from Table 8 (Pages 53 to 58) of Footnote 6.

Greenhouse gas source and sink categories	2005 (Mtpa)	2017 (Mtpa)	% Change from 2005 to 2017	2030 target (based on 28% of 2005 emissions) (Mtpa)	Reduction needed by 2030 relative to 2017 levels (Mtpa)
Energy	50.8	81.8	61%	36.6	45.2
Industrial process and product use	3.95	5.00	27%	2.84	2.16
Agriculture	10.2	9,01	-12%	7.35	1.66
Land use, Land-use Change and Forestry (LULUCF)	5.33	-8.80	-265%	3.84	-12.6
Waste	1.45	1.52	5%	1.04	0.48
Total CO_2 emissions including net CO_2 from LULUCF	**71.7**	**88.5**	**23%**	**51.6**	**36.9**

Table 1 shows that figures for 2017 for LULUCF (Land Use, Land Use Change and Forestry) are reducing emissions. If these reductions are maintained, the emissions reduction between 2017 and 2030 will be of the order of 37 Mtpa of CO_2e. However, taking the energy sector on its own, the emissions reduction required from the sector will be of the order of 45 Mtpa.

Table 1 shows the scale of work required to meet WA's share of the 2030 Paris target. A substantial amount of avoidance, reduction and offsets of GHG emissions will need to be undertaken.

Table 1 makes it clear that Stationary Energy is the largest contributor, with substantial growth to 2017, and Figure 3 reinforces this. It is essential that substantial reductions are made in the stationary energy sector, which under 'business as usual' is predicted to grow substantially into the near future (see Fig. 2).

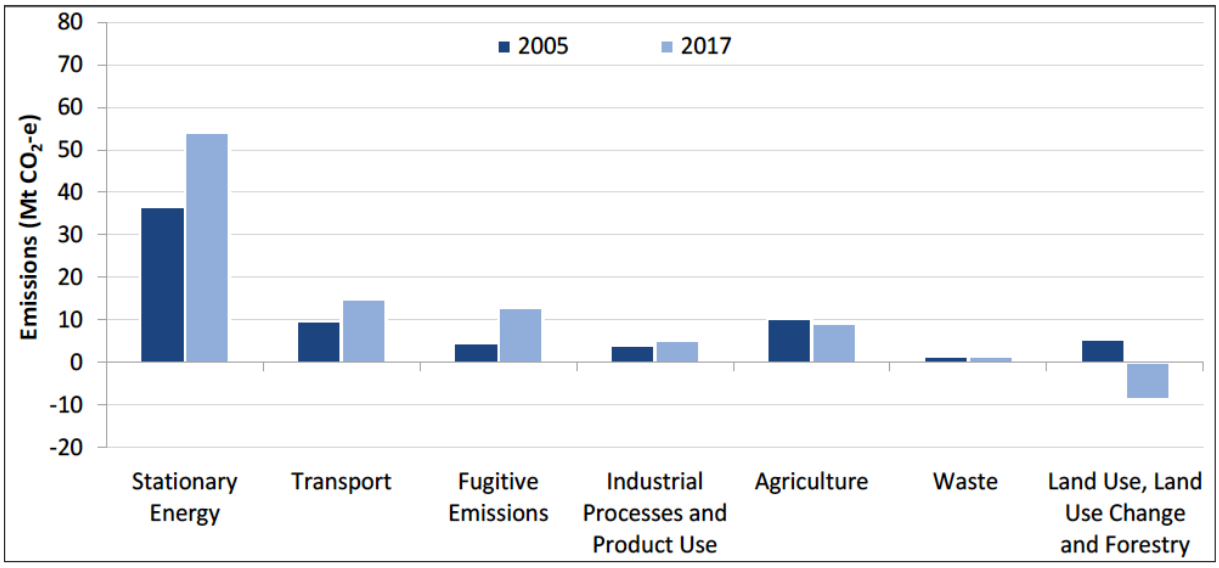

Figure 3. Western Australia, annual emissions by sector, 2005 and 2017. From the "CCWA Runaway Train Report 2019" Footnote 2.

As energy is the major contributor, Table 2 breaks down the energy figures from Table 1 into their components, using a 28% rate compared to 2005 values.

These figures reveal the biggest emission reductions that need to be offset are from the fuel combustion section, which comprise energy industries, manufacturing and construction, transport, and fugitive emissions sectors. It is clear that energy industries cause the major amount of emissions, and emissions will increase unless a strong State Climate Policy is in place, with appropriate regulations.

Table 2. Adapted from Pages 53 to 58 of Footnote 6.

	Annual emissions	2005 (Mtpa)	2017 (Mtpa)	2030 target (based on 28% of 2005 emissions) (Mtpa)	Reduction needed by 2030 relative to 2017 levels (Mtpa)
Fuel Combustion	i. Energy Industries	22.6	33.8	15.1	18.7
	ii. Manufacturing Industries and Construction	11.5	16.8	7.51	9.29
	iii. Transport	9.71	14.8	6.64	8.21
	iv. Other Sectors	2.45	3.54	1.58	1.96
Fuel Combustion Subtotal		46.3	69.0	30.8	38.1
Fugitive Emissions from Fuels		4.53	12.8	5.73	7.09
Total Energy Emissions		**50.8**	**81.8**	**36. 6**	**45.2**

These figures imply that the energy sector should reduce emissions by of 4.5 Mtpa CO_2e per year between 2020 and 2030 (based on 2017 emissions, and assuming a linear reduction, equating to a total reduction of 45 Mtpa).

SEN's analysis continues by considering the 2050 aspiration of net zero emissions. Table 1 indicates, that if WA meets its 2030 targets, there will still be 51.6 Mt of emissions in 2030. Nominally, this implies the 51.6 Mtpa will need to be abated by 2050.

However, recent research[8] indicates that some emissions are likely to continue in 2050. This implies that an equivalent amount of extraction must take place to ensure there is no net addition of GHGs to the atmosphere in that year or thereafter.

The world figure of likely emissions[8] at net zero is estimated as between 10 and 20 Gtpa CO_2e per annum. SEN uses the 20 Gtpa value to calculate Western Australia's indicative proportion of this global amount. 20 Gtpa is multiplied by the long term proportion of Australia's emissions as a percentage of the world's

[8] National Academy of Science. *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda*. 2019 [cited 2019 2 September]; Available from: https://www.nap.edu/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda. Page 6.

emissions[9] (1.1%), multiplied by 10% (based on the approximate proportion of the Australian population living in Western Australia).

Our estimate of WA's share of emissions at net zero is 22 Mtpa. The probability of error in this figure is very large, given that it is projected 30 years into the future. Nevertheless, it provides an indication that there will be a need to extract GHGs from the atmosphere into the future. This draw-down capability will also be needed in the medium term.

SEN is of the view that avoidance and reduction of GHG emissions, while crucial, will not be sufficient to meet the targets in Tables 1 & 2. In reality, offsets and draw-downs will be needed. While some of this can be achieved through land sector afforestation, (genuinely) regenerative agriculture practices and other sequestration techniques, SEN believes that Negative Emissions Technologies will need to be developed, and this is an opportunity for the state, as discussed further under Sector 2.

In summary:

- Total emissions should reduce by at least 3.7 Mtpa CO_2e per year between 2020 and 2030, equating to a total reduction of 37 Mtpa.
- The energy sector should reduce emissions by at least 4.5 Mtpa CO_2e per year between 2020 and 2030, equating to a total reduction of 45 Mtpa.
- A forward-looking policy will lead to avoidance and reduction of GHG emissions, and contribute to the targets identified.
- Some of the required reductions can be achieved through LULUCF and other sequestration techniques
- Negative Emissions Technologies will need to be developed to draw down GHG concentrations, and this is an opportunity for the state

Negative Emissions Technologies

The previous section emphasised the use of Negative Emissions Technologies (NETs) be explored by the Government. Examples of NETs are:

- Coastal blue carbon
- Terrestrial carbon removal and
- Management methods on croplands or pastures
- Planting forest
- Management practices that increase the amount of carbon per unit land area on existing forest
- Bioenergy with carbon capture and sequestration (Sustainable plantation inputs only – no native forestry or residue)
- Direct air capture
- Carbon mineralization
- Geologic sequestration (Not addressed in the consultation)

For more information on NETs, see Appendices A, B & C.

However, SEN asserts that care must be taken with regard to the capture of CO_2 and other GHGs by various Negative Emissions Technologies. The WA government should carefully consider policy development and potential incentivisation of NET technologies and potential utilisation of CO_2, in order to avoid perverse outcomes.

[9] Baumert, K.A., T. Herzog, and J. Pershing. *WRI Navigating the Numbers: Greenhouse Gas Data and International Climate Policy, Chapter 6, Figure 6.1*. 2005 [cited 2019 3 December]; Available from: https://pdf.wri.org/navigating_numbers.pdf. Chapter 6, Figure 6.1.

Appropriate criteria for incentivisation of NET research and development are that NETs are:

- Effective in reducing CO_2 and or Methane levels on a full lifecycle analysis (ie. SEN would caution against long-term plans for the utilisation of CO_2 to make fuels which have high Global Warming Potential (GWP), such as Methane (with a GWP over 20 years which is 86 times greater than CO_2), because even very minor leakage from manufacture to end-use/combustion could significantly reduce or negate the benefits.
- Technically feasible and realistically and economically deployable on the scale required.
- Verifiable by independent monitoring and other scientific methods. Several landmark reports and papers have indicated oil and gas industry assumptions and reporting of methane emissions have under assessed their levels of methane venting, leakage and flaring.
- Do not encourage the prolonging of, or adding to the consumption of fossil hydrocarbon fuels.
- Timely in their implementation and account for the rapid advances in other technologies which may render the NETs outdated and stranded assets. (i.e. it should be anticipated that electrification of transport, fuel-switching from natural gas to electric, and rapid implementation of renewable energy and battery storage, will cause significant displacement for demand of combustion based fuels).
- Not likely to divert resources away from the more promising NETs (based on the above criteria) into those which have a low likelihood of success or effectiveness.

WA Government Climate Policy

The government's policy on climate change must be based on the science of global warming and the climate models that provide the predictive tools needed to guide decision-making by policy makers.

It is essential that the Climate Policy focusses on all sources of emissions, particularly those from the energy sector, because they are the largest.

SEN recommends the climate change policy adopt the mitigation hierarchy contained in the Western Australian Environmental Protection Agency GHG Guidelines of avoidance, reduction and offsets of GHG emissions to rank emissions reduction actions.

SEN asserts that the emitters of GHGs must be held liable for removing or offsetting an equivalent amount of GHGs to that emitted and must be held responsible for the safe long-term storage of the extracted gases in solid, liquid or gaseous form.

SEN proposes the following actions be incorporated into the government's Climate Change Policy to assist the State to achieve its climate change goals:

1. Phase out subsidies for oil, gas and coal use and shift those to subsidies encouraging the use of renewable energy. (Not addressed in the consultation);
2. Achieve 100% renewables in electricity by 2030, for instance using batteries and other storage to balance the variability of renewables and demand, plus potentially hydrogen from renewable sources and or sustainable biofuels for longer term storage and backup (see Sector 1);
3. Achieve a high proportion of electric vehicles in the state's transport system by 2030 (see Sector 3);

4. Ensure by 2030 all vented CO_2 and methane from gas and oil production is captured and stored or utilised in processes minimising impact on the atmosphere (not addressed in the consultation);
5. Phase out reticulating gas to new residential and commercial/ industrial developments and encourage fuel-switching from gas to electric. (See Sectors 3 & 9);
6. Examine technologies that remove methane from the atmosphere that can be implemented immediately to provide a short term cooling impact so as to buy time on reducing and drawing down CO_2 emissions. (Not addressed in the consultation);
7. Provide incentives for the development of Negative Emissions Technologies (NETs) and replacements for carbon-based products such as fertilisers and those used in steel and concrete production. (Partly addressed in Sector 2)

The other initiatives proposed in the consultation document should also be progressed, but are likely to have a lower impact.

SEN advocates for consideration of the use of technologies that increase the ocean's capacity to safely sequester GHGs. As the US National Academy of Sciences (NAS) reports[10]:

> *The oceans already contain 36,000 GtC, mostly in the form of bicarbonate (equivalent to 132,000 $GtCO_2$). Once the fossil fuel age is over, almost all the anthropogenic CO_2 in the atmosphere will ultimately make its way into the oceans (centuries to millennia) and finally into carbonate minerals on the sea floor (tens of millennia). There are promising technologies for oceanic sequestration, some with potentially limited environmental impact, and the capacity of the oceanic carbon reservoir is obviously enormous. Approaches that have been explored include increased biomass production and ocean alkalization.*[11]

As well, SEN notes that the Reputex Energy report[4] found that all LNG emissions could be offset utilising biological techniques for a cost equivalent to only 2% of the profits of the LNG industry, with the additional benefit of approximately 4,000 jobs to the Western Australian economy.

A table and diagram showing 10 pathways for utilising and removing CO_2 from the atmosphere is included at Appendix A.

For additional information on carbon capture and storage see the BZE report https://bze.org.au/research/other/carbon-capture-storage/)

Monitoring of GHG emissions

In formulating its Climate Change Policy, the government must have regard to the means of measuring and monitoring the emissions. In particular it should use standard measures of methane that account for the actual effect of the gas on warming, that is GWP of 86x CO_2 (IPCC AR5, 2013) over a 20 year time horizon

[10] National Academy of Science. *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda (2019)*. 2019 [cited 2019 2 September]; Available from: https://www.nap.edu/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda. Ref 2 on p.10

[11] The NAS study did not "…cover the physical, chemical, and biological dimensions of oceanic options, or the complex international rules and negotiations that would permit oceanic disposal."

(GWP_{20}), rather than the 21x GWP index (IPCC AR4, 2009) used in national (AEGIS) accounting. Twenty years is the appropriate time horizon for methane and all Short Lived Climate Pollutants (SLCP), which include black carbon, carbon monoxide and HFCs. The state of New York has already legislated use of GWP_{20} recognising the huge risks of methane emissions emanating in the fracking industry.

SEN's submission to the EPA GHG guidelines[12] recommended:

> *That projects must demonstrate that where GHGs are emitted that concurrent drawdown of equivalent volumes of GHGs to those emitted by the project will be undertaken, including the independent monitoring of the method proposed by the proponents, for the expected lifetime of that method*

It is imperative that all emissions from extraction to final use must be continuously measured to a high degree of accuracy (<1%) in order to properly assess the impact of the industries on the atmosphere, in particular those industries emitting methane or other high GWP gases.

SEN notes that enhanced monitoring of pollution is being considered in the Environment Protection act revisions currently being developed.

[12] Sustainable Energy Now. *Submission to EPA on Greenhouse Gas Emissions Guidelines*. 2019 [cited 2019 1 December]; Available from: https://d3n8a8pro7vhmx.cloudfront.net/sen/pages/27/attachments/original/1570776945/SEN_EPA_GHG_Emissions_Submission_2019.pdf?1570776945.

Issues by Sector

In the remainder of the submission SEN provides commentary on the issues raised by the government's discussion paper and includes responses to some of the questions contained in the discussion paper.

In some sections, the response is based on detailed work by SEN. In others, the individual expertise of SEN members and other organisations has been used to provide points to be considered by DWER.

1. Transforming Energy Generation

What are the main challenges for decarbonising Western Australia's electricity supply while ensuring adequate generation capacity, security and reliability?

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

The State Government is already taking steps to decarbonise WA's electricity supply, while ensuring adequate generation capacity, security and reliability. The Energy Transformation Strategy (https://www.wa.gov.au/organisation/energy-policy-wa/energy-transformation-strategy) has three work streams:

- Whole of System Planning
- Redevelopment of Regulatory Frameworks
- Distributed Energy Resources Roadmap

SEN has been advocating for these steps since 2015, based on detailed modelling and analysis. It is gratifying that Government is beginning the process of renewing the State's electricity system.

SEN has conducted extensive modelling[13] [14] of how the SWIS can transition to renewable energy in a planned, orderly and secure series of steps.

When optimised for maximal renewables and minimised costs, SEN's 2016 work demonstrated that 85% renewable energy is completely feasible on WA's southwest interconnected system (SWIS) by 2030 at prices similar to that of business as usual approaches in 2016. This involves a mixture of wind and solar photovoltaic (PV) generation, supported by storage in various forms. Backup generation is required for occasional periods of low solar and wind resources by use of fuelled 'peaking' plants.

Figure 4 shows that, using 2016 prices for renewables, it is possible to phase out coal and baseload gas generation in a well-planned way. Prices of renewables continue to fall[15], to the extent that the levelised costs of both wind and solar PV now compete with the marginal cost of coal generation, where capital costs have been paid off.

Costs of Lithium battery storage also continue to fall[15], contributing to cheaper energy security.

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[13] Sustainable Energy Now. *Clean Energy WA Study*. 2016 [cited 2018 October 2018]; Available from: http://www.sen.asn.au/clean_energy_wa_study.

[14] Sustainable Energy Now. *Renewable Electricity in WA: the Economic Argument*. 2017 [cited 2019 2 September]; Available from: https://bit.ly/2LgCw8I.

[15] Lazard. *Levelized Cost of Energy and Levelized Cost of Storage 2019*. 2019 7 Nov 2019 [cited 2019 14 Nov].

While SEN's 2016 modelling still requires significant fast-response gas generation capacity, this is largely only required for about two weeks a year when it is cloudy with little wind. Over time, fuel for these generators can be displaced by sustainably harvested plantation biofuels such as Oil Mallee, or by Hydrogen generated from excess renewable energy.

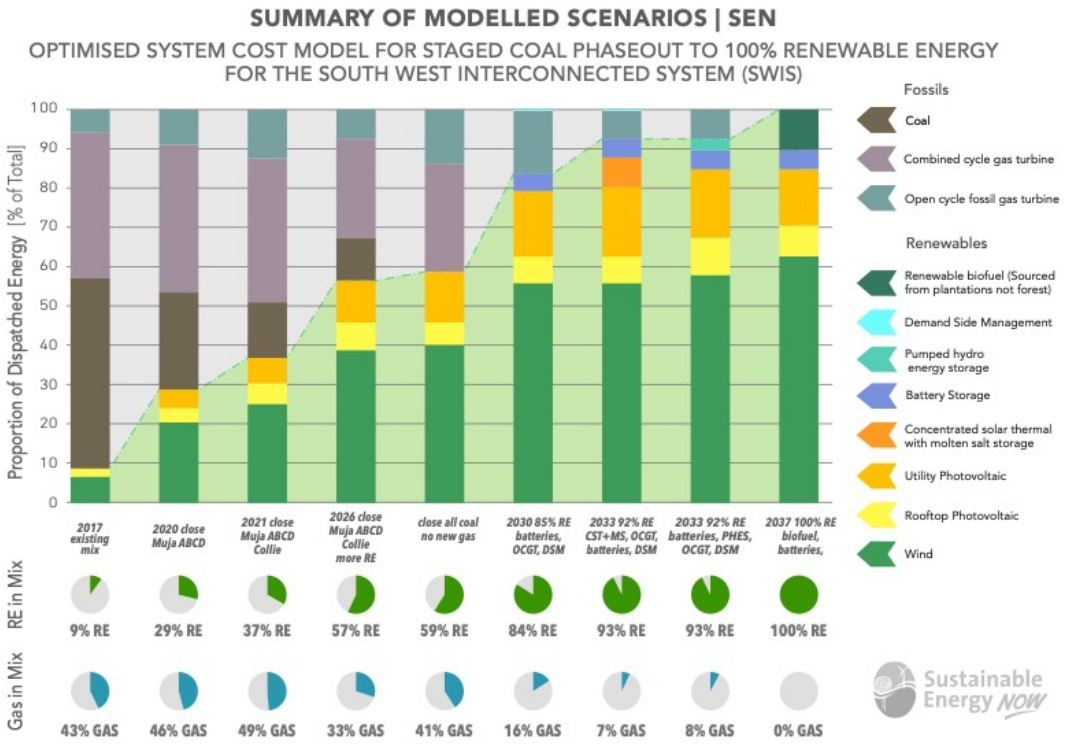

FIG. 4: SWIS renewable energy transition scenario modelling to 2030[2]

A further benefit resulting from the 85%+ renewable scenario is that there are large amounts of surplus electricity available (mostly in Summer), due to the inherent 'overbuild' of renewable generation capacity. This provides opportunities for industry to utilise this otherwise wasted low-cost energy resource, to desalinate water, generate Hydrogen, etc.

The low cost of renewable energy (both with and without storage) increases its attractiveness for regional areas covered by Horizon Power, mining and other off-grid users due to it displacing the use of typically more expensive gas and diesel generation[16] [17] [18] [19].

[16] Sustainable Energy Now. *Kimberley Clean Energy Roadmap*. 2018 [cited 2019 October 2019]; Available from: https://www.sen.asn.au/kcer.

[17] Vorrath, S., *WA utility to lead big switch to local generation, because it's cheaper*, in *Renew Economy*. 2017.

[18] Horizon Power. *Inquiry into Microgrids and Associated Technologies in Western Australia*. 2018 [cited 2018 20 October]; Available from: https://bit.ly/2R4flcy.

[19] Parkinson, G., *Rio Tinto looking at renewables and storage as part of $1 billion mine upgrade*, in *Renew Economy*. 2019.

SEN followed this work by analysing the total employment opportunities arising from this roll-out of renewables[20], concluding in 2016 that the transition to renewables would result in 2000 permanent Operations and Maintenance jobs – 1400 more than the 650 jobs in coal-fired electricity. Work in progress is mapping the jobs created across an 11 year transition to 85% renewables in 2030. Preliminary results are shown in Figure 5, which indicate that ongoing jobs over eleven years in construction and manufacturing can reach 6,000, in addition to the 2,000 permanent jobs in operations and maintenance.

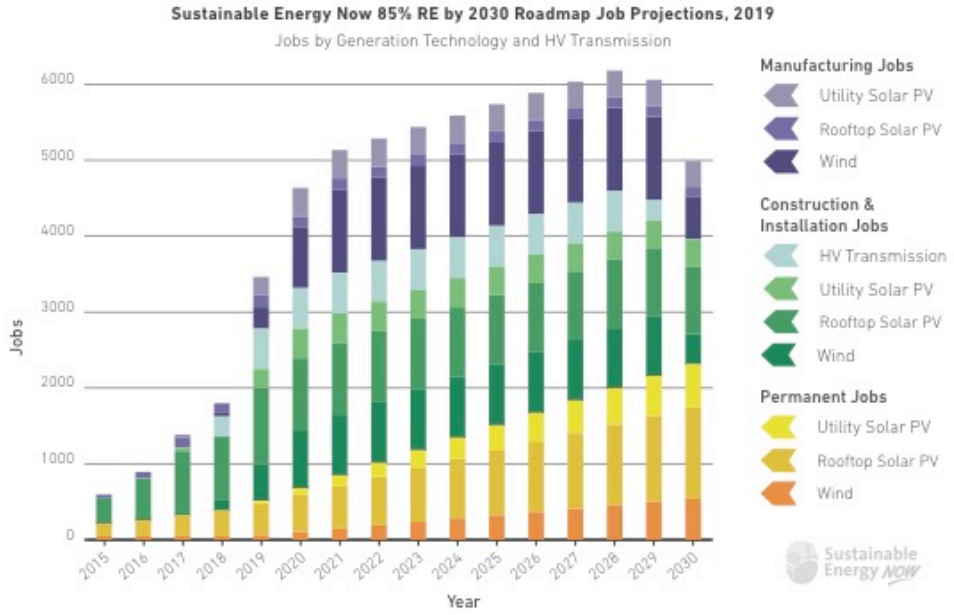

Figure 5. Types of jobs created through a 15 year transition to renewable electricity in the SWIS

Should the electricity sector make a pro rata (or greater) contribution to Australia's national greenhouse gas emission targets?

In terms of meeting national greenhouse gas emission targets, electricity generation is one of three 'low-hanging fruit'. The others are electrification of transport (Sector 3) and energy efficiency (partly addressed in Sectors 2 & 8). With appropriate policy settings, and relatively low investment, governments can make fast inroads into reducing GHG emissions.

However, this is not to imply that other sectors should be ignored, or have lower priority. Speedy reductions need to be made across the board in order to limit dangerous global warming.

How fast do you think the transition of the electricity sector should occur?

The transformation to renewable electricity is proceeding faster than anticipated. In particular, rooftop solar PV is currently over 1.3GW, by far the largest generation source in the state, and is increasing by around 26% per annum[21]. Excess solar PV in the middle of the day is resulting in the old 'baseload' coal and gas generators

[20] Sustainable Energy Now. *Renewable Electricity in WA: A Jobs Revolution*. 2017 [cited 2018 20 October]; Available from: https://bit.ly/2R0nRhS.

[21] Australian Photovoltaic Institute, *PV Postcode Data*. 2019 [cited 2019 14 Nov]; Available from: https://pv-map.apvi.org.au/postcode.

being 'ramped' up and down – for which they are not designed. SEN has been advocating urgent action at the technical and regulatory level to mitigate the risks.

SEN's modeling implies the SWIS can operate with 100% renewable energy by 2030 at prices similar to today's if sufficient storage is added to the grid, including pumped-hydro and or new technology options such as distributed battery storage, system level battery storage, sustainable biofuels and/or the production of Hydrogen.

As mentioned earlier, the government has instituted the Energy Transformation Strategy consisting of the Whole of System Plan (WoSP) and Distributed Energy Resource Roadmap (DERR) to address the planning needed for the transformation. The planning is being conducted in the context of reducing electricity prices while maintaining system stability and utilizing new energy and storage technologies.

However, the Terms of Reference for the planning do not include decarbonisation of the SWIS, a major oversight due to the significant likelihood that the costs associated with decarbonisation are likely to impact the system in the course of the planning period. To ignore these costs will potentially seriously undermine the validity of the planning.

Decarbonising the SWIS should be given priority in the WA Climate Change Policy, which should impact the Energy Transformation Strategy.

2. Industry Innovation

SEN's submission to the EPA GHG Guidelines Assessment consultation 2019 has supported the Environment Protection Authority's initiative to treat greenhouse gas emissions as pollution, and to apply the 'mitigation hierarchy' to that pollution: avoid, reduce, and lastly offset.

Industry must innovate to mitigate against climate change, and government policy should support the innovation. The largest polluters should be making significant contributions to the Climate Change policy. This is a weakness of the WA Climate Change policy discussion paper – which acknowledges WA's resource-based economy exposure to carbon transition risks, and then appears to ignore the risk in the consultation.

The first principle to be followed is to innovate to avoid the need to extract and utilise fossil fuels in the first place, in line with the EPA Guidelines. Reductions in GHG production can be achieved by *fuel switching* and process improvements. Fuel switching avoids or reduces demand for fossil sources of carbon by other means of achieving the same outcomes, typically using renewably generated electricity as the energy source. This provides numerous advantages, including lower overall cost and maintenance, high performance and efficiency, ability for self-generation by on-site solar PV or wind, and reduction for the need for gas infrastructure[22]. This is discussed further in subsequent sections.

The second principle is to reduce the amount of GHG pollution through innovative changes to production processes, and the rest of this section discusses this.

The third principle is to *offset* GHG emissions by drawing down Carbon from the environment, using carbon sequestration and NET techniques, as discussed in the Section "Negative Emissions Technologies" on page 12 of this submission.

[22] Forcey, T., *The switch is on: Consumers are turning away from gas*, in *Renew Economy*. 2018. https://reneweconomy.com.au/the-switch-is-on-consumers-are-turning-away-from-gas-98169/

Opportunities for business to lower energy use or emissions

Instances and references that demonstrate the opportunities available include:

- Agnew Gold Mine[23]
- Reducing emissions from cement production (Ref BZE report: https://bze.org.au/research/manufacturing-industrial-processes/rethinking-cement/)
- BZE Stationary Energy Report https://bze.org.au/research/renewable-energy-plan/
- Rio Tinto looking at renewables and storage[19]

Research and development is occurring around the world to address this issue and the Policy should include strategies to support universities and vocational education colleges identifying and transmitting the outcomes to local industry.

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

The resources sector is traditionally conservative in adopting new technologies, and is prone to 'greenwashing'. For example, Woodside was reported in *the West Australian* as contributing 9.5 million tonnes of carbon emissions per annum[24]. In the same issue, Woodside CEO, Peter Coleman, stated that Woodside had *"offset more than 500,000 tonnes of CO_2 associated with our Pluto gas project since 2008"* – in other words, over 10 years. While that offset figure seems large in itself, it only represents 0.5 percent of the 9.5 million tonnes actually being emitted per year.

In view of the risks involved in not addressing climate change, the Policy should include strategies for the government to bring the industry together to discuss how common actions may reduce emissions without affecting the competitive position of individual companies.

Such common action may assist in overcoming the resistance to change and lower the risks in adopting new technologies that commonly arrests the pace of change.

For additional discussion of this issue see the BZE report "Electrifying Industry" https://bze.org.au/research/manufacturing-industrial-processes/electrifying-industry/.

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

The government Policy should ensure that companies exporting from Western Australia are addressing at least their Scope 1 and 2 emissions, as defined by the WA EPA GHG Guidelines Assessment.

SEN acknowledges that Scope 3 emissions, that occur overseas, are out of scope for this Policy, although for LNG exports they are the major source of carbon

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[23] Mining Technology. *Gold Fields to operate Australian gold mine on renewable energy*. 2019 [cited 2019 14 Nov]; Available from: https://www.mining-technology.com/news/gold-fields-agnew-gold-mine-renewable-energy/.
ARENA. *Iron ore mining hub to be repowered with renewables*. 2019 [cited 2019 15 Nov]; Available from: https://arena.gov.au/blog/iron-ore-mining-hub-to-be-repowered-with-renewables/.
Energy and Mines. *Hydrogen and Mines*. 2019 [cited 2019 15 Nov]; Available from: https://australia.energyandmines.com/attendees2019/.

[24] West Business, *Future emissions shock for major LNG players*, in *West Australian*. 22 March 2019.

pollution. Western Australia should continue to lobby for a Federal policy on climate change. Australia has to recognise that international sanctions against Australian products are a risk if we are not seen to be actively pursuing these issues ourselves.

There should be no exemptions to trade exposed sectors. Highly-emitting projects should be required to meet EPA conditions relation to GHG pollution.

How can the Government of Western Australia foster clean industries and technologies?

The Policy should include strategies that will lead to the cost of carbon reduction/offsetting in the operation of the industry being incorporated in the price of the products sold, i.e. in their business models and investment decisions. Eventually, it should be illegal to emit GHGs in the course of production or consumption of the products, and, where GHGs are emitted, the cost of extraction of the gases from the atmosphere should be borne by the company producing the goods or services. Binding penalties should apply for non-compliance.

The Policy should promote clean energy exports (see for instance the BZE report https://bze.org.au/research/renewable-energy-superpower/).

In addition to fossil fuel use, other activities and products such as agricultural nutrients/fertilisers/chemicals, meat and dairy production, cement, aluminium and steel making are additional to the Earth's pre-industrial carbon cycle and must be included in the accounting of GHGs.

This section provides examples of fuel switching approaches.

Heating and other thermal processes, which typically have used gas as an energy source, can be displaced virtually entirely by electrical energy from renewables. Beyond Zero Emissions' "Electrifying Industry"[25] report shows that electricity can power:

- industrial heat pumps
- electromagnetic heating – infrared, induction and microwaves
- electric furnaces – resistance, arc and plasma
- renewable hydrogen production by electrolysis
- heat generation and storage – storing electricity as heat

Manufacturing of products such as food, paper, bricks, plastic and steel can be transformed away from fossil fuel use in the following ways [18]:

- Prepared food — Heat pumps, storage and infrared
- Beer — Heat pumps
- Milk powder — Heat pumps
- Paper — Infrared
- Aluminium casting — Induction
- Alumina refining — Electric resistance
- Brick — Microwave
- Glass — Electric resistance
- Plastic — Electric resistance
- Steel — Renewable hydrogen and electric arc furnace[26]
- Ammonia — Renewable hydrogen

[25] Beyond Zero Emissions, *Electrifying Industry*. 2018.

[26] Mazengarb, M., *Another nail in coal's coffin? German steel furnace runs on renewable hydrogen in world first*, in *Renew Economy*. 2019.

Further, the BZE "Rethinking Cement"[27] report shows how a zero carbon cement sector can be achieved through:

- Geopolymer cement
- Developing high-blend cements with reduced clinker content
- Mineral carbonation
- Minimising the use of cement
- Carbon negative cements

Further examples of substitute technologies for gas include:

- Industrial process heating, including replacement of aged Combined Heat and Power (CHP) units to use renewable electricity, which could potentially be made even more economically attractive by taking advantage of low-cost surplus renewable electricity
- 'Synthetic inertia' from electrical inverters running on battery and renewable generated electrical energy. This has the ability to substitute for, and out-perform, gas turbines for grid stability and ancillary services[28].

SEN advocates for the producers of emissions to be required to offset them within the same year they are released, preferably within WA, by either:

- Preventing or causing a reduction in emissions in other GHG emitting activities.
- Extracting and storing an equivalent amount of GHGs emitted (based on equivalent greenhouse warming potential over a twenty year period) in a form that prevents the gases from interacting with the atmosphere or the oceans for long periods of time (hundreds to thousands of years).

A recent study by Reputex[4] investigated the abatement potential and economic benefit to WA of offsetting direct emissions generated by the LNG industry within the state. It found that approximately 80 Mt of emissions could be offset per year, through activities related to agriculture, renewable energy, carbon farming, and vegetation management activities, including rangeland regeneration and savannah burning.

The report found that offsetting 30 Mtpa would create around 4,000 jobs, which is the majority of the current LNG emissions of 32Mtpa. There are clear benefits for offsets to be delivered in WA to create jobs and benefit the environment. There is little benefit to the state if abatement funds are spent outside of WA. However, Government needs to provide more policy certainty around the range of possible approaches.

3. Future Mobility

There are multiple options to reduce transport emissions, including the following:

- Increase the use of mass transit and cycling
- Increase the 'electrification' and 'electric-hybridization' of transport such as: personal vehicles, trucks, buses/trackless trams and utility vehicles such as rubbish trucks. This can be encouraged by education on the business case for reduced fuel and maintenance costs by utilising electric vehicles (EVs), as well

[27] Beyond Zero Emissions, *Rethinking cement*. 2017.

[28] Parkinson, G., *Plunging solar, wind costs means 'green' fuel exports could replace coal and gas*, in *Renew Economy*. 2017.

as incentives to make those options more attractive if required. Charging energy from EVs can be self-generated on-site by solar PV and batteries, as the latter become more common. Secondary benefits include the reduction of Particulate Matter (PM) and Ultrafine Particulate Matter (UFPM) particularly from diesel engines, which has serious health consequences, especially for children and babies. (Ref Doctors for the Environment https://www.dea.org.au/)

- Introduce fuel efficiency standards aligned with world best practice standards.
- Investigate and remove direct and indirect incentives and subsidies for fossil fuel use, including those offered as part of lend-lease or fleet vehicles, and 'novated' leases. (Ref: https://www.novatedleasing.com.au/?utm_source=google&utm_campaign=NLLongTail&utm_medium=SEM&utm_term=novated%20lease&utm_content=NovatedLease&gclid=Cj0KCQiAt_PuBRDcARIsAMNlBdrU7TPF95cho3wOsu1aprWQqAlSpab_NU0FlGqIeY1Yidml6QaeE0gaAwwBEALw_wcB).
- Launch a public and industry campaign to highlight the cost savings of electric and fuel-efficient vehicles and of simple ways to reduce consumption, noting the (inefficiencies) of driving with roof racks/boxes, unnecessary weight in vehicles, poor tire inflation and poor driving habits.
- Improve traffic management to reduce wasted fuel from stopping and idling time, such as: increased roundabouts and slipways, rush hour traffic leveling by encouragement of flexible work hours and adopting driving laws which allow traffic to make left turns at traffic-light intersections after stopping for red light (similar to USA).
- Review the policy on highway lighting with a view to limiting to only those areas of safety concerns such as intersections and entry/exits. Modern vehicles have superior headlights and no other vehicles are allowed on highways, so this is an opportunity to not only reduce energy consumption, but also light pollution.
- Propose the use of LED street lighting
- Increase the use of rail in preference to road transport for heavy haulage.

What are the barriers to purchasing and facilitating the uptake of a low-emissions or Electric Vehicle for your household or business?

- Launch a public 'education/information' campaign on the cost and other benefits of EVs and low emission (hybrid) vehicles, to address common concerns, such as:
  - The higher purchase price is usually the main detractor on the purchase of low- or zero emission vehicles. However, the ongoing fuel and maintenance cost savings of these vehicles, which make up the 'total ownership cost' over a typical ownership period, can significantly offset the higher purchase cost. The 'fuel' and maintenance cost savings of an electric vehicle for example can be up to $1,900/yr based on a typical Australian driving distance of 15,000km/yr, so the savings over a 5 year ownership could be $9,500. (Ref https://electricvehiclecouncil.com.au/about-ev/myth-busting/). It is commonly projected that "total ownership costs of EVs will be the same as conventional vehicles by 2021 and that upfront costs will be cheaper by 2025". (Ref: https://electricvehiclecouncil.com.au/about-ev/myth-busting/)
  - The perception of limited range per charge ('range anxiety') is now largely addressed with the advent of the latest EVs because their range is now 200-500+km, meaning that most owners need only charge at night, and that fast charging infrastructure is increasing to address those longer trips. Furthermore, many households/businesses with more than one vehicle could purchase an EV for the majority of shorter range trips.

- Lack of fast charging in outlying areas, by encouraging the installation of electric (DC and AC) charging units in regional areas (roadhouses, etc) to address the need for medium to long-range travel in EVs. The RACWA "SW Electric Highway" is an example. The new generation of EVs has ranges from 200km to 500+km and can fast charge to 80% range in less than 30 minutes. (Consider the same problem existed when combustion-vehicles first started to travel long distances).

- Incentivise the purchase of low or zero emission vehicles such as hybrids, EVs (electric bicycles/motorcycles), offsetting the incentivisation costs by savings or benefits resulting elsewhere, such as potentially the reduction of petroleum imports/ subsidies and storage requirements for transport energy security.
- Refer also to the submission by the Australian Electric Vehicle Association.

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

- Incentivise/subsidise the use of public/mass transit such as offering lower or zero cost fares, with those costs being offset by the reduced cost of ever-growing highway and road upgrades costs.
- Continue to build MetroNet, bus transport routes and cycleways. Cycleways and walking routes should be designed with the convenience, comfort and ambience of the rider in mind, such as shade trees, distance/isolation from high-speed and noisy traffic, water refilling points, etc. Cycleway apps to minimize travel distances may also encourage the uptake.
- Enable bikes and other 'last-mile' modes of transport to be taken on buses at all times by adding racks to the front, as is done elsewhere. Enabling bikes to be taken onto trains would also be effective, with possibly a trial of dedicated bike sections on trains that run more frequently to still provide the same mass transit capability being undertaken.
- Incentivise the purchase/use of electric bicycles (e-bikes) which not only reduce emissions but enable more people to cycle and therefore realise health benefits.
- Refer also to the WA Sustainable Transport Coalition and WA cycling groups.

How can we ensure that Western Australia isn't left behind in the transition to cleaner transportation?

- By 'electrification' of public transport (buses, potentially 'Trackless Trams'), which will also reduce the amount of Particulate Matter (PM) and Ultrafine Particulate Matter (UFPM) pollution.
- Incentivise the uptake of EVs.
- Refer also to the Beyond Zero Emissions' "Zero Carbon Australia, Electric Vehicles" report for recommendations https://bze.org.au/research/transport/ . Report available at: https://bze.org.au/wp-content/uploads/BZE-Electric-Vehicles-Report-Beyond-Zero-Emissions-Australia.pdf.
- Take up the suggestions in this section and invite the groups representing EVs, cycling, trucking, aviation and marine transport operators, to discussions with the state government.

4. Regional Prosperity

What steps can we take to further enhance the resilience of our regions and our primary industries?

The Policy should take into account that water security is essential for regional centres to survive.

SEN advocates against unconventional gas 'fracking' altogether, but particularly in agricultural areas[29].

Fracking is increasingly being shown to be detrimental in significant ways to the environment but its substantial release of methane in exploratory phases, plus ongoing leakage in Scopes 1 and 2, and potentially after end of production makes it a significant contributor to fugitive emissions, with high GWP value of 86 times that of CO_2 in a 20-year timeframe.

The other effects of fracking significantly detract from the ability of regions to cope with the warming effects of climate change due to its use of water, and potential contamination of water resources.

How can we support the agricultural sector to participate in the low-carbon transition?

The Policy should provide financial and regulatory support for Carbon farming and regenerative agriculture, as well as support for education campaigns to make farmers aware of the opportunities available to enable these to make a major contribution to reducing emissions.

Combining farming with solar and wind farms also provides additional, drought proof revenue for farms, e.g. Collgar wind farm. The conversion of the SWIS to renewables and potentially powering technologies such as Direct Air Capture (DAC) of CO_2 with renewable energy could also provide economic benefit to the regions.

Also developing off-grid renewable generation facilities on farms reduces transmission line expenditure and has side benefits such as removing potential spark ignition sources of wild fires.

The development of products such as biochar, from the use of sustainable biomass for renewable energy generation could also benefit the regions by making farms more productive. Biochar is the product of biomass heated without oxygen in a process known as pyrolysis; it is expected to be stable for thousands of years. A high proportion of carbon from the biomass remains within the biochar and can be added to soils without breaking down, and improves soils. Pratt & Moran[30] describe that in South America more than 2000 years ago biochar was used to improve soils ("Terra Preta"), which have higher yields than the surrounding areas without biochar.

The ancient soils in WA's wheatbelt, the sandy soils of the Swan Coastal Plain in WA and many other places can benefit from organic material, which also helps with the soil moisture content. This should also be seen as a measure to improve food security in a drying climate.

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[29] Sustainable Energy Now. *Western Australian Scientific Inquiry into Hydraulic Fracture Stimulation in Western Australia: Submission from Sustainable Energy Now*. 2018 [cited 2018 20 October]; Available from: https://bit.ly/2NQoKrf.

[30] Massy, C., *Transforming Landscapes, Regenerating country in the Anthropocene.* Griffith Review, 2019.

What opportunities do carbon offset markets present for Western Australian land managers, including Aboriginal groups?

The Policy should look to the following reports for information on opportunities arising from carbon market offsets.

The Reputex report[4] shows there is significant potential for the offsets market to provide support for carbon reduction actions in Western Australian land management, while providing substantial employment opportunities, including for Aboriginal groups.

By changing farming techniques to regenerative, no-tillage, dual use such as Profitable Perennials (REF Future Farmers CRC http://www.ioa.uwa.edu.au/__data/assets/pdf_file/0010/1147708/Ewing-Future-farm.pdf and https://grdc.com.au/research/reports/report?id=6274), significant benefits can be gained in the efficiency of the farms as well as providing carbon reduction benefits. Reports include the BZE Agric, Farm, Land Use report https://bze.org.au/research/agriculture-farming-land-use/regenerativeagriculture and from the website of Regen WA https://www.regenwa.com/.

Afforestation with mono cultures for plantation purposes may have the advantage of fast growing and easy management, but lack of biodiversity enhances the risk of diseases and pests. As an alternative, the concept of "strip cultivation"[31] could be adapted to forestry, where, for instance, a 50m wide strip is used for monoculture plantation separated by interconnected 50m strips of 'native' (regenerated) bush land that provide diversity in plant and insect species. The native bush 'strips' can provide forest floor residue that can be used for biochar production. This biochar can then be applied to the monoculture strips to enhance plantation growth potential and avoids depletion of nutrients.

The use of biomass for large-scale energy generation should be discouraged since the externalities are very large. Nevertheless, in certain cases, "growing" biofuel can be an overall benefit and particularly because the water input is low. Coppiced Oil Mallee plantations, where only the new shoots are harvested, can help sequester CO_2 emissions as well as stop/reverse land degradation due to dryland salinity problems. Currently the research appears to be focused on creating an aviation biofuel from mallee (McGrath, et al., 2015). There is a need for R&D in mini-distillers (as used in the second world war in country WA), so this biofuel can be produced and used locally by regional communities. This would also have socio-economic benefits to the regional economy, and the externalities of transport of this biofuel are near zero.

What matters should the State Government take into account in developing a strategy for carbon farming in Western Australia?

SEN supports the Policy incorporating the Aboriginal Ranger program to increase employment in the strategies to be used. The proposed Pastoral Land Reform package does not deal with the fundamental problem holding back sustainability in the rangelands: the legal requirement that all lease holders have grazing as their primary business. If this condition was changed, then leaseholders would be able to diversify into alternative income streams, such as carbon farming.

Other ideas from the BZE Repowering NT report may be applicable to WA https://bze.org.au/research/regional/repowering-nt/.

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[31] Wageningen University. *Strip Cultivation*. 2019; Available from: https://www.wur.nl/en/project/Strip-cultivation.htm.

5. Waste Reduction

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

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

The Policy should consider:

- Addressing the causes of waste generation in the first instance, all of which has a 'carbon and environmental footprint'. This starts with the manufacturer, importer or grower and includes reducing packaging, marketing and consumer habits, use-by dates which may be causing unnecessary waste of food or other. This can also include adopting existing legislation from elsewhere, which can be used to discourage waste, and designs with poor recyclability, and improve recycling, such as the:
  - Waste Electrical and Electronic Equipment (WEEE) Directive (http://www.repic.co.uk/What-is-WEEE)
  - Extended Producer Responsibility (EPR) requirements (https://www.aph.gov.au/parliamentary_business/committees/senate/environment_and_communications/completed_inquiries/2008-10/austwastestreams/report/c05)
  - Restriction of Hazardous Substances (RoHS) Directive https://www.rohsguide.com/
- Encouraging the recycling and reuse of all waste.
  - The WA Container Deposit Scheme 2020 is a welcome policy but is relatively limited in scope and must be monitored closely to ensure that the industry's conflicted interests do not discourage recycling of the maximum amount of containers. An updated scheme with larger scope and further incentives for recycling would further improve the potential outcome of this. (Ref CCWA http://www.ccwa.org.au/plasticfreewa, Boomerang Alliance https://www.boomerangalliance.org.au/).
  - Encouraging the channeling of waste streams from one industry/process to valued inputs to other industries. As an example, the business model of Ardea Waste PL (Ref https://www.ardeawaste.com/) is to match up industries with a waste that is costly to dispose of with other industries, which can use that as inputs, improving the economics of both. Total Green Recycling (TGR) (https://www.totalgreenrecycling.com.au/) recycles electrical and electronic waste by separating components into sorted waste streams which are then integrated into new manufactured products. One major issue identified by TGR with waste management and recycling is the lack of regulatory oversight/ monitoring, which results in lack of accountability in verifying the true portion of recycling occurring. Secondly, there is a serious issue that dangerous goods are allowed to contaminate the waste stream, resulting in safety issues and massively increased insurance costs which are threatening the economic viability of the industry.
  - Consulting with the waste management and recycling companies and organisations and Councils to learn about impediments and/or effective opportunities.
  - Discouraging the combustion of waste (waste-to-energy) particularly that of synthetics such as plastics, rubber, fabrics, tyres etc., made from petroleum, which is akin to simply burning fossil fuel. Plastics, rubber and other synthetic

materials that are not easily recyclable or remouldable, can be reused by innovative low-temperature high-speed processes, which mimic Nature to convert them back to oil from which they were made. These oils can be used to make new synthetics and thereby reduce their carbon and environmental footprint, by reducing the need for new petroleum. The methods which achieve this are known as 'Thermal Depolymerisation' (TPD) or 'Catalytic Depolymerisation' (CDP) processes, and have been demonstrated since the 1990's and are currently promoted by Green Distillation Technologies PL (https://www.gdtc6.com/) and https://www.licella.com.au/). Because they occur at low temperatures there are no toxic combustion byproducts, which result from other WTE processes, and they can be applied to a very wide range of synthetics.

- Ensuring landfills and other waste treatment processes are capturing Methane and as a minimum, combusting it to CO_2 to reduce its Global Warming Potential. Combustion of Methane should, preferably be usefully applied such as for electricity generation and/or heating.
- Consulting producers and researchers of the ABC's "War on Waste" program.

6. Safe and Healthy Communities

What are the main climate risks for your household or your community?

Climate risks include:

- Hotter metropolitan areas due to land clearing and high density developments which create 'heat islands'. Current infill practices further exacerbate the problem with designs which do not allow for trees and vegetation to provide a weather moderating and cooling benefit. (Brown, H., et al., 2014. Cool communities: Urban trees, climate and health. *Curtin University* http://ehia.curtin.edu.au/advisory-services/climate-change-health/);
- Reduction in rainfall and groundwater availability;
- Increased severity of storms and flooding;
- Rising sea and estuary levels on infrastructure, including electrical, communications, water, sewerage and gas.

What can be done to manage these risks?

SEN suggestions include:

- Change infill development approvals (buildings, parking and roads) to include mandatory design and layout requirements to avoid becoming heat islands, and include more local vegetation and large street trees (Ref Heat islands (Brown, H., et al., 2014. Cool communities: Urban trees, climate and health. *Curtin University* http://ehia.curtin.edu.au/advisory-services/climate-change-health/ *and* https://ehia.curtin.edu.au/local/docs/CoolCommunities.pdf, and https://walga.asn.au/News,-Events-and-Publications/Media/More-Liveable-Communities-A-Shade-Closer)
- Maintain and increase tree canopy, a major struggle for local councils with the pressure of infill. Councils have in general little or no jurisdiction over trees on private land. However the Fremantle Council is trying to address this with their "Fremantle Alternative" style of developments. There should be set standards of a minimum of 30% "Green space" on a block in addition to the standard open space requirement. As in the Fremantle Alternative at least one large tree should be planted. Housing design needs to become more innovative, with more emphasis on Biophylic design (Beatley, T., 2017. Handbook of Biophilic City

Planning & Design. *Island Press, Chicago, USA*.). Rain water tanks should be a legal requirement for all new building approvals.

- Stop development in low-lying area as these will be subject to more flooding events and storm water runoff from increased rainfall-intensity events and rising sea levels. This will also impact on any ground or underground utilities such as electricity, communications and sewerage. Existing developments in low-lying areas represent a serious problem and will be either devalued in time, and or insurance or other mitigating infrastructure will increase costs for owners and Councils. A plan to address this, and to prevent new developments in low-lying areas must be developed rapidly to minimize future cost and problems.
- A Public and Business education campaign which exposes the risks of climate change and provides solutions to minimize the impact, would help them make better choices, including building/dwelling design, cooling and heating, appliances and equipment, etc. This is also relevant to Sector 9.
- Rainfall will continue to decrease and the Water Corporation recognizes that reliance for most water in the metro areas will be transferred to desalination and groundwater recharge, and recent demonstrations of the latter appear to be successful. However, with the projected population growth in the southwest of the state, there will be a need for more efficient water use and reduced waste. The Water Corporation's past feedback on water consumption to customers has been successful but would be more useful if provided in real-time, potentially by use of digital metering monitored by customer apps, which could also expose leaks. All energy used for pumping, desalination and other for water delivery must be decarbonized.
- Underground water will not generally be replenished as fast as in the past in the southwest of WA, and bore-water sources should be metered and charged for to limit drawdown of the water tables. Rainwater harvesting and aquifer recharge (rather than simply discharging rainwater runoff into the ocean via drains and rivers) will help to offset some of the reduction in rainfall. Failure to do so will result in further loss of wetlands and the environmental benefits they critically provide to our ecosystems, well-being of humanity and other living beings. Hydraulic fracturing for gas production could further threaten water supplies where it is allowed.

For additional information see Better urban forest planning of Perth and Peel: https://www.dplh.wa.gov.au/projects-and-initiatives/metropolitan-planning/better-urban-forest-planning-of-perth-and-peel.

What are your biggest concerns about Western Australia's future climate?

Some comments here are also relevant to Sector 10.

- Changing weather and rainfall patterns will result in loss of biodiversity and extinction and or significant loss of species, including decline or loss of our unique Banksia Woodlands, Karri forests and state forests in the southwest in particular. The state will experience changes of weather patterns which will also impact:
  - The quality of life in terms of health, deaths and well-being for West Australians (Ref: Dr Carmen Lawrence https://ehia.curtin.edu.au/about/publications/ . See specifically: "Health Impacts of Climate Change – Adaptation Strategies for Western Australia https://ehia.curtin.edu.au/wpcontent/uploads/sites/42/2018/05/Health_Impacts_of_Climate_Change.pdf and Doctors for the Environment https://www.dea.org.au/)

- WA's tourist industry.
- Farming and agricultural regions, some of which rely on a relatively stable weather pattern (impacted by more/unseasonal rainfall and droughts), which will become increasingly unviable.

- There is an ethical imperative to preserve the Earth's ecosystems for the benefit of future generations and to acknowledge that these are also our life-support systems. These systems have been degrading for many decades without adequate action to protect them. For more information, see Appendix D.

What could be done to ensure your community is better prepared for possible climate impacts?

The government should instigate an ongoing public awareness campaign on the benefits of making decisions based on sustainable and life-cycle considerations in their choices in everyday life, including dwellings, energy efficiency, cooling and heating choices, transport, value of vegetation, etc.

7. Water Security

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

- Permit only below-surface irrigation systems in public spaces and road verges. The sprinklers only to be used for establishing the plants. Overhead sprinklers only to be used on sporting fields or recreational open spaces. There is a need to educate the irrigation industry.
- All water bores should be metered and licensed. No more new bores to be allowed within 3 km from the coastline, because of salt intrusion problem.

Are there policies adopted in other jurisdictions we should consider for Western Australia?

No comment.

What are the best management options to deal with the water security implications of climate change for our agricultural sector?

In a drying and warming climate in WA, water security becomes even more important. Methods to regulate use of and charge for water is described in Grafton[32] [33].

[32] Grafton, R.Q., *Responding to the 'Wicked Problem' of Water Insecurity.* Water Resources Management, 2017. **31**: p. 3023-3041.

[33] Katic, P. and R.Q. Grafton, *Optimal groundwater extraction under uncertainty: Resilience versus economic payoffs.* Journal of Hydrology, 2011. **406**: p. 215-224. https://www.sciencedirect.com/science/article/pii/S0022169411004240?via%3Dihub

8. Liveable Towns and Cities

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

Key barriers include:

- The conflict of interest between Developers for short-term profit and Purchasers or tenants who will have to live with the consequences of poor or inefficiently designed buildings, and site layout with inadequate room for vegetation.
- The conflict of interest between property owners who do not pay for energy or water use and therefore have no interest in efficiency, and tenants who only care about the cost of water and electricity use, but not the higher up-front cost of efficient design or appliances. A method for sharing the lifecycle cost savings between owner and tenant, is to have a rating system for all buildings (similar to the NABERS rating https://www.nabers.gov.au/), which should add rental value to the owner with the understanding by the tenant of the ongoing savings in utility costs which offset the higher rent cost.
- Lack of awareness of wasteful and inefficient energy use practices/habits and appliances, such as gas for cooking vs electric induction, and gas heating compared to reverse-cycle systems.
- Lack of public and business awareness of the benefits in overall cost, safety, efficiency, performance and low-carbon emissions of all-electric appliances over gas appliances, (such as gas for cooking vs electric induction, and gas heating compared to reverse-cycle systems) particularly given the increasing proportion of renewably generated electricity from our rooftops and electricity grid.
- Lack of awareness by the Public and Business of the benefits in cost and comfort of well-designed buildings which utilise solar-passive design as a starting point, to minimize the need for other cost-adders such as heating/cooling and lighting.
- A tendency for efficiency gains to be offset by increased use or wastage due to the 'Jevon's Paradox' effect (https://www.sciencedirect.com/science/article/pii/S0921800905001084). Humans have a tendency, when knowing that efficiency is increased, and that they are getting more value, to use the resource more. One example is that of the dramatic gain in lighting efficiency offered by LEDs that is now resulting in a significant increase in the use of much brighter lights.

What information or tools do you require to improve energy efficiency in your household or workplace?

The tools required include:

- Real-time energy monitoring and feedback to owners and tenants to educate and expose high energy use items, practices and instances where items malfunction. This, combined with existing solar PV real-time energy generation data via smartphone apps, can realise energy (or water) cost savings that would likely pay for the metering technology. Technologies that provide this are common, inexpensive and easily retrofitted. (Similar capabilities exist for water use monitoring). Examples include Reduction Revolution https://reductionrevolution.com.au/collections/wireless-energy-monitors , Canstar Blue https://www.canstarblue.com.au/electricity/home-energy-monitors/.

What energy efficiency standards or disclosure measures do you support for our homes and offices and the appliances we use in them?

Measures include:

- All residences and industrial/commercial properties should have an efficiency rating such as the NABERS rating.
- Minimum efficiency standards for goods and equipment manufactured in Australia and imported, similar to best practice globally, should be established to set a baseline.
- Ban gas utilities in new developments and phase out over time in existing areas
- Replace gas infrastructure and appliances with electric. See Fuel Switching under Sector 3 above

9. Resilient infrastructure and business

This is not an area of SEN expertise.

10. Protecting Biodiversity

Refer also to Sector 4 for more relevant information.

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

Following are options:

- Stop land clearing and native forestry logging.
- Continue to grow the Aboriginal Ranger program.
- Review prescribed burning practices to reduce environmental damage and improve outcomes. (Ref: Prescribed Burning Conference 2019 http://www.pbc2019.com.au/abstracts.php and https://www.bushlandperth.org.au/wp-content/uploads/2019/09/UBTWinter-2019.pdf
- Amend the Pastoral Lease System to allow primary businesses other than just grazing, as grazing is a major contributor to *increased* vulnerability and *decreased* resilience of the Rangelands. See also Sector 4 comments about allowing leaseholders to diversify into alternative income streams, such as carbon farming.

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

- Revegetate large areas of cleared land to reduce loss of rainfall and soil salinity in wheatbelt areas, and to help restore the regions' lost biodiversity.
- Preserve/rebuild wildlife corridors both in the metro areas (as described in the State government's own metro plans) and rural areas such as the Gondwana Link http://www.gondwanalink.org/.

11. Strengthening Adaptive Capacity

This is not an area of SEN expertise, although comments in other sections do can be applied here.

Conclusion

Western Australia's challenge to reduce its GHG emissions is daunting. The more we learn about the impact the emissions are having, and the rapidity with which the warming effects of the emissions are being experienced, the greater the challenge becomes.

It can no longer be ignored – we have to take drastic action, to begin reducing our emissions now. The Climate Policy is a first step, but we have to move with uncharacteristic pace, even though that involves political and perceived economic risks.

Large scale deployment of renewable energy and storage, and electrification of land based transport are now feasible and affordable. It is more than likely that most industrial processes currently relying on fossil fuels will become cheaper as industry fuel-switches away from fossil fuels. Examples are the smelting of minerals like iron ore and bauxite and the production of green steel – very relevant to Western Australia. There are many examples of disruptive technologies scaling to a dominant market position, and this Policy has the potential to position WA as a leader in this space.

SEN notes there are significant opportunities for Western Australia to replace its carbon based energy export industries with non-carbon based energy carriers that derive their energy input from renewables, and to create new industries for the state, including carbon farming, and to use its significant renewable energy resources to facilitate the drawdown and storage of CO_2.

Technologies that may still be conceptual, or in development phases have to be supported and implemented if they can contribute to reducing emissions in the short to medium term. SEN commends the consultation process for considering such innovations, but notes that care must be taken to ensure that potential technologies do not result in adverse or perverse outcomes, such as perpetuating carbon emissions.

SEN is of the view there are two policy priorities for the government in addressing climate change:

- The first is reflected in the targets already set out, that is minimising emissions and achieving net zero by 2050. Our submission quantifies the amounts required.
- The second is the need to draw down additional GHGs from the atmosphere to reduce concentrations to pre-industrial levels. This will flow from the first priority.

The targets for the policy are relatively clear. The State needs to:

- Find 37 Mtpa of total abatement, to move from 88 Mtpa (in 2017) to 51 Mtpa in 2030.
- Reduce total emissions by at least 3.7 Mtpa CO_2e per year between 2020 and 2030, equating to a total reduction of 37 Mtpa.
- Reduce energy sector emissions to 45 Mtpa by 2030, at a rate of at least 4.5 Mtpa CO_2e per year.
- Ensure there are monitored and verifiable emissions reduction trajectories to these targets.

Emissions reductions will need all elements of the mitigation hierarchy used by the EPA: avoidance, reduction and offsets of GHG emissions. SEN's submission

provides many practical and implementable ideas of where required abatement can be found.

The policy consultation document addresses avoidance and reduction strategies. It also addresses carbon farming and other LULUCF offsetting techniques, and these will enable some of the required reductions to be achieved. However, these are likely to be insufficient to meet the amount of offsets required.

SEN contends that Negative Emissions Technologies will need to be developed as to draw down GHG concentrations. For example, to achieve net zero emissions by 2050, while maintaining a small amount of ongoing fossil-fuel emissions, will require at least 22 Mtpa to be drawn down each year into the future. This is only to achieve the Paris 1.5-2° target. Ongoing drawdowns will be needed to bring CO_2 concentrations down from 410 ppm to 280 ppm.

SEN has argued that research and development into Negative Emissions Technologies provides an opportunity for the state.

Recommendations

SEN makes these recommendations to the consultation:

1. Phase out subsidies for oil, gas and coal use and replace with subsidies encouraging the use of renewable energy;
2. Achieve 100% renewables in electricity by 2030, for instance using batteries and other storage to smooth out the intermittencies of renewables and green hydrogen for longer term storage and backup;
3. Mandate a high proportion of electric vehicles in the state's transport system by 2030 through incentives and legislative measures;
4. The Policy should promote clean energy exports;
5. The Policy should include strategies that will lead to the cost of carbon reduction/offsetting in the operation of the industry being incorporated in the price of the products sold;
6. Ensure by 2030 all vented CO_2 and methane from gas and oil production is captured and stored or utilised in processes minimising impact on the atmosphere;
7. Prohibit reticulating gas to new housing developments and phase out reticulating gas to existing residential and commercial areas;
8. Begin a rapid mitigation of methane emissions in the LNG and agricultural sectors by monitoring and abating the sources of these emissions.
9. Examine technologies that remove *methane* from the atmosphere, that can be implemented immediately to provide short term relief;
10. Consider the use of, and provide incentives for the development of, NETs and replacements for fossil carbon-based products such as fertilisers and those used in steel and concrete production.
11. Provide financial and regulatory support for Carbon farming and regenerative agriculture, as well as support for education campaigns to make farmers aware of the opportunities available to enable these to make a major contribution to reducing emissions.

SEN is cognizant of the magnitude of the task, at policy, technical and political levels. The resources industry in WA will need to bear the brunt of the work. SEN believes that:

- The resources industry has to:
  - work together to eliminate their emissions;

    - work to identify the solutions (such as offsetting and negative emissions techniques) and their costs;
    - update their business models and investment decisions to factor in the costs of addressing their GHG emissions;
- Shareholders have to acknowledge the long-term benefits they will realise, and be prepared to bear the short-term costs and risks involved;

SEN will continue working to develop a coherent set of policies and strategies for the government, the public sector and the community to consider. SEN would be pleased to engage with the government at any level, and share our expertise.

In summary, there are also considerable opportunities for Western Australia, with our abundant renewable energy resources and natural carbon sinks. However, vision is needed to seize these opportunities, just as we did with building the water pipeline to Kalgoorlie; developing our iron ore industry; and developing the LNG export market. It is now time to accept the risks of disruptive technologies and turn them into economic reality. The reality of disruptive technologies is that industries which do not adapt to change will fall by the wayside. One purpose of a state climate policy is to set the stage for change while protecting the state from economic shocks.

Finally, the policy needs to explicitly acknowledge and address the 'elephant in the room', the stationary energy sector that contributes 90% of the emissions in WA, and which is dominated by the resources sector, and is predicted to grow substantially into the near future. Addressing only the proportion of emissions from the rest of WA's economy, as implied by the consultation document, is akin to 'fiddling while Rome burns'.

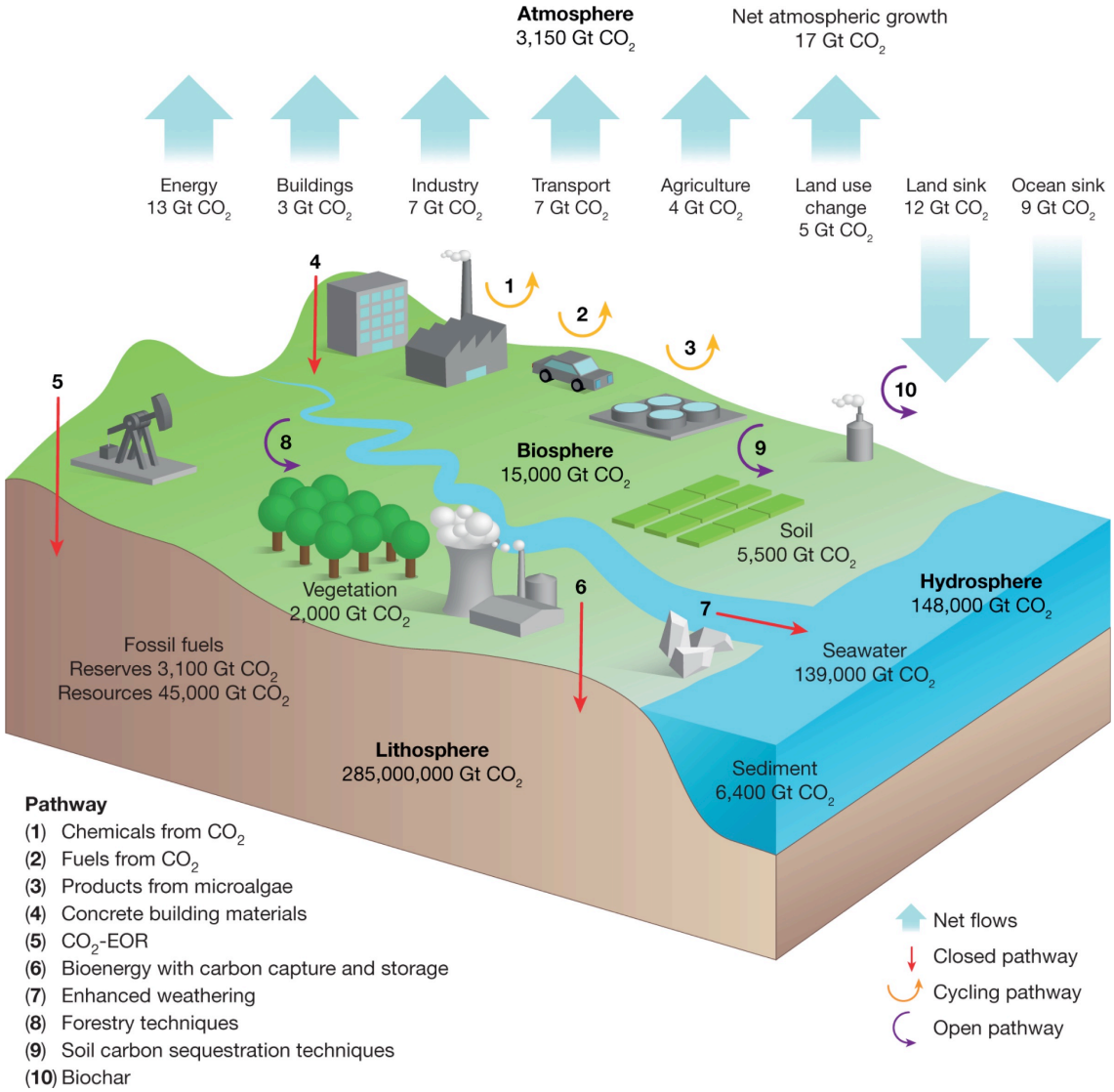
Appendix A. Ten CO_2 Utilisation and Removal Pathways

In an article published in Nature on 6 November 2019, Cameron Hepburn et al. reported on "the technological and economic prospects for CO_2 utilization and removal". https://www.nature.com/articles/s41586-019-1681-6

The article reviewed ten pathways for the utilization of CO_2.

These pathways may be of assistance in helping the state utilise offsets of its carbon dioxide emissions to achieve its emissions targets, where it is not possible to prevent emissions of CO_2, for instance from LNG exports.

The following table and diagram are copied from the article.



Orange, red and purple arrows (numbered 1–10, as described in Table 1) represent cycling, closed and open pathways for CO_2 utilization and removal. Teal block arrows represent annual flows to and from the atmosphere, with estimates averaged over the 2008–2017 period15,91. Estimates of stocks in the Earth's spheres (lithosphere, biosphere, hydrosphere and atmosphere, labelled in bold) and selected stock subcategories are given. All estimates are based on IPCC estimates16 except where noted, and are converted from C to CO_2. Carbon stocks in the hydrosphere comprise seawater, sediment, and dissolved organic carbon (not shown, around 2,600 Gt CO_2). The vast majority of carbon stocks in the lithosphere are locked in the Earth's crust92, with estimated accessible fossil fuel reserves and resources of more than 45,000 Gt CO_2. Atmospheric stocks are converted from the 2017 estimates of atmospheric CO_2 of 405 ppm93 using a conversion factor of 2.12. Carbon stocks in the biosphere include those stored in permafrost and wetlands (not shown, around 7,500 Gt CO_2), vegetation, and soils. Soil stocks to 1-m depth have been recently estimated at 5,500 Gt CO_2.

Table A1. Ten CO_2 utilization and removal pathways, From: The technological and economic prospects for CO2 utilization and removal. (https://www.nature.com/articles/s41586-019-1681-6/tables/1)

Pathway [a]	Removal and/or capture [b]	Utilization product	Storage [c, d] and likelihood of release (high/low)	Emission on use [f] or release during storage [g]	Example c ycles [h]
(1) Chemicals from CO_2	Catalytic chemical conversion of CO_2 from flue gas or other sources into chemical products	CO_2-derived platform chemicals such as methanol, urea and plastics	Various chemicals (days/decades) – high	Hydrolysis or decomposition	KCLG; KCLF; ALFJ; ALG
(2) Fuels from CO_2	Catalytic hydrogenation processes to convert CO_2 from flue gas or other sources into fuels	CO_2-derived fuels such as methanol, methane and Fischer–Tropsch- derived fuels	Various fuels (weeks/months) – high	Combustion	KCLG; ALG
(3) Products from microalgae	Uptake of CO_2 from the atmosphere or other sources by microalgae biomass	Biofuels, biomass, or bioproducts such as aquaculture feed	Various products (weeks/months) – high	Combustion (fuel) or consumption (bioproduct)	KCLG; BG
(4) Concrete building materials	Mineralization of CO_2 from flue gas or other sources into industrial waste materials, and CO_2 curing of concrete	Carbonated aggregates or concrete products	Carbonates (centuries) – low	Extreme acid conditions	KCLF; ALF
(5) CO2-EOR	Injection of CO_2 from flue gas or other sources into oil reservoirs	Oil	Geological sequestration (millennia) – lowe	n.a.	KCD
(6) Bioenergy with carbon capture and storage (BECCS)	Growth of plant biomass	Bioenergy crop biomass	Geological sequestration (millennia) – lowe	n.a.	BCD
(7) Enhanced weathering	Mineralization of atmospheric CO_2 via the application of pulverized silicate rock to cropland, grassland and forests	Agricultural crop biomass	Aqueous carbonate (centuries) – low	Extreme acidic conditions	BE
(8) Forestry techniques	Growth of woody biomass via afforestation, reforestation or sustainable forest management	Standing biomass, wood products	Standing forests and long-lived wood products (decades to centuries) – high	Disturbance, combustion or decomposition	BFJ
(9) Soil carbon sequestration techniques	Increase in soil organic carbon content via various land management practices	Agricultural crop biomass	Soil organic carbon (years to decades) – high	Disturbance or decomposition	BFJ
(10) Biochar	Growth of plant biomass for pyrolysis and application of char to soils	Agricultural or bioenergy crop biomass	Black carbon (years to decades) – high	Decomposition	BFJ

n.a., not applicable.

a The ten pathways are depicted in Fig. 1 and are represented as a combination of steps in Fig. 2.

b Removal and/or capture corresponds to steps A, B and/or C in Fig. 2.

c Storage corresponds to steps D, E or F in Fig. 2.

d Storage durations represent best-case scenarios. For instance, in CO_2-EOR, if the well is operated with complete recycle, the CO_2 is trapped and can be stored on a timescale of centuries or more. This is also relevant only for conventional operations.

e Release during geological storage is usually a consequence of engineering implementation error.

f Emission on use corresponds to step G in Fig. 2.

g Release during storage corresponds to steps H, I or J in Fig. 2.

h The letters stated are the steps from Fig. 2 that comprise the example cycle

Appendix B. Removing past (legacy) emissions ('drawdown')

The concentrations over the last 800,000 years particularly of CO_2 have varied between 180 ppm at the bottom of the ice ages and 280 ppm at the top of the warming cycles.

The temperatures experienced by civilisation have been remarkably consistent for the 10,000 years since the world emerged from the last ice age, apart from the early years when CO_2 concentrations rapidly increased from 180 to 280 ppm and temperatures did likewise (temperaturerecord.org).

The current concentration of CO_2 in the atmosphere is 410 ppm and the current global emissions trajectory will create warming of 3-4 degrees C, where a maximum of 1.5 degrees C is considered the upper limit for a relatively 'safe' climate future in which Life on Earth as we know it, would depend.

From the NAS study[34]:

> *Isotopic evidence shows that the increase in atmospheric CO_2 concentration from 280 ppm in 1750 to 407 ppm in 2017 was primarily caused by fossil fuel burning (IPCC, 2013; Le Quéré et al., 2016).*
>
> *Since 1750, 71% of the carbon atoms in anthropogenic CO_2 emissions have originated from geologic reservoirs of coal, oil, and natural gas, 2% from geologic reservoirs of limestone used in cement production, and 27% from terrestrial ecosystems; primarily due to the clearing of forests, draining of wetlands, and the conversion of forests and grasslands to croplands and pastures … NETs can be thought of as a way to reverse these transfers, by removing CO_2 from the atmosphere and transferring it back to geologic reservoirs and ecosystems. (page 17)*

Anthropomorphic emissions have added another 120 ppm of CO_2 to the atmosphere and the oceans and other mechanisms have apparently absorbed the equivalent of an additional approximately 180 ppm.

For instance the NAS study[30] states:

> *"The increase in atmospheric CO_2 since the industrial revolution would have roughly double the observed ~125 ppm, if carbon sinks in the terrestrial biosphere and oceans had not taken up half of anthropogenic emissions. The "atmospheric fraction" (AF) is the annual increase in atmospheric CO_2 divided by total anthropogenic emissions. Despite substantial interannual variation, much of it linked to the El Niño–Southern Oscillation (ENSO) cycle, the multi-year average atmospheric fraction has remained remarkably steady at ~45% since continuous measurements of atmospheric CO_2 began in*

[34] National Academy of Science. *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda (2019)*. 2019 [cited 2019 2 September]; Available from: https://www.nap.edu/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda.

the late 1950s, indicating that the sum of land and ocean sinks has grown in proportion to anthropogenic emissions." (p 17)

It is therefore conceivable that halting emissions may not be enough to halt the warming trend – instead, once we have stabilised emissions, we may need to progress to drawing down the concentration of the gases to return to previous levels to ensure temperatures stabilise.

As the NAS study[30] states:

"The 2°C target is exceedingly challenging—the global mean temperature has already risen about 1°C, and time lags in the carbon cycle and climate system likely mean that only about 2/3 of the warming that will eventually occur at current concentrations of atmospheric greenhouse gases has been reached (Hansen et al., 2011). The CO_2 concentration, currently 407 ppm (2017), would probably need to be kept beneath 450 ppm to prevent more than 2°C of warming (IPCC, 2013) It is currently increasing at about 2 ppm per year (… 7.82 Gt CO_2/ppm). Article 4 of the Paris Agreement states that increases in atmospheric CO_2 should cease "in the second half of the century", although it is important to understand that preventing the increase of atmospheric CO_2 does not require that anthropogenic emissions cease, only that they be less than or equal in strength to carbon sinks." (p 22)

This article highlights growing concerns that temperatures will increase beyond the 2C if net zero is not attained by 2050. https://sg.news.yahoo.com/amphtml/earth-warm-more-quickly-climate-models-show-074633712.html?__twitter_impression=true

SEN holds that there is a need to draw down the concentrations of GHG gases, particularly CO_2, to a level approximating the level at the end of the 17th century, or the pre-industrial level, and the level that represented the peak of CO_2 concentrations at the top of the warming cycles that have occurred over the last 800,000 years (see for instance temperaturerecord.org). Although the current climate goals contemplate temperature increases ceasing once net zero is reached, SEN asserts there is the potential for temperatures to continue to increase after net zero is reached, implying there will be a need to draw down GHGs in the atmosphere if a safe environment is to be maintained (see Footnote 30, p17, p 22).

Eventually, Climate Change Policy will need to be expanded to include policies related to reducing the concentrations of GHGs in the atmosphere to try to return the concentrations to something like that which prevailed at the commencement of the industrial revolution.

Appendix C. Negative Emissions Technologies

The following section expands on the list of negative emissions technologies mentioned at point 7 of the Section "WA Government Climate Policy "the submission, derived from Footnote 30.

a) Coastal blue carbon – land use and management practices that increase carbon stored in living plants or sediments in mangroves, tidal marshlands, seagrass beds and other tidal or salt-water wetlands

b) Terrestrial carbon removal and sequestration - land use and management practices within forests or agricultural lands that increase the total inventory of carbon in the terrestrial biosphere. These include:

   i. Management methods on croplands or pastures, such as reduced tillage or the planting of cover crops that increase the total amount of undecomposed organic carbon in the soils ("agricultural soils").

   ii. Planting forest on lands that used to be forest but were converted to another use ("reforestation"), or planting forest on lands that were originally grasslands or shrublands ("afforestation").

c) Management practices that increase the amount of carbon per unit land area on existing forest, such as accelerating regeneration after disturbance or lengthening harvest rotations ("forest management").

d) Bioenergy with carbon capture and sequestration - Photosynthesis captures atmospheric CO_2 and energy from sunlight and stores both in plant tissues. BECCS combines the production of energy from plant biomass to produce electricity, liquid fuels and/or heat with capture and sequestration of any CO_2 produced when using the bioenergy and any remaining biomass carbon that is not contained in the liquid fuels.

e) Direct air capture – Chemical processes capture CO_2 from ambient air and concentrate it, so that it can be injected into a storage reservoir. In some incarnations, the captured carbon dioxide may be reused in products though capture and reuse in short-lived products, like chemical fuels, which may result in the carbon in the products being returned quickly to the atmosphere (but does result in displacing fossil sources which increase the concentration of carbon in the atmosphere). Capture in long-lived products, like many structural materials, does not suffer from this disadvantage because the product itself is then the storage reservoir.

f) Carbon mineralization - Accelerated "weathering", in which carbon dioxide from the atmosphere forms a chemical bond with a reactive mineral (particularly mantle peridotite, basaltic lava, and other reactive rocks). Carbon mineralization includes both at the surface (ex situ) where CO_2 in ambient air is mineralized on exposed rock and in the subsurface (in situ) where concentrated CO_2 streams captured through either BECCS or direct air capture are injected into ultramafic and basaltic rocks where it mineralizes in the pores.

g) Geologic sequestration - Supercritical CO_2 is injected into a geologic formation where it remains in the pore space of the rock for a long period of time. This is not a NET, but rather an option for the sequestration component of BECCS or direct air capture.

Appendix D. Climate Emergency Indicators

Recently 11,000 Scientists have called for urgent action to address the Climate Emergency based on numerous indicators, excerpts illustrated below. (Ref https://academic.oup.com/bioscience/advance-article/doi/10.1093/biosci/biz088/5610806)

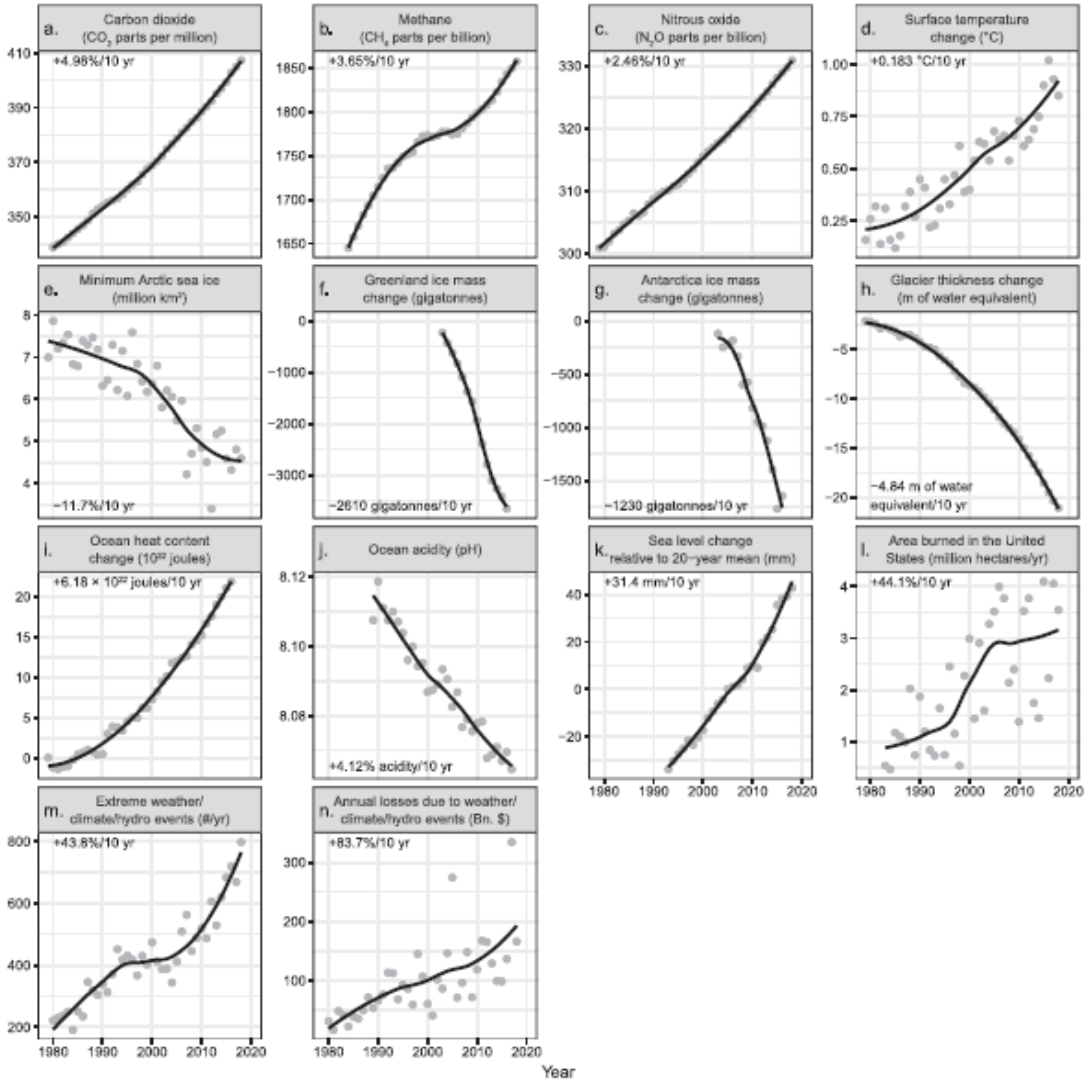


Figure 2. ***Climatic response time series from 1979 to the present. The rates shown in the panels are the decadal change rates for the entire ranges of the time series. These rates are in percentage terms, except for the interval variables (d, f, g, h, i, k), where additive changes are reported instead. For ocean acidity (pH), the percentage rate is based on the change in hydrogen ion activity, a_{H^+} (where lower pH values represent greater acidity). The annual data are shown using gray points. The black lines are local regression smooth trend lines. Sources and additional details about each variable are provided in supplemental file S2, including table S3.***