

The Senate

Select Committee into the
Resilience of Electricity Infrastructure
in a Warming World

Stability and Affordability: Forging a path to
Australia's renewable energy future

April 2017

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Table of Contents

Committee membership	iii
Acronyms and abbreviations	vii
Executive summary	ix
Recommendations	xv
Chapter One	1
Introduction	1
Conduct of the inquiry	1
Note on references	2
Structure of the report	2
Terminology	2
Other inquiries	3
Chapter 2.....	13
Background	13
Introduction	13
A warming world.....	13
Implications of climate change for electricity networks	14
Paris Climate Agreement.....	16
Australia's Electricity Generation.....	17
The National Electricity Market (NEM)	25
Issues facing the NEM.....	30
Chapter 3.....	31
Resilience from storage technologies and distributed generation	31
Introduction	31
Changing patterns of electricity supply and demand	31
Integrating renewables into the electricity system	32
New opportunities arising from storage technologies	35
Types of storage technologies	36
Ancillary services provided by a diversity of energy storage systems	48
Benefits arising from decentralised electricity generation	50

Committee view.....	54
Chapter 4.....	57
Policy and regulatory measures	57
Introduction	57
The business case for policy certainty on a carbon price signal	57
The renewable energy target	65
Market rule and regulatory changes to incentivise the deployment of storage technologies	66
Economic opportunities arising from deployment of renewable energy and energy storage technologies	77
Dissenting report by Labor Senators	81
Coalition Senators' Dissenting Report.....	91
Dissenting Report from Senator Roberts	99
Senator Nick Xenophon's Dissenting Report to the	147
Appendix 1	153
Submissions, additional information, tabled documents and answers to questions on notice.....	153
Appendix 2	157
Public hearings and witnesses	157

Acronyms and abbreviations

ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AGL	AGL Energy Limited
ANU	Australian National University
ARENA	Australian Renewable Energy Agency
ATSE	Australian Academy of Science, Technology and Engineering
CCGT	Combined Cycle Gas Turbine
COAG	Council of Australian Governments
COP21	Paris Climate Conference—21 st Conference of the Parties
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSP systems	Concentrating Solar-thermal Power systems
Genex	Genex Power, Australian public company
GW	gigawatt
MW	megawatt
MWh	megawatt hour
NEM	National Electricity Market
NSW	New South Wales
OECD	Organisation for Economic Co-operation and Development
PCM	Phase Change Materials
PV	Photovoltaic
RET	Renewable Energy Target

TCS	Thermo-Chemical Storage
TES	Thermal Energy Storage
TESS-EC	Thermal Energy Storage System – Energy Consumer
TESS-GRID	Thermal Energy Storage System – bulk grid storage technology
TESS	Thermal Energy Storage System
TIPSA	Torrens Island Power Station near Adelaide
WEM	Wholesale Electricity Market

Executive summary

This inquiry has unfolded against a background of power shortages and black-outs, extreme weather events such as record heat waves and storms, and ongoing climate change denialism within the ranks of the Coalition government that has caused an abject failure on climate and energy policy at the national level.

A key contributor to the current situation was the decision by the Coalition to divorce energy policy from climate policy and remove a carbon price signal. Let us be clear: there never was any real-world rationale for the abolition of a carbon price. Instead, it was done for ideological reasons and base political gain. The schism wrought in Australian politics over climate and energy policy by the Coalition has been disastrous for political discourse in this country and is now having severe adverse economic, social and environmental consequences for the nation.

Australia's existing electricity network was built to support the outdated and dirty coal-fired power stations. The world is moving rapidly to decarbonise electricity supply and the current owners of coal-fired power stations were quite emphatic in telling this committee (and the concurrent Senate Environment and Communications References Committee inquiry into the retirement of coal-fired power stations) that they are getting out of coal and have no intention of building any more coal-fired power stations. By definition, therefore, coal has no role to play in a secure energy future. Coal-fired power stations are being closed down and coal is in structural decline.

The market has moved. Investors have now priced climate risk into their calculations about the sources of future electricity generation. Investors know that a price on carbon is inevitable, but the debacle around climate and energy policy has left investors guessing about the timing and size of the price on carbon. In sum, the Coalition government's lack of any coherent policy on climate change and energy has led to an investment strike in sections of the energy sector that has imperilled the security and resilience of Australia's electricity infrastructure. The committee does recognise however that, while there is an investment strike in parts of the fossil fuel based energy generation market, multiple significant projects are being privately funded currently in the renewable energy sector. It is a testament to the economic viability of renewable energy projects that that investment is taking place, despite the outdated regulatory structure of the National Energy Market (NEM) and the ongoing carbon policy uncertainty at a Federal level.

Both the Australian Greens and the Australian Labor Party have long advocated the need for a clear, consistent, long-term price signal for carbon emissions. Coal has never had to pay for the enormous burden it has imposed on society for its role in causing climate change. The introduction of a market-based carbon trading scheme would effectively end the decades-long implicit subsidy that coal has received in the electricity generation market. Yet, like the proverbial ostrich, the Coalition government has buried its collective head in the coalmine and refuses to address in any meaningful way the crisis facing the nation. It used to be said that the Coalition was on the wrong side of history when it came to climate change and energy policy.

Yet it is now abundantly clear that the Coalition is also on the wrong side of the market.

Australia needs to move urgently to renewable sources of energy for electricity production in order to meet its international obligations for reducing emissions. Instead of gloating about its destruction of an effective carbon pricing mechanism, and propagandising on the floor of Parliament about a redundant technology (coal), the Coalition government has a responsibility to build a national consensus on carbon pricing. A range of stakeholders including BHP Billiton, Energy Networks Australia, Energy Australia, AGL Energy Ltd, Origin Energy, the Business Council of Australia and the National Farmers' Federation have demanded that the government put in place a price on carbon emissions. Yet the Coalition government has pre-emptively ruled out carbon pricing in an attempt to appease the climate deniers that have shackled government policy on this matter.

The terms of reference for this inquiry do not refer to the contribution of gas-fired power stations in improving the resilience of Australia's electricity infrastructure. Nevertheless, as part of the wider economic context, it is germane to touch on the potential role of natural gas in Australia's electricity production. Natural gas was once touted as the fuel that would ease the transition from Australia's heavy reliance on coal-fired electricity to an electricity grid powered by renewable energy sources.

However, the evidence received during this inquiry indicates that there are serious questions about whether gas can adequately fill this transitional role. Australia has a plentiful supply of natural gas. Yet the bulk of Australia's natural gas is liquefied and shipped offshore, primarily to fill long term export contracts to Japan, Korea and China. The export of the vast majority of Australia's natural gas has occurred because of the relatively high prices that were achieved overseas when long-term supply contracts were first signed. Even though the international gas price has now fallen substantially, the evidence suggests that the amount of Australia's gas being exported will increase even further in the future in order to fulfil existing long-term supply contracts overseas.

The entry of the east coast of Australia into the global gas market through the construction of the liquefaction plants near Gladstone in Queensland has had a dramatic impact on the domestic gas market. The domestic gas market is now in severe shortage, and this appears unlikely to change as increasing gas exports suck ever more gas away from the domestic market. It is therefore hardly surprising that domestic gas prices on the east coast of Australia have soared.

It has been suggested that the shortage of gas on the east coast could be alleviated by opening up more farmland to relatively high-cost unconventional gas mining such as coal seam gas. Quite apart from the irreparable damage that would be done to valuable farmland, the fugitive emissions from unconventional gas mining indicate that the greenhouse gas emissions from using this source of gas as a power generation source are every bit as bad as using coal. Furthermore, the misplaced notion that coal seam gas could provide a solution to the gas shortage on Australia's east coast displays a profound ignorance of how the market works. Any unconventional gas will surely find its way onto the export market if, as key witnesses indicated, the export market for gas is under-supplied in the future.

A gas reservation policy has also been touted as a potential solution to the east coast gas shortage. However, there is no guarantee that a gas reservation policy will reduce gas prices on the domestic market. Furthermore, there is a risk that a gas reservation policy would deter the necessary investment in, and deployment of, renewable energy.

Much has been made of the problems that intermittent renewable energy generation poses for the reliability of the electricity grid. The factors outlined above regarding the use of gas as a back-up source of power generation highlight the urgency of ensuring the security of Australia's electricity networks through a combination of storage technologies and decentralised electricity generation.

Fortunately, the committee received abundant evidence that a diverse range of complimentary storage technologies—including off-river pumped hydro, thermal energy storage, and batteries—are able to overcome the problems of intermittent generation and allow the grid to be converted to 100 per cent clean renewable energy at minimum cost.

Off-river pumped hydro can be developed on a small scale with minimal negative environmental impacts (in contrast to traditional large-river hydroelectric dams). Pumped hydro is a widely-used and well-developed technology with a strong track record. One utility-scale off-river pumped hydro project is being developed in Australia in a disused mine site in Northern Queensland, while a feasibility study in the Spencer Gulf in South Australia is examining a coastal pumped hydro system which would only require a single reservoir and has the potential to be co-located near wind and solar electricity generators.

The Australian National University is also conducting a study to identify suitable sites for off-river energy storage. Its initial report found a wealth of potential sites across the country. The committee is of the view that this study should be fast-tracked and that the Commonwealth government should commission a full scoping study to evaluate as a matter of priority issues such as the selection, planning and environmental assessments for the most appropriate off-river sites.

The committee also heard about two thermal energy storage technologies. The first, molten salt with solar thermal power is in operation overseas and is currently being proposed for a site in South Australia. The second, molten silicon, was initially developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and appears capable of being used 'behind the meter' and at intermediate scales.

In addition, both off-river pumped hydro and thermal energy storage offer a range of ancillary benefits that are critical for the security of grid networks, and these are discussed later.

The committee received evidence that perhaps the quickest solution to the immediate requirements of the national grid is the immediate roll-out on a massive scale of decentralised battery storage and smart technologies on various scales. Several battery technology proponents based in Australia have been working on storage solutions for several years and have identified locations where the technology can be deployed now.

Battery storage solutions have particular benefits:

- Firstly, if these projects are begun now, they could be in place ahead of the anticipated energy shortfalls next summer. Let there be no doubt about the speed with which this could occur: a newly-announced 330 megawatt solar farm with 100 megawatt battery storage located in South Australia is expected to be completed by the end of 2017.
- Secondly, the ability of people to produce, consume, store, aggregate and trade electricity allows for the democratisation and decentralisation of grid networks and the reduction of energy bills for households. It effectively puts power back in the hands of the people. Decentralisation of generation increases the resilience of the network as localised events have a limited impact. An added benefit of this transformation will be the reduction of rent-seeking behaviour by the major centralised players in the current electricity system who have profited at community expense by commodifying what is an essential service and what used to be considered a public good.

However, the committee emphasises that it is not endorsing one type of storage technology over another. On the contrary, the committee is of the view that a diversity of storage technologies in geographically diverse locations and at a diversity of scales is most likely to offer a complimentary array of services to households, businesses and industry and to contribute favourably to the resilience of grid networks.

Furthermore, the evidence is clear that only a diverse mix of storage technologies will provide grid networks with the full range of essential ancillary services—such as very fast primary frequency response, system inertia, spinning reserve and synchronous capacity for frequency and voltage support, energy balancing, and black-start capability—that are essential for the security of the electricity system.

The committee also received a wealth of evidence that Australia is well-endowed with renewable energy resources and that the renewable energy and energy storage transformation will create significant economic opportunities including a wave of new jobs that, if done in a well-planned way, will help secure a just transition for workers previously employed in the old energy systems.

The committee notes and commends recent initiatives of state governments, in particular the South Australian and Victorian governments, to support battery storage.

However, there are significant barriers to the introduction of energy storage technologies. The committee heard evidence that the rules that govern the NEM are arcane and no longer fit for purpose. The current rules favour the large fossil fuel generators who are able to game that system at community expense. At the same time, the rules systematically discriminate against storage systems. Yet modern electricity networks need far greater flexibility to respond rapidly to fluctuations in supply and demand. Storage systems such as batteries and pumped hydro can respond rapidly and are critical to balancing an electricity network.

The bidding and settlement systems under the NEM are out of alignment. Bids are accepted on five minute intervals, whereas payments are averaged over a 30 minute period. This means that storage systems such as batteries which are able to respond in seconds and milliseconds to sudden fluctuations in the system are unable to capture

the full value of the services that they offer because those high-value services may only be needed for a one minute, five minute or ten minute interval, and yet the price received could be averaged down over a half hour period. All the evidence available to the committee made it clear that the 30 minute settlement period for prices needs to be urgently changed to a five minute settlement period in order to encourage the necessary investment in storage that will provide electricity networks with the resilience and flexibility to respond to current and future challenges.

Evidence provided to the committee concerning the delay in the implementation of the five minute rule and the capacity for other rules to produce perverse and unintended outcomes demonstrate a deeper problem: the reluctance of the rule maker to embrace any change in a timely manner. The Australian Energy Market Commission (AEMC) is in need of fundamental reform. It is clearly both captive to the incumbent industry and hostile to the inevitable transition away from the current status quo. If the AEMC is unable to adequately address these concerns in a reasonable timeframe, it should be abolished and replaced with a more responsive and accountable regulatory body that is actually fit for purpose.

In summary, two key policy changes need to be made to ensure the market functions in the national interest. First, it is vital that a market signal is put in place to price carbon. This will provide business with increased certainty, allowing them to invest even more confidently in the clean renewable energy generation technologies required to reduce emissions and ensure a clean grid. Secondly, the payment settlement rules that operate in the NEM need to be changed to five minute intervals in order to encourage the rapid uptake of energy storage solutions.

Despite the enormous opportunities from energy storage and the rhetorical flourishes from the Prime Minister regarding storage, the Commonwealth government has failed to put in place policies that support businesses, households and grid level storage.

A feasibility study into Snowy Hydro pumped hydro is no substitute for comprehensive national policies and regulatory changes that will drive change across the whole grid and system.

The committee also found that these challenges to the electricity system will be exacerbated as climate change loads the dice in favour of more severe and, in some cases, more frequent extreme weather events.

The recent South Australian blackout caused by extreme weather toppling power pylons, the recent impact of heatwaves on fossil fuel generation in New South Wales (NSW) and the impact of Cyclone Debbie and subsequent floods in Queensland and NSW on electricity distribution highlight the effect extreme weather events can have on our electricity system.

Fortunately the solutions to the problem of transitioning our electricity grid to cleaner energy will also make our grid more resilient and better able to cope with the challenges of climate change as our energy generation becomes more diverse and storage proliferates through households, businesses and the grid.

In summary, the committee is strongly of the view that a diversity of storage technologies including batteries, thermal energy storage, and off-river pumped hydro, combined with decentralised generation and storage, will address the issues of

intermittency associated with wind and solar PV electricity generation, will help balance the grid, will ensure that grid networks are provided with the full range of necessary ancillary services, and will therefore significantly improve the resilience of Australia's electricity infrastructure in a warming world.

Recommendations

Recommendation 1

1.24 The committee recommends that the Commonwealth government adopt the recommendations made by the Senate Environment and Communications References Committee in its final report into the retirement of coal fired power stations.

Recommendation 2

2.84 The committee recommends that the Finkel Review incorporate the impacts of climate change on electricity security into its consideration and recommendations.

Recommendation 3

3.113 The committee recommends that the Commonwealth government conduct a detailed scoping study to evaluate options for distributed generation, new software services, and storage technologies to contribute to the resilience of Australia's electricity networks.

Recommendation 4

4.44 The committee recommends that the Commonwealth government continue and expand the Renewable Energy Target beyond 2020.

Recommendation 5

4.85 The committee recommends that the settlement time in the spot market be reduced from 30 minutes to 5 minutes, with phase-in of this rule change to be completed before 1 November 2017, and for the reliability of electricity frequency to be supported by new markets for additional services to support the grid.

Recommendation 6

4.86 The Committee recommends wholesale reform of the Australian Energy Market Commission (AEMC), to guarantee faster decision making and a prioritisation of the long term interests of the consumer over the interests of incumbent power generators, and a much tighter supervisory role over the Commission for the Commonwealth Energy Minister.

Recommendation 7

4.87 The committee recommends that the Finkel Review identifies other major rule impediments to assist in the full integration of renewable energy and storage with a view to speeding up the Australian Energy Market Commission (AEMC)

processes in regards to their reform. These should then be presented to the AEMC as an urgent agenda of reform work to be prioritised and completed within six months.

Recommendation 8

4.88 The committee recommends that investment in the renewable energy sector be further encouraged through the introduction of a market-based carbon trading scheme.

Recommendation 9

4.100 The committee recommends that the Finkel review specifically examine the market rule change introduced in 2001 redefining of the normal operating band from 49.9Hz to 50.1Hz to 49.85Hz to 50.15Hz, as well as the impact that change had on total system reliability and whether it should be reversed.

Recommendation 10

4.112 The committee recommends that the Commonwealth government undertake a detailed review of policy and regulatory barriers to, or tariff structures that hinder the implementation of, energy storage technologies.

Recommendation 11

4.113 The committee notes that, despite the Prime Minister's rhetoric on battery storage, the Commonwealth government has failed to put in place any policies that support businesses or households to invest in energy storage. The committee recommends the Commonwealth government put in place policies to support businesses and households to invest in energy storage, new software services and encourage grid decentralisation, resilience and greater energy security.

Chapter One

Introduction

1.1 On 12 October 2016, the Senate resolved to establish the Select Committee into the Resilience of Electricity Infrastructure in a Warming World to inquire into and report on the following matters by 10 February 2016:

- (a) the role of storage technologies and localised, distributed generation to provide Australia's electricity networks with the resilience to withstand the increasing severity and frequency of extreme weather events driven by global warming;
- (b) recommend measures that should be taken by federal, state and local governments to hasten the rollout of such technologies in order to:
 - (i) create jobs in installation, manufacture and research of storage and distribution technologies,
 - (ii) stimulate household and business demand for storage technologies,
 - (iii) anticipate the rapid deployment of localised distributed generation through changes to market rules,
 - (iv) drive the reduction in technology costs through economies of scale, and
 - (v) seize on the opportunities to be a global leader in deploying storage technologies because of Australia's high fixed electricity tariffs and significant penetration of rooftop solar; and
- (c) any other relevant matters.¹

Conduct of the inquiry

1.2 The committee would like to thank all the organisations and individuals that contributed to the inquiry.

1.3 A list of submitters to the inquiry is provided in Appendix 1. The committee has published 56 submissions. The committee advertised the inquiry on its website and wrote to organisations and individuals inviting submissions by 27 January 2017. The committee extended the closing date for submissions to 3 February 2017, and continued to accept submissions after this date.

1.4 On 29 November 2016, the Senate agreed to extend the inquiry's reporting date from 10 February 2017 to 24 March 2017.² On 22 March 2017, the Senate agreed to extend the reporting date to 7 April 2017.

1 *Journals of the Senate*, No. 10, 12 October 2016, p. 313.

2 *Journals of the Senate*, No. 21, 29 November 2016, p. 658.

1.5 A list of witnesses who gave evidence at public hearings is provided in Appendix 2. The committee held three public hearings in:

- Canberra on 10 February 2017;
- Adelaide on 20 February 2017; and
- Melbourne on 7 March 2017.

Note on references

1.6 References in this report to the Hansard for the public hearings are to the proof Hansard. Please note that page numbers may vary between the proof and the official transcripts.

Structure of the report

1.7 This report comprises four chapters. The matters covered in the remaining chapters are outlined below:

- Chapter 2 provides the context on a warming world, the implications of climate change for Australia's electricity networks, the Paris Climate Agreement, the main sources of electricity generation in Australia, and the National Electricity Market including its regulatory framework and the issues that it is facing.
- Chapter 3 assesses the resilience that various storage technologies and distributed generation are able to provide to Australia's electricity infrastructure.
- Chapter 4 discusses the imperatives for policy coherence within the context of a national energy plan.

Terminology

1.8 The Australian Energy Market Commission (AEMC) notes that 'Australia's energy policy objectives focus on promoting the long-term interests of consumers with respect to the price, quality, reliability and security of electricity services'.³

1.9 The AEMC define security and reliability as follows:

- Security—a secure power system is one that is being operated or managed such that all vital technical parameters such as voltage, equipment loading and power system frequency are within design limits and are stable and all persons are safe.
- Reliability—a reliable power system is one that has a high likelihood of supplying all consumer needs.⁴

3 Australian Energy Market Commission, *Integration of energy and emissions reduction policy*, 9 December 2016, p. i, <http://www.aemc.gov.au/Markets-Reviews-Advice/Integration-of-energy-and-emissions-reduction-poli/Final/AEMC-documents/Final-Report.aspx> (accessed 27 March 2017).

1.10 The Energy Change Institute at the Australian National University (ANU) describe resilience as follows:

In the context of this inquiry, resilience refers to the ability of the electricity infrastructure (generation, transmission, and distribution systems) to maintain uninterrupted supply of power to customers, in the face of inputs or external factors that are changing significantly on either very short to long time scales, and/or to restore that supply in the event of an interruption.⁵

Other inquiries

1.11 This inquiry into electricity infrastructure is not the first conducted in Australia in recent times. The committee acknowledges the work that has been and is being undertaken to explore alternative energy futures. In particular, the committee notes the following reports.

Finkel Review of Energy Security

1.12 Following the state-wide blackout in South Australia in September 2016, on 7 October 2016 the Council of Australian Governments (COAG) Energy Council announced A National Energy Review by Australia's Chief Scientist Dr Alan Finkel AO.⁶

1.13 The Finkel review will enable the COAG Energy Council to:

- properly understand the causes of recent events; and
- examine and advise on the broader issues facing the system due to the increasing penetration of intermittent generation'.⁷

1.14 The Finkel review will consolidate work initiated by the COAG Energy Council on energy security and consider other avenues to develop a national reform blueprint to maintain energy security and reliability within the National Electricity Market (NEM). Along with domestic sources, the United Kingdom, United States and the International Energy Agency will provide international input into the review.⁸

4 Australian Energy Market Commission, *Integration of energy and emissions reduction policy*, 9 December 2016, pp. i–ii.

5 ANU Energy Change Institute, *Submission 28*, p. 5.

6 COAG Energy Council, *Blueprint for Energy Security in the National Electricity Market: Independent Review*, 7 October 2016, <http://coagenergycouncil.gov.au/publications/independent-review-terms-reference> (accessed 17 November 2016).

7 COAG Energy Council, *Blueprint for Energy Security in the National Electricity Market: Independent Review*, 7 October 2016.

8 The Hon. Josh Frydenberg MP, Minister for the Environment and Energy, *UK and US Agree to Provide Input into Australian Energy Security Review*, Media Release, 16 November 2016, <http://www.joshfrydenberg.com.au/guest/mediaReleasesDetails.aspx?id=283> (accessed 17 November 2016).

1.15 A preliminary report from the Finkel review was delivered to the Commonwealth government in December 2016. Amongst other things, the preliminary report addressed issues of, and solutions to, intermittent generation:

The shift from coal-fired generators to wind and solar PV generators has implications for security and reliability. These variable renewable electricity generators do not inherently provide usable inertia to support power system security. They are also much less able to contribute to other ancillary services required to maintain a secure and reliable supply of power.

Fortunately, solutions are available to effectively integrate variable renewable electricity generators into the electricity grid, but we will have to change the way we operate. Such solutions include intelligent wind turbine controllers, batteries and synchronous condensers, all of which can contribute to system security. But the NEM does not currently encourage their adoption. Emerging markets for ancillary services, required to maintain system security, have not kept pace with the transition. New and updated frameworks, technical standards and rules may be required.⁹

1.16 On 17 February 2017, Dr Finkel AO addressed the COAG Energy Council on 'options to fast-track 'proof-of-concept' projects designed to increase security and reliability in Australia's physical electricity system as the generation mix continues to change into the future'.¹⁰

1.17 Dr Finkel's final report is expected in the first half of 2017.

Senate inquiry into the retirement of coal fired power stations

1.18 On 13 October 2016, the Senate referred the following matter to the Senate Environment and Communications References Committee for report by 1 February 2017 (since extended to 29 March 2017):

- a. the experience of closures of electricity generators and other large industrial assets on workers and communities, both in Australia and overseas;
- b. the role that alternative mechanisms can play in alleviating and minimising the economic, social and community costs of large electricity generation and other industrial asset closures, drawing on experiences in Australia and overseas;
- c. policy mechanisms to encourage the retirement of coal-fired power stations from the National Electricity Market, having regard to:
 - i. the 'Paris Agreement' to keep global warming below 2 degrees Celsius, and ideally below 1.5 degrees Celsius,

9 Dr Alan Finkel AO, *Preliminary Report of the Independent Review into the Future Security of the National Electricity Market*, 14 December 2016, p. 3.

10 COAG Energy Council, *9th COAG Energy Council Meeting Communique*, 17 February 2017, p. 1, <http://www.coagenergycouncil.gov.au/publications/9th-coag-energy-council-meeting-communique-0> (accessed 14 March 2017).

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- ii. the state and expected life span of Australia's coal-fired power plants,
 - iii. the increasing amount of electricity generated by renewable energy and likely future electricity demand,
 - iv. maintenance of electricity supply, affordability and security, and
 - v. any other relevant matters;
- d. policy mechanisms to give effect to a just transition for affected workers and communities likely impacted by generator closures, as agreed in the 'Paris Agreement', including:
 - i. mechanisms to ensure minimal community and individual impact from closures, and
 - ii. mechanisms to attract new investment and jobs in affected regions and communities;
 - e. the appropriate role for the Federal Government in respect of the above; and
 - f. any other relevant matters.

1.19 The terms of reference for the Senate Environment and Communications inquiry are set out in full to highlight the considerable overlap with the committee's own inquiry. Where this committee's remit includes the potential of storage technologies and localised distributed generation to provide the resilience to withstand climate change, the Environment and Communications committee has a greater focus on the experiences of coal fired power station closures in terms of the economic, social and community costs. Accordingly, this committee acknowledges but will not address in detail the significant weight of evidence received on the community and individual impact of the closure of coal-fired power stations.

1.20 Rather, this inquiry has examined measures that should be taken by all levels of government to hasten the rollout of new technologies to ensure the resilience of Australia's electricity networks, including changing market rules and stimulating household and business demand. These matters were addressed to some extent in the Senate Environment and Communications References Committee's interim and final reports. The interim report, presented on 28 November 2016 contained the following relevant recommendations:

Recommendation 1

The committee recommends that the Australian Government adopt a comprehensive energy transition plan, including reform of the National Electricity Market rules.

Recommendation 2

The committee recommends that the Australian Government, in consultation with industry, community, union and other stakeholders, develop a mechanism for the orderly retirement of coal fired power stations to be presented to the COAG Energy Council.

Recommendation 3

The committee recommends that the Australian Government, through representation on the COAG Energy Council, put in place a pollution reduction objective consistent with Australia's obligations under the Paris Agreement in the National Electricity Objectives.

Recommendation 4

The committee recommends that the Australian Government establish an energy transition authority with sufficient powers and resources to plan and coordinate the transition in the energy sector, including a Just Transition for workers and communities.¹¹

1.21 The Senate Environment and Communications References Committee's final report, presented on 29 March 2017, added five further recommendations to those contained in the interim report:

Recommendation 5

The committee recommends:

- **That the Australian Government commission a comprehensive and independent assessment of the health impacts of coal fired power stations.**
- **That the Australian Government develop a load-based licencing arrangement for coal fired power stations for adoption at COAG based on the New South Wales Load-Based Licencing scheme, with fees that reflect the health impacts and other externalities of power station emissions.**
- **That the Australian Government take additional measures to ensure compliance with the standards set in the National Environmental Protection (Air Quality) Measure and - in the case of sulphur dioxide and nitrogen dioxide - international best practice standards. In regions where these standards are exceeded such as the Hunter and Latrobe Valleys, coal fired power stations must be compelled to reduce emissions to levels below the NEPM standards.**
- **That the Australian Government ensure a more rigorous assessment of power station emissions through an independent audit of reports provided through the National Pollutant Inventory.**

Recommendation 6

The committee recommends that the Commonwealth and state energy ministers should undertake a national audit of likely rehabilitation costs for existing coal mines and power stations and assess these costs against the current provisions or bond arrangements.

11 Senate Environment and Communications References Committee, *Retirement of coal fired power stations: Interim report*, November 2016, p. vii.

The committee recommends that the Commonwealth and state energy ministers should also work to develop a common approach to setting rehabilitation bonds to ensure that rehabilitation costs are properly provisioned for.

Recommendation 7

The committee recommends that the Australian Government continue and expand the Renewable Energy Target beyond 2020 and consider adopting renewable energy reverse auctions such as adopted by the ACT to bring more new generation into the national electricity market.

The committee also recommends that the Australian Government support the continuing deployment grid level battery storage and of household solar and battery storage technologies, including making the necessary regulatory changes, such as aligning the settlement and bidding time periods in the National Electricity Market, to encourage the utilisation of products that promote decentralisation of electricity production while enhancing the stability of the grid.

Recommendation 8

The committee recommends that the Australian Government commit to not provide any direct funding, subsidies or other support for the construction of new coal fired power stations in Australia.

Recommendation 9

The committee recommends that the Australian Government reverse its ideological opposition to the introduction of a scheme for managing the transition in the electricity sector such as an Emissions Intensity Scheme or the setting of pollution intensity standards and commit to considering fairly all policy options presented by the forthcoming final report of the Finkel Review.¹²

Committee view

1.22 These recommendations are so congruent with the committee's own findings that they are echoed in this report. Additional evidence gathered by this committee in support of those recommendations is available in later chapters.

1.23 The committee encourages all levels of government to pay close attention to its findings.

Recommendation 1

1.24 The committee recommends that the Commonwealth government adopt the recommendations made by the Senate Environment and Communications References Committee in its final report into the retirement of coal fired power stations.

12 Senate Environment and Communications References Committee, *Retirement of coal fired power stations: Final report*, March 2017, pp. vii-viii.

Senate inquiry into the performance and management of electricity network companies

1.25 On 2 October 2014, the Senate referred an inquiry into the performance and management of electricity network companies to the Senate Environment and Communications References Committee. That committee presented three reports to the Senate. An interim report on 30 April 2015 with 18 recommendations, included the following:

Recommendation 15

The committee recommends that the Australian, state and territory governments increase and prioritise efforts to ensure that networks are prepared to efficiently respond to changes in the energy market, in light of:

- the increased uptake of small-scale solar generation;
- emerging energy storage technologies;
- the anticipation of customers going 'off-grid';
- the anticipation of further disruptive technologies; and
- the certainty of value destruction as a result of current business models.¹³

1.26 A government response received on 27 April 2016 accepted recommendation 15, stating that the COAG Energy Council had agreed in December 2015 to a Strategic Work Program that would 'work towards successfully transitioning energy markets to a future where energy provision is more decentralised and dynamic'.¹⁴

1.27 The government response further explained that the Strategic Work Program:
...aims to ensure regulatory frameworks are ready to cope with the effects of emerging technologies such as batteries and enable consumers to benefit from innovative services while mitigating risks.¹⁵

1.28 Officials were 'due to report back to the COAG Energy Council in the first instance at its next meeting in July 2016'.¹⁶ However, at its August 2016 meeting, the COAG Energy Council added 'consideration of the economic and operational impacts

13 Senate Environment and Communications References Committee, *Performance and management of electricity network companies: interim report*, April 2015, p. xv.

14 Australian Government, *Response to the Environment and Communications References Committee report: Performance and management of electricity network companies*, April 2016, pp. 11–12.

15 Australian Government, *Response to the Environment and Communications References Committee report: Performance and management of electricity network companies*, April 2016, p. 11.

16 Australian Government, *Response to the Environment and Communications References Committee report: Performance and management of electricity network companies*, April 2016, p. 12.

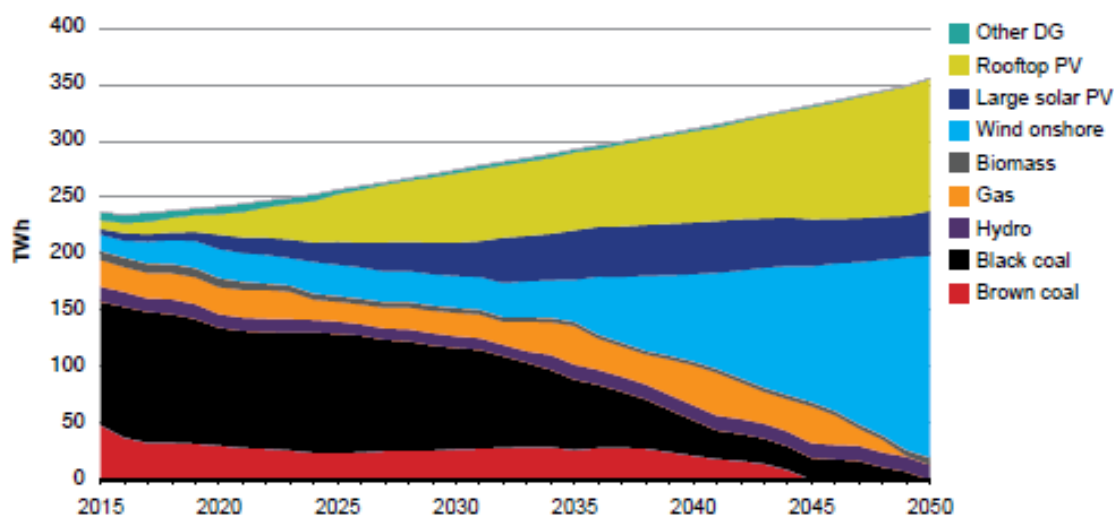
of existing state and territory emission reduction policies' to the remit of advice.¹⁷ The item was not addressed in communiqués from the Council's subsequent meetings of 14 December 2016 and 17 February 2017.¹⁸

Energy Networks Australia and CSIRO: Electricity Network Transformation Roadmap: Key Concepts Report

1.29 In December 2016, Energy Networks Australia and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) released the *Electricity Network Transformation Roadmap: Key Concepts Report*, which set out a pathway for Australia's transition to a more decentralised, clean electricity system. Energy Networks Australia is the peak national body representing gas distribution and electricity transmission as well as distribution businesses.

1.30 Modelling undertaken for the roadmap identified a mix of power generation which would allow Australia to meet wholesale energy requirements and achieve zero net emissions by 2050.¹⁹

Figure 1: Plausible projection of Australia's changing energy mix to 2050.



Source: Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Key Concepts Report*, December 2016, p. iii.

17 COAG Energy Council, *5th COAG Energy Council Meeting Communiqué*, 19 August 2016, p. 2, <http://www.coagenergycouncil.gov.au/publications/5th-coag-energy-council-meeting-communication-19-august-2016> (accessed 21 March 2017).

18 COAG Energy Council, *Meeting Communiqué, 8th COAG Energy Council Meeting Communiqué*, 14 December 2016, <http://www.coagenergycouncil.gov.au/publications/8th-coag-energy-council-meeting-communication> (accessed 21 March 2017); COAG Energy Council, *9th COAG Energy Council Meeting Communiqué*, 17 February 2017, <http://www.coagenergycouncil.gov.au/publications/9th-coag-energy-council-meeting-communication-0> (accessed 21 March 2017).

19 Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Key Concepts Report*, December 2016, p. iii.

Committee view

1.31 The committee encourages the government to take note of the roadmap.

Australian Energy Market Commission: 2016 Retail Competition Review

1.32 The third annual review of competition in electricity and gas markets across jurisdictions in the NEM was undertaken by the Australian Energy Market Commission (AEMC) at the request of the COAG Energy Council. The July 2016 report found that:

...competition continues to be effective in most jurisdictions and is delivering benefits for customers. We have also found that there is a need to make it easier for customers to access the choices available to them. New research undertaken for this year review reveals that this is particularly important for certain customer segments as new technology expands the range of options available in the market.²⁰

1.33 The AEMC made the following recommendations:

1. Jurisdictions continue to phase out retail price regulation for electricity and natural gas where effective retail competition can be demonstrated, as agreed under the Australian Energy Market Agreement.
2. Jurisdictions coordinate the development of NEM-wide awareness and engagement programs to make it easier for customers to access the best options for their circumstances and improve customer confidence in the energy markets.
3. Jurisdictions review concession policies to assess opportunities to better target them to customers most in need and to harmonise their structure across jurisdictions, where substantive differences exist.
4. Jurisdictions continue to harmonise regulatory arrangements to reduce the long-term costs of new businesses or retailers competing across jurisdictions.²¹

AEMC final report on the integration of energy and emissions reduction policy

1.34 The AEMC released its final report into the integration of energy and emissions reduction policy on 9 December 2016. The report examined the following three emissions reduction mechanisms that could be applied to the wholesale electricity generation sector to assist in the achievement of Australia's 2030 emissions reduction target:

- an emissions intensity scheme;
- an extension of the Large-scale Renewable Energy Target; and
- government regulation (forced closure of certain generators).²²

20 Australian Energy Market Commission, *2016 Retail Competition Review: Final Report*, 30 June 2016, p. i.

21 Australian Energy Market Commission, *2016 Retail Competition Review: Final Report*, 30 June 2016, p. v.

1.35 The report found that an emissions intensity scheme would have 'the lowest impact on wholesale prices, the lowest resource costs and the lowest cost of abatement to meet a given emissions reduction target'²³ where resource costs are defined as 'the costs of building new capacity (capital, fuel and labour), as well as the increase in operating costs from switching from lower cost to higher cost fuels (e.g. coal to Combined Cycle Gas Turbine (CCGT)), in order to achieve the emissions reduction target'.²⁴

1.36 Modelling for the AEMC report has been criticised for assuming much lower gas prices than current market conditions and for projected renewable energy prices that are significantly higher than current market projections.²⁵

1.37 The state and federal ministers acknowledged the report's release at the COAG Energy Council meeting on 14 December 2016, and the analysis was reported as being considered by Dr Finkel over the course of his review.²⁶

22 Australian Energy Market Commission, *Integration of energy and emissions reduction policy*, 9 December 2016, p. iii.

23 AEMC, *Integration of energy and emissions reduction policy*, 9 December 2016, p. viii.

24 AEMC, *Integration of energy and emissions reduction policy*, 9 December 2016, p. viii, fn 8.

25 Giles Parkinson, Modelling from government advisor shows high RET may be cheapest option, *Renew Economy*, 13 December 2016, <http://reneweconomy.com.au/modelling-from-government-advisor-shows-high-ret-may-be-cheapest-option-82484/> (accessed 3 April 2017).

26 COAG Energy Council, Meeting Communique, *8th COAG Energy Council Meeting Communique*, 14 December 2016; p. 1, <http://www.coagenergycouncil.gov.au/publications/8th-coag-energy-council-meeting-communique> (accessed 14 March 2017).

Chapter 2

Background

Introduction

2.1 This chapter begins with a brief outline of Australia's warming climate and the extreme weather events associated with climate change. It then looks at the implications of climate change and extreme weather events for Australia's electricity infrastructure. Australia's commitments under the Paris Climate Agreement are outlined, followed by a summary of the emissions in Australia's electricity sector. This is followed by a section on the main generation technologies currently used in Australia. The chapter then examines the National Electricity Market (NEM) and its regulatory framework, before concluding with a summary of the challenges facing the NEM as it moves towards a low and ultimately zero emissions energy future.

A warming world

2.2 Australia's climate is warming. The average air temperature has increased by around 0.9 degrees Celsius since national records began in 1910. Since the 1950s, each decade has been warmer than the preceding decade.¹

2.3 The Australian Academy of Science explains that human activities are amplifying the 'greenhouse effect' that is causing global warming:

Human activities are increasing greenhouse gas concentrations in the atmosphere. This increase is extremely likely to have caused most of the recent observed global warming, with CO₂ being the largest contributor. Some observed changes in Australia's climate, including warming throughout the continent and drying trends in the southwest, have been linked to rising greenhouse gas concentrations.²

2.4 The Australian government recognises the scientific evidence that the warming climate is predominantly due 'to the observed increases in human activities such as the burning of fossil fuels (coal, oil, and natural gas), agriculture and land clearing'.³

2.5 Nevertheless, during the course of the inquiry, witnesses were required to explain that the scientific academies of the world, including the United States, Britain, Germany, France, all the countries of Europe, Russia, China and India, as well as Australia, are 'clearly of the view that the link between carbon dioxide and other

1 Australian Government, Department of Environment and Energy, *Understanding climate change*, <https://www.environment.gov.au/climate-change/climate-science/understanding-climate-change> (accessed 16 March 2017).

2 Australian Academy of Science, *The science of climate change: questions and answers*, 2015, p. 5, available at <https://www.science.org.au/files/userfiles/learning/documents/climate-change-r.pdf> (accessed 16 March 2017).

3 Australian Government, Department of Environment and Energy, *Understanding climate change*.

greenhouse gas emissions and climate is a real one, and that humans have contributed the major part of the increase in greenhouse gases in the atmosphere over recent times'.⁴

2.6 Australia's warming climate has brought an increase in the severity of extreme weather events such as flooding, fire and drought. Indeed, Australia has already experienced the effects of climate change, particularly 'increases in extreme weather including longer and more severe heatwaves, increased bushfire weather, increased intensity of extreme rainfall events'.⁵

2.7 According to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology, under all future emissions scenarios, Australia will experience, amongst other effects of climate change, more heat extremes, more intense extreme rainfall events, a greater proportion of high intensity storms, more extreme fire-related weather in southern and eastern Australia, and a greater frequency of extreme drought.⁶

Committee view

2.8 The overwhelming weight of scientific evidence from around the world indicates that human activities are, in large measure, driving climate change. Furthermore, the scientific evidence indicates that climate change has already caused an increase in extreme weather events in Australia and will do so to an even greater extent in the future.

2.9 That the committee feels compelled to reiterate these basic facts about the scientific evidence is a damning indictment of the dire state of political discourse on the science of climate change in this country.

Implications of climate change for electricity networks

2.10 The economic consequences of extreme weather events are already substantial, and these negative impacts and economic costs are predicted to become vastly larger as the effects of climate change intensify. The committee received evidence from a range of submitters and witnesses, including electricity network providers, that a warming world poses significant challenges to the security and resilience of Australia's electricity infrastructure.

2.11 The CSIRO set out the enormous increase in the damage wrought on critical infrastructure by the rise in extreme weather events:

About \$450 million has been spent each year by governments on critical infrastructure restoration, which could rise to \$17 billion by 2050...the total

4 Professor Ross Garnaut, private capacity, *Committee Hansard*, 7 March 2017, p. 25.

5 Australian Government, *National Climate Resilience and Adaptation Strategy Summary*, 2015, p. 10, available at <https://www.environment.gov.au/system/files/resources/3b44e21e-2a78-4809-87c7-a1386e350c29/files/national-climate-resilience-and-adaptation-strategy.pdf> (accessed 16 March 2017).

6 Australian Government, *National Climate Resilience and Adaptation Strategy Summary*, 2015, p. 10.

economic costs...of natural disasters in Australia in 2015 exceeded \$9 billion, which is expected to double by 2030 and reach \$33 billion per annum by 2050...Both historical climate observations and climate projections into the future indicate that the frequency and intensity of many extreme weather events are on the rise. For this reason, there are likely to be significant benefits in directing investments towards mitigation efforts including improving infrastructure resilience to extreme weather events.⁷

2.12 The Electrical Trades Union drew attention not only to the impact of extreme weather events on electricity infrastructure, but also to the interdependency of electrical and other critical infrastructure:

The economic threat posed by the impacts of natural disasters to the Australian economy is staggering. More than a fifth of Australia's economic output is at high or extreme risk of disruption from cyclones, while more than a quarter of national gross domestic output is located in areas with high to extreme risk of flooding. Analysis undertaken by SGS Economics & Planning found that 11 per cent, or \$175 billion of national GDP, is located in areas subject to bushfire. Natural disasters and other large scale events that impact on electricity networks affect not only the electrical infrastructure in communities, but also many other infrastructure sectors, which are all interdependent with the electrical system...and often span several states and/or regions.⁸

2.13 Energy Networks Australia is the association that represents Australia's energy grid, supporting over 900,000 kilometres of electricity transmission and distribution lines. Mr John Bradley, Chief Executive Officer of Energy Networks Australia told the committee that:

Implications of climate change for our networks are significant, with potential for sea level rise, increased frequency and severity of extreme weather events and related events, including storms, cyclones, heat waves and bushfires. Given the long life of energy network assets, investment decisions made today must incorporate risk assessments from a whole diverse range of factors, including future climate change.⁹

2.14 Professor Ross Garnaut reminded the committee that the impact of extreme temperatures on electricity infrastructure can have disastrous consequences:

In the state of Victoria, the formal conclusions of the inquiry into the bushfires noted not only the role of extreme heat but also that developments through the interactions of extreme heat with electricity transmission contributed to the bushfires themselves.¹⁰

7 Commonwealth Scientific and Industrial Research Organisation (CSIRO), *Submission 23*, p. 3.

8 Electrical Trades Union of Australia, *Submission 53*, p. 14.

9 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 30.

10 Professor Ross Garnaut, private capacity, *Committee Hansard*, 7 March 2017, p. 20.

2.15 The Northern Alliance for Greenhouse Action pointed out that higher temperatures would place a greater burden on electricity networks as they work to meet a projected increase in peak demand:

...the cost to energy networks from climate change is estimated to be \$2.5bn over the next five years...the largest proportion of this cost arises from the requirement to augment networks to accommodate the increase in peak demand largely associated with air-conditioning use [although] this is likely to be a conservative estimate as the past few years have seen increased bushfire activity, increased intensity of storm events, and hotter and drier conditions.¹¹

Paris Climate Agreement

2.16 There is now global recognition of the catastrophic effects that will result without concerted efforts to dramatically reduce greenhouse gas emissions resulting from human activity.

2.17 The Paris Climate Conference (COP21) in December 2015 involved 195 countries signing the 'first-ever universal, legally binding global climate deal' setting out a global action plan to limit global warming to below 2°C.¹²

2.18 For the Paris Agreement to enter into force, at least 55 countries representing at least 55 per cent of global emissions were required to deposit their instruments of ratification. This was achieved when the European Union formally ratified the agreement, and it entered into force on 4 November 2016.¹³

2.19 Following a recommendation by the Joint Standing Committee on Treaties,¹⁴ the Prime Minister the Hon Malcolm Turnbull MP announced on 10 November 2016 that Australia would ratify the Paris Agreement:

The negotiation of the Paris Agreement was a turning point in the global transition to a lower emission future. Australia was one of more than 170 countries to sign the Agreement when opened for signature at the United Nations in New York in April 2016

...

Ratification of the Agreement confirms Australia's ambitious and responsible target to reduce emissions by 26 to 28 per cent below 2005 levels by 2030. This target is comparable with other advanced economies

11 Northern Alliance for Greenhouse Action, *Submission 17*, p. 1 referencing a quote from the 'Energy network infrastructure and the climate change challenge' report by Parsons Brinkerhoff to the Energy Networks Australia, <http://pandora.nla.gov.au/pan/120149/20100517-1251/www.ena.asn.au/udocs/PB-Report-and-Note.pdf>, March 2009, p. 1.

12 European Commission, *Climate Action: Paris Agreement*, https://ec.europa.eu/clima/policies/international/negotiations/paris_en (accessed 10 November 2016).

13 European Commission, *Climate Action: Paris Agreement*.

14 Joint Standing Committee on Treaties, *Report 163*, November 2016, p. xv.

and will halve our per capita emissions making it one of the highest targets in the G20 on that basis.¹⁵

Emissions in Australia's electricity sector

2.20 Australia's obligations under the Paris Agreement have a direct impact on the electricity sector because Australia's fossil fuel electricity generators, coal in particular, are a major source of greenhouse gas emissions.

2.21 In its 2016 report on policy options for Australia's electricity supply sector, the Climate Change Authority noted that coal-fired power accounted for 88 per cent of the emissions from electricity generation:

Of the generation sources that produce emissions, brown coal is the most emissions-intensive—that is, it produces the most greenhouse gas emissions per unit of generation—followed by black coal and gas...The total emissions from each fuel depend on the emissions intensity of the fuel itself and what share of total generation it makes up...Coal produces around 88 per cent of generation emissions, 35 per cent from brown coal and 53 per cent from black coal.¹⁶

2.22 Australia has an ageing fleet of high emissions coal-fired electricity generators. There are currently 24 coal-fired power stations operating in Australia. Nine coal-fired power stations were closed between 2010 and 2016 across the following states: New South Wales (three closures), Queensland (two closures), Victoria (two closures) and South Australia (two closures).¹⁷ In addition, Australia's oldest and most polluting power station, Hazelwood in the La Trobe Valley in Victoria, closed its doors at the end of March 2017.¹⁸

Australia's Electricity Generation

2.23 The following sections outline the main sources of power generation currently used in Australia, and the issues that the various generation technologies face as Australia and the rest of the world shifts to a low-emissions future.

15 Prime Minister the Hon Malcolm Turnbull MP, Ratification of the Paris Agreement on Climate Change and the Doha Amendment to the Kyoto Protocol, *Media Release*, 10 November 2016, <https://www.pm.gov.au/media/2016-11-10/ratification-paris-agreement-climate-change-and-doha-amendment-kyoto-protocol> (accessed 10 November 2016).

16 Australian Government, Climate Change Authority, *Policy Options for Australia's electricity supply sector: Special review research report*, August 2016, p. 15, <http://www.climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/SR%20Electricity%20research%20report/Electricity%20research%20report%20-%20for%20publication.pdf> (accessed 3 November 2016).

17 Senate Environment and Communications References Committee, *Retirement of coal fired power stations: Interim report*, November 2016, p. 5.

18 ENGIE, Hazelwood to close in March 2017, *Media Release*, 3 November 2016, <http://www.engie.com/en/journalists/press-releases/hazelwood-power-station-australia/> (accessed 21 March 2017).

Coal

2.24 Coal produced around 63 per cent of Australia's electricity in 2014–15, with black coal providing around 43 per cent and brown coal around 20 per cent.¹⁹

2.25 Within the NEM, coal accounts for 78 per cent of electricity generation and gas 9.9 per cent.²⁰

Coal-fired power is in structural decline

2.26 The imperative to address climate change by reducing greenhouse gas emissions has meant that the generation of electricity from coal-fired power stations is in structural decline as the world moves rapidly towards an economic transformation underpinned by clean energy sources.

2.27 It is crucial to recognise that the shift away from coal is being driven by the major energy players in the market. The committee received a raft of evidence that coal-fired generation has no future. Indeed, Australia's largest energy companies were quite clear that they have no intention of investing in coal-fired generation.

2.28 For example, Mr Jim Kouts, Head of Corporate Affairs at ENGIE in Australia, told the committee that 'we are moving out of coal'.²¹

2.29 Similarly, AGL Energy Limited's (AGL) Greenhouse Gas Policy states that AGL will not build, finance or acquire new conventional coal-fired power stations in Australia, nor extend the operating life of any of its existing coal-fired power stations.²²

2.30 When asked whether some gas-fired stations could be replaced with coal-fired stations as a way of dealing with the current domestic gas shortage, Mr Richard Wrightson, General Manager of Wholesale Markets at AGL, told the committee that AGL had no interest in developing further coal-fired power:

The issue is: can you then build coal to replace them in any meaningful time frame? It is not an area AGL, from a policy perspective, is interested in developing. Obviously we will use our existing coal assets to their maximum so that we can cover off our risk and exposures, but it is not an area that we see longer term being the key. It is about how you can develop renewables into that space and how you can firm up renewables and make

19 Australian Government, Department of Industry, Innovation and Science, Office of the Chief Economist, *Australian Energy Update*, October 2016, pp. 18–19, <http://www.environment.gov.au/energy/publications/australian-energy-update-2016>, (accessed, October 2016).

20 Senate Environment and Communications References Committee, *Retirement of coal fired power stations—Interim report*, November 2016, chapter 2, p. 3.

21 Mr Jim Kouts, Head of Corporate Affairs, ENGIE in Australia, *Committee Hansard*, 20 February 2017, p. 18.

22 AGL Energy Limited, *AGL Greenhouse Gas Policy*, 17 April 2015, p. 2, <https://www.agl.com.au/about-agl/media-centre/article-list/2015/april/agl-policy-to-provide-pathway-to-decarbonisation-of-electricity-generation>, (accessible from AGL, *Submission 56*, p. 7).

them reliable for the system so that we can use those to support our customer base.²³

2.31 AGL called for 'a market rule that suitably telegraphs the phase-out of legacy power plants' after 50 years.²⁴ They explained to the committee that:

This will enable market participants to plan and invest in the necessary generation and associated infrastructure. It will also minimise the impacts of short-notice periods for closure on wholesale electricity supplies, such as those experienced with the impending closure of the Hazelwood power station and the recent closures of the Northern and Playford coal power stations in South Australia.²⁵

2.32 AGL explained that a 50 year lifespan is being applied to their own facilities:

...at 50 years of age we say the end of tactical life has been achieved and you should shut down the unit. That is the process that we have established as part of our greenhouse gas policy that in 2022 will shut down the Liddell facility, in 2035 our Bayswater facility and in 2048 our Loy Yang facility.²⁶

Lack of investment prospects for coal fired power projects

2.33 Not only are the electricity generators getting out of coal, but investors have also deserted coal because it is simply uneconomic and the risks of investing in what will become stranded assets are too high.

2.34 For example, the Clean Energy Finance Corporation explained why it is highly unlikely to follow the Commonwealth government's suggestion to fund new coal-fired power stations, explaining that:

...in a market of such volatility it would be very difficult to find a private sector or a commercial investor making a decision to invest in a coal-fired power station in the Australian market today. So we, like a commercial investor, are very unlikely to find circumstances in which that would be an appropriate investment to expose the taxpayers to. Remember, we are investing the taxpayers' money. They are expecting us to operate commercially and carefully with that money, and we have to assess all of the investments appropriately.²⁷

23 Mr Richard Wrightson, General Manager, Wholesale Markets, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 6.

24 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, pp. 2, 4.

25 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 2.

26 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 4.

27 Mr Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation, *Committee Hansard*, 10 February 2017, p. 40.

2.35 Mr John Grimes, Chief Executive Officer of the Australian Solar Council, expressed similar views, telling the committee that banks are almost universally pulling out of coal, and that many large proposed coal projects will not be financed.²⁸

2.36 The corollary of the move away from coal by energy companies is an increase in the use of other energy technologies to generate electricity. However, gas-fired power generation faces significant obstacles as set out below. Renewable energy technologies are summarised in subsequent sections, and the solutions to issues of intermittency are covered in chapter 3.

Gas

2.37 Gas fired power stations accounted for approximately 21 per cent of Australia's total electricity generation in 2014–15.²⁹

2.38 The role of gas in Australia's future energy mix is a matter of significant debate at the current time, due to its potential as a replacement for coal-fired baseload generation, and shortage and price issues in the Australian domestic gas market. The committee heard diverse evidence about the future role of gas in Australia's energy future.

2.39 Professor Garnaut noted that back in 2008 the *Garnaut Climate Change Review* saw a significant role for gas as a transition fuel that could be used to balance the intermittent sources of electricity provided by renewables. However, he explained that developments since then have reduced the potential for gas to fulfil that transition role:

Since then the price of gas has increased several fold, incidentally at a time when there has been a dramatic reduction in the price of gas in the rest of the world—roughly a falling by half to two-thirds in the United States at time when there has been trebling or more of domestic gas prices in Australia. That is a challenge for keeping down the cost of the transition to renewables. It means that the economically efficient role of gas is smaller than it would have been.³⁰

2.40 AGL told the committee that they 'see natural gas as being a necessary transition fuel over the next 10 to 20 years'.³¹

2.41 Similarly, ENGIE told the committee that gas-fired generation will continue to play a key role in the transition to a renewable energy economy:

28 Mr John Grimes, Chief Executive Officer, Australian Solar Council, *Committee Hansard*, 10 February 2017, p. 25.

29 Australian Government, Department of Industry, Innovation and Science, Office of the Chief Economist, *Australian Energy Update*, October 2016, p. 19, <https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/aes/2016-australian-energy-statistics.pdf> .

30 Professor Ross Garnaut, private capacity, *Committee Hansard*, 7 March 2017, p. 20.

31 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 6.

Five to 10 years ago gas was often referred to as a transitional fuel. I think gas-fired generation is the transitional fuel. Looking at the technology that is before us, whether you are out at solar thermal, solar PV or wind, I think gas has a big part to play as we transition... Most experts agree that gas is the transitional fuel as we work our way through the technology.³²

2.42 However, the committee heard that the move away from a carbon price signal has reduced the advantage that natural gas would have over coal as a lower-emissions fuel source:

The challenge for gas has been exacerbated by the move away from carbon pricing. Carbon pricing recognises the advantage of gas over coal. It penalises coal more heavily than gas... I note that, as with the old Australian form of carbon pricing, a carbon intensity scheme would restore the differential treatment of gas and higher-emissions sources of fossil energy.³³

Problems with the domestic east-coast gas market

2.43 Despite the views expressed above by the energy companies that gas has a role as a transition fuel, the committee heard a raft of evidence that the domestic east-coast gas market faces significant problems. These problems have been highlighted in South Australia. AGL argued that:

South Australia is heavily reliant on gas now with the closure of Northern [coal-fired] power station, and I would claim there is a fair dysfunction in the gas market, which has created most of the systemic problems we are seeing in South Australia.³⁴

2.44 AGL told the committee that there is limited access to flexible gas contracts in South Australia:

So one of the major reasons the contract market has become so illiquid in South Australia, which is a sure sign that you have problems at a competition level, is the inability to source gas flexibly so that we can make decisions to come in and come out of that market and to contract or not. We would love to be able to contract more in that marketplace. One of the main restrictors on being able to do that is access to flexible gas contracts that we are able to trade in and out of.³⁵

2.45 AGL told the committee that building new power stations in South Australia is not feasible because access to gas remains limited:

32 Mr Jim Kouts, Head of Corporate Affairs, ENGIE in Australia, *Committee Hansard*, 20 February 2017, pp. 15–16.

33 Professor Ross Garnaut, private capacity, *Committee Hansard*, 7 March 2017, p. 20.

34 Mr Richard Wrightson, General Manager, Wholesale Markets, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 3.

35 Mr Richard Wrightson, General Manager, Wholesale Markets, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 3.

AGL would love to build a new power station to replace TIPSA [Torrens Island Power Station near Adelaide]. We want to maintain our customer base in South Australia and we would like to build a new power station. But if you cannot access gas to run it, it is not a feasible opportunity, and that is basically why you have had no new power stations announced in South Australia. People are trying to resolve how they access fuel to run those power stations on a consistent basis. There will be a way, and we will work it through, but access to gas is critical to that.³⁶

2.46 Beyond the supply problems in the east-coast gas market, AGL outlined a second dilemma facing energy companies, namely that battery prices may fall rapidly enough to render investment in new gas-fired generation redundant:

Do you develop gas fast enough to beat battery technology in? I do not know the answer to that question, but that will be one of the key things. Can we develop enough gas to make building fast-start gas peakers, an answer to intermittency—or given the gas restrictions in Australia will battery costs beat that through? I do not know the answer.³⁷

2.47 Finally, Mr Simon Corbell, the Victorian Renewable Energy Advocate, drew attention to a third issue relevant to any decision on developing new gas-fired generating capacity. He warned that any new investment in gas generation risks repeating the experience of coal with stranded assets:

...any policy setting that provides for support for gas-fired generation should have regard to the fact that you do not want to create a situation where you have stranded assets in gas-fired generation in 20, 30 or 40 years time in the same way that we currently experience in relation to coal-fired generation.³⁸

Solar

2.48 Australia has a high capacity for solar power generation. According to Geoscience Australia:

The Australian continent has the highest solar radiation per square metre of any continent and consequently some of the best solar energy resource in the world.³⁹

2.49 Solar power is generated when sunlight is converted into electricity or used to heat air, water or other materials and is usually generated using one (or both) of two major technologies:

36 Mr Richard Wrightson, General Manager, Wholesale Markets, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 9.

37 Mr Richard Wrightson, General Manager, Wholesale Markets, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 7.

38 Mr Simon Corbell, Victorian Renewable Energy Advocate, *Committee Hansard*, 7 March 2017, p. 15.

39 Australian Government, Geoscience Australia, *Solar energy*, <http://www.ga.gov.au/scientific-topics/energy/resources/other-renewable-energy-resources/solar-energy> (accessed 21 October 2016).

- solar thermal, which converts solar radiation into heat (thermal energy); and
- solar photovoltaic (PV), which converts sunlight into electricity directly by using photovoltaic cells.⁴⁰

2.50 Solar thermal electricity is often used for space heating, to generate electricity using steam (as the water is heated with solar heat), and for hot water heaters.⁴¹

2.51 The vast majority of the electricity generated from solar PV comes from small-scale rooftop installation. As at 20 March 2017, there were over 1.6 million solar PV panel systems in Australia with a rated output of just over 5500 MW, and over 1 million solar hot water heaters.⁴²

2.52 The Australian Bureau of Statistics (ABS) notes that the average size of roof top solar PV has increased as the price of panels has come down:

The average size of an installed roof-top solar PV system in Australia is currently just under 4 kW in capacity. In recent years, driven largely by falling prices for solar PV panels, the average size of systems has increased and are often over 5 kW in capacity.⁴³

2.53 However, solar PV can be scaled up to megawatt scale power plants. At the end of 2015, Australia had 17 solar PV farms larger than 1 MW in size with the two largest being the 102 MW facility in Nyngan, New South Wales (NSW) and the 53 MW facility in Broken Hill, NSW.⁴⁴

Wind

2.54 According to the Australian Energy Resource Assessment, Australia has some of the best wind resources in the world, in the south-western, southern and south-eastern margins and extending inland, and including highland areas in south-eastern Australia.⁴⁵

2.55 In contrast to solar PV, the vast majority of electricity generated by wind comes from large-scale wind farms. In 2015, there were 76 wind farms in Australia,

40 Australian Government, Geoscience Australia, *Solar energy*.

41 Australian Government, Geoscience Australia, *Solar energy*.

42 Australian Government, Clean Energy Regulator, *Postcode data for small-scale installations*, 17 March 2017, <http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations> (accessed 20 October 2016).

43 Australian Bureau of Statistics, *4631.0 - Employment in Renewable Energy Activities, Australia 2014-15*, <http://www.abs.gov.au/ausstats/abs@.nsf/0/0BC8668DB3C26EAECA257E23001108A5?OpenDocument> (accessed 19 October 2016).

44 Clean Energy Council, Large-scale solar PV, <https://www.cleanenergycouncil.org.au/technologies/large-scale-solar-PV.html> (accessed 28 March 2017).

45 Australian Government, Department of Industry, Geoscience Australia, Bureau of Resources and Energy Economics, *Australian Energy Resource Assessment*, Second Edition, 2014, p. 237, <https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/GA21797.pdf> (accessed 19 October 2016).

with a combined capacity of 4187 MW from more than 2000 turbines.⁴⁶ In addition to this large-scale infrastructure, as at 20 March 2017, more than 400 small-scale wind systems have been installed in Australia, with a rated output of approximately 1.4 MW.⁴⁷

2.56 Wind resources are currently prioritised within the NEM because wind energy is automatically dispatched. This means that electricity generated from wind is used before other, more controllable, sources are dispatched.⁴⁸

Hydroelectricity

2.57 As at 2014, Australia had 124 operating hydroelectricity plants, with a total installed capacity of 8500 MW. The main hydro resources in Australia are in NSW and Tasmania.⁴⁹

2.58 Hydroelectricity provided around 40 per cent of renewable energy in 2014–15.⁵⁰ Although hydroelectricity currently accounts for the largest share of Australia's renewable electricity, the potential for future growth of hydroelectricity generation in Australia is limited by issues of water availability:

Climate models suggest long-term drying over southern areas of Australia during autumn and winter, which will be superimposed on larger natural rainfall variability, resulting in Australia having variable surface water resources.⁵¹

2.59 The future growth of hydroelectricity is likely to be limited to 'the development of small-scale hydroelectricity plants and efficiency gains from the refurbishment of large-scale hydroelectricity plants'.⁵²

2.60 Similarly, the Australian Renewable Energy Agency (ARENA) has stated that 'most major hydropower opportunities in Australia have already been realised' and:

In the future there may be some growth in use of 'mini-hydro' schemes—which can be 'run-of-river', with no dam or water storage, or developed

46 Clean Energy Council, *Wind energy*, <https://www.cleanenergycouncil.org.au/technologies/wind-energy.html> (accessed 12 January 2017).

47 Australian Government, Clean Energy Regulator, *Postcode data for small-scale installations*, (accessed 20 October 2016).

48 Australian Government, Department of Industry, Geoscience Australia, Bureau of Resources and Energy Economics, *Australian Energy Resource Assessment*, Second Edition, 2014, p. 240.

49 Australian Government, Department of Industry, Geoscience Australia, Bureau of Resources and Energy Economics, *Australian Energy Resource Assessment*, Second Edition, 2014, p. 223.

50 Australian Government, Department of Industry, Innovation and Science, Office of the Chief Economist, *Australian Energy Update*, October 2016, pp 19-20.

51 Australian Government, Department of Industry, Geoscience Australia, Bureau of Resources and Energy Economics, *Australian Energy Resource Assessment*, Second Edition, 2014, p. 223.

52 Australian Government, Department of Industry, Geoscience Australia, Bureau of Resources and Energy Economics, *Australian Energy Resource Assessment*, Second Edition, 2014, p. 223.

using existing or new dams whose primary purpose is local water supply, river and lake water-level control, or irrigation.⁵³

The National Electricity Market (NEM)

2.61 The NEM is the wholesale electricity market for the eastern and southern Australian states and includes Queensland, NSW (including the Australian Capital Territory(ACT)), South Australia, Victoria and Tasmania.⁵⁴

2.62 Western Australia and the Northern Territory are the only Australian state and territory not connected to the NEM, largely due to the distances that would be involved in their connection to the network. These areas have their own electricity systems and regulatory arrangements. Power in WA is supplied by the Wholesale Electricity Market (WEM) which has been operated by the Australian Energy Market Operator (AEMO) since 2016.⁵⁵

2.63 The NEM is described as follows:

The NEM facilitates the exchange of electricity between generators and retailers. Retailers resell the electricity to business and households. Some large consumers also purchase electricity directly from the market. High voltage transmission lines transport electricity from generators to electricity distributors, who deliver it to homes and businesses on lower voltage 'poles and wires'.⁵⁶

2.64 There are more than 100 registered participants in the NEM, including market generators, transmission network service providers, distribution network service providers, and market customers.⁵⁷

2.65 One of the issues raised by witnesses was the vulnerability brought about by having a long, thin grid. The Australian Academy of Science, Technology and Engineering (ATSE) stated:

Our view is that the Australian grid suffers particularly because it is a long, thin grid and South Australia and Queensland are particularly vulnerable to

53 Australian Government, Australian Renewable Energy Agency (ARENA), *Hydropower*, <https://arena.gov.au/about-renewable-energy/hydropower/> (accessed 3 November 2016).

54 Australian Energy Market Operator, National Electricity Market, <https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM> (accessed 1 November 2016).

55 Australian Energy Market Operator, *Wholesale Electricity Market*.

56 Australian Energy Market Commission, *National Electricity Market*, <http://www.aemc.gov.au/Australias-Energy-Market/Markets-Overview/National-electricity-market> (accessed 13 October 2016).

57 Australian Energy Market Operator (AEMO), *National Electricity Market Fact Sheet*, p. 1, <https://www.aemo.com.au/-/media/Files/PDF/National-Electricity-Market-Fact-Sheet.pdf> . (accessed 20 October 2016).

that because they are at the ends of a very long, thin line. In South Australia's case there are only a few interconnections into Victoria.⁵⁸

2.66 The committee heard that ATSE has modelled improvements to the NEM based on further interconnections:

...modelling that has been done by fellows of the academy that looks at increased interconnections, either through New South Wales or indeed through South Australia to Queensland, to create a loop of the NEM that would, potentially, relieve some of those issues and then you can spread out the weather variation across a larger area.⁵⁹

Regulatory framework

2.67 The NEM is governed by a set of regulatory bodies—the Australian Energy Market Operator (AEMO), the Australian Energy Market Commission (AEMC), and the Australian Energy Regulator (AER)—established through the Australian Energy Market Agreement, an intergovernmental agreement developed through the COAG process and signed by the leaders of state, territory and Commonwealth governments in its initial form in 2004.⁶⁰

Australian Energy Market Operator (AEMO)

2.68 AEMO is responsible for managing the power grid in the NEM and its secure operation.⁶¹ Mr David Swift, Executive General Manager of Corporate Development at AEMO, outlined its operational role as follows:

AEMO operates the National Electricity Market in eastern and south-eastern Australia and manages the power system underpinning it. AEMO is also the market and power system operator in Western Australia. In gas, we operate a range of wholesale and retail gas markets and trading hubs around Australia.⁶²

2.69 The NEM works as a 'pool' or 'spot' market in which supply and demand of power is matched in real time through a centrally coordinated dispatch process. A generator of power offers to supply the market with a specified amount of electricity at a specified price for a set time period, although they can re-submit the

58 Dr Matt Wenham, Executive Manager Policy & Projects, Australian Academy of Technology and Engineering, *Committee Hansard*, 7 March 2017, p. 28.

59 Dr Matt Wenham, Executive Manager Policy & Projects, Australian Academy of Technology and Engineering, *Committee Hansard*, 7 March 2017, p. 28.

60 Mr John Pierce, Chairman, Australian Energy Market Commission (AEMC), *Committee Hansard*, 7 March 2017, p. 50; COAG Energy Council, Australian Energy Market Agreement (as amended December 2013), <http://www.coagenergycouncil.gov.au/publications/australian-energy-market-agreement-amended-december-2013> (accessed 20 March 2017).

61 Mr David Swift, Executive General Manager, Corporate Development, Australian Energy Market Operator, *Committee Hansard*, 10 February 2017, p. 60.

62 Mr David Swift, Executive General Manager, Corporate Development, Australian Energy Market Operator, *Committee Hansard*, 10 February 2017, p. 59.

offered amounts at any time. AEMO will decide from these bids which generator will supply the electricity to the grid, with the cheapest generator being used first.⁶³

2.70 AEMO also has 'planning roles across both electricity and gas markets that aim to inform market participants, regulators and policymakers'.⁶⁴ Significantly, AEMO is responsible for the development of national forecasts of electricity and gas demand. Mr Swift stated:

Electricity demand is forecast annually, down to the transmission connection point. We plan the Victorian transmission system and publish material on that. We undertake national planning and produce a National Transmission Network Development Plan. We also provide occasional papers from time to time, looking at specific issues.⁶⁵

2.71 Mr Swift pointed out that while 'AEMO operates the systems and markets, it does not own any physical assets such as pipelines, transmission towers or wind farms'.⁶⁶

Australian Energy Market Commission (AEMC)

2.72 Mr John Pierce, Chairman of the AEMC, explained the regulatory role of the AEMC as follows:

We are the rule maker for the Australian energy markets, which includes the rules that govern...the NEM, the transmission and distribution networks, wholesale gas markets, natural gas pipelines and the retail sale of energy to consumers.⁶⁷

2.73 Mr Pierce described the process for changing the market rules made by the AEMC as follows:

Anyone except the Australian Energy Market Commission itself can propose to us a change in those rules, so those rules evolve over time in response to proposals for changes that are put to the commission. In that sense, the future development and evolution of the market framework is in the hands of the market participants, the other market institutions, governments, consumer groups, environment groups and various stakeholders within the sector.⁶⁸

63 Australian Energy Market Commission (AEMC), *National Electricity Market Fact Sheet*, (accessed 20 October 2016), p. 2.

64 Mr David Swift, Executive General Manager, Corporate Development, Australian Energy Market Operator, *Committee Hansard*, 10 February 2017, p. 59.

65 Mr David Swift, Executive General Manager, Corporate Development, Australian Energy Market Operator, *Committee Hansard*, 10 February 2017, p. 59.

66 Mr David Swift, Executive General Manager, Corporate Development, Australian Energy Market Operator, *Committee Hansard*, 10 February 2017, p. 59.

67 Mr John Pierce, Chairman, Australian Energy Market Commission, *Committee Hansard*, 10 February 2017, p. 50.

68 Mr John Pierce, Chairman, Australian Energy Market Commission, *Committee Hansard*, 10 February 2017, p. 50.

2.74 Mr Pierce advised that since the AEMC was established in 2005, there have been 'about 214 different changes in the rules'.⁶⁹

2.75 The AEMC's review function was described by Mr Pierce as follows:

[W]e also undertake reviews that are normally under terms of reference issued by the COAG Energy Council where they are seeking advice on how improvements to the regulatory and energy market arrangements may be made. A short way to understand how this process works is that, if somebody thinks that there is a problem and they think they also know what the solution is, they will put a rule change to us. If governments think that there is an issue and want potential solutions explored, that is when they tend to ask us to do a review. Recently, in addition to our statutory functions, the commission has been provided with terms of reference from the COAG Energy Council, requesting what is referred to as 'targeted strategic advice to inform the council's energy market strategy and priority setting process', so that will form part of our work program for this year.⁷⁰

2.76 All of the AEMC's work is governed by three national energy policy objectives: the national electricity objective, the national gas objective and the national energy retailer objective. Mr Pierce explained in relation to these objectives:

They are three different objectives, but they all sort of have a common theme, which is referred to as 'promoting the long-term interests of consumers' but with respect to a very specific set of variables: price, quality, reliability and security of those energy services as well as the system as a whole.⁷¹

2.77 The AEMC currently has four suggested priority areas in terms of market development, namely:

- systems security;
- the integration of the mechanisms used to achieve emission-reduction policy objectives and energy policy objectives so that they are aligned and work together;
- redesigning the way in which gas is bought and sold in gas markets; and
- the promotion of a competitive retail energy services sector.⁷²

69 Mr John Pierce, Chairman, Australian Energy Market Commission, *Committee Hansard*, 10 February 2017, p. 50.

70 Mr John Pierce, Chairman, Australian Energy Market Commission, *Committee Hansard*, 10 February 2017, p. 50.

71 Mr John Pierce, Chairman, Australian Energy Market Commission, *Committee Hansard*, 10 February 2017, p. 50.

72 Mr John Pierce, Chairman, Australian Energy Market Commission, *Committee Hansard*, 10 February 2017, p. 50.

Australian Energy Regulator (AER)

2.78 The AER regulates energy markets and networks under national energy market legislation and rules, with functions including:

- monitoring wholesale electricity and gas markets to ensure energy businesses comply with the legislation and rules, and taking enforcement action where necessary;
- setting the amount of revenue that network businesses can recover from customers for using networks (electricity poles and wires and gas pipelines) that transport energy;
- regulating retail energy markets in Queensland, NSW, South Australia, Tasmania (electricity only) and the ACT; and
- publishing information on energy markets, including the annual State of the energy market report, to assist participants and the wider community.⁷³

2.79 Ms Michelle Groves, Chief Executive Officer of the AER, informed the committee that it has been undertaking work in recent times aimed at ensuring that the regulatory framework meets the challenges currently facing it. This work includes:

- developing new 'ringfencing' guidelines preventing networks from favouring their own affiliates over other businesses offering competitive energy services, such as rooftop solar, smart appliances and storage;
- working to implement more cost reflective network tariffs, to help consumers make informed decisions on how and when they should use electricity as new technologies evolve; and
- developing a new demand management incentive scheme and innovation allowance which will provide electricity distribution businesses with an incentive to undertake efficient expenditure on non-network options relating to demand management.⁷⁴

Clarity around responsibilities of regulatory bodies

2.80 An issue of concern raised with the committee has been possible uncertainty about the responsibilities of the different regulatory bodies involved in the NEM, particularly during power outages. AEMO explained the particular responsibilities of each body in relation to the South Australian system failure event in 2016:

In terms of the real-time event and the behaviour on the day, that is clearly our responsibility. In respect of the behaviours of parties and whether they complied with the rules, that would be the AER's responsibility. Then when

73 Australian Energy Regulator, 'About Us', <https://www.aer.gov.au/about-us> (accessed 20 March 2017).

74 Ms Michelle Groves, Chief Executive Officer, Australian Energy Regulator, *Committee Hansard*, 10 February 2017, p. 51.

we look at policies and rules that gets back to the COAG Energy Council and the AEMC.⁷⁵

Issues facing the NEM

2.81 Stakeholders to the inquiry identified various issues that have seriously undermined the functioning of the NEM and that need to be resolved in order for Australia's electricity market to function effectively into the future. In addition to the physical impacts of a changing climate on electricity infrastructure (discussed in earlier sections), major issues cited by submitters and witnesses included:

- reduced and changing patterns of electricity demand from the grid;
- the integration of intermittent renewable energy into the grid;
- the uptake of energy storage solutions and decentralised forms of electricity generation without the necessary changes to the structure and rules of the electricity market to facilitate this; and
- a protracted period of policy uncertainty relating to carbon issues, creating an environment where industry is unable to make long term planning and investment decisions.
- an inefficient and change-resistant regulatory authority which is absurdly slow and has a strong bias towards incumbent players, and is technically ignorant of modern trends in overseas markets and technology.

2.82 The changing patterns of electricity demand and usage, the integration of intermittent renewable energy into the grid, and the uptake of energy storage solutions and decentralised forms of electricity generation are covered in chapter 3.

2.83 The issues arising from policy uncertainty and the need for a carbon price signal, certainty around renewable energy targets, and necessary changes to the structure and rules of the NEM to facilitate the uptake of storage technologies are covered in chapter 4.

Recommendation 2

2.84 The committee recommends that the Finkel Review incorporate the impacts of climate change on electricity security into its consideration and recommendations.

75 Mr David Swift, Executive General Manager, Corporate Development, Australian Energy Market Operator, *Committee Hansard*, 10 February 2017, p. 60.

Chapter 3

Resilience from storage technologies and distributed generation

Introduction

3.1 This chapter begins by outlining the changing patterns of electricity supply and demand. It then considers the challenges involved in integrating renewable energy and decentralised forms of electricity generation into grid networks.

3.2 The chapter then considers a range of energy storage technologies and examines how storage technologies can contribute to the successful integration of renewables and decentralised forms of generation and at the same time, improve the resilience of Australia's electricity system.

3.3 Finally, the need for energy and storage system diversity is considered, particularly in relation to the provision of certain necessary ancillary services to grid networks.

Changing patterns of electricity supply and demand

3.4 One of the key challenges facing the electricity grid arises from the rapidly changing nature of electricity supply and demand.

3.5 Australia has historically generated its electricity from a relatively small number of centralised fossil-fuel power stations and delivered electricity to a large number of consumers. However, the supply side of the equation is undergoing rapid change. Dr Noel Simento, Managing Director for Australian National Low Emissions Coal Research and Development, commented:

Our electricity supply has traditionally been delivered through the state grids to state based grids and large interconnectors between them. Our market systems were built on this basis, and it has served us well to date in achieving a competitive objective. We are, however, in a period of change and our commitment to reduce greenhouse gas emissions requires the deployment of low emissions energy technologies at an increasingly rapid rate. The inherent nature of these technologies is placing new demands on resilience and the operation of a network to grid.¹

3.6 At the same time, the demand side of the equation is shifting too. Over the last several years, overall electricity demand in Australia has declined due to factors including increased energy efficiency. Simultaneously, peak electricity demand during extreme events (for example, prolonged heatwaves in the summer months) has placed increasing strain on the generation and distribution system during those periods. This trend has been quickened by the increasing uptake of rooftop solar by households in Australia, which means that demand from large-scale generators is lessened during the

¹ Dr Noel Simento, Managing Director, Australian National Low Emissions Coal Research and Development, *Committee Hansard*, 10 February 2017, p. 2.

middle of the day. Mr Robert Riebolge, Chief Network Analyst for 1414 Degrees, described these changes in electricity demand to the committee:

The electricity demand profile in most Australian jurisdictions is becoming characterised by peaks and troughs that are increasingly widening and a baseload that is decreasing so that the ratio of the difference between the peak and the trough to the base is increasing. The generation mix and market rules in Australia have not been designed to meet this kind of demand profile, so the resilience of the electricity infrastructure will continue to deteriorate if measures are not put in place to address this problem quickly.²

3.7 In addition, there is the rise of what has been termed the 'prosumer', meaning an increasing number of households that also produce as well as consume electricity. The interactions between the changing nature of electricity supply and demand, the changing nature of generation technologies, the rise of the 'prosumer' and distributed electricity production, and the solutions offered by various energy storage technologies are covered in the following sections.

Integrating renewables into the electricity system

3.8 The integration of renewables into the electricity system was acknowledged by Energy Networks Australia as 'inevitable'.³

3.9 Despite this, it is clear that the pathway to ensuring this integration is accomplished successfully is still being developed. For example, the Australian Renewable Energy Agency (ARENA) outlined some of the challenges of guaranteeing security and reliability in the electricity system and the need for 'whole-of-system change across technology, markets and regulation' to ensure successful integration:

As the mix of electricity generation changes to a higher level of renewables, Australia's electricity system will need to continue to provide secure, reliable power with more diverse, variable and distributed energy sources. This will involve a higher level of integration with flexible capacity, smart control systems, demand management, and improved technical standards to help withstand unexpected and extreme events.⁴

3.10 AEMO told the committee that it is currently a challenge to integrate intermittent renewables into the electricity market:

AEMO sees the changing generation mix, with more asynchronous generation and intermittent generation as a challenge to the security of the system. Our ability to balance the security and reliability of energy supplied by these new technologies against the changing needs and preferences of the consumer is a primary focus for AEMO. The challenges arise in

² Mr Robert Riebolge, Chief Network Analyst, 1414 Degrees, *Committee Hansard*, 20 February 2017, p. 21.

³ Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 34.

⁴ Australian Renewable Energy Agency, *Submission 32*, pp. 2 and 3.

managing everyday 'credible contingencies', as we call them, as well as in extreme events.⁵

3.11 AEMO outlined the work it is currently doing to address these challenges:

To help us deal with these issues, AEMO is conducting ongoing work in our Future Power System Security program, which aims to identify and quantify the challenges of main power system security in the NEM. We are also working in collaboration with the AEMC to change the market and regulatory frameworks to ensure these issues are managed into the future.⁶

3.12 Dr Evan Franklin, a fellow of the Energy Change Institute at the Australian National University (ANU), acknowledged the intermittent nature of renewable energy production from wind farms, solar farms and rooftop PV. He noted that one possible solution would be to have 'levels of ramp rate control' so that the power output from wind and solar PV does not fluctuate so rapidly. Another option would be to limit the speed with which intermittent generators could alter their output. However, Dr Franklin observed that requirements or incentives would be needed to bring about the widespread adoption of these changes by companies and individual homeowners.⁷

3.13 Mr John Bradley, Chief Executive Officer of Energy Networks Australia, was of the view that a new and more active role would be required from electricity distribution businesses to help integrate renewables into grid networks:

The transition there to integrate renewables into the distribution system is to move towards much more active management—having good sensing, so you can see the power quality, the voltage rise, the fluctuations and power quality occurring in the network, and you can anticipate and respond to that.⁸

3.14 Meanwhile, the Australia Institute submitted that what were previously the two key obstacles to the widespread adoption of renewables, namely price and intermittency, are now capable of being resolved:

Solar and wind costs have fallen so rapidly over the past decade that they are now competitive with fossil fuels, so the price argument is losing traction [while] battery and other forms of storage technology are rapidly overcoming the variability argument.⁹

5 Mr David Swift, Executive General Manager, Corporate Development, Australian Energy Market Operator, *Committee Hansard*, 10 February 2017, p. 60.

6 Mr David Swift, Executive General Manager, Corporate Development, Australian Energy Market Operator, *Committee Hansard*, 10 February 2017, p. 60.

7 Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 6.

8 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 34.

9 The Australia Institute, *Submission 54*, p. [iv].

3.15 However, Mr Oliver Yates, Chief Executive Officer of the Clean Energy Finance Corporation, pointed out that, in order to address the issue of intermittent generation, there needed to be far greater investment in large-scale storage technologies and electricity distribution infrastructure. However, he also noted that storage technologies faced 'regulatory challenges in entering the market'.¹⁰

3.16 The Clean Energy Finance Corporation set out what they saw as the key factors that needed to be planned for in order to achieve a balanced grid:

- diverse generation technologies within the system;
- geographically diverse generation technologies so that uncorrelated renewable resources can be drawn on from across Australia;
- strong transmission interconnections between regions to move power around Australia to balance supply and demand;
- large-scale storage, whether it be in batteries, solar-thermal, pump hydro or the coordination of small-scale batteries; and finally
- markets and a regulatory system that encourage all of these factors to occur at the same time.¹¹

3.17 Similarly, Dr Matthew Stocks, a fellow of the College of Engineering and Computer Science at the ANU, also noted that the current transmission network is very weak. He argued that both storage and stronger inter-state connections would be crucial elements in strengthening the resilience of the electricity network because improved interconnections would strengthen the whole network and allow stored energy to be shared more easily between states.¹²

3.18 However, Dr Stocks also made the important point that even in the case of a grid supplied solely by renewable energy, the amount of storage required to balance the system and the additional costs was less than might be imagined:

The work that we have done there demonstrates that, if you distribute this generation very widely and develop an appropriate transmission network, you need a surprisingly small amount of storage and a relatively small amount of support to ensure that you can have a reliable balancing of energy supply over that five-year period. We have shown that the additional premium is quite small. We are talking less than three cents a kilowatt hour to enable the entire system to behave in a balanced manner in order to

10 Mr Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation, *Committee Hansard*, 11 February 2017, p. 39.

11 Mr Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporations, *Committee Hansard*, 10 February 2017, p. 39.

12 Dr Matthew Stocks, Fellow, College of Engineering and Computer Science, Australian National University, *Committee Hansard*, 10 February 2017, p. 5.

ensure that the energy is distributed across the country in such a way that you meet all of the vagaries of the supply and demand in the network.¹³

3.19 The role of storage technologies in helping to integrate diverse renewable energy generation technologies into the electricity system is discussed next. The issue of markets, policies and regulations is discussed later in chapter 4.

New opportunities arising from storage technologies

3.20 As noted at the beginning of the chapter, the supply and demand for electricity in Australia is undergoing rapid change. The so-called baseload generators such as coal-fired power stations that have dominated Australia's electricity production in the past are relatively inflexible: that is, they are unable 'to quickly increase or reduce supply on a minute-by-minute or hour-by-hour basis'.¹⁴

3.21 In addition, the ability of consumers to modify their electricity demand is relatively limited at present. The end result of the inflexibility inherent in the current approach to supply and demand is an excess of electricity generation capacity because there has to be sufficient supply to meet peaks in demand.¹⁵

3.22 Mr Oliver Yates, Chief Executive Officer of the Clean Energy Finance Corporation explained to the committee that the real-time matching of supply and demand is very rare in markets, and consequently requires some form of balancing:

The concept of a market where [a good or service] is produced and sold immediately, absolutely perfectly matching demand, does not exist in many markets around the world. In many markets, there is always a period where demand does not equal supply, and it is important that it is balanced out.¹⁶

3.23 Furthermore, as noted in the previous section, the increasing amount of intermittent electricity generation in the network poses an additional challenge in balancing supply and demand. The committee received evidence from a range of witnesses that energy storage would have significant value in balancing periods of shortage and excess in electricity supply and demand and was the key component that would allow a high penetration of intermittent renewable energy into the grid.¹⁷

13 Dr Matthew Stocks, Fellow, College of Engineering and Computer Science, Australian National University, *Committee Hansard*, 10 February 2017, pp. 1–2.

14 Mr Justin Flint, *Submission 34*, p. 1.

15 Dr Matthew Stocks, Fellow, College of Engineering and Computer Science, Australian National University, *Committee Hansard*, 10 February 2017, p. 5; Mr Justin Flint, *Submission 34*, p. 1.

16 Mr Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation, *Committee Hansard*, 11 February 2017, p. 45.

17 See, for example, Dr Matthew Stocks, Fellow, College of Engineering and Computer Science, Australian National University, *Committee Hansard*, 10 February 2017; Mr Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation, *Committee Hansard*, 11 February 2017; Mr Justin Flint, *Submission 34*.

3.24 For example, Dr Stocks made the point that Australia actually has excess energy capacity:

We do not, in this country, have a shortage of energy; we have a vast oversupply of energy capacity. What we have is periods of deficit and periods of excess, and storage is very good at being able to come in and fill that gap.¹⁸

3.25 Similarly, Mr Justin Flint pointed out in his submission that the increasing availability of cost-effective storage technologies would allow a situation where supply exceeded demand to be managed because the energy could be stored. Conversely, where demand exceeded supply, the system could draw on the stored energy.¹⁹

3.26 In addition, storage technologies can respond far more rapidly to changes in demand than a large traditional power station. This supply response would be further enhanced by modern communications technologies and distributed generation.²⁰

3.27 AES Energy Storage submitted that energy storage should be considered as a viable alternative to building new generation capacity:

Power systems that need new capacity – whether it is to meet growing peak demand or to compensate for the retirement of aging thermal generation – should be evaluating energy storage as an economic alternative to building new generation.²¹

Types of storage technologies

3.28 The following sections consider three types of storage technologies:

- battery storage;
- pumped hydro technology; and
- thermal storage.

Battery storage

3.29 Dr Evan Franklin, a fellow at the Energy Change Institute at the ANU, told the committee that while battery storage is an old technology, recent advances in lithium batteries have brought the costs down.²² Dr Franklin noted that battery storage

18 Dr Matthew Stocks, Fellow, College of Engineering and Computer Science, Australian National University, *Committee Hansard*, 10 February 2017, p. 5.

19 Mr Justin Flint, *Submission 34*, pp. 2–3.

20 Mr Justin Flint, *Submission 34*, pp. 2–3.

21 AES Energy Storage, *Submission 56*, p. 3.

22 Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 6.

has already become a sizeable industry with the result that battery storage 'can be deployed now'.²³

3.30 Similarly, Mr Ivor Frischknecht, Chief Executive Officer of ARENA, told the committee that while battery storage technology had historically been very expensive, costs had fallen and would continue to fall significantly.²⁴

3.31 Mr Frischknecht noted that ARENA was currently 'in the process of demonstrating a whole variety of different ways of deploying storage and, very importantly, getting value from storage'. Mr Frischknecht emphasised the point that getting value from battery storage was critical to ensuring deployment on a commercial basis.²⁵ The issue of allowing batteries to capture appropriate value is a critical matter and one to which the committee returns in the following section.

3.32 At the household scale, Mr Osborne observed that a house with a smart battery system should be able to supply about 80 per cent of its own needs, and buy the remaining 20 per cent 'when it is cheapest and most abundant in the grid'.²⁶

3.33 The next step beyond the generation of electricity on rooftops is the imminent deployment of substantial amounts of battery storage. Mr Osborne noted that Morgan Stanley has predicted that Australia could have five gigawatts of battery storage by around 2020. As Mr Osborne noted:

...so we are going to move that five gigawatts from being out of control, going up and down with the sun, to being in control by 2020. So it will be the biggest controlled power station—about three or four times bigger than Tumut 3 pumped hydro dam—by 2020. So that is not very far away. It is very rapid.²⁷

3.34 Dr Franklin told the committee that predictions about the future uptake of battery storage systems at the household level in Australia vary from a million in 2025 (Morgan Stanley) to 2.5 million in 2035 (Bloomberg New Energy Finance). Dr Franklin set out both the scale of the predicted contribution to the grid:

Two-and-a-half million households with a battery storage system would end up being equivalent to something like 10 gigawatts of power generation capacity if it was arranged so that it could be deployed when required.²⁸

23 Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 6.

24 Mr Ivor Frischknecht, Chief Executive Officer, Australian Renewable Energy Agency, *Committee Hansard*, 10 February 2017, p. 40.

25 Mr Ivor Frischknecht, Chief Executive Officer, Australian Renewable Energy Agency, *Committee Hansard*, 10 February 2017, p. 40.

26 Mr Luke Osborne, Director and Chief Operating Officer, Reposit Power, *Committee Hansard*, 10 February 2017, p. 18.

27 Mr Luke Osborne, Director and Chief Operating Officer, Reposit Power, *Committee Hansard*, 10 February 2017, p. 19.

28 Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 8.

3.35 Dr Franklin also explained the mechanism by which battery systems could charge and discharge:

Battery systems can discharge and charge very rapidly... You would normally charge batteries from solar during the day, of course, and have that available in the evening. If you depleted all of the batteries in the evening, then you would require other sources: wind or other generators to provide that recharging of batteries.²⁹

3.36 The committee also received evidence about the development of utility scale battery storage from Australian companies including Lyon Group and Zen Energy.

3.37 Mr David Green, a partner in Lyon Group, told the committee that over the past two years, Lyon Group has brought together more than 1500 MW of solar PV utility-scale projects and more than 1000 MW of large-scale battery storage projects. Both the solar PV and battery storage projects are ready to be deployed and be operational within two years.³⁰

3.38 Mr Green also noted that funding for the solar PV projects was underpinned by a major United States fund. The utility-scale battery storage would be developed in Australia in alliance with Mitsubishi Corporation and AES (headquartered in the United States).³¹

3.39 State and territory governments have embraced not only renewable energy generation, but are also focused on battery storage. For example, Mr Simon Corbell, a former Australian Capital Territory (ACT) Environment Minister, explained the ACT's Next Generation Renewables Program which started in early 2016:

...the ACT government embarked on a significant program of supporting and subsidising the rollout of battery installations at 5000 individual household and small business sites across the territory. That program is ongoing and it highlights the importance of providing support to new technologies to bring forward their deployment at scale, to allow lessons to be learnt about how that deployment can take place in the most efficient way, and to build support for a growing industry.³²

3.40 In his current role as the Victorian Renewable Energy Advocate, Mr Corbell told the committee that the Victorian state government had decided 'to invest significantly in large-scale battery storage to improve grid stability and provide for dispatchable load into the Victorian NEM region'. Mr Corbell noted that the Victorian

29 Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 9.

30 Mr David Green, Partner, Lyon Group, *Committee Hansard*, 20 February 2017, p. 22.

31 Mr David Green, Partner, Lyon Group, *Committee Hansard*, 20 February 2017, p. 22.

32 Mr Simon Corbell, Victorian Renewable Energy Advocate, *Committee Hansard*, 7 March 2017, p. 15.

government had committed to developing '20 megawatts of large-scale battery storage in grid-constrained parts of the state'.³³

3.41 Nevertheless, the committee received evidence which suggested that even though battery prices are declining rapidly, other storage technologies are more cost-competitive at a utility-scale:

Battery storage technology is rapidly advancing and costs are declining fast as production increases to meet growing demand from electric vehicles and stationary energy storage applications. However, the cost of batteries for bulk energy storage is still relatively high (compared to both wholesale costs of energy and compared to other forms of bulk energy storage – thermal and hydro in particular). This means that small, behind-the-meter battery systems, the market being driven by retail tariff margins, will dominate over utility-scale battery systems for some time to come.³⁴

Committee view

3.42 The committee notes that the large-scale deployment of batteries at both household level and utility-scale is imminent and will occur rapidly from this point.

3.43 The committee considers that the rapid uptake of battery storage will help deliver important elements of system security relatively quickly compared to other generation and energy storage systems.

3.44 The committee is also of the view that the installation of batteries at the household level would provide citizens with greater control over their power and the committee returns to this theme later in the chapter in the section on distributed generation and storage.

3.45 The committee is also aware that there are certain regulatory barriers currently hindering the rapid deployment of storage technologies, and this matter and associated recommendations are presented in chapter 4.

Pumped hydro storage

3.46 This section outlines two distinctly different types of pumped hydro:

- large river-based pumped hydro storage; and
- small off-river pumped hydro storage.

Traditional large river-based pumped hydro

3.47 Pumped hydro has traditionally been based on large rivers. Large river-based pumped hydro storage is a well-established technology that has been in place in Australia and other countries for decades. Dr Stock informed the committee that:

33 Mr Simon Corbell, Victorian Renewable Energy Advocate, *Committee Hansard*, 7 March 2017, p. 15.

34 ANU Energy Change Institute, *Submission 28*, p. 12.

There are more than 150 gigawatts deployed around the world, including two gigawatts deployed within the Australian network in Tumut 3 in the Wivenhoe scheme and also in the Shoalhaven.³⁵

3.48 The ANU Energy Change Institute informed the committee that owing to its relatively low cost, pumped hydro was the dominant form of energy storage worldwide:

Pumped hydro energy storage is the dominant form of worldwide energy storage because it is an established technology, is cheap and provides a broad range of support services for the electrical grid. Water is pumped up a height difference when there is excess energy generating capacity available (i.e. when it is low cost) and the water is released to generate power when demand (and hence cost) is high. Owing to its comparatively low cost, over 96% of all energy storage installed in global electrical power systems to date have used pumped hydro technology.³⁶

3.49 However, large river-based pumped hydro storage systems have significant environmental impacts and developments have been hotly disputed in the past. In some cases large river-based pumped hydro storage systems have been part of water management and diversion systems such as the Snowy river scheme. Such schemes have delivered water to farms, but have environmental costs, including the degradation of the diverted river.³⁷

Off-river pumped hydro

3.50 Pumped hydro storage can also be operated off-river. The ANU Energy Change Institute submitted that the small size of off-river pumped hydro means that a wide range of sites could be developed across Australia:

Recent research, meanwhile, has shown that there are numerous excellent sites in Australia for systems which are off-river, requiring relatively small reservoirs (oversize farm dams) at the top and bottom of hills with the water cycling between as supply and demand varies. Abandoned mines may also be used as reservoirs, as per the proposed Kidston mine being developed by Genex.³⁸

3.51 The Alternative Technology Association informed the committee of research undertaken by the Melbourne Energy Institute:

35 Dr Matthew Stocks, Fellow, College of Engineering and Computer Science, Australian National University, *Committee Hansard*, 10 February 2017, pp. 1–2.

36 ANU Energy Change Institute, *Submission 28*, p. 14.

37 Australian Government, The Snowy Mountains Scheme—Environmental impacts of the scheme, <http://www.australia.gov.au/about-australia/australian-story/snowy-mountains-scheme> (accessed 4 April 2017); Joshua Larsen, Badin Gibbes and John Quiggin, 'Dam hard: water storage is a historic headache for Australia', *The Conversation*, 27 October 2014, <https://theconversation.com/dam-hard-water-storage-is-a-historic-headache-for-australia-33397> (accessed 4 April 2017).

38 ANU Energy Change Institute, *Submission 28*, p. 14.

According to the Melbourne Energy Institute (MEI), the best option is to build a dam on a tall hill or cliff. This height creates strong water pressure, enabling significant energy to be stored with a relatively small dam. Suitable sites are plentiful, and the theoretical cost is \$200 per kWh of usable storage capacity. When added to a solar farm, a dam to store 5 hours of generation would increase the system cost by about 25%.³⁹

3.52 The Melbourne Energy Institute has developed the following table which provides a comparison of conventional large river-based hydro, and off-river pumped hydro systems. One of the key findings arising from the comparison is that the much smaller size of off-river pumped hydro storage means there are thousands of potentially suitable sites in Australia.

Table 3.1: Comparison of conventional hydro power and off-river pumped hydro.

	Conventional large river hydro	Off-river pumped hydro
Purpose	Energy generation, irrigation, flood control, recreation	Short-term energy storage and use
Electricity output	High	High
Water requirement	Once-through, no recycling	Recycled. Make-up required for evaporation minus rainfall
Water storage period	Months or years	Hours
Reservoir size	Can be > 10,000 hectares	5 to 50 hectares
Location	Yes	Can be off-river using 'turkey-nest'
Number of possible sites in Australia	Limited	Thousands

Source: Melbourne Energy Institute, *Pumped Hydro Energy Storage*.⁴⁰

3.53 Genex submitted that off-river pumped hydro systems have advantages relative to battery storage systems:

- large scale (e.g. able to provide storage for macro scale wind or solar PV farms);

39 Alternative Technology Association, *Submission 26*, p. 3.

40 Tim Forcey, *Pumped Hydro Energy Storage*, Melbourne Energy Institute, 8 May 2014, p. 21, http://energy.unimelb.edu.au/_data/assets/pdf_file/0003/1526592/Tim-Forcey-AESCE-2014.pdf, (accessed 22 March 2017).

- long lived asset—up to a century life-cycle;
- clean and environmentally sustainable form of energy storage that requires less mining of rare elements and less toxic materials to recycle or dispose of after use than chemical storage systems; and
- poses no fire risk.⁴¹

New off-river pumped hydro developments in Australia

3.54 The committee notes that the Clean Energy Finance Corporation and ARENA are assisting Genex Power to investigate the feasibility of developing an off-river pumped hydro scheme in an old mining site at Kidston in Northern Queensland.⁴²

3.55 Genex Power (Genex), an Australian public company, is currently developing a large-scale hydroelectric pumped storage project in an old gold mining site at Kidston in Northern Queensland.⁴³

3.56 The Clean Energy Finance Corporation and ARENA provided funding for Genex to conduct a technical feasibility study which is now complete.⁴⁴

3.57 Genex notes that the Kidston pumped hydro storage project will be a closed loop system that will transfer water from an upper to a lower reservoir. The lower storage reservoir will be the existing Eldridge Pit. The upper storage reservoir will be a 'turkey's nest' type dam constructed on the waste rock dump to the north of Eldridge Pit. The project will also utilize the existing Wises Pit to act as a balancing storage to hold excess water and to mitigate flood risks.⁴⁵

3.58 The completed Kidston pumped hydro project will have an installed generation capacity of 250MW, with a total energy storage capacity of 1500MWh based on a 6 hour full generation cycle.⁴⁶

3.59 It is also possible to develop pumped hydroelectricity storage using seawater and a cliff-top dam such as the facility in Okinawa, Japan.⁴⁷

41 Genex, *Submission 3*, p. 5.

42 ANU Energy Change Institute, *Submission 28*, p. 14; The Prime Minister, the Hon Malcolm Turnbull MP, Media Release, *ARENA Finalising Grant to Energy Australia*, 21 February 2017, <https://www.pm.gov.au/media/2017-02-21/arena-finalising-grant-energyaustralia>, (accessed 22 March 2017); for further details see Kidstone solar and pumped hydro projects, <http://www.genexpower.com.au/>, (accessed 22 March 2017).

43 Genex, *Submission 3*, p. 1.

44 Genex, *Submission 3*, p. 1; see also The Prime Minister, the Hon Malcolm Turnbull MP, Media Release, *ARENA Finalising Grant to Energy Australia*, 21 February 2017, <https://www.pm.gov.au/media/2017-02-21/arena-finalising-grant-energyaustralia>, (accessed 22 March 2017).

45 Genex, *The Kidston Pumped Storage Hydro Project (250MW)*, <http://www.genexpower.com.au/the-kidston-pumped-storage-hydro-project-250mw.html> (accessed 30 March 2017).

46 Genex, *Submission 3*, p. 1.

3.60 One such project has already been identified in Australia with ARENA providing EnergyAustralia with \$450 000 to conduct a feasibility study for a 100MW to 200MW pumped hydro storage project close to Port Augusta and Whyalla in South Australia's Upper Spencer Gulf.⁴⁸

3.61 The committee also notes that ARENA has funded an ANU study to identify potential off-river sites across Australia.⁴⁹

Committee view

3.62 The committee draws attention to the significant difference between traditional hydroelectric generation that involves the damming of rivers as compared to off-river pumped hydro that can be installed on a much smaller scale with minimal negative environmental impacts.

3.63 The committee considers that off-river pumped hydro-electricity storage has the potential to provide a significant contribution to the effective operation and resilience of Australia's electricity systems.

3.64 The committee also notes the potential for coastal pumped hydro storage which only requires a single reservoir, is not susceptible to drought or evaporation, and has the potential to be co-located near wind and solar electricity generators.

3.65 Combining renewable generation systems with nearby off-river pumped hydro can provide an excellent way to balance the variable timing of renewable electricity supply with the fluctuations in electricity demand.

3.66 The committee also notes that a combination of pumped hydro, batteries, and thermal storage has the capacity to provide a full range of ancillary services required for electricity system stability and this matter is dealt with later in this chapter.

3.67 Finally, the committee received evidence about regulatory changes that could encourage the deployment of large scale pumped hydro (and thermal energy) storage systems. These matters are discussed in chapter 4.

Thermal energy storage

3.68 Thermal energy storage is a technology that stores thermal energy by heating or cooling a storage medium so that the stored energy can be used at a later time for

47 Melbourne Energy Institute, *Pumped Hydro Energy Storage*, <http://energy.unimelb.edu.au/mwg-internal/de5fs23hu73ds/progress?id=IoMdMs2VI9SLXou6B4MdHprxGwY-t-eqLQub2PHV7D0>, (accessed 22 March 2017).

48 The Prime Minister, the Hon Malcolm Turnbull MP, Media Release, *ARENA Finalising Grant to Energy Australia*, 21 February 2017, <https://www.pm.gov.au/media/2017-02-21/arena-finalising-grant-energyaustralia>, (accessed 22 March 2017); Khama Reid, 'umped hydro power station ideal for SA Spencer Gulf site, EnergyAustralia says', *PM*, ABC, 22 February 2017, <http://www.abc.net.au/news/2017-02-22/pumped-hydro-power-in-spencer-gulf-energy-australia/8292596> (accessed 30 March 2017).

49 The Prime Minister, the Hon Malcolm Turnbull MP, Media Release, *ARENA Finalising Grant to Energy Australia*, 21 February 2017.

heating and cooling applications and power generation. There are three kinds of thermal energy storage systems:

- sensible heat storage that is based on storing thermal energy by heating or cooling a liquid or solid storage medium (e.g. water, sand, molten salts, rocks);
- latent heat storage using phase change materials or PCMs (e.g. from a solid state into a liquid state); and
- thermo-chemical storage (TCS) using chemical reactions to store and release thermal energy.⁵⁰

3.69 The International Renewable Energy Agency summarised the relative performance of the above systems as follows:

A TES [thermal energy storage] system's economic performance depends substantially on its specific application and operational needs, including the number and frequency of storage cycles. In general, PCM and TCS systems are more expensive than sensible heat systems and are economically viable only for applications with a high number of cycles. In mature economies (e.g. OECD countries), a major constraint for TES deployment is the low construction rate of new buildings, while in emerging economies TES systems have a larger deployment potential.⁵¹

The storage of thermal energy (typically from renewable energy sources, waste heat or surplus energy production) can replace heat and cold production from fossil fuels, reduce CO₂ emissions and lower the need for costly peak power and heat production capacity. In Europe, it has been estimated that around 1.4 million GWh per year could be saved— and 400 million tonnes of CO₂ emissions avoided—in the building and industrial sectors by more extensive use of heat and cold storage. However, TES technologies face some barriers to market entry. In most cases, cost is a major issue. Storage systems based on TCS and PCM also need improvements in the stability of storage performance, which is associated with material properties.⁵²

3.70 Many applications of thermal energy storage use and store heat directly, however the technology can also be effective for storing or creating electrical energy. The committee was informed about two types of thermal energy storage for electricity, one based on molten salt and the other based on molten silicon.

50 International Renewable Energy Agency, *Thermal Energy Storage Technology Brief*, January 2013, p. 1.

51 International Renewable Energy Agency, *Thermal Energy Storage Technology Brief*, January 2013, p. 1.

52 International Renewable Energy Agency, *Thermal Energy Storage Technology Brief*, January 2013, p. 1.

Molten salt with solar-thermal power

3.71 Molten salt and related thermal storage technologies are often used in conjunction with concentrating solar-thermal power (CSP) systems. CSP systems use a large array of mirrors to concentrate sunlight onto a 'receiver' where the energy is collected by heating a fluid. This fluid can be stored and used later to make steam and run a turbine to produce electricity.⁵³

3.72 The ANU Solar Thermal Group explained that CSP with integrated storage was capable of delivering utility-scale round-the-clock solar energy:

The particular benefit of CSP is that its configuration allows energy storage as an easily and cost effectively integrated part of the system. Systems with as much as 15 h of storage capacity have been installed (eg Gemasolar, Spain and Crescent Dunes, USA), achieving commercial supply of 24-h solar energy for the first time.⁵⁴

3.73 The ANU Solar Thermal also noted the potential for CSP systems to be hybridised in order to manage the transition to a totally renewable electricity grid:

CSP systems can also be hybridised with small amounts fossil or biomass fuels, for higher levels of reliability with minimal redundant equipment, a configuration which may [assist] in a reliable migration towards 100% renewables in coming years. CSP systems can also be beneficially hybridised with other renewables such as PV.⁵⁵

3.74 The Australian Solar Thermal Energy Association told the committee that most new CSP systems and more than half of the existing CST systems incorporate intermediate storage use molten salt thermal energy storage to provide dispatchable energy:

Concentrating Solar Thermal Power plants use steam turbines with synchronous generators for power generation and have thermal energy storage built in to the overall system for typically 6-15 hours of full load operation at any time that dispatch is desired. Their ideal size is in the range 50–250MW.⁵⁶

3.75 Importantly, CSP also provides a range of ancillary benefits traditionally supplied by coal-fired generators and are capable of being configured to provide black-start capability.⁵⁷

3.76 The ANU Solar Thermal Group argued that while CSP with storage is more expensive than wind and solar PV systems (that provide no storage or ancillary

53 ANU Solar Thermal Group, *Submission 40*, p. 1.

54 ANU Solar Thermal Group, *Submission 40*, p. 1.

55 ANU Solar Thermal Group, *Submission 40*, p. 1.

56 Australian Solar Thermal Energy Association Ltd, *Submission 43*, p. 1.

57 Australian Solar Thermal Energy Association Ltd, *Submission 43*, p. 1.

benefits), studies in the United States indicate that CSP with storage is cheaper than batteries (and likely to remain so for the foreseeable future) and pumped hydro.⁵⁸

3.77 Further advantages of CSP with molten salt storage include:

- minimal carbon footprint;
- ability to withstand changing climatic conditions;
- a decrease in the annualised cost of electricity with integrated storage; and
- significant potential job creation from production of local content.⁵⁹

Molten silicon

3.78 The committee was informed about another thermal energy storage technology based on molten silicon. Silicon has a high melting point, 1414 degrees Celsius, which allows for high efficiency energy recovery relative to lower temperature thermal technologies.⁶⁰

3.79 1414 Degrees Limited is a South Australian company set up to commercialise a Thermal Energy Storage System (TESS) originally developed by the CSIRO. 1414 Degrees informed the committee that TESS possesses a significant competitive advantage over other storage technologies because of its scalability and high energy density:

The heat store is constructed from readily available, low cost components and production units will be containerised and modular. A TESS module approximately the size of a 40ft shipping container could house 10MWh_{th} of energy storage and to scale up, modules may be added and to scale down, modules may be removed or smaller ones manufactured. For all sizes of the TESS, the heat store shares a common design principal.⁶¹

3.80 The committee was informed that the TESS was well suited to medium scale energy storage and had a number of advantages, including:

- the potential to be installed in any location;
- low environmental impact due to use of abundant, relatively non-toxic materials;
- an ability to supply both electricity and heat;
- simultaneous and rapid charging and discharging;
- the potential to be very cost effective; and

58 ANU Solar Thermal Group, *Submission 40*, p. 1.

59 ANU Solar Thermal Group, *Submission 40*, p. 1.

60 1414°, *Submission 51*, pp. 1–2.

61 1414°, *Submission 51*, p. 2.

- the ability to provide ancillary services as the energy recovery system will be a rotating generator.⁶²

3.81 Silicon based TESS is complimentary to other storage technologies as shown in the following table. It can operate as:

- smaller 'behind the meter' technology (TESS-EC (energy consumer)) for commercial energy consumers that require heat as well as electricity; or
- bulk grid storage technology (TESS-GRID).

Table 3.2: Comparison of energy storage technologies

Rating	Technology	Discharge time	Efficiency	Network benefits
<10MWh/h	TESS-EC	High hours	Medium	Demand management
	Super capacitors	Minutes	High	Peak shaving
	Lithium Ion Advanced Lead Acid Flow Batteries	Low hours	High	Peak shifting Time of use tariffs PV self-sufficiency
	Sodium sulphur	High hours		Network augmentation deferral
Between 10MWh/h and 100MWh/h	TESS-Grid	High hours	Medium	Network augmentation deferral
	Molten salt Compressed air energy storage		Medium Low	Congestion relief Utilisation of surplus renewables Frequency regulation Spinning reserve Voltage support
100MWh/h	Pumped hydro storage	High hours	Medium	Frequency regulation Spinning reserve Voltage support Arbitrage

Key: TESS-EC = 'behind the meter' Energy Consumer storage technology

TESS-Grid = bulk grid storage technology

Source: 1414^o, *Submission 51*, p. 3.

Committee view

3.82 The committee considers that thermal storage technologies such as those discussed above have the potential to make significant contributions to the operation

62 1414^o, *Submission 51*, p. 2.

and resilience of Australia's electricity networks. The committee views these technologies as being complementary to other storage technologies, including batteries and pumped hydro. In particular, it appears that thermal storage technologies may offer a number of advantages for medium or intermediate scale storage of electricity and other forms of energy.

3.83 From the evidence that the committee has received it appears that there is an abundance of complementary technology options for energy storage to facilitate the operation and resilience of Australia's electricity networks.

Ancillary services provided by a diversity of energy storage systems

3.84 A range of ancillary services such as system inertia, spinning reserve and synchronous capacity for frequency and voltage support are essential for the security of the electricity system.

3.85 One of the main arguments traditionally raised against the greater use of intermittent renewable energy is the inability of renewable technologies to provide the ancillary services that were typically rendered by fossil fuel-fired power generators.

3.86 Dr Noel Simento, Managing Director of the Australian National Low Emissions Coal Research and Development, explained that traditional synchronous generators such as coal-fired power stations have traditionally provided inertia and voltage support to the network at no additional cost.⁶³

3.87 Mr Karl Rodrigues, Acting Director of Energy at the CSIRO, acknowledged that while storage technologies would be particularly useful as a means of sharing the increase in intermittent renewable electricity in the grid, he noted that some means of providing system inertia would still be needed for frequency control.⁶⁴

3.88 However, the committee received evidence that a diversity of storage technologies, in addition to providing a readily available source of power, can support other aspects of electricity network operations and resilience, including black-start capabilities, an issue that has become particularly pertinent in the aftermath of the power black-out in South Australia in September 2016.

3.89 The Energy Change Institute explained that the characteristics offered by pumped hydro vary according to how it is configured:

Pumped hydro plants can be configured in a number of different ways: most plants use a single turbine/pump set and a single electric machine (generator/motor), but some may use a separate turbine and pump with a single machine, or for greatest flexibility but highest cost a separate turbine-generator and pump-motor configuration. Configuration and electric

63 Dr Noel Simento, Managing Director, Australian National Low Emissions Coal Research and Development, Committee Hansard, 10 February 2017, pp. 2–3.

64 Mr Karl Rodrigues, Acting Director, Energy, CSIRO, *Committee Hansard*, 11 February 2017, p. 38.

machine type together determine the ability of the plant to offer flexibility in terms of power system operation.⁶⁵

3.90 The Energy Change Institute also explained how direct electro-mechanical synchronous pumped hydro can provide black-start capability

Synchronous pumped hydro systems can provide black start capabilities without requiring additional power generation support. Such systems are thus well-suited to rapid recovery after region-wide black events (such as occurred in the South Australian system in September 2016) with conventional hydro plants typically considered be the generator of choice for initiating system black starts.⁶⁶

3.91 Genex noted that pumped hydro 'has the potential to support grid stability through inertial spinning reserve and very fast ramp rates from zero to 100 per cent in minutes'.⁶⁷

3.92 The Energy Change Institute set out the contributions that a diverse mix of storage technologies could contribute to the resilience of electricity infrastructure—including very fast primary frequency response, spinning reserve, inertia, voltage stability, energy balancing, and black-start capability—as Australia transitions to an electricity system based largely (or even solely) on intermittent renewable generation:

- Battery storage will provide:
 - very fast dynamic primary frequency response;
 - secondary response (or spinning reserve) services;
 - local demand smoothing; and can also
 - facilitate islanded or microgrid operation.
- Pumped hydro technology will be used for:
 - provision of inertia;
 - primary frequency response;
 - secondary spinning reserve;
 - medium term (in the order of days) energy balancing;
 - voltage stability; and
 - black-start capabilities.
- Concentrating solar power with thermal storage can provide:
 - inertia;
 - voltage stability;

65 ANU Energy Change Institute, *Submission 28*, p. 14.

66 ANU Energy Change Institute, *Submission 28*, p. 16.

67 Genex, *Submission 3*, p. 5.

- short to medium term (hours to overnight) energy balancing;
- some spinning reserve capability; and
- black-start capabilities.⁶⁸

Benefits arising from decentralised electricity generation

3.93 Some of the challenges facing Australia's electricity system have arisen from a lack of diversity and the centralisation of electricity generation and storage which makes the system inflexible and unable to respond to challenging events. In the past the system has been characterised by a small number of large scale generation facilities and a very small number of large scale storage systems (large river pumped hydro such as the Snowy scheme). Mr Steve Blume, President of the Australian Solar Council, provided an example of the potential challenges facing centralised systems:

Take, for example, the UK. If they build that nuclear power plant of 2,000 gigawatts, that will be eight per cent of their electricity system. If that goes out, even for maintenance, what do you use to get the eight per cent when that is not running? It is a big question. If you start relying on individual things that is what will happen.⁶⁹

3.94 In contrast to the challenges facing a centralised system, several witnesses commented on the potential benefits of decentralising electricity generation in Australia through the further uptake of household solar PV and battery storage.

3.95 Innovative approaches are springing up without market intervention. The committee heard evidence from software providers, Reposit Power, about the 'community power station' concept:

We add intelligence to home and business energy systems, so these are home and businesses that are investing in solar panels on their roofs and batteries, usually wall-mounted batteries. We do a couple of things. One is we make those systems achieve a lower bill for the consumer by adding intelligence behind the meter, making those systems interact better with appliances that they have in their home and business. We also allow those systems to band together when it makes sense and form what I will call for today a 'community power station'. That is a power station that can operate very much like a hydro dam or a pump storage dam: it can consume energy when it is cheap and produce energy when it is expensive. When it is not required, those systems all go back to helping the home or business have a low energy bill and a good interesting electricity experience.⁷⁰

3.96 Mr Luke Osborne, Director and Chief Operating Officer of Reposit Power, expanded on the potential of the 'community power station' to provide resilience through distributed generation:

68 ANU Energy Change Institute, *Submission 28*, p. 1.

69 Mr Steve Blume, President, Australian Solar Council, *Committee Hansard*, 10 February 2017, p. 27.

70 Mr Luke Osborne, Director and Chief Operating Officer, Reposit Power, *Committee Hansard*, 10 February 2017, p. 13.

It is decentralised...this power station is everywhere. It is everywhere where there are homes and businesses, and already there are 1½ million homes and businesses that have solar panels on their roofs, and they are distributed everywhere there are populations. So decentralisation is inherently safer, if you like, than centralisation because you do not have a point of failure. If we think about what happened in South Australia: we lost transmission lines, which then led to the loss of the interconnector, which then lost the whole state. Those are problems of centralisation. You do not have that in a decentralised world. We can lose one or two houses or one or two businesses, but that is not important in the context of the whole community power station.⁷¹

3.97 Dr Andrew Mears, Director and Chief Executive Officer of SwitchDin, similarly argued that decentralised electricity generation would help future-proof electricity infrastructure by increasing system resilience:

a decentralised energy service based around renewable energy technology and battery storage is a key factor for building a futureproof and resilient electricity infrastructure. What has happened in many countries, including Australia, is that we have seen a deconvolution of the energy sector. We have moved from a time when we had very centralised governance arrangements around a centralised infrastructure. We are moving to disaggregate those governance arrangements, so now we have separate retail, distribution, transmission and generation elements in our energy system... [W]e are getting much greater participation now for consumers in this energy market, which did not exist before, so there is a much more a dynamic marketplace. I think that inherently brings us a more resilient electricity sector.⁷²

3.98 Mr Osbourne also informed the committee that a 'community power station' can potentially be implemented very quickly because the additional infrastructure (over and above panels and batteries that residents are already installing) is cheap and easy to implement and the approval processes are far simpler than for a larger industrial scale facility.⁷³

3.99 In summary, Mr Osbourne contended that the key advantages of 'community power stations' were that they were:

- fast to respond;
- decentralised;
- cheap to build; and

71 Mr Luke Osborne, Director and Chief Operating Officer, Reposit Power, *Committee Hansard*, 10 February 2017, p. 13.

72 Dr Andrew Mears, Director and Chief Executive Officer, SwitchDin, *Committee Hansard*, 10 February 2017, p. 14.

73 Mr Luke Osborne, Director and Chief Operating Officer, Reposit Power, *Committee Hansard*, 10 February 2017, p. 1.

- quick to approve.⁷⁴

3.100 Dr Mears was of the view that SwitchDin had resolved the issues of integration and control, thereby enabling small-scale, distributed systems to participate in the new energy sector of the future.⁷⁵

3.101 Similarly, Mr Osborne stated that companies facilitating distributed generation were already operating successfully within the NEM:

I do not think there are many barriers at all. We are up and operating. A customer can go right now and buy our gear. They can put it on their house. They can choose a plan from one of a number of retailers that are for battery participants and that allow them to do this interactive stuff. We can do it today, and that is because in the nineties we went through a great reform. We built the NEM... I think it is well designed. We can operate in it.⁷⁶

3.102 Mr Blume was of the view that aggregators were the future of the electricity market:

There will be aggregators who will look at individual businesses and homeowners and what their energy resources are and they will say: 'We'll give you a deal. Here's the deal. We will manage your system for you.'⁷⁷

3.103 The committee heard numerous examples of community led-proposals that had grasped or were working towards this goal. For example, Mr Phil Browne submitted that:

It makes great sense that the government should lead the way...by creating a network of many solar energy plants with battery storage distributed across the country. In addition to being cheaper in the long term, these solar plants would distribute power to local communities, and importantly, in the event of a storm disrupting power supply, it would not cause the massive loss of power to most of the state as occurred in South Australia when the current distribution grid was destroyed in a super storm.⁷⁸

3.104 The Northern Alliance for Greenhouse Action noted that collaborative action to develop distributed energy networks might lead to some unlikely partnerships between the public and private sector:

The design of local energy solutions requires collaboration between parties that have traditionally not worked in close partnership, such as local

74 Mr Luke Osborne, Director and Chief Operating Officer, Reposit Power, *Committee Hansard*, 10 February 2017, p. 1.

75 Dr Andrew Mears, Director and Chief Executive Officer, SwitchDin, *Committee Hansard*, 10 February 2017, p. 14.

76 Mr Luke Osborne, Director and Chief Operating Officer, Reposit Power, *Committee Hansard*, 10 February 2017, p. 14.

77 Mr Steve Blume, President, Australian Solar Council, *Committee Hansard*, 10 February 2017, p. 27.

78 Mr Phil Browne, *Submission 18*, p. 1.

governments and electricity networks. Distributed energy resources require participation and collaboration from diverse stakeholders in order to ensure that overall system security and reliability is maintained.⁷⁹

3.105 Local energy trading was seen as a particularly important driver in reducing the costs of new energy storage technology through economies of scale:

...local energy trading improves the return on investment of energy storage and related devices significantly which will serve to increase the frequency of uptake and accelerate the reduction in system costs in accordance with technology maturity curves.⁸⁰

3.106 Concerns were raised that the shift to decentralised electricity generation by consumers created uncertainty that neither government nor industry can control. Mr Bradley warned that:

Customers could drive 25 to 40 per cent of all system expenditure between now and 2050. The significance of that is it is going to be over \$200 billion worth of expenditure that is actually determined by customers or their agents. In that environment, neither the industry nor governments can command and control the way in which the system develops.⁸¹

3.107 Mr Bradley stated, however, that the right incentives from both government and industry would lead to better market outcomes:

All we can do is send incentives. So that is government sending incentives, which is around carbon abatement, through outcome based carbon policy. In the industry's case, it is sending incentives about the potential rewards for customers that could use their solar and batteries to help reduce the need for network expenditure and rewarding customers for those kinds of services.⁸²

3.108 Dr Mears added that with such a system consumers may become 'prosumers' and there may need to be different mechanisms to reflect the value of their contributions to the electricity system:

The Power of Choice review has led to transformations in the expectation of incumbents around what the consumer will mean in the future of this sector. The really big shifts that need to happen are about extending that more deeply. How do consumers who are now becoming what we call 'prosumers'—they are producing energy as well as consuming energy—fully participate? At the moment, for example, if your solar system generates excessive electricity, you can export it onto the network. You are remunerated with an amount, which perhaps does not reflect the potential value you could otherwise get if you were allowed to find a better buyer for

79 Northern Alliance for Greenhouse Action, *Submission 17*, p. [2].

80 Nexergy, *Submission 25*, p. 5.

81 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 32.

82 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 32.

that electricity, for example. So enabling the sorts of peer-to-peer trading opportunities, being able to quantify the costs that the networks would charge for allowing you to do that sort of activity and clarifying or making these process more transparent would enable a whole range of new business models for energy services.⁸³

Electricity demand management

3.109 The committee also heard about other smart devices that can contribute to managing electricity demand. Mr Blume explained how what are termed 'demand response enabling devices' work:

They are very simple little things. There are 750 000 households with them on their hot-water systems. And what do they do? When there is big demand, they either pump electricity into those hot-water systems or turn the hot-water systems off. There are about half a million of them on air conditioners, and they drive the air conditioners. It is not like all of a sudden your air conditioner turns off and you think, 'Bugger—I've got no air conditioning.' They turn it off in lumps all over the network—two minutes off here, two minutes off there. That is called demand response, and the demand response technology up until now has not been used very much.⁸⁴

3.110 Energy Networks Australia noted developments in Australia that help incentivise fleets of millions of distributed energy resources to contribute towards lowering the cost of the centrally delivered infrastructure:

The kinds of resources we are talking about are not only solar—or solar with smart inverters, particularly—or storage; they are also sophisticated demand response programs. There are aggregators of demand response that will offer customers a simple interface to allow them to control devices like hot water or pool pumps, so that they can respond on call and help beat the peak and manage the peak lopping...⁸⁵

Committee view

3.111 The committee considers that a diversity of distributed generation and storage technologies have the potential to greatly enhance the operation and resilience of Australia's electricity networks. The committee further considers that in Australia we are collectively past the small scale proto-typing of such technologies and it is now time to move forward with a detailed scoping study for substantial deployments of distributed generation and storage technologies. The committee wishes to emphasise that the scoping study it is recommending should address academic research on the resilience of distributed systems.

83 Dr Andrew Mears, Director and Chief Executive Officer, SwitchDin, *Committee Hansard*, 10 February 2017, p. 14.

84 Mr Steve Blume, President, Australian Solar Council, *Committee Hansard*, 10 February 2017, p. 26.

85 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 33.

3.112 The committee affirms that it is essential for the Commonwealth government to show leadership in the high level design of Australia's electricity system. While acknowledging that markets will play a necessary role in the implementation of the electricity system, left to their own devices, markets and corporations cannot and will not achieve an overall design for Australia's electricity system that is in the best interests of Australia and its people.

Recommendation 3

3.113 The committee recommends that the Commonwealth government conduct a detailed scoping study to evaluate options for distributed generation, new software services, and storage technologies to contribute to the resilience of Australia's electricity networks.

Chapter 4

Policy and regulatory measures

Introduction

4.1 This chapter considers key policy and regulatory measures to hasten the rollout of storage technologies and localised, distributed electricity generation including:

- a coherent and consistent long-term carbon price signal to drive investment in both renewable generation and a diverse range of energy storage technologies;
- a consistent national renewable energy target including ways in which Large-scale Generation Certificates could be used to incentivise the deployment of pumped hydro and thermal storage systems; and
- the reduction of the price settlement time in the NEM to five minutes to incentivise the rapid deployment of storage technologies such as batteries.

The business case for policy certainty on a carbon price signal

4.2 A consistent theme that ran through this inquiry was that a substantial majority of Australia's generating capacity has already reached the end of its life-span and urgently needs replacement.

4.3 For example, representatives from AGL told the committee that about 70 per cent of the electricity generation supply in Australia is now past its designed technical end of life.¹ Similar figures were provided by the Australian Solar Council, which stated that 65 per cent of these generation assets need to be replaced by 2030 and 85 per cent by 2040.²

4.4 Despite the urgent need to replace ageing coal-fired (and some gas-fired) electricity generation infrastructure, the committee heard striking evidence that the lack of policy certainty over the last decade has prevented investors from making efficient decisions to invest in any new generators. Mr Danny Price, Managing Director of Frontier Economics, described this situation to the committee:

[T]he power system...security and reliability [is] visibly deteriorating. It is often said that this is the fault of the market—that there is some form of market failure that is causing this. I am very confident that it is not the market; it is a political failure to have a national plan for the way in which the market should operate. Investors simply cannot respond to the uncertainty that we see in the market. They cannot invest in conventional plant because that could well be redundant in the future with a carbon price and they cannot invest in high-cost and low-emission plant because at the moment it would not be economic. They are basically caught between a

1 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 7.

2 Australian Solar Council and Energy Storage Council, *Submission 36*, p. 3.

rock and a hard place. There is no investment that they can make that is going to be economic at the moment, so they are doing what is completely rational and that is just sitting on their hands, and as they sit on their hands the system gets worse. That is our basic problem.³

4.5 Similarly, King & Wood Mallesons submitted that policy failure had undermined investor and business confidence:

Policy stability and consistency is crucial for investment confidence. For businesses to take risks on the future and invest, they need to be confident that emissions reduction policies and the mechanisms to achieve them...are stable. The lack of clarity and long-term direction with respect to Australia's renewable energy policy has impacted the industry in a profound way.⁴

4.6 The Australian Academy of Technology and Engineering observed that the failure of government to provide a level playing field in electricity generation was preventing the necessary deployment of innovative solutions:

Current market conditions mean that large-scale storage is not economically viable in most cases. While carbon emissions remain a market externality, cheap but greenhouse gas intensive resources (i.e. coal, gas) dominate generation and the provision of inertia and other system services. Correcting this market externality failure would provide a level playing field for all generation technologies and incentivise development of innovative supply – and demand-side solutions, which are likely to hasten the deployment of significant quantities of energy storage.⁵

4.7 Professor Ross Garnaut explained how a failure to price carbon, and a lack of political leadership at the national level, had caused such uncertainty amongst business that it had paralysed investment in the energy sector:

While there is extreme uncertainty about policy, it raises the supply price of investment to every form of generation and inhibits investment in every form of generation. While there is such uncertainty there will not be new investments.⁶

4.8 Describing the current political debate around climate and energy policy as 'incoherent', Professor Garnaut warned that the failure to adopt a coherent policy meant that Australia was missing the opportunity to secure a low-cost path to the 'necessary low-emissions electricity system of the future'.⁷

4.9 Mr Price emphasised that the critical element in the energy policy debate was what investors thought about carbon pricing:

3 Mr Danny Price, Managing Director of Frontier Economics, *Committee Hansard*, 7 March 2017, p. 27.

4 King & Wood Mallesons, *Submission 37*, p. 4.

5 Australian Academy of Technology and Engineering, *Submission 38*, p. 2.

6 Professor Ross Garnaut, *Committee Hansard*, 7 March 2017, p. 24.

7 Professor Ross Garnaut, *Committee Hansard*, 7 March 2017, p. 21.

It does not require a belief in climate science to accept that carbon pricing is necessary. It does not matter what you or I think; what really matters and the only thing that matters is what investors think. If they think there is the possibility that a carbon price could come in place in the lifetime of an investment, they will have to make investments with that as a possibility. The argument about the climate science is neither here nor there for us. It really comes down to what investors think.⁸

4.10 Along similar lines, Professor Garnaut advised the committee that the removal of a carbon price had left business in the untenable position of second-guessing government policy:

...the absence of a carbon price since the middle of 2014 has contributed to the uncertainty about the investment environment. Business knows that we have to move towards a low-emissions energy sector. A carbon price provided very clear guidelines for making business decisions on how to proceed. In the absence of those guidelines, business has to second-guess regulatory decisions by government. They know they will come and it is a matter of second-guessing them. That is a problem for the environment and for the cost of energy.⁹

4.11 Professor Garnaut argued that a form of carbon pricing, including an emissions intensity scheme, would increase business confidence. He told the committee:

If, for example, we had bipartisan support for a form of carbon pricing, which could be an emissions intensity scheme, and business had confidence that was going to last for quite a long time, then it would be much easier for business to calculate that there was going to be a role for gas for a certain period of time, which would justify investment. In current circumstances the extreme uncertainty about policy inhibits all investment.¹⁰

4.12 Mr John Bradley, Chief Executive Officer of Energy Networks Australia, told the committee that policy uncertainty and blame would lead to higher costs for consumers and 'a less secure transition to a lower carbon economy'.¹¹ He argued that Australia 'cannot afford to have inconsistent or fragmented policy frameworks across state and federal governments'.¹²

4.13 Mr Douglas Jackson, the AGL Energy Limited (AGL) Executive General Manager, told the committee that policy certainty was critical because energy assets

8 Mr Danny Price, Managing Director, Frontier Economics Property Ltd, *Committee Hansard*, 7 March 2017, p. 28.

9 Professor Ross Garnaut, *Committee Hansard*, 7 March 2017, p. 22.

10 Professor Ross Garnaut, *Committee Hansard*, 7 March 2017, p. 24.

11 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 31.

12 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 36.

are long-term 'bets' as they typically have a life-span of 20 to 40 years during which investors need to make a return on their money.¹³

4.14 Likewise, Mr Richard Wrightson, General Manager of Wholesale Markets at AGL, told the committee that the Commonwealth government's failure to secure a bipartisan national policy approach had crippled energy investment:

For any policy in this space, be it that or any other policy, if you want to drive a 30-to-40-year investment, you need that bipartisan support.¹⁴

4.15 Dr Noel Simento, Managing Director of Australian National Low Emissions Coal Research and Development, told the committee that the electricity sector needs policy certainty in order to create investment certainty because of the risks involved in investing the substantial funds needed to deploy low-emissions generation technologies.¹⁵

4.16 Mr John Pierce, Chairman of the Australian Energy Market Commission (AEMC), responded to questions about an emissions intensity scheme with the following observation about the need for policy certainty over the long-term investment cycle:

...the main thing the sector needs to provide that sense of certainty and security that will then enable the market participants to do what they do—make investments and operate their businesses—is certainty around the policy framework and the policy instruments that are going to be operating and affecting the sector...

They need to know what investments are going to fly or not, which means they need to know what is the policy framework that is going to apply, not just today but in five years' time, 10 years' time and 15 years' time. It is the confidence people have in the stability, not necessarily in the specifics but of the framework, that underpins the confidence that people have for an investment.¹⁶

4.17 Mr John Bradley, Chief Executive Officer of Energy Networks Australia, was of the view that a national approach that incorporated 'an integrated, outcome focused transition plan' was necessary to overcome the 'technical economic and regulatory challenges' facing the industry. He warned the committee:

...without a well-planned approach with timely action by governments to create policy and regulatory cohesion, Australia's energy system is unlikely

13 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 8.

14 Mr Richard Wrightson, General Manager, Wholesale Markets, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 11.

15 Dr Noel Simento, Managing Director, Australian National Low Emissions Coal Research and Development, *Committee Hansard*, 10 February 2017, p. 7; Mr Jim Kouts, Head of Corporate Affairs, ENGIE in Australia, *Committee Hansard*, 20 February 2017, pp. 5 and 12.

16 Mr John Pierce, Chairman, Australian Energy Market Commission, *Committee Hansard*, 10 February 2017, pp. 56–7.

to efficiently and securely integrate diverse technologies, large-scale renewable energy sources and customer owned distributed energy resources.¹⁷

4.18 Mr Oliver Yates, Chief Executive Officer of the Clean Energy Finance Corporation, outlined why energy policy requires a coordinated national approach and the reasons that the private market alone cannot solve the problem:

The private market will not be able to make long-term investment decisions in a highly volatile situation...People do not quite know the direction of government policy. People do not know the timing of the need to make adjustments in carbon emissions. People do not know the speed with which that may or may not have to be made. In that environment it is very hard for the private sector to make long-term investment decisions, which are necessary if you are going to move from one type of asset to another type of asset. It is incumbent on all governments to work together to come up with a pathway and a framework, which has to be bound around a long-term objective that is set around general scientific terms as to what we need to do, and then they need to build an investment climate that facilitates the market to go from A to B.¹⁸

4.19 Mr John Grimes, Chief Executive Officer of the Australian Solar Council told the committee that the market had already moved and that what was required from government was leadership and a national plan to manage the inevitable transition to a clean energy future:

Most of all, we need a plan. We need a plan to get us from where we are today to where the market is going to take us. Whether you believe in this stuff or not, this is inevitable and it is unstoppable. It is the market.¹⁹

4.20 Mr Price of Frontier Economics argued that the lack of national plan, rather than market failure, is to blame for the deterioration of the power system. He stated:

It is often said that this is the fault of the market—that there is some form of market failure that is causing this. I am very confident that it is not the market; it is a political failure to have a national plan for the way in which the market should operate. Investors simply cannot respond to the uncertainty that we see in the market.²⁰

4.21 AGL emphasised that a staged transition would allow market participants time to plan:

17 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 30.

18 Mr Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation, *Committee Hansard*, 10 February 2017, p. 39.

19 Mr John Grimes, Chief Executive Officer, Australian Solar Council, *Committee Hansard*, 10 February 2017, p. 24.

20 Mr Danny Price, Managing Director, Frontier Economics, *Committee Hansard*, 7 March 2017, p. 27.

We support something that is transparent and creates a transition plan that I think customers, the communities, the markets and policymakers can respond to. The market participants need time to plan; there are often five to 10 years in planning horizon, and we need some sort of predictability of when to replace assets to avoid the disorderly transition we are currently experiencing today.²¹

4.22 In terms of the Finkel Review, some witnesses expressed optimism that the terms of reference and approach of the review could deliver a holistic approach. Mr John Bradley, Chief Executive Officer of Energy Networks Australia stated:

We would be optimistic that, if we take an evidence based approach through that Finkel review, if it focuses on outcomes rather than trying to pick technology winners or identify the most likely solutions and instead creates resilient market frameworks within which a technology competition can occur to get the outcome we want, whether it is decarbonisation, security or energy affordability, that will be the right model.²²

4.23 However, other witnesses such as Mr Grimes expressed disappointment that the Commonwealth government had pre-emptively ruled out certain options in relation to energy policy:

Why the Finkel review is so important, in our estimation, is that it has the ability to produce that plan, that blueprint for the future—to recognise what technology is doing and to recommend the most efficient way possible to transition to the new reality, which is coming, ready or not. So we are very supportive of that process. We are disappointed when some things are pre-empted, are already ruled out.²³

Emissions intensity scheme

4.24 A number of witnesses expressed support for an emissions intensity scheme. For example, AGL argued that it would enable a stable, predictable and low-cost path to a lower emissions system.²⁴

4.25 Mr Price told the committee that an emissions intensity scheme would allay the concerns of consumers who are 'very sensitive' to electricity prices and might not favour carbon pricing. He outlined that:

One of the great features of the emissions intensity scheme is that effectively the costs of that scheme fall on high-emission generators, but the way that you introduce that can be easily managed by those high-emission generators. In fact, only yesterday the two biggest emitters of greenhouse

21 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 4.

22 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 32.

23 Mr John Grimes, Chief Executive Officer, Australian Solar Council, *Committee Hansard*, 10 February 2017, p. 25.

24 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 2.

gas—carbon dioxide—AGL and Energy Australia have called for an emissions intensity scheme. That is how much they value the certainty that comes with that type of scheme over the damage that it does to their business. They have already accepted that this is going to come into place, as most investors have.²⁵

4.26 Amidst calls by the National Farmers Federation,²⁶ AGL²⁷ and Energy Australia²⁸ for an emissions intensity scheme, Mr Price informed the committee that '[p]eople are already making decisions as if there was a carbon price in place'.²⁹

4.27 Professor Garnaut told the committee that despite its limitations, 'an emissions intensity scheme in the electricity sector would do the job', advising that:

...an emissions intensity scheme would serve the purpose of providing appropriate incentives for investment in lower emissions technologies. In fact, as far as the climate change objectives, the emissions reduction objectives, and also the energy investment efficiency objectives are concerned, the emissions intensity scheme is very similar in its merits to carbon pricing.³⁰

Committee view

4.28 Evidence received by the committee makes it clear that the debilitating investment strike in some sections of the electricity sector has been caused by the abolition of a price on carbon and changes to the renewable energy target. Witnesses were very clear that political failure at the Commonwealth level to agree on a carbon price had caused such extreme uncertainty in sections of the energy sector that investors and energy companies were unwilling to invest in new electricity infrastructure.

4.29 Contrary to the evidence provided to the committee by Mr Price and a number of incumbent operators, the committee does not accept the assertion that investment in generation capacity is stalled, across the entire energy sector, due to uncertainty.

25 Mr Danny Price, Managing Director, Frontier Economics, *Committee Hansard*, 7 March 2017, p. 28.

26 Mr Paul Karp, 'National Farmers' Federation joins calls for market mechanism to lower carbon emissions', *The Guardian*, 7 March 2017, <<https://www.theguardian.com/australia-news/2017/mar/07/national-farmers-federation-joins-calls-for-market-mechanism-to-lower-carbon-emissions>>, accessed 21 March 2017.

27 Ms Caroline Winter, 'AGL joins calls from National Farmers' Federation for carbon price', ABC News, 7 March 2017, www.abc.net.au/news/2017-03-07/agl-joins-calls-from-farmers-peak-body-for-carbon-price/8332058, (accessed 21 March 2017).

28 Mr Mark Ludlow, EnergyAustralia and AGL back an emissions intensity scheme for the electricity sector, Australian Financial Review, 5 March 2017, www.afr.com/news/politics/energyaustralia-and-agl-back-an-emissions-intensity-scheme-for-the-electricity-sector-20170305-guqyn2, (accessed 21 March 2017).

29 Mr Danny Price, Managing Director, Frontier Economics, *Committee Hansard*, 7 March 2017, p. 28.

30 Professor Ross Garnaut, *Committee Hansard*, 7 March 2017, p. 23.

4.30 While it is certainly the case that investment in new *fossil fuel generation* is stalled because of the uncertainty around future carbon scenarios, the committee notes that investment in new *renewable* energy capacity, either under construction or due to commence construction in 2017, equates to an enormous 2.2GWs.³¹

4.31 Far from there being a poor investment climate for electricity generation, the evidence of actual projects being built demonstrates that there is a thriving renewable energy sector at the moment despite the impediments of an outdated regulatory framework and the Commonwealth government's refusal to give the sector long-term carbon policy certainty.

4.32 The committee further notes that, in addition to the 2.2GWs of generation referred to above, there have been a further series of enormous renewable energy projects announced in just the last two months. These include:

- Riverland Solar Storage in Morgan, South Australia that will add 330MW plus significant storage which is aimed to be constructed and operational during 2017;
- Kingfisher Solar Storage in Roxby Downs, South Australia which will add 120MW plus significant storage in 2018;
- Bodangora wind farm near Wellington in NSW which will add 113MW; and
- a potential expansion of the Snowy Hydro system, which is estimated to add 2GW of capacity to the NEM.

4.33 Discussions also continue around the construction of a 100MW solar thermal power generator at Port Augusta, South Australia. While a long term purchase agreement and confirmation of any grant or loan funding are still required before this project can proceed, it will ultimately contribute significant generation and storage capacity to the market.

4.34 The committee urges the Commonwealth government to reconsider its approach to carbon policy. A carbon price is so clearly in the national interest and so clearly required for stable investment in the electricity sector that the committee is strongly of the view that a mechanism for signalling a price on carbon be considered and implemented as a matter of priority.

4.35 There is much to be gained from a carbon price. The weight of evidence over at least the last decade has indicated that a carbon price will drive the necessary investment in renewable energy technologies required to reduce greenhouse gas emissions. Furthermore, the evidence going back to both the *Stern Review* (2006) and the *Garnaut Review* (2008) indicates that the costs of mitigating climate change are significantly less than the costs of doing nothing. The intervening years since those two reviews have shown that Australia is uniquely placed to become a renewable

31 Clean Energy Council, New renewable energy projects point to biggest year for industry since Snowy Hydro, 11 February 2017, <https://www.cleanenergycouncil.org.au/news/2017/February/2017-renewable-energy-projects-snowy-hydro.html> (accessed 3 April 2017).

energy superpower, a position that will bring enormous economic benefits in a carbon constrained world and one that will create many tens of thousands of new jobs in the clean energy sector.

4.36 Beyond the investment in renewable energy that a carbon price would help deliver, the committee also received a wealth of evidence (see chapter 3) that a range of storage technologies are available to help successfully integrate intermittent renewable energy sources such as wind and solar PV into grid networks. Furthermore, a diverse range of storage technologies that will offer the full range of ancillary services required for the grid security are capable of being deployed now.

4.37 However, the NEM contains antiquated rules that act as a barrier to the uptake of storage technologies. These matters are discussed in a later section of this chapter.

The renewable energy target

4.38 Just as with carbon pricing, the committee heard that a failure to secure a consistent political approach at the national level to the renewable energy target (RET) had plagued investment in renewable energy projects because of the massive uncertainty it created for business. Mr Wrightson, AGL, told the committee:

A renewable scheme that has a review of its targets every three years creates such a huge political uncertainty. I know the option is that those targets could be increased, and, as we discovered, they could also be decreased.³²

4.39 AGL described how the three-year reviews of the renewable energy targets held back investment in long-term renewable energy generation:

When you are looking at building a wind farm that hopefully has something like a 20-year life, bearing in mind that the bulk of the earnings from a wind farm actually comes from the renewable energy certificates, a three-year cycle for reviewing targets is difficult and has hindered investment up until now.³³

4.40 The committee also received evidence that changes to the RET could be used to incentivise the deployment of macro scale renewable energy storage projects such as pumped hydro.³⁴

4.41 Genex noted that pumped hydro storage is currently ineligible for Large-scale Generation Certificates under the RET because the amount of 'auxiliary loss', that is, the amount of electricity consumed in pumping, always exceeds the total electricity generated. Genex argued that pumped hydro storage should be recognised as an eligible Large-scale Generation Certificates under the Renewable Energy (Electricity)

32 Mr Richard Wrightson, General Manager, Wholesale Markets, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 5.

33 Mr Richard Wrightson, General Manager, Wholesale Markets, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 5.

34 Genex, *Submission 3*, p. 6.

Regulations 2001 and proposed that the definition of auxiliary loss be redefined in the Regulations:

3B Definition of auxiliary loss

(i) For a power station, auxiliary loss means the amount of electricity used in generating electricity, and operating and maintaining the power station, but does not include any electricity used for network control ancillary services.

(ii) Subject to clause 3B(iii), for a hydro-electric power station, auxiliary loss also includes the amount of electricity that is used to pump or to raise water before its release for hydro-electric generation.

(iii) For a pumped storage hydro-electric power station that is accredited under section 15 of the Act on or after [a nominated future date] auxiliary loss does not include the amount of electricity used to pump or to raise water before its release for hydro-electric generation.³⁵

Committee view

4.42 The committee is aware that the future of the renewable energy target is shrouded in uncertainty beyond 2020. The committee notes that in the absence of a carbon price, the renewable energy target has been a necessary mechanism to drive new investment in renewable energy generation. The committee is of the view that the renewable energy target has performed a vital function in encouraging investment in renewable energy, particularly in the absence of a carbon price, and for this reason alone, it should be maintained and expanded beyond 2020.

4.43 The committee is also aware that aspects of the renewable energy target could be modified to incentivise investment in macro scale energy storage systems. Given the importance of macro scale energy storage, the committee is of the view that such proposals should be given careful consideration as part of a detailed review to examine whether there are any policy and regulatory barriers to the implementation of energy storage technologies to facilitate the operation and resilience of Australia's electricity networks.

Recommendation 4

4.44 The committee recommends that the Commonwealth government continue and expand the Renewable Energy Target beyond 2020.

Market rule and regulatory changes to incentivise the deployment of storage technologies

4.45 This section considers a proposition put forward throughout the inquiry that the key to the rapid deployment of storage technologies is a change to economic and regulatory requirements that would allow storage technology providers to better capture the value that storage offers.

35 Genex, *Submission 3*, p. 6.

4.46 The NEM rules currently provide for different dispatch and settlement periods. That is, bids to supply electricity into the market are made every five minutes, whereas payments for supplying that electricity are averaged from the prices over a 30 minute period.³⁶

4.47 Dr Matt Wenham, Executive Manager of Policy and Projects at the Australian Academy of Technology and Engineering (ATSE) told the committee that ATSE had spoken to over 80 organisations and stakeholders involved in the energy sector and the need to change the settlement rules was mentioned repeatedly by stakeholders. Dr Wenham stated that feedback from stakeholders indicated that storage providers would be much more able to enter the market if the settlement period was changed to five minutes to align with the dispatch period because they would be able to access a clearer revenue stream.³⁷

4.48 In response to questions from the committee, Dr Wenham explained that the current settlement rules were a hangover from the days of coal and gas-fired electricity generation and the rules were no longer adequate to deal with large fluctuations over short timeframes.³⁸

4.49 Dr Evan Franklin, from the Energy Change Institute, ANU, told the committee that a key advantage of battery storage was the ability of a battery to provide one element of system resilience, namely responding rapidly to dynamic system disturbances that occur over a matter of seconds.³⁹

4.50 Dr Franklin explained that under the current rules, if prices spike dramatically for a five minute period, a supplier of electricity for that period may only get a fraction of the value of that electricity supplied to the system because it is averaged over a 30 minute price:

If there is one five-minute period where you need a lot of extra generation to meet demand, it will come in at a very high price, but the average price over that 30-minute period may not reflect the need over that five-minute period. So if you are a generator who supplies much-needed electricity during that five-minute period, you get paid for the five minutes but you get paid on the 30-minute price. You may get paid a fraction of the value of that electricity for that period of time.⁴⁰

36 Dr Matt Wenham, Executive Manager Policy & Projects, Australian Academy of Technology and Engineering, *Committee Hansard*, 7 March 2017, p. 29.

37 Dr Matt Wenham, Executive Manager Policy & Projects, Australian Academy of Technology and Engineering, *Committee Hansard*, 7 March 2017, pp. 28–29.

38 Dr Matt Wenham, Executive Manager Policy & Projects, Australian Academy of Technology and Engineering, *Committee Hansard*, 7 March 2017, p. 29.

39 Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 3.

40 Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 4.

4.51 Similarly, Mr Bruce Mountain, Director of CME, explained that his research revealed the market is flawed because it fails to adequately reward batteries for the value they can contribute by putting power into the system at very short notice:

The market we operate sets prices in five-minute trading intervals or auctions. The trading period, the settlement period price—the price that the generators receive and that the consumer pays in the mandatory wholesale market—is the average of those five-minute trading prices. So batteries, which can actually respond in very short intervals and can adjust either the demand that they are taking from the grid or the exports back into the grid at a very rapid pace, are not getting their full compensation for that because the value they offer is very high in that five-minute interval but the price they get is the average over the half-hour. Essentially, the market is not reflecting that very short transient value that batteries, first and foremost, and hydro, secondly, have the greatest value in actually producing. So a lot of the economic value that batteries has is not captured by that particular market flaw.⁴¹

4.52 In effect, therefore, the current rules which provide for a 30 minute settlement period for prices may have a perverse effect because they act as a disincentive to the provision of batteries that are able to provide resources within milliseconds for periods of one, five or ten minutes.⁴²

4.53 Even worse, the committee heard very forceful arguments made by some witnesses that the current rules allow, and possibly encourage, perverse behaviours in the market during times of extreme stress in the system. These behaviours, while within the rules, do not benefit the system, but rather benefit particular operators.⁴³

4.54 For example, Dr Matthew Stocks, from the College of Engineering and Computer Science, ANU, explained that not only are operators such as storage providers being deprived of the full value of the services that they supply, but other generators are encouraged to make negative bids merely in order to participate during periods of high stress when they will also reap a share of the rewards provided by storage operators:

Dr Stocks: I will certainly take a much stronger position on the settlements. One of the challenges with having a different dispatch and a different settlement period is that you have people who come in and support the system at times of very high stress and then, when that stress disappears, people who continue to generate get rewarded for the very high prices in that period. One of the things that are happening, particularly with storage, is that people will be able to respond faster—we are talking seconds for batteries and less than a minute for pumped hydro. People can respond to the needs of the system much more rapidly, so if the price heads

41 Mr Bruce Mountain, Director, CME, *Committee Hansard*, 7 March 2017, p. 61.

42 See, for example, Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 3.

43 See, for example, Dr Matthew Stocks, Fellow, College of Engineering and Computer Science, Australian National University, *Committee Hansard*, 10 February 2017, pp. 4–5.

to a price gap of \$14,000 a megawatt hour then everyone, for that 30-minute period, benefits from that divided by six for that entire half-hour. So if you are just idling along through that entire period then you get rewarded for somebody coming in and helping out, at a very high price, for a short period of time, and it then drives behaviour like what we have seen recently in South Australia, where operators will bid at negative prices to ensure that they get that average price for that entire period. There were examples where people bid at minus—

CHAIR: Isn't that price gouging?

Dr Stocks: No, it is working within the market that exists. If you have a set of market rules then everyone will behave to optimise their outcome within those rules. So what we have is a difference between settlement and dispatch which rewards particular behaviours, and they are not necessarily behaviours that are best for the resilience of the system; they are best for those particular operators. The technology and the ability to respond are changing, and to some extent this has really come out of old established rules where things did happen much more slowly, and it really did not matter that there was this five-minute period, because everyone had to ramp up, ramp down and take much longer periods of time. The challenge there is that, if storage is going to come into that, if you really want it to develop that very fast instantaneous response, it needs to be rewarded for filling in that gap and not end up being paid six times less than what that was deemed to be worth because whoever supplies in that six-minute period only gets about \$2,000 a megawatt hour rather than the \$14,000 that they bid. So it drives different behaviours in the system, and not necessarily those that best balance out the overall system.⁴⁴

4.55 The committee heard from a number of witnesses that changing interval pricing to allow payment for short-term storage and discharge would incentivise battery storage.⁴⁵

4.56 Mr Oliver Yates, Chief Executive Officer of the Clean Energy Finance Corporation, told the committee that:

Currently you only get paid on 30-minute interval pricing. Five-minute interval pricing, from our own analysis on battery projects, would change the revenue profile significantly and would then encourage batteries to come into the market and be available for short-term supply. This is exactly what you want: a very fast response.⁴⁶

4.57 Dr Franklin pointed out that a change in the market rules could encourage batteries to be installed at the household level and that this would make that stored

44 Dr Matthew Stocks, Fellow, College of Engineering and Computer Science, Australian National University, *Committee Hansard*, 10 February 2017, pp. 4–5.

45 Mr Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation, *Committee Hansard*, 11 February 2017, p. 41; Mr Ivor Frischknecht, Chief Executive Officer, Australian Renewable Energy Agency, *Committee Hansard*, 10 February 2017, p. 40.

energy 'available to provide fast-frequency response in the case of supply-demand imbalance in the wider system'.⁴⁷

4.58 Dr Stocks observed that a change to the market rules could also incentivise macro solutions to energy storage such as pumped hydro.⁴⁸

4.59 The Australia Institute explained that 'fully rewarding demand side market participants for 5 or 10 minute entries to the market' would not only encourage them to participate in the market but would have the added benefit of 'moderating overall price levels'.⁴⁹

4.60 Mr John Pierce, Chairman of AEMC told the committee that the AEMC had already received a proposal to change the settlement time within the spot market from 30 minutes to five minutes. Mr Pierce advised that the AEMC was currently assessing the proposal against the National Electricity Objective. The assessment includes a consultation process, a directions paper containing options for implementation, and the publication of draft rules 'akin to exposure drafts of legislation' on 6 July 2017.⁵⁰

4.61 The committee also heard that the design of the electricity tariff paid at the household level also acts to undermine the full value that customers could receive from installing a battery:

Around one-third of the residential price to a household consumer or a small business consumer is a fixed charge, which does not vary as a consequence of how much the customer consumes. Batteries and solar, which are a fixed cost outlay to a household, do not capture that value because the household or the business is still exposed to the fixed charge, so the economic value that it has is actually diminished to the householder or the small business that puts in a battery by virtue of the tariff structure.⁵¹

4.62 Mr Bruce Mountain, director of CME, also explained to the committee that, in many instances, high prices were not necessarily the result of any genuine shortage of electricity. Rather, many generators exploit the current rules to game the system by forcing prices higher and therefore maximising their profits at consumers' expense:

It is my view that in many trading intervals and half-hour settlement periods, most notably in South Australia and in Queensland, the prices we see do not reflect a genuine scarcity in the market; they reflect the exercise of market power. Generators through their actions can withdraw capacity from the market by either not making it available to the market at all or, alternatively, only making it available at extremely high priced bands and

47 Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 3.

48 Dr Evan Franklin, Senior Lecturer; Fellow, Energy Change Institute, Australian National University, *Committee Hansard*, 10 February 2017, p. 4.

49 The Australia Institute, *Submission 54*, p. 41.

50 Mr John Pierce, Chairman, Australian Energy Market Commission, *Committee Hansard*, 10 February 2017, p. 53.

51 Mr Bruce Mountain, Director, CME, *Committee Hansard*, 7 March 2017, p. 61.

as a consequence, although they lose production through the smaller volume that they are dispatched to, they gain a price which is a multiple of the lost production. This is a straightforward exercise in market power. In my opinion it is well documented by the regulators and noted duly. I think the enforcement regime we have in Australia is inadequate in dealing with that. I think prices would be lower if those issues were adequately addressed.

...

The maximum price that a generator can receive in a half-hour is \$14,000 per unit that they produce. The typical annual average price is in the range of \$50 per megawatt hour to \$100. So by withdrawing capacity and achieving extremely high prices in a number of these half-hourly periods they can obtain two orders of magnitude or three orders of magnitude more revenue than they otherwise would. It is impossible to say how much they actually get because the amount they get is a function of their contracts in the market. The wholesale market is a mandatory spot market. They have to produce and sell into that market but they can hedge around it by entering into contracts.

Not knowing the contract position, I cannot identify how much any individual market participant gets, but I know that they can affect spot market outcomes and hence contract market outcomes and hence enforce their own competitive position in the wholesale market and most notably in the retail market, where they can drive out competitors who can otherwise not get access to contracted positions that will hedge this extreme volatility.⁵²

4.63 Mr Mountain did not agree with the proposition put forward by regulators that this type of behaviour was reasonable. Instead, he argued that it indicated the exercise of market power by generators who were able to 'make the price' at certain times:

But I am of the view that that sort of picture and that pattern of behaviour is consistent over time, and is a form of capacity withdrawal. It is a market, and the regulators will say: 'This is reasonable market behaviour; there is a capacity shortfall, or a prospect of one, and so we do not have to make our plant available.' In market economics, that is pure and simple the exercise of market power. You are not taking the price in the market, you are making the price in the market.⁵³

4.64 Mr Mountain also warned that the concentration of market power after the closure of Hazelwood brown coal-fired power station in Victoria would intensify the problems arising from the vertical integration of the incumbent power generators:

I think there is a vertical integration and incumbency problem, and I think it is particularly acute in South Australia. I think it is also a problem in Queensland and then New South Wales and Victoria, in that order. I think the loss of Hazelwood will probably introduce the problem into Victoria

52 Mr Bruce Mountain, Director, CME, *Committee Hansard*, 7 March 2017, p. 61.

53 Mr Bruce Mountain, Director, CME, *Committee Hansard*, 7 March 2017, p. 62.

because Hazelwood has been a largely uncontracted trader. It has had excess capacity compared to the retail generation that its owner, ENGIE, had through its retailer, called Simply. And as a consequence, the loss of that generation will put greater contractual authority and power in the hands of the incumbent generators. This evidence is quite visible, simply looking at the number of contracts traded in the contracts markets, for which there is good data; there are almost none traded on the SA market and, as a consequence, if you are seeking to compete in that market you are at a disadvantage.⁵⁴

4.65 Mr Mountain was of the view that the only way to tackle the perverse incentives within the energy market that currently incentivise the exercise of market power was to institute 'a combination of a capacity payment, a payment to be available, and a payment to actually produce'.⁵⁵

Committee view

4.66 A recurrent theme throughout the inquiry was the need to align the time periods for price bids and price settlements in the NEM. Currently, the bid period is at five minute intervals, but the payment settlement period is set at 30 minute intervals.

4.67 The committee heard that the rules in the NEM are now outdated and merely serve to privilege the old fossil-fuel generators. The committee also heard evidence that the current rules allow the larger players to game the system.

4.68 The committee is aware that the current market rules may engender perverse unintended outcomes where suppliers may choose not to bid into the market to deliberately create a price spike and then only bid at the peak of the spike.

4.69 The evidence provided to the committee concerning the five minute rule issue and the capacity for other rules to produce perverse and unintended outcomes demonstrate a deeper problem: The outdated regulatory framework and the reluctance of the rule maker to embrace any change in a timely manner, proves the need for reform in this area.

4.70 The committee has received evidence from a number of witnesses indicating the surprising ignorance of both the AEMC and the Australian Energy Market Operator (AEMO) concerning new technology.

4.71 The fact that AEMO was not even aware of the proper technical settings to enable windfarms to 'ride through' certain disturbances on the grid in the South Australian 'blackout' event in 2016, even though these had been in operation for many years overseas, demonstrates a blatant lack of competence.

4.72 It betrays a culture of both astounding ignorance and of an attitude completely averse to change. The committee considers that this is unacceptable and requires immediate substantial reform.

54 Mr Bruce Mountain, Director, CME, *Committee Hansard*, 7 March 2017, pp. 61–62.

55 Mr Bruce Mountain, Director, CME, *Committee Hansard*, 7 March 2017, p. 62.

4.73 The AEMC is in need of fundamental reform. It is clearly both captive to the incumbent industry and hostile to the inevitable transition away from the current status quo. It is mired in pointless process and delay in any matters that threaten the revenue streams of the incumbent generators. The committee considers that this method of operation is completely contrary to the statutory duty and obligations of the AEMC which is to pursue the long term interests of consumers.

4.74 A case study on the five minute rule in this context demonstrates the counterproductive model we have now — and the immediate need for comprehensive reform.

Case Study – the 5 Minute rule

4.75 The AEMC operates by examining and ruling on requests for amendments to the rules of the electricity market. It can change rules or it can reject them — so it is the key regulatory body.⁵⁶

4.76 A major electricity user, Sun Metals, operates a zinc smelter in northern Queensland. It has requested the AEMC to amend the rules to introduce the so-called 5 minute rule.⁵⁷

4.77 The primary result of not introducing the 5 minute rule to this point has been to the long-term detriment of the consumer—effectively the generators are being allowed to rip them off. One would expect that the AEMC would be keen to fulfil its statutory duty but, unfortunately, the opposite has happened.

4.78 Sun Metals made their application for a rule change to the AEMC on 4 December 2015.⁵⁸ Then, a full six months later, the AEMC formally initiated the review process.⁵⁹ That is, it took the AEMC six months to issue a consultation paper of about thirty pages on an issue that it had examined in the context of an earlier rule change process.⁶⁰

56 Australian Energy Market Commission, *Energy Rules*, <http://www.aemc.gov.au/Energy-Rules> (accessed 5 April 2017).

57 Sun Metals, Letter to the Australian Energy Market Commission— Proposed rule change: To have 5 minutes settlement pricing instead of 30 minute average settlement pricing, 4 December 2015, <http://www.aemc.gov.au/getattachment/6a518011-533d-49dd-bb27-e6e8175bcabd/Rule-change-request.aspx> (accessed 3 April 2017).

58 Sun Metals, Letter to the Australian Energy Market Commission— Proposed rule change: To have 5 minutes settlement pricing instead of 30 minute average settlement pricing, 4 December 2015.

59 Australian Energy Market Commission, Notice under National Electricity Law, 19 May 2016.

60 Australian Energy Market Commission, Consultation Paper—National Electricity Amendment (Five Minute Settlement) Rule 2016, 19 May 2016.

4.79 The rule change decision is supposed to be made within six months, but this did not happen. On 25 August 2016 the AEMC gave notice that it was extending the date for its draft determination from November 2016 to 30 March 2017.⁶¹

4.80 Then, on 2 February 2017, the AEMC gave further notice that it was extending the time for the draft decision to 6 July 2017 with a final determination date of 14 September 2017. It made the point in the announcement that it had only convened two stakeholder meetings on this issue during 2016.⁶² Clearly where there is a threat to the revenue of incumbents the AEMC does not work efficiently to protect consumers. There is a culture of appeasing the status quo by glacial process with no accountability at all.

4.81 Disturbingly it appears that the AEMC has missed the next deadline in this process. When announcing the delay from March to July it promised the release of another issues paper by 30 March 2017. At the time of publication there is no such document on the AEMC website.

4.82 Apart from the consumer and competition issues relevant to the five minute rule another interesting point was raised in submissions by Zen Energy. It makes the point that the 5 minute rule would improve the stability of the electricity system as well.⁶³

4.83 For the above reasons the committee strongly supports moving to a five minute settlement process as soon as possible. It does not consider the conduct of the AEMC on this matter to be acceptable, and does not accept the need for a further delay through a protracted phasing in of the new rule.

4.84 The committee is strongly of the view that the NEM rules more broadly currently incentivise the gaming of the system by generators with substantial market power. Such outcomes have seriously adverse consequences for the electricity prices paid by electricity consumers. The committee therefore recommends that an urgent review be undertaken of the payment systems operating within the NEM including careful consideration of the merits of instituting two payments, namely a payment to be available and a payment to generate.

Recommendation 5

4.85 The committee recommends that the settlement time in the spot market be reduced from 30 minutes to 5 minutes, with phase-in of this rule change to be completed before 1 November 2017, and for the reliability of electricity

61 Australian Energy Market Commission, Notice under National Electricity Law, 25 August 2016. See also Australian Energy Market Commission, Information sheet: extension of time for a draft rule determination, 25 August 2016.

62 Australian Energy Market Commission, Information sheet: extension of time for draft rule determination (February 2017), 2 February 2017.

63 Zen Energy, Letter to the Australian Energy Market Commission— Proposed rule change: To have 5 minutes settlement pricing instead of 30 minute average settlement pricing, 30 June 2016, <http://www.aemc.gov.au/getattachment/82e102ba-5aae-4925-9305-7f7c4b852820/ZEN-Energy.aspx> (accessed 3 April 2017).

frequency to be supported by new markets for additional services to support the grid.

Recommendation 6

4.86 The Committee recommends wholesale reform of the Australian Energy Market Commission (AEMC), to guarantee faster decision making and a prioritisation of the long term interests of the consumer over the interests of incumbent power generators, and a much tighter supervisory role over the Commission for the Commonwealth Energy Minister.

Recommendation 7

4.87 The committee recommends that the Finkel Review identifies other major rule impediments to assist in the full integration of renewable energy and storage with a view to speeding up the Australian Energy Market Commission (AEMC) processes in regards to their reform. These should then be presented to the AEMC as an urgent agenda of reform work to be prioritised and completed within six months.

Recommendation 8

4.88 The committee recommends that investment in the renewable energy sector be further encouraged through the introduction of a market-based carbon trading scheme.

Frequency Control Default Settings

4.89 The committee has also become aware of an emerging debate occurring in the context of the resilience of the electricity network due to the relaxation of control settings concerning the frequency of dispatches.

4.90 Put simply the standards which govern the rules by which generators contribute to the NEM were relaxed in 2001 to allow greater variation in frequency around the control frequency of 50 hertz (Hz).

4.91 Previously generation equipment was regulated to only be allowed to submit electricity onto the NEM if its frequency was between 49.9Hz and 50.1Hz. Most often it was considerably closer to 50Hz.

4.92 However, in order to create a larger frequency control market this standard was relaxed. What this means is that the electricity going into the NEM is now less 'reliable' than was previously the case.

4.93 In the context of concerns around system stability, having an electricity system that is deliberately less frequency-stable than it could be is a matter that should be reviewed immediately.

4.94 The committee understands that the former tighter frequency control range could be re-imposed on most if not all existing synchronous generators in a very short period of time and at essentially no cost. This would then improve the resilience of the NEM by lessening the frequency variations that ordinarily occur, thereby minimizing the likelihood of failure in parts of the system.

4.95 The committee has not had sufficient time to examine the issue in detail, but suggests that the Finkel Review should examine this issue as a priority. Whilst this is a difficult technical issue on the face of it, it could provide a significant boost to the resilience of the system whilst the transition to renewable energy proceeds.

4.96 The committee notes a submission to an inquiry by the South Australian regulator, the Essential Services Commission of South Australia which deals with this issue, inter alia, which contends:

A re-assessment of the NEM frequency control ancillary services (FCAS) markets should be undertaken. The governor control that was required prior to the start of the ancillary services (FCAS) markets illustrates why there appears to be a serious decline in the ability of the power system to withstand significant events. The introduction of a market structure and the separation of various ancillary services has brought with it a level of risk which has been highlighted by the system black that occurred in South Australia on 28th September 2016.

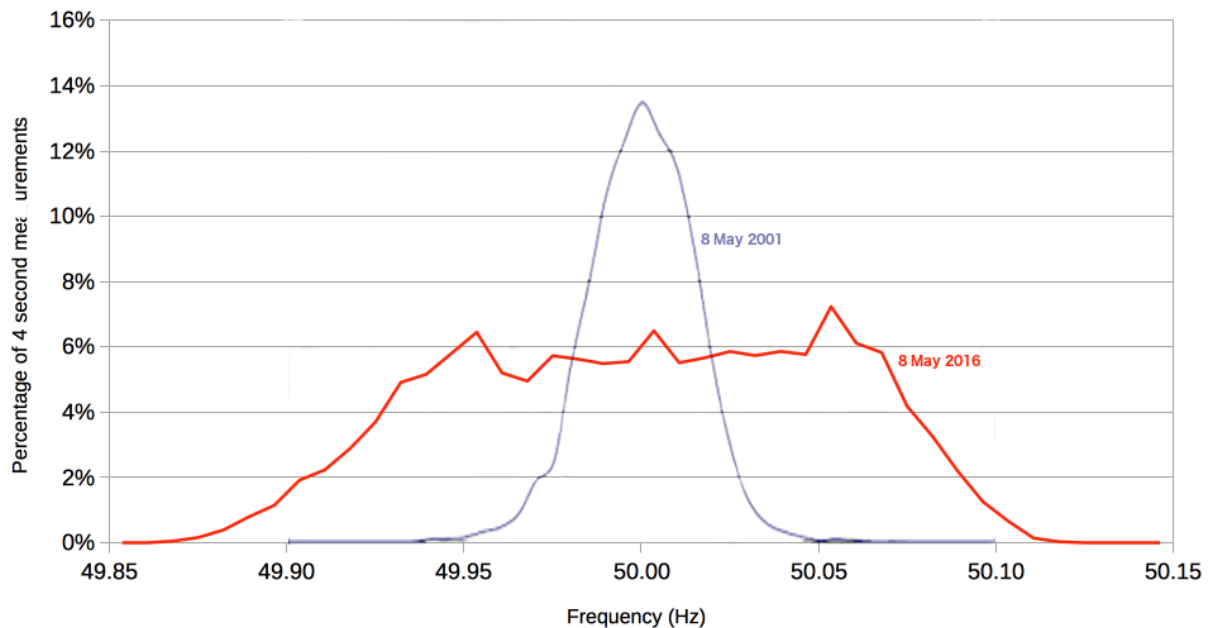
It is time to re-examine the technical risk and inefficiencies introduced by a culmination of more than a decade of decision making (and flow-on regulatory changes) which have led to a significant decline in the primary frequency control systems on the synchronous units within the NEM. Many other markets treat ancillary services that are necessary to support the energy trade as part of the mandatory requirements, this is in contrast to the NEM in which the frequency control is optional and economically sourced.⁶⁴

4.97 Most other countries simply regulate this issue, as Australia used to, whereas deregulation in our system has contributed to instability and a lack of resilience.

4.98 The issue is highlighted by Ms Summers in Figure 4.1 below.

64 Kate Summers, Fast Frequency Service – Treating the symptom not the cause?, *Submission to the ESCOSA Inquiry into licensing arrangements under the Electricity Act 1996 for inverter-connected generators*, p. 1, available at <http://www.escosa.sa.gov.au/ArticleDocuments/1047/20170208-Inquiry-LicensingInverterConnectedGeneratorsIssuesPaperSubmission-KSummers.pdf.aspx?Embed=Y> (accessed 3 April 2017).

Figure 4.1: Frequency distribution 8 May 2016 vs 8 May 2001



Source: Kate Summers, Fast Frequency Service – Treating the symptom not the cause?, *Submission to the ESCOSA Inquiry into licensing arrangements under the Electricity Act 1996 for inverter-connected generators*, p. 4.

4.99 Figure 4.1 demonstrates the significant increase in variability of frequency levels over the last 15 years. Given that this is an indication of a lessening of the total system resilience, this issue should be examined immediately to determine if corrective action is desirable.

Recommendation 9

4.100 The committee recommends that the Finkel review specifically examine the market rule change introduced in 2001 redefining of the normal operating band from 49.9Hz to 50.1Hz to 49.85Hz to 50.15Hz, as well as the impact that change had on total system reliability and whether it should be reversed.

Economic opportunities arising from deployment of renewable energy and energy storage technologies

4.101 This section briefly outlines the evidence that Australia is well placed to capture substantial economic value from implementing measures such as a carbon price and changes to the NEM rules that would incentivise the rapid deployment of renewable energy including distributed generation and a panoply of storage technologies.

4.102 Professor Ross Garnaut reminded the committee that Australia possessed a huge advantage in a world that was moving to low-emissions energy:

Of all the developed countries in the world, Australia has by far the richest endowment of renewable energy resources. The exact combination of resources that makes greatest sense varies across the continent. In Queensland it will be a combination of solar and biomass, usually; in

southern Australia it will be a combination of solar and wind. Later on, with the development of new technologies, there will be other renewable energies in that mix.⁶⁵

4.103 Given the huge advantages outlined above, Professor Garnaut was of the view that Australia could supply 'low-emissions energy-intensive goods' to the global market. Such an outcome would secure substantial economic benefits for Australia in terms of both employment and income.⁶⁶

4.104 Similarly, Mr John Grimes, Chief Executive Officer of the Australian Solar Council emphasised the value that would accrue to Australia positioning itself as a global leader in the new economy:

Our message for regulators and legislators is that it is better for Australia to identify what is going to happen and position Australia so we can win a disproportionate value of that change—skills development, training and providing consulting advice to the rest of the world. We are actually leading the world in this stuff, so there are huge economic opportunities.⁶⁷

4.105 Both Professor Garnaut and Mr Steve Blume, President of the Australian Solar Council, warned the committee that policy incoherence was a grave threat to Australia's ability to take full advantage of the global transition to a low emissions future. Mr Blume noted that the government's energy policy was reactive rather than properly considered, and as such, was a poor foundation on which to develop good 'long-term policy in the public interest'.⁶⁸

Jobs created by deployment of energy storage technologies

4.106 The committee heard that as well as providing an economic benefit to households and increasing system resilience, increased uptake of energy storage systems would create jobs in the industries that support them.⁶⁹ The Australia Institute observed that:

If Australia is smart then we can create local jobs and generate export opportunities right across the value chain, from the storage hardware, to control software and in creative new finance and business models that can power the smart grid of the future.⁷⁰

4.107 The School of Photovoltaic and Renewable Energy Engineering at the University of New South Wales pointed out that job creation in the renewable and distributed energy market is likely to be concentrated in installation:

65 Professor Ross Garnaut, *Committee Hansard*, 7 March 2017, p. 21.

66 Professor Ross Garnaut, *Committee Hansard*, 7 March 2017, p. 21.

67 Mr John Grimes, Chief Executive Officer, Australian Solar Council, *Committee Hansard*, 10 February 2017, p. 24.

68 Mr Steve Blume, President, Australian Solar Council, *Committee Hansard*, 10 February 2017, p. 23; Professor Ross Garnaut, *Committee Hansard*, 7 March 2017, p. 21.

69 Nexergy, *Submission 25*, p. 4

70 The Australia Institute, *Submission 54*, p. 9.

Renewable and distributed energy technologies, due to their relative small scale, modularity and distributed deployment are more employment intensive than conventional large scale generation...[t]he key driver of job creation will...likely be the level of local deployment, rather than just seeking to develop and sell distributed energy systems into international markets.⁷¹

4.108 Nexergy was of the view that the cost savings that would accrue to participants engaged in distributed energy trading would lead to a virtuous cycle of increased jobs in new fields:

By improving the return on investment of energy storage systems, local energy trading would increase the frequency of purchase and installation of systems, thereby improving overall system resilience. Consequently, greater funding will be available for storage system installation and supply, research and development, and manufacturing. Further, peripheral industries which support energy storage systems such as control devices, Internet of Things solutions and smart-grid offerings would also benefit. The result is the creation of new jobs in each of these fields.⁷²

4.109 Meanwhile, the Australian Academy of Technology and Engineering argued that manufacturing jobs associated with battery technology are unlikely to arise without some form of government assistance:

Significant local job creation in energy storage manufacturing would be unlikely without government support to attract international partners...it will be next to impossible to compete with established battery manufacturers that all are located overseas...Even the more successful products developed from Australian intellectual property...are manufactured internationally.⁷³

Committee view

4.110 The committee consider that Australia is uniquely placed to capture substantial economic value from becoming a renewable energy superpower. It is clear from the evidence received by this committee that energy companies, both locally and globally, are moving out of coal. Coal is in structural decline and investors have now shunned any new investment in coal-fired electricity generation (see chapters two and three). As a consequence, there is an urgent need to replace Australia's ageing fleet of coal-fired power stations with electricity generated from renewable energy and with electricity storage.

4.111 The committee recognises that jobs will be lost in coal communities and therefore the transition to a clean energy economy requires careful planning that needs to begin immediately in order to avoid a chaotic and painful transition that would damage livelihoods and communities. The committee is of the view that a well-

71 University of New South Wales, School of Photovoltaic and Renewable Energy Engineering, *Submission 48*, p. 6.

72 Nexergy, *Submission 25*, p. 4.

73 Australian Academy of Technology and Engineering, *Submission 38*, p. 2.

planned transition will lead to far more jobs in the clean energy economy than are currently available in the coal economy, and that many of the skills that workers in the old energy economy possess will be valuable in the new energy economy.

Recommendation 10

4.112 The committee recommends that the Commonwealth government undertake a detailed review of policy and regulatory barriers to, or tariff structures that hinder the implementation of, energy storage technologies.

Recommendation 11

4.113 The committee notes that, despite the Prime Minister's rhetoric on battery storage, the Commonwealth government has failed to put in place any policies that support businesses or households to invest in energy storage. The committee recommends the Commonwealth government put in place policies to support businesses and households to invest in energy storage, new software services and encourage grid decentralisation, resilience and greater energy security.

**Senator Sarah Hanson-Young
Chair**

Dissenting report by Labor Senators

1.1 Labor senators do not support the chair's report.

1.2 This inquiry presented a unique and timely opportunity to articulate a clear policy vision for Australia's energy future. Labor senators are concerned that the Chair's report fails to fully grasp this opportunity.

1.3 Although we believe it fairly and accurately sets out much of the evidence received by this committee, Labor senators emphasise different elements and reach different conclusions.

1.4 We do not consider it productive to document each of the areas of disagreement with the Chair's report. Instead, this dissenting report will set out our views on the evidence that has been received by this committee.

Climate change threatens the resilience of Australia's electricity network

1.5 It is not proposed to exhaustively prove that climate change is real. That task has already been ably completed by decades of scientific research and countless government and intergovernmental commissions. The existence of anthropogenic climate change is uncontroversial in the scientific community. It should be likewise in our politics. The challenge now is how best to respond.

1.6 The fact of climate change poses two distinct challenges to the resilience of Australia's energy network.

The challenge of a warming world

1.7 Climate change poses risks to physical infrastructure. As the CSIRO explained, '[b]oth historical climate observations and climate projections into the future indicate that the frequency and intensity of many extreme weather events are on the rise'.¹

1.8 It is difficult to establish the role of climate change in any particular weather event. Nonetheless, the weather events that lead to black outs and load-shedding in the last twelve months illustrate the vulnerability of electricity infrastructure to the types of events that we can expect more frequently in a warming world.

1.9 On 8 February 2017, there was a heatwave across much of Australia. The high summer temperatures translated into high electricity demand in South Australia. An unexpected drop in wind generation coincided with numerous forced outages of thermal generators (including two that reduced capacity due to high ambient temperatures and one that was not allowed to bid into the market). The shortfall was

1 Commonwealth Scientific and Industrial Research Organisation (CSIRO), *Submission 23*, p. 3.

transferred across South Australia's interconnectors, which threatened to trip interconnector limits. As a result, AEMO enacted load shedding.²

1.10 On 10 February 2017, the eastern states continued to experience a heatwave, translating into high electricity demand in New South Wales. At the same time, technical faults took a number of thermal generators offline. As a result, AEMO enacted load shedding for a large commercial user in New South Wales.³

1.11 On 28 September 2016, tornadoes damaged a number of transmission lines in South Australia. The damage to these lines caused them to trip, and set off a cascade of faults that triggered protective features in a number of wind turbines as well as the Heywood Interconnector, taking them offline. As a result, the entire state lost power for several hours.⁴

1.12 These events are not one-offs. Instead, the evidence to the committee was that network assets would increasingly face these types of physical challenges.⁵ Despite this, the committee also heard from transmission and distribution companies that there was limited guidance from the AER about what investment should be undertaken to protect against climate change risk:

Senator McALLISTER: So no definitive position [from the AER] about whether or not climate risk ought to be incorporated in your planning framework?

Mr Vincent: That is correct.⁶

1.13 Labor senators are concerned by this vacuum, and consider the AER has a key coordinating role (see **Recommendation 1** below).

The challenge of a low carbon future

1.14 As well as physical risks, climate change also poses economic and regulatory risks to carbon emitting generating assets. Australia will need to transition away from carbon intensive electricity generation if we are to satisfy our international commitments and make an effective contribution towards addressing climate change.

1.15 Coal provided around 63 per cent of Australia's electricity in 2014-15.⁷ It also produced 88 per cent of the total emissions from electricity generation.⁸ It is well

2 Australian Energy Market Operator, *System Event Report – South Australia, 8 February 2017*, p. 3.

3 Australian Energy Market Operator, *System Event Report – New South Wales, 10 February 2017*, p. 1.

4 Australian Energy Market Operator, *Black System - South Australia 28 September 2016 – Final Report*, p. 6.

5 Mr John Bradley, Chief Executive Officer, Energy Networks Australia, *Committee Hansard*, 10 February 2017, p. 30.

6 *Committee Hansard*, 10 February 2017, p. 42. See also evidence by Mr Rainer Korte, Executive Manager, Asset Management, ElectraNet, *Committee Hansard*, 10 February 2017, p. 34.

understood and acknowledged amongst industry that this mix is not sustainable. AGL and Engie gave evidence to this committee that they were 'moving out of coal'.⁹ The Clean Energy Finance Corporation explained that 'it would be very difficult to find a private sector or a commercial investor making a decision to invest in a coal fired power station in the Australian market today'.¹⁰

1.16 The committee's hearings took place against a background of public discussion by the Australian government of public investment or subsidies for new coal fired power stations. Labor senators believe it would be inappropriate, uneconomical, and unsustainable for this to occur. Australia's energy future must rest more heavily on renewable and low carbon energy sources (see **Recommendation 2** below).

The need to replace out-of-date infrastructure gives Australia the opportunity to transition to cleaner energy sources

1.17 Australia is due for a round of investment in energy infrastructure. This need arises independently of the demands of climate change — instead it is a consequence of the age and capabilities of existing plants.

1.18 Many of Australia's generating assets are near or at the end of their design life. The dirtiest plants are also amongst the oldest. These generators would have to be replaced irrespective of the need to respond to climate change.

1.19 Australian's energy consumption patterns are also changing, putting new demands on the electricity network. Changes in lifestyles and technologies have transformed the way that electricity is consumed. The uptake in use of air conditioners has moved periods of peak demand from winter to summer. The uptake in the use of rooftop solar has meant that there is lessening demand in the middle of the day. The committee heard that:

The generation mix and market rules in Australia have not been designed to meet this kind of demand profile, so the resilience of the electricity infrastructure will continue to deteriorate if measures are not put in place to address this problem quickly.¹¹

7 Australian Government, Department of Industry, Innovation and Science, Office of the Chief Economist, *Australian Energy Update*, October 2016, p. 18.

8 Australian Government, Climate Change Authority, *Policy Options for Australia's electricity supply sector: Special review research report*, August 2016, p. 15.

9 Mr Jim Kouts, Head of Corporate Affairs, ENGIE in Australia, *Committee Hansard*, 20 February 2017, p.18. See also Mr Richard Wrightson, General Manager, Wholesale Markets, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 6.

10 Mr Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation, *Committee Hansard*, 10 February 2017, p. 40.

11 Mr Robert Riebolge, Chief Network Analyst, 1414 Degrees, *Committee Hansard*, 20 February 2017, p. 21.

1.20 The need to respond to replace aging infrastructure and manage Australia's changing demand patterns presents an opportunity to invest in assets that meet the shared need to reduce carbon. This investment would have to occur irrespective of climate change — Australia has the chance to transition to cleaner energy sources at the same time.

Australia has the technology to make this transition now

1.21 There is a wealth of existing and emerging technologies that would enable Australia to meet these needs. These technologies include different renewable generation and energy storage options. We also draw particular attention to demand management technologies, which are often forgotten in discussion about future energy networks.

1.22 It is not proposed to explain these technologies in this dissenting report, as the descriptive portions of chapter 3 of the chair's report set them out in considerable detail. We note, however, that these technologies are at different stages of development and commercialisation. Ongoing government support is required for them to be integrated fully into the NEM, and deliver benefits to Australians. This support should be provided (see **Recommendation 3** below).

1.23 Labor senators acknowledge that renewable technologies have a different profile from fossil fuel generators. In particular, there are issues arising from wind and solar being intermittent and asynchronous sources of power.

1.24 There have been some suggestions by public commentators that these issues mean that government should act to limit the penetration of renewables. We do not believe this is a satisfactory response.

1.25 Different generating and storage technologies have their own set of benefits and liabilities. This is equally as true for older technologies as it is for the new. As was explained to the committee by way of anecdote:

This term 'baseload' is appropriated and elevated to some particular level as if it has some intrinsic value. Baseload, per se, is not useful. In my ceiling in my house, when I changed the insulation some years ago, I had a look at my old water heater, which is a big, thin-steel container, exposed to an uninsulated roof, and I inquired as to why this was such a wasteful device. The answer is that the coal-fired generators in Victoria had a minimum stable generation level. They were baseload. They could not operate other than flat-out, and to keep them going they had to soak up their generation at night. They were inflexible.¹²

1.26 The state electricity markets (and later the NEM) developed market rules and structures to accommodate the strength and limitations of previous generating technology. As technology changes, so too must the market. Labor senators believe that market rules should be adjusted to reward market participants for providing ancillary services that contribute to the grid stability and reliability that the public expects (see **Recommendation 4** below.) In practice this may mean, for instance,

12 Mr Bruce Mountain, Director, CMF, *Committee Hansard*, 7 March 2017, p. 67.

separate markets for storage to complement renewables and smooth out intermittency, or for the provision of inertia.

1.27 Labor senators also believe that market rules should be adjusted to recognise and reward the new types of benefits that emerging technologies are capable of delivering. The committee heard from a number of witnesses that the current settlement period for prices of 30 minutes meant that the NEM was unable to reward the ability of batteries to provide very fast dynamic primary frequency response.¹³ This, the committee was told, acts as a disincentive to the provision of batteries.

1.28 Likewise, the committee was told of regulations that may discourage consumers from purchasing home batteries:

Mr Osbourne: The biggest selling battery in the market is the Tesla Powerwall. It is a very nice looking thing...If you read some of the non-binding installation standards that have been published, you are required to put that in a cage...

Senator URQUHART: So what is the purpose of the cage?

Mr Osborne: It is to stop people touching it.¹⁴

1.29 Labor senators believe that, where it is safe and appropriate, market regulators should seek to lower the regulatory barriers to entry to new technologies and put in place appropriate rules to incentivise investments that contribute to the security, reliability and affordability of the NEM (see **Recommendation 5** below.)

The need for national leadership to manage the transition to renewables

The path to decarbonisation

1.30 It is rare to conduct an inquiry where almost every witness is in agreement. This was such an inquiry. The committee heard from witness after witness that the failure of the Australian government to articulate a plan to transition to a low carbon future was crippling industry.¹⁵

1.31 AGL explained that the lifespan of electricity assets required long term planning:

The market participants need time to plan; there are often five to 10 years in planning horizon, and we need some sort of predictability of when to replace assets to avoid the disorderly transition we are currently experiencing today.¹⁶

13 See testimony set out at paragraphs 4.40 to 4.56 of the chair's report.

14 *Committee Hansard*, 10 February 2017, p. 16.

15 See testimony set out at paragraphs 4.4 to 4.23 of the chair's report.

16 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 4.

1.32 That long term planning was not possible given the policy uncertainty that had been created by the government over the last four years. Mr Oliver Yates of the Clean Energy Finance Corporation explained that:

People do not quite know the direction of government policy. People do not know the timing of the need to make adjustments in carbon emissions. People do not know the speed with which that may or may not have to be made. In that environment it is very hard for the private sector to make long-term investment decisions, which are necessary if you are going to move from one type of asset to another type of asset.¹⁷

1.33 The end result, according to Mr Danny Price of Frontier Economics, has been an 'investment strike' in new electricity infrastructure.¹⁸

1.34 Labor senators believe that the government should, as a matter of urgency, develop a policy that provides stability, certainty and direction to industry (see **Recommendation 6.**)

1.35 Labor senators consider that there are clear benefits to energy policy being bipartisan and having broad industry support.

1.36 We note that the terms of reference for the Finkel Review enable it to develop a framework for this policy. The Review's report should be made public when it is received, and responded to as soon as possible (see **Recommendation 7.**)

1.37 Labor senators note that senior government ministers have already ruled out adopting an emissions intensity scheme. We consider that an emissions intensity scheme is an appropriate and effective mechanism for transitioning Australia's energy sector to a low carbon future. Industry agrees.

1.38 At the time of writing, notable supporters of an emissions intensity scheme included Snowy Hydro, the Business Council of Australia, BHP, AGL, EnergyAustralia, the National Farmers Federation, Origin Energy, the Australian Energy Markets Commission, the CSIRO, Energy Networks Australia, the Chief Scientist, the Climate Change Authority, the Clean Energy Finance Corporation, as well as numerous state and territory governments.

1.39 Professor Ross Garnaut told the committee that:

...an emissions intensity scheme would serve the purpose of providing appropriate incentives for investment in lower emissions technologies. In fact, as far as the climate change objectives, the emissions reduction objectives, and also the energy investment efficiency objectives are concerned, the emissions intensity scheme is very similar in its merits to carbon pricing.¹⁹

17 Mr Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation, *Committee Hansard*, 10 February 2017, p. 39.

18 Mr Danny Price, Managing Director of Frontier Economics, *Committee Hansard*, 7 March 2017, pp. 29–30.

19 Professor Ross Garnaut, *Committee Hansard*, 7 March 2017, p. 23.

An orderly exit for aging plant and a just transition for workers

1.40 AGL spoke of the need for 'a market rule that suitably telegraphs the phase-out of legacy power plants'. In their view:

This will enable market participants to plan and invest in the necessary generation and associated infrastructure. It will also minimise the impacts of short-notice periods for closure on wholesale electricity supplies, such as those experienced with the impending closure of the Hazelwood power station and the recent closures of the Northern and Playford coal power stations in South Australia.²⁰

1.41 Labor senators believe this is sensible. The regulators of the NEM have a role in coordinating an orderly exit of aging plant, in particular the suite of old coal fired power plants (see **Recommendation 8.**)

1.42 There is a significant informational asymmetry between the owners of aging generators on the one hand, and those who depend on it on the other hand. Adequate notice that an asset is to be retired would help smooth out the 'lumpiness' of investment in infrastructure by providing potential investors with notice of a gap in the market.

1.43 More notice of exit would also provide governments with a better opportunity to protect plant workers, and their communities. The committee was fortunate to hear from Mr Rowbottom, who had worked at the Port Augusta power stations as a mechanical technical officer for 17 years, and subsequently was able to find a role with solar thermal company Repower Port Augusta.²¹ Not all workers are able to find a similar path.

1.44 The AMWU in their evidence reminded the committee that 'The Paris Agreement includes a requirement that governments take immediate and specific action to "create decent work and quality jobs for workers that are affected by adaptation to climate change"'.²² The AMWU and the ETU pointed in particular to the success of the Victorian Government's Latrobe Valley Worker Transfer Scheme.²³

1.45 The transition from fossil fuels to a cleaner energy future promises benefits to Australia. We should promise a just transition to those adversely affected by it (see **Recommendation 9.**)

20 Mr Douglas Jackson, Executive General Manager, Group Operations, AGL Energy Limited, *Committee Hansard*, 7 March 2017, p. 2.

21 Mr Gary Rowbottom, Chairperson, Repower Port August, *Committee Hansard*, 20 February 2017, p. 67.

22 Mr Warren Tegg, Economic and Industrial Adviser, Australian Manufacturing Workers' Union, *Committee Hansard*, 7 March 2017, p. 43.

23 Mr Warren Tegg, Economic and Industrial Adviser, Australian Manufacturing Workers' Union, *Committee Hansard*, 7 March 2017, p. 47.

Recommendations

Recommendation 1

1.46 The AER and AEMC consider reviewing existing policies to ensure transmission and distribution asset owners have clear guidance as to what constitutes prudent investment to protect networks against climate change risk.

Recommendation 2

1.47 The Government does not provide public financing for new coal fired power plants, noting such public support would not represent value for taxpayer money, violate notions of competitive neutrality and would not be consistent with meeting international emission reduction objectives.

Recommendation 3

1.48 The Australian government provide ongoing support for emerging energy technologies to overcome technical and regulatory hurdles to entering the market, including continuing to fund the development and commercialisation of these technologies through ARENA and the CEFC.

Recommendation 4

1.49 The AER and AEMC consider making reforms to the NEM that reward the provision of ancillary services, including services associated with reliability and stability.

Recommendation 5

1.50 The AER and AEMC consider making reforms to the NEM (where safe) to reduce the technical barriers of entry for new energy technologies, and recognise and reward the new services they are able to offer to the grid.

Recommendation 6

1.51 The Australian government end the uncertainty about national energy policy, and develop a stable and consistent policy (such as an emissions intensity scheme) that can support investment in new energy infrastructure whilst meeting Australia's international climate change obligations.

Recommendation 7

1.52 The Australian government commit to making public the report issued by the Chief Scientist (the Finkel Review), and responding to the recommendations as soon as possible.

Recommendation 8

1.53 In order to avoid chaotic, unplanned closures and their significant impacts on the NEM and affected workers and communities, the Australian Government work with stakeholders, including the AEMC, on a framework to provide for the orderly exit of ageing generators, including options such as requiring market participants to provide adequate notice of their intention to exit.

Recommendation 9

1.54 The Federal Government establish mechanisms to support a just transition for workers and communities resulting from the retirement of aging power generators, including a national framework for worker redeployment schemes modelled on the Victorian Government's Latrobe Valley Worker Transfer Scheme.

**Senator Jenny McAllister
Deputy Chair**

Senator Alex Gallacher

Senator Anne Urquhart

Coalition Senators' Dissenting Report

1.1 Coalition Senators fundamentally reject the central tenant, conclusions and most recommendations of the Chair's draft report. The Coalition Senators question the wisdom and considerable public expenditure of conducting a Senate Inquiry with hearings in locations around Eastern Australia to produce a report that is so biased that it could have been written before the Inquiry even commenced.

1.2 Coalition Senators reject the proposition contained within the Chair's report that the Coalition Government is responsible for the ill-informed and misguided decisions of the South Australian Labor Government in destroying the supply of cheap energy for households and businesses in that State.

1.3 The electrical network was designed to transmit reliable and affordable electricity to consumers. Distributed generation will continue to be part of the modern electrical grid as it is now. Generation type is the issue. The Coalition Government has adopted a technology agnostic approach with the central aim to keep energy secure, reliable and affordable for all Australians.

1.4 It is a perverse but tragic irony that South Australia was the envy of the nation under the Premiership of Sir Thomas Playford (1938 – 1965) due to his vision of supplying cheap, reliable energy to that State through the generation of electricity using locally available coal.

1.5 In so doing Sir Thomas was able to attract industries such as motor vehicle and naval shipbuilding manufacturing which led to sustained high employment and cheap domestic power for generations.

1.6 Coalition Senators note the contrast existing with the current situation in South Australia which now has the nation's highest electricity prices, the least reliable supply of power, lost industry, high unemployment and a sense of despair.

1.7 The Chair's report fails to outline that the primary cause of this reversal has been the ill-considered policy of the Weatherill Labor Government to shut down the State's largest base load coal fired power station at Port Augusta while promoting an ideologically driven expansion of wind generated electricity with its attendant failure to deliver reliable and affordable power to the citizens of that State.

1.8 Coalition Senators reject the proposition advanced in the Chair's report that natural gas has little or no role to play in the supply of electricity into the Eastern Australian grid. Quite the opposite is true. Without gas fired peaking stations to balance and stabilise intermittent energy on the grid, the entire grid system could be destabilised. This was supported by evidence from submissions and hearings with calls for renewable energy generation to be required to partner with complementary 'firm and dispatchable' capacity, such as gas generation, among others.

1.9 The very fact that, in his desperation, the South Australian Premier has now committed some \$550 million of his taxpayers' dollars to purchase gas fired electricity infrastructure is further evidence of the importance of this power source to “keep the lights on.”

1.10 It is beyond the comprehension of Coalition Senators that South Australia, Victoria and New South Wales could impose moratoria on the exploration and extraction of onshore natural gas in their States in the face of supply shortages, rising electricity prices and international experience where countries are increasingly turning to natural gas for supply of reliable, sustainable and affordable electricity.

1.11 As South Australian households and businesses are coming to learn: 'Gas is good'. This lesson will be reinforced by the Victorian community in coming months and years following the closure of the coal fired Hazelwood power station in Victoria following policies of the Andrews Labor Government to increase coal royalties and force costs up to a level which accelerated the closure of that State's largest base load power station which supplies up to 25% of Victoria's energy demand.

1.12 Coalition Senators point to the experience of the USA following the development of the shale gas industry in that country in recent years. Transition to natural gas powered electricity has allowed the USA to drive down greenhouse gas emissions (GHG) while American manufacturers are now paying one third the price of electricity to that of their German competitors. This has encouraged a flood of manufacturing activity back to the United States, creating more high paid jobs and economic activity.

1.13 Furthermore the USA is now becoming a net exporter of hydrocarbons and will soon compete with Australia for LNG contracts in our traditional markets.

1.14 The Chair's report speaks of natural gas being, at best, a transition source of energy. If 50 to 100 years is regarded as being 'transitional' then this may be an accurate description. However coal and gas will continue to be the dominant sources of energy for electricity throughout the world for many generations to come.

1.15 The Chair's report is dismissive of coal as a generator for electricity. Coalition Senators note that 78% of the electricity supplied to the National Electricity Market (NEM) is generated from coal and 9% from gas. Under current policy settings no fossil fuel based investment will occur – an oversupply of generation capacity plagues new investment into the NEM. This would mean that in the absence of any reliable base-load alternative, further black outs can be expected.

1.16 The Coalition Senators highlight that the Chair's report ignores the evidence from submissions and hearings urging caution in the transition to alternative and renewable energy generation due to the impact that this has on baseload power. Further, evidence supported a managed and gradual stepdown from conventionally-generated baseload power with backup options in place. The Chair's report repeatedly ignores the importance of baseload power and the incapacity for wind or solar generated power to provide the essential baseload power requirements.

1.17 Importantly, a study by Dr Wheatley of the 2014 NEM data clearly showed that the integration of wind energy into the grid was not reducing emissions by the amounts claimed.¹ It also found that wind energy displaces gas from the grid rather

1 Dr Joseph Wheatley, *CO₂ Emissions Savings from Wind Power in the National Electricity Market (NEM)*, 2015.

than coal fired power. In the interests of ensuring a safe reliable supply of electricity in the future, this analysis should be extended.

1.18 Coalition Senators note that China is in the midst of a revolution of building High Energy Low Emission (HELE) power stations and continue to source high energy low polluting thermal coal from Australian mines. Possibly the greatest contribution our country is making to the reduction of GHG's internationally is to supply this form of thermal coal. With Australia emitting less than 1.5% of the world's GHG's, our greatest contribution globally may be to supply high energy, low polluting coal to the burgeoning economies of China and India as they transition their populations from subsistence living to middle class aspiration.

1.19 Coalition Senators are keenly watching the advances in Carbon Capture and Storage technologies in both Australia and overseas to contain and dispose of carbon dioxide underground. The CCS project for Gorgon on Barrow Island offshore Western Australia is set to be commissioned in 2017 while reports from China indicate promising results associated with the new HELE efficient coal producing power stations.

1.20 Coalition Senators find the accusations contained in the Chair's report condemning the Turnbull government's energy policies to be false and misleading. Given that the Australian Greens Party voted against the Rudd Government's ill-conceived carbon pollution reduction scheme in the Senate in 2009, the comments contained in the Chair's report are at best hypocritical.

1.21 Then Prime Minister John Howard introduced the Renewable Energy Target set at 2% in 1997.

1.22 But this target was hijacked and set at unrealistically high levels by the incoming Labor governments of Mr Rudd and Ms Gillard in subsequent years. The ethically questionable diversion of taxpayers' monies to subsidise projects such as large scale industrial wind turbines (IWT) can be traced back to this era.

1.23 The widespread construction of IWT's in South Australia to meet unrealistic targets of 50% electricity generation from 'renewables' is at the core of that State's insecure and highly expensive power situation today.

1.24 Coalition Senators draw attention to the conclusions and recommendations of the Senate Select Committee Inquiry into wind turbines in 2015. That report highlighted the fact that this source of power is of limited value in contributing to an energy grid given the inability to supply stable synchronised power. That committee also noted the fact that most energy from wind power is delivered at low periods of demand and that the wholesale price of wind power delivered to the grid has corrupted pricing mechanisms.

1.25 The actions of other governments are illustrative. The United Kingdom has withdrawn any financial support for the construction of land based IWT's in that country.

1.26 Denmark has the highest number of IWT's in Europe/Scandinavia. It also has the highest cost of household and commercial electricity in that region. The Danish government has placed a moratorium on support for new IWT's until the next decade.

1.27 The chronic adverse health effects experienced by people residing in the proximity of IWT's will be the emerging issue for authorities and operators in years to come. The Coalition Government has committed funding to study these health effects through the National Health and Medical Research Centre.

1.28 Coalition Senators concur with comments contained in the Chair's report in relation to the potential for new and emerging power generation and storage technologies such as molten salt and molten silicon.

1.29 Battery storage, if shown to be economically viable, could have significant impact in the future with the establishment of localised 'micro-grids' and greater independence from traditional large scale power generation and distribution systems.

1.30 Coalition Senators await the conclusions of the Finkel Report before recommending further policy in this space.

1.31 Coalition Senators continue to urge the Turnbull Government to adopt a key recommendation of the Wind Turbine Inquiry and direct the Productivity Commission to conduct research into the impact of wind turbine generation on retail electricity prices in Australia. At the same time, this research should be expanded to include the cost of battery storage and the Frequency Ancillary Control Services required to support renewable energy generation.

1.32 A recent report by BAEconomics has advised that the bill to prop up green power has hit \$3 billion per year.

1.33 Coalition Senators note that the AEMC completed a comprehensive market review into the integration of energy storage in 2015. Further, given the evidence presented to the committee the Coalition Senators have concerns regarding the efficacy and cost of current battery storage technologies.

1.34 The Chair's report briefly discussed the recent announcement from the Prime Minister to investigate expansion of pumped hydro capacity at the Snowy Hydro scheme.

1.35 Contrary to the assertions contained in the Chair's report, advice from the executives of Snowy Hydro is that such a proposal is eminently practicable. Coalition Senators understand that much of the data required to undertake a feasibility study is already available given the wealth of knowledge that exists in the scheme and the advanced meteorological data compiled over many years in the region. The Snowy Mountains Scheme 2.0 plan will increase the generation of the Snowy Hydro scheme by 50 per cent, adding 2000 megawatts of reliable, baseload renewable energy to the NEM.

1.36 Advice to Coalition Senators is that such an expansion, once completed, could provide power to support the grid during periods of high demand, such as extremely hot weather, for an uninterrupted 187 hours. This contrasts with the predicted contribution of power from battery storage under similar circumstances of one hour.

1.37 The Renewable Energy Target (RET) acts as a tax on energy consumers and conventional energy suppliers to fund a subsidy to selected renewable energy generators. After 16 years of operation it has become clear that the objectives of the

Act have not been reflected in the outcomes. While the investment in renewable energy sources has increased, from a carbon abatement perspective, the Act has been ineffective in its objective to reduce greenhouse gas emissions within the electricity sector.

1.38 The RET is causing retail electricity prices to rise significantly. Energy generated by wind turbines do not reduce greenhouse gas emissions within the electricity sector by the amount claimed. In fact, there is some evidence that the addition of wind energy onto the grid actually increases carbon emissions. This is the great tragedy of the scheme.

1.39 It is a legislated requirement that 600 million renewable energy certificates (RECs) will be issued between now and 2031, adding a cost of at least \$50 billion to power bills. This represents a significant wealth transfer to wind power companies from Australian power consumers and achieves no measurable benefit to the environment.

1.40 South Australia's disastrous electricity supply situation had its origins with the decision of that State Government to move towards 50% of electricity being delivered from renewable sources without adequate backup from synchronous base load generation or guaranteed supply from alternative sources.

1.41 Coalition Senators fear a similar outcome if or when the Labor Premiers of Victoria and Queensland attempt to carry out similar plans in their States. It is interesting to note that the incoming Labor Premier of Western Australia very quickly reversed a statement of his Shadow Energy Minister to commit to such a target in the days leading up to the recent WA State election.

1.42 Coalition Senators note the change in language by the leader of the Federal Opposition Mr Bill Shorten from his original undertaking to increase the supply of electricity supplied by renewable means to 50%. This aim seems to have become 'aspirational' as the reality of the South Australian debacle has played out.

1.43 Bloomberg New Energy Finance estimates that around 25.4 gigawatts of new large-scale renewables, representing some \$48.2 billion of new investment, would be required to meet Federal Labor's renewable electricity target by 2030. It is predicted that a 50% target would require around 43 terawatt hours (TWh) of additional renewable energy generation by 2030. This is a substantially lower quantity than may be expected at first, primarily due to projections that the continuing uptake of small-scale PV is likely to contribute an additional 22.5 TWh of generation to the Australian energy market by 2030.

1.44 If current policies are to be met, it is forecast that around 52.1 TWh of large-scale generation and 32.2 TWh of small-scale supply will already be in place by 2030 (including large-hydro). If achieved, the current 33 TWh Large-scale Renewable Energy Target (LRET) will require some 21.4 TWh of new large-scale generation.

1.45 Coalition Senators note that other reputable sources predict much higher costs would be imposed on long suffering household and commercial consumers if Labor's 50% target became reality.

1.46 The statement contained in the Chair's report that Australia could move to a 100% reliance on renewable sources for electricity generation is not supported by the evidence presented to the Committee.

Coalition Senators' responses to the recommendations of the Chair's report.

Recommendation 1:

1.47 Coalition Senators do not support the recommendations made by the Senate Environment and Communications References Committee in its report into the retirement of coal fired power stations as outlined in the Coalition's dissenting report. The majority report of that inquiry does not adequately or fairly reflect the evidence presented to the Committee. Fundamentally, and contrary to the recommendations, Coalition Senators do not believe that the best way to achieve an effective transition is to force the exit of coal-fired power generation from the electricity system. Further the Coalition Senators object to the ideologically driven conclusions which are counter to the Government's technology agnostic policy approach.

Recommendation 2:

1.48 The Federal Government, in conjunction with the COAG Energy Council, is currently developing a long-term national blueprint for the national energy sector through the Finkel Review. A final report to the Energy Council is expected mid-2017. Coalition Senators refute the assertion that the review is not focused on the stable supply of electricity in the future.

Recommendation 3:

1.49 Coalition Senators note that the Australian Electricity Market Commission (AEMC) completed a comprehensive market review into the integration of energy storage in 2015 and is in the process of examining market rules to ensure the electricity system remains reliable and affordable.

Recommendation 4:

1.50 Coalition Senators reject this recommendation and note that the review of climate change policies which follows the Government's commitment to review its policies when it set Australia's target to reduce emissions by 26 to 28 per cent below 2005 levels by 2030 is underway and set to be completed by the end of 2017.

1.51 Coalition Senators note that the Renewable Energy Target (RET) acts as a tax on energy consumers and is causing retail electricity prices to rise significantly. The RET is not reducing emissions within the electricity sector by the amount claimed.

Recommendation 5:

1.52 Coalition Senators note that the Federal Government, in conjunction with the COAG Energy Council, is currently developing a long-term national blueprint for the national energy sector through the Finkel Review. The final report to the Energy Council is expected mid-2017.

1.53 Coalition Senators comment that the market price is currently averaged over 30 minutes. If generators were expected to jump on and off the grid every 5 minutes,

the stability of the grid will be compromised. Many generators need more than half an hour to synchronise to the grid and have set forward contracts. To transition from one generator to another generator, a smooth and comparable synchronised transition is needed. Some larger generators can take up to 38 hours to build up a head of steam. As was made clear during the Inquiry, Pelican Point takes 4 hours to be available to the grid.

Recommendation 6:

1.54 Coalition Senators note that the Australian Energy Market Commission (AEMC) was established in 2005 by the Council of Australian Governments (COAG) as part of new governance arrangements to oversee the nation's main energy markets and provide advice to the nation's energy ministers.

1.55 Coalition Senators agree with prioritising the long term interests of the consumer – to keep energy secure, reliable and affordable.

Recommendation 7:

1.56 Coalition Senators note that the AEMC completed a comprehensive market review into the integration of energy storage in 2015 and is in the process of examining market rules to ensure the electricity system remains reliable and affordable.

1.57 The Coalition Senators regard this recommendation as redundant as the COAG Energy Council Independent Review Terms of Reference for the 'Blueprint for Energy Security in the National Electricity Market' includes consideration of any national policy, legislative and rule changes required to maintain the security, reliability and affordability of the NEM in light of the transition taking place.

Recommendation 8:

1.58 Coalition Senators reject this recommendation as a price on carbon was rejected by the Australian public in the 2013 federal election.

Recommendation 9:

1.59 Coalition Senators note that the AEMC has begun a review of the Frequency Operating Standards that will be completed by 22 December 2017.

1.60 Coalition Senators note that a change of frequency is a major problem for modern electrical equipment. The grid is designed for a stable supply of electricity harmonised at 50 Hertz.

Recommendation 10:

1.61 Coalition Senators note that the AEMC completed a comprehensive market review into the integration of energy storage in 2015 and is in the process of examining market rules to ensure the electricity system remains reliable and affordable.

1.62 The Coalition Senators regard this recommendation as redundant as at the Coalition Government's request, ARENA and the Clean Energy Finance Corporation agreed to work together on a new funding round for large-scale storage and other flexible capacity projects, including pumped hydro. The Coalition Government is

making energy storage infrastructure a critical priority to ensure better integration of wind and solar into the energy market and more efficient use of conventional power.

Recommendation 11:

1.63 Coalition Senators note that the Government will not duplicate or override the existing statutory responsibilities of other jurisdictions. The Prime Minister has announced a feasibility study of Snowy Hydro 2.0 which has the capacity to substantially increase the resilience and security of the electricity grid.

1.64 The Coalition Senators regard this recommendation as redundant as at the Coalition Government's request, ARENA and the Clean Energy Finance Corporation agreed to work together on a new funding round for large-scale storage and other flexible capacity projects, including pumped hydro. The Government is making energy storage infrastructure a critical priority to ensure better integration of wind and solar into the energy market and more efficient use of conventional power.

1.65 In summary, Coalition senators reject the substantial text and recommendations of the Chair's report into this Inquiry.

Senator Chris Back

Senator Jonathon Duniam

Dissenting Report from Senator Roberts

- 1.1 The committee uncovered many deficiencies in current electricity supply including needless high prices, insecurity of supply and instability of the electricity grid.
- 1.2 The fundamental reason for the committee's premise is false.
- 1.3 There is no empirical scientific evidence that the world has warmed or is warming due to the human production of carbon dioxide.
- 1.4 There is nothing from any climate data that shows anything unprecedented in climate:
 - Not temperature, nor rainfall, droughts, floods, ocean PH, storms, sea levels, ice coverage extent etc.
- 1.5 Climate data prove a continuation of natural cycles.
- 1.6 Please refer to the accompanying responses to the CSIRO and reply to the chief scientist. Both documents reference extensive empirical data from international agencies including those cited by the CSIRO and UN IPCC.
- 1.7 Until there is empirical evidence proving carbon dioxide from human activity is affecting global climate and needs to be cut, there is no justification for such measures.
- 1.8 The current needless disruption to electricity supplies is a highly regressive tax on the poor, disrupts regional and national economies and is a threat to livelihoods and security.
- 1.9 Decisions and policies must be based on empirical evidence.

Senator Malcolm Roberts



Senator Malcolm Roberts
One Nation Senator for Queensland

ON CLIMATE, CSIRO LACKS EMPIRICAL PROOF

**We have a choice:
the tyranny of controlling opinions
versus the freedom of objective scientific evidence**

As a servant to the people of Queensland and Australia, I see peoples' needs include, collectively: safety and security of self, family and society; care of self and for others; contribution to protecting our planet.

And, individually: truth and accuracy; reassurance on climate; validation and belonging. Sound policy meets these needs and is based on solid cost-benefit analysis. This is my responsibility to my constituents.

Senator Malcolm Roberts
7 November 2016

TABLE OF CONTENTS

INTRODUCTORY COMMENTS

Our Key Findings	7
Our Scientific Team	8

EXECUTIVE SUMMARY	9
--------------------------	---

HOW AUSTRALIANS ARE AFFECTED BY COSTLY POLICY FAILURES

1. Desalination Plants – Rushed and Mothballed	10
2. Costly Brisbane Flooding due to Political Climate Panic	10
3. The Political Push for Renewable Energy that Increases Global Pollution	11
4. The Effects on Australia’s Fishing Industry	12
5. Queensland’s Great Barrier Reef?	12
6. Queensland Industry and Jobs Threatened by Foreign Activists	12
7. Global Claims	12

ADDITIONAL COSTS

1. The Real Victims of Climate Claims	13
2. Some People Benefit from Climate Alarm	13
3. Gillard’s Carbon Tax Lie Replaced by ...Hunt’s Carbon Tax by Stealth	13
4. More Costs for Taxpayers Based on Climate Claims	13
5. CSIRO Started Pushing Climate in the 1980s with the UN’s climate body	14

SUMMARY OF SENATOR MALCOLM ROBERTS’ RESEARCH ON CLIMATE CHANGE	15
---	----

CONTEXT – PROCESS CHANGE VERSUS NATURAL VARIATION	16
--	----

RESPONSE TO CSIRO’S CLAIMS

1. Is the Earth Really Warming Unusually?	17
2. CSIRO’s Claims about Carbon Dioxide	23
3. Claimed Greenhouse Effect	24
4. Questionable Computerised Numerical Models	25
5. Summary of Temperature and Carbon Dioxide Claims	27

FACTUAL DRIVERS OF TEMPERATURE VARIABILITY AND CLIMATE VARIABILITY	29
---	----

PROBLEMS WITH CSIRO’S METHODOLOGY	30
--	----

WHY AND WHO?

You May Ask: Why Haven’t People Seen This Before?	32
You May Ask: Why Are They Doing This?	33
You May Ask: Who Benefits from Climate Alarm?	33
You May Ask: Who Pays?	34

CONCLUSIONS AND CALL TO ACTION	36
---------------------------------------	----

APPENDIX 1	39
-------------------	----

Letter to Dr Larry Marshall, CSIRO	
Biographies of Scientific Team	

LIST OF FIGURES

Figure 1: Rainfall for September in the Murray Darling Basin	10
Figure 2: Understanding the two main causes of variation	16
Figure 3: Ice core temperatures showing past warmer periods and today's temperatures	17
Figure 4: El Nino temperatures and ground-based temperature plots	18
Figure 5: Satellite temperature data from UAH and RSS	19
Figure 6: Australian summer temperatures – Satellite	20
Figure 7: Australian temperatures – Reconstructed	21
Figure 8: Monthly carbon dioxide levels Northern and Southern hemispheres	23

INTRODUCTORY COMMENTS

To protect the people we represent, we are holding CSIRO accountable.

As I said in my first senate speech on Tuesday 13 September 2016 “Australians should be able to rely on the information from Australian government bodies and institutions (such as the CSIRO) but we can’t”.

As a result of poorly researched climate policies, I said “Queenslanders, everyday Australians, have lost jobs, paid higher taxes, wasted opportunities, lost businesses and fritted away scarce resources... Nowhere is this issue more important than in our resource rich Queensland, which stands to lose the most of all our states”.

Billions of dollars have been wasted on mothballed white elephants such as useless desalination plants.

Queenslanders and Australians want to know why?

On Monday 26 September 2016 CSIRO presented, at my request, its case on climate.

That revealed that:

- i) CSIRO has no empirical evidence proving carbon dioxide from human activity affects climate
 - ii) CSIRO’s presentation contradicted the empirical climate evidence.
-

After being sworn in, my first task as a senator was to write to the CSIRO Chief Executive Dr Larry Marshall requesting a presentation on the empirical evidence - the measured data, physical observations, hard facts - proving that carbon dioxide from human activity detrimentally affects climate.

The heart of science is objectivity based on data and logic. Empirical evidence decides science, not whims, unfounded beliefs and opinions, votes, fashion, bullies, money or emotion. Dr Marshall agreed on the need to provide empirical evidence and to do so with logical reasoning that shows statistical significance.

Being sceptical and demanding empirical evidence is the first duty of a scientist and a copy of my letter is in Appendix 1.

Having received no reply, two days before the desired presentation, my office called Dr Marshall’s office and they confirmed the presentation would be made in my office on 16 September as requested. The next day, being the day before the presentation, we were advised there would be no presentation.

After lobbying with Senator Canavan, Minister for Northern Development, and after my letter to Mr Greg Hunt, Minister for Science, we finally locked CSIRO into a presentation in Sydney ten days later.

I opened the meeting with the CSIRO with an assurance that we would be listening, and not arguing, and would only ask questions to clarify. Dr Marshall acknowledged and appreciated that approach. CSIRO’s climate scientist Dr Steve Rintoul had the floor and the meeting was recorded.

Our team and I later analysed the material with international scientists including climatologists, physicists, geologists, botanists, engineers and independent investigators.

Our Key Findings

In the spirit of the straight-talking Sir Joh Bjelke-Petersen, and with the courage and strength of Pauline Hanson, our investigations of CSIRO's claims and presentation confirm that:

- CSIRO has ***no empirical evidence*** proving human carbon dioxide affects global climate;
- CSIRO relies on unscientific Australian and overseas manipulations of data that have ***fabricated warming temperatures*** and that the CSIRO has ***failed to do its due diligence*** on the data upon which it relies;
- CSIRO ***contradicts*** the multiple lines of empirical evidence that prove carbon dioxide from human activity does not, and cannot, affect climate variability. CSIRO's approach has serious deficiencies.

Our analysis of CSIRO's six core statements and claims is available at <https://checkvist.com/checklists/583700> and includes datasets and scientific references. The site is laid out specifically in response to CSIRO's six numbered claims in the same sequence as CSIRO's presentation to me as Senator on Monday 26 September 2016.

Our Scientific Team

I am supported in Canberra this morning by:

- Internationally eminent Canadian climatologist, geographer and environmentalist Professor Tim Ball, whose expertise includes deep understanding of the United Nations' climate body, the Intergovernmental Panel on Climate Change (IPCC) cited by CSIRO;
- American engineer, investigator and researcher Mr Tony Heller, internationally respected for exposing manipulation of temperature data by a small unit within NASA's Goddard Institute of Space Studies and relied upon by CSIRO;
- Australian scientist, engineer and inventor Mr Peter Bobroff who was awarded an Order of Australia Medal for his services to research and compiled the site reviewing CSIRO's claims and presenting supporting data: <https://checkvist.com/checklists/583700> that includes datasets and scientific references.

EXECUTIVE SUMMARY

Policy failures at global, national, state and regional levels based on failed and ridiculous forecasts are costing lives, costing taxpayers billions of dollars, exporting jobs and destroying energy security and reliability.

CSIRO refused to comment on whether anything in the 2,000 year climate record indicates impending danger.

CSIRO provided no empirical evidence proving carbon dioxide from human activity affects climate.

CSIRO contradicts multiple lines of empirical evidence that prove carbon dioxide from human activity does not, and cannot, affect climate variability.

CSIRO relies on unscientific Australian and overseas remodelling of data that have made warming trends from actual cooling trends.

CSIRO failed to do its due diligence on the data on which it relies.

CSIRO's approach on climate has serious scientific deficiencies. Instead of policy based 'evidence' we need evidence based policy.

We note CSIRO's standard disclaimer on reports including scenarios based on computer modelling: "This report relates to climate change scenarios based on computer modelling. Models involve simplifications of the real world that are not fully understood. Accordingly, no responsibility is accepted by the CSIRO for the accuracy of forecasts or predictions inferred from this report or for any person's interpretations, deductions, conclusions, or actions in reliance of this report".

Scrutinising climate alarm reveals a comprehensive failure in governance, journalism, education, federal politics and state politics.

We need to bring attention and resources back to real and serious humanitarian and environmental challenges and we need to protect our nation's sovereignty and our Australian way of life.

We need an independent inquiry into CSIRO and the Australian Bureau of Meteorology (BOM).

Our government must reject the Paris 'Agreement'.

We need an Aus-exit to remove our country from the UN.

HOW AUSTRALIANS ARE AFFECTED BY COSTLY POLICY FAILURES

Before commenting on CSIRO's claims, consider recent climate policies and forecasts and their cost to Queenslanders, Australians and humanity.

1. Desalination Plants - Rushed and Mothballed

Prominent Australian academics such as mammal palaeontologist and media celebrity Tim Flannery, Chief Commissioner of the Gillard-Greens Climate Commission, said the dams would never fill again. State premiers, all but one at the time being Labor, panicked into spending \$10bn on desalination plants. Then the floods came and dams overflowed. Queenslanders were \$1.2bn out of pocket and pay \$120M each year servicing our Tugun desalination plant. Families don't realise that this cost is hidden in water bills.

Flannery was on the advisory board of Siemens that built the desalination plants. *Why?*

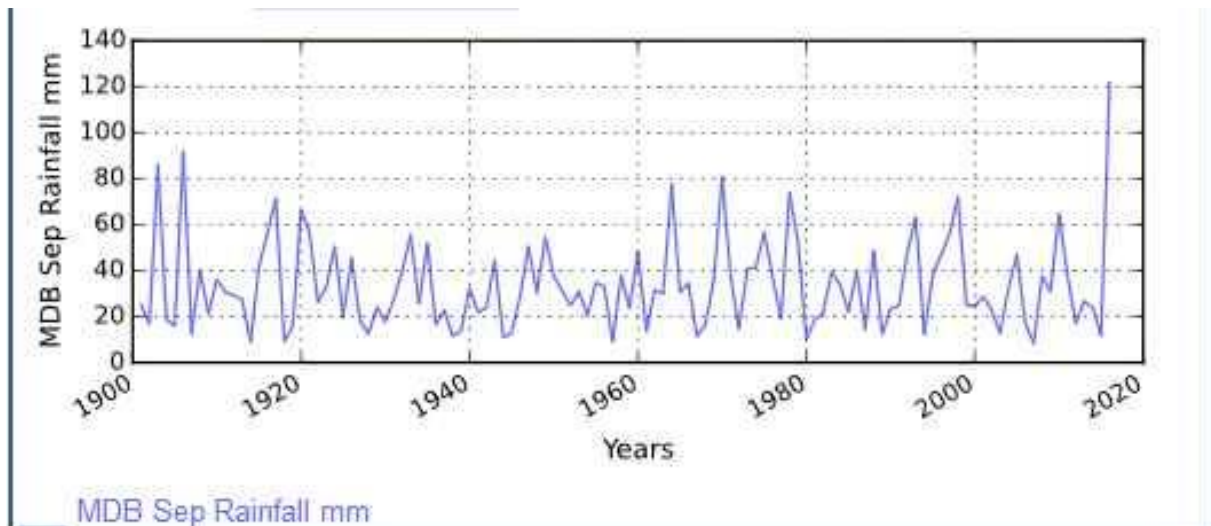


Figure 1: Rainfall for September in the Murray Darling Basin

After recent floods it is apt to consider figure 1 showing rainfall for September in the Murray Darling Basin, an area claimed in recent years to be under drought stress and water shortage from human-caused climate change.

2. Costly Brisbane Flooding due to Political Climate Panic

In August 2010 Brisbane Lord Mayor Campbell Newman warned of the possibility of flooding after learning of forecast summer weather. Yet after Flannery, and others such as prominent UN climate academic David Karoly reportedly warned of never-ending drought, Anna Bligh's government seemingly panicked and compromised Wivenhoe Dam's flood mitigation capacity. When heavy summer rains came the Dam's management reportedly lost control of the dam's level and had to open floodgates during a high tide causing the flooding of 22,000 homes and 7,600 businesses across 94 suburbs and towns in and around Brisbane and Ipswich. As a result, some people suffered with mental illness problems leading to tragic circumstances. The financial cost ran into billions of dollars, including infrastructure costs to the Brisbane City Council alone of \$440M.

David Karoly, who receives millions of dollars in climate change grants, reportedly blamed the floods on climate change yet the apparently avoidable flooding was far less severe than in the 1890's.

3. The Political Push for Renewable Energy that Increases Global Pollution

We're told that we must cut the human production of carbon dioxide from gas, coal and oil and that, at a time of exploding debt, we must borrow \$400 billion dollars for renewable energy. The federal government estimates Queensland's fantasy of converting to 50 per cent renewables will cost our state \$27bn alone and destroy jobs in power generation. South Australia already suffers with 47 per cent renewables, and South Australian Senator Birmingham, Minister for Education and Training, advises that his state had "four large economic contributors who, by being without power for 15 days, have cost the economy tens, if not hundreds, of millions of dollars".

Despite subsidies, renewable energy prices are higher than conventional energy. Those high prices are destroying industry. In this absurd situation, Senator Nick Xenophon wants subsidies to keep South Australian industry live. *Why?*

South Australia is now forced to rely for security on Victorian coal-fired electricity. *Why?*

Queensland's major electricity users such as LNG export plants, open cut mines, Boyne smelters and thousands of small and large businesses depend on secure, reliable and affordable energy to earn our state and country vital export dollars and keep jobs. Yet our state Premier now wants a higher renewable energy target than South Australia's current level and cut use of our state's international competitive advantage: clean coal. *Why?*

One hundred and sixty years of industrialisation proves that cheap, reliable energy increases productivity which in turn increases prosperity, security, comfort and ease. Yet climate extremists and populist politicians now want to reverse human progress. *Why?*

Assisting the Liberal Party Leader in the House and Minister for Defence Industry Christopher Pyne's 2016 re-election the government decided submarines should be built in the state with the highest energy costs and lowest energy reliability and lowest energy security. What will save South Australia after Victoria's Hazelwood power station shuts in four months? *Why?*

During the recent election campaign the federal government flushed \$400 million into windfarms in the Deputy Prime Minister's New England electorate despite Barnaby Joyce being the most outspoken climate sceptic politician until Greg Hunt enacted his Direct Action plan in 2014. *Why?*

Tim Flannery was associated with a geothermal renewable energy producer relying on Labor government handouts. His book *The Weather Makers* was analysed by Dr Wes Allen who observes that Flannery's 307 statements created 577 issues, including 14 baseless extreme comments, 70 factual errors and 11 failed predictions. Yet the climate industry has been a financially boon to Tim Flannery. *Why?*

As the Greens Party policies raise Australian energy prices, manufacturing jobs are transferred from clean Australian plants to third world nations that use old pollution equipment. The global emission of real pollutants such as sulphur dioxide, nitrous oxides and particulates then increases. *Why?*

Instead of subsidising renewables how many hospitals and schools could've been built? How many local infrastructure projects across Australia could we have done?

4. The Effects on Australia's Fishing Industry

Our island continent is surrounded by ocean and has, by some definitions, the world's largest fishing zone. Yet federal Labor and Liberal ministers are quietly implementing the UN's so-called sustainability, bio-diversity and other regulations based on climate claims that are killing our fishing industry and forcing us to now import almost three quarters of the seafood we eat. *Why?*

5. Queensland's Great Barrier Reef?

Green politicians, activists and nongovernment organisations tell us our Great Barrier Reef is dying yet scientific researchers and tour boat operators who live on the reef confirm that it's thriving. What is threatened is the reef's tourist industry as international tourists are scared away from visiting an imagined dead reef fabricated by emotional campaigns. *Why?*

Formerly as federal Environment Minister, Greg Hunt reported to the UN on the state of our Great Barrier Reef. That undermined Australian sovereignty and governance. We have no responsibility to report to the UN. Australia's governing document is our constitution.

6. Queensland Industry and Jobs Threatened by Foreign Activists

We remember vegetation laws that stole farmers' property rights while enabling Prime Minister Howard to comply with the UN's Kyoto climate protocol.

As reported in the Australian media, Wikileaks confirms that associates of President Obama and Secretary Hillary Clinton fund activists threatening our coal industry. They ally with American billionaires publicly proclaiming climate alarm and depress coal company share prices. They now buy American coal producers while paying activists to shutdown Australian mining industry competitors. *Why?*

The politically driven CFMEU coal miners' union publicly supports cutting carbon dioxide output and donates money to GetUp! and the Greens, despite those activists' efforts to shutdown Australian coal mining. GetUp! is linked to international financial manipulator George Soros who bought into American coal producer Peabody Energy after successfully driving down the share price. *Why?*

7. Global Claims

In 2005, the United Nations Environment Programme forecast that by 2010, climate change would create 50 million climate refugees fleeing rising sea levels, increases in cyclones, and disruption to food production. The actual number of climate refugees is zero while islands are increasing in size as uplift takes them above a nearly stagnant sea level. According to the Queensland state government's Maritime Safety department, Australian sea levels are rising at the rate of 0.3 mm per year, and at that rate over the next 100 years, sea levels will be 3 cm higher. SEAFRAME, the world's most comprehensive sea level study shows sea levels in the south Pacific islands are flat. Yet Australia promises \$1bn in aid to protect island citizens. *Why?*

The floating Arctic ice cap continues varying naturally while Antarctica continues growing. Worldwide, glaciers are increasing in size, others are shrinking and others are stationary.

It seems that every year for the last 20 years we are told we have five years before catastrophe. *Why?*

ADDITIONAL COSTS

1. The Real Victims of Climate Claims

The cost to Queenslanders and Australians is enormous - directly in taxes and energy costs and indirectly in terms of lost jobs, shuttered industries, cost-of-living increases, extra regulations, higher energy prices, reduced energy security, reduced reliability, and Greens' guilt and fear. These workers and the forgotten people of outer-suburbs and regional Queensland, working families enduring rising costs of living while carrying the tax burden for foreign companies, and protest voters are increasingly anti-establishment.

Around Australia people are feeling washed out, blacked out, left out. There has been no destruction due to climate change, yet enormous destruction of people's prosperity. Can we justify this with science? If not can we let it continue? *Why?*

Taxpayers money should be spent based on solid facts and structured plans, unlike the NBN, renewables and climate policies.

2. Some People Benefit from Climate Alarm

Before becoming a federal Labor MP, Greg Combet was ACTU secretary and a director of the union controlled Industry Super Holdings Pty Ltd owner of Australia's largest windfarm operator, Pacific Hydro. As Minister for climate change he later gave tens of millions of dollars in subsidies to Pacific Hydro in guaranteed income. Later as windfarms destroyed South Australian jobs the Abbott government paid him to advise on redeploying unemployed workers. *Why?*

3. Gillard's Carbon Tax Lie Replaced by ... Hunt's Carbon Tax by Stealth

As part of their 2013 election campaign, former Prime Minister Tony Abbott and Greg Hunt promised to repeal the Gillard-Greens carbon dioxide tax. Abbott kept his promise. After Mr Abbott was later dumped as Prime Minister, Hunt quietly enacted a new carbon dioxide tax in the form of an emissions trading scheme having a cap on carbon dioxide output, with penalties for exceeding caps and with credits for producing less. Hunt's scheme can be linked to an international price on carbon dioxide that will give control of Australian energy prices to overseas interests. *Why?*

4. More Costs for Taxpayers Based on Climate Claims

In research provided to my office on 30 September 2016, the Parliamentary Library identified a number of significant federal climate policy costs such as:

- Clean Energy Finance Corporation (allocated \$2 billion annually from 2013-14 to 2016-17),
- Emissions Reduction Fund (established in 2014-15 for \$2.6 billion),
- Australian Renewable Energy Agency (budgeting \$258 million for 2017-18, \$235 million for 2018-19, \$255 million for 2019-20, \$134 million for 2020-21 and \$132 million for 2021-22),
- Commonwealth Renewable Energy Target (accounting for 5.1% of average Australian household electricity costs), and
- The discontinued CPRS (which raised \$3.6 billion in taxes in 2012-13 and \$4.3 billion in 2013-14).

Other hidden federal climate policy costs include (in part or full): Antarctic Climate and Ecosystems Cooperative Research Centre; Australian Institute of Marine Sciences; Australian Nuclear Science and Technology Organisation; Australian Research Council; Australian Bureau of Meteorology (BOM); Clean Energy Regulator; Climate Change Authority; CSIRO; Department of the Environment and Energy; National Climate Change Adaptation Research Facility; and National Landcare Programme. It is vital to note that each state and territory government as well as local councils also have a plethora of climate policies and related economic impacts, including the various 'public utility' regulators. On

top of this are foreign aid and UN institutions as well as 'Green' politics, industries and lobbyists. It is estimated that the cost of calculating these hidden costs would itself run into many millions of dollars of consultants' fees.

5. CSIRO Started Pushing Climate in the 1980s with the UN's Climate Body

CSIRO itself imposes direct costs. According to CSIRO, "[i]n the 1980s" they "were already raising the risks of climate change" and from "[a]round 1990, the Climate Variability 'multi-divisional program' started formally bringing these efforts together". In 2007, the Commonwealth budget provided \$44 million over four years to help establish the Climate Adaptation Flagship. The Flagship grew steadily to an annual budget of \$43 million (2010-11, similar in the subsequent 3 years) and about 160 full-time equivalent staff.

Remember?

In the mid-1970s we were warned of imminent, catastrophic irreversible damage due to humans causing global **freezing**. Some experts claimed this was due to ... coal and oil. Quoting Newsweek magazine, 28 April 1975: "The central fact is that after three quarters of a century of extraordinarily mild conditions, the earth's climate seems to be cooling down."

Yet experts, including some of the experts previously predicting global cooling, now tell us that earth has been warming for a century.

Globally recent climate claims have destroyed or wasted trillions of dollars' worth of assets away from serving humanity. The UN climate body's failed predictions hurt humanity.

Academics, politicians and subsidised climate 'industries' are lining their pockets with taxpayer funds after making false, and in some cases fraudulent, predictions. Everyday Australians now pay daily in many ways for this fraud.

SUMMARY OF SENATOR MALCOLM ROBERTS' RESEARCH ON CLIMATE CHANGE

My qualifications are similar to those of the immediate past UN IPCC chairman, Rajendra Pachauri. These include an honours degree in engineering that covered atmospheric gases including carbon dioxide, an MBA from the University of Chicago Graduate School of Business famous for rigorous statistical analysis, and my stringent statutory qualifications in QLD and NSW that cover study and examination of atmospheric gases including carbon dioxide, that was the basis for my responsibility for the lives of hundreds of people.

During the last eight years I have researched the extensive empirical data on global temperature and climate and on carbon dioxide, including data that the UN IPCC cites and relies upon at the core of its reports to national governments and media.

- responses from the Bureau of Meteorology (BOM) and CSIRO to my requests made under federal Freedom of Information (FOI) statutes for the period 2005-2013 across the Howard-Rudd-Gillard-Milne governments;
- correspondence from the BOM's then Director Dr Rob Vertessy and from the CSIRO's then Chief Executive Dr Megan Clark and CSIRO's Group Executive-Environment Dr Andrew Johnson;
- detailed and quantified analysis of BOM and CSIRO reports by internationally respected climate scientists and by other independent researchers including my quantified analyses;
- thorough reviews of United Nations Intergovernmental Panel on Climate Change (UN IPCC) reports by internationally respected scientists and political observers and my quantified analyses;
- personal correspondence with the nine most prominent Australian 'climate' academics pushing climate alarm while in receipt of funds from the Gillard/Rudd-Greens coalition being David Karoly one of the UN IPCC's most senior advisers on climate, Will Stefan, Tim Flannery, Ross Garnaut, Ove Hoegh-Guldberg, Lesley Hughes, Matthew England, Kurt Lambeck and Andy Pitman, all advocates of the ALP-Greens climate taxes (*see below);
- investigating and making formal complaints to prominent Australian universities that depend on, and are compromised by, ALP-Greens government climate funding;
- meetings with members of Parliament, senior cabinet ministers including Greg Hunt, then Minister for the Environment, Deputy Prime Minister Barnaby Joyce, and Deputy Liberal Leader Julie Bishop;
- letters to and from ALP Members including Cabinet ministers responsible for climate being Senator Penny Wong and her successor Mr Greg Combet, former Attorney General Senator Robert McClelland and other ALP and Greens federal MPs;
- prominent journalists including those of the government's ABC.

*Most responded to my letters. All failed to provide empirical evidence for their claim that carbon dioxide affects climate and must be cut. In their public statements all contradict empirical evidence. All were government-funded under the Gillard-Greens regime.

CONTEXT – INHERENT VARIATION VERSUS PROCESS CHANGE

A Simple Overview

The understanding of statistics among academia, journalists, members of parliament, legal professionals and the public is limited. Few people learn of, much less understand, the two main causes of data variation: inherent variation and process change, as depicted in the diagram below. Simply put, inherent or routine variation is ever-present and due to the random combination of many factors within a continuing process. In the event of an exceptional variation this reveals a process change.

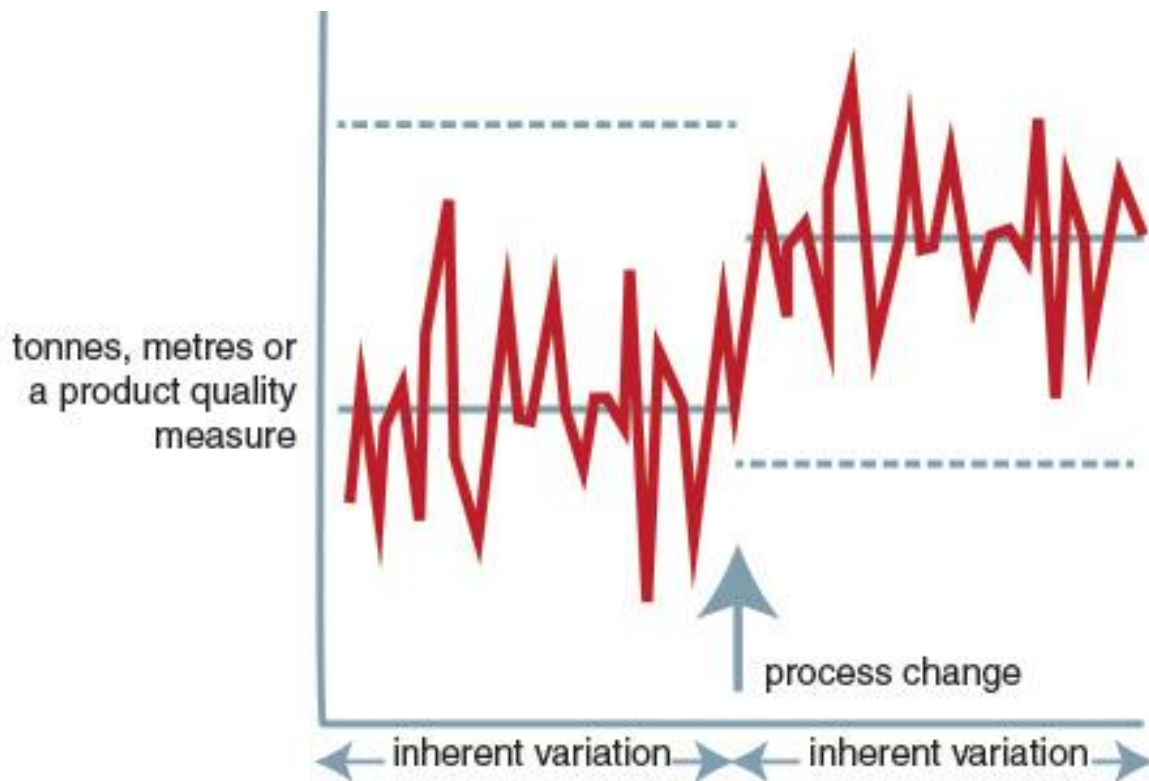


Figure 2: Understanding the two main causes of variation

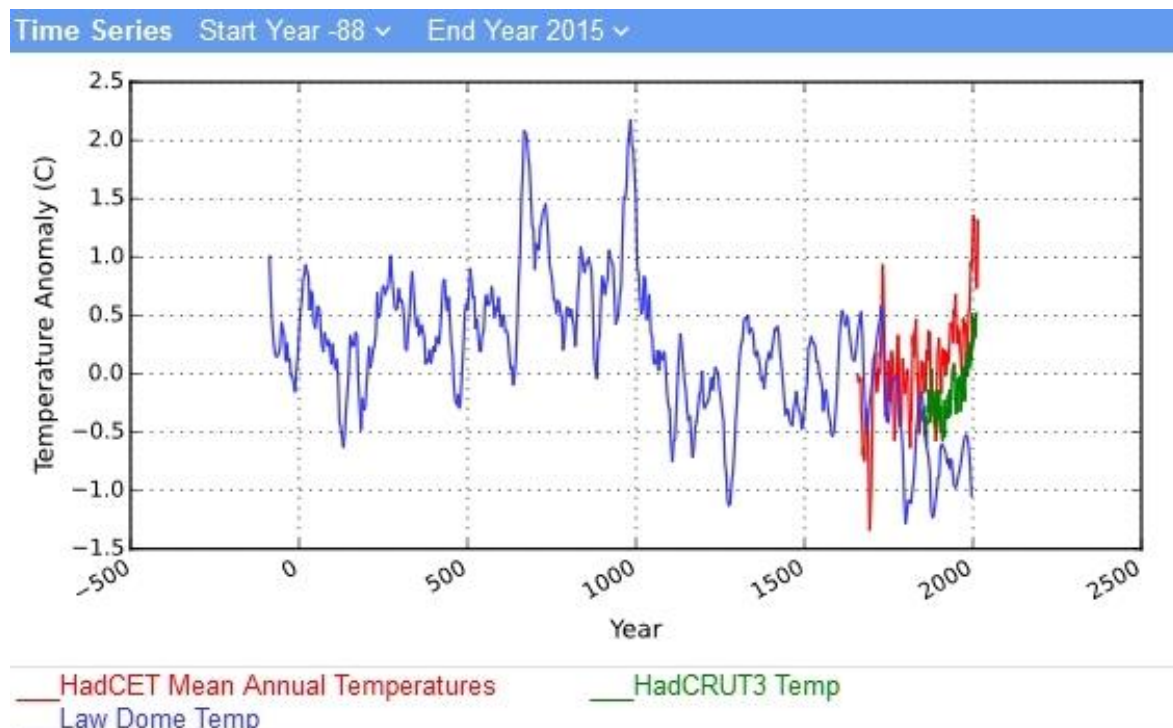
RESPONSE TO CSIRO'S CLAIMS

The following are my responses to CSIRO's key climate claims and are supported by material at this site: <https://checkvist.com/checklists/583700>. It includes datasets and scientific references.

The site is laid out specifically in response to CSIRO's six numbered claims in the same sequence as CSIRO's presentation to me as Senator on Monday 26 September 2016. The summary responses below though respond in terms of the key overall claims about temperature and carbon dioxide.

1. Is the Earth Really Warming Unusually?

In the last 100 years it is erratically true that earth has warmed. Yet figure 3 shows earth is now cooler than in past warmer periods.



HadCET Mean Annual Temperatures: Adjusted to show as anomalies based on 9.2 deg (1961-1990).

Data source: <http://www.metoffice.gov.uk/hadobs/hadcet/data/download.html>

Noisy series: HadCET Mean Annual Temperatures filtered by Savitzky-Golay, 17, 3.

HadCRUT3 Temp: Data source: <http://www.metoffice.gov.uk/hadobs/hadcet/data/download.html>

Law Dome Temp: Converted from d18O to deg(C) using 0.44 permille/degreeC. Converted to anomaly using base of -50.0 deg(C).

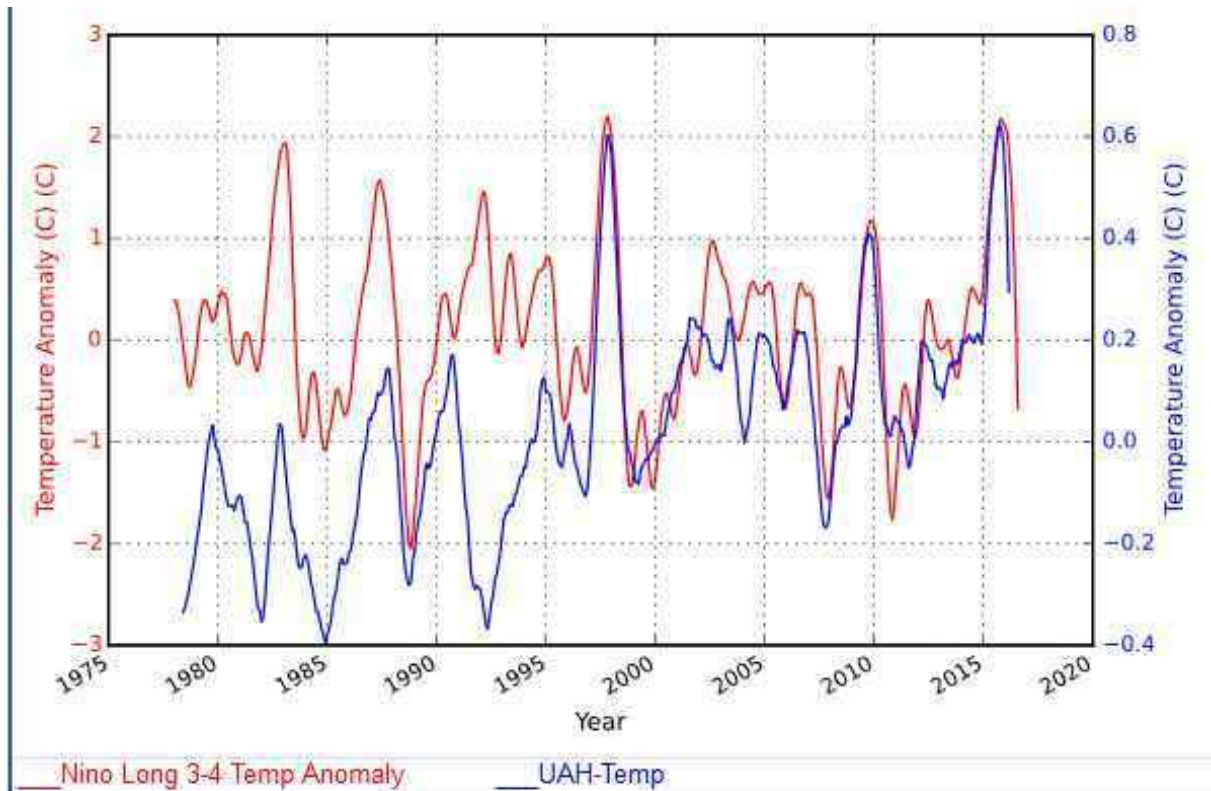
Data source: [http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=amd_au&KeywordPath=&EntryId=\[AADC\]ASAC_757_LD_d18O&MetadataView=Data&MetadataType=0&lnode=mdlb3](http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=amd_au&KeywordPath=&EntryId=[AADC]ASAC_757_LD_d18O&MetadataView=Data&MetadataType=0&lnode=mdlb3)

Notes on data: [http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=amd_au&KeywordPath=&EntryId=\[AADC\]ASAC_757_LD_d18O&MetadataView=Text&MetadataType=0&lnode=mdlb1](http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=amd_au&KeywordPath=&EntryId=[AADC]ASAC_757_LD_d18O&MetadataView=Text&MetadataType=0&lnode=mdlb1)

Noisy series: Law Dome Temp filtered by Savitzky-Golay, 17, 3.

Figure 3: Ice core temperatures showing past warmer periods and today's temperatures

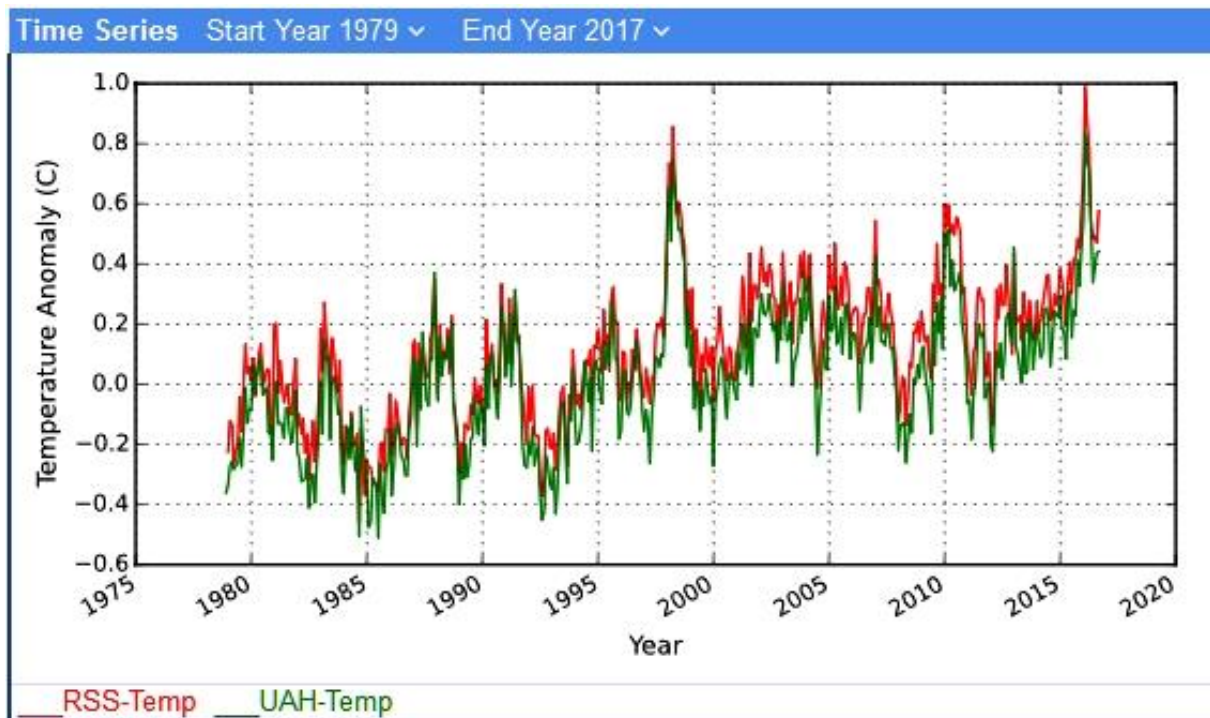
Close scrutiny of the data shows that temperature is highly variable, largely in association with well-established natural El Niño cycles. See Figure 4.



Nino Long 3-4 Temp Anomaly: NOAA Converted to anomaly using base of 27.0
 Data source: http://www.esrl.noaa.gov/psd/gcos_wgsp/Timeseries/Data/nino34.long.data
 Noisy series: Nino Long 3-4 Temp Anomaly filtered by Savitzky-Golay, 17, 3.
UAH-Temp: UAH Raw data was lower troposphere monthly means.
 Data source: http://www.nsstc.uah.edu/data/msu/v6.0beta/tilt/tiltghmam_6.0beta5.txt
 Notes on data: <http://www.drroyspencer.com/2015/04/version-6-0-of-the-uah-temperature-dataset-released-new-tilt-trend-0-11-cdecade/>
 Noisy series: UAH-Temp filtered by Savitzky-Golay, 17, 3.
 Series: UAH-Temp offset by -0.5 years.

Figure 4: El Nino temperature and ground-based temperature plots

Figure 5 shows weather was dominated in 1998 and 2015/16 by natural spikes in El Nino cycles. Beyond that, it is clear that there has been no warming trend since around 1995



RSS-Temp: Raw data was lower troposphere monthly means.
 Data source: ftp://ftp.remss.com/msu/monthly_time_series/RSS_Monthly_MSU_AMSU_Channel_TLS_Anomalies_Land_and_Ocean_v03_3.txt
 Notes on data: <http://www.remss.com/measurements/upper-air-temperature>

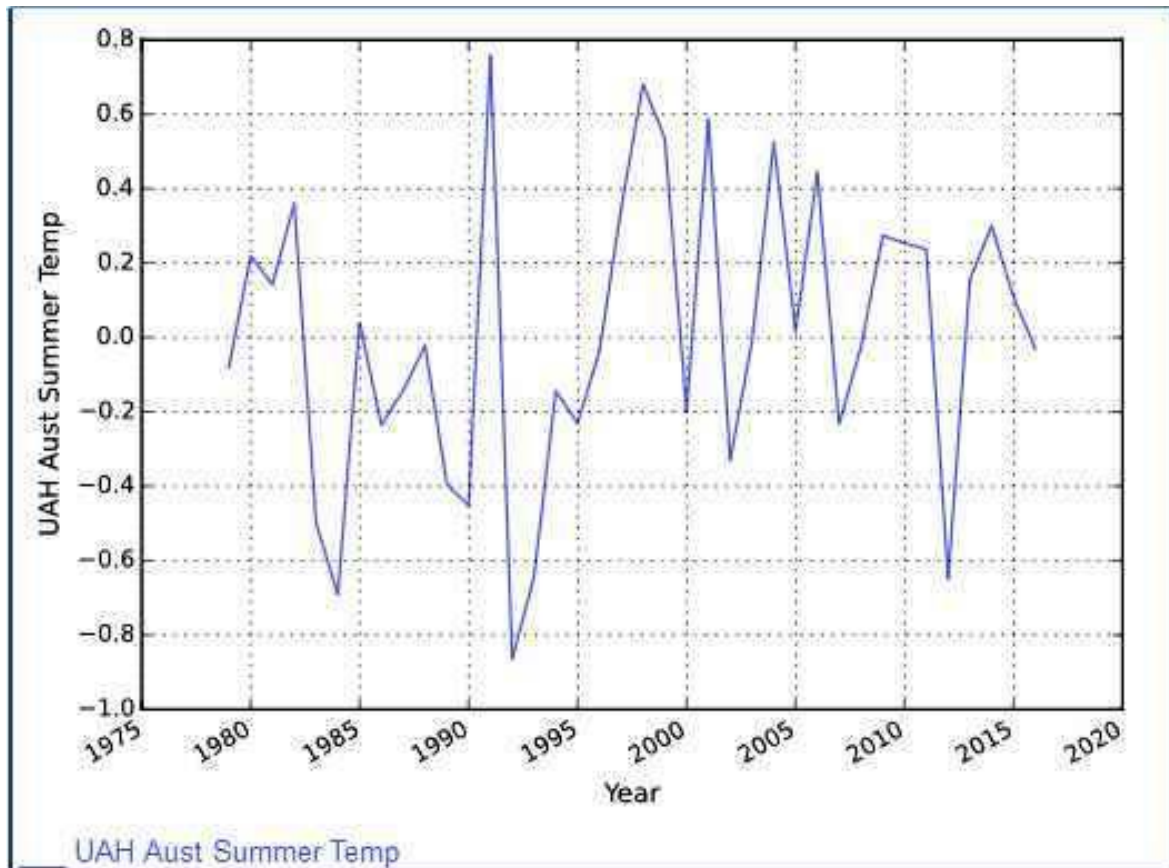
UAH-Temp: Raw data was lower troposphere monthly means.
 Data source: http://www.nsstc.uah.edu/data/msu/v6.0beta/tlt/tltglhmmam_6.0beta5.txt
 Notes on data: <http://www.drroyspencer.com/2015/04/version-6-0-of-the-uah-temperature-dataset-released-new-lt-trend-0-11-cdecade/>

Figure 5: Satellite temperature data from UAH and RSS

Figure 6 shows Australian summer temperatures in the satellite era using data from John Christy at the University of Alabama Huntsville.

As an aside, in 2013 the politically motivated Gillard-Greens Climate Commission under Tim Flannery's leadership stole headlines around Australia labelling the Australian summer of 2013 as the *angry summer*, purporting temperatures to be unusually warm. The facts tell a different story based on 37 years of satellite temperatures. Yet such is the state of climate 'science' among federal government-funded agencies.

Note the overall downward trend in Australian summer atmospheric temperatures since 1991 despite ever-increasing global human production of carbon dioxide due to the Chinese and Indian industry.



UAH Satellite data Dec, Jan, Feb from UAH-John Christy private communication.
 Notes on data: <http://www.drroyspencer.com/2015/04/version-6-0-of-the-uah-temperature-dataset-released-new-11-trend-0-11-cdecade/>

Figure 6: Australian summer temperatures - Satellite

Satellite data of atmospheric temperatures has been confirmed by weather balloon radiosonde data. Both are more accurate and credible than the ground-based atmospheric temperature data used by CSIRO.

Curiously, CSIRO's presentation slides and briefing document contained graphs showing that temperature in 1998 was not prominent while a later slide showed 1998 as a prominent spike. The latter is reality.

The 1998 El Nino spike was used in the early 2000's to justify claims of global warming yet has since been reduced apparently to highlight the 2015 El Nino in order to imply continued warming.

Dr Marohasy and Tony Heller have researched and reported on temperature re-modelling by BOM and NASA-GISS. In both organisations a small group of people have re-modelled data to reverse actual cooling temperatures thereby making warming trends.

Dr Marohasy is an Australian scientist with peer-reviewed papers on temperature and rainfall as well as other fields of science. She is an expert on the Murray-Darling Basin and has stated: "Claims that the earth is heating up because of human-caused global warming are based on datasets that generate temperature profiles based on a weighted-subset of remodelled surface-air temperature measurements."

Figure 7 shows Tony Heller's reconstruction of Australian temperatures since 1880 using the GHCN temperature data for Australia compared with homogenised data from the Australian Bureau of

Meteorology (BOM). ACORN-SAT are BOM's Surface Air Temperatures and GHCN refers to the Global Historical Climatology Network temperature data that include BOM's Australian temperatures.

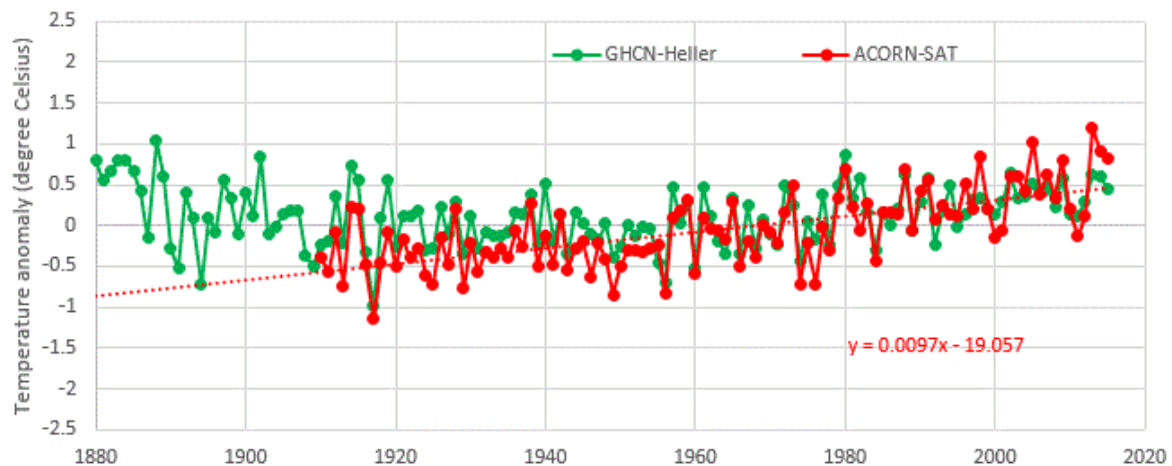


Figure 7: Australian temperatures - reconstructed

Although Heller's reconstruction has weighting to south east Australia and does not allow for changes in temperature recording modes at some weather stations it is clear that temperatures in the 1880s-1890s were at least similar to current temperatures and more likely were hotter than today. Yet the Bureau of Meteorology's homgenisation (red line ACORN-SAT) has omitted warmer temperatures earlier than 1910, has drastically lowered temperatures in the 1930s and 1940s and raised temperatures in recent years. In doing so the Bureau of Meteorology (BOM) made a warming trend.

In an email on 1 November 2016 Dr Marohasy advised: "In reality, the hottest years ever recorded in Australia are probably 1914-15; the hottest January perhaps 1896 – when people were evacuated from places like Bourke in western NSW."

"Of course the late 1930s and early 1940s were also hot. The summer of 1938-39 at Rutherglen in Victoria (in the Murray Darling Basin) was a full 2°C hotter than the ten most recent summers – including this last summer."

Marohasy states: "There is nothing unprecedented about recent temperatures in Australia." And: "There is compelling evidence that the Bureau of Meteorology remodels historical temperature data until it conforms to the failed theory of human-caused global warming." It seems that in Australia we now have policy based 'evidence' instead of evidence based policy.

It has been said that even with the wildest of imaginations it would be difficult to match the BOM's remodelling. One could cheekily conclude that warming over the last 100 years is indeed man-made?

In responding Dr Marohasy's inquiries and requests BOM failed to provide its methodology for adjusting temperatures. I am advised that in its responses BOM provided contradictory and conflicting statements.

Curiously, CSIRO, BOM and NASA-GISS rely on ground-based temperature data that is known from the diligent work of American meteorologists Anthony Watts and Joe D'Aleo (http://scienceandpublicpolicy.org/images/stories/papers/originals/surface_temp.pdf) to be corrupted due to being sub-standard. Deliberate unscientific omissions and alterations further corrupt the data.

It is telling that under the leadership of James Hansen and then Gavin Schmidt, NASA-GISS continues to rely on discredited and manipulated ground-based temperature data instead of NASA's own accurate satellite data. This raises serious questions as to whether NASA-GISS by its actions has been politicised and cannot be trusted.

Tony Heller has published NASA-GISS's graphs that show extensive adjusting of data.

In the period since industrialisation (~1850) and using data prior to the latest adjustments, the longest temperature trend occurred from the mid-1930's to 1976, forty years of cooling. This cooling occurred at a time when human output of carbon dioxide rose dramatically during World War 2 and the post-war western economic boom.

For the last 21 years, there has been no warming trend despite record levels of human carbon dioxide output due to economic growth in China and India, and ongoing industry and transport in America and Europe.

In the longer term, the earth has cooled, and warmed, and cooled, and warmed, and cooled...

In America, the 1930s-1940s were warmer than today.

Globally, most of the Holocene Period, being the 10,000 years since the last ice age, has been warmer than the present. The Medieval Warm Period around a thousand years ago was warmer than today. That fact is recognised in the UN IPCC's first report in 1990.

Figure 6 showing Australian summer temperatures reveals nothing unusual in the atmosphere above Australia and confirms that the 2015/2016 El Nino was not as significant for summer temperatures in Australia as the 1998 El Nino event.

CSIRO implied in its presentation that recent periods of rising temperatures are unusual yet data confirms they are entirely normal. In the temperature records there are many periods of temperatures rising at similar rates and this is as expected from cyclical warming and cooling.

In answer to my question, CSIRO repeatedly declined to confirm whether it did due diligence on BOM temperature data. Instead it just accepts BOM's data, despite extensive unscientific and sometimes contradictory re-modelling. It is clear that CSIRO has not done its independent due diligence on temperatures.

Empirical data proves there is nothing unique about temperature since industrialisation (~1850), neither in absolute temperature nor in rate of warming or cooling.

The empirical data shows that over the last 130 years that there has been no process change (exceptional variation) in temperatures and no process change in earth's climate data. There is only natural cyclical variation in temperature, rainfall, droughts, floods, snowfall, cyclones, storms and sea levels. Despite some activists among the media, academics and politics telling us human carbon dioxide is affecting climate, the data shows no unusual, unnatural or human cause of global climate variability and nothing is happening with temperature or climate, just ongoing natural cyclical variation.

Understanding the many superimposed cycles enables understanding of climate and weather.

When temperatures are shown only selectively from the end of an earlier cooling period and a subsequent warmer period (1930s-1940s) is removed from the data, it is easy to convince the public, politicians and journalists of so-called warming. There is nothing in the climate record of the last 2000 years indicating anything abnormal, much less impending danger.

2. CSIRO's Claims about Carbon Dioxide

There is no justification for saying that human carbon dioxide output determines carbon dioxide levels in the air.

Figure 7 depicts monthly carbon dioxide levels showing enormous natural variation that clearly overrides human production. This is different again in the northern hemisphere from the southern hemisphere.

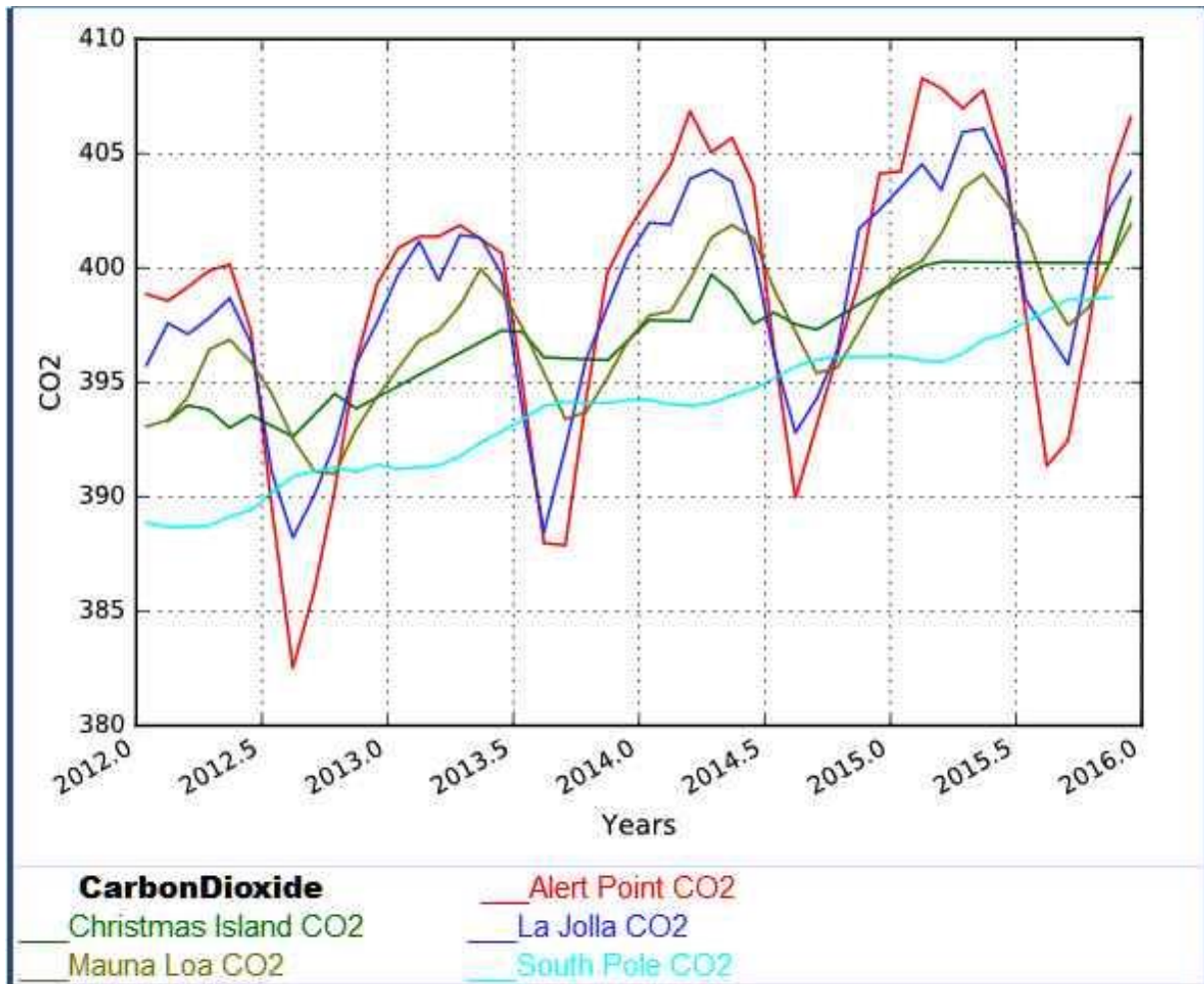


Figure 8: Monthly carbon dioxide levels Northern and Southern hemispheres

On a seasonal and annual basis changes in carbon dioxide levels follow changes in temperature. This means that carbon dioxide cannot drive temperature and that temperature likely drives carbon dioxide levels. This is consistent with and supported by Henry's Law and an understanding of the spatial distribution of the oceans across the southern hemisphere versus the northern hemisphere as explained by Professor Lance Endersbee.

In the 100,000-year cycles temperature changes occur before or at the same time as changes in carbon dioxide level and never after carbon dioxide changes. Clearly changes in carbon dioxide levels do not drive temperature.

Note: It is widely accepted that changes in temperature occur before changes in carbon dioxide levels and it has been accepted that changes in temperature cause changes in carbon dioxide levels yet we couldn't find evidence of this in the longer term.

Carbon isotopes in carbon dioxide from hydrocarbon (gas, coal, oil) usage are the same as in carbon dioxide from deep magma. The isotope in carbon dioxide from volcanoes depends on the volcano's location. CSIRO commonly claims that carbon isotopes in carbon dioxide can differentiate between human and natural carbon dioxide. This is not the case as the same isotope in carbon dioxide occurs in the same isotope from volcanic activity.

Note additional relevant facts: Natural production of carbon dioxide dwarfs human production of carbon dioxide. According to estimates provided by the UN's climate body and cited by America's EPA, nature annually produces an estimated 32 times more carbon dioxide than is produced from all human activity. Further, the range itself of measurement in estimating natural carbon dioxide production is four times the total human production of carbon dioxide.

Regardless, the level of carbon dioxide in air is determined by ocean and atmospheric temperatures and is not and cannot be, affected by human production.

Figure 7 shows that on intermediate time scales and in monthly data, enormous natural forces clearly overwhelm human production. This is supported by known natural phenomena driving carbon dioxide production. With support from Henry's Law this rules out the claim that human carbon dioxide determines the level of carbon dioxide in air.

All these facts and data lead to the logical conclusion that the human production of carbon dioxide does not and cannot affect the level of carbon dioxide in air. Instead, enormous natural forces determine the level of carbon dioxide in air.

Recessions, such as the marked global reduction in human carbon dioxide output in 2009, do not appear in the data and graph of carbon dioxide levels in the air. This omission confirms that human production of carbon dioxide has no effect on the level of carbon dioxide in air.

Regardless, empirical data shows that temperature is not determined by or controlled by the levels of carbon dioxide in air. Further, empirical data shows there is nothing unusual occurring in climate with ongoing natural warming, cooling, warming, cooling, warming, ... cycles.

Because the empirical data confirms that we cannot and do not affect the level of carbon dioxide in air it means that cutting human carbon dioxide output can have no effect. A carbon dioxide tax and switching to renewable energy would be useless and cannot affect the level of carbon dioxide in air. It would do enormous economic damage for no change in the atmosphere or climate.

There is no evidence over the last 800,000 years that shows carbon dioxide drives climate. There is much in the last 60 years that shows carbon dioxide from human activity cannot and does not drive climate.

Empirical evidence proves that cutting our carbon output has no effect on the level of carbon dioxide in air. In turn the level of carbon dioxide has no effect on temperature.

3. Claimed Greenhouse Effect

CSIRO said it relies on a claimed greenhouse effect that it neither defined nor substantiated. It failed to provide any empirical evidence that additional carbon dioxide warms the dynamic open atmosphere despite this being the base of its argument and we have asked for clarification and supporting evidence.

It never ceases to amaze that this claim is made repeatedly by advocates of climate alarm yet there are 63 differing versions of the greenhouse effect and nowhere has any evidence been provided that additional carbon dioxide in the open atmosphere has a significant warming effect.

There is a wide range of views. Prof David Karoly, a lead contributor, review editor and drafter of the summary for policy makers for the UN IPCC, says the greenhouse effect is real and that higher levels of carbon dioxide will lead to catastrophe. Others such as meteorologist Richard Lindzen claim higher levels of carbon dioxide will have a slight effect on earth's atmospheric temperature yet this is offset by natural feedbacks. Still others, including physicists such as Gerlich and Tschuschner (2009), geologist Chillingar et al (2008) and astrophysicist Joe Postma, show that carbon dioxide has a cooling effect. Physicist and former Dean of Science John Nicol theorises that carbon dioxide up to 0.004% of earth's atmosphere has an effect of raising earth's atmospheric temperature yet at levels of more than 0.004% could result in insignificant changes in temperature. Further discussion is available at: <https://checkvist.com/checklists/583700>

There are 62 atmospheric processes defined on pages 156 & 157 of Green and Wyatt's book entitled '*Atomic and Space Physics*' published by Addison Wesley, let alone the many combinations of materials within our atmosphere. Four and a half billion years of earth's history cannot be boiled down to one natural trace gas whose only 'sin' is to be associated with taxable hydrocarbon fuels and whose many benefits are ignored, let alone that it cannot affect climate.

Earth's dynamic open atmosphere is the very opposite of a physical greenhouse and internationally eminent Canadian climatologist Professor Tim Ball explains the fundamental dynamics well when he says that on our planet the sun warms earth's surface. The surface by contact (conduction) warms the moving circulating atmosphere. Through conduction and convection the atmosphere cools earth's surface.

It then becomes a matter of conjecture that occupies hours of scientific debate as to whether something that cools the surface can warm it as the UN IPCC and CSIRO claim.

Secondly, latent heat of water cools earth's surface.

Yet these primary movers of heat and proven dominant heat transfer mechanisms (conduction, convection, latent heat) are ignored and instead a greenhouse effect is conjured based supposedly on the work of pioneers in atmospheric studies 200 years ago. Those scientists did not understand mechanisms in the atmosphere and contradicted each other. Arrhenius, on whom the UN IPCC relies, contradicted his own claims within a matter of years.

During our questioning, the CSIRO admitted that it has not advised any politician to label carbon dioxide as "carbon pollution" or in any way to label carbon dioxide as a pollutant. The UN IPCC has confirmed that nowhere in its reports is carbon dioxide listed as a pollutant. Yet such labels are rife among Labor and Greens politicians.

With the UN IPCC, politicians and CSIRO relying on the undefined, unsupported and vague 'greenhouse' claim it is easy to understand why the UN IPCC's climate models have failed.

4. Questionable Computerised Numerical Models

CSIRO cannot explain the reality that temperature and carbon dioxide show many divergences. The empirical data shows divergence is more common than correlation. Why would anyone think there's any relation at all? Scientists wouldn't.

Clearly, CSIRO's empirical evidence does not prove that carbon dioxide from human activity needs to be cut. Perhaps that is why, tellingly in a presentation requested on empirical evidence, CSIRO chose to cite output from computerised numerical models in support of their case.

Computerised numerical 'models' relied upon by CSIRO and the UN IPCC fail to mimic atmospheric principles and processes. The models are based on cells each of which covers large geographical

parts of earth and this dictates adhoc simplifications and fiddling rather than proper application of the laws of physics.

The models are unvalidated and based largely on factors with very low levels of understanding and omit or downplay significant natural drivers of climate variability known to control climate.

Even the UN IPCC's latest report in 2013 admitted that its models are erroneous and the UN IPCC has no understanding of why its models are wrong. That confirms that the UN IPCC does not understand climate's real drivers.

Quoting climate researcher and investigator John McLean on facts from the latest UN IPCC report is revealing:

"The fifth and latest IPCC assessment report, published in 2013, showed that climate models failed to predict the absence of warming from 1998 and 2012, and that climate scientists have no clear idea of why they failed.

1. *"... the rate of warming over the past 15 years (1998–2012; 0.05 [–0.05 to 0.15] °C per decade) ... is smaller than the rate calculated since 1951 (1951–2012; 0.12 [0.08 to 0.14] °C per decade)." [UN IPCC Summary for Policy Makers (SPM), page 3, section B.1, bullet point 3, and in full Synthesis Report on page SYR-6]*

2. *"... an analysis of the full suite of CMIP5 historical simulations (...) reveals that 111 out of 114 realisations show a GMST trend over 1998– 2012 that is higher than the entire HadCRUT4 (temperature data) trend ensemble (ground- based atmospheric temperature measurements)" [WGI contribution, chapter 9, text box 9.2, page 769, and in full Synthesis Report on page SYR-8]*

3. *"There may also be a contribution from forcing inadequacies and, in some models, an overestimate of the response to increasing greenhouse gas and other anthropogenic forcing (dominated by the effects of aerosols)." [SPM, section D.1, page 13, bullet point 2, and full Synthesis Report on page SYR-8]*

4. *"This difference between simulated [i.e. model output] and observed trends could be caused by some combination of (a) internal climate variability, (b) missing or incorrect radiative forcing and (c) model response error". [WGI contribution, chapter 9, text box 9.2, page 769]*

Explanations:

1 – *According to statistical practices the trend in temperature from 1998 to 2012 (the 15 years prior to the report being drafted) falls somewhere between slight warming and slight cooling. In other words there is no certainty that any warming occurred.*

2 – *Despite claims of the accuracy of climate models most of the model runs (97%) wrongly predicted warming from 1998 to 2012.*

3 – *The IPCC is admitting that "some models" – we are not told how many, so maybe it's almost all – exaggerate the influence of CO₂ (carbon dioxide) and other greenhouse gases.*

4 – *The models could be wrong for a number of very basic and general reasons; the IPCC really doesn't know why the models failed."*

Canadian statistician Professor Ross McKittrick has identified that the UN IPCC has subsequently modified previous UN IPCC projections in an effort apparently to reduce the perceived discrepancy between erroneous projections and actual temperature measurements. Nonetheless CSIRO relies

upon these erroneous, unvalidated, ‘theoretical’ numerical computer models contradicting empirical evidence and based on a vague and unsubstantiated greenhouse supposition.

Has CSIRO resorted to computer models because there is no way that empirical data can prove carbon dioxide drives temperature and climate change? If so and instead of the causal logic why did CSIRO resort to models that are unvalidated and have been proven wrong, a fact admitted by the UN’s climate body?

It is telling that the UN IPCC, in its charter, is specifically restricted to investigate only human drivers of climate and ignore natural drivers. That means it doesn’t understand and cannot understand natural causes, or at the very least is forced to neglect natural causes.

Various graphs at <https://checkvist.com/checklists/583700> show that El Nino and solar factors provide better explanations of climate variability than does carbon dioxide.

Instead of wasting money investigating carbon dioxide in support of a political agenda, we need to spend a fraction of that money to investigate natural drivers of climate, and better understanding of what really drives climate. That would help us to protect people and enhance their lives. It would make for sound policy protecting and supporting the people of Queensland and Australia.

CSIRO’s statement 6.5 in its presentation to us that “the earth has warmed as a result of the enhanced greenhouse effect” is not supported and is false. The data outlined above proves this statement is false.

Referring to our compilation of empirical evidence (<https://checkvist.com/checklists/583700>), Jones (2016) in the journal Nature, concludes that climate model simulations that include anthropogenic forcing are not compatible with the observed trends in empirical data.

CSIRO’s statement 6.6 that “other forcings cannot explain the magnitude, timing and distribution of observed trends” is not substantiated and contradicts the empirical data.

Perhaps that is why CSIRO clearly states that it accepts no responsibility for the accuracy of its models. For example, the CSIRO’s common disclaimer states: “This report relates to climate change scenarios based on computer modelling. Models involve simplifications of the real world that are not fully understood. Accordingly, no responsibility is accepted by the CSIRO for the accuracy of forecasts or predictions inferred from this report or for any person’s interpretations, deductions, conclusions, or actions in reliance of this report”.

The basic scientific test is: can the models forecast into the unknown future? Climate models based on carbon dioxide cannot and they fail.

It is disturbing that CSIRO relies on and supports the UN’s politicised climate body, the IPCC. In each of the UN IPCC’s last three reports there is just one chapter claiming warming and attributing it to carbon dioxide from human activity. These are in 2001 chapter 12, in 2007 chapter 9 and in 2013 chapter 10. These contain no empirical evidence or logic proving human cause. They contradict scientific principles yet CSIRO offers its support for the UN IPCC.

In our discussion with CSIRO it refused to state that carbon dioxide from human activity is a danger. CSIRO has never advised that carbon dioxide is “carbon pollution”.

Summary of Temperature and Carbon Dioxide Claims

In summary, recent temperatures are not unprecedented and neither are rates of warming that ended 21 years ago. Neither are carbon dioxide levels and variability unprecedented. Humans affect neither for the following reasons:

- a) The empirical data proves no change is occurring in temperatures or climate factors. That is the reverse of what we're told.
- b) At times changes in the carbon dioxide level are often not associated with changes in temperatures and at other times are as a result of changes in temperature, not a cause. That is the reverse of what we're told.
- c) Humans do not and cannot affect the level of carbon dioxide in air globally. Physical evidence, natural processes and Henry's Law combine to show human activity does not and cannot affect global climate. That too is the reverse of what we're told.
- d) Warming is beneficial because after all science classifies past warmer periods as climate optimums. Again, that is the reverse of what we're told.

The empirical evidence repeatedly contradicts CSIRO's core claim that is based on selective data that misrepresents climate.

Nowhere did CSIRO state that warming is detrimental and that carbon dioxide from human activity needs to be cut. Nowhere did CSIRO specify any effect in terms of specific temperature changes. It can't because the UN's fabled 2-degree temperature increase was plucked out of the air and contradicts science.

CSIRO has not yet provided any evidence that their climate models can predict the future climate with such certainty that extraordinarily large sums of money should be spent on mitigating climate change rather than addressing other serious and real humanitarian and environmental issues.

The cost of CSIRO to Australia is enormous, directly and indirectly:

- Direct costs are the cost of operating CSIRO and the opportunity cost of CSIRO resources that could be used more effectively elsewhere;
- Indirect cost of policies 'justified' on CSIRO advice and the enormous opportunity cost of real and serious humanitarian and environmental challenges that could be addressed when we stop diverting resources to chasing carbon dioxide, nature's trace atmospheric gas essential to life on earth;
- Indirect cost of climate policies shutting down industry and wrecking our economy;
- Indirect costs of destroying the scientific method responsible for human safety, security and comfort;
- Indirect costs of freedom curtailed by the UN's 1992 Rio Declaration for twenty first century global governance enacted through stifling regulations dictated by the UN in the name of sustainability, biodiversity and climate change.

Chief Scientist Finkle's written response is now awaited after his unconvincing reply in Senate Estimates questioning on Thursday 20 October 2016 raised serious concerns about his vague responses.

FACTUAL DRIVERS OF TEMPERATURE VARIABILITY AND CLIMATE VARIABILITY

Climate and Weather are about Energy Moving Around our Planet

Understanding weather and climate requires understanding the flow of energy around our rotating planet as parts are alternately heated and cooled every 24 hours. The amounts of energy involved are mind-boggling as one cyclone, for example, can 'pump' water from the Pacific Ocean and lift it hundreds of kilometres inland to drown much of our large state. These are incomprehensible volumes, weights and energies in a natural and common weather event.

With this understanding of climate's complexity it is remarkable that in their peer-reviewed scientific paper McLean, Carter, de Freitas (2009) show that Southern Oscillation El Nino cycles are closely related to changes in temperature. (See Figure 4).

Among factors from galactic to terrestrial, the factors proven to be most influential on climate include: regional cyclical decadal ocean-atmosphere circulation patterns such as El Nino Southern Oscillation and North American Oscillation; variations in the sun's solar output, solar particles, magnetic field polarity and strength; atmospheric water content and cloud cover; ocean temperature, salinity, currents and sea surface temperature and volcanic activity.

Temperature correlates far better with the sun (solar effect) than with carbon dioxide. See graphs at <https://checkvist.com/checklists/583700>

Incidentally, although we cannot affect global temperature or climate through our use of hydrocarbon fuels, if we could control earth's thermostat we would raise the temperature because past warm periods are shown in history and in science to be beneficial.

Similarly, although the data proves we cannot affect the level of carbon dioxide in air, if we could, we would increase plant growth rates and agricultural yields, as proven in the earth's many past periods with far higher carbon dioxide levels when life flourished.

PROBLEMS WITH CSIRO'S METHODOLOGY

CSIRO has not provided empirical evidence proving carbon dioxide from human activity affects global climate or temperatures.

We note that CSIRO has not done its due diligence on BOM's temperature data and has not adequately investigated cause-and-effect. Both these issues are fundamental to science.

CSIRO admits that its advice on climate is not suitable for policy, yet Minister Greg Hunt has repeatedly stated that his climate policy relies on advice from CSIRO.

CSIRO contradicts science and history.

Its presentation was in some ways unscientific in that it:

- Relied on varied, arbitrary and inconsistent time periods and scales;
- Used periods of varied duration yet ignored earth's history;
- Showed poor understanding of variation, especially cyclical variation and inexplicably it assumed linear trends for part of data sets;
- Used assumptions based on a presumption that we will see significant impact within a lifetime;
- Grossly misled in not showing the entire temperature data set from 1860;
- Excluded reliable data showing Australia was warmer in the 1880's and 1890's and excluded periods that were wetter and with more floods and excluded Australia's most severe drought.

When questioned about using land-based temperatures only from 1910 onwards CSIRO said that it omits land-based temperatures before 1910 because they are unreliable, yet CSIRO uses sea-surface temperatures from before 1910 despite admitting they were from just a few ships.

In reality, reliable temperatures from before 1910 are available yet show temperatures were warmer before 1910 and in many cases temperatures in the 1880s-1890s were warmer than today.

Datasets were not specified for some of CSIRO's graphs, including one attributed to NASA.

CSIRO's presentations included false claims.

CSIRO's graph presented mean temperatures. That shows warming. Yet temperature maximums are generally considered a better measure of regional temperature variability and shows much less warming. That reduces the trend to 0.4°C per century. Further, CSIRO did not mention the included urban heat island effect.

CSIRO is closely connected with David Karoly, one of the most prominent academics in a senior position within the UN's Intergovernmental Panel on Climate Change (UN IPCC). Like the other nine most prominent Australian academics advocating climate alarm, he has repeatedly failed to provide empirical evidence of causation; he contradicts empirical evidence and is funded by taxpayers.

CSIRO was not able to show that the UN IPCC is an unbiased independent organisation, that the UN IPCC is not a political organisation, that the UN IPCC is objective in showcasing the work of its authors, or that the UN IPCC has remediated all the many serious shortcomings and deficiencies listed in the Inter-Academy Council's (IAC) Climate Change Assessments in August 2010, Review of the Processes and Procedures of the UN IPCC. The IAC is the world's peak scientific academic body.

The onus is on CSIRO to prove its climate advice and claim. They have not done that.

My 2013 report on CSIRO provided in my role as a management consultant raises many serious issues. It is available together with appendices at:

<http://www.climate.conscious.com.au/CSIROh!.html>

The report, and its appendices 6 and 6a, detail serious issues including the apparent conflicts of interest of the then CSIRO Chief Executive Dr Megan Clark. It raises the advocacy for global governance by CSIRO 'scientists' funded by taxpayers. Finally, it includes disturbing comments by Professor Garth Paltridge who was a chief research scientist with the CSIRO division of atmospheric research and the chief executive of the Antarctic and Southern Ocean Co-operative Research Centre.

Peter Bobroff AM advises that a former CSIRO Deputy CEO advised him that '*CSIRO would never utter a public statement that imperilled its funding.*' Sadly and disturbingly, such anecdotes are not rare.

WHY AND WHO?

You May Ask: Why Haven't People Seen This Before?

The answer is partly because members of Parliament, journalists and academics have failed to do their due diligence and understand the basics of scientific process. They've fallen for excuses and imitations of science, not science itself. Additionally people have found it daunting because of the powerful and clever emotive campaign initiated by the UN in its political agenda, later supplemented by Al Gore's movie *An Inconvenient Truth* that successfully shutdown debate by framing opponents to his climate claims as anti-environment and as being part of an 'uncaring, dishonest and shameful tiny minority'.

Instead of empirical evidence proving cause-and-effect, modern media force-feed us with myths that are easy to understand yet are the very opposite of science. These include:

- People in authority such as ministers expressing beliefs or opinions not science;
- Implied or explicit fearful projections that naturally cause emotion to overrule reasoning despite contradicting the science;
- Emotive statements and pictures of cute cuddly animals and smiling baby dolphins that distract from the lack of empirical evidence;
- Activists invoking morality and shaming those who dare to present facts disagreeing with the activists' position; invocations of morality such as claiming to protect our children's future or to protect emotive icons such as the Great Barrier Reef or Bondi Beach, ...
- Name-calling, labelling and smearing people who disagree so as to silence their colleagues afraid of speaking out. Use of dishonest labels such as 'denier' implying holocaust denier; anti-Semitic; conspiracy theorist; smearing directly or subtly those questioning alarming climate claims;
- Portraying natural weather events and inherent natural variation as process change when in reality they confirm natural weather events in an unchanged climate;
- Falling for, citing and relying on manipulated data taken out of context;
- Broad and generalised yet unsubstantiated claims contradicting empirical evidence yet sounding plausible and appearing 'scientific';
- False and misleading claims of 'consensus'. When the data on John Cook's claimed 97 per cent 'consensus of scientists' is analysed, it reveals only 0.03 per cent of those scientists make the claim of dangerous warming and none has empirical evidence;
- Universities and schools today subtly teach people what to think, not how to think;
- Using the UN IPCC's politically driven allocation of levels of uncertainty that imply statistical validity yet are allocated politically;
- Appeals to authority implying that the experts such as CSIRO, BOM, UN IPCC, NASA-GISS have the evidence when they do not;
- Implying peer-review despite the scientific literature lacking empirical evidence of cause that is essential for true scientific peer-review;
- Output, directly or implicitly from unvalidated computerised numerical models that the UN IPCC admits are erroneous and based largely on factors with very low levels of understanding and that omit or downplay significant natural drivers of climate variability and that are known to control climate;
- Use of UN IPCC diagrams that depend on the implied assumption of the unusually high temperatures that are not really occurring;
- Hiding behind the UN's damaging Precautionary Principle;

Sadly, glossy CSIRO booklets and public speeches by CSIRO employees use many of these methods.

Some MPs have tried to obtain the empirical evidence. In May 2006, my own federal MP Jane Prentice advised me and two fellow constituents that she continued to have difficulty getting empirical evidence of human cause from Minister Greg Hunt despite her many requests.

There is a larger agenda though as shown by the late Maurice Strong, first Secretary-General of the United Nations Environmental Program that has pushed a political agenda to have control over people and nations.

You May Ask: Why Are They Doing This?

A lot of people have been misled, including a lot of good people with honest and noble intentions.

Understandably, many seem upset and threatened with the fear and thought of the possibility that they could be wrong in assuming humans are changing climate.

For most people the reasons are easily understood and have been repeated throughout history. These include groupthink driven by a desire to conform and belong, weakness, compelling propaganda and the herd mentality that leads to mob rule, especially within parliament.

It is simply human behaviour for humans to want to conform and this is repeatedly shown throughout history, making us vulnerable to herd mentality and groupthink. This is worsened by compelling propaganda such as the cleverly designed movie *An Inconvenient Truth*. Once respected groups are swayed it becomes easier to influence the wider community. For example, the National Press Club has in the last decade hosted 23 advocates of alarm, just two advocates of scepticism and one debate. Most recently my request for a debate with Greens Senator Larissa Waters has been rejected on the basis of "it won't sell tickets." Similarly once a few key people in each party are converted away from science and onto beliefs it becomes easy for whole parties and parliaments to be moved and managed.

Additionally the money involved is astronomical and Maurice Strong's cleverest stroke was in systematically aligning the interests of many diverse groups. We are facing down a trillion dollar industry.

Strong was remarkably successful in gaining control of weather agencies such as BOM, NOAA (USA), UK Met Office, Environment Canada in major western nations and science agencies, hijacking once-honest agencies, such as the British climate research facilities established by Henry Lamb, and through politicians such as Al Gore getting control over government agencies such as NASA-GISS and through government funding of agencies such as CSIRO.

You May Ask: Who Benefits from Climate Alarm?

- Academics and climate scientists feeding off government grants. Many climate scientists and many other scientists have a conflict of interest because without the claim of human effect, they would lose their income. The grants would end. With the government funding only one side of the discussion it promotes only one side of the argument. Ironically, that side, even without empirical evidence gets to set the agenda in the media and in politics;
- Politicians such as Kevin Rudd in 2007 wanting power and buying votes;
- Politicians such as John Howard in 2007 clinging to power and buying votes. Howard, to protect his Prime Ministership, endorsed human cause of climate variability yet after his dismissal he publicly stated he was agnostic on climate. Despite this he lumbered Australia with the Renewable Energy target. His was the first party to have a carbon dioxide trading scheme (tax) and he was the man who stole farmers' private property rights to ensure compliance with the Kyoto Protocol; despite not signing the protocol;
- Major international banks who openly admit trading carbon dioxide credits is worth trillions of dollars to their income and whose boards included the previous CSIRO Chief Executive;

- Universities seeking grants and funding;
- Government agencies such as CSIRO and BOM dependant on government funding;
- Quasi-government agencies such as the Great Barrier Reef Marine Park Authority required to make claims supporting government policy; contradicting empirical evidence;
- Parliamentary backbenchers who are promoted to ministry for parroting the party line and once appointed as minister are afraid of breaking the party line;
- UN bureaucrats whose position relies on departments set up to push climate claims;
- Government broadcasters such as the ABC that rarely presents sceptic arguments and misleads the public in subtle ways including the use of billowing steam to backdrop discussions on invisible and scarce carbon dioxide. The ABC takes no responsibility for academics misrepresenting climate or science yet continues to give them a voice. The ABC does not insist on empirical evidence of cause-and-effect and instead endorses unscientific myths. It gives little airtime to sceptics and smears or ridicules sceptics while validating advocates of alarm. The ABC faces no external scrutiny and, unlike commercial broadcasters, complaints are answered by ABC staff. The ABC has become a propaganda outfit;
- The UN itself as a vehicle for people such as Maurice Strong who pushed a personal agenda as a way of taking political power and control over others. This is particularly easy in massive bureaucracies such as the UN where accountability is non-existent and the representatives from many countries follow like a herd;
- Nongovernment organisations such as Greenpeace and WWF aided by foreign-funded agencies such as GetUp! who build political power and influence.

We all assume the best in people and in institutions yet there is absolutely no evidence for that assumption of faith in institutions. Although individuals are usually honest and intelligent, when collected as a herd, rationality can be lost. Examples of herds include parliament, universities and agencies depending on external funding. As history and current events show, without the discipline of a market these can be hijacked for political ends.

Senator Birmingham, former Parliamentary Secretary to the Minister for the Environment (Greg Hunt) on Thursday 13 October 2016 answering a question in the Senate, on behalf of the Energy Minister said: “The Turnbull government accepts the science of climate change. We take our advice from the Chief Scientist, the CSIRO. The Bureau of Meteorology, the Department of the Environment and Energy as well as leading world scientific organisations such as the World Meteorological Organisation”. Note his use of appeals to authority despite these organisations using the same corrupted temperature datasets and despite none having any empirical evidence showing that carbon dioxide from human activity affects climate and must be cut. Senator Birmingham relies on these appeals to authority despite the CSIRO saying (a) that government should not rely on CSIRO’s advice to form policy and (b) that CSIRO refuses to state that carbon dioxide from human activity is a danger.

Misrepresentation of science and climate is a form of control over people’s minds. It is yet another example of the everpresent tussle between control and freedom that has been playing out as part of the Human Condition for millenia. It is another example of the tyranny of the minority who control the political and media agenda.

You May Ask: Who Pays?

- Taxpayers;
- The progress of civilisation as it depends on science, that is being destroyed;
- Public policy, when it is based on opinions and political and personal agendas, rather than objective science and hard facts;
- Children whose critical thinking ability is being eroded by an education system that is brainwashing people rather than developing people;

- The Australian community broadly through the destruction of our constitution in implementing the UN's global governance agenda;
- All taxpayers who fund academics and politicians misrepresenting the science as a way of justifying further tax increases including the open-ended upward-ratcheting carbon dioxide tax, implemented on 1 July 2016 by the Government with assistance from the Greens and ALP.

We acknowledge the courage of MPs publicly sceptical of climate claims. These include: Craig Kelly, George Christensen, Cory Bernardi, Pauline Hanson and others.

We acknowledge the courage of scientists within academia who show the fortitude to base comments on science and to question orthodoxy, sometimes despite threats of dismissal for speaking out. These include: Peter Ridd, Stewart Franks and Cliff Ollier and others.

We acknowledge journalists such as Andrew Bolt, Paul Murray, Alan Jones, Chris Kenny, Grant Goldman, Graham Lloyd and others, who show the courage to research the evidence and then speak out.

We acknowledge prominent business people who speak out against the corruption or misrepresentation of science and especially those such as Maurice Newman who speak out against the UN's governance campaign.

We acknowledge the many scientists and everyday Australians now breaking free of the fear of being called names and labelled 'deniers' in order to speak out.

That is the real climate issue: freedom of thought and speech.

CONCLUSIONS AND CALL TO ACTION

This report, by citing the empirical evidence, conclusively proves that carbon dioxide from human activity has no affect on climate and does not need to be cut.

Australia must now move to unravel this enormous mess.

The report publically demands that we need:

- Government policy based on science.
- CSIRO to:
 - a) Restore scientific integrity and make decisions based on empirical evidence proving causation;
 - b) Stop the waste of the public's money;
 - c) Bring attention and resources back to real and serious humanitarian and environmental issues and protect our nation's sovereignty and way of life.
- An independent inquiry into CSIRO and BOM.
- Our government to reject the Paris 'Agreement'.
- An Aus-exit from the UN.
- Australian business leaders and union bosses to stand up on climate and protect jobs.
- Australian university Vice-Chancellors to stop presiding over and endorsing the work of so-called scientists who cannot provide cause-and-effect and to dismiss such academics misrepresenting science.
- To bring back constitutional governance. Our federal government has become a central government and is out of control with waste, debt and low accountability. We need to restore competitive federalism with states returning to behaving as sovereign states.
- The State governments to hold an inquiry into desalination plants, renewable energy and other failed policy outcomes.
- To reform our public institutions from public service, government agencies, universities, education,

Climate alarm reveals a comprehensive failure in governance, journalism, education, federal politics and state politics. CSIRO's behaviour shows low accountability and confirms that modern governance cannot be trusted to protect people's assets. The only solution is to minimise central government by restoring to tax payers the decision on who is best to spend taxpayers' money.

We need to rebuild our state's solid financial and asset base, as did Sir Joh Bjelke-Petersen, in service to the people of Queensland. Pauline Hanson is the singular leader that can continue this legacy of building a great state and nation.

As mentioned in my first media conference as a senator, accountability, cost-of-living and security are my three priorities, with tax featuring in all three. Our Party will be digging deeply into taxation and other topics hidden by weak or dishonest politicians that have lacked accountability since 1944.

We will not allow the continued deindustrialisation of our country. There is no reason for reversing the human progress of the last 160 years that has seen billions of people liberated from nature's vagaries and threats.

We must continue to expose the Greens for their policies and behaviours that are anti-science, anti-environment, anti-industry, anti-development, anti-education, anti-poor, anti-social, anti-integrity, anti-morals, anti-family, anti-women, anti-Australian, anti-freedom and anti-human.

We call on Greg Hunt as Minister for Science, Josh Frydenburg as Minister for Energy and the Environment, Mark Butler as Labor spokesperson for climate change and Anastacia Palaszczuk as Premier of Queensland, to restore government integrity.

We invite the Greens, Labor, Liberals and Nationals to present their empirical evidence that is the basis of their policies harming everyday Australians and destroying our country. We invite them to join with us in bringing back our country.

**Freedom is the power to think, speak and act as we want or need
with implicit responsibility for the impacts of our actions.**

APPENDIX 1

1. Letter to Dr Larry Marshall, CSIRO
2. Biographies of Scientific Team

Surplus notes:

Some academics misunderstand this simple statement and confuse the issue as they get lost on other topics such as thermodynamics. Yet the fundamentals are clear.



Senator Malcolm Roberts

One Nation Senator for Queensland

BIOGRAPHIES

Professor Tim Ball, Canada

BA (Honours), Gold Medal Winner, University of Winnipeg
1970 MA, University of Manitoba
1971 PhD (Doctor of Science), Queen Mary College
1982 University of London (England)

Professor Ball has prolifically published material in the arena of busting climate change myths. His material includes:

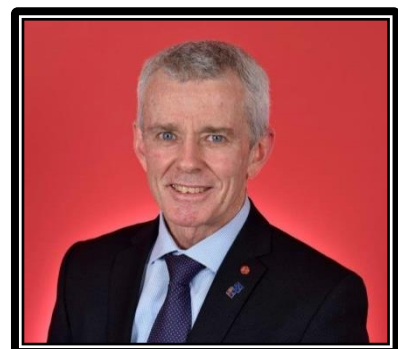
- Briggs, Smithson and Ball, 1992 of **"Fundamentals of Physical Geography"**, Second Edition
- Copp Clark and Pitman Toronto p604, **"An Iconoclast's View of Climatic Change"** *Canadian Water Resources Journal*, Vol 17, No2 1992 2007
- MG Dyck, W Soon, RK Baydack, DR Legates, S Baliunas, TF Ball and LO Hancock' **Polar bears of western Hudson Bay and climate change: Are warming spring air temperatures the "ultimate" survival control factor?** *Ecological Complexity* September, p 73-84, 2009
- Ball T, **Climate Change: Dangers of a Singular Approach and Considerations of a Sensible Strategy.** *Energy and Environment* Volume 20, Number 1 – 2 pp 201-205



Senator Malcolm Roberts, Australia

B Eng (Honours) (University of Queensland)
MBA (University of Chicago Graduate School of Business)

Malcolm was elected to the Senate for Queensland as a member of Pauline Hanson's One Nation Party in 2016. He has spent the previous years researching the extensive empirical data on global temperature and climate and on carbon dioxide, including data that the UN IPCC cites and relies upon at the core of its reports to national governments and media.



After starting his working life as a vineyard worker and coal face underground miner, Senator Roberts' professional experience includes extensive management and leadership.

Mr Tony Heller, America

Bachelor of Science Geology (Arizona State University)
Masters in Electrical Engineering (Rice University)



Under the pen name of Steve Goddard, Mr Heller is a climate blogger, climate historian, climate analysis software developer and his work has been featured at US Senate hearings. As a lifetime environmentalist he testified at a Congressional hearing at age 15 in support of a wilderness area in Utah.

Tony has worked professionally as a geologist on the Safety Analysis Report for the Department of Energy's Nuclear Waste Disposal Project (WIPP) and at the Los Alamos National Laboratory in geothermal energy research, oil shale development (for President Carter), volcano research, geothermal energy research and methane hydrate research.

Mr Heller has taught math and science to high school students at Oak Creek Ranch School in Arizona, and served as the Athletic Director. As an engineer at the Sandia National Laboratory he worked as the Hardware representative to Vice President Al Gore's public key encryption consortium, and as a climate and weather model software development consultant to the National Centre for Atmospheric Research.

His other professional experience includes:

- Member of the Power PC microprocessor design team at Motorola/IBM/Apple, the Itanium / 17 microprocessor design team of Intel and SH_5 microprocessor design manager at ST Microelectronics
- Founder and lead developer of the Visual Media graphics startup in the UK
- BAE - Department of Defense drone imaging software development
- QRC - Department of Defense cell phone and trunked radio monitoring software
- Google - motion tracking software development for their virtual reality system
- Xetawave - software development for remote control radio systems



Mr Darren Nelson, America / Australia

Bachelor of Economics (Honours) ANU (economic history)
Master of Commerce (Distinction) UNSW (business law)

Darren Brady Nelson is a dual citizen of Australia and the USA. Darren was born and raised in Milwaukee Wisconsin but has spent most of his adult life in Australia.

Darren's career as an economist in the mid-1990s to early 2000s largely centred around National Competition Policy for the likes of NSW Treasury and the Queensland Competition Authority. His focus afterwards at Arthur Andersen and as a freelance economist throughout the rest of the 2000s has been mainly on the applied economics of infrastructure regulation and pricing. This included two years in the UK.

From 2010 to the present, Darren has increasingly devoted his time and efforts to the economics and ethics of liberty in Australia, the UK and the USA. During this time he has increasingly drawn from the real-world-based Austrian School of economics, whilst retaining the best of the other schools like Chicago and Virginia.



SENATOR MALCOLM ROBERTS
One Nation Senator for Queensland

Dr. Larry Marshall
Chief Executive
CSIRO
GPO Box 1700
Canberra ACT 2600
Larry.Marshall@csiro.au
+61 2 6276 6621

Dear Dr. Marshall:

As you likely know, from 2008 and onwards, government ministers have stated that their climate policy and position are based on advice from CSIRO.

As a newly elected senator for Queensland I am deeply concerned with the spending of billions of dollars of my constituents' money as a direct result of climate policies based on the claim that carbon dioxide from human activity is detrimentally affecting Australia's climate. I am further concerned with the current and potential damage to the viability of key industries and loss of jobs. These climate policies are exporting Queensland jobs and adding significant burdens hurting my constituents' cost-of-living and security.

My research and investigations in Australia and internationally during the past eight years confirms that government climate policies contradict empirical evidence. Nonetheless, I am open to learning of your views directly and so I formally request that you provide me with CSIRO's empirical scientific evidence proving statistically valid human cause-and-effect on climate.

With your background I am confident that you understand that policy on such matters must be based on sound science; that empirical evidence decides science; and, that causation must be statistically valid and proven in a logical framework demonstrating cause-and-effect.

Given the devastation of economies and industries such as those of South Australia whose alternative energy policy is based on claims that carbon dioxide from human activity detrimentally affects climate, I respectfully request CSIRO's empirical evidence proving human causation be presented to me on Friday 16th September 2016 in my parliamentary office at a time mutually convenient to us both.

As a public servant to the people of Queensland and Australia I intend to fulfill my responsibilities and seek your clarification as a matter of importance and urgency.

I look forward to you and CSIRO fulfilling our joint responsibilities to my constituents.

Yours sincerely,

Malcolm Roberts
Senator for Queensland



Senator Malcolm Roberts
One Nation Senator for Queensland

Dr. Alan Finkel AO

Chief Scientist

GPO Box 9839

Canberra ACT 2601

+61 2 6276 1727

Chief.scientist@chiefscientist.gov.au

Dear Dr. Finkel:

Thank you for your letter dated 9 November 2016 providing your response to my question in Senate Estimates on 20 October 2016, being: “On what basis do you believe that carbon dioxide from human activity affects climate and needs to be curtailed?”

Disturbingly, your response does not provide empirical scientific evidence that proves human causation and instead raises many serious questions. These questions have been listed and substantiated by reference to published data and comments provided at <https://checkvist.com/checklists/585071> and some are incorporated as part of this reply.

In preparing these questions we’ve collected and interrogated 278 time series datasets and over 7,000 weather stations of the Global Historical Climate Network, version 3. In reading and replying to your letter we have simply relied upon access to publicly available datasets from around the world. These are easily accessed and include datasets upon which the United Nations Intergovernmental Panel on Climate Change (UN IPCC), CSIRO, Bureau of Meteorology (BOM) rely.

The empirical data appears to contradict many of the claims in your letter and we welcome discussion on your remaining claims. This letter presents just five contradictions and the link above provides further contradictions. We invite you to a public event in parliament house after senate estimates later this month and early March. We will advise the date in March and welcome you and your staff to publicly ask any question about any aspect of the empirical evidence to be presented on climate.

Firstly, regarding your statement quote: “*that anthropogenic emissions of CO₂ enhance the greenhouse effect by trapping more outgoing radiation.*” Specifically

refer to item 4.5 being your imputed claim and item 4.5.2 that presents the empirical evidence showing no such enhancement. Please note graph 4.5.2.1 presenting data from the National Oceanic and Atmospheric Administration (NOAA) satellite measuring outgoing longwave radiation that shows no increased trapping of longwave as atmospheric CO₂ levels increased.

Please note further in items 5 and 5.1 that the ModTrans 6 Atmospheric Radiation simulator predicts an infinitesimal (virtually no change) in the upward flux at 100 km for atmospheric CO₂ concentrations above 0.03 per cent (300 ppm). That is, regardless of the source of atmospheric CO₂ above 0.03 per cent, whether natural or human, there is virtually no change in outgoing longwave radiation.

As you know, empirical evidence and not simulators decides science. Nonetheless, unlike the UN IPCC's global circulation models that have been proven erroneous, ModTrans 6 is based on accepted physics and its results are relied upon for many practical real-world applications verified in implementation.

Secondly, referring to item 7 and 7.1, why is the warming since the Little Ice Age any different to the warming leading to previous far warmer warm periods? Please note that the warming from 1500BC to 1300BC and other past warm periods since occurred at levels of 0.027 per cent (270 ppm) atmospheric CO₂, being obviously much lower than current CO₂ levels. Note further from the graph that the warming from 1500-1300BC occurred at a time of falling CO₂ levels.

Significantly, you provide no evidence or causal logic suggesting that any recent warming could not be due to the causes of past far warmer periods.

Thirdly, regarding your statement, quote: "as the temperature rises so does its water holding capacity." Specifically, the NOAA satellite measuring precipitable water at item 4.6 and item 4.6.1 with graph 4.6.1.1 showing that the rise in water vapour lags temperature rise by ten years. In fact, (precipitable) water increased while temperature remained stable with no increase.

Fourthly, regarding your claims about sea level please note that tide gauges around the world contradict your claim about acceleration of rises in sea level after 1993. Specifically refer to item 4.22 being your claim and item 4.23 in response to your claim presenting empirical evidence and graphs at items 4.24 and 4.25.

Fifthly, regarding ocean heat content, please refer to item 4.19 being your claim and item 4.20 in response to your claim, being a simple question for you based on the empirical evidence.

Further, please note items 4.21 and 4.21.1 showing oceans are cooling.

And so on ... with empirical evidence contradicting many of your core and fundamental claims and statements.

We invite you to specify any errors in the data and responses presented at the URL above.

Disappointingly, referring to your statement in item 8.2, you include in your response to my request for empirical evidence reference to, and reliance upon, computer models that have been proven comprehensively wrong. In response please note items 8.2 and 4.8 and the fact that such models have been proven erroneous and contradict reality.

It is perplexing as to why you as the Chief Scientist cite the evidence of any model, much less erroneous computer models, in response to my request for empirical evidence proving causation.

Where, in your letter or anywhere in the world is there any empirical evidence within a causal framework logically proving cause-and-effect as justification for making any conclusions for policy driving cuts to human production of CO₂? There is none.

I look forward to your response and to you scrutinising the empirical data to be presented at a public forum in parliament house in March.

Yours sincerely,

Malcolm Roberts

Senator representing the state of Queensland

per Robyn Cross

Senator Nick Xenophon's Dissenting Report to the Select Committee into the Resilience of Electricity Infrastructure in a Warming World

"The Lights Aren't On, But Everyone's Home"

An Important Issue

1.1 Anthropogenic climate change is one of the greatest challenges of our time. There is a preponderance of considered scientific studies and literature that details the potential consequences of global warming, and the dire consequences of not dealing with it as a matter of utmost urgency.

1.2 For those that question the science, or doubt the consequences of climate change, the words of Rupert Murdoch '*we should give the planet the benefit of the doubt*', should at least resonate. That is, in a world of uncertainty it is important to understand the risks inherent in not doing all that is reasonable to address potential consequences of human induced climate change.

1.3 We should be mindful of Giddens' paradox. This is the central paradox of climate change politics, argued by the sociologist and a member of Britain's House of Lords, Anthony Giddens, that electorates can't grasp the significance of climate change because it is too abstract, and not dramatic enough (they need catastrophe footage), and won't — until it's too late.

1.4 Australia needs a national energy market framework, backed up by policies and rules, that are consistent with the Government's target of reducing emissions by 26–28 per cent (on 2005 levels) by 2030 and the further greater challenge of meeting the Paris Agreement targets by 2050.

1.5 Australia also desperately needs national energy market policies that enjoy bipartisan support so that crucial investment confidence, currently absent, is restored to the generation market. Australia now faces an effective drought in energy investment because of unnecessary uncertainty.

1.6 On the matter of investment uncertainty Professor Garnaut raised this issue when giving evidence to the inquiry:

While there is such uncertainty there will not be new investments. If, for example, we had bipartisan support for a form of carbon pricing, which could be an emissions intensity scheme, and business had confidence that was going to last for quite a long time, then it would be much easier for business to calculate that there was going to be a role for gas for a certain

period of time, which would justify investment. In current circumstances the extreme uncertainty about policy inhibits all investment.¹

1.7 This inquiry has been most useful for establishing a much clearer understanding of the current electricity market environment, and inherent problems with it, including the factors which led to my home state of South Australia experiencing a complete blackout on 28 September 2016 and to experience load shedding on 8 February 2017. The inquiry has also helped identify solutions to our system price, security and reliability problems.

1.8 However, I believe the Chair's report is making a fundamental error in seeking to pit gas against renewables. Gas is an important transitional fuel to help us meet our climate change targets, that can complement, not necessarily compete with renewables. The consequences of the approach in the Chair's report will be that energy prices will be driven so high and reliability will be driven so low that it will lead to a damaging deindustrialisation of the Australian economy. Whilst our emissions will inevitably reduce with this deindustrialisation the paradox is that businesses will go offshore to other countries where the environmental standards and carbon pollution policies will not be as robust.

1.9 A practical alternative proposition must be advanced to provide political certainty, and with it, policy certainty.

Proceed with Care

1.10 South Australia serves as a good example of how to avoid the pitfalls inherent in reducing emissions without compromising grid stability.

1.11 The SA Government, in proceeding down the renewable pathway, carried out the relevant due diligence but then ignored the advice provided to it.

1.12 A Report prepared in 2009, recently revealed, to the South Australian Department of the Premier and Cabinet by McClennan Magasanik Associates (MMA), entitled 'Potential for Renewable Energy in South Australia'² unambiguously states:

A level of 20% wind capacity is proposed as a level that can be achieved without compromising grid stability.

1.13 The MMA report also set out a number of measures and market developments that had to take place before that 20% level of intermittent wind energy could be exceeded without compromising grid stability. That clearly did not take place and as a consequence South Australia was left vulnerable.

1.14 A second independent report prepared in May 2009 (the same month as the MMA report) prepared for the Sustainability and Climate Change Division of the

1 Professor Ross Garnaut, private capacity, *Committee Hansard*, 7 March 2017, p. 24.

2 McClennan Magasanik Associates, Potential for Renewable Energy in South Australia, *Report to South Australian Department of the Premier and Cabinet*, 11 May 2009, http://www.renewablessa.sa.gov.au/files/2009report_potential.pdf

Department of the Premier and Cabinet of South Australia came to similar conclusions. That report prepared by the National Institute of Economic and Industry Research³ sounded similar dire warnings. It stated:

Limitations on wind power output to ensure South Australian grid stability is estimated to be associated with about a 20 per cent limit on wind capacity (emphasis in original).

1.15 The failure to heed the expert advice contained in the above two reports as well as other independent advice has led to serious price, security and reliability problems in South Australia which has required dramatic Government intervention. I believe such intervention would not have been necessary had these reports been heeded and acted upon.

Power Affordability and Security Scheme

1.16 Australia must adopt a scheme that ensures that the price of energy is affordable and is supplied reliably.

1.17 To ensure price affordability, gas must be used as a transitional energy until such time as renewables can offer the affordability and security that consumers and businesses require and expect.

1.18 Such a scheme would require high emission generators to buy credits from low and zero emission generators. The process would simultaneously raise the cost of the high emissions generators and lower the cost of low and zero emission generators. These offsetting costs mean prices stay the same. As old power stations are shut because of the costs of staying open is too high, the credits for cleaner generation will fund the investment in new generators. Having extra power stations operating pushes prices lower through greater competition.

1.19 Setting the baseline at current levels and dropping to zero between now and 2050, and leaving it on this trajectory will provide the investor the certainty needed for a secure power system.

1.20 Such a scheme would ensure all technologies compete in the same market. The only thing that will distinguish one technology from another is the price they charge for a credit and the value of the energy produced. Naturally, energy sources that provide more certain reliability will be valued by the market more than facilities where reliability is less certain.

1.21 The above approach was first described in work⁴ that I jointly commissioned with the then Opposition Leader, the Hon Malcolm Turnbull, in 2009.

3 National Institute of Economic and Industry Research, *The future prospects for renewable energy in South Australia, A report for the Sustainability and Climate Change Division of the Department of Premier and Cabinet of South Australia*, 14 May 2009, <http://www.renewablessa.sa.gov.au/files/nieir-the-future-prospects-for-renewable-energy-in-south-australia.pdf>

Essential Rule Changes

Professor Garnaut made the point to the Committee that the rules of the National Electricity Market were set for a world in which big coal based generators provided nearly all of the power. He went on to say:

Some of the rules of our system systematically discriminate against new technologies that could help that; for example, an arcane Australian approach to settlement of pricing in the wholesale electricity markets, where the average price is over half an hour, when generators and users now bid every five minutes. That averaging takes away a lot of the value of a battery, which can respond in less than a second to requirements of power, whereas many of the coal based and gas based generators take much longer to respond.⁵

1.22 That is why pricing must be recalibrated to five minute settlement, but it must be done in an orderly manner such that it does not cause unintended consequences to the market.

1.23 Professor Garnaut also gave evidence that there could be a secondary market to ensure that renewables could provide 'backup power' in any contracts entered into, something supported by Mr Danny Price of Frontier Economics. Such an approach would be essential to provide greater grid stability and lower prices. The following exchange sets out the dilemma and what needs to be done:

Senator XENOPHON: Professor Garnaut, we have had these debates and discussions over many years. As you remember, Mr Turnbull as opposition leader supported the emissions intensity scheme. Now he does not, and both parties have gone 180 degrees. Further to Senator McAllister's line of questioning, you talk about having two markets in respect of this. Wouldn't it make more sense to require changes in the market rules so that renewables need to bring with them market system security services when they connect? In other words, we would have the renewables but we would ensure that they have to provide that backup, whether it is battery or a contract with a thermal or gas generator, for instance. Wouldn't that be more efficient than having two markets that could be discordant with each other?

Prof. Garnaut: I think you are suggesting something that is entirely consistent with having two markets. If you required the large-scale supplier of intermittent energy to pay for the services that are necessary to balance it, they could pay for it either by putting in the battery themselves or contributing, through the Australian Energy Market Operator, to the costs of someone else contributing it. There you could get a lower cost response. If you required every wind farm to have a battery, you would not get the full value out of each of those batteries.

4 Frontier Economics, *The economic impact of the CPRS and modifications to the CPRS*, Report for the Coalition and Senator Nick Xenophon, August 2009, <http://www.frontier-economics.com.au/documents/2009/08/cprs-report.pdf>

5 Professor Ross Garnaut, private capacity, *Committee Hansard*, 7 March 2017, p. 22.

Senator XENOPHON: I understand now. So you are saying it does not matter how you get there; the most efficient way of getting there is to ensure that, in order for a supplier of intermittent renewable power—I hasten to add that the proposal for Port Augusta, the solar thermal, is not intermittent; that is effectively baseload. But, if it is an intermittent supply, so long as there is an efficient contracting mechanism to provide backup power, that would have the same effect.

Prof. Garnaut: Yes, and we do have in our electricity markets elements of that. We have got markets run by AEMO for frequency control ancillary services for what I would describe as slow-response frequency control ancillary services, but we do not have markets for fast-response services, which are the kind you need when you have got a large amount of wind and you get sudden changes in the contributions, or, similarly, large amounts of large-scale solar and suddenly the cloud goes over. You need quick responses.⁶

Reducing Gas Prices

1.24 An essential element to achieving greater energy affordability is to have affordable and fair gas prices, which tragically Australia doesn't have due to abject market and policy failures. Australia has an abundance of gas yet consumers and businesses are, in many cases, paying twice to three times as much as their counterparts overseas (some of whom are consuming exported Australian gas). This dries up personal disposable income that could otherwise be being spent in the general economy. This makes businesses uncompetitive by comparison to their international competitors. Prices are so high now that businesses and consumers are being hit hard, with an increasing number of energy intensive businesses facing economic ruin as a result.

1.25 Urgent policy measures needed for increasing the supply of gas and reducing prices include:

- Gas and gas pipeline market transparency so that consumers and businesses are not left negotiating in the dark.
- Ensuring gas company exports are subject to a public interest test, having regard to, amongst other things, the affordable, reliable, efficient and long-term domestic supply to Australian energy consumers. As an interim measure until such a test could be brought in and applied to new gas fields, the government should, short of an alternate domestic supply agreement from them, prohibit gas companies with extant gas export contracts from buying up domestic gas supplies to meet their export needs.
- Ensuring that the significant gas reserves are not left untapped by companies holding back from developing them because it is not in their commercial

6 Professor Ross Garnaut, private capacity, and Senator Nick Xenophon, *Committee Hansard*, 7 March 2017, p. 24.

interests to do so. A strict 'use it or lose it' test is required for retention leases in order to help address the commercial barriers to commercial development of gas fields. This test must be applied rigorously.

1.26 These and other approaches to deal with the failed market conditions must be brought in now.

Encouraging Renewables

1.27 There is a need to encourage renewables that supply the grid in a manner that meets consumers demand and in a way that adds, rather than detracts, from system security.

1.28 An example of such an approach is the solar thermal project under consideration by Government for installation at Port Augusta.

1.29 One exemplar is SolarReserve's proven solar thermal solution which uses a large array of tracking mirrors to heat molten salt which in turn drives a steam turbine generator. It's a solution that supplies to the grid without the sun shining and does so with 'inertia' which helps grid stability.

1.30 Such an installation at Port Augusta would serve as an iconic and lead example for other renewable projects providing more reliable energy.

Summary

1.31 In coming months, noting the closure of Hazelwood power station and a deeply flawed and dysfunctional energy market, there is the real prospect that Australian consumers and businesses in the eastern states will be subject to 20 to 30% increases in their energy bills compared to today's prices.

1.32 Australia needs to address the current energy price and security in a manner that recognises the reality of climate change and the need to transition to a renewable system in a calm and careful manner that brings the community along with it and does not destroy businesses and jobs along the way. The following recommendations are made.

Recommendation 1: That the National Electricity Market Rules be urgently reformed in order to ensure investment certainty, to drive greater power reliability, grid stability and lower prices whilst at the same time meeting our international agreements to reduce Carbon Emissions.

Recommendation 2: That in acknowledging that gas is an important transitional fuel to meet our carbon pollution reduction targets, that there be urgent reforms to gas market transparency, a strong public interest test involving exports, and a strict 'use it or lose it' approach to gas reserves.

NICK XENOPHON

Independent Senator for South Australia

Appendix 1

Submissions, additional information, tabled documents and answers to questions on notice

Submissions

- 1 Mr Michael Gunter
- 2 Mrs Penelope Charles
- 3 Genex Power Limited
- 4 Mr K.G. Blake
- 5 Geoscience Australia
- 6 Ms Michelle Drummond
- 7 Mr William Holliday
- 8 Mr Duncan Marshall
- 9 Mr Mark Walker
- 10 Dr Clint Steele
- 11 Mr Peter Gardner
- 12 Mr Harry Audus
- 13 Mr Barry Hadaway
- 14 Mr Robert Fincher
- 15 Ms Edwina Swierc
- 16 Dr Oscar Archer
- 17 Northern Alliance for Greenhouse Action
- 18 Mr Phil Browne
- 19 Mr Robert Adams
- 20 QUT Power Engineering
- 21 TransGrid
- 22 Energy Networks Australia
- 23 Commonwealth Scientific and Industrial Research Organisation
(CSIRO)
- 24 Department of the Environment and Energy
- 25 Nexergy
- 26 Alternative Technology Association (ATA)
- 27 Origin Energy Limited
- 28 The Australian National University - Energy Change Institute

- 29 NSW State Emergency Service
- 30 Australian National Low Emissions Coal Research and Development
(ANLEC R&D)
- 31 Mr Ivan Powell
- 32 Australian Renewable Energy Agency (ARENA)
- 33 Reposit Power
- 34 Mr Justin Flint
- 35 Australian National University Research School of Engineering,
College of Engineering and Computer Science
- 36 Australian Solar Council and Energy Storage Council
- 37 King & Wood Mallesons
- 38 Australian Academy of Technology and Engineering
- 39 AusNet Services
- 40 Australian National University Solar Thermal Group
- 41 Australian Energy Council
- 42 Eastern Alliance for Greenhouse Action (EAGA)
- 43 Australian Solar Thermal Energy Association (Austela)
- 44 Australian Gas Networks Limited
- 45 Dr Neville Lockhart
- 46 Mr James Kilby
- 47 University of Technology Sydney, Institute for Sustainable Futures
- 48 University of New South Wales (UNSW), School of Photovoltaic
and Renewable Energy Engineering
- 49 Repower Port Augusta
- 50 Australian Institute for Disaster Resilience
- 51 1414 Degrees
- 52 Energy Security for South Australia Party
- 53 Electrical Trades Union of Australia
- 54 The Australia Institute
- 55 AES Energy Storage
- 56 AGL

Additional Information

- 1 Additional information received from AES Energy Storage on 20 February 2017 -
'Right-Sizing Transmission & Distribution Infrastructure'.

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- 2 Additional information received from the Alternative Technology Association on 7 March 2017.
 - 3 Additional information provided from the Electrical Trade Union on 7 March 2017 - 'In depth exploration into the state of Victoria's power assets'.
 - 4 Additional information provided from the Electrical Trade Union on 7 March 2017.
 - 5 Additional information provided from the Electrical Trade Union on 7 March 2017 - 'Grid Renationalisation - a discussion paper'.

Tabled documents

- 1 AES: Summary (public hearing, Adelaide, 20 February 2017).
- 2 Lyon Group: Large Scale Batteries (public hearing, Adelaide, 20 February 2017).
- 3 Repower Port Augusta: Newspaper article - Liberals promise to help fund construction of Port Augusta solar thermal power station (public hearing, Adelaide, 20 February 2017).

Answers to questions on notice

- 1 Australian Energy Market Operator: Answers to questions taken on notice from public hearing 10 February 2017 (received 24 February 2017).
- 2 Australian Energy Market Commission: Answers to questions taken on notice from public hearing 10 February 2017 (received 24 February 2017).
- 3 Australian Energy Regulator: Answers to questions taken on notice from public hearing 10 February 2017 (received 27 February 2017).
- 4 Australian National University, Energy Change Institute, Dr Evan Franklin: Answers to questions taken on notice from public hearing 10 February 2017 (received 24 February 2017).
- 5 SolarReserve: Answers to questions taken on notice from public hearing 20 February 2017 (received 7 March 2017).
- 6 Government of South Australia, Department of the Premier and Cabinet: Answers to questions taken on notice from public hearing 20 February 2017 (received 7 March 2017).
- 7 ENGIE: Answers to questions taken on notice from public hearing 20 February 2017 (received 15 March 2017).

Appendix 2

Public hearings and witnesses

Friday, 10 February 2017 – Canberra

ADAMO, Mr Joe, Acting Executive General Manager, Stakeholders and Information, Australian Energy Market Operator

ADAMS, Mr Peter, General Manager, Wholesale Markets, Australian Energy Regulator

BLUME, Mr Steve, President, Australia Solar Council

BRADLEY, Mr John, Chief Executive Officer, Energy Networks Australia

BROOKER, Mr Simon, Executive Director, Clean Energy Finance Corporation

CRAWFORD, Mr Garth, Executive Director, Economic Regulation, Energy Networks Australia

FRANKLIN, Dr Evan, Senior Lecturer; Fellow, Energy Change Institute, Australian National University

FRISCHKNECHT, Mr Ivor, Chief Executive Officer, Australian Renewable Energy Agency

GRAHAM, Mr Paul, Principal Research Scientist, Energy, CSIRO

GRIMES, Mr John, Chief Executive Officer, Australian Solar Council

GROVES, Ms Michelle, Chief Executive Officer, Australian Energy Regulator

JAMES, Dr Craig, Research Director, CSIRO

KAY, Mr Ian, Chief Finance Officer, Australian Renewable Energy Agency

MEARS, Dr Andrew Neville, Founder and Chief Executive Officer, SwitchDin Pty Ltd

OSBORNE, Mr Luke, Director and Chief Operating Officer, Reposit Power

O'TOOLE, Mr James, Assistant Secretary, Electricity Branch, Energy Division, Department of the Environment and Energy

PIERCE, Mr John, Chairman, Australian Energy Market Commission

RICHARDSON, Mr Stuart, Director, Technology and Demand Side Policy Section, Electricity Branch, Energy Division, Department of the Environment and Energy

RODRIGUES, Mr Karl, Acting Director, Energy, CSIRO

SEWELL, Ms Margaret, First Assistant Secretary, Energy Security Office, Department of the Environment and Energy

SIMENTO, Dr Noel, Managing Director, Australian National Low Emissions Coal Research and Development

STOCKS, Dr Matthew, Fellow, College of Engineering and Computer Science, Australian National University

SWIFT, Mr David, Executive General Manager, Corporate Development, Australian Energy Market Operator

WANG, Dr Chi-Hsiang, Principal Research Scientist, CSIRO

WEBSTER, Ms Catriona, General Counsel, Australian Energy Market Commission

WILKIE, Ms Joann, Acting First Assistant Secretary, Energy Division, Department of the Environment and Energy

YATES, Mr Oliver, Chief Executive Officer, Clean Energy Finance Corporation

Monday, 20 February 2017 – Adelaide

APPLEBY, Mr Simon, Senior Manager, Regulation and Land Management, ElectraNet

BATES, Dr John, Director, Australian Institute for Disaster Resilience

FOULDS, Mr Darren, Head of Trading and Portfolio Management, ENGIE in Australia

GEORGIS, Mr Tom, Senior Vice President, Development, SolarReserve

GONZALEZ, Mr Ismario, Director, Global Business Development, AES Energy Storage

GREEN, Mr David, Partner, Lyon Group

HAMDEN, Mr Rohan, Director, Rohan Hamden and Associates

KATHPAL, Mr Praveen, Vice President for Global Market Development, AES Energy Storage

KORTE, Mr Rainer, Executive Manager, Asset Management, ElectraNet

KOUTS, Mr Jim, Head of Corporate Affairs, ENGIE in Australia

O'DAY, Mr Nicholas, Partner, Lyon Group

RIEBOLGE, Mr Robert, Chief Network Analyst, 1414 Degrees

ROWBOTTOM, Mr Gary, Chairperson, Repower Port Augusta

RUSSELL, Dr Don, Chief Executive, Department of the Premier and Cabinet, Government of South Australia

SCHOENEMANN, Mr Richard, Director of Economics, Policy and Regulation, Sunverge Energy

SIBLY, Mr Richard, Acting Head of Regulation, SA Power Networks

SPENCER, Mr Daniel, Campaigner, Repower Port Augusta

THOMPSON, Mr Daniel , Director of Development, SolarReserve

VINCENT, Mr Mark, Manager Network Strategy, SA Power Networks

Tuesday, 7 March 2017 – Melbourne

CORBELL, Mr Simon, Victorian Renewable Energy Advocate

CROCKETT, Mr Lane, Energy Associate, Australia Institute; and Head of Renewable Energy Infrastructure, Impact Investment Group

GARNAUT, Professor Ross, Private capacity

GODFREY, Dr Bruce, Director and Energy Forum Chair, Australian Academy of Technology and Engineering

JACKSON, Mr Douglas, Executive General Manager, Group Operations, AGL Energy Limited

KERSHAW, Ms Ruth, Director, Strategic Research and Special Projects, Electrical Trades Union

LOVEGROVE, Dr Keith, Director, Australian Solar Thermal Energy Association

MOUNTAIN, Mr Bruce, Director, CME

PRICE, Mr Danny, Managing Director, Frontier Economics Pty Ltd

REDDAWAY, Mr Andrew, Energy Analyst, Alternative Technology Association

TEGG, Mr Warren, Economic and Industrial Adviser, Australian Manufacturing Workers' Union

WENHAM, Dr Matt, Executive Manager Policy & Projects,
Australian Academy of Technology and Engineering

WILSON, Mr Adam David, Chief Executive Officer,
Essential Services Commission of South Australia

WRIGHTSON, Mr Richard, General Manager, Wholesale Markets, AGL Energy Limited