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POLICY SUGGESTIONS FOR THE TRANSITION TO A SUSTAINABLE ENERGY FUTURE

JAMES AHERN - volunteer researcher
with HOUSEHOLDERS' OPTIONS FOR THE PROTECTION OF THE ENVIRONMENT (HOPE) INC.

1. Introduction

This report aims to provide a policy framework for the transition to a sustainable energy future in Australia. For these purposes, an energy system is considered to cover all facets of energy production and usage at a societal level. This includes electricity generation to meet residential and commercial needs, energy generation to supply the needs of industrial activities, and fuel for transportation (spanning personal vehicles, industrial transportation, long-haul transport, marine transport, and aviation).
Achieving a holistic transition will therefore necessitate:

- switching away from fossil fuels in favour of low- and zero-emissions energy sources for both electricity production and transport-related fuel consumption,
- improving efficiency in energy usage, and
- stimulating research and development into new technologies.

The policy areas outlined in this report are each focussed on advancing one or more of these goals.

1.1. Why transition to a sustainable energy future?

Creating an energy system that utilises clean energy generation and efficient usage would help to mitigate the threat of climate change, while simultaneously providing a significant number of economic and social advantages for Australia.

Governments have long understood the need to address climate change by changing the ways in which energy is produced and consumed at a societal level. This goal has recently taken on renewed urgency, following the release of consecutive reports by the Intergovernmental Panel on Climate Change (IPCC), which emphasised the short timeframe available to avoid climate catastrophe[1]. In other words, transitioning to a sustainable energy future at a global level is an unavoidable necessity, and must be achieved quickly. To this end, each country must undertake its own energy transition.

Transitioning to a sustainable energy future is also likely to improve the stability of energy supply. For some countries, this may come as a result of reducing reliance on imported energy by increasing the prevalence of local energy production projects, or otherwise seeking to import fuels from partners who are seen as less adversarial[2]. On the other hand, Australia already generates most of its own energy needs through domestic generation, and this capacity is well-positioned to further increase in a sustainable energy system[3]. This means improving consistency of energy supply is achievable via upgrades to transmission infrastructure and increasing the national capacity for energy storage[4]. On top of reducing instances of power outages, improving this area would result in lower amounts of wastage as excess energy is transferred to areas of high-demand, which could also expand profit margins for energy producers[5].

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[1] IPCC (2018), *Special Report: Global Warming of 1.5℃ (Summary for Policy Makers)*; IPCC (2021), *Climate Change 2021: The Physical Science Basis (Summary for Policy Makers)*
[2] see for example: EC, "Eurostat: From where do we import energy?"; Isis Almeida, Anna Shiryaevskaya, & Todd Gillespie (21-12-2021), "Europe's Energy Crunch Threatens Recovery as Prices Hit Records"; The Washington Post (24-12-2021), "How Europe can Break Its Dependence on Russian Energy"
[3] GA, "Australia's Energy Production, Consumption and Exports, https://www.ga.gov.au/scientific-topics/energy/overview#heading-1; opennem.org.au., https://opennem.org.au/energy/au/?range=1y&interval=1M
[4] Matthew D. Leonard, Efstathios E. Michaelides, Dimitrios N. Michaelides (2018), "Substitution of coal power plants with renewable energy sources – Shift of the power demand and energy storage", pg. 28; Alberto Boretti (2019), "Energy Storage needs for an Australian national electricity market grid without combustion fuels", pg. 7; Rian van Staden, Filippo Boselli & Anna Leidreiter (2020), "The Pathway to 100% Renewable Energy – A Vision", in Uyar (ed.), *Accelerating the Transition to a 100% Renewable Energy Era,* pp. 173, 180-182
[5] Dr. Michael McGreevy, Colin MacDougall, Dr. Matt Fisher, Mark Henly, Fran Baum (2021), "Expediting a renewable energy transition in a privatised market via public policy: The case of South Australia 2004-18", pg. 1; van Staden et. al., "The Pathway", pg. 181ßßß

A global transition to a sustainable energy future also presents significant economic opportunities, of which Australia is well-positioned to take advantage. Australia is uniquely positioned to export renewable energy to Southeast Asia and the Pacific, given our relative abundance of solar and wind potential[6]. There is also a massive potential for the production and export of green hydrogen, with some trading partners already looking to secure supplies from Australia[7]. Furthermore, the relative newness of many green technologies means there is a lot of room for Australian researchers and engineers to drive innovation and development[8]. Importantly, Australia has already established a successful market for green research and development, with significant scope for further expansion[9]. Australia could further drive economic growth in this area by fully committing to a transition to a sustainable energy future. As shall be further outlined in later sections of this report, this would provide clear direction for governmental, societal and business efforts (see section 2.1.).

Conversely, Australia is facing increased international pressure due to its hesitation on climate action[10]. This is likely to become more problematic as diplomatic and trading partners look to take further action – for example, implementing carbon border taxes on imports from countries which do not have sufficient carbon pricing[11]. Taking action on climate change is therefore prudent for maintaining positive diplomatic relations with key international partners. As previously stated, the transition to a sustainable energy future is a central component of this goal.

The factors outlined in this report show that Australia is particularly well-positioned to reap the benefits of growing demand for green energy. In transitioning to a sustainable energy future, Australia can create a system which facilitates economic growth and energy security, while simultaneously addressing the threat of climate change. However, this is only possible if governments and enterprises at all levels of society act decisively to change the ways in which Australia generates and uses energy. On the other hand, failure to act decisively will likely result in negative environmental, economic, and diplomatic impacts.

1.2. Research Method

Research for this report focussed on a number of areas. Previous policies, implemented overseas and within Australia, were reviewed to gain a full understanding of which approaches have proven successful to-date. These policies were also examined in relation to ideas and opinions presented by academics and experts from a number of fields, spanning environmental sciences, economics, political and social sciences, and engineering. Examining the interaction between expert opinion and existing policies provided a key insight as to which policy options would be most effective in Australia. Finally, the environmental, political, and technological conditions within Australia were also considered to tailor policy ideas to the national context.

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[6] see: Michael Mazengarb (28-1-2021), "World's biggest solar and battery project lands planning deal with NT government"; asianrehub.com

[7] Joe Hildebrand (11-10-2021), "Australia's $2.1 trillion future with 672,000 jobs and net zero emissions". Further outlined in sections below; Hans van Leeuwen (2-2-2021), "How Europe aims to book a seat on Australia's hydrogen express"; Vera Eckert (15-4-2021), "RWE plans to bring Australian 'green' hydrogen to Europe".

[8] ClimateWorks Australia (2020), *Measuring green innovation in Australia*, pp. 8-18

[9] ISA (2017), *Australia 2030: Prosperity through Innovation – A pan for Australia to thrive in the global innovation race*, pp. 7-24; ClimateWorks, *Measuring green innovation*, pp. 16-18

[10] see: Nick O'Malley (12-2-2021), "Australia faces 'constellation' of diplomatic pressures over climate"; Adam Morton (8-11-2021), "Australia to face growing international pressure to improve 2030 emissions target"

[11] see: Kate Abnett & Susanna Twidale (14-7-2021), "EU proposes world's first carbon border tax for some imports"; Emma Beal & Luke Heeney (15-7-2021), "EU carbon border tax is a warning to Australia: cut emissions or lose exports"; Lisa Friedman (19-7-2021), "Democrats Propose a Border Tax Based on Countries' Greenhouse Gas Emissions"

2. Policy Options for a Sustainable Energy Future

This section outlines a list of policy options for the transition to a sustainable energy future. Options are categorised based on their primary goals, although it is important to note that some policies will affect other areas outside of their specified category. In particular, improving government messaging and coordination (2.1.) and introducing a mandatory and comprehensive price on carbon (2.2.) will likely result in changes across all levels of society. Additionally, investing in research and development of clean technologies will lead to improvements for not only renewable energy generation (2.4.4.), but also for transport fuels (2.6.4.) and energy efficient appliances (2.5.2.). Finally, there are also cases of two-way interactions between different policy categories, meaning policies in one category may be mutually beneficial with policies in another. For example, phasing out the usage of fossil fuels (2.3.) is generally compatible with maintaining the uptake of clean energy for electricity generation (2.4.) and transitioning to clean transport options (2.6.).

2.1. Improve Messaging and Coordination between Different Levels of Government

So far, efforts to transition to a sustainable energy future have been largely led by businesses and state governments acting on their own initiative, resulting at times in policy inconsistencies across jurisdictions[12]. Additionally, the current chaotic nature of Australia's energy transition means the country is at risk of developing an inefficient system with uncertain results regarding overall emissions reduction and energy security[13]. It is therefore necessary for the Australian federal government to provide a clear and unifying message which supports the energy transition, and to improve coordination between federal, state, and local governments.

2.1.1. Legislate a net-zero emissions target

Many governments and businesses worldwide have increasingly adopted net-zero targets, with many now also outlining intermediary targets to ensure progress towards their overall goals[14]. This can assist the transition to a sustainable energy future in a number of ways.

First, setting a net-zero target specifies one of the main aims of the sustainable energy transition, providing clear direction for policy formation as a result[15]. It is important to note however, that a net zero emissions target must be accompanied by a genuine commitment by governments to follow through with ambitious and meaningful policies. This may necessitate the solidification of such a target through legislation to ensure accountability and consistency regardless of governmental changes[16].

Additionally, many governments have attempted to use net-zero emissions declarations to galvanise transitionary efforts within their own countries by providing a clear and consistent message for businesses operating within Australia[17]. In this way, a mandated net-zero target can motivate private actors to change their own practices to prepare for the upcoming change in business conditions.

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[12] Philip Harrington & Virginia Hoy (2019), "The Trajectory to a Net Zero Emissions Built Environment: The Role of Policy and Regulation", in P. Newton et. al., *Decarbonising the Built Environment*, pp.193-197; Climate Action Tracker, "Country Summary: Australia"

[13] Harrington & Hoy, "The Trajectory", pp. 194-195

[14] Kelly Levin, David Rich, Katie Ross, Taryn Fransen, & Cynthia Elliot (2020), *Designing and Communicating Net-Zero Targets*, pg.5; Albert C. Lin (2021), "Making Net Zero Matter", pp. 11-16; Ian Lowe (6-10-2021), "Five reasons why the Morrison government needs a net zero climate target – not just a plan"

[15] Lin, "Making Net Zero Matter", pg. 10; Levin et. al., *Designing*, pg. 5

[16] Steve Pye, Francis G.N. Li, James Price, & Birgit Fais (2017), "Achieving net-zero emissions through the reframing of UK national targets in the post-Paris Agreement era", pp. 1-6

[17] Lin, "Making Net Zero Matter", pg. 10; Levin et. al., *Designing*, pg. 5

Finally, a net-zero target should be combined with the establishment of independent regulatory bodies, to monitor progress and ensure accountability over the long term[18]. There are a number of existing examples in which this has been achieved. For example, the European Union has established a broad set policies, mechanisms, and monitoring bodies to ensure member states are successful in developing and achieving their own contributions to the EU's overall net-zero efforts[19]. By contrast, the Canadian federal government has opted to mandate a number of expected processes and timeframes to guide the efforts of all provinces[20]. Both of these approaches could be applied in Australia.

2.1.2. Improve cooperation between Federal, State, and Local governments

Improved cooperation between federal and state governments is necessary to ensure a cohesive and efficient energy transition. One way to achieve this is by prioritising the transition to a sustainable energy future, and climate change mitigation generally, during future National Cabinet discussions. This platform was effective during initial outbreak of COVID-19, as governments were able to communicate directly, improve both vertical and horizontal coordination, and share information and ideas to quickly resolve issues as they arose[21]. Furthermore, there is a unique opportunity to refocus intergovernmental discussions as Australia looks to recover from the recent pandemic[22].

2.2. Place a Meaningful Price on Carbon

It is widely accepted that a mandatory, comprehensive, and economy-wide carbon pricing scheme is the best single policy instrument for reducing overall greenhouse gas emissions[23]. Additionally, the current Australian Emissions Reduction Fund (ERF) has proven to be ineffective in reducing emissions due to lack of coverage and poor incentivisation (as shall be outlined below, these figures are a stark contrast to those seen under the former Carbon Tax)[24]. It is therefore necessary for Australia to overhaul its current carbon pricing scheme and replace the ERF with a more effective policy mechanism. This section examines the two most common methods of carbon pricing employed around the world: a mandatory cap-and-trade emissions trading scheme and a direct carbon tax. Both of these options can encourage behavioural changes across multiple sectors, achieving wide-reaching emissions reductions as a result. They can both either be tailored to cover specific industries or implemented economy-wide, allowing flexibility in their implementation.

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[18] Harrington & Hoy, "The Trajectory", pp. 201-202; Lin, "Making Net Zero Matter", pp. 10-11
[19] Harrington & Hoy, "The Trajectory, pg. 200
[20] Harrington & Hoy, "The Trajectory, pg. 200; Federal Government Canada (2021), *Canadian Net-Zero Emissions Accountability Act*
[21] Jenny Child, Rolan Dillon, Eija Erasmus, & Jacob Johnson (15-12-2020), "Collaboration in crisis: Reflecting on Australia's COVID-19 response"; Cheryl Saunders (11-6-2020), "The National Cabinet has worked. Can it last?"; Anika Stobart & Stephen Duckett (4-6-2020), "Four ways Australia's coronavirus response was a triumph – and four ways it could have done better"
[22] see for example, UNECE (2021), *Building Back Better: pathways for a more inclusive, environmentally sustainable and resilient recovery*; UNECE (1-2-2021), "UN system in Europe and Central Asia calls on countries to better include environmental and climate change perspectives in their recovery plans"; OECD, "Focus on green recovery"
[23] Jessica F Green (2021), "Does carbon pricing reduce emissions? A review of ex-post analyses", pg. 2; Marion Terrill, Ingrid Burfurd & Lachlan Fox (2021), *The Grattan car plan: Practical policies for cleaner transport and better cities*, pg. 17
[24] Clean Energy Regulator, "Emissions Reduction Fund", http://www.cleanenergyregulator.gov.au/ERF; Paolo Yanguas Parra, Bill Hare, Ursula Fuentes Hutfilter, Niklas Roming (2019), *Evaluating the significance of Australia's global fossil fuel carbon footprint.*, pg. 3: UNEP (2018), *Emissions Gap Report 2018*, pp. 8-12. See also: Julian Atchison (6-3-2020), "Australia's Ill-fated Emissions Trading Scheme"; Lisa Cox (6-6-2019), "Australia's emissions still rising, says report withheld in defiance of Senate order"; Adam Morton (2-8-2019), "Coalition's emissions reduction fund labelled 'a joke' after first post-election auction".

2.2.1. Cap-and-Trade Emissions Trading Scheme

Despite being a relatively new concept, cap-and-trade emissions trading schemes (ETS) have already been adopted by multiple governments worldwide, most notably within the EU[25]. And ETS places a set limit (or 'cap') on the emissions that each company can produce, with the permissible amount measured in 'credits'. Companies which exceed their quota of allowances either need to buy additional credits from other companies, or are penalised through fines. Conversely, companies which reduce their emissions ahead of time are able to sell their excess credits for financial gain. The carbon limit can then be incrementally reduced to ensure ongoing change[26]. In this way, an ETS theoretically present a cost-effective way for countries to incrementally reduce their emissions.

To date however, analyses of ETSs' effectiveness in reducing emissions have produced mixed results[27]. A number of recent studies indicate that well-managed ETSs can be successful. For example, industries covered by the second phase of the EU's ETS are estimated to have reduced emissions by 8-12%, with minimal negative impact on the regulated businesses[28].

The increasing prevalence of ETSs globally may also present future opportunities to link up with carbon markets internationally. This could lead to the creation of a comprehensive international carbon market, helping to coordinate international efforts to reduce emissions and mitigate climate change[29].

In some places however, the effectiveness of ETSs has been compromised by instances of 'carbon leakage'. In these cases, firms have moved activities which produce high amounts of emissions to neighbouring jurisdictions to artificially reduce their emissions in areas covered by an ETS[30]. Moreover, concerns have been raised that companies have been able to get away with breaching their quotas due to lack of proper supervision[31]. These issues illustrate the need for an ETS to be implemented collaboratively across neighbouring jurisdictions, with effective regulation to ensure compliance.

2.2.2. Carbon Tax

Carbon taxes have so far proven to be effective in reducing carbon emissions by encouraging behavioural change at all levels of society[32]. In fact, Australia provides a unique example of this – emissions decreased by up to 8.2% in just two years under the former carbon tax, before immediately rising again after the tax's repeal in 2014[33]. In some European countries, carbon taxes have been central to emissions-mitigation plans from as early as the 1990s, contributing to significant declines in overall emissions[34]. The carbon tax in the Canadian province of British Columbia is also credited with reducing emissions by 5%-15% between 2008-2015[35].

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[25] EC, "The EU Emissions Trading System (EU ETS)"; ICAP, *Emissions Trading Worldwide*, pp. 37-160; Green, "Does carbon pricing reduce emissions?", pg. 2

[26] ICAP (2021), *Emissions Trading Worldwide*, pp. 8-9; EUClimateAction (2014), "The EU Emissions Trading System explained", YouTube video, https://www.youtube.com/watch?v=yfNgsKrPKsg&t=108s

[27] Green, "Does carbon pricing reduce emissions?", pp. 5-11

[28] Patrick Bayer and Michael Aklin (2020), "The European Union Emissions Trading System reduced CO2 emissions despite low prices", pp. 8805-8807; Jonathan Colmer, Ralf Martin, Mirabell Muuls, Ulrich J. Wagner (2020), *Does Pricing Carbon Mitigate Climate Change? Firm-Level Evidence From the European Union Emissions Trading Scheme*, pp. 17-18); Colmer et. al., *Does Pricing Carbon Mitigate Climate Change? pg. 3*

[29] See for example: EC, "International carbon market"

[30] Green, "Does Carbon Pricing Reduce Emissions", pg. 12

[31] The Economist (2021), "How do Carbon Markets Work?", https://www.youtube.com/watch?v=m5ych9oDtk0&t=2s

[32] Steven Geroe (2019), "Addressing Climate Change Through a Low-Cost, High-Impact Carbon Tax", pp. 7-14; Amulya Gurtu, Cory Searcy, Mohamad Y. Jaber (2016), "A Framework for Reducing Global Manufacturing Emissions", pp.165-166; Julian Andersson (2019), "Carbon Taxes and CO2 Emissions: Sweden as a Case Study", pp. 14-27; Lin Liu, Charlie Z. Huang, Guohe Huang, Brian Baetz, Scott M. Pittendrigh (2018), "How a carbon tax will affect an emission-intenseive economy: A case study of the Province of Saskatchewan, Canada", pp. 817-823

[33] Geroe, "Addressing Climate Change", pp. 10-12

[34] Andersson, "Carbon Taxes and CO2 Emissions", pg. 14; Nicoletta Batini, Ian Parry, Philippe Wingender (2020), *Climate Mitigation policy in Denmark: A Prototype for Other Countries*, pp. 1-14

[35] Green, "Does carbon pricing reduce emissions?", pg. 10

Moreover, the revenue raised by carbon taxes can be used to lower the tax burden in other economic sectors, such as income and business taxes. In these cases, a portion of the overall tax burden effectively shifts to heavy polluters in a way which takes pressure off the rest of the economy.[36]. This can be useful for alleviating financial concerns for households and businesses, thus reducing any negative impacts caused by the carbon tax's introduction[37]. Alternatively, revenue from carbon taxes can be used to subsidise other carbon-mitigation efforts, such as investing in renewable energy, funding research into climate-friendly technology and industries, or improving infrastructure to increase efficiency. In this way, a carbon tax can be a used to fund climate-mitigation plans and accelerate wider societal and economic change[38].
Despite their overall benefits however, carbon taxes are often politically unpopular and therefore difficult to implement effectively. Additionally, concerns remain about the potential for job losses resulting from a carbon tax's effect on certain emissions-intensive industries[39].

2.3. Phase out Usage of Fossil Fuels in Electricity Generation

The burning of fossil fuels to produce electricity, and particularly the usage of coal, contributes almost half of all greenhouse gas emissions worldwide[40]. Removing fossil-fuel sources from electricity generation is therefore a necessary and unavoidable step in creating an environmentally sustainable energy system. Furthermore, the ageing of current power plants, combined with rapid advances in renewable energy technology in recent years, means there is now an opportunity to ensure a smooth transition[41]. Governments can aid this transition with appropriate policies and messaging, as shall be outlined in this section and the next.

2.3.1. Commit to no new coal projects and set an end-date for existing coal-fired electricity generation

Coal is both the most commonly used and the highest greenhouse gas-emitting energy source in current power mixes, contributing around 40% of total global CO2 emissions[42]. While there is some hope that these emissions could be mitigated by using carbon capture and storage (CCS), the development of this technology has so far been slow and installation is relatively expensive. Consequently, CCS has so far proven to be insufficient given the urgency required to keep global warming below 1.5°C[43]. Long-term usage of coal in electricity generation is therefore incompatible with the goal of creating a sustainable energy system which properly mitigates climate change. To further illustrate this point, countries which have already phased out or reduced their usage of coal have seen significant drops in the amount of CO2 emissions from their power sectors. For example, the United Kingdom saw a decline of around 70 metric tons of CO2 between 2013-2016, corresponding with the closures of its coal-fired power plants[44]. In the United States, a 37% reduction

[36] Geroe, "Addressing Climate Change", pp. 16-18; Andersson, "Carbon Taxes and CO2 Emissions", pp. 1-6. See also: OECD (2013), *Taxing Energy Use: A Graphical Analysis*, pp. 57-231
[37] See for example, Liu et. al., "How a carbon tax will affect an emission-intensive economy", 823-825
[38] Geroe, "Addressing Climate Change", pp. 14-16
[39] Geroe, "Addressing Climate Change, pp. 10-12; Liu et. al., "How a Carbon Tax will affect an emissions-intensive economy", pp. 823-825
[40] Dan Welsby, James Price, Steve Pye, & Paul Ekins (2021), "Unextractable fossil fuels in a 1.5°C world", pp. 230-231; Anthony Burke & Stefanie Fishel (2020), "A coal elimination treaty 2030: Fast tracking climate change mitigation, global health and security", pg. 5; Paul J. Burke, Rohan Best, & Frank Jotzo (2019), "Closures of coal-fired power stations in Australia: local unemployment effects", pp. 142-143
[41] Burke et. al. "Closures", pp. 142-146; Andrew Stock (2014), *Australia's Electricity Sector: Aging, Inefficient and Unprepared*, pg. 17
[42] Welsby et. al., "Unextractable fossil fuels", pp. 230-231; Burke & Fishel (2020), "A coal elimination treaty", pg. 5; Burke et. al., "Closures", pp. 143
[43] Burke & Fishel, "A coal elimination treaty", pg. 5
[44] Geroe, "Addressing Climate Change", pg.12

in coal-usage between 2008-2016 contributed to a 23% reduction in CO2 emissions from the power sector[45].

Moreover, the price of coal has consistently been higher than alternative fuel sources, resulting in price hikes for energy consumers[46]. The costs of both coal and natural gas increase even further with the usage of CCS, meaning renewable energy sources present the most price-efficient sources of clean energy production[47]. Consequently, coal-fired power plants are becoming increasingly financially uncompetitive, with economists warning that many existing plants could be at risk of becoming unprofitable within the next decade[48]. Proposals from the federal government to prop up these plants to avoid closure would likely place unnecessary financial burden on tax-payers and consumers alike[49].

Finally, as the majority of the existing coal-fired power plants in Australia near the end of their life cycle, their energy output has become increasingly inefficient[50]. This has resulted in higher excess greenhouse gas emissions, unstable power pricing, and increased occurrences of plants tripping and needing to temporarily shut down[51].

This combination of factors necessitates the steady removal of coal from national power mixes, beginning with a commitment from governments to completely phase out coal-fired electricity generation[52]. In particular, and as previously stated, the timing to do so is ideal given the majority of coal-fired power stations are already nearing their scheduled closure-dates. Adding to this is the abundance of different renewable energy sources in Australia (see 2.4.).

2.3.2. Reduce government subsidies to fossil fuels

In the financial year 2020-21, Australia provided over $10 billion in subsidies to fossil fuels, comprising $8.95 billion in tax concessions (mostly from the fuel tax credit) and $1.39 billion in spending measures. Of the tax concessions, around $7.84 billion was provided under the fuel tax credit system[53]. Additionally, fossil fuel subsidies in Australia increased by 48% between 2015-2019[54]. The ongoing provision of fossil fuel subsidies risks delaying the transition to a sustainable energy future in a few ways. First, subsidising fossil fuels distorts the energy market by artificially improving the relative cost of fossil fuels, thus encouraging their ongoing usage in favour of cleaner energy sources. Second, by propping up ageing energy systems, governments delay the motivation for

[45] John Coglianese, Todd D. Gerarden, & James H. Stock (2020), "The Effects of Fuel Prices, Environmental Regulations, and Other Factors on U.S. Coal Production, 2008-2016", pg. 1
[46] Paul Graham, Jenny Hayward, James Foster, & Lisa Havas (2020), *GenCost 2019-20*, pp. 3-6; Carlos Fernandez Alvarez & Gergely Molnar (12-10-2021), "What is behind soaring energy prices and what happens next?"; Sam Meredith (19-8-2021), "Soaring demand for the word's least liked commodity sees thermal coal prices jump 106% this year"
[47] Graham et. al., *GenCost 2019-20*, pg. 5; IRENA (2020), *Renewable Power Generation Costs in 2019*, pp. 19-38
[48] Elouise Fowler & Peter Ker (2021), "Up to five coal plants 'unprofitable by 2025'"; Angela Macdonald-Smith (30-11-2018), "Coal 'stranded asset' warning takes on fresh edge with Adani go-ahead"; Michael Mazengarb (12-3-2020), "Governments warned: $1 trillion in coal power investments at risk"
[49] Johanna Bowyer & Tristan Edis (2021), *Energy Security Board's Capacity Payment: Burden on Households*, pp. 1-16
[50] Burke et. al. "Closures", pp. 142-146; Stock, *Australia's Electricity Sector*, pp. 13-17
[51] Michael Mazengarb (30-09-2021), "Queensland coal plants hit by more huge write-downs, as failures and rooftop PV rattle market"; Giles Parkinson (12-07-2021), "Chart of the Day: Australia's ageing coal plants are not so reliable"' Giles Parkinson (24-09-2021), "Energy Ministers to rethink Taylor's rule changes, as coal plants trip on cue"
[52] Welsby et. al., "Unextractable fossil fuels", pp. 230-231
[53] Rod Campbell, Eliza Littleton, Alia Armistead (2021), *Federal and state government assistance to fossil fuel producers and major users 2020-21*, pp. 10-11
[54] BloombergNEF (2021), *Climate Policy Factbook: Three priority areas for climate action*, pg. 14

energy producers to transition by creating an artificial sense of security[55]. Conversely, removing fossil fuel subsidies has been found to encourage more even competition, whereby fossil fuels no longer have a disproportionate financial advantage, thus reducing the instances of fossil fuel usage in energy generation[56]. This would theoretically result in significant reductions in greenhouse gas emissions, and also create more balance and stability in the national energy grid[57]. The reduction of fossil fuel subsidies would also potentially free up a significant amount of government funds which could be redirected to support clean energy uptake, thereby accelerating the energy transition[58].

2.3.3. Note: need to transition economies of coal-dependent regions

The global trend is increasingly moving away from coal, with governments and private actors around the world looking to remove coal-fired electricity generation from their power mixes[59]. While this is positive in terms of mitigating climate change, it also creates an uncertain future for Australian regions which currently depend on the coal mining and exports for their economic viability[60]. It is therefore prudent for federal and state governments alike to work with local councils, to build long-term economic resilience and reduce the impact of the global transition away from coal. A complete in-depth examination of the necessary policies in this area is beyond the parameters of this report. However, the interconnectedness between this issue and a transition to a sustainable energy future mean it would be remiss to not briefly mention some general ideas to advance policy in this area. First, there are some emerging cases of industrial regions transforming their local economies by developing new sustainable energy industries. For example, the construction of new wind and solar farms provided Port Augusta with renewed economic positivity following the closure of the nearby coal-fired power plant in 2016[61]. A number of similar approaches have already been proposed for other existing coal hubs, including the Latrobe Valley, Upper Hunter, and Gladstone[62]. Regional initiatives such as these theoretically allow current coal-reliant regions to reap some of the benefits of the global transition to a sustainable energy future. Additionally, many of these regions are perfectly positioned to become prominent renewable energy production sites, given their proximity to existing transmission infrastructure (see 2.4.1.)[63].

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[55] Richard Bridle & Lucy Kitson (2014), *The Impact of Fossil-Fuel Subsidies on Renewable Energy Generation*, pp. 5-16

[56] Valeria Jana Schwanitz, Franziska Piontek, Christoph Bertram, Gunnar Luderer (2014), "Long-term climate policy implications of phasing out fossil fuel subsidies", pp. 885-886; Jonas Kuehl, Andrea M. Bassi, Philip Gass, Georg Pallaske (2021), *Cutting Emissions Through Fossil Fuel Subsidy Reform and Taxation*, pg. 7

[57] Nordic Council of Ministers (N.C.M.) (2017), *Making the Switch: From fossil fuel subsidies to sustainable energy*, pp. 27-34

[58] N.C.M., *Making the Switch*, pp. 16-21

[59] IPCC *Special Report: Global Warming of 1.5℃ (Summary for Policy Makers)*, pp. 14-17; IPCC, *Climate Change 2021: The Physical Science Basis (Summary for Policy Makers)*, pp. 36-41; Antonio Guterres (22-04-2021), "Red alert for the planet: UN chief's call to phase out coal by 2030"; Akshat Rathi (24-09-2021), "UN Launches Pledge to Stop Building New Coal Power Plants"; Joshua S. Hill (14-09-2021), ""No new coal:" Majority of coal projects abandoned since Parish but China is key"; SBS News (22-09-2021), "In a landmark climate move, China pledges to stop funding coal projects overseas"; UNFCC (21-09-2020), "Commitments to Net Zero Double in Less Than a Year"; there100.org, "RE100 Members"

[60] Productivity Commission (2017), *Transitioning Regional Economies*, pp. 136-138; Chris Briggs (12-03-2021), "The death of coal-fired power is inevitable – yet the government still has no plan to help its workforce"; Nick Toscano and Mike Foley (27-09-2021), "It's a $50b-a-year export industry. How long until coal's rivers of gold run dry?"

[61] Burke et. al., "Closures", pg. 161; Stephen Long (5-10-2018), "'Renewable's capital of Australia'? Port Augusta shows off its green energy credentials"; Giles Parkinson (21-9-2021), "Final turbine installed at Australia's biggest wind and solar hybrid project"

[62] Sophie Vorrath (26-10-2021), "Australia's oldest open cut coal mine to be transformed into major renewables hub"; David Waterworth (29-10-2021), "New Life from the Void – Another Coal Hub Repurposed"; Mike Foley (4-10-2021), "Winds of change blow hope into industrial towns and net zero deal"; Miki Perkins (27-9-2021), "Power shift: The Latrobe valley looks for a new future, again"; Daniel Ziffer (8-11-2021), "Latrobe Valley coal community already looking to future as COP26 delegates discuss end of fossil fuel"; Giles Parkinson (9-9-2021), "Huge wind, solar and battery project proposed for central Queensland"; Xanthe Gregory (24-11-2021), "Iconic Lithgow coal-fired power station demolished, paving way for renewable energy hub"

[63] CEC (2021), *Clean Energy Australia Report 2021*, pp.25-41; MGreevy et. al. 2021, "Expediting", pg. 5

However, relying on ad-hoc regional initiatives alone can be inefficient and lead to new problems. For this reason, a holistic approach is also needed to provide a stable basis for an overall economic transition based on existing and emerging opportunities. This will require wide-reaching adjustments to economic policies, which balance the long-term economic needs of coal mining regions with the imperative changes required to provide a sustainable energy future[64].

2.4. Maintain the Uptake of Clean Energy

Australia has recently seen significant increases in renewable energy capacity – averaging 6GW of new wind and solar energy per annum between 2018-2020, with a further 10GW of large-scale renewable energy projects proposed or under construction at the end of 2020[65]. This uptake has mostly been driven by private sector commitments with support from state governments, indicating a strong appetite for private investment in renewable energy[66]. However, there are concerns among some observers that this trend could be short-lived, with a noticeable decline in new projects committed for construction after 2022 compared with recent years[67]. With this in mind, future government policies are arguably best focussed on maintaining private interest in new clean energy investments via a mixture of incentivisation and streamlining supply.

Maintaining the rapid uptake of renewable energy is central to establishing a sustainable energy future, and would provide a number of direct and indirect benefits. Renewable energy sources produce far fewer greenhouse gas emissions than fossil fuels, and have fewer negative environmental impacts during their establishment[68]. The injection of renewable energy sources has also contributed to reductions in wholesale power prices in recent years, with state governments now looking for ways to ensure these reductions are passed onto consumers[69]. Finally, where a grid has previously struggled to produce reliable energy, renewable sources combined with energy storage have provided stability by boosting local production and supply at times of peak demand[70].

2.4.1. Upgrade and expand transmission infrastructure

New electricity generation projects need to be accompanied by sufficient transmission infrastructure, connecting them to cities and industrial regions which have high energy needs[71]. For this reason, renewable energy zones have been established in existing energy hubs where they can connect to existing transmission infrastructure[72]. To date however, the construction of new transmission infrastructure has struggled to keep up with the pace of new generation projects, resulting in

[64] Burke et. al., "Closures", pp. 161-162; Productivity Commission, *Transitioning Regional Economies*, pp. 141-187

[65] Blakers et. al., *Australia*, pp. 3-6

[66] CEC, *Clean Energy Australia*, pp. 6-41; Andrew Blakers, Ken Baldwin & Matthew Stocks (3-9-2020), "Australia, the global renewable energy pathfinder"; Harrington & Hoy, "The Trajectory", pp. 193-197; Sophie Vorrath (13-10-2021), ""Unstoppable transition": Australia can hit 91% renewables by 2030"

[67] Peter Hannam (13-08-2021), "'Energy chaos: Wind and solar industry facing roadblocks in Australia";

[68] Nana Yaw Amponsah, Mads Troldborg, Bethany Kington, Inge Aalders, Rupert Lloyd Hugh (2014), "Greenhouse gas emissions from renewable energy sources: A review of lifecycle considerations", pp. 463-472; Geroe, "Addressing Climate Change", pg. 12; Amponsah et. al., "Greenhouse gas emissions", pg. 471; EEA (2018), *Renewable energy in Europe – 2018: Recent growth and knock-on effects*, pp. 37-41

[69] Joachim Seel, Andrew D. Mills, Ryan H. Wiser (2018), *Impacts of High Variable Energy Futures on Wholesale Electricity Prices, and on Electric-Sector Decision Making* pp. 23-25; Andrew D. Mills, Todd Levin, Ryan Wiser, Joachim Seel, Audun Botterud, "Impacts of variable renewable energy on wholesale markets and generating assets in the United States: A review of expectations and evidence", pg. 5. See also, Silvio Marcacci (21-1-2020), "Renewable Energy Prices Hit Record Lows: How Can Utilities Benefit From Unstoppable Solar And Wind?"; Gian De Poloni (28-4-2021), "Solar panels, cooler summer drive power prices into negative territory in South Australia"

[70] McGreevy et. al., "Expediting", pg. 1; van Staden et. al., "The Pathway", pg. 181. See also: Daniel Keane (29-09-2021), "SA's statewide blackout was five years ago – here's how energy supply has evolved since then"; Giles Parkinson (29-10-2021), "South Australia makes big leap towards 100 pct renewables as wind and solar set free"

[71] CEC, *Clean Energy Australia*, pg. 54; McGreevy et. al., "Expediting", pp. 3-5

[72] CEC, *Clean Energy Australia*, pp.25-41; MGreevy et. al. 2021, "Expediting", pg. 5

increased risk of wastage, congestion and overload[73]. New transmission lines are therefore needed to resolve these issues.

At the same time, there is growing interest in exploring new industrial opportunities, such as hydrogen exports, 'green steel' production, and advanced manufacturing (to name a few)[74]. While the vast energy requirements of these projects could help to alleviate concerns of oversupply, new transmission infrastructure would nevertheless be vital for supplying the extra demand created by such an expansion in industrial activity.

Building new interconnectors between states, and with neighbouring countries in Southeast Asia and the Pacific, presents another option. This would minimise wastage and address supply issues by allowing excess energy to be exported to where it is most needed. Increasing the opportunities for exports would also improve the financial viability of major projects and provide significant opportunities for the wider economy[75].

2.4.2. Invest in energy storage infrastructure

In practice, renewable energy sources often fluctuate in their generation capacity due their reliance on variable natural conditions. Consequently, more energy storage is needed to reduce reliance on coal- and gas-fired energy when providing baseload power to the grid[76]. Storage technology has advanced significantly in recent years, resulting in lower prices and presenting significant opportunities for future deployment[77]. Furthermore, state governments have already implemented a number of policies aimed at boosting energy storage capacity, such as the establishment of 'Virtual Power Plants' (VPPs), investment in new utility-scale battery-storage, and funding research into green hydrogen for chemical storage[78]. These policies can provide blueprints for future government decision-making in this area.

2.4.3. Remove unnecessary impediments for admission of new projects wherever possible

In 2017, the Productivity Commission outlined the need to streamline approval and construction of new projects by removing unnecessary impediments[79]. This has been echoed by a number of groups who have criticised the federal government for policies which impede the development of new clean energy projects in favour of fossil fuels[80]. With this in mind, there are a number of ways in which legislation can be enacted to streamline future projects. Perhaps the most immediate possibility in this area is the provision of federal approval for construction of off-shore wind farms. Advocates often point to the vast potential of offshore wind generation in Australia, with a number of projects already

[73] CEC, *Clean Energy Australia*, pg. 54; Blakers et. al. pp. 3-4; Keane, "SA's statewide blackout"
[74] Hildebrand, "Australia's $2.1 trillion future"
[75] van Staden et. al., "The Pathway", pg. 173, 180-181; McGreevy et. al., "Expediting", pg. 12; see also: Mazengarb, "World's biggest solar and battery"; Asian Renewable Energy Hub, https://asianrehub.com/
[76] Leonard et. al., "Substitution of coal power plants with renewable energy sources", pg. 28; Boretti, "Energy Storage", pg. 7; van Staden et. al., "The Pathway", pg. 182
[77] Jonathan Radcliffe (19-3-2021), "Energy storage technology is accelerating – but grids aren't ready for the transition";
[78] see, ABC News (1-6-2021), "Tesla battery scheme rolled out to homes without solar to build virtual power plant in SA"; ARENA (4-9-2020), "Australia's largest virtual power plant ramps up in South Australia"; Jasmine Hines (13-12-2021), "Elon Musk's Tesla to back central Queensland battery project in Australian-first collaboration"; Sumeyya Ilanbey (8-12-2021), "In a field near Geelong, switch flicked on Australia's biggest battery"; Sara Tomevska (2-9-2020), "Tesla battery in South Australia expanded by 50 percent, energy minister lauds benefits"; Dan van Holst Pellekaan MP (24-3-2021), "Biggest battery bolstering energy grid"; Angela Macdonald-Smith (13-12-2021), "$15b NT hydrogen project to such water from air"; Royce Kurmelovs (18-11-2021), "Green hydrogen beats blue on emissions and financial cost, Australian study finds"; Gillian Aeria, "$750 million hydrogen facility plan for Port Pirie with engineering study underway by SA government, Trafigura"
[79] Productivity Commission, *Transitioning Regional Economies*. pp. 142-147
[80] see for example: Tim Buckley (26-11-2021), "Morrison chaos and fossil fuel funding is undermining Queensland's efforts to go green"; Climate Council (4-10-2021), "Politics Preventing Australia's Switch to 21st Century Energy"; Peter Hannam "'Energy chaos': Wind and solar industry facing roadblocks in Australia"

proposed for construction[81]. Importantly, many of these projects would be placed near current energy hubs, and could therefore provide economic opportunities for current fossil-fuel reliant regions (see 2.3.3.)[82].
Furthermore, a number of policies have been invoked in ways which have directly prevented Australian state and local governments from undertaking their own steps towards a sustainable energy transition[83]. Guaranteeing a smooth energy transition requires such policies to be reviewed as soon as issues emerge.

2.4.4. Invest in clean energy research and innovation

Technological development forms the cornerstone of the Australian federal government's climate mitigation strategy, with funding provided through agencies such as ARENA and the Clean Energy Finance Corporation[84]. Research into new clean energy technology is important for maintaining the ongoing transition to a sustainable energy future, as is innovation in the deployment of existing technologies[85]. In particular, improvements are needed to fill technological gaps which have so far limited the large-scale deployment of green hydrogen, battery storage, and electric vehicles[86].

2.4.5. Subsidise further uptake of renewable energy

Well-placed financial subsidisation can be an effective tool for maintaining high levels of investment in new renewable energy projects from both supply- and demand-side actors[87]. The best type of subsidisation varies depending a number of contextual factors, however previous studies have emphasised the effectiveness of subsidy-types which provide financial certainty – such as conditional tax breaks to alleviate financial losses and rebates for installation of new energy systems[88]. Simultaneously phasing out existing fossil fuel subsidies would also ensure that renewable energy is comparatively more financially attractive, while also displacing the cost of new renewable energy subsidies (see 2.3.2. for more)[89]. This would also ensure that prices better reflect the long-term external costs of each fuel source[90].

[81] Blue Economy Cooperative Research Centre (BECRC) (2021), *Offshore Wind Energy in Australia*, pp. 3-8; Mike Foley (4-10-2021), "Winds of change blow hope into industrial towns and net zero deal"; Selina Green and Todd Lewis (10-9-2021), "Offshore wind farm projects in the pipeline to accelerate new renewable energy sector"; Royce Kurmelovs (9-10-2021), "'Good seas, good grids and good wind': Australia's tentative first steps towards an offshore wind industry"; Madeline Taylor & Tina Soliman Hunter (3-9-2021), "Australia's first offshore wind farm bill was a long time coming, but here are 4 reasons it's not up to scratch yet"
[82] see: BECRC, *Offshore Wind Energy*, pg. 8; Foley, "Winds of change"; Kurmelovs, "Good seas"
[83] Dr. Daniel Pejic, "Local Climate Action Blocked by Foreign Relations Laws";
[84] DISER (17-9-2020), "Australia invests in lower emissions through future technologies"; Al-Jazeera News (10-11-2021), "Australia launches $738m fund to support green tech"; Phillip Coorey (26-10-2030), "PM pins net zero hopes on technology, updates 2030 projections".
[85] Bin Chen, Rui Xiong, Hailong Li, Qie Sun, & Jin Yang (2019), "Pathways for sustainable energy transition", pp. 1566-1569
[86] see: Chen et. al., "Pathways for sustainable energy transition", pp. 1566-1569; van Staden et. al. "The Pathway", pg. 182; Joe Hildebrand (11-10-2021), "Australia's $2.1 trillion future with 672,000 jobs and net zero emissions";
[87] Xiaolei Yang, Lingyun He, Yufei Xia, & Yufeng Chen (2019), "Effect of government subsidies on renewable energy investments: The threshold effect", pp. 157-165; Xiaoling Ouyang & Boqiang Lin (2014), "Impacts of increasing renewable energy subsidies and phasing out fossil fuel subsidies in China", pg. 941
[88] Marcella Nicolini & Massimo Tavoni (2017), "Are renewable energy subsidies effective? Evidence from Europe", pp. 413-416; Nicolini & Tavoni, "Are renewable energy subsidies effective?", pg. 418-419"; Yang et. al., "Effect of government subsidies", pp. 157, 161
[89] Ouyang & Lin, "Impacts of increasing", pg. 934; van Staden et. al., "The Pathway", pp. 178, 185
[90] see van Staden et. al., "The Pathway", pg. 172; Ouyang & Lin, "Impacts of increasing", pp. 934-935

2.5. Improve Energy Efficiency in Buildings

Buildings account for a large percentage of total energy usage and greenhouse gas emissions[91]. Reducing excessive energy consumption within buildings is therefore a crucial step in achieving a sustainable energy system[92]. Furthermore, improving energy efficiency in buildings can provide relatively quick and low-cost results for improving sustainability, making energy efficiency strategies useful for supporting more complex and time-consuming supply-side policies[93]. Finally, the best policy solutions will depend on local contexts, including environmental factors and existing policies. Given Australia has already seen significant success in improving energy efficiency[94], new policies should complement and update existing strategies without impeding ongoing efforts.

2.5.1. Monitor and benchmark energy efficiency performance.

Monitoring and benchmarking the energy efficiency of individual buildings can provide useful information for coordinating policy responses[95]. Additionally, this information can be used to inform green certification schemes for buildings which allow prospective tenants to better factor energy efficiency into their decision-making process when choosing where to rent. This would theoretically incentivise ongoing efficiency measures from building operators, as they attempt to remain competitive within the rental market[96]. For monitoring to be effective however, auditors must be well-trained in observing and communicating areas of potential improvement, necessitating periodic reviews and updates to training standards[97]. Finally, the procurement of new on-site monitoring equipment should be supported both financially and logistically[98].

2.5.2. Mandate updated installation of energy efficient appliances

The installation of efficient lighting and temperature control provides the simplest and most cost-effective way to improve overall energy efficiency in buildings[99]. Consequently, mandating the installation of energy efficient appliances sets a minimum standard for retrofits, thus ensuring action is taken to at least the most basic extent required[100]. Establishing a uniform labelling system for energy

[91] IEA (2021), *Key World Energy Statistics 2021*, pp. 2021; Athina G. Gaglia et. al. (2019), "Energy performance of European residential buildings: Energy use, technical and environmental characteristics of the Greek residential sector – energy conservation and CO2 reduction", pp. 86-87; Birol Kilkis (2020), "Accelerating the Transition to 100% Renewable Era. But How? Exergy Rationality in the Built Environment", pp. 1-2; N. Abdou, Y. El Mghouchi, S. Hamdaoui, N. El Asri, M. Mouqallid (2021), "Multi-objective optimization of passive energy efficiency measures for net-zero energy building in Morocco", pg. 1

[92] van Staden et. al., "The Pathway", pp. 176-178; Jeffrey D. Sachs, Guido Schmidt-Traub & Jim Williams (2016), "Pathways to zero emissions", pg. 800; Sonia Vera & Enzo Sauma (2015), "Does a carbon tax make sense in countries with still a high potential for energy efficiency? Comparison between the reducing-emissions effects of carbon tax and energy efficiency measures in the Chilean case", pp.478-479. See also: Matthew Taylor (24-9-2021), "'Low-hanging fruit': Insulate Britain's message makes sense, say experts"; Stephanie Chalmers (20-10-2021), "A green home can not only save money but even turn a profit. But how do you know if you own one?"; Ben Deacon & Kate Doyle (30-10-2021), "Climate change now"

[93] van Staden et. al., "The Pathway", pp. 176-178. See also: Gaglia et. al., "Energy Performance", pg. 89; Vera & Sauma, "Does a carbon tax make sense", pg. 485; Gregory Trencher & Jeroen van der Heijden (2019), "Instrument interactions and relationships in policy mixes: Achieving complementarity in building energy efficiency policies in New York, Sydney and Tokyo", pp. 34-35

[94] Trencher & van der Heijden, "Instrument interactions", pp. 41-42; Robert Cohen & Paul Bannister (1-2017), "Why is Australia better than the UK at building energy efficiency?"

[95] Trencher & van der Heijden, "Instrument interactions", pp. 38-39; Morshed Alam, Patrick X.W. Zou, Rodney A. Stewart, Edoardo Bertone, Oz Sahin, Chris Buntine, & Carolyn Marshall (2019), "Government championed strategies to overcome the barriers to public building energy efficiency retrofit projects", pp. 60-65

[96] Trencher & van der Heijden, "Instrument interactions", pg. 39; Cohen & Bannister, "Why is Australia better"

[97] Alam et. al., "Government championed strategies", pp. 63-65

[98] Alam et. al., "Government championed strategies", pp. 63-65; Trencher & van der Heijden, "Instrument interactions", pg. 39

[99] Yuling Fan & Xiaohua Xia (2018), "Energy-efficiency building retrofit planning for green building compliance", pg. 318; van Staden et. al., "The Pathway", 178

[100] Trencher & van der Heijden, pg. 38.

efficiency of products provides a useful supporting policy here, allowing owners and operators to make informed decisions when choosing new appliances[101].

2.5.3. Provide financial subsidies and incentives for deep energy efficiency retrofits

Retrofitting a building to improve its energy efficiency can present significant costs for owners and operators, and can be disruptive for tenants[102]. Additionally, building owners and tenants may disagree on the extent of changes required, or on who should be responsible for bearing which costs[103]. Developing an easily accessible financing scheme for undergoing a deep energy-efficiency retro fit which alleviates financial pressure and streamlines the decision-making process is a useful way to address these challenges[104]. In particular, a progressive financing model which provides higher incentives for deeper retrofits has been applied with success in Germany. However, the experience here also shows the need to mandate a minimum standard for energy efficiency to ensure retrofits provide meaningful results[105].

2.5.4. Encourage energy efficient behaviours among occupants

Aside from structural and technological changes, adjustments in the behaviour of occupants can lead to significant improvements in energy efficiency[106]. This can be achieved in a number of ways. For example, awareness campaigns can be useful for conveying the importance of efficient energy usage, and for suggesting behavioural changes[107]. Feedback strategies can also provide an effective tool for triggering behavioural changes in residential households. For example, including strategies for energy efficiency in power bills has been found to be effective, likely due to the implied incentive of saving money on electricity and water bills[108]. Some studies have also illustrated the potential to amplify these results by providing comparisons between a household's energy usage and that of their peers[109].

2.6. Transition to a sustainable transport system

Transportation is the third largest sector of the Australian energy system, accounting for a third of total energy consumption, and a growing percentage of total greenhouse gas emissions.[110]. Adopting clean energy in the transportation sector is therefore a vital component of the transition to a sustainable energy future. There have been a number of significant advances in clean transport technology in recent years, particularly in regard to increasing the practical viability of hybrid and electric vehicles[111]. These developments mean it is now possible for governments to initiate meaningful change in this area through a mixture of policy and infrastructural development[112]. With this in mind, this section will

[101] Alam et. al., "Government championed strategies", pg. 64-65
[102] Karsten Neuhoff, Hermann Amecke, Aleksandra Novikova, Kateryna Stelmakh (2011), *Thermal Efficiency Retrofit of Residential Buildings: The German Experience*, pp. 9-10
[103] Dorothee Charlier (2015), "Energy efficiency investments in the context of split incentives among French households", pp. 465-466
[104] Neuhoff et. al., *Thermal Efficiency Retrofit*, pp. 9-10; Alam et. al., "Government championed strategies, pg. 63
[105] Neuhoff et. al., *Thermal Efficiency Retrofit*, pg. 9
[106] van Staden et. al., "The Pathway", 175-176; Antonio Paone & Jean-Phillipe Bacher (2018), "The Impact of Building Occupant Behaviour on Energy Efficiency and Methods to Influence It: A Review of the State of the Art", pp. 4-6
[107] Fernando Casado, M. Carmen Hidalgo & Patricia Garcia-Leiva (2017), "Energy efficiency in households: The effectiveness of different types of messages in advertising campaigns", pp. 202-204; Neuhoff et. al., *Thermal Efficiency Retrofit*, pg. 6
[108] Paone & Bacher, "The Impact of Building Occupant Behaviour", pp. 8-9; Neuhoff et. al., *Thermal Efficiency Retrofit*, pg. 7
[109] Panoe & Bacher, "The Impact of Building Occupant Behaviour", 9-10
[110] D.F. Dominkovic, I. Bacekovic, A.S. Pederson, G. Krajacic (2018), "The future transportation in sustainable energy systems: Opportunities and barriers in a clean energy transition", pg. 1823
[111] Antonio Garcia-Olivares, Jordi Sole & Oleg Osychenko (2018), "Transportation in a 100% renewable energy system", pp. 266-270.
[112] Terrill et. al., *The Grattan car plan*, pp. 27-38

outline some possible policy options for a timely and cost-effective transition to a sustainable transport system.

2.6.1. Set a mandatory emissions ceiling for new vehicles

Passenger and light duty utility vehicles contribute around a tenth of total greenhouse gas emissions in Australia[113]. Increasing the market penetration of low- and zero-emission vehicles for personal use – and especially that of hybrid and electric vehicles – is therefore necessary to reduce overall emissions[114]. To this end, some countries have introduced mandatory emissions ceilings and similar performance standards in recent years, resulting in rapid increases in the number of hybrid and electric vehicles sold. For example, the share of electric vehicles among new car sales in the EU tripled in the first year under an emissions ceiling, resulting in overall emissions reductions of 12% from new cars and 1.5% from vans[115]. Furthermore, some manufacturers have promised to exclusively sell hybrid and electric vehicles in EU countries, illustrating the growing acceptance of these vehicle types[116].

As well as increasing the number of low- and zero-emission vehicles, many manufacturers have also sought to find new ways to improve the fuel efficiency of conventional petrol vehicles in their range. This has resulted in reduced emissions even in larger and more specialised vehicles, such as vans, 4x4s, and utilities (i.e., pickup trucks)[117]. This is important for the Australian context, where a number of practical and political factors (such as long distances between most major cities, the prevalence of remote heavy industries, and concerns about restrictions in choice) will likely necessitate the continued use of such vehicles over the next decade[118].

2.6.2. Update and electrify urban public transport systems

Improving and electrifying public transport systems can simultaneously reduce transport-related greenhouse gases and relieve pressure on roads. A number of studies have estimated that the electrification of bus systems and remaining diesel rail networks could directly reduce emissions by between 19%-24%[119]. It is important to note that this total accounts for emissions from electricity production charging[120], which could be further reduced by increasing the total contribution of renewable energy to the grid (see 2.4.). Moreover, incentivising increased usage of public transport would potentially reduce traffic congestion, resulting in further reductions of total transport emissions[121]. This issue will only become more important as urban populations continue to grow in the future.

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[113] Terrill et. al., *The Grattan car plan*, pp. 17
[114] Garcia-Olivares et. al., "Transportation", pp. 267-268; Terrill et. al., *The Grattan car plan*, pp. 17-26.
[115] EEA (29-6-2021), "Sharp decrease in CO2 emissions from new cars in 2020"; EC (29-6-2021); "Average CO2 emissions from new passenger cars registered in Europe decreased by 12% in 2020 and the share of electric cars tripled as new targets start applying"; Marion Terrill & Lachlan Fox (24-10-2021), "Tough car emissions ceilings could get us well on the road to net-zero"; Peter Martin (16-11-2021), "The embarrassingly easy, tax-free way for Australia to cut the cost of electric cars"; Ingrid Burfurd (3-12-2021), "Most Australian households are well-positioned for electric vehicles – and an emissions ceiling would help"
[116] Terrill et. al. *The Grattan car plan*, pp. 21-23; Peter Martin (25-5-2021), "Going electric could be Australia's next big light bulb moment"
[117] Terrill et. al., *The Grattan car plan*, pp. 17-23; Martin, "The embarrassingly easy"
[118] Terrill et. al, *The Grattan car plan*, pg. 23
[119] Feng Mao, Zhiheng Li & Kai Zhang (2020), "Carbon dioxide emissions estimation of conventional diesel buses electrification: A well-to-well analysis in Shenzhen, China", pp. 5-9; Michael Glotz-Ricther & Hendrik Koch (2016), "Electrification of public transport in cities", pg. 2616
[120] Mao et. al., "CO2 emissions estimation", pg. 7-9
[121] Garcia-Olivares et. al., "Transportation", pg. 269; Glotz-Richter & Koch, "Electrification of public transport", pg. 2615. For interaction between congestion and greenhouse gas emissions, see: Matthey Barth & Kanok Boriboonsomsin (2009), "Traffic Congestion and Greenhouse Gases", pp. 2-6; C. Kim, M. Ostovar, A.A. Butt, & J.T. Harvey (2018), "Fuel Consumption and Greenhouse Gas Emissions from On-road Vehicles on Highway Construction Work Zones", pp. 6-10

Moreover, the rapid production of new hybrid and electric small vehicles to replace conventional petrol cars will likely increase the pressure on certain resources. Increasing the usage of alternative transports such as public transport in place of personal cars provides a partial solution to this problem[122].

2.6.3. Improve pedestrian and cycling infrastructure

The goals described in the above sub-section – to reduce emissions, relieve congestion on roads, and simultaneously reduce pressure on resources – require a comprehensive solution aimed at encouraging alternative travel options to personal cars. To this end, the increased utilisation of pedestrian and cycling infrastructure presents another important component of a sustainable transport system[123]. This can be achieved with relative ease via a mixture of increased infrastructure investments and smart urban planning, aimed at improving safety and convenience of these alternative travel options[124].

2.6.4. Encourage further research and development of alternative fuels

There is significant potential for development of hydrogen, biofuels, and fuel-cell hardware in Australia, with a number of major production and refuelling facilities already proposed for construction[125]. Such alternative fuel sources are particularly useful for the Australian context, given the likely ongoing importance of fuel-intensive industries (for example, mining for minerals and precious metals, advanced manufacturing, steel production, long-haul transport and aviation). It is unlikely that hybrid and electric vehicles will be able to satisfy the fuel demands of these industries in the foreseeable future, thus necessitating the development of clean fuel cells to provide an alternative to diesel[126]. Furthermore, clean fuel options (especially green hydrogen) look especially likely to become important commodities, thus providing significant economic opportunities through both exports and technological developments[127]. Supporting further research and development in this area is therefore likely to produce a number of positive outcomes for Australia, and should be a priority for governments at all levels.

[122] Garcia-Olivares et. al., "Transportation", pg. 268-269

[123] Billie Giles-Corti, Sarah Foster, Trevor Shilton, & Ryan Falconer (2010), "The co-benefits for health of investing in active transportation", pp. 123-124; Todd Litman (1997), *Quantifying the Benefits of Nonmotorized Transportation For Achieving Mobility Management Objectives*, pp. 10-21; van Staden et. al., "The Pathway", pg. 175-176, 179

[124] Bille Giles-Corti et. al. (2016), "City planning and population health: a global challenge", pp. 2913-2914; Sanja Dimter, Dina Stober & Martina Zagvozda (2019), "Strategic planning of Cycling Infrastructure Towards Sustainable City Mobility – Case Study Osijek, Croatia", pp. 2-7; Garcia-Olivares et. al., "Transportation", pg. 268

[125] See for example: Dan van der Holst Pellekaan (9-12-2021), "$750 million Green Hydrogen Project for Port Pirie; Miki Perkins (1-12-2021), "Nation's first commercial green hydrogen station set for Melbourne"; Kelly Fuller (7-12-2021), "Bluescope, Shell announce plan for green hydrogen future at Port Kembla; Scarlett Evans (14-12-2021), "Australia's Northern Territory to host major green hydrogen project"

[126] Sonja van Renssen (2020), "The hydrogen solution?", pg. 799; Meryem Gizem Surer & Huseyin Turan Arat (2018), "State of the art of hydrogen usage as a fuel on aviation", pp. 21-28; Australian Hydrogen Council, *Unlocking Australia's hydrogen opportunity*, pp. 45-46; Garcia-Olivares et. al., "Transportation", pp. 270

[127] van Renssen, "The hydrogen solution?" pg. 801; See also: van Leeuwen, "How Europe aims to book a seat on Australia's hydrogen express"; Eckert, "RWE plans to bring Australian 'green' hydrogen to Europe"; Matt Garrick (14-12-2021), "NT outback to host Australian-first green hydrogen project at Tennant Creek"

3. Conclusion

Undertaking a successful transition to a sustainable energy future is vital for addressing the threat of climate change. Additionally, such a transition presents a wide array of opportunities for Australia so long as governments are willing to move swiftly and decisively. It is clear that, to-date, the federal government has failed to take sufficient action in this area. In fact, certain government policies have arguably stalled progress by continuing to support fossil fuel industries, even when doing so is at odds with the best interests of Australia's long-term energy market. Australia cannot afford any further such delays if it is to reap the benefits of the coming changes to the global energy market. It must also be acknowledged that transitioning an entire energy system is a huge undertaking. As such, it will require a complete commitment from governments and private enterprises at all levels of society, accompanied by a comprehensive mixture of policies and constant monitoring to ensure ongoing effectiveness. This report has outlined just a few of the policy options which are available for stimulating the transition to a sustainable energy future, spanning domestic and commercial electricity usage, industrial activity, and transportation.

Improving governmental messaging and coordination will provide clear direction for policy formation in all areas of society, paving the way for more rapid change. Additionally, providing businesses and investors with certainty will allow them to adjust their practices to accommodate the new business conditions. This will simultaneously increase the pace of the energy transition and reduce the economic shock of such a change.

Establishing a meaningful carbon pricing scheme arguably provides the most effective individual policy for reducing greenhouse gas emissions and stimulating practical changes across the entire economy. The two most-proven options here are either a cap-and-trade ETS or a carbon tax. A well-managed ETS can stimulate change while minimising the financial burden for businesses, and has proven to be a more politically popular option. However, a carbon tax arguably achieves more rapid results, which is important given the urgent nature of change needed for climate change mitigation. The revenue raised by a carbon tax can also be used to lower the tax burden in other economic areas, or can otherwise be re-invested to further accelerate the energy transition.

Phasing out the usage of fossil fuels in favour of renewable sources for electricity generation is central to a sustainable energy future, especially considering the slow rate at which CCS technology has advanced. Moreover, there is already a strong appetite for investment in renewable energy projects in Australia, with significant potential to export clean energy overseas. Government policy is best focussed on maintaining this interest. This can largely be achieved through a mixture of infrastructural investments to ensure consistency of supply, and subsidies designed to incentivise further renewable energy uptake.

Improving energy efficiency can take pressure off the grid and reduce a large percentage of current greenhouse gas emission. Additionally, policies focussed on reducing demand can deliver rapid interim results to support longer-term supply-side policies.

Finally, transitioning to a sustainable transport system will significantly reduce overall greenhouse gas emissions, while simultaneously reducing traffic congestion on roads. This requires policies designed to increase the market penetration of hybrid and electric vehicles, in conjunction with policies and infrastructural investments to increase the usage of alternative transport options.

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