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# Green technology and regulatory settings in Australia: an overview and discussion paper

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# Contents

# About this discussion paper

Green technology offers the tantalising possibility that human ingenuity, through the medium of technological development, may be capable of engineering humanity's way out of environmental crisis. But the embrace of technological solutions – especially to the problems posed by climate change – cannot be undertaken uncritically. This discussion paper proposes a principles-based approach to the regulation of green technology in Australia: one capable not only of understanding the applications of that technology, but also its social context.

This discussion paper explores four green technologies related to energy. Each promises the potential to deliver carbon abatement and other environmental benefits. These four technologies are:

> Electric vehicles;
> Renewable energy storage systems - particularly batteries;
> Hydrogen; and
> Waste to Energy.

The purpose of this discussion paper is to assess regulatory settings related to each of them. To do so effectively, the paper places these technologies in a wider and more fundamental context. This is necessary because it is impossible to provide a meaningful assessment of appropriate regulation for distinct technologies without first asking larger questions about the kind of society we want to live in. Carbon mitigation is a worthy – indeed, a vital – goal, and one whose sincere pursuit requires substantial social transformation. But embarking on this transformation with the sole goal of carbon abatement represents not only a missed opportunity to imagine and effectuate a better future, but also the potential to entrench particular pathways and thereby preclude the possibility of other, more desirable, options.

It is for this reason that we urge that any regulatory program for green technology be approached with a firm understanding of a broader societal context. Alongside the achievement of carbon abatement, we propose three principles that must inform any such approach:

> Energy justice;
> Just access to space and mobility; and
> Respect for the totality of ecological limits.

We offer these principles as a starting point for discussion: their content may be debated, consulted upon and further refined. But what is beyond debate is that the development of a principles-based approach, with all that this entails in terms of careful thought about the shape of the desired future, is necessary in order for the gains of the developing social and technological transformation to be fully realised, and for foreseeable social harms to be avoided.

## About the Author and Acknowledgements

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# List of Abbreviations

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|---|---|
| ABC | Australian Broadcasting Corporation |
| AEMO | Australian Energy Market Operator |
| AEMC | Australian Energy Market Commission |
| ANU | Australian National University |
| ARENA | Australian Renewable Energy Agency |
| BEV | Battery Electric Vehicle |
| CCS | Carbon Capture and Storage |
| CEFC | Clean Energy Finance Corporation |
| CET | Clean Energy Target |
| $CO_2$ | Carbon Dioxide |
| COAG | Council of Australian Governments |
| DER | Distributed Energy Resources |
| DNSP | Distributed Network Service Provider |
| EES | Electric Energy Storage |
| EPA | Environment Protection Authority |
| EV | Electric Vehicle |
| FCEV | Fuel Cell Electric Vehicle |
| FFS Discussion Paper | Future Fuels Strategy Discussion Paper |
| FFVS | Future Fuels and Vehicles Strategy |
| GWh | Gigawatt Hour |
| ICE | Internal Combustion Engine |
| IEA | International Energy Agency |
| Km | Kilometre |
| KWh | Kilowatt Hour |
| MWh | Megawatt Hour |
| NEM | National Electricity Market |
| NGO | Non-Government Organisation |
| PHEV | Plug-in Hybrid Electric Vehicle |
| PV | Solar Photovoltaics |
| RET | Renewable Energy Target |
| SWIS | South West Interconnected System |
| WtE | Waste to Energy |
| ZEV | Zero Emissions Vehicle |

# 1. Introduction

The term 'green technology' can refer to many things. In 1993, the Chair of a United States (US) House of Representatives Subcommittee defined it by reference to 'those products and processes which are designed so that throughout their lifecycle any negative impact which they may have on the environment is accounted for and minimized'.[1] While this definition contemplates a wide range of environmental effects, green technology is now most often associated with climate change; and where it concerns energy transitions, with attempts to mitigate greenhouse gas emissions.[2] This relatively narrow scope, which we will adopt in this discussion paper, therefore refers to technologies that are deployed in order to achieve climate change-related (or other environmental) goals. As will become clear, to explore the regulation of 'greentech' even within this relatively narrow focus still raises broad and important implications relating to systemic change and normative values. Keeping the empirical focus relatively narrow helps to clarify and link the wider stakes with immediate regulatory practical issues.

This discussion paper explores four green technologies related to energy, whether in its production, storage, distribution or use. Each promises the potential to deliver carbon abatement and other environmental benefits. These four technologies are:

> Electric vehicles;
> Renewable energy storage systems - particularly batteries;
> Hydrogen; and
> Waste to Energy.

The purpose of this discussion paper is to examine regulatory settings related to each of them. To do so effectively, the paper places these technologies in a wider and more fundamental context. This is necessary because it is impossible to provide a meaningful assessment of appropriate regulation for distinct technologies without first asking larger questions about the kind of society we want to live in. Carbon mitigation is a worthy – indeed, a vital – goal, and one whose sincere pursuit requires substantial social transformation. But embarking on this transformation with the sole goal of carbon abatement represents not only a missed opportunity to imagine and effectuate a better future, but also the potential to entrench particular pathways and thereby preclude the possibility of other, more desirable, options.

It is for this reason that we urge that any regulatory program for green technology be approached with a firm understanding of a broader societal context. This involves appreciating that 'low-carbon transitions are not merely technical tasks, but socially, politically and culturally challenging processes that must be managed in fairer and more equitable ways'.[3] Alongside the achievement of carbon abatement, we propose three principles that should inform any regulatory approach:

> Energy justice;
> Just access to space and mobility; and
> Respect for the totality of ecological limits.

We offer these principles as a starting point for discussion: their content may be debated, consulted upon and further refined. But what is beyond debate is that the development of a principles-based approach, with all that this entails in terms of careful thought about the shape of the desired future, is necessary in order for the gains of the developing social and technological transformation to be realised fully, and for foreseeable social harms to be avoided.

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1 *Green Technology Initiatives* Hearing before the Subcommittee on Technology, Environment and Aviation of the Committee on Science, Space and Technology, US House of Representatives (One Hundred Third Congress, First Session, July 19, 1993) 1 (Tim Valentine).

2 See, e.g. Pallab Paul, 'Green Technology Investing' in Dustin Mulvaney and Paul Robbins (eds), *Green Technology: An A-to-Z Guide* (Sage Publications, 2011) 234.

3 Benjamin K Sovacool et al, 'The Whole Systems Energy Injustice of Four European Low-Carbon Transitions' (2019) 58 *Global Environmental Change* 101958, 2.

In what follows, we outline each of these principles. We then go on to describe the carbon regulatory landscape in Australia. Drawing on these principles and with a background understanding of the wider picture on carbon, this paper then sets out the regulatory environments surrounding each of the four technologies we consider.

These environments are changing rapidly. The substantive content of this paper was finalised in early June 2022, shortly after the election of the Albanese Government, and has not been updated for subsequent developments. Unless otherwise stated, financial amounts are expressed in AUD.

## 1.1 Energy justice

The concept of 'energy justice' is receiving increasing scholarly attention. One study defines it as 'a global energy system that fairly disseminates both the benefits and costs of energy services, and one that contributes to more representative and impartial energy decision-making'.[4] This definition contains three key elements. The first relates to costs, or 'how the hazards and externalities of the energy system are disseminated throughout society'.[5] For our purposes, 'costs' incorporates not only economic burdens but also factors including hazards to health, to environmental quality and to cultural and other heritage. The second relates to benefits, involving 'how access to modern energy systems and services is distributed throughout society'.[6] The third concerns '[p]rocedures, or ensuring that energy decision-making respects due process and representation'.[7] Three central principles of energy justice have elsewhere been articulated as 'distribution, recognition and procedure'. This entails that in order to address injustice, it is necessary to '(a) identify the concern – distribution, (b) identify who it affects – recognition, and only then (c) identify strategies for remediation – procedure'.[8] For the purposes of this paper, the 'distribution' and 'recognition' elements overlap considerably with, and are covered by, the first two elements set out above: the distribution of costs and benefits. This is because we understand that distribution analysis to include a recognition of the people who are affected by that distribution. This is especially so if we pay attention to the kinds of misrecognition that can occur if that analysis of distribution is not carried out with sufficient care: 'cultural domination, non-recognition and disrespect'.[9]

Even directing attention predominantly to the domestic dimensions of the 'global energy system', as we do in this paper, these three key elements continue to resonate. Present in each of the three tenets is the necessity of ensuring that the energy transition is a just one for Aboriginal and Torres Strait Islander peoples. Among other aspects of the transition that are relevant for these groups, as we go on to discuss, energy production has often involved large-scale geological resource extraction. Both domestically and internationally, these processes that can have disproportionate effects on the interests of Indigenous populations. Even as the energy mix changes, this relation is likely to continue. Among other things, then, energy justice in Australia requires that the benefits and detriments of the energy transition be carefully considered in all the ways they may concern Aboriginal and Torres Strait Islander peoples, including in terms of what that transition may mean for recognition of culture and heritage. Additionally, at the level of procedure, Aboriginal and Torres Strait Islander groups must be able to 'freely give or withhold their consent to any decision that will affect their lands, territories or livelihoods'[10] through a robust process of free, prior and informed

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4 Benjamin K Sovacool et al, 'Energy Decisions Reframed as Justice and Ethical Concerns' (2016) 1(5) *Nature Energy* 16024, 4.

5 Ibid.

6 Ibid.

7 Ibid.

8 Kirsten Jenkins et al, 'Energy Justice: A Conceptual Review' (2016) 11 *Energy Research & Social Science* 174, 175.

9 Ibid 177, citing Nancy Fraser, 'Social Justice in the Age of Identity Politics' in George Henderson and Marvin Waterstone (eds), *Geographic Thought: A Praxis Perspective* (Routledge, 2009) 72.

10 Adrienne McKeehan and Theresa Buppert, 'Free, Prior and Informed Consent: Empowering Communities for People-Focused Conservation' (2014) 35(3) *Harvard International Review* 48, 49.

consent.[11] The proposed First Nations Voice to Parliament, which would make representations to the Commonwealth Parliament and Executive Government on matters relevant to Aboriginal and Torres Strait Islander peoples, may assist in the achievement of a just outcome in the energy transition.[12] It must be recalled, however, that the reach of this body is directed to engagement with government processes, rather than with the private sector.

Examining green technology with the aid of energy justice principles helps to identify the winners and losers of the green energy transition. It makes clear that 'it is not only fossil fuels or large-scale systems such as hydroelectricity that can generate their own injustices; solar energy, nuclear power, smart meters and EVs can erode justice principles or create justice concerns as well'.[13] Adopting the principles thus helps to illuminate the ways that technological innovations promising significant carbon abatement may have other, less desirable effects, and underscores that 'we cannot achieve a sustainability transition without justice, indeed that an unjust transition is not sustainable'.[14] Once those effects are identified, they can be weighed against the prospective carbon abatement and other benefits. More importantly, a concern with energy justice helps identify measures that will assist in spreading costs and benefits more equitably, and will ensure that decisions are made using procedures that facilitate the participation of all stakeholders.

### 1.2 Just access to space and mobility

The principle of 'just access to space and mobility' is concerned with ensuring that access to spaces and to means of transportation is equitably shared between all those who live in, frequent or visit a given area. This is particularly salient when it comes to urban settings and associated questions about city design and liveability.

The content of the principle draws from the concept of 'mobility justice', a field of inquiry that among other things examines 'governance and control of movement and how political power shapes the patterns of unequal mobility and immobility in the circulation of people, resources, and information at different geographic scales'.[15] Among its concerns are 'justice questions raised by difficulties some people face in moving around, whether that is moving around neighbourhoods, or over long distances', and by the 'impacts of [t]ransport, and the often uneven distribution of those impacts'.[16] Caroline Mullen and Greg Marsden note that although people make choices about their transportation, these choices are circumscribed by the kinds of built environment in which they live. A core question for them, as for this paper, is 'what possibilities (or sets of choices) do we collectively want to attempt to facilitate?'.[17]

This concern with mobility, which includes not only transportation by machines but also walking, is of specific relevance in the climate context,

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11 Various aspects of this right are cited in provisions of *United Nations Declaration on the Rights of Indigenous Peoples*, UN GAOR, 61st Sess, 107th Mtg, UN Doc A/61/L67 (13 September 2007). See also Stephen Young, *Indigenous Peoples, Consent and Rights: Troubling Subjects* (Routledge, 2020) 3–6.

12 See Gabrielle Appleby, Sean Brennan and Megan Davis, 'Constitutional Enshrinement of a First Nations Voice-Issues Paper for Public Discussion. Issues Paper 1: The Constitutional Amendment (September 2022)' static1.squarespace.com/static/602f123f11087d603fa92730/t/631a73c9700b2b4827cff5a7/1662677963921/ILC+Issues+Paper+%231+-+The+constitutional+amendment.pdf.

13 Sovacool et al (n 3) 2; For examples of injustices wrought by solar development see, e.g. Komali Yenneti, Rosie Day and Oleg Golubchikov, 'Spatial Justice and the Land Politics of Renewables: Dispossessing Vulnerable Communities through Solar Energy Mega-Projects' (2016) 76 *Geoforum* 90; Lauren Kaori Gurley, 'Shifting America to Solar Power Is a Grueling, Low-Paid Job', *Vice* (online, 27 June 2022) vice.com/en/article/z34eyx/shifting-america-to-solar-power-is-a-grueling-low-paid-job, considering India and the United States, respectively.

14 Stephen Williams and Andréanne Doyon, 'Justice in Energy Transitions' (2019) 31 *Environmental Innovation and Societal Transitions* 144, 144.

15 Jason Henderson, 'EVs Are Not the Answer: A Mobility Justice Critique of Electric Vehicle Transitions' (2020) 110(6) *Annals of the American Association of Geographers* 1993, 1994.

16 Caroline Mullen and Greg Marsden, 'Mobility Justice in Low Carbon Energy Transitions' (2016) 18 *Energy Research & Social Science* 109, 109.

17 Ibid 114.

given that '24% of direct $CO_2$ emissions from fuel combustion' are attributable to the transport sector.[18] The concerns of this discussion paper with various dimensions of energy production are closely linked to their relationship with transportation. Additionally, the aspects of this principle that concern mobility bear a particularly direct connection to policy settings connected with electric vehicles, as we discuss in Section 3 below.

Furthermore, the content of this principle extends beyond a concern with movement also to encompass concerns about the use of, and access to, spaces – particularly in cities. As we set out in Section 3 below, for example, the car-ownership culture that continues to be presupposed and perpetuated by some visions of the electric vehicle transition relies on infrastructures and allocations of urban space, such as roadways, parking and charging stations, that preclude other potentially more equitable and beneficial uses. The more static, spatial aspect of this principle also has other dimensions, which relate closely to the energy justice principles set out above. For instance, the location and pricing structures of potentially desirable infrastructures such as community owned batteries may increase local house prices, just as the location of potentially undesirable infrastructures, such as waste-to-energy plants, may decrease them. This may place socioeconomic constraints on, among other things, access to housing in desirable locations, and may have other effects on urban design and on just access to space.

## 1.3 Respect for the totality of ecological limits

Climate change can be understood as being the result of overconsumption of fossil fuels, generated by overconsumption of the goods and services that burning those fuels has enabled, particularly in the developed world. One way to mitigate this effect is to focus on substitutes for fossil fuels, of the kinds we assess in this paper. These kinds of substitutions can be understood as technological fixes for complex problems. Reliance on technological fixes of this kind runs the risk of generating complacency, and thereby undermining the larger social and economic adjustments that are required to ensure that human lifestyles and consumption patterns do not exceed the Earth's ecological limits.

These larger adjustments can be viewed from increasingly systemic viewpoints. To begin with, widening one's perspective from a narrow focus on carbon abatement highlights the potential of carbon-abating technologies to generate other kinds of environmental externalities. For instance, as we consider in Sections 3 and 4, promoting the use of electric vehicles, and developments in battery storage for renewable energy bring with them demands for other minerals such as cobalt and lithium, alongside associated mining and related environmental concerns.

More broadly, overconsumption patterns that underpin the overshooting of the Earth's ecological limits are a structural problem that requires structural solutions. Even while accepting that any solution to this problem cannot be reliant on behaviour changes at the individual consumer level (though these can also have considerable impact),[19] it is important that implementing measures for substitution of fossil fuels does not drown out other initiatives for curtailing consumption and making more thorough use of resources. This concern is relevant to all the

18 Jacob Teter, Jacopo Tattini and Apostolos Petropoulos, *Tracking Transport 2020* (International Energy Agency, May 2020) iea.org/reports/tracking-transport-2020.

19 See Katie Williamson et al, *Climate Change Needs Behavior Change: Making the Case for Behavioral Solutions to Reduce Global Warming* (Rare, Centre for Behavior and Economics, 2018) rare.org/wp-content/uploads/2019/02/2018-CCNBC-Report.pdf.

technologies we discuss in this paper, but we return to it most explicitly in Subsection 6.3.1 below in considering waste to energy systems.

Most challenging of all is the implication that solving the structural problems that underpin overshoot-related consumption must involve thinking critically about the sustainability implications of prioritising growth as the key measure of nations' economic and political success.[20] As has been observed:

> climate is … distinctive as a policy domain for the fact that, given the scale and scope of the crisis, its general, long-term telos has to be the facilitation of a broad socio-technical transformation of society, as captured by emerging paradigms like the 'green new deal', 'strong ecological modernisation', or 'ecological civilisation'.[21]

Even green new deals or varieties of ecological modernisation may be insufficiently transformative: the rising popularity of Kate Raworth's 'doughnut economics'[22] challenges growth assumptions even more directly by embedding into economics the dual normative goals of minimum social foundations and ecological ceilings. Similarly, the degrowth movement advocates 'a planned reduction of energy and resource throughput designed to bring the economy back into balance with the living world in a way that reduces inequality and improves human well-being'.[23]

In short, the three principles that this discussion paper argues should be threaded through a regulatory assessment of green technology in Australia have systemic implications at three levels: the necessity for analysis of cross-sectoral and unexpected externality impacts; the importance of focusing on consumption as much as production; and the long-term tenability of underlying models of economic growth and development. Bearing in mind both the principles themselves and the variable implications they might have on large-scale system change provides a fertile entry-point for debating the detailed technical and regulatory dimensions of green technology explored in the remainder of the discussion paper.

Before we enter into our detailed analysis of each of our four specific technologies, we examine one more broadly impactful segment of the carbon regulatory landscape – carbon pricing, and other related market interventions. We set this out separately here at the outset because this aspect of the regulatory landscape affects regulation of each of the four more specific technologies we go on to discuss. We also explain the relationship of carbon pricing to energy justice.

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20 See, e.g. George Monbiot, '"*Green Growth" Doesn't Exist – Less of Everything Is the Only Way to Avert Catastrophe*', *The Guardian* (online, 29 September 2021) theguardian.com/commentisfree/2021/sep/29/green-growth-economic-activity-environment.

21 Robert MacNeil, 'Swimming against the Current: Australian Climate Institutions and the Politics of Polarisation' (2021) 30(sup1) *Environmental Politics* 162, 178.

22 Kate Raworth, *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist* (Chelsea Green Publishing, 2017). Both normative dimensions have a foundation in science and policy: the minimum social foundations are mapped by the UN Sustainable Development Goals and the ecological ceilings by the Stockholm Institute's planetary boundaries.

23 Jason Hickel, 'What Does Degrowth Mean? A Few Points of Clarification' (2021) 18(7) *Globalizations* 1105, 1106.

# 2. Carbon pricing and other market interventions

In 2021, ahead of the Glasgow Conference of the Parties to the United Nations Framework Convention on Climate Change, the Morrison Government committed to a carbon abatement goal of 'net zero by 2050'. We set out briefly here what that commitment entails, before noting three associated regulatory strategies that have played a part in Australia's climate change response: carbon pricing; incentivised targets for renewable energy generation; and the provision of direct and indirect subsidies to climate-related industries. A consistent and clear national set of emissions reductions policies might involve considering aspects of any or all of these practices. One advantage often cited for the adoption of such policies is that it would contribute to certainty, thus allowing for a clearer pathway for investment decisions to be made in relation to the adoption of green technology solutions to the climate crisis. This point was underscored in the 2017 review of the reliability of the National Electricity Market (NEM) chaired by Chief Scientist Alan Finkel (*Finkel Review*). The *Finkel Review*'s report noted that the 'lack of a transparent, credible and enduring emissions reduction mechanism for the electricity sector is now the key threat to system reliability'.[24]

Further underlining its relevance to the concerns of this discussion paper, the Morrison Government's Glasgow commitment focused on technological solutions to the climate crisis. Accompanying this commitment, the Morrison Government released a suite of policy documents: *Australia's Long-Term Emissions Reduction Plan*[25] (*Emissions Reduction Plan*) and its accompanying *Modelling and Analysis*;[26] a summary document entitled *The Plan to Deliver Net Zero the Australian Way*;[27] and a yearly *Low Emissions Technology Statement*[28] that forms part of the *Technology Investment Roadmap.*[29]

The *Emissions Reduction Plan* promises that it 'does not rely on taxes and it will not put industries, regions or jobs at risk. No Australian jobs will be lost as the result of the Commonwealth Government's actions or policies under the Plan.'[30] Furthermore, it promises not to 'impose new costs on households or businesses', 'raise the price of our energy or reduce the competitiveness of our export industries' or 'shut down coal or gas production or require displacement of productive agricultural land'.[31]

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24 Alan Finkel et al, 'Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future' 75 energy.gov.au/sites/default/files/independent-review-future-nem-blueprint-for-the-future-2017.pdf.

25 Australian Government, 'Australia's Long-Term Emissions Reduction Plan: A Whole-of-Economy Plan to Achieve Net Zero Emissions by 2050' dcceew.gov.au/climate-change/publications/australias-long-term-emissions-reduction-plan.

26 Australian Government, 'Australia's Long-Term Emissions Reduction Plan: Modelling and Analysis' dcceew.gov.au/climate-change/publications/australias-long-term-emissions-reduction-plan.

27 Australian Government, 'The Plan to Deliver Net Zero the Australian Way' dcceew.gov.au/climate-change/publications/australias-long-term-emissions-reduction-plan.

28 Australian Government Department of Industry, Science, Energy and Resources, 'Technology Investment Roadmap: First Low Emissions Technology Statement - 2020' dcceew.gov.au/sites/default/files/documents/first-low-emissions-technology-statement-2020.pdf; Australian Government Department of Industry, Science, Energy and Resources, 'Low Emissions Technology Statement 2021' dcceew.gov.au/sites/default/files/documents/low-emissions-technology-statement-2021.pdf.

29 'Technology Investment Roadmap', *Australian Government Department of Industry, Science, Energy and Resources* (14 September 2021) industry.gov.au/data-and-publications/technology-investment-roadmap.

30 Australian Government, 'Australia's Long-Term Emissions Reduction Plan: A Whole-of-Economy Plan to Achieve Net Zero Emissions by 2050' (n 25) 11, 26.

31 Ibid 11.

The *Emissions Reduction Plan* is premised on five principles: 'technology not taxes'; 'expand choices, not mandates'; 'drive down the cost of a range of new energy technologies'; 'keep energy prices down with affordable and reliable power'; and 'be accountable for progress'.[32]

As part of its technological solutions, the Morrison Government proposed spending of over $20 billion on low emissions technologies by 2030, alongside 'helping to secure over $80 billion in total investment from the private sector and state governments'.[33] The Morrison Government set out its priority technologies as being: clean hydrogen; ultra low-cost solar; energy storage for firming; low emissions steel; low emissions aluminium; carbon capture and storage; and soil carbon.[34] These technological priorities are closely connected to the four major topics of this report – hydrogen and energy storage directly, and low-cost solar, low emissions steel and aluminium production and carbon capture and storage as relating to those four main topics.

In order to achieve its goal of net zero by 2050, the Emissions Reduction Plan relies for 40% of the necessary abatement on the Technology Investment Roadmap, 10-20% on international and domestic offsets, and up to 15% on future technological breakthroughs.[35] The remainder is comprised of emissions to date (20%) and global technology trends (15%).

The *Emissions Reduction Plan* has received criticism. Renewable energy entrepreneur and prominent climate campaigner Simon Holmes á Court has noted that it is vague on details about the technologies it proposes to deliver, while at the same time neglecting to implement the existing technologies that would have a very real impact on diminishing Australia's carbon emissions – for instance, augmenting national capacities in wind and solar energy generation, and storage.[36] Michael Mazengarb has argued that the plan is short on detail, and that leaving the final 15% of emissions reductions to as-yet non-existent technology is tantamount to aiming only for an 85% emissions reduction by 2050, rather than net zero.[37] Mazengarb has also noted that 'the government is counting on a substantial and ongoing role for Australia's fossil fuel industries'.[38] He further criticised the *Emissions Reduction Plan* for its lack of detail on clean energy transitions in electricity provision and industry and other sectors, and for failing to show how Australia can capitalise on increasing demand for emission free goods, such as renewable hydrogen and green metals.[39] Other criticism has focused on the modelling of soil and plant carbon storage, arguing that it significantly overstates the amount of sequestration achievable;[40] on the continued reliance on fossil fuels;[41] and on other features, including a focus

32 Ibid.

33 Ibid 15.

34 Ibid.

35 Ibid.

36 Simon Holmes á Court, 'Scott Morrison Is Hiding behind Future Technologies, When We Should Just Deploy What Already Exists', *RenewEconomy* (8 November 2021) reneweconomy.com.au/scott-morrison-is-hiding-behind-future-technologies-when-we-should-just-deploy-what-already-exists.

37 Michael Mazengarb, 'Morrison Chooses Fossil Fuels over Farmers in "Laughable" Net Zero Modelling', *RenewEconomy* (12 November 2021) reneweconomy.com.au/how-the-morrison-government-chose-fossil-fuels-over-farmers-detailed-in-laughable-net-zero-modelling/.

38 Ibid.

39 Ibid.

40 Adam Morton and Peter Hannam, 'Australia's 2050 Net Zero Emissions Plan Relies on "Gross Manipulation" of Data, Experts Say', *The Guardian* (online, 29 October 2021) theguardian.com/australia-news/2021/oct/30/australias-2050-net-zero-emissions-plan-relies-on-gross-manipulation-of-data-experts-say.

41 Damien Cave, 'Australia Pledges "Net Zero" Emissions by 2050. Its Plan Makes That Hard to Believe.', *The New York Times* (online, 26 October 2021) nytimes.com/2021/10/26/world/australia/net-zero-delay.html.

on a global temperature increase of 2°C rather than 1.5°C, the failure to adopt a new 2030 target, and its dependence on voluntary taxes.[42] By contrast, Holmes á Court has noted that '[m] ost economists agree that the most efficient way to reduce emissions is to put a price on carbon and let the market respond', but that the way that politics has served to make this impossible 'leaves policymakers with few tools'.[43]

The federal election in May 2022 saw the Coalition Government under Scott Morrison replaced by a Labor Government under Anthony Albanese, and substantial electoral gains to the Greens and to Independents who had made stronger action on climate change a key element of their campaigns. Labor's campaign pledge was to achieve a 43% reduction in emissions over 2005 levels by 2030; compared with the Coalition's 26-28%. Experts suggest neither pledge would be sufficient to bring Australia within the more ambitious Paris Agreement target of 1.5°C.[44]

Carbon pricing was briefly a reality in Australia between 2012 and 2014, operating as part of what has been described as a 'broadly based, administratively smooth, environmentally effective, economically efficient and equitable set of emissions-reduction policies, largely governed by market processes'.[45] The price on carbon was accompanied by the Renewable Energy Target (RET – described below), and the establishment of the Australian Renewable Energy Agency (ARENA), the Clean Energy Finance Corporation (CEFC), the Carbon Farming Initiative and the Climate Change Authority.[46] The carbon price as enacted in Australia by legislation in 2011[47] was a hybrid scheme, involving features of both an emissions trading scheme and a carbon tax.[48] In the first three years of its scheduled operation, the price on carbon was to be fixed, thus operating as a tax. Carbon emitters were to pay a set price per year per tonne of CO2 equivalent they emitted.[49] Initially priced for the first three years at $23 per tonne plus interest and inflation, the price was to float from mid-2015 through an emissions trading scheme that was to be linked to the European trading scheme.[50] Despite its economic efficiency and demonstrated emissions reductions, the carbon price was abolished in 2014.[51]

The RET was introduced by the Howard Government in 2001, with a target of 9500 gigawatt hours (GWh) of renewable generation by 2010. The Rudd Government extended it, to a target of 41,000 GWh, or 20% of expected

42 Ross Garnaut, 'Morrison "Plan" Is Kidding about Australia Reaching Net Zero', *Australian Financial Review* (online, 21 November 2021) afr.com/policy/energy-and-climate/morrison-plan-is-kidding-about-australia-reaching-net-zero-20211120-p59alh; Rayane Tamer and Rashida Yosufzai, '"Comically Flawed": Climate Experts Criticise Australia's Net Zero Modelling', *SBS News* (13 November 2021) sbs.com.au/news/comically-flawed-climate-experts-criticise-australia-s-net-zero-modelling/c0797e3d-0514-466c-a9a4-884ea8b3cc43.

43 Holmes á Court (n 36).

44 'Q&A: What Does the New Australian Labor Government Mean for Climate Change?', *Carbon Brief* (24 May 2022) carbonbrief.org/qa-what-does-the-new-australian-labor-government-mean-for-climate-change.

45 Ross Garnaut, *Superpower: Australia's Low Carbon Opportunity* (La Trobe University Press, 2019) 31.

46 Ibid.

47 *Clean Energy Act 2011* (Cth).

48 Jacqueline Peel, 'The Australian Carbon Pricing Mechanism: Promise and Pitfalls on the Pathway to a Clean Energy Future' (2014) 15(1) *Minnesota Journal of Law, Science & Technology* 429, 436.

49 Ibid 439.

50 Garnaut (n 45) 31; Peel (n 48) 439.

51 Garnaut (n 45) 33; Neil Gunningham and Megan Bowman, 'Energy Regulation for a Low Carbon Economy: Obstacles and Opportunities' (2016) 33 *Environmental and Planning Law Journal* 118, 123–4.

demand by 2020. In 2015, the Abbott Government decreased it to 33,000 GWh, or between 15% and 20% of expected demand.[52] The RET had two principal components: small-scale, involving projects such as rooftop solar, up to 100 kilowatt hours (KWh); and large-scale projects.[53] The large-scale RET operated by implementing a market for the trading of renewable energy generation certificates: generators would create certificates per quantity of renewable energy they produced, which they could then sell to retailers, who would use them as proof they had met their mandated obligations to purchase a set quantity of renewable energy.[54] Neil Gunningham and Megan Bowman argue that measures such as the RET are 'both effective and efficient because, while prescribing socially preferred outcomes, they leave the means of achieving them up to regulatees, thereby providing incentives for least cost solutions', with the RET itself appearing to be 'one of the most cost-effective emissions reductions policies available'.[55] The revised RET target was met before schedule. It is understood to have contributed to bringing down the costs of renewable energy generation, to the extent that subsidies are no longer required.[56] The winding-down of the RET was, however, accompanied by a winding-down of new investment in renewable generation capacity.[57] Even though renewables are now low cost, their installation costs decrease their competitiveness against already constructed assets, such as coal-fired power stations. One analyst, referencing the goals of the 2015 Paris Climate Change Agreement, has warned that 'unless emissions-intensive generation closes or renewable energy support is reintroduced, renewable energy expansion in Australia is unlikely to proceed at the pace required to meet the Paris targets'.[58] In 2020, the Clean Energy Council noted that the ongoing 'absence of a policy to replace the RET leaves clean energy, and the energy industry as a whole, in a state of uncertainty at a time when investment in new generation should be increasing to replace our ageing fleet of coal-fired power stations and meet our emissions reduction commitments'.[59]

The *Finkel Review* recommended a continuation of the RET in the form of a Clean Energy Target, or CET, under which electricity generators would be granted certificates for new generation carried out below a set emissions intensity threshold, in proportion to how far it fell below that threshold. Electricity retailers would then be required to purchase these certificates in fulfilment of a requirement that a set proportion of their electricity was sourced from low-emissions sources.[60] The *Finkel Review* considered that this scheme would increase renewable energy's share of generation in Australia to 42% by 2030.[61] The CET was not implemented.[62]

Finally, the question of subsidies for various energy sources is ripe for review. While it is difficult to reach a single figure on the quantum

52 Ketan Joshi, *Windfall: Unlocking a Fossil-Free Future* (NewSouth Publishing, 2020) 90.

53 Garnaut (n 45) 77.

54 'Large-Scale Renewable Energy Target', *Australian Government Clean Energy Regulator* (2 August 2022) cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Large-scale-Renewable-Energy-Target.

55 Gunningham and Bowman (n 51) 126.

56 Joshi, *Windfall: Unlocking a Fossil-Free Future* (n 52) 90–94.

57 Dylan McConnell, 'Australia Has Met Its Renewable Energy Target. But Don't Pop the Champagne', *The Conversation* (6 September 2019) theconversation.com/australia-has-met-its-renewable-energy-target-but-dont-pop-the-champagne-122939.

58 Ibid.

59 Clean Energy Council, *Clean Energy Australia Report 2020* (2020) assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2020.pdf.

60 Finkel et al (n 24) 89.

61 Ibid 92.

62 Joshi, *Windfall: Unlocking a Fossil-Free Future* (n 52) 172–75.

of fossil fuel subsidies, not least because there is debate over what measures constitute a subsidy,[63] a 2019 International Monetary Fund report calculated Australia's post-tax fossil fuel subsidy as totalling $US 29 billion in 2015.[64] A 2021 report by the think tank The Australia Institute found that subsidies across the Commonwealth and the states amounted to $10.3 billion in the budget year 2020-21, of which the largest component, the federal Fuel Tax Credit Scheme, amounts to $7.8 billion.[65] In 2016, Gunningham and Bowman cited research from the Australian Conservation Foundation that stated that fossil fuel subsidies would comprise $47 billion over the four years between 2014 and 2018.[66] Other estimates of yearly fossil fuel subsidies range between $1 billion and $12 billion.[67] By contrast, research commissioned by the Minerals Council of Australia was reported in 2017 to have calculated subsidies for renewable energy by Australian governments at $2.8 billion per year to 2030, in order to meet the RET.[68]

Each of the measures cited in this section can be examined through an energy justice lens. For instance, while removing subsidies for fossil fuels may have benefits for carbon abatement, it will also have disproportionate impacts on certain sectors, affecting most obviously the livelihoods of those directly employed in fossil fuel extraction, alongside those employed in dependent and related industries. For this reason, such measures require careful phasing, and the provision of alternative sources of employment and training.[69] Although the term is contentious in some communities whose economies have historically depended on fossil fuel industries,[70] literature

63 Jeremy Moss, 'Matt Canavan Says Australia Doesn't Subsidise the Fossil Fuel Industry, an Expert Says It Does', *The Conversation* (3 June 2020) theconversation.com/matt-canavan-says-australia-doesnt-subsidise-the-fossil-fuel-industry-an-expert-says-it-does-131200.

64 David Coady et al, *Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates* (IMF Working Paper No WP/19/89, International Monetary Fund, May 2019) 35. The report defines 'post-tax subsidies' as 'differences between actual consumer fuel prices and how much consumers would pay if prices fully reflected supply costs plus the taxes needed to reflect environmental cost and revenue requirements': 7-8. And see Moss (n 63).

65 Rod Campbell, Eliza Littleton and Alia Armistead, *Fossil Fuel Subsidies in Australia: Federal and State Government Assistance to Fossil Fuel Producers and Major Users 2020-21* (Australia Institute, April 2021) 1.

66 Gunningham and Bowman (n 51) 138.

67 Moss (n 63); Campbell, Littleton and Armistead (n 65) 4.

68 Mark Ludlow, 'Renewable Energy Subsidies to Top $2.8b a Year up to 2030', *Australian Financial Review* (online, 13 March 2017) afr.com/politics/renewable-energy-subsidies-to-top-28b-a-year-up-to-2030-20170313-guwo3t; The research was commissioned from consultancy BAEconomics, which found that 'Australian electricity customers paid more than $2.1 billion to subsidise large-scale power station developers and small customers with rooftop solar installations': Sabine Schnittger and Brian S Fisher, *Primer on Renewable Energy Subsidies in Australia: Report to the Minerals Council of Australia* (BAEconomics, January 2017) 2. BAEconomics's conclusions on subsidies have been questioned: see, e.g. Giles Parkinson, 'How Alan Jones Made Josh Frydenberg Look like a Moderate', *RenewEconomy* (19 May 2018) reneweconomy.com.au/how-alan-jones-made-josh-frydenberg-look-like-a-moderate-21752/.

69 See, e.g. Garnaut (n 45).

70 Gareth Edwards et al, *Towards a Just Transition from Coal in Australia?* (Sydney Environment Institute, April 2022) sei.sydney.edu.au/wp-content/uploads/2022/04/SEI-formatted-Just-Transition-from-Coal-in-Aus-Summary-Report.pdf.

and practice on 'just transitions' and related concepts may be of assistance in identifying and implementing programs to ensure that the pain of the renewable energy transition is not disproportionately borne by those communities.[71] Concerted and careful government action is required to bring this about.[72] Similarly, any implementation of a price on carbon requires measures to offset disproportionate impacts. For this reason, the carbon price legislated in 2011 was accompanied by a range of compensation measures to households to offset increases in energy prices.[73]

The system reliability concerns noted by Alan Finkel, as cited at the beginning of this section, are also unlikely to affect all energy consumers equally. At the household level, for example, some households are capable of insulating themselves from grid stability issues through purchasing solar panels and batteries or backup generators. Others are not, for a range of reasons including not just the affordability of these measures, but also because they may be renting, or living in apartments.

These kinds of market interventions raise concerns from the perspective of procedure and due process. For one, determining the extent of fossil fuel subsidies can be complicated: the Australia Institute's report notes, for example, that while in some instances, 'identifying which budget items meet the criteria of a fossil fuel subsidy is straightforward', further investigation was required to determine whether and which fossil fuel operators would be the beneficiaries of government-funded infrastructure projects.[74] A lack of accessible and transparent data about government decision-making on this topic makes it difficult for the public to engage with the issue and participate in determining how government resources should best be deployed. This lack of transparency about funding can be coupled with other instances of limited transparency in Commonwealth climate policies,[75] and which people, industries and lobbies are involved in influencing government climate programs through political donations or other means.[76]

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71 See George Goddard and Megan A Farrelly, 'Just Transition Management: Balancing Just Outcomes with Just Processes in Australian Renewable Energy Transitions' (2018) 225 *Applied Energy* 110; John Quiggin, *Getting off Coal: Economic and Social Policies to Manage the Phase-out of Thermal Coal in Australia* (Discussion Paper, Australia Institute, May 2020) australiainstitute.org.au/wp-content/uploads/2020/12/P881-Getting-Off-Coal-WEB.pdf.

72 Quiggin (n 71) 23–4.

73 Jeremy Thompson, 'Gillard Reveals Carbon Price Scheme', *ABC News* (online, 10 July 2011) abc.net.au/news/2011-07-10/gillard-reveals-carbon-price-scheme/2788842.

74 Campbell, Littleton and Armistead (n 65) 5.

75 See, e.g. Simon Holmes à Court, 'As Angus Taylor Ducks, Weaves and Dithers, China Zooms Past', *The Guardian* (online, 13 June 2019) theguardian.com/commentisfree/2019/jun/13/as-angus-taylor-ducks-weaves-and-dithers-china-zooms-past.

76 See Marian Wilkinson, *The Carbon Club* (Allen & Unwin, 2020).

# 3. Electric Vehicles

## 3.1 Introduction

An 'electric vehicle' (EV) is a vehicle that uses an onboard electric motor to provide its motion. Electric vehicles differ from traditional internal combustion engines (ICEs), which are powered by burning fossil fuels. Electric motors come in three main kinds: Battery-Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Fuel Cell Electric Vehicles or Hydrogen Fuel Cell Vehicles (FCEVs).[77] BEVs have batteries that must be recharged using an external source of electricity. PHEVs have both a battery that is recharged from an external electricity source, and an internal combustion engine that can extend the range of the vehicle between charges. FCEVs power their electric motors with electricity they generate themselves through hydrogen fuel cells. They are then refuelled with hydrogen gas.[78]

Viewed from the perspective of climate change abatement, there may be tangible benefits to encouraging the uptake of EVs in Australia.[79] The extent of those benefits depends significantly on the source of the electricity powering those vehicles. As at 2019 the state of Victoria, with its reliance on energy generated from inefficient brown coal, was the only Australian jurisdiction where emissions from electric vehicles compared unfavourably with emissions from ICEs.[80] The calculus of carbon benefit may differ depending on the parameters of the modelling used, including the extent to which the carbon emissions embedded in vehicle manufacture are included in the relevant calculations.[81] EV batteries, in particular, generate high emissions in their manufacture: breaking even on these emissions may require considerable amounts of driving, and the emissions benefit is in turn negated if the battery requires replacing.[82] As we outline below, the environmental, human rights and financial costs of extracting the necessary raw materials is considerable, and may grow as the highest quality and most accessible minerals are depleted first.[83] Evaluating the beneficial effects of EV adoption requires taking all of these factors into account.

One benefit of EVs compared with ICEs is that their emissions profiles are capable of improving as the electricity grid adopts cleaner generation technologies,[84] though there may be limits to how far generation can be made renewable in the near term.[85] Further benefits are to be found, among other things, in reduced exhaust pollution and its

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77 Senate Select Committee on Electric Vehicles, *Report* (Parliament of Australia, January 2019) 3–4; Tom Gotsis, *Electric Vehicles in NSW* (e-brief No 1/2018, NSW Parliamentary Research Service, May 2018) 1–2.

78 Senate Select Committee on Electric Vehicles (n 77) 3–4; Gotsis (n 77) 1–2. A fourth kind of vehicle, a Hybrid Electric Vehicle or HEV, is powered by both an internal combustion engine and one or more electric motors, but is not considered here because it cannot be plugged in to an external electricity source.

79 Robin Smit, Jake Whitehead and Simon Washington, 'Where Are We Heading with Electric Vehicles?' 52(3) *Air Quality and Climate Change* 18; and see, in the US context on comparative emissions, Reichmuth, David, 'Are Electric Vehicles Really Better for the Climate? Yes. Here's Why', *Union of Concerned Scientists* (blog, 11 February 2020) blog.ucsusa.org/dave-reichmuth/are-electric-vehicles-really-better-for-the-climate-yes-heres-why.

80 Senate Select Committee on Electric Vehicles (n 77) 36; and see Alannah Milton, 'Visions of Electrification and Potential for Decarbonisation: The Absence of Ridesharing and Carsharing in Australia's Electric Vehicle Policy' (2021) 38 *Environmental and Planning Law Journal* 132, 140; Florian Knobloch et al, 'Net Emission Reductions from Electric Cars and Heat Pumps in 59 World Regions over Time' (2020) 3(6) *Nature Sustainability* 437, 441, 444.

81 See Paul Wolfram and Thomas Wiedmann, 'Electrifying Australian Transport_ Hybrid Life Cycle Analysis of a Transition to Electric Light-Duty Vehicles and Renewable Electricity | Elsevier Enhanced Reader' (2017) 206 *Applied Energy* 531.

82 Henderson (n 15) 1997.

83 International Energy Agency, *The Role of Critical Minerals in Clean Energy Transitions* (World Energy Outlook Special Report, May 2021) 12.

84 Reichmuth, David (n 79).

85 Henderson (n 15) 2001–02.

associated health benefits,[86] and opportunities to generate new industries in the manufacture and repair of vehicle components.[87]

These benefits do not mean that Australian jurisdictions should uncritically rush to adopt policies to encourage EV uptake. Any such policies must be weighed carefully against their potential social, economic and environmental effects. While under the right conditions EVs may represent a better environmental performance than ICE vehicles, their adoption should be considered in light of wider questions about what kinds of cities we want. One model of the EV future revolves around substitution: EVs replace ICE vehicles, with associated changes to charging infrastructures, but everything else remains the same. Another model is predicated on thinking more critically about all available options for urban regeneration, recognising that there may be other, better ways forward than planning cities around existing or growing levels of car usage. Cars, after all, are deadly.[88] Cars, even electric cars, also produce high degrees of particulate pollution, which can have significant human health effects,[89] caused by wear on their brakes, tyres and road surfaces, and their stirring up of road dust. A report in the United Kingdom (UK) found that brake, tyre and surface wear emissions were responsible for 7.4% of all UK primary $PM_{2.5}$ emissions, and 8.5% of $PM_{10}$ emissions.[90] There will continue to be problems of road congestion, which may worsen, and there will continue to be a need for expensive infrastructure, including parking and roads.[91]

These considerations have significant implications for each of the three energy transition principles we develop in this paper. The spatial and mobility justice implications are particularly salient so they are what we focus on here.

One recent study determined that New South Wales (NSW) and federal EV policies are largely predicated around a conservative, substitutive model, thus constraining their decarbonisation capacity.[92] This is because of EVs' '[l]ife-cycle emissions, increased driving, use as an additional car, and competition with green mobility options such as public transport, cycling and walking'.[93] Milton takes note of the various policy settings that are designed to boost substitution and private EV uptake, including tax incentives for vehicle purchases, support for the rollout of private charging facilities, and incentivisation

86 Smit, Whitehead and Washington (n 79) 21.

87 Senate Select Committee on Electric Vehicles (n 77) 49–52.

88 Worldwide, road traffic accidents account for some 1.3 million deaths per year and are the principal cause of death for people between the ages of 5 and 29: 'Road Traffic Injuries: Fact Sheet', *World Health Organization* (Web Page, 20 June 2022) who.int/news-room/fact-sheets/detail/road-traffic-injuries. In Australia, there were 1,195 road crash deaths in 2019. Of these, 160 were pedestrians and 39 were cyclists. There were 39,330 hospitalised injuries in 2017, of which 24.9% constituted a high threat to life: Bureau of Infrastructure, Transport and Regional Economics, *Road Trauma Australia 2019 Statistical Summary* (Australian Government Department of Infrastructure, Transport, Regional Development and Communications, 2020) 4, 26.

89 Doug Brugge and Kevin James Lane, 'Fine Particle Air Pollution Is a Public Health Emergency Hiding in Plain Sight', *The Conversation* (15 November 2018) theconversation.com/fine-particle-air-pollution-is-a-public-health-emergency-hiding-in-plain-sight-106030.

90 Air Quality Expert Group, *Non-Exhaust Emissions from Road Traffic* (Department of Environment, Food and Rural Affairs; Scottish Government; Welsh Government; Department of the Environment in Northern Ireland, 2019) 8 uk-air.defra.gov.uk/assets/documents/reports/cat09/1907101151_20190709_Non_Exhaust_Emissions_typeset_Final.pdf.

91 Amelia Thorpe, Declan Kuch and Sophie Adams, 'On an Electric Car Road Trip around NSW, We Found Range Anxiety (and the Need for More Chargers) Is Real', *The Conversation* (8 February 2021) theconversation.com/on-an-electric-car-road-trip-around-nsw-we-found-range-anxiety-and-the-need-for-more-chargers-is-real-154071.

92 Milton (n 80) 133.

93 Ibid 138.

of electrification of government and business fleets.[94] In the conservative model, ICE manufacturers transition to EV manufacture, but continue to rely on mass uptake by individual consumers.[95]

In line with the overarching concerns of this paper – that green technology transitions need to be considered in a larger context that involves careful consideration of the shape of the desired future – Milton points to a missed opportunity in failing to imagine the EV transition as a component of a shared intermodal system in which '[e]lectrified public transport, ridesharing and carsharing become the dominant forms of automobility'.[96] Electrified ridesharing and carsharing have the potential to increase decarbonisation, as compared with the substitution model of private car ownership and use.[97]

Jason Henderson's scholarship has identified some of the assumptions underpinning optimistic predictions of EVs' environmental performance. These assumptions are worth questioning. One such assumption is that car production and use will continue to grow.[98] A related assumption pertains to projections about the use of EVs as mobile charging stations for houses. Because peak household demand occurs during the evenings, this assumes that people will charge their EVs during the day, for instance while at work or out shopping, 'compelling routine driving as necessary to stabilize the electricity grid and balance energy loads'.[99] Furthermore, because EVs are perceived to be environmentally beneficial, they may begin to substitute trips that might have been undertaken by other, less environmentally-damaging means, such as bicycles. Assumptions about the desirability of substitution, wherein decarbonisation is achieved through strategies such as swapping ICEs for EVs in ways that require no significant change to individual lifestyles, make policy choices that seek to limit cars and driving politically unpalatable.[100]

The justice implications of adopting these assumptions are profound. At an economic level, it is worth noting that EVs are frequently marketed to higher income consumers, who are also better placed to benefit from tax incentives and other regulatory measures designed to hasten EV uptake.[101] In terms of spatial and mobility justice more generally, there may be spatial conflicts as the ongoing roll-out of infrastructure for EVs, including chargers and all the circuitry, transformers and other structures associated with them, compete for space with other road uses, including bus lanes, cycle lanes and efforts at urban pedestrianisation.[102] Henderson argues that

> From a mobility justice perspective, demand for EV spaces and EV electricity capacity (whether renewable or nonrenewable) commodifies and privatizes access in new ways and could spike electricity prices and limit or control mobility for the kinetic underclasses – the slower moving, spatially constrained, lower income majority of the world's population.[103]

94 Ibid 138–39.
95 Ibid 139.
96 Ibid 140.
97 Ibid 142.
98 Henderson (n 15) 1995–97.
99 Ibid 1997.
100 Ibid 1998.
101 Ibid 1998–99.
102 Ibid 2002–03.
103 Ibid 2004.

Among these effects, any holistic regulatory strategy aimed at hastening the EV transition must be acutely aware that policies privileging the use of EVs, and especially policies supporting the heavier SUV and luxury forms of these vehicles that favour the wealthy, stand a high chance of being accompanied by reduced investment in transport infrastructure. This in turn contributes to forcing less wealthy citizens into the periphery of cities, with longer commutes and other reductions in amenity.[104] Better carbon abatement may be achieved by different strategies, including making cities denser, more walkable and richer in mass transit options.[105] In short, we urge that, as Amelia Thorpe, Declan Kuch and Sophie Adams have noted, EVs 'need to be part of a much wider transformation – especially in urban areas where other transport options are available'.[106]

With the understanding that any policy changes must be more sophisticated than simply clearing the path for wholesale adoption of EVs, we next provide a snapshot of the current regulatory landscape across Australia. We then consider five areas of regulatory complication concerning EVs: energy source; vehicle lifecycle, particularly of batteries; stability of electricity grids; dislocation of existing manufacturing and mechanical expertise, including the right to repair; and the environmental justice implications presented by increased demands for components in EV batteries. Aside from the space and mobility justice implications we have already described, these factors demonstrate that policies promoting accelerated EV uptake also have important reverberations for the third of the three framing considerations we set out at the outset: the need to ensure that the planet remains within its ecological limits.

## 3.2 The regulatory environment

In February 2021, the Morrison Government released for consultation its *Future Fuels Strategy Discussion Paper (FFS Discussion Paper)*. This replaced its previously-proposed National Electric Vehicles strategy, and has a broader ambit than that strategy, covering also biofuel-powered vehicles.[107] The finalised *Future Fuels and Vehicles Strategy* (FFVS) was released in November 2021.[108] The *FFS Discussion Paper* and the FFVS can be usefully read together, since the strategy document omits, without disavowing, some of the material advanced in the *FFS Discussion Paper*.

The FFVS rules out subsidising ownership of BEVs, with the *FFS Discussion Paper* arguing that this would not represent value for money in terms of abatement of carbon emissions.[109] The *FFS Discussion Paper* also claims that in NSW, Victoria, Queensland and the Australian Capital Territory (ACT), hybrids have lower emissions profiles than BEVs, and that the reverse is only true in South Australia (SA) and Tasmania.[110] These claims have been widely criticised as being based on inaccurate data and faulty reasoning.[111] The *FFS Discussion Paper* outlines the Government's five priority initiatives as 'electric vehicle charging and hydrogen refuelling infrastructure where it is needed'; 'early focus on commercial fleets'; 'improving information for motorists and fleets'; 'integrating battery electric vehicles into the electricity grid'; and 'supporting

104 Ibid.

105 Ibid 2005.

106 Thorpe, Kuch and Adams (n 91).

107 Adam Morton, 'Coalition Accused of Wasting 18 Months on "nothing" Electric Vehicle Strategy', *The Guardian* (online, 16 December 2020) theguardian.com/environment/2020/dec/16/coalition-accused-of-wasting-18-months-on-nothing-electric-vehicle-strategy.

108 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels and Vehicles Strategy: Powering Choice (November 2021)'.

109 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels Strategy: Discussion Paper (February 2021)' 4; Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels and Vehicles Strategy: Powering Choice (November 2021)' (n 108) 5.

110 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels Strategy: Discussion Paper (February 2021)' (n 109) 4.

111 Giles Parkinson, 'Angus Taylor's Trouble with Numbers Continues as He Snubs EVs on Emissions Costs', *The Driven* (5 February 2021) thedriven.io/2021/02/05/angus-taylors-trouble-with-numbers-continues-as-he-snubs-evs-on-emissions-costs; Ketan Joshi, 'Taylor Rehashes Old Climate Delay Tactics with New Hybrid Vehicle Plan', *RenewEconomy* (5 February 2021) reneweconomy.com.au/taylor-rehashes-old-climate-delay-tactics-with-new-hybrid-vehicle-plan; Adam Morton, '"Do-Nothing Document": Australian Electric Vehicle Strategy Lets Emissions Keep Rising', *The Guardian* (5 February 2021) theguardian.com/environment/2021/feb/05/do-nothing-document-australian-electric-vehicle-strategy-allows-emissions-to-keep-rising.

Australian innovation and manufacturing'.[112] The FFVS ties the strategy more explicitly to the *Emissions Reduction Plan* discussed in Section 2 above, stating that it 'is an example of those 5 principles in action', namely: technology not taxes; expand choices, not mandates; drive down the cost of a range of new technologies; keep energy prices down with affordable and reliable power; and be accountable for progress.[113] More specifically, the FFVS is guided by three principles: 'partnering with the private sector to support uptake and stimulate co-investment in future fuel technologies'; 'focusing on reducing barriers to the rollout of future fuel technologies, not taxes'; and 'expanding consumer choice by enabling informed choices and minimising costs of integration into the grid'.[114]

In September 2020, the Morrison Government announced a $74.5 million Future Fuels Fund, which it said was designed for 'helping businesses and regional communities take advantage of opportunities offered by hydrogen, electric and bio-fuelled vehicles'.[115] This was expanded with the release of the FFVS – a press statement from Prime Minister Morrison's office referred to $178 million in new funding, bringing the total Future Fuels Fund to a $250 million sum that is referred to in the FFVS document.[116] The FFVS proclaims that 'the Australian Government has now committed $2.1 billion to partner with industry to support uptake of low and zero emission vehicles. This includes investment totalling close to $360 million by 2026 for projects and programs focused on new vehicle technologies and future fuel redevelopment, through the Australian Renewable Energy Agency (ARENA)'.[117]

In February 2021, applications opened for the first round of the Future Fuels Fund: $16.5 million in grants, administered by ARENA, to 'support battery electric vehicle fast-charging stations across capital cities and key regional centres', with at least four fast charging stations to be set up in each of the Central Coast of NSW, Wollongong, Geelong, the Sunshine Coast and the Gold Coast.[118] Other initiatives included a two-year trial of BEVs for the parliamentary transport service COMCAR, designed to help determine 'how to integrate battery electric vehicles into other Government fleets', and upgrades to the

112 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels Strategy: Discussion Paper (February 2021)' (n 109) 7.

113 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels and Vehicles Strategy: Powering Choice (November 2021)' (n 108) 6.

114 Ibid 9.

115 Hon Angus Taylor MP, 'Investment in New Energy Technologies: Joint Media Release with Prime Minister Scott Morrison' minister.industry.gov.au/ministers/taylor/media-releases/investment-new-energy-technologies.

116 Scott Morrison and Angus Taylor, 'Driving Consumer Choice & Uptake of Low-Emissions Vehicles: Media Release' minister.industry.gov.au/ministers/taylor/media-releases/driving-consumer-choice-and-uptake-low-emissions-vehicles; Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels and Vehicles Strategy: Powering Choice (November 2021)' (n 108) 9–10.

117 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels and Vehicles Strategy: Powering Choice (November 2021)' (n 108) 9.

118 Hon Angus Taylor MP, 'Future Fuels Fund Opens: Media Release' minister.industry.gov.au/ministers/taylor/media-releases/future-fuels-fund-opens.

Green Vehicle Guide website.[119] The FFVS refers to $24.55 million of funding in Round 1 of the Future Fuels Fund, with 403 fast charging stations to be built in '14 of Australia's most populous regions'. The Future Fuels Fund is expected eventually to give charging coverage to some 84% of Australia's population.[120] The second round of the Future Fuels Fund opened in February 2022, comprising 'a $127.9 million funding envelope to support fleets to shift to zero emissions vehicle (ZEV) technology over the next four years'.[121]

The Future Fuels Fund was to be part of a strategy of co-investment with both the private sector and other governments. The Morrison Government laid out four investment strategies 'to support early uptake and consumer choice':

- public electric vehicle charging and hydrogen refuelling infrastructure;
- heavy and long distance vehicle fleets;
- light vehicle commercial fleets; and
- household smart charging.

This is designed to 'deploy charging infrastructure in over 400 businesses, 50,000 households and 1,000 public charging stations'.[122]

In addition, the FFVS notes $1.3 billion invested by the CEFC, since its inception, in co-financing programs with other lenders, to assist in uptake of low emissions vehicles and related programs. These investments include support for fleets of electric buses, alongside e-bikes for parcel, mail, food and grocery deliveries.[123]

The plan has been criticised by groups such as the Electric Vehicle Council, which, in response to the *FFS Discussion Paper*, has argued that Australia's inertia on EVs, as exemplified in the strategy, will do nothing to change practices already undertaken by manufacturers to withhold from the Australian market 'the best and most affordable electric vehicles'.[124] The Australia Institute has characterised it as 'all talk, no action', arguing that the 'government is spending more effort defending its lack of policies than it is in developing them'. It has noted that while the *FFS Discussion Paper* argues that incentives such as reducing taxes and costs on vehicles are not cost effective, this 'conveniently is a metric not used when subsidising the fossil fuel industry'.[125] Reporting in *The Guardian* has noted that unlike in countries such as Britain, Japan and Norway, the policy contains no planned phase-out of sales of new fossil fuel vehicles and no direct financial assistance for consumers to buy EVs, stating that Australia 'is one of few nations without emissions or fuel efficiency standards for passenger cars'.[126] Similar criticisms have been levelled at the finalised FFVS. Commentators criticised the lack of fuel efficiency standards and financial

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119 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels Strategy: Discussion Paper (February 2021)' (n 109) 15, 18.

120 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels and Vehicles Strategy: Powering Choice (November 2021)' (n 108) 12.

121 ARENA, 'Media Release: Future Fuels Funding Round Open for Fleets' arena.gov.au/assets/2022/02/ARENA-Media-Release_Future-Fuels-Fund-Program.pdf.

122 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels and Vehicles Strategy: Powering Choice (November 2021)' (n 108) 13.

123 Ibid 16.

124 Electric Vehicle Council, 'Incentives for Electric Vehicles Make Sense to Biden, Boris, and OECD – but Taylor Apparently Knows Better: Media Release' (5 February 2021) electricvehiclecouncil.com.au/news/incentives-for-electric-vehicles-make-sense-to-biden-boris-and-oecd-but-taylor-apparently-knows-better.

125 The Australia Institute, 'EV Policy Paralysis Driving Australia Backwards: Media Release' (5 February 2021) australiainstitute.org.au/post/ev-policy-paralysis-driving-australia-backwards.

126 Morton, 'Coalition Accused of Wasting 18 Months on "nothing" Electric Vehicle Strategy' (n 107).

incentives for uptake of EVs, alongside a failure to electrify the Government's own vehicle fleet.[127]

The leading jurisdictions in providing support for the uptake of EVs have been, at least by one assessment, NSW and the ACT.[128] In 2021, NSW released its electric vehicles strategy. The state will make EVs more affordable by removing stamp duty on cars under $78,000, and on all EVs, including PHEVs, on the earlier of 1 July 2027 or when EVs amount to at least 30% of new car sales. The NSW Government pledged $3000 rebates on the first 25,000 EVs under $68,750 sold from 1 September 2021.[129] It will also offer incentives for small and medium-sized fleets to transition to electric cars, including a target of completely electrifying the NSW Government passenger vehicle fleet by 2030.[130] The strategy also includes a government investment of $171 million over four years to expand charger coverage, including $131 million 'for ultra-fast charging infrastructure in areas with limited off-street parking, as well as to build EV Commuter Corridors and Super Highways across the State', alongside ensuring that new buildings and precincts are designed to be ready for EV charging infrastructure.[131] The NSW Government also seeks to generate economic benefits for the state through both investigating the possibility of mining and refining the minerals that will be in demand in EV manufacture, and in boosting regional tourism by enticing EV drivers to take advantage of charging facilities along nominated tourist routes and at tourist sites.[132] Finally, the plan seeks to create equity in road funding. Increased EV uptake will result in diminished fuel excise and stamp duty, which will in turn affect the state's ability to fund the upkeep of roads. At the earlier of 1 July 2027 or when EVs comprise 30% or more of new car sales, the government will introduce a distance-based road user charge for EVs, set at 2.5c per kilometre (km) for EVs, and 2c per km for PHEV.[133]

In 2020, the ACT introduced interest-free loans of up to $15,000 for households and non-profit organisations to assist them in purchasing items such as rooftop solar panels, battery storage, and zero-emissions (that is, electric) vehicles.[134] In 2020, the ACT moved to 100% renewable electricity, which means that charging vehicles in the ACT generates no carbon emissions.[135] Zero emissions vehicles in the ACT are also exempt from stamp duty and are eligible for two years' free registration.[136] The ACT Government has also committed to transitioning all vehicles in the

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127 Electric Vehicle Council, 'Future Fuels a Fizzer: Government's Strategy Misses Opportunity to Electrify Australian Transport (9 November 2021)' electricvehiclecouncil.com.au/news/future-fuels-a-fizzer-governments-strategy-misses-opportunity-to-electrify-australian-transport; Australia Institute, 'Media Release: Federal Government's Future Fuels Electric Vehicle Announcement Little More Than Another Pamphlet (9 November 2021)' australiainstitute.org.au/post/federal-governments-future-fuels-electric-vehicle-announcement-little-more-than-another-pamphlet; Bridie Schmidt, 'FFS: Coalition EV Policy Fizzles out with No Grand Plan, and No Emissions Limits', *The Driven* (8 November 2021) thedriven.io/2021/11/09/ffs-coalition-ev-policy-fizzes-out-with-no-grand-plan-and-no-emissions-limits; Giles Parkinson, 'Scott Morrison's Hopeless Spin and Failure on Electric Vehicles', *RenewEconomy* (9 November 2021) reneweconomy.com.au/scott-morrisons-hopeless-spin-and-failure-on-electric-vehicles.

128 Electric Vehicle Council, *State of Electric Vehicles* (August 2021) 14 electricvehiclecouncil.com.au/wp-content/uploads/2021/08/EVC-State-of-EVs-2021-sm.pdf.

129 NSW Government, 'NSW Electric Vehicle Strategy' 19 environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Climate-change/nsw-electric-vehicle-strategy-210225.pdf.

130 Ibid 20.

131 Ibid 21, 25.

132 Ibid 27–28.

133 Ibid 29.

134 Peter Brewer, 'Zero-Interest Loans Coming for ACT Electric Car Buyers', *Canberra Times* (online, 16 November 2020) canberratimes.com.au/story/7007002/zero-interest-boost-for-electric-cars-in-canberra.

135 *The ACT's Transition to Zero Emissions Vehicles: Action Plan 2018-21* (ACT Government, 2018) 1; Brett Mason, 'The ACT Is Now Running on 100 Renewable Energy', *SBS News* (online, 1 January 2020) sbs.com.au/news/the-act-is-now-running-on-100-renewable-electricity.

136 *The ACT's Transition to Zero Emissions Vehicles: Action Plan 2018-21* (n 135); ACT Government Environment, Planning and Sustainable Development Directorate, 'Zero Emissions Vehicles' (Web Page, 20 December 2021) environment.act.gov.au/cc/zero-emissions-vehicles.

Government fleet to EVs over three years. This will also have the effect of introducing more EVs into the second-hand market.[137]

On the other hand, some policies proposed by state and territory governments have been said to retard the growth in electric vehicle uptake. For example, from 1 July 2021, the Victorian Government introduced a road usage charge of 2.5c per km for electric and other zero emission vehicles and hydrogen vehicles, and a charge of 2c per km for plug-in hybrids. These charges were represented as amounting to 2c less per kilometre than the average fuel excise charge for other road users.[138] The Victorian charges have been modelled as potentially causing a 25% decline in projected 2050 EV sales, in the absence of other incentives,[139] though Victoria has also introduced more positive policies to promote EV uptake.[140] Premature introduction of road-user charges has been criticised by the EV industry. For example, when SA was proposing a similar model, the Electric Vehicle Council argued that this was a retrograde step that would cost the state the benefits to be gained from a diminished reliance on fossil fuels, and that roads should be paid for from general revenue rather than a discrete finance source such as fuel excise charges or their equivalent.[141] Debates over issues such as these point to the importance of understanding the financial incentives for governments in proposing one strategy over another.

Among existing policy and regulatory frameworks relating to EVs, there is a notable lack of any sustained engagement with the potential of e-bikes to help decarbonise the transport sector.[142] E-bikes are 'pedal-assisted bicycles offering users electric motor assistance up to speeds of 25km/h'.[143] E-bikes and e-cargo bikes have significant potential to replace, respectively, car trips and cars entirely, to a notably greater extent than non-electric versions.[144] Their limited inclusion in plans for decarbonisation may represent a lack of awareness of their potential as alternatives to both ICE and electric cars, not only among policymakers but also among climate activists in the Non-Government Organisation (NGO) sector.[145] Around the world, e-bikes and e-cargo bikes are being trialled for use in the delivery of letters, parcels and food orders.[146]

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137 *The ACT's Transition to Zero Emissions Vehicles: Action Plan 2018-21* (n 135) 5–6; Senate Select Committee on Electric Vehicles (n 77) 93–4.

138 VicRoads, 'ZLEV Road-User Charge', *VicRoads* (Web Page, 23 February 2022) vicroads.vic.gov.au:443/registration/registration-fees/zlev-road-user-charge.

139 Adam Morton, 'Victoria's Electric Vehicle Tax Could Reduce Clean Car Sales by 25%, Researcher Says', *The Guardian* (online, 26 November 2020) theguardian.com/environment/2020/nov/26/victorias-electric-vehicle-tax-could-reduce-clean-car-use-by-25-researcher-says.

140 Electric Vehicle Council, 'State of Electric Vehicles' (n 128) 17.

141 'SA Becomes Only Jurisdiction on Planet to Disincentivise Electric Vehicles with Tax', *Electric Vehicle Council* (11 November 2020) electricvehiclecouncil.com.au/sa-becomes-only-jurisdiction-on-planet-to-disincentivise-electric-vehicles-with-tax.

142 See, e.g. Christian Brand, 'Cycling Is Ten Times More Important than Electric Cars for Reaching Net-Zero Cities', *The Conversation* (30 March 2021) theconversation.com/cycling-is-ten-times-more-important-than-electric-cars-for-reaching-net-zero-cities-157163.

143 Madison Bland, Abraham Leung and Benjamin Kaufman, 'Why E-Bikes Can Succeed Where Earlier Bike-Share Schemes Failed', *The Conversation* (2 February 2021) theconversation.com/why-e-bikes-can-succeed-where-earlier-bike-share-schemes-failed-151844.

144 David Zipper, 'It's Time to Treat E-Bikes Like Vehicles', *Bloomberg.com* (online, 15 March 2022) bloomberg.com/news/articles/2022-03-15/the-electric-vehicles-we-need-now-are-e-bikes.

145 Ibid.

146 Jennifer C Hartle et al, *Assessing Public Health Benefits of Replacing Freight Trucks with Cargo Cycles in Last Leg Delivery Trips in Urban Centers* (No 22–18, Mineta Transportation Institute, June 2022) scholarworks.sjsu.edu/mti_publications/395; Micah Toll, 'USPS Already Testing Mail Delivery by Electric Bike with These Neat Little US-Built Mail Bikes', *Electrek* (3 June 2022) electrek.co/2022/06/03/usps-mail-delivery-electric-mail-bike; Benjamin Schneider, 'Newest Trend in Delivery Apps: Move from Cars to e-Bikes', *San Francisco Examiner* 3 March 2022) sfexaminer.com/archives/newest-trend-in-delivery-apps-move-from-cars-to-e-bikes/article_09497565-e108-5477-916c-c7095caf913a.html.

Properly factoring e-bikes into decarbonisation plans requires understanding how people use them, how they might use them into the future with appropriate incentives, and the benefits they represent in terms of public safety, affordability, reducing particulate pollution, lower use of resources in their manufacture, carbon emission reductions, boosting user health and freeing up street space. [147] They thus have the potential to advance all three of the overarching principles of this discussion paper: energy justice, just access to space and mobility, and staying within the planet's ecological limits. There is a strong case for treating them as vehicles, and thus regulating them alongside the better-understood car model of EVs. This involves factoring them into any larger plans for urban rejuvenation along the lines discussed above, including devising appropriate subsidies and other incentives to bolster uptake.

## 3.3 Policy complexity

Any regulatory proposal directed at incentivising the purchase of EVs in Australia must be evaluated in light of a complex interplay of regulatory settings. We consider the following five below:

- energy source;
- vehicle lifecycle;
- grid effects;
- transition of expertise; and
- battery component mining and the environment.

### *3.3.1 Energy source*

As noted above, the carbon abatement potential of EVs is only as good as the carbon generation profile of the energy sources used to power them. Modelling published in 2018 suggests that across the current Australian energy mix, BEVs represent a 35% reduction in carbon emissions compared with ICEs. If Australia adopted an energy mix comparable to Norway's (98% renewable, 2% fossil fuel), BEVs would achieve a 98% reduction in emissions compared to ICEs.[148] Figures from the Commonwealth Department of Industry, Science, Energy and Resources suggest that in 2019, fossil fuels accounted for 79% of Australian energy generation, while renewables accounted for 21%.[149]

The policy debate over Australia's energy transition and decarbonisation has a complicated history, some aspects of which are explored in other parts of this discussion paper. The measures outlined in Section 2 concerning incentives for renewable generation are of particular relevance here: to the extent that they motivate increased renewable generation, they will also assist in improving the carbon abatement potential of EVs.

### *3.3.2 Vehicle lifecycle*

Measures aimed at facilitating the uptake of EVs by governments, individuals and private actors must take into account that the environmental effects of EVs extend beyond the carbon reduction promise of their energy sources. One such effect relates to the process of mining lithium and other minerals required in battery manufacture. We consider this further below. Here, we consider another environmental aspect of EVs: lifecycles.

Personal passenger vehicles are not the only model of EVs worthy of policy consideration. The adoption of electric modes of public transport, such as buses, poses significant potential for carbon abatement and other environmental

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147 See, e.g. Damian Carrington, 'Car Tyres Produce Vastly More Particle Pollution than Exhausts, Tests Show', *The Guardian* (online, 3 June 2022) theguardian.com/environment/2022/jun/03/car-tyres-produce-more-particle-pollution-than-exhausts-tests-show; David Zipper, 'Electric Bicycle Incentives Go Local', *PeopleForBikes* (25 March 2022) peopleforbikes.org/news/electric-bicycle-incentives-go-local.

148 Smit, Whitehead and Washington (n 79) 19–20. The authors note that these gains are not translatable to adoption of FCEVs due, among other things, to the high energy cost involved in generating hydrogen: at 20.

149 'Australian Energy Statistics, Table O Electricity Generation by Fuel Type 2018-19 and 2019', *Australian Government Department of Industry, Science, Energy and Resources* (Web Page, 26 May 2020) energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2018-19-and-2019.

benefit. There are, however, claims that electric buses have a considerably shorter life than diesel buses, and that they may have a higher mass than conventional buses, resulting in greater road degradation.[150] These are factors that must be considered in any government decision to transition to electric bus fleets.

More significant are concerns about the lithium-ion battery lifecycle. Increased demand for EVs has been projected to result in increased demand for components of current-generation batteries, such as lithium, cobalt and graphite.[151] Batteries themselves have a limited lifecycle and have been commonly projected to last eight to 10 years.[152] At the end of their utility as a component of EVs, these batteries are thought to still have some 70% capacity. There are options for their reuse: the specific components that have worn out can be replaced; the batteries can be reused as part of stationary energy storage systems; or the batteries – or components of them – can be recycled.[153]

The recycling task is complex and there are limitations to its economic feasibility, especially since batteries are generally not designed to facilitate the easy recovery of their component materials.[154] Australia lacks in facilities for recycling lithium-ion batteries, and even those manufacturers that have implemented procedures for battery retrieval and recycling often send these components overseas for processing.[155] The CSIRO highlighted in 2018 that lithium ion battery waste was growing in Australia at a rate of more than 20% per year, as a result of use in EVs and in other portable electric devices.[156] As the use of EVs in Australia continues to grow, so too will this category of waste, most of which is disposed of in landfill. There are significant opportunities in the development of local lithium-ion battery recycling capabilities, though these have their own environmental costs, including the requirement to deal with toxic and hazardous by-products.[157] In reference to batteries generally, the International Energy Agency (IEA) estimates that 'by 2040, recycled quantities of copper, lithium, nickel and cobalt from spent batteries could reduce combined primary supply requirements for these minerals by around 10%'.[158]

More generally, estimates of the carbon offset potential of EVs may not always take into account the full lifecycle of their production, especially when aspects of that production take place offshore – this makes the full picture of their effects uncertain. Henderson notes that '[d]uring manufacturing, EVs produce almost twice as much [greenhouse gases], toxins harmful to humans, and toxins harmful to air and water compared to conventional cars, mainly due to

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150 Senate Select Committee on Electric Vehicles (n 77) 25, summarising submissions from the Bus Industry Confederation and Volvo.

151 Melissa N Diaz, *Electric Vehicles: A Primer on Technology and Selected Policy Issues* (No R46231, Congressional Research Service, 14 February 2020) 16.

152 Ibid; Gotsis (n 77) 9.

153 Diaz (n 151) 16; and see Australian Energy Market Operator, *2020 ISP Appendix 10: Sector Coupling* (Australian Energy Market Operator, July 2020) 19 aemo.com.au/-/media/files/major-publications/isp/2020/appendix--10.pdf?la=en.

154 Patrick Hughes, 'The Drive to Recycle Lithium-Ion Batteries', *Chemistry World* (14 September 2020) chemistryworld.com/features/the-drive-to-recycle-lithium-ion-batteries/4012222.article.

155 Gotsis (n 77) 10.

156 Sarah King, Naomi J Boxall and Anand I Bhatt, *Lithium Battery Recycling in Australia: Current Status and Opportunities for Developing a New Industry* (No EP181926, CSIRO, April 2018) iv, 16.

157 See Sarah King and Naomi J Boxall, 'Lithium Battery Recycling in Australia: Defining the Status and Identifying Opportunities for the Development of a New Industry' (2019) 215 *Journal of Cleaner Production* 1279. Research on the problem is underway in Australia: see, e.g. fbicrc.com.au/research/resources-processing-and-recycling.

158 International Energy Agency (n 83) 15.

the battery and to electronic equipment, as well as using more aluminium'.[159] Nonetheless, other studies have found that, even accounting for the full vehicle lifecycle, BEVs are likely to be significantly greener than ICE vehicles.[160]

Considerations such as these make clear the necessity of ensuring that, for all that EVs might represent a benefit in terms of carbon abatement and other environmental effects, the very real and potentially serious impacts of their production rocess are not forgotten. The overarching principle, outlined above, of ensuring that global consumption stays within the planet's ecological limits, is of significance here.

### 3.3.3 Grid effects

A significant obstacle to widespread adoption of EVs is a lack of public and private charging infrastructure, including charging infrastructure in apartment blocks. Government policies exist to support the rollout of charging facilities, but there is also a need to consider the effects of widespread EV rollout on the functioning of electricity grids. We briefly outline here salient aspects of the relationship between EV charging and the grid. We consider grids in greater detail in Section 4 of this report.

Electricity for charging EVs is likely to be sourced from the existing electricity grid, though there is also potential to source electricity from household and other distributed solar panels and stationary battery infrastructure.[161] In 2020, the Australian Energy Market Operator (AEMO) noted that uptake of EVs had been slow in Australia, and was expected to remain low in the 2020s in the absence of policy changes and market reforms, but with increasing effect on electricity consumption from the 2030s.[162] The *FFS Discussion Paper* noted that, even with 50% of the light vehicle fleet as BEVs, this would add around 9% to annual demand in the NEM and Western Australian market.[163]

The effect of EVs on the electricity grid depends on the nature of consumer charging behaviour. If consumers plug in their EVs in the evenings after work, this coincides with peak load time.[164] AEMO notes that an 'unmanaged transition to electrified transmission could prove challenging and costly', for instance if it requires upgrading the distribution network to allow simultaneous household charging of large numbers of EVs.[165] For this reason, AEMO urges the implementation of policy measures to incentivise customers to move to daytime charging. These include the use of smart chargers, which will help consumers take advantage of peak charging times during the day, with the potential to use car batteries to charge homes, potentially reducing future demand for home batteries;[166] and the possibility of EVs discharging excess battery power into the grid at times of high demand.[167] In 2021, the Australian Energy Market Commission (AEMC) enacted new rules to support the development of a two-way grid, which require power network companies to implement changes that will facilitate customers exporting back to the grid. This includes removing export bans, which had prevented those exports,

159 Henderson (n 15) 2000.

160 See Nikolas Hill and Sofia Amaral, *Lifecycle Analysis of UK Road Vehicles* (Final Report for Department of Transport, Ricardo Energy & Environment, 25 November 2021).

161 Senate Select Committee on Electric Vehicles (n 77) 43.

162 Australian Energy Market Operator, '2020 ISP Appendix 10: Sector Coupling' (n 153) 17.

163 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels Strategy: Discussion Paper (February 2021)' (n 109) 20.

164 Senate Select Committee on Electric Vehicles (n 77) 43; Australian Energy Market Operator, '2020 ISP Appendix 10: Sector Coupling' (n 153) 19.

165 Australian Energy Market Operator, '2020 ISP Appendix 10: Sector Coupling' (n 153) 19.

166 Ibid.

167 Senate Select Committee on Electric Vehicles (n 77) 44; Smit, Whitehead and Washington (n 79) 23.

and reforming the export price system.[168]

The *FFS Discussion Paper* outlined investigations into bidirectional charging capacities, which would better allow EV batteries to provide excess capacity to the grid, and noted that it had mandated the Energy Security Board to 'develop a design for a two-sided electricity market that could enable distributed energy resources, including battery electric vehicles, to contribute to system security and reliability, while improving market efficiency'.[169]

### 3.3.4 Transition of expertise

A transition to EVs will have significant effects on the industries associated with ICE vehicles, including manufacture and, more significantly in Australia, repair.

Australia's ICE car manufacturing industry ended in 2017 when General Motors closed the Holden plant in Adelaide.170 Representations to the Senate Select Committee from a variety of bodies flagged the possibility that, since EV manufacture is simpler and less costly than the manufacture of ICE vehicles, the existing auto manufacturing workforce might be redeployed in the manufacture of EVs; or that Australia might beneficially move to investment in EV component manufacture, including battery manufacture and recycling.[171]

These opportunities must be balanced against costs to existing business and livelihoods. Increased uptake of EVs, for instance, is likely to result in the large-scale reorganisation of fuel distribution and the closure of many service stations, as well as the loss of jobs in automotive repair and parts retailing.[172] Overseas analysis about the effects of EV uptake on service station employment may be instructive. In Norway, where sales of diesel and electric vehicles have peaked and where, in 2020, BEVs accounted for 60% of the new car market and PHEVs a further 15%, there is some evidence about the effects on service station employment.[173] One analysis suggests that although the number of services stations has peaked, and sales of petrol have been declining steadily in the last 10 years, it is unclear whether the growth in EVs has meant declining sales in groceries and other food services offered by these businesses, especially given that in many places in Norway, there are few other options open at night.[174] This analysis suggests that in the US, the service stations most affected will be those in suburban areas where customers are easily capable of charging at home, rather than, for instance, well-frequented large stations along highways.[175]

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168 'Smart Solar Reforms Will Inject More Clean Energy into the Grid', *AEMC* (12 August 2021) aemc.gov.au/news-centre/media-releases/smart-solar-reforms-will-inject-more-clean-energy-grid; 'Information Sheet: Integration of Distributed Energy Resources' aemc.gov.au/sites/default/files/2021-08/Information%20sheet%20-%20Access%2C%20pricing%20and%20incentive%20arrangements%20for%20DER_0.pdf.

169 Australian Government Department of Industry, Science, Energy and Resources, 'Future Fuels Strategy: Discussion Paper (February 2021)' (n 109) 21.

170 Mike Ladd, 'Holden Closure: Australia's History of Car Manufacturing Comes to an End', *ABC News* (Web Page, 8 October 2017) abc.net.au/news/2017-10-08/holden-closure-australia-history-car-manufacturing/9015562.

171 Senate Select Committee on Electric Vehicles (n 77) 51–73.

172 Ibid 47–48.

173 Nathaniel Bullard, 'When Is a Gas Station Not a Gas Station? When All the Cars Are EVs', *Bloomberg Green* (online, 18 February 2021) bloomberg.com/news/articles/2021-02-18/when-cars-are-all-electric-we-ll-still-have-gas-stations; Jon Henley and Elisabeth Ulven, 'Norway and the A-Ha Moment That Made Electric Cars the Answer', *the Guardian* (19 April 2020) theguardian.com/environment/2020/apr/19/norway-and-the-a-ha-moment-that-made-electric-cars-the-answer.

174 Bullard (n 173).

175 Ibid.

Furthermore, increasing electrification of vehicles raises a crucial issue about the right to repair: whether EV owners will have the ability to undertake repairs to their vehicles outside anything but approved dealership channels. This issue is complicated by the presence of considerable amounts of software in electric vehicles. In Massachusetts in 2020, voters approved a ballot initiative that would extend the right to repair, requiring manufacturers of EVs to grant vehicle owners and independent repairers access to data.[176] In Australia, the Productivity Commission has conducted an inquiry into the right to repair, releasing the report of that inquiry in 2021.[177]

### 3.3.5 Battery component mining and the environment

Lithium and the other components of lithium-ion batteries, such as cobalt and nickel, must be mined. Mines are located both in Australia and overseas: 75% of world lithium resources are located in Argentina, Chile and Bolivia, while two thirds of the world's cobalt is located in the Democratic Republic of the Congo.[178] Australia is currently the major producer of lithium, and lithium mining has been proposed as part of a just transition for coal miners away from fossil fuel extraction.[179] The principal Australian lithium deposits are located in Western Australia (WA).[180] The IEA notes that the 'typical electric car requires six times the mineral inputs of a conventional car'.[181] It projects that clean energy technologies (most significantly, EVs and battery storage) will drive a quadrupling of mineral requirements by 2040. The achievement of net zero globally by 2050 will 'require six times more mineral inputs in 2040 than today'.[182]

176 Stephen Edelstein, 'EV Makers Need to Rethink Data Policies with Passage of "Right to Repair" Law', *Green Car Reports* (5 November 2020) greencarreports.com/news/1130196_ev-makers-need-to-rethink-data-policies-with-passage-of-right-to-repair-law; Bryan Reimer, 'Right To Repair Or A Fight For Survival?', *Forbes* (4 October 2020) forbes.com/sites/bryanreimer/2020/10/04/right-to-repair-or-a-fight-for-survival/?sh=5a527ec390bb.

177 Productivity Commission, *Right to Repair: Productivity Commission Inquiry Report* (No 97, Australian Government Productivity Commission, 29 October 2021) pc.gov.au/inquiries/completed/repair/report/repair.pdf.

178 Alejandro González and Esther de Haan, *The Battery Paradox: How the Electric Vehicle Boom Is Draining Communities and the Planet* (SOMO (Centre for Research on Multinational Corporations), December 2020) 4 somo.nl/wp-content/uploads/2020/12/SOMO-The-battery-paradox.pdf.

179 Max Opray, 'How Australia's "white Gold" Could Power the Global Electric Vehicle Revolution', ***the Guardian*** (10 September 2020) theguardian.com/australia-news/2020/sep/10/how-australias-white-gold-could-power-the-global-electric-vehicle-revolution.

180 David Champion, *Lithium 2018* (Geoscience Australia, 2018) 12, 2.

181 International Energy Agency (n 83) 5.

182 Ibid 8.

Like all other kinds of mining, the mining of lithium and other battery component minerals can have severe environmental and social effects, including breaches of expectations or requirements of free prior and informed consent, and human rights infringements in local communities.[183] Processes in the global mining trade have been shown to have effects such as chemical contamination of water supplies, use of scarce water resources, and human rights implications for labour forces employed in often toxic extraction processes.[184] More than half of contemporary cobalt and lithium production occurs in areas of high water stress.[185] The Australian industry is far from immune from these concerns: among other things, as Rio Tinto's destruction of priceless Aboriginal heritage in WA's Juukan Gorge demonstrated, there are significant gaps in cultural heritage protection in WA (and elsewhere).[186]

It is vital to consider ways to ameliorate these costs, through measures such as investigating alternatives, setting up effective recycling schemes, and considering processes whereby lithium is leased rather than sold to consumers, thus setting up new, potentially greener, supply chains.[187]

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183 See e.g. González and de Haan (n 178) 35–44; Amit Katwala, 'The Spiralling Environmental Cost of Our Lithium Battery Addiction' (5 August 2018) *Wired UK* wired.co.uk/article/lithium-batteries-environment-impact; Pía Marchegiani, Jasmin Höglund Hellgren and Leandro Gómez, *Lithium Extraction in Argentina: A Case Study on the Social and Environmental Impacts* (Fundación Ambiente y Recursos Naturales, 2019).

184 Katwala (n 183); and see Henderson (n 15) 2000–01.

185 International Energy Agency (n 83) 12.

186 John Southalan, 'Sorry, Not Sorry: The Operation of WA's Aboriginal Heritage Act', *AUSPUBLAW: Australian Public Law* (11 September 2020) auspublaw.org/2020/09/sorry-not-sorry-the-operation-of-was-aboriginal-heritage-act; Hannah McGlade, 'Western Australia after the Juukan Gorge Inquiry: Little Solace for Aboriginal People', *Indigenous Constitutional Law* (10 December 2021) indigconlaw.org/home/western-australia-after-the-juukan-gorge-inquiry.

187 Damien Giurco and Ben McLellan, 'Lithium: Australia Needs to Recycle and Lease to Be Part of the Boom', *The Conversation* (22 March 2016) theconversation.com/lithium-australia-needs-to-recycle-and-lease-to-be-part-of-the-boom-54037.

# 4. Renewable Energy Storage

## 4.1 Introduction

Australia has extensive natural endowments of renewable energy sources, particularly solar and wind. Its ability to exploit them in a manner that is cost-effective, reliable and capable of achieving meaningful carbon abatement depends significantly on its ability to store generated energy and to meet grid demands for it.[188] That technological capability exists: claims that increased use of renewable generation will lead to unreliable and uneconomic energy supplies tend to be misleading.[189] In this section, we outline some of the key mechanisms and initiatives in renewable energy, before setting out some areas of policy complexity.

We begin in Subsection 4.2 by providing a snapshot of the status of renewable energy storage (referred to in the literature as 'electric energy storage', or EES) in Australia, setting out the principal storage capacities and resources, along with a glance at how governments have been involved. In Subsection 4.3, we set out four areas of policy complexity. The first concerns integration of EES with the existing electricity grid. The second relates to environmental outcomes, requiring the caution that even though storage solutions – and particularly batteries – represent real promise in terms of carbon abatement, they are not without their own ecological consequences. The third addresses questions of incentives, asking what kinds of governmental intervention are best positioned to promote EES investments, while paying close attention to socioeconomic implications of such interventions. The fourth examines the possibility and transformative capacity of new models of ownership of energy storage.

## 4.2 State of the industry

The major forms of renewable energy storage are batteries (lithium ion and other forms), compressed air energy storage, molten salt, pumped hydro, and power to gas (hydrogen). We consider the latter – hydrogen – in a separate part of this paper. We focus here principally on battery storage technologies, with some discussion of pumped hydro. Compressed air energy storage has presently only very limited operation in Australia,[190] while molten salt and other forms of concentrated solar thermal storage have also not been extensively deployed.[191]

188 See Tony Wood, *Australia's Energy Transition: A Blueprint for Success* (Grattan Institute, September 2019) 5 grattan.edu.au/wp-content/uploads/2019/09/922-Australia-energy-transition-a-blueprint-for-success.pdf.

189 See, e.g. the 2017 claims of former Prime Minister Tony Abbott to this effect: Louise Yaxley, 'Tony Abbott: Two Years since Spill, "resilient" Former PM Campaigning on Energy and Coal', *ABC News* (online, 14 September 2017) abc.net.au/news/2017-09-14/tony-abbott-campaigning-on-coal-rails-against-renewables/8946878; and see also in relation to the 2016 South Australian blackout and related issues: Tony Wood, Guy Dundas and Lucy Percival, *Keep Calm and Carry On: Managing Electricity Reliability* (Grattan Institute, 2019) 6–8 grattan.edu.au/report/keep-calm-and-carry-on.

190 J Rutovitz et al, *Storage Requirements for Reliable Electricity in Australia* (Institute for Sustainable Futures for the Australian Council of Learned Academics, 2017) 21; Blake Matich, 'Australian Utility Tests Compressed Air Storage', *pv magazine* (20 July 2021) pv-magazine.com/2021/07/20/australian-utility-tests-compressed-air-storage; Michael Mazengarb, 'Australia's First Compressed Air Energy Storage System Gets Development Approval', *RenewEconomy* (17 July 2019) reneweconomy.com.au/australias-first-compressed-air-energy-storage-system-gets-development-approval-36150; Michael Bloch, 'Compressed Air Energy Storage Project In South Australia Dumped', *SolarQuotes Blog* (24 January 2021) solarquotes.com.au/blog/hydrostor-caes-strathalbyn-mb1852; Callum Marshall, 'Hydrostor Seeks Clarity over Compressed Air-Energy Facility in Broken Hill', *ABC News* (online, 12 January 2022) abc.net.au/news/2022-01-12/hyrdostor-seeks-clarity-on-compressed-air-energy-at-broken-hill/100749252; 'Compressed Air Energy Storage Systems', *UNSW Sydney Research Capability & Technology Portfolio* capabilities.unsw.edu.au/compressed-air-energy-storage-systems.

191 Carl Kitchen, 'Lights out for Solar Thermal?', *Australian Energy Council* (11 April 2019) energycouncil.com.au/analysis/lights-out-for-solar-thermal; ARENA, 'Concentrated Solar Thermal (CST)', *Australian Renewable Energy Agency* arena.gov.au/renewable-energy/concentrated-solar-thermal.

The Hornsdale Power Reserve in SA was, until recently, the world's largest lithium-ion battery.[192] It had an initial capacity of 129 megawatt hours (MWh), with an expansion of 64.5MWh completed in September 2020. The battery was constructed after SA grid failures in 2017, and a Twitter interaction between US billionaire Elon Musk and Australian billionaire Mike Cannon-Brookes about whether Musk could install a battery in SA that would be operational within 100 days.[193] Musk was successful, and according to the project's website, the battery saved SA consumers more than $150 million in its first two years.[194]

The Hornsdale 'battery' is actually the aggregate of hundreds of Tesla Powerpacks, which are each in turn made up of 16 'battery pods' that contain thousands of lithium-ion cells. These battery pods are similar to those used in Tesla's Model S EVs.[195] This form of battery has considerable environmental impacts throughout its lifecycle – we discuss these in Subsection 4.3 and above in Subsection 3.3.

In 2020, Victoria announced the Victorian Big Battery, which is to be the largest lithium-ion battery in the country. The project's Fact Sheet proclaims its major benefits as being to 'increase the power flow through the Victoria-New South Wales Interconnector' and to 'provide crucial energy storage'.[196] The Fact Sheet notes that batteries are better able to react to acute market demands than other technologies such as gas, and suggests also that the Big Battery 'acts as cost-effective insurance against a high impact, low probability event' such as a coal-fired power station failing on a very hot day. The project was advertised as providing financial savings for Victorians, since it would lower wholesale prices, with $2.40 projected to be delivered for every $1 spent.[197]

In addition to these industry-scale batteries, households are also purchasing batteries. In 2019, households installed 22,661 home energy systems.[198] In 2020, the figure had risen to 31,000 battery energy systems overall, with this growth also led by households.[199] In total as at 2019, home systems comprised 738 MWh of storage, while non-residential systems totalled 361 MWh of storage.[200]

Pumped hydro involves pumping water from a lower to a higher reservoir at times when electricity is cheap and abundant, and then running that water downhill through a turbine to generate electricity when demand increases and electricity is costlier.[201] At present, river-based pumped hydro projects exist at Wivenhoe (Queensland), and Shoalhaven and Tumut 3 (NSW). The new Snowy 2.0 Project is presently being built and is projected to begin generating early in 2025. At full capacity, it will provide enough storage to 'power three million homes over the course of a week'.[202] As is a theme of this discussion paper, the benefits to the uptake of renewables provided by the grid stabilisation effects of a reliable pumped hydro project cannot be evaluated in the absence of consideration of environmental downsides. In the case of Snowy 2.0, significant concern has been raised by environment groups over the potential effects on the fragile Snowy Mountains National Park of Transgrid's proposal to construct overhead,

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192 Sophie Vorrath and Giles Parkinson, 'Australia's Tesla Big Battery Is No Longer Biggest Battery in the World', *RenewEconomy* (21 August 2020) reneweconomy.com.au/australias-tesla-big-battery-is-no-longer-biggest-battery-in-the-world-30125.

193 Aleesha Rodriguez, 'Happy Birthday, SA's Big Battery, and Many Happy Returns (of Your Recyclable Parts)', *The Conversation* (online, 30 November 2018) theconversation.com/happy-birthday-sas-big-battery-and-many-happy-returns-of-your-recyclable-parts-105739.

194 'South Australia's Big Battery', *Hornsdale Power Reserve* (Web Page, 2021) hornsdalepowerreserve.com.au.

195 Rodriguez (n 193).

196 Victorian Department of Environment, Land, Water and Planning, 'The Victorian Big Battery: Fact Sheet' energy.vic.gov.au/__data/assets/pdf_file/0030/494850/The-Victorian-Big-Battery-Fact-sheet.pdf.

197 Ibid.

198 Sophie Vorrath, 'Australians Installed 22,661 Home Battery Systems in 2019', *RenewEconomy* (16 April 2020) reneweconomy.com.au/australians-installed-22661-home-battery-systems-in-2019.

199 Sophie Vorrath, 'Australians Installed 31,000 Batteries in 2020, Led by Households', *One Step Off The Grid* (19 March 2021) onestepoffthegrid.com.au/australians-installed-31000-batteries-in-2020-led-by-households.

200 Vorrath, *Australians Installed 22,661 Home Battery Systems in 2019* (n 198).

201 Andrew Blakers, Matthew Stocks and Bin Lu, *Australian Electricity Options: Pumped Hydro Energy Storage* (No Research paper series 2020-21, Parliamentary Library, Parliament of Australia, 20 July 2020) 1.

202 'Snowy 2.0: About', *Snowy Hydro* (2020) snowyhydro.com.au/snowy-20/about.

rather than underground, transmission lines to link the project to the NEM.[203] A 2000 MWh pumped hydro project operating out of a former gold mine in Far North Queensland is under construction, with funding support from the Northern Australia Infrastructure Facility in the form of a loan of up to $610 million.[204] Five other projects are under consideration for Commonwealth government support under the Underwriting New Generation Investments program.[205]

Government interventions in EES have taken various forms. Both the SA and Victorian giant batteries have been directly funded, at least in part, by government. The $71 million Hornsdale Power Reserve Upgrade received $15 million in funding over five years from the SA government; $8 million from ARENA, and up to $50 million from the CEFC.[206] The CEFC also contributed a senior debt facility of $160 million to the Victorian big battery.[207]

## 4.3 Policy complexity

### *4.3.1 Integration with the grid*

Renewable energy presents a challenge to the traditional structure of the electricity grid. As AEMO has noted, the

> current regulatory framework supports a traditional electricity supply chain model, where electricity is produced by large generators (suppliers) and transported through transmission and distribution systems to industrial, commercial, and residential customers who purchase the electricity.[208]

In Australia, the 'grid', or transmission network, is comprised chiefly of the NEM. This refers to the interconnected transmission and market infrastructure of Queensland, NSW (including the ACT), Victoria, SA and Tasmania. Tasmania is connected to the NEM through a cable running across the Bass Strait.[209] The NEM accounts for roughly 92% of the total electricity demand.[210] The other major electricity market in Australia is

203 Michael Mazengarb, 'Transgrid Prefers Above-Ground Transmission Link for Snowy 2.0, despite Opposition', *RenewEconomy* (16 March 2022) reneweconomy.com.au/transgrid-prefers-above-ground-transmission-link-for-snowy-2-0-despite-opposition.

204 Michael Mazengarb, 'Genex Commences Early Works at Flagship Pumped Hydro Project', *RenewEconomy* (23 December 2020) reneweconomy.com.au/genex-commences-early-works-at-flagship-pumped-hydro-project-95383/; 'Genex Kidston Pumped Hydro Scheme', *Northern Australia Infrastructure Facility* naif.gov.au/what-we-do/case-studies/genex-power-kidston-stage-2-indicative-term-sheet; Blakers, Stocks and Lu (n 201) 2.

205 'Underwriting New Generation Investments Program', *Australian Government Department of Industry, Science, Energy and Resources* energy.gov.au/government-priorities/energy-programs/underwriting-new-generation-investments-program; Blakers, Stocks and Lu (n 201) 2.

206 ARENA, 'South Australian Battery Grows Bigger and Better', *ARENAWIRE* (4 September 2020) arena.gov.au/blog/south-australian-battery-grows-bigger-and-better.

207 'CEFC Backs 300 MW Victorian Big Battery to Strengthen Grid and Support More Renewable Energy - Clean Energy Finance Corporation' (25 February 2021) cefc.com.au/media/media-release/cefc-backs-300-mw-victorian-big-battery-to-strengthen-grid-and-support-more-renewable-energy.

208 Australian Energy Market Operator, 'Emerging Generation and Energy Storage in the NEM: Stakeholder Paper (November 2018)' 3 aemo.com.au/-/media/files/electricity/nem/initiatives/emerging-generation/eges_stakeholder_paper_final.pdf?la=en.

209 Australian Energy Market Operator, 'Fact Sheet: The National Electricity Market (July 2020)' aemo.com.au/-/media/files/electricity/nem/national-electricity-market-fact-sheet.pdf.

210 Felix Keck et al, 'The Impact of Battery Energy Storage for Renewable Energy Power Grids in Australia' (2019) 173 *Energy* 647, 648.

the Wholesale Electricity Market, which operates through the South West Interconnected System (SWIS) in south-western WA.[211] Electricity in other parts of Australia is supplied off the grid, or through micro-grids.[212]

The traditional one-way operation of grid transmission, from large-scale generator to consumer, is altering, not only because industrial and commercial customers are increasingly using onsite electricity generation and storage systems, but also because storage is being used in the integration of renewable energy into the NEM and households are seeking to feed electricity they generate, through rooftop solar and other sources, back into the NEM.[213] The energy generated on the 'consumer's side of the meter' is referred to as 'distributed energy resources' or DER. DER includes, as mentioned, rooftop solar, alongside, among other things, battery storage and batteries in electric vehicles that can supply power back into the grid.[214]

The AEMC notes that the integration of DER into the grid has financial benefits not only for individual consumers, who may be able to access cheaper and/or more reliable electricity by installing DER units, but also for consumers as a whole, since the integration of increased DER can make it cheaper to enhance the existing power system, thus reducing electricity costs for consumers. The AEMC also notes the potential to achieve emissions reductions through increased DER pushing out higher-emitting energy generation.[215] In a 2017 report, Energy Networks Australia and the CSIRO estimated that by 2050, up to 45% of all electricity would be generated by customers.[216] AEMO has established a program for whole-of-industry coordination to better integrate DER into the grid.[217]

In 2019/20, coal accounted for 68.39% of the generation in the NEM. Gas accounted for 8.04%, wind for 7.53%, hydro for 7.12%, grid-scale solar for 2.93%, rooftop solar for 5.95%, and battery energy storage for 0.04%.[218] Comparing these figures with 2020/21 illustrates the path of the transition away from fossil fuels, with the following figures: coal (64.67%); gas (6.57%); wind (10.45%); hydro (7.21%); grid-scale solar (3.85%); distributed PV (7.09%); battery energy storage (0.05%); and biomass (0.09%).[219] As the grid transitions into greater reliance on renewable sources, including from storage, the two key concerns are energy adequacy and energy security. Energy adequacy refers to whether there is sufficient energy at any given point to meet usage requirements; energy security concerns the system's ability to respond to sudden shocks.[220] The extent to which these are of concern depends on the extent to which renewable energy forms part of the generation matrix. Thus, storage only becomes 'economically relevant in scenarios with high [renewable energy supply] penetration.

211 Australian Energy Market Operator, 'About the Wholesale Electricity Market (WEM)' (Web Page, 2020) aemo.com.au/energy-systems/electricity/wholesale-electricity-market-wem/about-the-wholesale-electricity-market-wa-wem.

212 Keck et al (n 210) 648.

213 Australian Energy Market Operator, 'Emerging Generation and Energy Storage in the NEM: Stakeholder Paper (November 2018)' (n 208) 3.

214 Distributed Energy Resources, *Australian Energy Market Commission* (Web Page) aemc.gov.au/energy-system/electricity/electricity-system/distributed-energy-resources.

215 Ibid.

216 Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report* (April 2017) 2 energynetworks.com.au/resources/reports/entr-final-report.

217 Australian Energy Market Operator, 'About the DER Program', *AEMO* (Web Page, 2022) aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/about-the-der-program.

218 Australian Energy Market Operator, 'Fact Sheet: The National Electricity Market (July 2020)' (n 209).

219 Australian Energy Market Operator, 'Fact Sheet: The National Electricity Market (December 2021)' aemo.com.au/-/media/Files/Electricity/NEM/National-Electricity-Market-Fact-Sheet.pdf.

220 Rutovitz et al (n 190) iii.

This is because when enough dispatchable fossil assets are part of the generation portfolio, [storage] is not needed to supply energy at times of low [renewable energy supply]'.[221]

As can be seen from the breakdown of NEM generation by source, renewable energy can be discharged directly into the grid without the need for storage. When deployed effectively, however, storage can provide additional flexibility to the grid, since it does not require such precise matching of supply and demand. Effective storage means a lower requirement for variable renewable energy supply generation capacity to be installed.[222] Furthermore, storage can prevent spillage of generated energy, which might occur at times when generation is high but demand is low.[223] Traditionally, the grid has relied on baseload generation, which is a kind of generation that, like a coal-fired power station, has high capital but low operating costs and is therefore efficient to run to provide a continuous 'base' supply of power. A 2019 report from the Grattan Institute notes that in order to be reliable, a grid need not have any baseload generation. Instead, 'a reliable grid can combine wind and solar with sufficient flexible dispatchable generation, such as gas, hydro and batteries'.[224] The report suggests that these kinds of dispatchable generation benefit from the volatility of solar and wind generation, since 'they buy power when prices are low and sell when prices are high'.[225]

Regulation of the grid is also becoming more complex because most renewable electricity sources, even those that are not as widely decentralised and distributed as household solar, connect to the grid in a different way (through inverters) than traditional sources of power, known as synchronous generation.[226] AEMO notes that

> the number of online synchronous generators is being displaced by increasing penetrations of IBR [inverter-based resources], without compensation for the loss of synchronous services. As a result, system strength and inertia have reduced, and the system is reaching the bounds of known stability limits.[227]

In 2020, AEMO predicted that if its recommendations were implemented, 'the NEM could be operated securely with up to 75% instantaneous penetration of wind and solar', but if the actions were not taken, that penetration would be limited to 50-60%.[228]

A 2018 CSIRO analysis found that up to 50% market penetration of renewables, there would be little to no requirement for storage. At 50-75% penetration, two to three hours of storage is needed; at up to 90%, up to eight hours' storage is required.[229] Joshi notes that, because of the rare times that both wind and solar cease generating for an extended period of more than a couple of days, renewable penetration of over 90% is the

221 Keck et al (n 210) 650.

222 Ibid 652.

223 Ibid.

224 Wood, Dundas and Percival (n 189) 19.

225 Ibid 21.

226 For an overview of these differences, see Nick Harmsen, 'Australia's Power Grid Weakened by Wind, Solar Generation, AEMC Calls for Plan for Security', *ABC News* (online, 24 March 2017) abc.net.au/news/2017-03-24/aemc-says-australias-power-system-weakened-by-wind-solar/8381356.

227 Australian Energy Market Operator, *Renewable Integration Study: Stage 1 Report* (April 2020) 29 aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integration-study-stage-1.pdf?la=en.

228 Ibid 4.

229 Paul W Graham et al, *GenCost 2018: Updated Projections of Electricity Generation Technology Costs* (CSIRO, December 2018) 26 publications.csiro.au/rpr/download?pid=csiro:EP189502&dsid=DS1; Joshi, *Windfall: Unlocking a Fossil-Free Future* (n 52) 119–20.

most difficult scenario in terms of grid stability.[230] Blakers et al argue that in a scenario of 100% renewable energy penetration, the amount of storage required to stabilise the grid is about 450 GWh, widely distributed. A recent study has identified suitable sites capable of about 300 times more storage than needed.[231]

### 4.3.2 Environmental impacts of batteries: mining and waste

We considered the environmental impacts of batteries – in particular, the effects of mining their component minerals and the limitations in recycling facilities – in Subsection 3.3.5 above. Following our discussion in Subsection 1.3, we also note here that the increased use of renewables that storage makes possible may generate another kind of moral hazard in posing an obstacle to consumers' consciousness of their energy use and desire to decrease it.[232] That is, identifying that their energy is sourced from renewables has the risk of introducing complacency in consumers, who may perceive that no further effort is required to modify their behaviour in favour of further limiting their consumption. This draws in consideration of the third of our three overarching themes – the necessity to live within the planet's ecological limits. It bears repeating that the shift from fossil fuel to renewable energy, with everything this entails in terms of storage, infrastructure and other developments, is just one part of that process. Any process to hasten that transition must grapple with the fact that it, too, has environmental costs, and that simply 'business as usual', but with renewables replacing fossil fuels, will fall far short of ensuring a sustainable model of existence that respects the planet's ecological boundaries.

### 4.3.3 What incentives, and where should they be targeted?

As we noted in Section 2, there is a profound need for regulatory certainty around carbon abatement strategies. Stable policies are required in order to plan a secure, reliable and low-emissions grid infrastructure. Researchers from the Grattan Institute have recommended government leadership in creating a 'stable policy framework within which investors can commit to new generation'.[233] They argue that ideally, such measures would involve a carbon price; but failing this, they recommend other clean energy targets of kinds already proposed by government reviews.[234] They also recommend that retailers be subjected to reliability obligations, requiring them to contract for enough dispatchable generation to meet predicted shortfalls.[235]

Grattan Institute researchers also caution against government investment in new generation on the grounds of reliability, including in this caution government investment in the Snowy 2.0 pumped hydro project. This, they argue, is because such investment tends to deter private investors; and in the case of Snowy 2.0, the benefits of the project will arrive too late to meet upcoming projected shortfalls to 2024, thus having the potential to 'harm, rather than help, reliability in the intervening period'.[236]

However support is targeted, the need to keep energy justice at the forefront of consideration is paramount. Interventions that, for instance, increase the price of electricity will have disproportionate effects on those with lower incomes. Disruptions to electricity supply caused by, for instance, inefficient grid integration will likewise have differentiated impacts on different groups.

### 4.3.4 Community batteries

Scale of ownership and operation is an important consideration in determining the optimal kinds of battery storage. Advances in battery technology have made it possible for energy storage to be controlled not only by large-scale grid operators or by individual households, but also at intermediate levels. In this subsection, we examine the costs and benefits of community-scale batteries. Community-scale batteries are

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230 Joshi, *Windfall: Unlocking a Fossil-Free Future* (n 52) 120.

231 Blakers, Stocks and Lu (n 201) 4.

232 Rodriguez (n 193); and see Hedda Ransan-Cooper, *Stakeholder Views on the Potential Role of Community Scale Storage in Australia* (Battery Storage and Grid Integration Program, Australian National University, 2020) 44 arena.gov.au/assets/2020/08/stakeholder-views-on-community-scale-storage-in-australia.pdf.

233 Wood, Dundas and Percival (n 189) 22.

234 Ibid.

235 Ibid.

236 Ibid 27.

localised, shared batteries that allow users within a defined geographical area both to store excess solar photovoltaics (PV) and then to access it when required.[237]

Community-scale batteries have various benefits. They are argued to enhance the reliability of the grid, and it is easier to manage storage from one larger battery than from numerous household batteries.[238] According to Ausgrid CEO Richard Gross, they represent the 'most cost effective way to bring renewable energy into the grid' and support the local network.[239] Among other things, they may also allow participants to save money on their energy bills, address issues of reliability in local networks, provide charging capacity for electric vehicles, and assist in meeting emissions reduction targets. They may also build community ties through shared ownership and may address inequities in accessing DER benefits among people who rent or who live in apartments, etc.[240] It is on the latter equity aspect that this subsection focuses.

In February 2021, Ausgrid launched its first community-scale battery in Beacon Hill, NSW, as part of a two-year trial.[241] Ausgrid owns and maintains the battery, and argues that the benefits of community batteries include that they promote uptake of solar among households, and make 'access to battery storage more equitable and accessible for all customers, particularly those who are not currently able to install their own household battery'.[242] They are also promoted as a flexible substitute for poles-and-wires investment, which can help meet peak demand and thus lower electricity prices. Participants in the trial receive credits for the amount of energy they store in the battery less the amount of energy they use. They may store up to 10 KWh per day, and Ausgrid estimates that credits will total $50-$250 per year. Participants are able to monitor the generation and usage through a mobile app and online portal.[243]

The Ausgrid model is an example of ownership by Distribution Network Service Providers (DNSPs). Other models of ownership are batteries owned by retailers, and batteries owned by third parties, including investors, the community, state or local governments, or a combination.[244] Research carried out at the Australian National University (ANU) (partially funded by ARENA) has found that DNSPs 'face regulatory challenges, retailer-owned models face trust issues, and community-owned models face logistical issues'.[245] These regulatory issues include current regulatory limitations on the kinds of services that DNSPs are allowed to provide, and will not be explored further here.[246] Trust issues centre around consumers' perception of electricity retailers as

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237 See KPMG, *Ausgrid Community Battery: Feasibility Study Report* (February 2020) 4 ausgrid.com.au/-/media/Documents/Reports-and-Research/Battery/Ausgrid-Community-Battery-Feasibility-Study-Report-2020.

238 Battery Storage and Grid Integration Program, *Implementing Community-Scale Batteries: Final Report for the ARENA-Funded Community Models for Deploying and Operating DER Project* (Australian National University, December 2020) 5 arena.gov.au/assets/2020/12/implementing-community-scale-batteries-bsgip.pdf; 'Ausgrid Launches Community Based Battery To Inject Renewable Energy Into The Grid - Ausgrid', *Ausgrid* (15 February 2021) ausgrid.com.au:443/About-Us/News/community-battery-trial.

239 'Ausgrid Launches Community Based Battery To Inject Renewable Energy Into The Grid - Ausgrid' (n 238).

240 Ransan-Cooper (n 232) 13–14.

241 'Ausgrid Launches Community Based Battery To Inject Renewable Energy Into The Grid - Ausgrid' (n 238). Ausgrid is operated by the NSW Government in partnership with Australian Super and IFM Investors, an investment fund: 'About Us', *Ausgrid* (Web Page, 2020) ausgrid.com.au:443/About-Us.

242 'Community Battery Trial Participant FAQs', *Ausgrid* (Web Page) ausgrid.com.au:443/In-your-community/Community-Batteries/Community-battery-FAQ.

243 Ibid.

244 Battery Storage and Grid Integration Program (n 238) 16.

245 Ibid 2, 16.

246 See ibid 13.

being overly concerned with profit and with not providing value for money.[247] These also are not discussed further here. As for community battery storage, among other things, the ANU study noted concerns for logistics, for instance around battery maintenance, the transaction costs of establishing necessary collaborations, lack of community expertise in managing batteries, and potential difficulties in establishing governance schemes.[248]

Community-scale batteries, as Ausgrid notes, have the potential to promote equity between those able to harness solar power, and those not able to do so. But the ANU study cautions that 'battery schemes tailored to solar-PV owners … could in fact exacerbate energy inequality'.[249] Interviewing householders, the study found a strong preference for 'models that are simple to interact with, owned by local government, and that are run as a not-for-profit entity'. Householders wanted a model that could demonstrate benefit to the local community.[250] The ANU study notes that any evaluation of community storage models 'must consider different stakeholders, particularly "solar haves" vs "solar have-nots" and other differing levels of resources between energy users that affect capacity to participate (financial and non-financial)', along with questions about the geographical scope of who gets to participate. Other equity questions concern decisions around who is able to access the battery if there is an outage – for instance, whether the elderly should have priority access in a heat wave. The study further noted that community-scale storage could add to community resilience, including 'through local jobs and training, keeping money circulating within the community, and increasing the physical resilience of the local power supply to disturbances'.[251]

Community batteries thus present clear possibilities not only for enhancing grid stability but also for facilitating access to the financial benefits of renewable generation by those not able to install individual household batteries. They also present clear challenges from the perspective of energy justice. Determining who gets access to these batteries and under what financial and other conditions, and who is able to participate in decision-making about battery operation and maintenance, raises some complex questions. These require careful thought in ensuring that the energy transition is undertaken in as just a manner as possible.

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247 Ransan-Cooper (n 232) 47; and see James Purtill, 'A Community Battery "like a Corner Store": Is This the Future of Home Energy Storage?', *ABC News* (online, 5 April 2022) abc.net.au/news/science/2022-04-05/battery-solar-energy-storage-community-neighbourhood-home/100128416.

248 Ransan-Cooper (n 232) 18, 25, 30–31, 49.

249 Battery Storage and Grid Integration Program (n 238) 5.

250 Ibid 12.

251 Ibid 14, 60–62.

# 5. Hydrogen

## 5.1 Introduction

In a 2020 address to the National Press Club, Chief Scientist Alan Finkel hailed hydrogen as a 'hero'.[252] In Australia's National Hydrogen Strategy, compiled by the COAG (Council of Australian Governments) Energy Council,[253] hydrogen is described as a 'flexible, safe, transportable and storable fuel', which 'can be used to power vehicles and generate heat and electricity' and 'is a key ingredient for producing chemicals such as ammonia and methanol'.[254] When combusted, hydrogen produces no carbon dioxide – its only by-product is water.[255] The National Hydrogen Strategy has high hopes for the future of hydrogen production in Australia, suggesting that it

> could generate thousands of jobs, many of them in regional areas. It could add billions of dollars to GDP over coming decades. Managed well, it could help us to reliably integrate extensive renewable generation into the electricity grid. Using hydrogen, we can reduce dependence on imported fuels. And we can reduce carbon emissions, in Australia and around the world.[256]

Hydrogen is more than simply a storage mechanism for renewable energy generated elsewhere, ready to be fed into the grid. Instead, it is touted as having a variety of industrial uses. Finkel argues, for instance, that in the transportation sector, hydrogen is a good alternative fuel for long-haul trucks and buses, trains transporting minerals long distances from mines to ports, and ships.[257] He notes elsewhere that because of the amount of energy lost in the process of producing and using it, hydrogen is not currently financially competitive with batteries and pumped hydro as a storage option.[258] It will not be competitive unless the energy used to produce it is basically costless (e.g. from solar panels), or if it is able to provide particularly extended storage. Thus, he suggests that the 'economics will be most favourable for storage longer than twelve hours and on a very large scale', which may favour storage in large natural sites such as underground caves, rather than in tanks.[259]

Alongside its promise, hydrogen also presents challenges in production and transportation. The environmental difficulties it presents are of three kinds: carbon emissions, energy use and water use.

A carbon emissions challenge arises from all but one method of hydrogen production. There are three main ways to produce hydrogen currently under contemplation in Australia: gasification using coal; steam methane reforming, using natural gas; and electrolysis of water, using either renewable or non-renewable electricity. The first two methods are currently the most common and, because of their employment of fossil fuels, generate carbon emissions. For all three production processes, where fossil fuels are used, carbon capture and storage (CCS) has been proposed as a way to mitigate the carbon emissions. CCS is not relevant to electrolysis

252 Alan Finkel, 'The Orderly Transition to the Electric Planet' (National Press Club Address, Canberra, 12 February 2020) 9.

253 Finkel chaired the hydrogen working group

254 COAG Energy Council, *Australia's National Hydrogen Strategy* (Commonwealth of Australia, 2019) 3 dcceew.gov.au/sites/default/files/documents/australias-national-hydrogen-strategy.pdf.

255 Ibid 1.

256 Ibid.

257 Finkel (n 252) 10. On the potential and role of hydrogen fuel cell vehicles in transport in Australia, particularly as a complement to battery EVs, see Jamie Ally, Trevor Pryor and Attilio Pigneri, 'The Role of Hydrogen in Australia's Transport Energy Mix' (2015) 40 *International Journal of Hydrogen Energy* 4426.

258 Alan Finkel, 'Getting to Zero: Australia's Energy Transition' (2021) (81) *Quarterly Essay* 54.

259 Ibid 55.

using renewable energy sources.[260] 'Clean' hydrogen, then, might refer to hydrogen either produced through renewable-source electrolysis, or using fossil fuels and CCS,[261] though some commentators express scepticism about whether the latter might fairly be called 'clean'.[262] CCS is argued to be more effective for dealing with the carbon emissions from hydrogen processing than from other kinds of emissions generation, mainly because carbon dioxide is a by-product of the hydrogen production process, and does not need to be further extracted, but also because this process occurs at a high enough pressure that the extraction is energy efficient and the carbon dioxide less difficult to store.[263] We explore these arguments below.

As for energy use and water, hydrogen production using electrolysis requires a significant amount of both. Making one kilogram of hydrogen from electrolysis requires 39.4 KWh of electricity and nine litres of water.[264] Thus, even if hydrogen can be produced entirely from renewable energy and therefore without carbon emissions, a truly green hydrogen industry will require careful resource planning. This, too, is an issue we explore further below.

This section proceeds as follows. First, we examine the current status of hydrogen processing in Australia. Next, we analyse the potential and pitfalls of hydrogen processing. The potential lies in hydrogen's environmental performance, and its capacity to support desirable socio-economic outcomes through facilitating aspects of a just transition to a lower-carbon future. This potential cannot be reached without making some complex policy choices, centring on the management of electricity grids and the standards of carbon reduction that any policy setting must aim for.

## 5.2 State of the industry

Hydrogen has received investment support from the Commonwealth and from the states and territories. The Morrison Government's 2021 *State of Hydrogen* report proclaims a direct Commonwealth funding figure of over $1.2 billion, which includes:

- 'Activating a Regional Hydrogen Industry: Clean Hydrogen Industrial Hubs' program ($464 million);
- Carbon capture and storage, plus carbon capture, use and storage project development support (over $300 million);
- Three 10MW electrolyser projects, via ARENA (over $100 million); and
- Research, development and demonstration activities (over $300 million).[265]

The National Hydrogen Strategy is designed to 'remove market barriers, effectively build supply and demand, and accelerate our global cost-competitiveness'.[266] An aspect of this strategy is to create 'hydrogen hubs', aiming to take advantage of economies of scale produced by large-scale demand. This industry support is also directed toward ensuring 'a positive influence on energy prices and energy security'.[267] The Strategy outlines 57 strategic actions, grouped around a series of subject areas designed to facilitate coordinated growth of the industry.[268]

260 COAG Energy Council (n 254) 1; Finkel (n 252) 9; For further explanation of the nature of these processes, and some of their sustainability considerations, see: Canan Acar, Ahment Bekese and Gül Tekin Temur, 'Sustainability Analysis of Different Hydrogen Production Options Using Hesitant Fuzzy AHP' (2018) 43 *International Journal of Hydrogen Energy* 18059.

261 Finkel (n 258) 62.

262 Richie Merzian, 'Getting to Zero: Correspondence' (2021) (82) *Quarterly Essay* 105, 107.

263 Finkel (n 252) 9–10.

264 Finkel (n 258) 66.

265 Australian Government Science, Energy and Resources Department of Industry, *State of Hydrogen 2021* (Commonwealth of Australia, 2021) viii.

266 COAG Energy Council (n 254) viii.

267 Ibid.

268 The identified subject-areas are: an adaptive pathway to clean hydrogen growth; large-scale market activation; assessing our hydrogen infrastructure needs; supporting research, pilots, trials and demonstrations along the supply chain; using clean hydrogen in Australian gas networks; initial steps towards using hydrogen for transport; responsive regulation; shared principles for nationally consistent regulation; a coordinated approach to planning and regulatory approvals for hydrogen projects; integrating hydrogen into energy markets; hydrogen's role in secure and affordable energy supply; certainly around taxation, excise and other fees or levies for hydrogen; bilateral partnerships to build markets; hydrogen certification; building community knowledge and engagement; responsible industry development; skills and training for the hydrogen economy; hydrogen training for Australian emergency services; hydrogen training for regulators; national coordination: Ibid 78–83.

The Strategy outlines four measures of success:

1. 'Australia is one of the top three exporters of hydrogen to Asian markets';
2. 'Australia has an excellent hydrogen-related safety track record';
3. 'hydrogen is providing economic benefits and jobs in Australia', and
4. 'Australia has a robust, internationally accepted, provenance certification scheme in place'.[269]

By 'clean hydrogen', the strategy refers to the definitions, noted above, of hydrogen produced either from renewable sources or from fossil fuels and CCS.[270] The ACT Government sought an amendment to the strategy, to support hydrogen production only from renewable energy, precluding hydrogen production from fossil fuels. This was not approved.[271]

Across Australia, there are over a dozen projects under development that are enhancing local capacities and showing the operation of clean hydrogen.[272] To take an example of one state's programs, as at 2019 SA had devoted over $40 million in loans and grants to hydrogen project development.[273] These include three megawatt-scale hydrogen developments within the state, among them the 'hydrogen superhub' at the Crystal Brook Energy Park in the state's mid-north. Operated by French company Neoen (the owner and operator of the Hornsdale giant battery), the park is aimed at 'providing firm power 24-hours a day' from renewables. The park will combine wind generation, solar PV and battery storage, with facilities to transmit the power generated into the state's grid.[274] The SA Government has provided $1 million in grant funding to study the 'technical and economic feasibility' of hydrogen production at the park, with a possible capacity to produce 25,000 kilograms of hydrogen each day using entirely renewable energy.[275] A further $4 million in grants and $20 million in loans is promised if the project moves to financial close and construction.[276] Further government-supported large scale projects have been promised in the state.[277]

Australian iron ore billionaire Andrew 'Twiggy' Forrest has also begun a series of rapid investments in renewables, including in green hydrogen. In 2021, he formed 'Fortescue Future Industries' and announced among its goals one of producing 15 million tons of green hydrogen per year by 2030. At present, global green hydrogen production is at 1 million tons per

269 Ibid xiii.

270 Ibid 3. It is worth noting that there are other criteria by which the 'cleanliness' of hydrogen production methods might be assessed: see Furat Dawood, Martin Anda and GM Shafiullah, 'Hydrogen Production for Energy: An Overview' (2020) 45 *International Journal of Hydrogen Energy* 3847.

271 Yvette Berry and Shane Rattenbury, 'COAG Energy Council Meeting (Joint Media Release: 22 November 2019)' cmtedd.act.gov.au/open_government/inform/act_government_media_releases/rattenbury/2019/coag-energy-council-meeting.

272 As at 2018: see S Bruce et al, *National Hydrogen Roadmap: Pathways to an Economically Sustainable Hydrogen Industry in Australia* (CSIRO, 2018) 8.

273 COAG Energy Council (n 254) xxvi.

274 'Neoen Australia Hydrogen Superhub', *Renewables SA* (Web Page) renewablessa.sa.gov.au/topic/hydrogen/hydrogen-projects-south-australia/neoen-australia-hydrogen-super-hub.

275 Ibid.

276 Ibid.

277 Sophie Vorrath, 'South Australia Seeks Ideas for Whyalla Hydrogen Hub, Both Blue and Green', *RenewEconomy* (31 May 2022) reneweconomy.com.au/south-australia-seeks-ideas-for-whyalla-hydrogen-hub-both-blue-and-green.

year.[278] Fortescue's goal is estimated to need approximately 200GW of new solar and wind capacity, or slightly less if the final product is green ammonia (a form of hydrogen storage) rather than liquid hydrogen.[279]

## 5.3 Policy complexity

### *5.3.1 Supporting regional development*

Hydrogen is touted as having export potential, in terms of both the export of hydrogen itself, and the refined mineral products that can be manufactured from it. This in turn has potential to help rejuvenate regional and industrial employment. Thus, in a report for ARENA on the potential of a hydrogen export industry, ACIL Allen Consulting noted that most of the jobs that might be created through investing in hydrogen export would be located near hydrogen production or export facilities, which are likely to be near sources of renewable energy. The report suggests that such sources, especially those dependent on sunlight, such as solar PV, are 'most likely to be located where solar irradiance is high in Australia' and where appropriately large parcels of land are available. This is likely to be in regional areas, and thus producing hydrogen for export 'may therefore particularly benefit regional communities, traditional owners of the land, and the broader Australian community through the direct employment associated with hydrogen production facilities'.[280]

As noted above, the National Hydrogen Strategy aims to position Australia as a key exporter of hydrogen to Asia. This strategy has not received unqualified support from experts. Economist Ross Garnaut argues that because of the high cost and difficulty of processing hydrogen into a liquefied form suitable for export, 'the economics strongly favour the use of Australian electricity and hydrogen to process Australian minerals at home, rather than sending both the raw materials and the hydrogen or electricity to Asian destinations for conversion into metals'.[281]

These minerals, such as iron ore and alumina, are presently sent overseas for processing into products such as steel and aluminium. Garnaut argues that, using hydrogen, the process should be repatriated, allowing Australia to access the economic benefits involved in refining minerals through low-emissions processes. For aluminium, he argues that smelting half of Australia's alumina exports domestically would require four or five large plants, and would 'increase Australian electricity demand by around a quarter'.[282] Because smelters can be turned off for around one hour in 20, they can be used to offset short-term shocks in electricity supply.[283] Producing steel from iron ore, meanwhile, is 'one of the most electricity-intensive major industrial processes', and processing domestically even 10% of our iron ore export would 'roughly double Australia's total electricity demand', though like aluminium smelting, the processes may be switched off where grid security is needed.[284] These new industrial capacities can efficiently be located in areas of previous industrial strength, for instance 'at the transmission nodes built around the declining fossil power generation',[285] and thus may assist with employment transformations away from reliance on fossil fuel power. Such claims require scrutiny: for instance, the Neogen Crystal Brook project, (which is, it must be noted, not a mineral refining project) has been projected to

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278 Giles Parkinson, 'Fortescue Says Its "Very Stretch" 15m Tonne Green Hydrogen Targets Now Very Achievable', *RenewEconomy* (21 March 2022) reneweconomy.com.au/fortescue-says-its-very-stretch-15m-tonne-green-hydrogen-targets-now-very-achievable.

279 Ibid; see also Adam Morton, 'Twiggy Forrest Sets Sights on Making the Impossible Possible When It Comes to "Pure Green Energy"', *The Guardian* (online, 26 March 2021) theguardian.com/environment/2021/mar/27/twiggy-forrest-sets-sights-on-making-the-impossible-possible-when-it-comes-to-pure-green-energy.

280 ACIL Allen Consulting for Arena, *Opportunities for Australia from Hydrogen Exports* 6–7.

281 Garnaut (n 45) 112.

282 Ibid 115.

283 Ibid.

284 Ibid 117–20.

285 Ibid 125.

create 200 construction jobs, but only a dozen permanent operating positions.[286] Other evidence suggests, however, that overall job growth in the renewable energy sector is likely to exceed job losses in coal. While many of these new jobs are likely to be in construction, economist John Quiggin argues that 'the scale of the required energy transition means that a high level of construction activity will be needed for at least the next three decades'.[287] Furthermore, he notes that 'employment averaged over the operating life of the asset' is higher for renewable projects than it is for coal mining and coal-fired power.[288] While the net job creation figures may represent positive news at a national level, it would be an error to expect the benefits to be spread evenly. Some coal-dependent communities will be affected in a way that the founding of new renewables projects in other locations, including new hydrogen projects, will not necessarily offset.[289]

The energy justice framework we outlined at Subsection 1.1 above has crucial application in decisions about hydrogen's role in the energy transition, and its relationship to employment and regional development. The construction and maintenance of renewable energy resources needed in the production of green hydrogen, alongside the production itself and the newer, greener materials processing that new hydrogen reserves open up, have the potential to provide sustainable jobs into the future. The core principles of energy justice – distribution of costs, distribution of benefits, and due process and representation in decision-making – are all engaged in the planning process for hydrogen deployment. In considering industry transition from fossil fuels to renewables such as hydrogen, it is important to note that it is not only the interests of workers directly affected that must be taken into account. Edwards et al note that '[t]ransition thinking displays a worrying lack of specific attention to both Indigenous owners and communities and women.'[290]

It is noteworthy that mining jobs tend to be well paid, and that transitioning workers to other industries may involve reductions in remuneration. Quiggin notes that average full-time mining wages are around $130,000 per year, compared to a national average full-time earning of $80,000 per year for the labour market generally.[291] This is partly to offset the demanding nature of work that is frequently Fly-In, Fly-Out in nature, but is also a result of high levels of unionisation in the mining sector. Quiggin argues that the appropriate response, then, to concerns about lower wages in the renewable transition is 'not to defend old unionised industries against emerging industry with low levels of unionisation. It is to reverse the long decline in union membership across the economy as a whole, with a particular focus on growing employment'.[292]

For all that concern and careful planning for affected workers, livelihoods and communities is vital, energy justice principles also require maintenance of a focus on the bigger picture: the urgency of restricting carbon emissions in order to bolster the wellbeing and livelihoods of communities throughout Australia and the world.

286 Sophie Vorrath, 'Neoen Halves Wind Component of SA Renewable Hydrogen Superhub', *RenewEconomy* (9 October 2018) reneweconomy.com.au/neoen-halves-wind-component-of-sa-renewable-hydrogen-superhub-89566.

287 Quiggin (n 71) 14, 23.

288 Ibid 23.

289 Ibid.

290 Edwards et al (n 70) 20.

291 Quiggin (n 71) 10.

292 Ibid 13.

### *5.3.2 Generation capacity issues*

As noted above, the possibility of Australia developing a hydrogen export industry has been explored. One significant consideration in scaling up the hydrogen production industry relates to the amount of energy it will consume. A study published in 2022 modelled a scenario in which the nation's chief energy exports, alongside its exports in iron ore, bauxite and alumina, were replaced with equivalent exports of zero carbon energy and refined metals. This assumed 80% of the new energy exports would be through liquefied hydrogen and 20% through undersea cables, and that green metals would be made using renewable electricity and green hydrogen.[293] Accounting for the energy required not just to produce the hydrogen from electrolysis, but also to desalinate the water and to liquefy the hydrogen gas, the study found that the amount of solar and wind generation required is roughly 27 times the electricity Australia currently generates annually.[294] On one estimate, the land area involved in this generation would be approximately 168,000 km$^2$, an area roughly equivalent to 2% of Australia's land area or 4% of area now used for grazing livestock.[295] Alan Finkel estimates that to replace the energy value of one year of Australia's liquefied natural gas exports[296] with hydrogen produced from renewables would require approximately eight times as much electricity as Australia produced in 2019.[297] If this were all produced from solar power, it would require approximately 20,000 square kilometres of land, or approximately 0.25% of Australia's landmass, or considerably less if some of that energy were produced from wind. This, Finkel suggests, is plausible – especially if it is phased in over three decades.[298]

We have noted above Ross Garnaut's opposition to the promotion of investment in hydrogen liquefication for export. Others have also suggested focusing on targeted areas of domestic industry. Whitehead, Newman and Bräuni argue, for instance, that 'Australia must use hydrogen intelligently and strategically. Otherwise, we risk supporting a comparative energy-intensive technology in uses that don't make sense. This would waste valuable renewable energy resources and land space, increase costs for Australians and slow emissions reduction'.[299] They argue that the best use of hydrogen is in sectors where electrification is difficult, such as 'steel, cement, aluminium, shipping and aviation', while export may be an option in the long-term.[300]

The significant energy requirement of large-scale green hydrogen production, alongside the vast land reserves required when that energy is produced from solar sources, make clear the relevance of the framework principles we set out in the introduction to this discussion paper. Together with the considerations around CCS and water usage set out in the following two subsections, any amplification of hydrogen production requires close attention to the Earth's ecological limits and the necessity of ensuring that development stays within them. The resources required to produce the necessary volume of solar panels alone will be considerable.

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293 Paul J Burke et al, 'Contributing to Regional Decarbonization: Australia's Potential to Supply Zero-Carbon Commodities to the Asia-Pacific' (2022) 248 *Energy* 123563, 5.

294 Ibid 6: 7000 TWh per year vs the current 264 TWh per year.

295 Ibid.

296 The year to June 2020

297 Finkel (n 258) 66.

298 Ibid 67.

299 Jake Whitehead, Peter Newman and Thomas Bräunl, 'Time to Get Real: Amid the Hydrogen Hype, Let's Talk about What Will Actually Work', *The Conversation* (31 August 2020) theconversation.com/time-to-get-real-amid-the-hydrogen-hype-lets-talk-about-what-will-actually-work-144579.

300 Ibid. See also Whitehead's submission to consultations on the National Hydrogen Strategy: Jake Whitehead, 'National Hydrogen Strategy - Request for Input' consult.industry.gov.au/national-hydrogen-strategy-request-for-input/submissions/view/12.

As we have seen, there will be significant demands on land. Where proposed developments are to take place on Aboriginal land, free, prior and informed consent will be required from traditional owners.

Conflicts may also arise where the land has a variety of environmental values. One example is the Asian Renewable Energy Hub, which is a proposed development in the Pilbara region of WA being promoted by a consortium of energy development companies. According to the project's website, it will produce up to 26 GW of combined solar and wind power generating capacity, and around 1.6 million tonnes of hydrogen or 9 million tonnes of green ammonia each year.[301] In June 2021, the Morrison Government rejected the proposal on environmental grounds. Particular concerns cited included effects on nearby Ramsar wetlands and threatened bird species. The proponent is reported to be proceeding with plans to meet the objections that were raised to the project.[302] As illustrated by this example, the generation of renewable hydrogen may raise environmental concerns beyond those relating to energy and water inputs.

### *5.3.3 The viability of CCS*

The National Hydrogen Strategy identifies CCS as an option to diminish the emissions of hydrogen production from non-renewable sources, such as coal and gas. It suggests, in a context in which it identifies carbon capture as more efficient for hydrogen production than for other forms of electricity generation, that the 'best areas for CCS hydrogen production would be close to coal or gas sources and to subsurface storage for carbon dioxide'.[303] Drawing on analysis from Geoscience Australia, it identifies some likely sites and notes that there may be some markets where CCS hydrogen is accepted as part of decarbonisation efforts, and that 'establishing [CCS] sites will, of course, require close engagement with nearby communities'.[304]

In its submission to the strategy, the Australian Conservation Foundation argues that

> despite hundreds of millions of dollars being spent on CCS development in Australia it is still nowhere near commercial. There is no reason to divert further resources into unproven CCS to shore up further fossil fuel use. Even if carbon-capture and storage could be technically, economically, and legally established (which is currently not the case), the greenhouse-gas emissions of fossil-based hydrogen controlled, fossil-fuel mining remains a highly damaging practice.[305]

Research by the Australia Institute notes that as at 2018, CCS had missed every one of its international targets.[306] The Australia Institute's own submission to the National Hydrogen Strategy warns that investing in fossil hydrogen offset by CCS risks extending and amplifying the life of the gas industry,[307] a concern also

301 'Renewable Energy Hub in Australia', *BP* https://bp.com/en/global/corporate/what-we-do/gas-and-low-carbon-energy/renewable-energy-hub-in-australia.html.

302 Louise Myolin and Susan Standen, 'Asian Renewable Energy Hub Plan for WA Rejected by Federal Government on Environmental Grounds', *ABC News* (online, 20 June 2021) abc.net.au/news/2021-06-21/government-rejects-plans-for-massive-renewable-energy-hub/100228008.

303 COAG Energy Council (n 254) 13.

304 Ibid.

305 Australian Conservation Foundation, 'National Hydrogen Strategy Submission, 28 March 2019' consult.industry.gov.au/national-hydrogen-strategy-request-for-input/submissions/view/36.

306 Bill Browne, 'Sunk Costs: Discussion Paper' australiainstitute.org.au/wp-content/uploads/2020/12/P546-Sunk-costs-WEB.pdf; Joshi, *Windfall: Unlocking a Fossil-Free Future* (n 52) 141; and see Bill Browne and Tom Swann, 'Money for Nothing: Discussion Paper' australiainstitute.org.au/wp-content/uploads/2020/12/P357-Money-for-nothing_0.pdf.

307 Tory Bridges and Richie Merzian, 'Hydrogen and Climate: Trojan Horse or Golden Goose?' 4 australiainstitute.org.au/wp-content/uploads/2020/12/P695-National-Hydrogen-Strategy-Input-WEB.pdf.

expressed by other commentators.[308] This is especially a danger if CCS is proven not to be feasible, either economically or technologically. A 2020 opinion piece by two authors involved in CCS research noted that over 260 million tonnes of $CO_2$ have been captured and injected underground since the 1970s, globally, and pointed to some CCS projects underway currently in Australia, including the Gorgon gas project off WA, projected to 'reduce Gorgon's emissions by more than 100 million tonnes over the next 25-plus years'.[309] In 2019, the Australia Institute expressed doubt about the effectiveness of the Gorgon project.[310]

The technical feasibility of CCS has been explored elsewhere,[311] but the extent to which it is a feasible solution to Australian and global emissions profiles, its long-term security, and questions of intergenerational equity are important considerations. Any claims about clean hydrogen must factor in the extent of CCS capacity, its expense and sustainability, and the extent to which such capacity should be used to mitigate hydrogen production, compared to whether it should be deployed to offset other carbon emitting activities.

The long-term storage of carbon dioxide poses social and environmental risks, and there are important questions about the location and management of those risks that must be considered in any larger strategy. The CSIRO road map, for instance, argues that there is 'an important role for government in managing the long term risk associated with $CO_2$ storage in underground aquifers, a risk that is unlikely to be accepted by the private sector'.[312] Careful consideration is required of the regulatory frameworks to apportion long-term legal liability: the CSIRO road map, for instance, outlines a hydrogen-production and underground $CO_2$ storage project in Alberta, Canada, where by legislation, the Albertan Government received long-term liability for, and ownership of, the sequestered $CO_2$.[313] Once again, aside from questions about the ecological limits of the Earth, proposals for hydrogen manufacture using CCS raise important questions of energy justice. Assuming technical feasibility, Australia must avoid any scenario in which private enterprises receive short-term profits, while taxpayers are left with the long-term bill of maintaining CCS facilities and meeting any liabilities. Likewise, any assessment of potential benefits must factor in the costs to individuals if, for example, CCS containment fails and there is contamination of land or water.

#### 5.3.4 How much water is required?

One of the key components of hydrogen production through electrolysis is water. The process requires nine litres of water for every kilogram of hydrogen, and this water must be of high purity to prevent side reactions being caused by salts in the water. For this reason, the CSIRO notes that most 'commercial electrolysers therefore have an integrated deioniser allowing them to use fairly low grade potable water as an

308 Tim Flannery, 'Getting to Zero: Correspondence' (2021) (82) *Quarterly Essay* 84, 85; Ketan Joshi, 'Getting to Zero: Correspondence' (82) *Quarterly Essay* 122, 126.

309 David Byers and Peter Cook, 'Hydrogen and CCS Could Be the Energy Road-Map Winners', *The Australian Financial Review* (Melbourne, Australia, 1 June 2020) 39.

310 Bridges and Merzian (n 307) 13.

311 Mai Bui et al, 'Carbon Capture and Storage (CCS): The Way Forward' (2018) 11(5) *Energy & Environmental Science* 1062; Jonathan Paul Marshall, 'Disordering Fantasies of Coal and Technology: Carbon Capture and Storage in Australia' (2016) 99 *Energy Policy* 288.

312 Bruce et al (n 272) 23.

313 Ibid 24.

input'.[314] The National Hydrogen Strategy notes that 'using desalinated seawater or waste water, if available, may be the most feasible approach', and argues that the energy cost of desalinating seawater is low, at under 5c per kilogram of hydrogen.[315]

In a continent as dry as Australia, the question of what is the best allocation of water resources is an important one. The National Hydrogen Strategy suggests that under a high growth setting for the hydrogen industry, in which Australia would be a major supplier of global hydrogen by 2050, the water used 'might be the equivalent of about one-third of the water used now by the Australian mining industry'.[316] The report points out that 'other uses for water may have higher economic, social or cultural values. Social acceptance of hydrogen production will depend on it not unduly affecting these existing uses'.[317] The 2022 study by Burke et al, mentioned at Subsection 5.3.2 above, which looked at resource requirements for replacing all Australia's energy exports and some of its mineral exports with green alternatives, estimated that hydrogen production in that scenario would require about 865 gigalitres of water per year, which equates to approximately 80% of the water used by Australian mining.[318] That study noted that at least some of this water requirement could be generated through desalination, and that the energy required for this desalination would be less than a thousandth of the total energy required by the electrolysis process.[319]

The concerns raised above, of energy justice and respect for planetary ecological limits also apply to questions of water allocation and supply. Water, even desalinated water, is a precious commodity in Australia and, increasingly, globally. Careful thought needs to be given to its most effective and just deployment, including, where relevant, for environmental flows in rivers.

314 Bruce et al (n 272).
315 COAG Energy Council (n 254) 10, 12.
316 Ibid 12.
317 Ibid.
318 Burke et al (n 293) 6.total g
319 Ibid 7.

# 6. Waste to Energy

## 6.1 Introduction

In 2016-2017, Australia generated 67 million tonnes of waste, of which 37 million tonnes were recycled. Two million tonnes of waste annually are recovered into energy.[320] In 2018-19, Australia generated 75.8 million tonnes of solid waste, of which 38.5 million tonnes were sent for recycling and 27%, or 20.5 million tonnes, to landfill. In total, 45 million tonnes were 'recovered' – that is, sent for recycling, used for energy production or exported.[321]

In 2018, the Commonwealth, state and territory governments and the Australian Local Government Association developed a National Waste Policy that prioritises the circular economy, which it refers to as 'retain[ing] the value of materials in the economy for as long as possible, reducing the unsustainable depletion of natural resources and impacts on the environment', and as being a 'whole-of-system approach that requires accounting of the full cost and life-cycle of materials'.[322] In 2019, some of these goals were elaborated in the National Waste Policy Action Plan, which set targets for, among other things, resource recovery and imposed bans on the export of certain kinds of waste plastic, paper, glass and tyres.[323] A 2021 agreed communiqué of a meeting of National Environment Ministers reported that the Ministers had agreed to measures for national harmonisation of waste collection and regulation, including identifying eight kinds of plastic for national phase out, by 2025 or earlier, under the National Waste Policy Action Plan.[324]

A 2020 Commonwealth House of Representatives committee report on waste defines waste to energy (WtE) as 'a range of technologies that convert waste that would otherwise go to landfill into energy sources such as electricity, heat and fuel'.[325] This report sets out the most significant categories of WtE: harnessing the methane emissions from landfill to generate electricity; food waste processed through biological methods such as anaerobic digestion, with any residue used in agriculture; and 'thermal processes' such as 'incineration, gasification, pyrolysis and plasma arc technologies'.[326]

Transforming waste into energy appears to solve two problems at once: the problem of waste and increasing levels of landfill congestion; and the

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320 Commonwealth of Australia, State and Territory Governments, and Australian Local Government Association, 'National Waste Policy: Less Waste, More Resources' 2, 13 environment.gov.au/system/files/resources/d523f4e9-d958-466b-9fd1-3b7d6283f006/files/national-waste-policy-2018.pdf.

321 'Waste Account, Australia, Experimental Estimates, 2018-19 Financial Year' abs.gov.au/statistics/environment/environmental-management/waste-account-australia-experimental-estimates/latest-release.

322 Commonwealth of Australia, State and Territory Governments, and Australian Local Government Association (n 320) 8.

323 Commonwealth of Australia, State and Territory Governments, and Australian Local Government Association, 'National Waste Policy Action Plan' environment.gov.au/system/files/resources/5b86c9f8-074e-4d66-ab11-08bbc69da240/files/national-waste-policy-action-plan-2019.pdf. On export bans and regulations, see *Recycling and Waste Reduction Act 2020* (Cth); and 'Waste Exports', *Australian Government Department of Climate Change, Energy, the Environment and Water* (22 March 2022) dcceew.gov.au/environment/protection/waste/exports.

324 'Environment Ministers Meeting 1: Agreed Communique, 15 April 2021' awe.gov.au/sites/default/files/documents/emm-1-agreed-communique.pdf.

325 House of Representatives Standing Committee on Industry, Innovation, Science and Resources, *From Rubbish to Resources: Building a Circular Economy* (Parliament of the Commonwealth of Australia, December 2020) 85.

326 Ibid.

ongoing need[327] for electricity generation. But it also poses challenges, both at a technological level, and in terms of wider questions about what a commitment to a circular economy requires. The concept of the 'waste management hierarchy' is relevant to understanding this issue. This hierarchy refers to the order of priority in management of wastes. The first and second steps involve removing materials from the waste stream itself, through, first, avoiding and reducing waste, and second, reusing materials. The third step is recycling: converting materials in the waste stream into materials that can be used to create new products. The fourth is energy recovery, or WtE, and the final two are treatment and disposal (usually, in Australia, to landfill).[328]

In the following subsections, we first set out the state of the industry in Australia, before examining two areas of policy complexity: first, how to understand the value of waste; and second, the environmental justice and social licence implications of WtE facilities.

## 6.2 State of the industry

WtE is in a nascent stage of development in Australia. In 2018, then environment minister Josh Frydenberg told the Australian Broadcasting Corporation (ABC) that there were over 30 WtE projects under development in Australia.[329] Most projects in Australia are smaller 'bioenergy' plants, which produce energy from organic waste,[330] but there is increasing interest in the development of facilities for incinerating non-recyclable waste. In early 2020, ARENA announced $18 million in grant funding for Australia's second WtE plant producing energy from non-recyclable waste, alongside up to $57.5 million in debt financing from the CEFC. Located in the Rockingham Industrial Zone near Perth, WA the plant is to use 300,000 tonnes of municipal, industrial and commercial rubbish in generating the capacity to power 40,000 homes, and it has entered into contracts to receive waste from local councils and other sources. The ash that is a by-product of the process is to be used in road construction.[331] The first such plant, also in WA, is to process 400,000 tonnes of waste each year and has received $23 million in funding from ARENA and up to $90 million in debt financing from the CEFC.[332] The waste it diverts from landfill is estimated to comprise one quarter of Perth's total post-recycling rubbish. Macquarie Capital, one of the plant's proponents, projects that it will be able to deliver 36MW of electricity to the grid, sufficient to power 50,000 households, and will avert 486,000 tonnes of carbon dioxide emissions per year compared with electricity produced via the Western Australian grid.[333] That plant, the Kwinana WtE project, was due to be completed in 2021 but appears to have been delayed.

Other plants are also under development. For instance, in Victoria, Opal Australian Paper (formerly Australian Paper), together with Veolia (formerly SUEZ) (a waste management company) and other partners, is developing a plant that will use kerbside and other waste to power its paper mill in Maryvale, Latrobe Valley.[334] The plant, stage one of which was due to begin construction in late 2021 and to be operational in 2025, was to have capacity to process 325,000 tonnes of residual waste each year – SUEZ had pledged to provide 150,000 tonnes of residual commercial and industrial waste each year, and noted that it planned 'to source the remaining residual waste from Gippsland and a few key metropolitan councils'.[335] In 2019, the ABC reported that

327 ARENA, 'Second Waste-to-Energy Plant Gets Green Light', *ARENAWIRE* (22 January 2020) arena.gov.au/blog/second-waste-to-energy-plant-gets-green-light.

328 House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 14–15.

329 Nick Kilvert, 'Waste-to-Energy Incineration Should Be "last Resort" as Josh Frydenberg Flags Expansion', *ABC News* (27 April 2018) abc.net.au/news/science/2018-04-27/waste-incineration-last-resort-experts-warn-frydenberg/9702490.

330 House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 86.

331 ARENA, *Second Waste-to-Energy Plant Gets Green Light* (n 327).

332 ARENA, 'The Waste to Energy Plant Future Is Here', *ARENAWIRE* (Web Page, 23 October 2018) arena.gov.au/blog/the-waste-to-energy-plant-future-is-here.

333 ARENA, 'Kwinana Waste to Energy Project', *Australian Renewable Energy Agency* (20 January 2021) arena.gov.au/projects/kwinana-waste-to-energy-project.

334 Jarod Whittaker and Jonathan Kendall, 'Australian Paper to Proceed with Victorian-First Energy-from-Waste Project', *ABC News* (online, 7 February 2019) abc.net.au/news/2019-02-07/victorian-first-energy-from-waste-project-gets-green-light/10791686.

335 SUEZ and Opal Australian Paper, 'Maryvale Energy from Waste (EFW): Project Update October 2020' opalanz.com/app/uploads/2020/10/Maryvale-Energy-from-Waste-project-update-October-2020-fact-sheet.pdf.

Australian Paper was working with SUEZ to secure 25-year contracts for waste with municipal governments, and aimed to have these concluded by early 2020.[336] In May 2022, the project announced its receipt of a $48.2 million grant from the Morrison Government's Modern Manufacturing Initiative.[337] Noting that the project would process 325,000 tonnes of residual waste and lower Victorian greenhouse gas emissions by 270,000 tonnes annually, the announcement projected construction to begin in 2022 with operations to commence in late 2025.[338] As at December 2019, ARENA had provided $44.4 million in grant funding to five incineration projects.[339]

By contrast, under its Waste-to-Energy Policy 2020-25, the ACT Government banned thermal WtE, including incineration, gasification and pyrolysis, but continued to support non-thermal methods such as anaerobic digestion, refuse derived fuel production, and landfill gas capture and electricity generation, and noted that any WtE activities in the ACT could only use residual waste as fuel.[340] It defines residual waste as 'non-hazardous waste materials which can no longer be reused, recycled and for which no alternative markets exist, after genuine source separation from mixed waste and resource recovery operations have occurred, and would otherwise be sent to landfill'.[341] The policy instead promotes focusing on minimising the amount of waste going to landfill, 'starting with waste avoidance in line with the waste hierarchy'.[342]

Australia's WtE industry is less developed than in other countries.[343] The House of Representatives Committee found that this was not because of lack of interest by project proponents, but because 'inconsistent regulations, dated legislation, and a lack of policy certainty have all inhibited progress in this space'.[344] A number of submissions to the Committee pointed to the disharmony of regulations across jurisdictions, and called for the Federal Government to take the lead in policy harmonisation.[345] One component of this inconsistent regulation concerns landfill levies. WtE projects draw revenue from charging for waste processing, but their capacity to enact these charges is constrained when dumping rubbish is cheaper. Landfills in Australia are generally inexpensive for users, and although states charge waste levies on disposing to landfill, the rates vary.[346]

In addition, submissions argued that investment of a scale required to make WtE projects viable was difficult to obtain in a scenario where it was unclear whether regulations, at federal and intermediate levels, were likely to change.[347] Part of the policy uncertainty has been attributed to the failure of federal governments to elaborate a clear policy position on emissions reductions.[348] Noting the inconsistency in regulation, the House of Representatives Committee recommended that the Commonwealth Government develop, in consultation with the states and territories, a national WtE policy, stating that 'consideration

336 Whittaker and Kendall (n 334).

337 'Maryvale Energy from Waste Project Secures $48.2M Grant - 2 May 2022', *Veolia Australia and New Zealand* (2 May 2022) veolia.com/anz/newsroom/maryvale-energy-waste-project-secures-482m-grant.

338 Ibid.

339 Darren Miller, 'ARENA Submission to the Inquiry into Innovative Solutions in Australia's Waste Management and Recycling Industries January 2020'.

340 ACT Government, 'ACT Waste-to-Energy Policy 2020-25' 4 s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.act-yoursay.files/3815/8509/9072/TCCS_ACT_Waste_to_Energy_Policy.pdf.

341 Ibid 11.

342 Ibid 9.

343 House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 86; Monique Vella, 'Waste to Energy or Waste of Energy: Social and Regulatory Barriers for Waste-to-Energy in Australia' (2019) 36 *Environmental and Planning Law Journal* 262, 262.

344 House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 91.

345 Ibid 92–3.

346 Vella (n 343) 267–8; Clean Energy Finance Corporation, *Energy from Waste in Australia: A State-by-State Update* (Market Report, November 2016) 3; and see, e.g. *Protection of the Environment Operations (Waste) Regulation 2014* (NSW) cl 11; NSW EPA, 'Levy Regulated Area and Levy Rates', *NSW Environment Protection Authority* (3 July 2020) epa.nsw.gov.au/your-environment/waste/waste-levy/levy-regulated-area-and-levy-rates; *Waste Reduction and Recycling Regulation 2011* (Qld) sch 1; Queensland Government, 'Levy Rates', *Queensland Government* (Web Page) qld.gov.au/environment/pollution/management/waste/recovery/disposal-levy/about/levy-rates.

347 House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 93–4.

348 Vella (n 343) 265.

should be given to where waste to energy fits into the waste management hierarchy', and that this policy should aim to ensure 'national consistency across planning, approval and operational processes'.[349]

On 17 February 2022, the Morrison Government provided its response to the House of Representatives inquiry. Its response to the recommendation cited above was to note it, and also to note that the 'National Waste Policy explicitly incorporates the waste hierarchy where waste avoidance, reduction, reuse and recycling are prioritised over waste recovery (including waste to energy … applications), and provides an existing framework for collective national action by businesses, government, communities and individuals until 2030'.[350]

## 6.3 Policy complexity

Of the three major WtE technologies outlined in the introduction, thermal processing, particularly incineration, has been the most contested. This is the technology we focus on in this subsection.[351]

### *6.3.1 How is waste best managed?*

WtE has some clear environmental benefits. Landfills pose environmental risks, such as carbon emissions and toxic leachate[352] – diverting waste from landfills helps to mitigate these risks, though it is questionable whether WtE is the most effective form of diversion. WtE can also contribute to meeting Australia's energy needs, though its capacity to do so must be carefully assessed. In 2016, the CEFC cited research suggesting WtE 'could generate baseload electricity equivalent to 2% of Australia's electricity needs'.[353] Another study looking just at NSW found that taken together, generation from anaerobic digestion of food waste and combustion of combustible waste diverted from landfills could provide 5.9% of total NSW energy generation, while preventing around 3 million tonnes of waste each year flowing to landfills.[354] As noted above in relation to the Kwinana WtE plant, the energy generated may also displace carbon dioxide emissions that would otherwise be generated through the grid.

The capacity to divert waste from landfill is the second principal potential environmental benefit of WtE but is not without complication. The House of Representatives Committee noted that 'a potential area of concern is that the technology might, in the long-term, be at odds with efforts to improve waste management and resource recovery and transition to a circular economy'.[355] It is not necessarily straightforward to evaluate the extent of this risk. If thermal processing is to be undertaken at all in the generation of energy, then ideally it will only be applied to residual waste – the very minimum amounts of waste left over once all possible strategies of avoidance, reduction, reuse and recycling have been undertaken. But there are constraints on the extent to which these can be effective.

At the recycling end of the waste management hierarchy, a significant constraint is the availability of recycling facilities. In 2018, China implemented an effective ban on importing Australian paper and plastics by imposing a contamination threshold that is in practice impossible to meet from household waste. A total of 99% of the recyclables that Australia had sold to China were blocked from its market.[356] In 2017, China had received 29% of paper and 36% of plastic retrieved from Australia's kerbside recycling, comprising around 65% of the export market for each

349 House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 98. A second recommendation was for the Commonwealth, state and territory governments to 'develop a national methane-to-power program for landfill sites in cities and larger regional centres': 98.

350 'Australian Government response: Inquiry into Australia's Waste Management and Recycling Industries, 17 February 2022' industry.gov.au/data-and-publications/australian-government-response-inquiry-into-australias-waste-management-and-recycling-industries.

351 House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 97.

352 Vella (n 343) 263.

353 Clean Energy Finance Corporation (n 346) 5.

354 B Dastjerdi et al, 'An Evaluation of the Potential of Waste to Energy Technologies for Residual Solid Waste in New South Wales, Australia' (2019) 115(109398) *Renewable and Sustainable Energy Reviews* 11.

355 House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 98.

356 Jenni Downes, 'China's Recycling "ban" Throws Australia into a Very Messy Waste Crisis', *The Conversation* (Web Page, 27 April 2018) theconversation.com/chinas-recycling-ban-throws-australia-into-a-very-messy-waste-crisis-95522.

product.[357] The 2018 ban meant that the price of paper dropped from $124 per tonne to $0, while the price of scrap plastics dropped from $325 to $75 per tonne, making recycling uneconomical for many recycling businesses and leading to government rescue packages for businesses and councils.[358]

Some experts cautioned at the time against prioritising WtE to fill the recycling gap, noting that 'this has the least environmental benefit compared to avoidance, reuse and recycling', and that it was not appropriate as a stop-gap measure, because 'once these facilities are built they need to be fed'.[359] Research suggests that incinerators work best, and most cleanly, when they are operating at full capacity:[360] the need to keep them constantly supplied raises a concern that this will disincentivise the minimisation of waste generation. One commentator from industry has also noted that usually, 'commercial-scale WtE facilities are cost-effective at scales greater than 100,000 tonnes per annum', but that in Australia it would be unusual for a local government area to be able to generate this amount of post-recycled waste. Generating this amount of waste might occur with council amalgamations, or if councils coordinate with one another, but arrangements between councils and project developers may not always be straightforward.[361]

Overseas experience has shown that because WtE incineration facilities are expensive to build, operators seeking a steady flow of waste input will enter into long-term contracts, frequently two or three decades, with municipalities which are then committed to producing a given amount of waste.[362] It is possible to draft contracts in such a way that they effectively deal with the disincentivising of recycling that this occasions, but contracting parties will need to be aware of the issue and capable of implementing the appropriate language. In its submission to the House of Representatives Committee, referring to the Rockingham WtE plant noted above, ARENA stated that

> the 'waste-arising' contractual structure employed in the East Rockingham project allows the local council (as waste provider) to maintain or increase recycling rates for wastes to higher value purposes without financial penalty. The commercial innovation displayed in this project illustrates how [WtE] can be integrated into broader waste management strategies for councils.[363]

Other examples in Europe point to situations where recycling efforts are hindered because it is cheaper and easier to incinerate materials than to sort and recycle them.[364]

At the reuse and avoidance end, it is worth noting that the National Waste Policy Action Plan targets include: 'reduce total waste generated in Australia by 10% per person by 2030'; '80% resource recovery rate from all waste streams following the waste hierarchy by 2030'; and 'phase out problematic and unnecessary plastics'.[365] This accompanies government efforts to support product stewardship.[366] It remains to be seen

357 Ibid.

358 Ibid.

359 Ibid.

360 Thomas Kinnaman, 'China's Garbage Ban Upends US Recycling – Is It Time to Reconsider Incineration?', *The Conversation* (21 August 2018) theconversation.com/chinas-garbage-ban-upends-us-recycling-is-it-time-to-reconsider-incineration-98206.

361 Chani Lokuge, 'What Is Holding Back Waste-to-Energy Developments in Australia?', *Sustainability Matters* (12 April 2016) sustainabilitymatters.net.au/content/waste/article/what-is-holding-back-waste-to-energy-developments-in-australia--910997839. Lokuge is identified as an Associate Director - Waste Management in AECOM's Sydney Office.

362 Nate Seltenrich, 'Incineration Versus Recycling: In Europe, A Debate Over Trash (28 August 2013)', *Yale Environment 360* e360.yale.edu/features/incineration_versus_recycling__in_europe_a_debate_over_trash.

363 Miller (n 339); and see House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 90.

364 Seltenrich (n 362).

365 Commonwealth of Australia, State and Territory Governments, and Australian Local Government Association (n 323).

366 See, e.g. *Recycling and Waste Reduction Act 2020* (n 323) Pts 3-5.

to what extent these goals will be achieved, especially in the context where COVID-19 safety responses have included increases in the use of disposable products such as packaging and masks. In 2020, the *Recycling and Waste Reduction Act 2020* (Cth) came into force. It phases out the export of various classes of waste, including mixed unprocessed plastics.[367] Among the objects of the legislation is 'to develop a circular economy that maximises the continued use of products and waste material over their life cycle and accounts for their environmental impacts'.[368]

Attention to the circular economy also draws attention to the question of the value of waste. Waste is not a renewable resource. The items that become waste require energy to produce: once they are burnt, they are destroyed forever, along with their embedded energy.[369] Those opposed to WtE, which include NGOs and the Australian Greens, argue that the resource value of waste, including the energy and resources it took to produce the products in the first place, are further wasted where those materials are incinerated rather than recycled.[370] Others argue that WtE can be effectively deployed as an alternative to landfill rather than as an alternative to recycling, maintaining its rightful place in the waste hierarchy.[371] Careful economic analysis is required to determine the extent to which this is a tenable position.

Finally, there remains the spectre of a larger moral hazard. Aside from the possibility of disincentivising recycling at the municipal level, there is a chance that large-scale investment in thermal WtE projects promotes perceptions among individuals that present levels of resource consumption are sustainable, or even desirable. This resonates with the third of our three framework principles – the requirement to respect the totality of ecological limits. A 2021 CSIRO analysis on circular economy in Australia identified that 'a major cultural-cognitive barrier is that people largely prefer (and are used to) using new products'.[372] Cultural factors of this kind should not be under-estimated as an obstacle to achieving lasting transitions toward more sustainable modes of economic organisation. Any suggestion that WtE presents a more general solution to the problems of waste than the specialised niche in which it may be environmentally effective could be counter-productive in efforts to bring about needed cultural change. In addition, even when WtE takes up just one component of a larger circular economy structure, it must not be forgotten that both energy generation and the accumulation of waste become lesser problems if environmental limits are at the forefront of all decisions about consumption and manufacturing. That is to say, if those limits were factored into every decision made by producers and consumers of energy and of goods, and if production and consumption were thus limited in line with those limits, any necessity for WtE would also diminish.

Additionally, the role of WtE in a carbon-constrained world has been questioned. The generation of energy from waste also generates carbon dioxide emissions, which may pose a problem for countries' emission reduction plans. For this reason, European Union funding and support for those projects has greatly diminished, with some commentators suggesting that if the circular economy is implemented as planned, such plants will no longer be viable.[373]

### *6.3.2 Social licence and justice principles*

To be most effective, WtE plants should be situated close to the sites of waste generation –

367 A summary of the rules is available at 'Waste Exports' (n 323).

368 *Recycling and Waste Reduction Act 2020* (n 323) s3(1)(c).

369 Seltenrich (n 362).

370 The Greens, 'Fact Sheet - Waste to Energy: Greenwash at Its Best' greens.org.au/sites/default/files/2019-09/Waste%20Incinerators%20Fact%20Sheet.pdf; National Toxics Network, '10 Reasons Why Burning Waste for Energy Is a Bad Idea' zerowasteoz.org.au/wp-content/uploads/2017/12/10-reasons-why-burning-waste-to-make-energy-is-a-bad-idea.pdf.

371 Vella (n 343) 268–9.

372 H Schandl et al, *National Circular Economy Roadmap for Plastics, Glass, Paper and Tyres: Pathways for Unlocking Future Growth Opportunities for Australia* (CSIRO, Australia, January 2021) 116, 8 csiro.au/-/media/News-releases/2021/circular-economy/20-00205_LW_CircularEconomyReport_WEB_210121.pdf.

373 Beth Gardiner, 'In Europe, a Backlash Is Growing Over Incinerating Garbage' (1 April 2021) *Yale Environment 360* e360.yale.edu/features/in-europe-a-backlash-is-growing-over-incinerating-garbage; Paul Hockenos, 'EU Climate Ambitions Spell Trouble for Electricity from Burning Waste', *Clean Energy Wire* (online, 26 May 2021) cleanenergywire.org/news/eu-climate-ambitions-spell-trouble-electricity-burning-waste.

that is, near populations – and also near facilities that will allow for the distribution of the electricity generated, or near industrial facilities that will use the generated capacity for power and/or heat.[374]

The need to site plants near populations raises concerns about social licences to operate: there may be community opposition to living near such facilities. This is particularly the case in relation to incineration facilities, which may release toxins such as nitrogen oxide and dioxin.[375] Researchers have found that the human health effects of incinerators remain unclear,[376] and some groups vigorously contend that WtE incinerators are dangerous to human health.[377] In 2018, the NSW Government Independent Planning Commission rejected a proposal for an incinerator WtE facility at Eastern Creek, in Western Sydney. The Commission's report noted, among other things, public comments relating to concerns about the human health effects of the facility, including its capacity to generate carcinogenic dioxins and furans and hazardous nanoparticles, and relating to uncertainty about the concentration and mix of pollutants likely to be emitted.[378] The project was also opposed by the NSW Environment Protection Authority (EPA) and the Department of Health, which considered that it was 'unable to determine' what health effects the facility might have.[379] The Commission accepted the finding of the Department of Planning and Environment 'that the human health risks cannot be appropriately managed through operational controls and conditions of consent'.[380] A new proposal for a different WtE facility at a neighbouring site was launched by Cleanaway Waste Management in 2019, with projections that it would use up to 500,000 tonnes of non-recyclable household and business waste in order to power 65,000 homes.[381] Media reporting suggests that of more than 600 submissions made to the Department of Planning about the project, only four were in support.[382] While the technology exists to filter out these kinds of dangerous emissions,[383] even if such technology is employed, care must be taken that the community is not otherwise disadvantaged from the location of such sites nearby, such as through falling property values or other stigma. Furthermore, any commitments by industry to be meeting emissions standards will require monitoring by relevant state authorities, such as the EPA. This will, in turn, require appropriate resourcing for those bodies, alongside the prioritisation of this monitoring goal. State EPAs have not always had a strong track record of effectiveness in monitoring pollution levels from emitting facilities.[384]

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374 Vella (n 343) 270.

375 Thomas Cole-Hunter et al, 'Can We Safely Burn Waste to Make Fuel like They Do in Denmark? Well, It's Complicated', *The Conversation* theconversation.com/can-we-safely-burn-waste-to-make-fuel-like-they-do-in-denmark-well-its-complicated-148250.

376 Ibid.

377 National Toxics Network (n 370) 2; The Greens (n 370) 5.

378 Independent Planning Commission, 'Independent Planning Commission Statement of Reasons: Eastern Creek Energy from Waste Facility (SSD 6236)' 26.

379 Ibid 27.

380 Ibid 28.

381 Michael Mazengarb, 'Controversial Incineration Projects Shifted out of Sydney in Waste-to-Energy Plan', *RenewEconomy* (10 September 2021) reneweconomy.com.au/controversial-incineration-projects-shifted-out-of-sydney-in-waste-to-energy-plan. According to the project's website, the project would generate green energy for more than 79,000 homes and abate the equivalent of 85,000 cars' worth of greenhouse gas emissions. Cleanaway, 'Cleanaway Western Sydney Energy & Resource Recovery Centre' (Web Page, 2022) energyandresourcecentre.com.au.

382 Mazengarb, *Controversial Incineration Projects Shifted out of Sydney in Waste-to-Energy Plan* (n 381).

383 See Vella (n 343) 270; and see House of Representatives Standing Committee on Industry, Innovation, Science and Resources (n 325) 89; Cole-Hunter et al (n 375).

384 Vella (n 343) 273–4.

The siting of WtE facilities raises clear issues, not only in relation to the need to respect the planet's ecological boundaries, but also in relation to our other framing principles: energy justice, and space and mobility justice. To take an example from one state, in 2021, the NSW Government released its Energy from Waste Infrastructure Plan. The Plan noted that given current growth in waste generation in Sydney, Greater Sydney landfills accepting household waste would be at capacity within 15 years, while commercial and construction waste landfills would be at capacity by 2030.[385] Drawing on other NSW Government strategy, which suggested that by 2030, one large scale WtE plant may be needed to meet Greater Sydney's requirements, and that by 2040 an additional three may be required, the Plan nominated four priority areas for the development of these facilities. These are located at West Lithgow, Parkes, Richmond Valley and Southern Goulburn Mulwaree, or at facilities that use waste in place of less environmentally-friendly fuels to generate energy, where that energy is used mainly for the industrial and manufacturing processes on site.[386]

Plans to build a WtE facility in the fourth of these zones has raised community objection, including on the grounds that it makes regional NSW a dumping ground for Sydney's waste, in circumstances where WtE has been deemed an unacceptable health hazard in a metropolitan setting. Among other objections, local farmers are reported to have raised concerns about the ongoing viability of their land for farming if the facility is built.[387] Their objections resonate with the energy justice framework, in the concern that regional NSW will have to bear the environmental and potential health costs of development that is for the benefit of urban Sydney. They also raise questions about the extent and appropriate scale of participatory decision-making, and the extent to which the local community's views will, or should, be considered in development facilitated by state government.

Space and mobility justice issues are at play here too, though in a less explicit manner than in relation to the discussion of electric vehicles at Section 2 above. Access to space may be a relevant consideration where local residents find that their ability to access or enjoy their land or region is impaired by the operation of a facility. Moreover, although transport is not directly implicated, there are mobility effects where land is devalued by neighbouring development but where residents lack financial or other resources to move away.

385 'Energy from Waste Infrastructure Plan: Supporting the NSW Waste and Sustainable Materials Strategy 2041, September 2021' 3 epa.nsw.gov.au/-/media/epa/corporate-site/resources/waste/21p3261-energy-from-waste-infrastructure-plan.pdf.

386 Ibid 3, 5.

387 Clare McCabe, '"David and Goliath" Battle over Waste-to-Energy Plan in Angus Taylor's NSW Seat Generates Electoral Heat', *The Guardian* (online, 27 March 2022) theguardian.com/australia-news/2022/mar/27/david-and-goliath-battle-over-waste-to-energy-plan-in-angus-taylors-nsw-seat-generates-electoral-heat.

# 7. Conclusion

In a resource-constrained world whose citizens are increasingly aware of the necessity of energy transition as a means to avert catastrophic climate change, this discussion paper is offered as a reminder that technological solutions, for all the benefits they offer, must not be embraced without careful thought for their societal context. We have proposed three guiding principles that should structure regulatory decisions surrounding the transition: energy justice; just access to space and mobility; and respect for the totality of Earth's ecological limits. As we noted at the outset of this discussion paper, these principles are just a starting point – their content may be debated, consulted upon and further refined.

The transition is happening quickly, accelerated by the gas price shock occasioned by Russia's invasion of Ukraine. In Germany, moves toward rationing gas supplies follow previous incentive structures to wean the nation off coal.[388] They could be the harbingers of ongoing economic and industrial realignment. In Australia, a meeting of the nation's energy ministers on 9 June 2022 agreed to work toward a national energy transition plan.[389]

While opportunities and possibilities are evolving quickly, it is imperative that regulatory framework not play catch-up in a piecemeal fashion. We propose, instead, that we begin by imagining an Australia that embraces principles of energy, space and mobility justice, and that is committed to keeping within the Earth's ecological limits. These principles represent a starting point for devising Australia's green technology future.

388 John O'Donnell and Christoph Steitz, 'Analysis: Fearing Russian Cutoff, German Industry Braces for Gas Rations Race', *Reuters* (online, 20 May 2022) reuters.com/business/energy/fearing-russian-cutoff-german-industry-braces-gas-rations-race-2022-05-20.

389 Chris Bowen, 'Press Conference on the Energy Ministers' Meeting, 9 June 2022' minister.industry.gov.au/ministers/bowen/transcripts/press-conference-energy-ministers-meeting.