GREENHOUSE GAS REMOVAL IN AUSTRALIAN CLIMATE LAW: A POSITIVE ROLE FOR NEGATIVE EMISSIONS

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Australia's path to net zero emissions must include both emissions reduction and removal of greenhouse gases from the atmosphere. Australia's large landmass and expansive marine estates provide significant opportunities for implementing these negative emissions technologies ('NETs'). Significant further legal innovation will be needed to facilitate NETs crediting and adapt existing environmental, health and safety legislation to this large-scale challenge. As a starting point, this article surveys the current state of Australian law and identifies priority areas for developing a legal framework to facilitate responsible research and development of NETs in Australia. It shows that the enormous scale of greenhouse gas removal requires: a market for NETs credits administered to ensure the legitimacy of crediting practices; special arrangements to facilitate research and development; technology-specific law reform targeting the most promising technologies; and regulatory coordination to ensure that environmental and social risks are adequately managed.

I INTRODUCTION

The Glasgow Conference of the Parties meeting of the *United Nations Framework Convention on Climate Change* ('*UNFCCC*')[1] concluded in November 2021 with an affirmation of the *Paris Agreement* and its approach to global emission

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1 *United Nations Framework Convention on Climate Change*, opened for signature 4 June 1992, 1771 UNTS 107 (entered into force 21 March 1994) ('*UNFCCC*').

reductions.[2] Achieving the *Paris Agreement* temperature goals of holding human-induced warming to 1.5–2˚C above pre-industrial levels will require aggressive reductions in global greenhouse gas ('GHG') emissions.[3] The global community will need to achieve net zero emissions by 2050 to have reasonable prospects for limiting global warming to 1.5˚C above pre-industrial levels.[4] That is, by 2050, we will need to achieve a balance between the amount of GHGs emitted into the atmosphere and the amount of GHGs being removed from the atmosphere. According to the Intergovernmental Panel on Climate Change ('IPCC'), to achieve this, 'rapid and deep and in most cases immediate GHG emission reductions' must be made across all sectors.[5] However, to offset unavoidable emissions under a 2050 net zero target and lower atmospheric concentrations of carbon dioxide and other greenhouse gases, technologies that remove GHGs from the atmosphere – referred to as 'negative emission technologies' – will need to be deployed at scale by most major emitters.[6] In 2022, the IPCC's sixth assessment report affirmed that the deployment of negative emissions technologies ('NETs') is now 'unavoidable' if net zero emissions are to be achieved.[7]

NETs encompass a diverse range of terrestrial and ocean-based activities with the potential to remove and store atmospheric GHGs.[8] Terrestrial NETs propose removing CO_2, methane and other GHGs directly from the atmosphere, while marine NETs propose removing CO_2 that has been dissolved in the oceans, thereby increasing the ocean's capacity to absorb more atmospheric CO_2.[9] Many NETs can also deliver important co-benefits, such as more productive and drought-resilient

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2 United Nations Framework Convention on Climate Change, *Report of the Conference of the Parties on Its Twenty-First Session, Held in Paris from 30 November to 13 December 2015*, UN Doc FCCC/CP/2015/10/Add.1 (29 January 2016) annex ('*Paris Agreement*').

3 Richard P Allan et al, Intergovernmental Panel on Climate Change, 'Summary for Policymakers' in Valerie Masson-Delmotte et al (eds), *Climate Change 2021: The Physical Science Basis* (Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 2021) 3, 14 [B.1].

4 Joeri Rogelj et al, 'Net-Zero Emissions Targets' in United Nations Environment Program, *Emissions Gap Report 2021: The Heat Is On* (Annual Report, 26 October 2021) 18.

5 Jim Skea et al, 'Summary for Policy Makers' in Intergovernmental Panel on Climate Change, *Climate Change 2022: Mitigation of Climate Change* (Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 2022) SPM-1, SPM-32 [C.3].

6 SM Smith et al, *The State of Carbon Dioxide Removal* (Report, 1st ed, 2023) <https://www.stateofcdr.org>; Gareth Davies, 'Climate Change and Reversed Intergenerational Equity: The Problem of Costs Now, for Benefits Later' (2020) 10 *Climate Law* 266, 275 <https://doi.org/10.1163/18786561-10030002>; National Academies of Sciences, Engineering, and Medicine, *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda* (National Academies Press, 2019) <https://doi.org/10.17226/25259>; Guy Lomax et al, 'Reframing the Policy Approach to Greenhouse Gas Removal Technologies' (2015) 78 *Energy Policy* 125 <https://doi.org/10.1016/j.enpol.2014.10.002>.

7 Skea et al (n 5) SPM-47 [C.11].

8 See Australian Academy of Science, *Greenhouse Gas Removal in Australia: A Report on the Novel Negative Emissions Approaches for Australia Roundtable* (Report, December 2022) 13–15; Jan C Minx et al, 'Negative Emissions Part 1: Research Landscape and Synthesis' (2018) 13(6) *Environmental Research Letters* 063001 <https://doi.org/10.1088/1748-9326/aabf9b>.

9 For an overview of key land and marine-based proposals, see Duncan McLaren, 'A Comparative Global Assessment of Potential Negative Emissions Technologies' (2012) 90(6) *Process Safety and Environmental Protection* 489 <https://doi.org/10.1016/j.psep.2012.10.005>; National Research Council, *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration* (National Academies Press,

soils,[10] a process for production of building materials,[11] and the reversal of ocean acidification.[12]

As a major emitter of GHGs and a major fossil fuel exporter,[13] Australia is under increasing international pressure to develop realistic domestic policies that evidence a pathway to achieve net zero emissions by 2050.[14] The passage of the *Climate Change Act 2022* (Cth) takes the first step along this path, by formally committing to a 43% reduction in emissions by 2030 and net zero by 2050, but the Act contains no prescriptions about achieving these targets. Problems with Australia's main tool for delivering emissions reduction, the Safeguard Mechanism, meant that it imposed no hard limits on emissions from Australia's largest emitters (which account for 28% of Australia's emissions) and rarely required companies to acquire carbon credits to offset exceedances in the early years of its operation.[15] The Australian Government released its proposed amendments to the Safeguard Mechanism in January 2023. If enacted, these amendments will strengthen the Safeguard Mechanism's capacity to drive down *new* emissions, by setting a declining baseline for regulated entities, but would do little to incentivise the removal of GHGs.[16]

2015) <https://doi.org/10.17226/18805>; Philip Boyd and Chris Vivian (eds), *High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques* (GESAMP, 2019).

10 Toshichika Iizumi and Rota Wagai, 'Leveraging Drought Risk Reduction for Sustainable Food, Soil and Climate via Soil Organic Carbon Sequestration' (2019) 9(1) *Scientific Reports* 19744, 19745 <https://doi.org/10.1038/s41598-019-55835-y>.

11 Fernando Pacheco-Torgal, Caijun Shi, Angel Palomo Sanchez (eds), *Carbon Dioxide Sequestration in Cementitious Construction Materials* (Woodhead Publishing, 2018) <https://doi.org/10.1016/B978-0-08-102444-7.00001-0>.

12 Jens Hartmann et al, 'Enhanced Chemical Weathering as a Geoengineering Strategy to Reduce Atmospheric Carbon Dioxide, Supply Nutrients, and Mitigate Ocean Acidification' (2013) 51(2) *Reviews of Geophysics* 113 <https://www.doi.org/8755-1209/13/10.002/rog.20004>.

13 Australia's 2020 emissions were 512 megatonnes, and the World Resources Institute ranks it the world's 16th largest emitter, in the top 10 per capita emissions: 'Australia', *Climate Action Tracker* (Web Page, 15 September 2021) <https://climateactiontracker.org/countries/australia/2021-09-15/>; 'New Analysis: Australia Ranks Third for Fossil Fuel Export', *The Australia Institute* (Web Page, 19 August 2019) <https://australiainstitute.org.au/post/new-analysis-australia-ranks-third-for-fossil-fuel-export/>.

14 See, eg, Daniel Hurst, 'US Calls on Australia to Increase 2030 Emission Reduction Pledge to Help Prevent "Greater Destruction"', *The Guardian* (online, 18 April 2022) <https://www.theguardian.com/environment/2022/apr/19/us-calls-on-australia-to-increase-2030-emission-reduction-pledge-to-help-prevent-greater-destruction>; Michael Slezak and Melissa Clarke, 'Australia Widely Criticised over Emission Reduction Targets ahead of COP26 Climate Talks', *ABC News* (online, 20 August 2021) <https://www.abc.net.au/news/2021-08-20/climate-change-ipcc-australia-uk-conference-glasgow/100392252>; Daniel Hurst, 'US Urges Australia to Adopt "More Ambitious Climate Goals" as Pressure Mounts on Morrison to Act', *The Guardian* (online, 4 July 2021) <https://www.theguardian.com/environment/2021/jul/05/us-urges-australia-to-adopt-more-ambitious-climate-goals-as-pressure-mounts-on-morrison-to-act>; Joshua McDonald, 'Australia Risks Losing Allies in Pacific over Climate Policies', *The Diplomat* (online, 21 August 2019) <https://thediplomat.com/2019/08/australia-risks-losing-allies-in-pacific-over-climate-policies/>.

15 Ilona Millar and Sophie Whitehead, 'Climate Change Law in Australia: A History and the Current State of Play' (2018) 92(10) *Australian Law Journal* 756, 763–4.

16 See Department of Climate Change, Energy, the Environment and Water (Cth), 'Safeguard Mechanism Reforms Position Paper' (Paper, January 2023).

Policies for achieving net zero are not yet in place,[17] but NETs are likely to form a critical plank in Australia's future climate policy for several reasons.[18] First and most importantly, it will be impossible to eliminate all emissions completely,[19] so NETs will be needed to offset those hard-to-abate emissions. NETs will also be needed to accelerate Australia's mitigation efforts, given the slow pace of emissions reduction over the last three decades.[20] Third, greenhouse gas removal is likely to be needed to lower existing high levels of GHG concentrations and reverse likely temperature overshoot and, potentially, return to lower temperatures.[21] Finally, Australia has unique geographical features favourable to NETs activities which present unique opportunities for Australia to benefit from NETs research, development and deployment. These include a large landmass and one of the world's largest marine estates, considerable mineral resources and significant industrial capabilities.[22]

Despite the policy imperative for Australia to engage in large-scale GHG removal,[23] there are significant barriers and risks to the development and large-scale deployment of NETs, either on land or in the ocean.[24] These barriers and risks are political, technical, economic, environmental, and social. For example, GHG removal activities may cause and/or be limited by path dependencies;[25] some

17 Australian Government, 'Australia's Nationally Determined Contribution Communication 2021' (Communication, 2021) <https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx>. See also *Climate Action Tracker* (n 13).

18 For an assessment of the role of negative emissions technologies ('NETs') in modelling pathways to achieve net zero CO_2 and global greenhouse gas ('GHG') emissions, see Skea et al (n 5) SPM-32–5, SPM-47–8.

19 For an assessment of the role of NETs in modelling pathways to achieve net zero CO_2 and global GHG emissions, see Skea et al (n 5) SPM-32–35; SPM-47–48.

20 For a synthesis of Australia's 'ineffective action' and its failure to reduce emissions over recent decades, see Climate Council, *Aim High, Go Fast: Why Emissions Need to Plummet This Decade* (Report, 2021) 29–30.

21 For an international analysis allocating responsibility to undertake carbon dioxide removal, see Kaylin Lee, Claire Fyson and Carl-Friedrich Schleussner, 'Fair Distributions of Carbon Dioxide Removal Obligations and Implications for Effective National Net-Zero Targets' (2021) 16(9) *Environmental Research Letters* 094001 <http://doi.org/10.1088/1748-9326/ac1970>.

22 Simon Torok, 'Positive Interest in Negative Emissions', *CSIRO: ECOS* (online, 18 December 2019) <https://ecos.csiro.au/positive-interest-in-negative-emissions/>. The Australian Academy of Science also notes Australia's interdisciplinary science expertise: Australian Academy of Science (n 8) 19–20.

23 Holly Jean Buck, 'Rapid Scale-Up of Negative Emissions Technologies: Social Barriers and Social Implications' (2016) 139(2) *Climatic Change* 155, 162 <http://doi.org/10.1007/s10584-016-1770-6>.

24 Sabine Fuss et al, 'Betting on Negative Emissions' (2014) 4(10) *Nature Climate Change* 850, 851–2 <https://doi.org/10.1038/nclimate2392>; European Academies' Science Advisory Council, *Negative Emission Technologies: What Role in Meeting Paris Agreement Targets?* (Policy Report, February 2018) 29. Cf R Stuart Haszeldine et al, 'Negative Emissions Technologies and Carbon Capture and Storage to Achieve the *Paris Agreement* Commitments' (2018) 376 *Philosophical Transactions of the Royal Society* 20160447 <http://dx.doi.org/10.1098/rsta.2016.0447>; Mathias Fridahl, Anders Hansson and Simon Haikola, 'Towards Indicators for a Negative Emissions Climate Stabilisation Index: Problems and Prospects' (2020) 8(6) *Climate* 75:1–22 <https://doi.org/10.3390/cli8060075> (categorising barriers and risks (as well as benefits) focusing on effectiveness, efficiency, scale, risk and synergies).

25 Christopher GF Bataille, 'Physical and Policy Pathways to Net-Zero Emissions Industry' (2020) 11(2) *Wiley Interdisciplinary Reviews: Climate Change* e633:1–20 <https://doi.org/10.1002/wcc.633>; Fridahl, Hansson and Haikola (n 24).

technologies are not yet ready to deploy, particularly at scale;[26] and NETs may have negative effects on public environmental values. For instance, GHG removal activities may favour the value of ecosystem simplification, if land restoration focuses on rapid growing vegetation (to store carbon quickly), rather than other ecological values.[27]

Significant investment in NETs research, development and deployment will be essential to devise solutions to these challenges, to identify and up-scale 'best candidate' technologies, and to minimise undesirable trade-offs and maximise co-benefits.[28] Political commitment to both strong mitigation and the role for GHG removal is a fundamental precondition, but a robust legal framework will also be essential to build public confidence in NETs as a plank of Australian climate policy. Strong laws can ensure that the expansion of NETs advances, rather than undermines, Australia's mitigation efforts and avoid adverse social or environmental impacts.

In this article, we examine the current state of Australian law to understand its capacity to enable the development and deployment of NETs and we propose reform priorities for NETs research, development and deployment. Existing laws provide the foundations of a GHG accounting framework, which will have a key role to play in NETs governance. However, we show that legal innovation is needed to incentivise public and private actors to develop and upscale NETs. Existing environmental law and health and safety legislation will also need to be adapted to provide necessary safeguards in accelerating NETs implementation. Building political commitment remains a challenging precondition to progressing the NETs agenda in Australian climate policy and there are promising signs that this is emerging. Our focus is on the priority legal reforms required to deliver that commitment.

The article proceeds as follows. In Part II, we explain what NETs are and how they differ from traditional climate mitigation activities. In Part III, we outline how NETs are governed under existing international, Commonwealth and state laws, and highlight issues and gaps in current legal frameworks. Part IV outlines where new laws are likely to be needed and considers how NETs research and development ('R&D') can be promoted responsibly, ahead of large-scale deployment. We conclude that, with a well-designed legal framework, NETs can provide significant opportunities for Australian climate change policy to achieve net zero emissions by 2050, while also opening up new economic opportunities that may assist in the transition away from use of fossil fuels.

26 Fridahl, Hansson and Haikola (n 24) 10–14.

27 See, eg, Fabrizio Albanito et al, 'Mitigation Potential and Environmental Impact of Centralized versus Distributed BECCS with Domestic Biomass Production in Great Britain' (2019) 11 *Global Change Biology Bioenergy* 1234 <http://doi.org/10.1111/gcbb.12630>; Lars Gamfeldt et al, 'Higher Levels of Multiple Ecosystem Services Are Found in Forests with More Tree Species' (2013) 4 *Nature Communications* 1340 <http://doi.org/10.1038/ncomms2328>.

28 Emily Cox and Neil Edwards, 'Beyond Carbon Pricing: Policy Levers for Negative Emission Technologies' (2019) 19(9) *Climate Policy* 1144 <http://doi.org/10.1080/14693062.2019.1634509>. See also Skea et al (n 5) SPM-36 [C.11.5].

II WHAT ARE NETS?

From the outset, it is important to be clear about what NETs are and how they differ from traditional mitigation policies that involve avoiding new GHG emissions. There is no agreed legal definition of NETs at an international or national level. To explain our understanding of NETs, this section draws on distinctions made in scientific and policy literatures, which can help inform NETs definitions in future legal frameworks. We then provide an overview of key categories of NETs.

A Emissions Avoidance Technologies Are Not NETs

To achieve *negative* emissions, an activity must remove GHGs from the atmosphere and store it long-term, if not permanently.[29] The entire process, including any associated energy use, transportation and storage activities, must result in a net reduction in atmospheric GHGs, meaning that more is sequestered than produced.[30] This net reduction in atmospheric GHGs distinguishes NETs from activities that merely aim to reduce GHG emissions at source. In determining the extent to which an activity will achieve negative emissions, it is important to adopt a 'cradle-to-grave' approach, recognising that emissions may occur from both upstream and downstream activities when implementing NETs.[31] For example, the emissions involved in the mining, transportation, and application of alkaline rock for technologies such as enhanced mineral weathering, or the construction of new GHG sequestration facilities for bioenergy with carbon capture and storage, would need to be factored into the determination of the *net* emissions that have been achieved.[32] Robust accounting of GHG sequestration capacity and emissions across the full lifecycle of a NET is critical to ensure that the activities that are proposed to deliver negative emissions actually do so.[33]

There are numerous low-emissions or emissions-abatement methods that do not qualify as NETs. For example, technologies that capture and store emissions from coal- or gas-fired power stations are not in themselves NETs, as they simply avoid new emissions of CO_2 entering the atmosphere at source (though, as will be discussed below, such storage technology may be required as a part of some NETs).[34] Similarly, preventing the loss of vegetation from land clearing might avoid new emissions which would be caused if that vegetation was removed, but only afforestation or reforestation (ie activities that produce new vegetation) can deliver

29 JB Robin Matthews et al (eds), Intergovernmental Panel on Climate Change, 'Annex VII: Glossary' in Valerie Masson-Delmotte et al (eds), *Climate Change 2021: The Physical Science Basis* (Contributions of Working Group I of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 2021) 2215, 2240.

30 Samantha Eleanor Tanzer and Andrea Ramírez, 'When Are Negative Emissions Negative Emissions?' (2019) 12(4) *Energy & Environmental Science* 1210, 1211 <http://doi.org/10.1039/c8ee03338b>.

31 Ibid.

32 Ibid.

33 Ibid.

34 Ibid 1213; Simon Nicholson, 'Carbon Removal to the Rescue?' (2021) 120(829) *Current History* 301, 303 <http://doi.org/10.1525/curh.2021.120.829.301>.

an overall reduction in atmospheric CO_2, and hence qualify as NETs.[35] Activities that avoid new GHG emissions entering the atmosphere have an important role to play in addressing climate change. However, because such abatement methods do not reduce existing concentrations of CO_2 in the atmosphere, they do not qualify as NETs, and are therefore not considered further in our analysis.[36]

B Categories of NETs

The scientific literature identifies a wide range of NETs and provides different taxonomies for grouping and classifying them. Distinctions are drawn between NETs that involve terrestrial and marine removal and storage; the types of natural or industrial processes involved in both removing and sequestering the GHG; and whether a NET is likely to have transboundary implementation or consequences.[37] Many of these taxonomies are complex and of limited utility for guiding a legal analysis of NETs. In contrast, Nicholson proposes a relatively straightforward method for categorising NETs.[38] It distinguishes removal from storage and classifies removal and storage techniques as being either 'biological', which predominantly rely on natural systems or processes, or 'engineered', which require mechanical or chemical processes. For some NETs, such as afforestation/reforestation, the removal and storage techniques are one and the same. However, for others, there is a considerable difference between removal and storage techniques, and each presents discrete governance challenges. The distinction between removal and storage, and between biological and engineered, is useful for identifying legal rules that might apply to NETs and for identifying the potential for legal issues to arise.

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35 Requirements for afforestation/reforestation to qualify as NETs were defined by Conference of Parties 9 in *Decision 19/CP.9: Report of the Conference of the Parties on its Ninth Session, Held at Milan from 1 to 12 December 2003 – Addendum – Part Two: Action Taken by the Conference of the Parties at its Ninth Session*, UN Doc FCCC/CP/2003/6/Add.2 (30 March 2004) 13, adopted by the Conference of Parties in 5CMP.1 in *Report of the Conference of the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol on its First Session, Held at Montreal from 28 November to 10 December 2005 – Addendum – Part Two: Action Taken by the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol at its First Session*, UN Doc FCCC/KP/CMP/2005/8/Add.2 (30 March 2006), adopted at the first session of the COP/MOP as decision 5/CMP.1: see *Report of the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol on its First Session, held at Montreal from 28 November to 10 December 2005 – Addendum – Part Two: Action Taken by the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol at its First Session*, UN Doc FCCC/KP/CMP/2005/8/Add.1 (30 March 2006) 61.

36 For the same reason, solar radiation management technologies that seek to cool global temperature by reflecting a percentage of incoming sunlight do not qualify as NETs. For an overview of these technologies, see National Academies of Sciences, Engineering, and Medicine, *Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance* (National Academies Press, 2021).

37 See, eg, Minx et al (n 8) 5–6 [Figure 2]; Kate Dooley, Ellycia Harrould-Kolieb and Anita Talberg, 'Carbon-Dioxide Removal and Biodiversity: A Threat Identification Framework' (2021) 12(1) *Global Policy* 34, 36 [Figure 2] <http://doi.org/10.111/1758-5899.12828>.

38 Nicholson (n 34) 302–3.

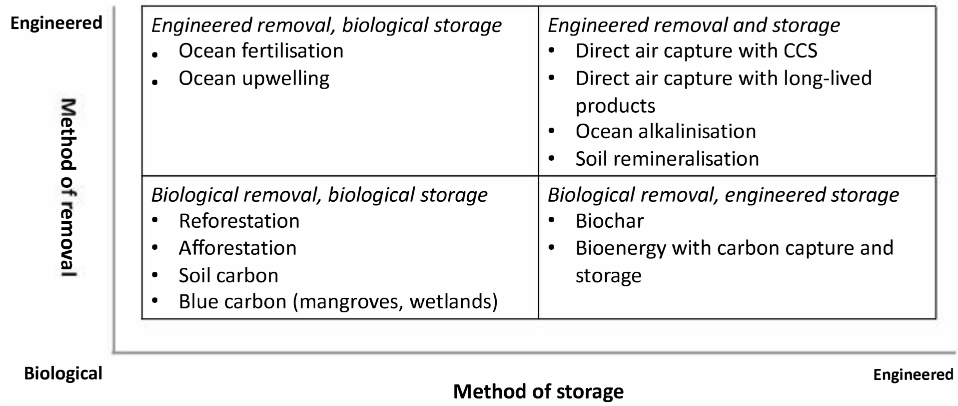

Figure 1 Types of NETs, based on method of capture ('removal') and method of storage

1 Biological Removal and Storage

There are both terrestrial and marine-based biological methods for removing GHGs from the atmosphere. NETs that use forms of 'ecosystem stewardship' both sequester *and* store CO_2.[39] Reforestation and afforestation involve planting or restoring forests to draw CO_2 from the atmosphere through photosynthesis.[40] Soil carbon sequestration involves the implementation of grazing, cropping and other land management practices to improve nutrient levels, water retention and also increase the amount of CO_2 drawn down and sequestered into soil.[41] The most prominent marine-based biological method is enhancing 'blue carbon' ecosystems. This is essentially the marine-equivalent of reforestation/afforestation on land, in that it involves restoring mangroves, tidal marshes, seagrass meadows, and other coastal and marine vegetation to enhance their natural capacity as a carbon sink.[42]

These so-called 'nature-based' proposals could have important co-benefits, such as enhancing resilience to climate change impacts and, in the case of soil carbon sequestration, increased crop yields.[43] Expansion of forestry sequestration on degraded land offers significant potential for co-benefits, provided that the

39 Christopher B Field and Katharine J Mach, 'Rightsizing Carbon Dioxide Removal: Betting the Future on Planetary-Scale Carbon Dioxide Removal from the Atmosphere is Risky' (2017) 356(6339) *Science* 706, 706 <http://doi.org/10.1126/science.aam9726>.

40 Ibid.

41 Keith Paustian et al, 'Soil C Sequestration as a Biological Negative Emission Strategy' (2019) 1(8) *Frontiers in Climate* 8:1–11 <https://doi.org/10.3389/fclim.2019.00008>; Ronald Amundson and Léopold Biardeau, 'Opinion: Soil Carbon Sequestration is an Elusive Climate Mitigation Tool' (2018) 115(46) *PNAS* 11652.

42 Peter I Macreadie et al, 'Can We Manage Coastal Ecosystems to Sequester More Blue Carbon' (2017) 15(4) *Frontiers in Ecology and the Environment* 206 <http://doi.org/10.1002/fee.1484>; 'About Blue Carbon', *The Blue Carbon Initiative* (Web Page, 2019) <https://www.thebluecarboninitiative.org/about-blue-carbon>.

43 See, eg, Hannah Gosnell, Susan Charnley and Paige Stanley, 'Climate Change Mitigation as a Co-benefit of Regenerative Ranching: Insights from Australia and the United States' (2020) 10(5) *Interface Focus* 20200027:1–14 <https://doi.org/10.1098/rsfs.2020.0027>.

selection of suitable sites is managed to prevent native vegetation clearance.[44] However, there are significant questions about their potential to deliver significant GHG removal at the scale at which these methods can be feasibly implemented.[45] There are also questions about developing necessary technical infrastructure and expertise, how to monitor the amount of carbon sequestered, and the permanence of such sequestration.[46] In particular, these types of sinks are vulnerable to fire, cyclones and other natural events that could disturb or destroy them, re-releasing CO_2 into the atmosphere.[47]

2 Biological Removal, Engineered Storage

Some NETs use biomass to draw CO_2 from the atmosphere in a similar way to those methods described in the previous section, but are coupled with engineered storage solutions.[48] One example is biochar, for which biomass is grown, harvested and transformed into charcoal through pyrolysis. Exposing the biomass to extremely high temperatures in the absence of oxygen avoids burning (and associated emissions); adding this biochar to soils stores the captured carbon and can have positive co-benefits, including enhanced crop-production.[49]

The most prominent method of biological removal with engineered storage is bioenergy with carbon capture and storage ('BECCS'). BECCS involves growing biomass, such as fast-growing trees and grasses, or using waste from agricultural plants such as sugar cane, and burning that biomass for electricity generation or in industrial kilns/smelters. The CO_2 produced by that combustion process is then

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44 David Lefebvre et al, 'Assessing the Carbon Capture Potential of a Reforestation Project' (2021) 11(1) *Scientific Reports* 19907 <http://doi.org/10.1038/s41598-021-99395-6>; Anna B Harper et al, 'Land-Use Emissions Play a Critical Role in Land-Based Mitigation for Paris Climate Targets' (2018) 9 *Nature Communications* 2938 <http://doi.org/10.1038/s41467-018-05340-z>; Shaun C Cunningham et al, 'Balancing the Environmental Benefits of Reforestation in Agricultural Regions' (2015) 17(4) *Perspectives in Plant Ecology, Evolution and Systematics* 301 <https://doi.org/10.1016/j.ppees.2015.06.001>.

45 Duncan Brack and Richard King, 'Managing Land-Based CDR: BECCS, Forests and Carbon Sequestration' (2021) 12(1) *Global Policy* 45 <http://doi.org/10.1111/1758-5899.12827>.

46 Field and Mach (n 39) 706; Aurora M Ricart et al, 'High Variability of Blue Carbon Storage in Seagrass Meadows at the Estuary Scale' (2020) 10 *Scientific Reports* 5865 <https://doi.org/10.1038/s41598-020-62639-y>. Though sophisticated protocols for measuring carbon uptake, storage and loss for some blue carbon ecosystems is advancing rapidly, including in the form of technical guidelines for reporting on blue carbon in national greenhouse gas inventories, created in 2006 and updated in 2013 to include an additional five blue carbon methods: T Hiraishi et al, *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (Report, 2014).

47 Field and Mach (n 39) 706. For detailed analysis of these risks in an Australian context see Stephen Roxburgh, Keryn Paul and Libby Pinkard, Commonwealth Scientific and Industrial Research Organisation, *Technical Review of Physical Risks to Carbon Sequestration under the Emissions Reduction Fund* (Report, 9 October 2020) vii, ix–x <https://doi.org/10.25919/5f85eb3423299>.

48 Field and Mach (n 39) 706.

49 Frank Verheijen et al, European Commission Joint Research Centre Institute for Environment and Sustainability, *Biochar Application to Soils: A Critical Scientific Review of Effects on Soil Properties, Processes and Functions* (Report, 2010) 122 [Table 0.1], 8–9 <http://doi.org/10.2788/472>; Getachew Agegnehu, AK Srivastava and Michael I Bird, 'The Role of Biochar and Biochar-Compost in Improving Soil Quality and Crop Performance: A Review' (2017) 119 *Applied Soil Ecology* 156, 163 <https://doi.org/10.1016/j.apsoil.2017.06.008>.

captured using existing industrial carbon capture and storage ('CCS') technology and stored in geological reservoirs, essentially transferring the carbon from the atmosphere to the ground.[50] Despite being the most widely promoted terrestrial NET globally,[51] BECCS faces economic, technical, environmental and social challenges that will limit its capacity for upscaling. These include: the high cost of CCS facilities; the need to co-locate or transport biomass to the power plant, and to transport sequestered CO_2 to sometimes-distant sequestration sites (including offshore); the biodiversity impacts of habitat conversion for growing biomass; the water and soil impacts of rapid-growth monocrops; and the food security implications of diverting large areas of agricultural land to biomass production.[52]

3 Engineered Removal, Biological Storage

Whereas BECCS uses natural 'capture' and engineered storage methods, some NETs use engineered methods to trigger CO_2 drawdown but then rely on biological processes to store the captured carbon. One such method is ocean fertilisation, whereby iron or other macronutrients are added to the ocean to stimulate a phytoplankton bloom, drawing CO_2 from the atmosphere via photosynthesis.[53] Dead biological matter then sinks and decomposes, and the captured carbon is pressure-trapped on the deep-sea floor.[54] Ocean fertilisation is technically feasible and has been the subject of field experiments, albeit with the aim of understanding marine biological processes rather than its potential as a NET.[55] However, uncertainty remains over the capacity for ocean fertilisation to sequester and store carbon in the long term, and whether it may need to be conducted repeatedly, even in perpetuity, to maintain any draw-down benefit.[56] Ocean fertilisation may also

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50 Mathilde Fajardy and Niall Mac Dowell, 'Can BECCS Deliver Sustainable and Resource Efficient Negative Emissions?' (2017) 10(6) *Energy & Environmental Science* 1389 <https://doi.org/10.1039/C7EE00465F>; Mathilde Fajardy et al, 'BECCS Deployment: A Reality Check' (Briefing Paper No 28, Grantham Institute, January 2019) ('Grantham Institute Briefing Paper').

51 Fajardy et al, 'Grantham Institute Briefing Paper' (n 50) 4; Clair Gough et al, 'Challenges to the Use of BECCS as a Keystone Technology in Pursuit of 1.5˚C' (2018) 1 *Global Sustainability* e5 <https://doi.org/10.1017/sus.2018.3>; Intergovernmental Panel on Climate Change, 'Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development' in *Special Report on the Impacts of Global Warming of 1.5°C* (Report, 2018).

52 Brack and King (n 45); Fajardy et al, 'Grantham Institute Briefing Paper' (n 50); Kevin Anderson and Glenn Peters, 'The Trouble with Negative Emissions' (2016) 354(6309) *Science* 182 <http://doi.org/10.1126/science.aah4567>. Deployment of bioenergy with carbon capture and storage ('BECCS') at scale will require significantly expanded production of biomass, which in turn risks displacement of, or competition with other activities and water resources. For example, the Grantham Institute estimates that a global 12 gigatonnes CO_2 per year in the BECCS industry would require the equivalent of between 25% to 80% of current global cropland: 'Grantham Institute Briefing Paper' (n 50) 3.

53 Boyd and Vivian (n 9) 42–4.

54 Ibid.

55 Andrew R Bowie et al, The Antarctic Climate & Ecosystems Cooperative Research Centre, *Position Analysis: Ocean Fertilisation* (Report, 2016) 6.

56 Jean-Pierre Gattuso et al, 'The Potential for Ocean-Based Climate Action: Negative Emissions Technologies and Beyond' (2021) 2 *Frontiers in Climate* 575716, 3 <https://doi.org/10.3389/fclim.2020.575716>.

have negative environmental impacts, including depriving 'downstream' regions of nutrients.[57]

Similar concerns exist regarding another biological and engineered NET: ocean upwelling activities that seek to pump nutrient-rich water from the deep ocean to the surface to enhance the ocean's 'biological pump.'[58] Ocean upwelling and downwelling proposals could potentially have significant environmental impacts and side effects. As with other marine NETs, it may be necessary to permit small-scale experimentation so that the impacts of any larger-scale deployment of such activities can be assessed.

4 Engineered Removal and Storage

The final category of NETs uses engineered means – encompassing chemical reactions and mechanical devices – to both draw-down and store CO_2. The various technologies that are being developed to directly extract CO_2 from the atmosphere are referred to as direct air capture ('DAC'). These technologies involve removing CO_2 from the air using liquid chemical solutions or solid sorbent filters that react with, and bind to, CO_2.[59] Once removed from the atmosphere, the CO_2 can be stored in geological formations using techniques like CCS, or can be integrated into building products such as cement or aggregate for long-term storage and repurposing. According to the International Energy Agency, there are currently nine DAC facilities operating worldwide.[60] Orca, the largest and best-known facility, is located in Iceland and captures 4 kilotonnes of CO_2 annually, storing the captured carbon in basalt formations.[61]

A second important category of engineered NETs involves chemical processes, such as 'mineral weathering'. These methods use minerals, such as ground carbonate or silicate rocks, to draw CO_2 directly from the atmosphere or from the ocean.[62] Soil remineralisation is one of these methods, and involves the application of basalt dust to degraded soils, which mineralises and stores CO_2 as well as improves soil nutrients and water retention.[63] Mine waste may also be mineralised *in situ or ex situ* in purpose-built facilities, creating new forms of economic value for mining waste repurposed as a NET.[64]

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57 Andreas Oschlies et al, 'Side Effects and Accounting Aspects of Hypothetical Large-Scale Southern Ocean Iron Fertilization' (2010) 7 *Biogeosciences* 4017, 4021 <https://doi.org/10.5194/bg-7-4017-2010>.

58 Colin D Hills, Nimisha Tripathi and Paula J Carey, 'Mineralization Technology for Carbon Capture, Utilization and Storage' (2020) 8 *Frontiers in Energy Research* 142 <https://doi.org/10.3389/fenrg.2020.00142>.

59 Sarah Budinis, 'Direct Air Capture', *IEA* (Web Page, November 2021) <https://web.archive.org/web/20211207002032/https:/www.iea.org/reports/direct-air-capture>.

60 Ibid.

61 Ibid.

62 Gattuso et al (n 56) 3.

63 Garcia de Oliveira et al, 'Impacts of Enhanced Weathering on Biomass Production for Negative Emission Technologies and Soil Hydrology' (2020) 17(7) *Biogeosciences* 2107 <https://doi.org/10.5194/bg-17-2107-2020>.

64 Liam A Bullock et al, 'Global Carbon Dioxide Removal Potential of Waste Materials from Metal and Diamond Mining' (2021) 3 *Frontiers in Climate* 694175:1–12 <http://doi.org/10.3389/fclim.2021.694175>; Manuel Siegrist et al, 'Analysis of the Potential for Negative CO_2 Emission Mine

Ocean alkalinisation is another engineered NET that relies on chemical processes. Ocean alkalinisation involves adding lime or other alkalinising minerals to the ocean to react with dissolved CO_2.[65] This can enhance the ocean's existing capacity to store CO_2, as well as potentially reducing ocean acidification.[66]

Finally, researchers are investigating new mineralisation methods that would fall into the NETs category of 'engineered' capture and storage methods. For example, it may be possible to couple mineral weathering with renewable hydrogen production to achieve climate mitigation and negative emission co-benefits. Researchers are investigating using seawater instead of freshwater to produce 'green' hydrogen through electrolysis, and then absorbing CO_2 from the water using silicate or carbonate mineral.[67] Coupling hydrogen production with a CO_2 absorption process will ensure that it replaces high-emissions fuels such as coal and gas with a negative emission, rather than simply a zero emission, fuel. Furthermore, hydrogen produced with seawater circumvents the need to rely on large quantities of freshwater: a major critique of hydrogen as a fuel source.[68]

The diversity of capture and storage methods and the different challenges facing the upscaling of each NET raise important issues for governance. First, Australia is most likely to develop a portfolio of NETs, so a versatile approach to measuring, monitoring and verifying GHG removal that can be used across different technologies is essential. Second, it is unhelpful to think about the governance of all NETs collectively, as each type of GHG capture and each type of GHG sequestration poses different risks and faces different challenges.[69] This means that the development of safeguards and enablers must be largely technology-specific. In the next section, we therefore outline in broad terms the current legal arrangements for incentivising NETs and protecting against environmental, health, economic or social consequences.

III THE GOVERNANCE OF NETS

To ensure the long-term acceptability of NETs, governance arrangements must first stimulate R&D and then facilitate deployment of NETs at scale. An effective framework will require mechanisms for monitoring, reporting, verifying and 'rewarding' the volume of GHGs removed, on a full life-cycle basis. This needs to

Sites through Bacteria-Mediated Carbon Mineralisation: Evidence from Australia' (2017) 114 *Energy Procedia* 6124 <https://doi.org/10.1016/j.egypro.2017.03.1749>.

65 Gattuso et al (n 56) 3.

66 Ibid.

67 Greg H Rau, Heather D Willauer and Zhiyong J Ren, 'The Global Potential for Converting Renewable Electricity to Negative-CO_2-Emissions Hydrogen' (2018) 8(7) *Nature Climate Change* 621 <https://doi.org/10.1038/s41558-018-0203-0>.

68 Naomi Bergman and Emily Johnstone, 'Water Access for Hydrogen Projects: Don't Let Your Options Dry Up', *Allens* (Web Page, 25 October 2021) <https://www.allens.com.au/insights-news/insights/2021/10/Water-access-for-hydrogen-projects/>.

69 See Rob Bellamy and Oliver Geden, 'Govern CO_2 Responsibly from the Ground Up' (2019) 12(11) *Nature Geoscience* 874 <http://doi.org/10.1038/s41561-019-0475-7>.

be designed in a way that does not create perverse incentives that undermine the 'overall mitigation ambition' of the *Paris Agreement*. Incentivising and establishing accounting methods for NETs is the province of Australian climate law and policy, guided by international standards and methodologies.

As well as facilitating development and deployment, an effective legal framework must manage the likely social and environmental risks and conflicts associated with scaling up NETs activities. The measures needed to reduce or manage these risks derive from a wide range of local, state, national and, in the case of ocean NETs, international laws.[70] They include those relating to: environmental impact assessment, biodiversity conservation,[71] marine and coastal management, native title, water management, forestry,[72] mining, energy production and distribution, waste management,[73] and workplace health and safety. In the following sub-sections, we survey current Australian law. We highlight areas that are likely to require strengthening so that NETs can play a positive role in achieving a rapid, efficient and effective shift to net-zero emissions in Australia.

A Facilitating the Research, Development and Deployment of NETs

Common to all NETs approaches is the need for a clear framework for incentivising research and development and, eventually, facilitating large-scale deployment. This framework must include mechanisms for accurately measuring, reporting, verifying, and assigning value to the GHG removal performance of each process. Australia's current legal arrangements, including obligations under the *Paris Agreement*, provide a foundation for doing this, but the current lack of a GHG pricing mechanism provides a weak overall incentive structure.

1 Facilitating NETs under the International Climate Regime

The international climate regime, through the *UNFCCC* and *Paris Agreement*, establishes what role NETs should play in global emissions reduction, and thereby influences the way in which NETs are incentivised through national law. The enhancement of carbon sinks is expressly contemplated under both the *UNFCCC* and the *Paris Agreement*. The *UNFCCC* calls on parties to 'promote, and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all

70 Kerryn A Brent et al, 'Carbon Dioxide Removal Geoengineering' (2018) 92 *Australian Law Journal* 830.

71 Phillipa C McCormack, Jan McDonald and Kerryn A Brent, 'Governance of Land-Based Negative-Emission Technologies to Promote Biodiversity Conservation: Lessons from Australia' (2020) 10 *Climate Law* 123 <https://doi.org/10.1163/18786561-01002001>.

72 Megan C Evans, 'Effective Incentives for Reforestation: Lessons from Australia's Carbon Farming Policies' (2018) 32 *Current Opinion in Environmental Sustainability* 38 <https://doi.org/10.1016/j.cosust.2018.04.002>. In some countries such as the United Kingdom, forestry laws were the initial source of NETs governance: Felix Schenuit et al, 'Carbon Dioxide Removal Policy in the Making: Assessing Developments in 9 OECD Cases' (2021) 3 *Frontiers in Climate* 638805:1–22. But in Australia, the agricultural sector and soil carbon accounting, in particular, has played a more significant role (but see discussion of limitations in Part III(A)(2), below).

73 See, eg, Deloitte and Enea, *Australia's Bioenergy Roadmap Report* (Report, November 2021).

[GHGs]'.[74] Similarly, the *Paris Agreement* expressly recognises the importance of conserving and enhancing sinks and reservoirs.[75] These provisions lay the broad foundations for an obligation to conserve and enhance terrestrial biomass and coastal and marine ecosystems and, potentially, to enhance artificial sinks and reservoirs.[76] They enable parties to include NETs in their nationally determined contribution ('NDC') commitments submitted under the *Paris Agreement*.

The *Paris Agreement* emphasises the importance of ensuring that NETs contribute to strengthened mitigation ambition, rather than substituting for tough emissions reduction commitments.[77] Measures to facilitate NETs should be designed to avoid creating perverse incentives for continuing high-emissions activities.[78] While the *Paris Agreement* contains no specific provisions relating to NETs, the implementation mechanisms of the *Paris Agreement* provide a foundation for incorporating NETs into emission reduction efforts.[79]

The *Paris Agreement*'s Sustainable Development Mechanism ('SDM') (successor to the *Kyoto Protocol*'s Clean Development Mechanism) could mobilise NETs[80] by allowing for the generation of GHG credits from projects undertaken in accordance with approved methodologies.[81] The Clean Development Mechanism's modalities and procedures are a starting point for the approval of NETs methodologies under the SDM. For example, land sector accounting rules developed for the *Kyoto Protocol* explicitly account for impermanence and

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74 *UNFCCC* (n 1) art 4.1(c)–(d); Matthias Honegger, William CG Burns and David R Morrow, 'Is Carbon Dioxide Removal "Mitigation of Climate Change"?' (2021) 20 *Review of European, Comparative & International Environmental Law* 327 <https://doi.org/10.1111/reel.12401>; A Neil Craik and William CG Burns, *Climate Engineering under the Paris Agreement: A Legal and Policy Primer* (Special Report, November 2016) 6–7.

75 *Paris Agreement* (n 2) Preamble. The *UNFCCC* defines 'sinks' broadly, as 'any process, activity or mechanism which removes a greenhouse gas … from the atmosphere', which clearly encompasses both natural and artificial sinks. Reservoirs are defined as 'a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored': *UNFCCC* (n 1) art 1(7)–(8).

76 Honegger, Burns and Morrow (n 74); A Neil Craik and William CG Burns, 'Climate Engineering under the *Paris Agreement*' (2019) 49(12) *Environmental Law Reporter* 11113, 11123.

77 For example, article 4 of the *Paris Agreement* contains a collective obligation on all countries to reach peak greenhouse gas emissions 'as soon as possible', and to then achieve 'a balance between anthropogenic sources and removals by sinks of greenhouse gases in the second half of this century': *Paris Agreement* (n 2) art 4(1). Article 6 establishes the framework for three cooperative approaches to drive higher mitigation ambition: 'internationally [transferable] mitigation outcomes' (ie international carbon markets); the 'sustainable development' mechanism; and 'non-market approaches'.

78 Wim Carton et al, 'Negative Emissions and the Long History of Carbon Removal' (2020) 11(6) *Wiley Interdisciplinary Review Climate Change* e671:1–12 <https://doi.org/10.1002/wcc.671>; Craik and Burns, 'Climate Engineering under the *Paris Agreement*' (n 76) 11124. See also D Compagnon, 'Governing a Mirage? False Promises of Negative Emissions Technologies' (2019) 13(2) *Carbon & Climate Law Review* 104 <https://doi.org/10.21552/cclr/2019/2/5>.

79 Honegger, Burns and Morrow (n 74); Craik and Burns, 'Climate Engineering under the *Paris Agreement*' (n 76).

80 Matthias Honegger and David Reiner, 'The Political Economy of Negative Emissions Technologies: Consequences for International Policy Design' (2018) 18(3) *Climate Policy* 306, 314 <https://doi.org/10.1080/14693062.2017.1413322>.

81 Ibid.

the possibility of reversals.[82] There is also a Clean Development Mechanism Methodology for carbon capture and storage which provides guidance on baseline methodology and the selection, characterisation and development of geological storage sites, and requires parties to have legal frameworks for risk and safety assessments and governing liability and redress.[83]

Whichever mechanism is ultimately used,[84] it will need to provide ways to quantify the volume of GHGs removed by each activity; avoid double counting of avoided emissions; demonstrate the overall mitigation of emissions; and address non-permanence, including responsibility for accounting for net reversals and liability issues.[85] Building confidence in this framework requires that national laws encourage the research, development and deployment of NETs in a manner that complements other domestic mitigation efforts.

2 Facilitating NETs Research, Development and Deployment in Australian Climate Law

Demonstrating compliance with Australia's Nationally Determined Contribution under the *Paris Agreement* is the responsibility of the Australian Government. There is currently no national law that requires any form of emissions reduction, voluntary approaches being preferred.[86] The Safeguard Mechanism is intended to limit emissions from large emitters (representing about half of Australia's emissions)[87] to a pre-determined baseline, with an expectation that credits will be purchased for any exceedance of the baseline.[88] While this approach could operate as a cap on emissions that creates demand for credits, in practice it has not done so. The baselines were all set at historically-high levels, and have not been adjusted downward to reflect changed practices or higher mitigation

82 Jim Penman et al (eds), *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (Institute for Global Environmental Strategies, 2003).

83 *Report of the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol on its Sixth Session, held in Cancun from 29 November to 10 December 2010 Addendum Part Two: Action Taken by the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol at its Sixth Session*, UN Doc FCCC/KP/2010/12/Add.2 (15 March 2011) decision 7/CMP.6, 27. Although this Methodology has been in place since 2010, it has yet to be used.

84 The immaturity of NETs makes them unlikely candidates for the market mechanisms of articles 6.2 and 6.4 of the *Paris Agreement* (n 2) in the short term. Carton et al (n 78).

85 Matthias Honegger, Axel Michaelowa and Joyashree Roy, 'Potential Implications of Carbon Dioxide Removal for the Sustainable Development Goals' (2020) 21(5) *Climate Policy* 678 <https://doi.org/10.1080/14693062.2020.1843388>; Kate Dooley and Sivan Kartha, 'Land-Based Negative Emissions: Risks for Climate Mitigation and Impacts on Sustainable Development' (2018) 18(1) *International Environmental Agreements* 79.

86 Millar and Whitehead (n 15).

87 Defined as facilities where the total direct greenhouse gas emissions exceed 100,000 tonnes of carbon dioxide equivalence per annum. *National Greenhouse and Energy Reporting Act 2007* (Cth) s 22XJ; *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* (Cth) pt 2 r 8.

88 Established under part 3H of the *National Greenhouse and Energy Reporting Act 2007* (Cth). Most of the detail is contained in the *National Greenhouse and Energy Reporting Regulations 2008* (Cth) and the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* (Cth).

ambition. Moreover, it is possible to apply to increase a baseline, if the historical level is considered too low.[89]

In the absence of a national carbon or wider GHG pricing mechanism, most of the current requirements for emissions reduction are contained in state and territory level laws. Victoria and Western Australia now regulate greenhouse gas emissions under their pollution control regime.[90] These arrangements do not yet establish trading or crediting options that would create markets for NETs credits, and even if they did, such measures would only apply in respect of emissions in that jurisdiction. Given that Australia's emission reduction targets are set nationally, and that sub-national regulation is limited to activities within each state or territory, it is essential that the national government take the lead on achieving those goals.

Australia's current national policy to reduce greenhouse gas emissions only includes NETs to a very limited degree. The main component of Australia's national policy is the Climate Solutions Package, implemented through the Emissions Reduction Fund ('ERF'). The ERF is an incentive-based scheme encouraging private actors, such as businesses and farming interests, to reduce their greenhouse gas emissions by selling emission reductions proposals through a 'reverse auction' process to the Clean Energy Regulator.[91] The Clean Energy Regulator purchases emissions based on cost-per-tonne of GHGs (described as 'CO_2e' or 'carbon dioxide equivalent') avoided or sequestered, with the lowest cost proposal for avoided emissions being purchased first, provided that factors such as permanence and other safeguards are demonstrated.[92]

The ERF currently recognises emission reductions from two land-based NETs activities and one marine based activity: human-induced regeneration (afforestation/reforestation),[93] carbon sequestration in soils,[94] and blue carbon

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89 Sophie Power, 'Australia's Climate Safeguard Mechanism: A Quick Guide' (Research Paper, Parliamentary Library, Parliament of Australia, 3 December 2018).

90 Victoria does not directly regulate emissions but does require that the Environment Protection Authority consider how new development would contribute to Victoria's emissions profile when permitting new activities: *Climate Change Act 2017* (Vic) s 17. The Western Australian Government is regulating GHGs from major resources projects through the *Environmental Protection Act 1986* (WA) part IV (environmental impact assessment): Environment Protection Authority (WA), 'Environmental Factor Guideline: Greenhouse Gas Emissions' (Guideline, April 2020).

91 'How Does It Work', *Australian Government Clean Energy Regulator* (Web Page, 12 July 2022) <http://www.cleanenergyregulator.gov.au/csf/how-it-works/Pages/how-it-works.aspx>.

92 Other factors, such as employment opportunities (especially for Indigenous landholders) and watershed protection, are only secondary or tertiary considerations.

93 *Carbon Credits (Carbon Farming Initiative – Reforestation and Afforestation 2.0) Methodology Determination 2015* (Cth).

94 The first methodology for soil carbon was heavily criticised as expensive and complex and was replaced in December 2021: *Carbon Credits (Carbon Farming Initiative–Estimation of Soil Organic Carbon Sequestration Using Measurement and Models) Methodology Determination 2021* (Cth); and see 'Carbon Capture and Storage Method', *Department of Industry, Science, Energy and Resources* (Web Page, 7 October 2021) <https://www.industry.gov.au/regulations-and-standards/methods-for-the-emissions-reduction-fund/carbon-capture-and-storage-method>, for an explanatory statement and amendment to the carbon capture and storage ('CCS') projects rule.

sequestration from tidal restoration projects.[95] Human-induced regeneration accounts for almost a third of all ERF activities. Recent analysis raised concerns about the amount of abatement these projects actually deliver. Macintosh and colleagues questioned the integrity of project conditions and their compliance with the approved method, especially the requirement for additionality which is particularly important for claims of *negative* emissions.[96] An independent review of the scheme published in 2023 concluded that the scheme was 'essentially sound', but nonetheless recommended improvements to the governance arrangements to ensure their integrity.[97]

About 200 soil carbon projects are now registered, but so far carbon credits have only been issued to one soil carbon project.[98] While the sequestration capacity of Australian soils depends heavily on rainfall,[99] the Australian Government's net zero by 2050 plan sees strong potential for this technique, suggesting that soil carbon projects could sequester up to 17 million tonnes of CO_2e by 2050, earning $400 million for landholders.[100] The complexity and cost of demonstrating compliance with the approved methodology has limited uptake, and the Australian Government is currently offering a $5,000 advance payment as incentive for landholders to undertake the upfront soil sampling costs.[101] CCS was added as an approved method under the Climate Solutions Fund in September 2021,[102] so the

95 'Tidal Restoration of Blue Carbon Ecosystems Method', *Australian Government Clean Energy Regulator* (Web Page, 20 January 2022) <https://web.archive.org/web/20220326010431/http:/www.cleanenergyregulator.gov.au/ERF/Choosing-a-project-type/Opportunities-for-the-land-sector/Vegetation-methods/tidal-restoration-of-blue-carbon-ecosystems-method>.

96 Andrew Macintosh et al, *The ERF's Human-Induced Regeneration (HIR): What the Beare and Chambers Report Really Found and a Critique of Its Method* (Report, 16 March 2022).

97 Ian Chubb et al, *Independent Review of Australian Carbon Credit Units* (Final Report, December 2022) 2 <https://www.dcceew.gov.au/sites/default/files/documents/independent-review-accu-final-report.pdf>.

98 Kath Sullivan, 'Carbon Soil Projects Pivotal in Government's Net Zero Plan, but Market Progress "Slow"', *ABC News* (online, 10 November 2021) <https://www.abc.net.au/news/rural/2021-11-10/soil-solution-to-australias-net-zero-climate-commitment/100592298>. The methodology for blue carbon from tidal restoration projects was finalised in January 2022. It is therefore too early to comment on its uptake.

99 Cécile M Godde et al, 'Understanding the Impacts of Soil, Climate, and Farming Practices on Soil Organic Carbon Sequestration: A Simulation Study in Australia' (2016) 7 *Frontiers in Plant Science* 661 <https://doi.org/10.3389/fpls.2016.00661>. Though the implications of climate-driven changes to rainfall is only acknowledged once in the Government's net-zero report, which cites Commonwealth Scientific and Industrial Research Organisation, *Australian National Outlook 2015: Living Standards, Resource Use, Environmental Performance and Economic Activity, 1970–2050* (Report, October 2015).

100 Department of Industry, Science, Energy and Resources (Cth), McKinsey & Co and the Australian Office of the Chief Economist, *Australia's Long-Term Emissions Reduction Plan: Modelling and Analysis* (Report, November 2021) 34.

101 'Up to $5000 Advance Payment to Help with Soil Sampling Costs for Emissions Reduction Fund Projects', *Australian Government Clean Energy Regulator* (Web Page, 9 February 2022) <http://www.cleanenergyregulator.gov.au/ERF/Pages/Want%20to%20participate%20in%20the%20Emissions%20Reduction%20Fund/Step%202-Contracts%20and%20auctions/Advance-to-support-soil-method-baseline-sampling.aspx>.

102 *Carbon Credits (Carbon Farming Initiative – Carbon Capture and Storage) Methodology Determination 2021* (Cth). See also 'Carbon Capture and Storage Method', *Department of Industry, Science, Energy and Resources* (Web Page, 7 October 2021) <https://web.archive.org/web/20211014232836/https://www.industry.gov.au/regulations-and-standards/methods-for-the-emissions-reduction-fund/carbon-capture-and-storage-method> for an explanatory statement and amendment to the CCS projects rule.

terrestrial modalities for biological carbon capture could be refined and extended to include BECCS at source and offshore geological disposal in used oil and gas reserves. Reducing the complexity of current requirements or providing more assistance to land managers seeking to apply could facilitate greater uptake.

B Safeguards against Environmental and Social Risks of Terrestrial NETs Deployment

The implementation of robust safeguards can minimise risks posed by NETs and build public legitimacy and trust. This is especially important for NETs that the public perceives to be 'unnatural'.[103] Legal safeguards should attend to the substantive risks of such technologies; provide opportunities for public engagement, including prior to field testing and/or deployment phases and, if appropriate, at critical points during the research phase;[104] and ensure that risks are distributed fairly. Below, we map the laws in place to assess and mitigate the potential social and environmental risks of developing and deploying NETs. Since the range of possible NETs is wide, the range of potentially applicable laws is diverse. Accordingly, the discussion seeks to identify the most important risks and challenges arising from each technology, and the way in which these issues are governed under current Australian law.

1 Risks from Biological Capture and Storage NETs

The key risks arising from terrestrial NETs that use biological capture techniques include conflicts with biodiversity conservation obligations and other land uses (such as food production); impacts on water resources; and use of agricultural chemicals.[105] Expanded forestry activity and biomass production will conflict with biodiversity conservation priorities if they involve clearing of existing native vegetation or linear infrastructure such as roads, pipelines or electricity transmission lines, which fragment important habitat and ecological connectivity.[106] It is beyond the scope of this article to analyse the existing legal framework for biomass projects in every state and territory. Instead, we use New

103 Rob Bellamy, Javier Lezaun and James Palmer 'Public Perceptions of Geoengineering Research Governance: An Experimental Deliberative Approach' (2017) 45 *Global Environmental Change* 194 <https://doi.org/10.1016/j.gloenvcha.2017.06.004>; Kate E Gannon and Mike Hulme, 'Geoengineering at the "Edge of the World": Exploring Perceptions of Ocean Fertilisation through the Haida Salmon Restoration Corporation' (2018) 5(1) *Geo: Geography and Environment*, e00054:1–21 <https://doi.org/10.1002/geo2.54>; Rob Bellamy, Javier Lezaun and James Palmer, 'Perceptions of Bioenergy with Carbon Capture and Storage in Different Policy Scenarios' (2019) 10 *Nature Communications* 743 <https://doi.org/10.1038/s41467-019-08592-5>; Javier Lezaun et al, 'Governing Carbon Dioxide Removal in the UK: Lessons Learned and Challenges Ahead' (2021) 3 *Frontiers in Climate* 673859 <https://doi.org/10.3389/fclim.2021.673859>.

104 Rob Bellamy, 'Incentivize Negative Emissions Responsibly' (2018) 3(7) *Nature Energy* 532 <https://doi.org/10.1038/s41560-018-0156-6>; Rebecca M Colvin et al, 'Learning from the Climate Change Debate to Avoid Polarisation on Negative Emissions' (2019) *Environmental Communication* <https://doi.org/10.1080/17524032.2019.1630463>.

105 See discussion and references in Part II(B), above.

106 McCormack, McDonald and Brent (n 71).

South Wales as an example to illustrate the inherent legal complexity surrounding proposals for terrestrial biomass NETs.

A New South Wales-based project that involves conversion of existing land uses to biomass production will likely require approvals under the local planning scheme, including development, building and native vegetation clearing approvals, and may require state government approvals under regimes such as the *Electricity Supply Act 1995* (NSW), *National Parks and Wildlife Act 1974* (NSW) (including in relation to Aboriginal cultural heritage), *Water Management Act 2000* (NSW), *Biodiversity Conservation Act 2016* (NSW) and *Protection of the Environment Operations Act 1997* (NSW). Depending on its scale and location, a state-based biomass project may also require an environmental impact assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) ('*EPBC Act*'), for example if nationally listed threatened species will be affected or the biomass site neighbours a World Heritage Area. A state-based biomass project may also require approvals under the *Water Act 2007* (Cth) if the site is located within the area of the Murray-Darling Basin Plan. Other Commonwealth standards and approvals processes that may be relevant include the *Carbon Credits (Carbon Farming Initiative) Act 2011* (Cth), GHG tenure and sequestration approvals under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) ('*National Offshore Storage Act*'), and the National Greenhouse and Energy Reporting ('NGER') System, under the *National Greenhouse and Energy Reporting Act 2007* (Cth).

Large-scale biomass projects will almost certainly be subject to high levels of public scrutiny at every scale of government assessment, raising the potential for approvals to be challenged in both merits and judicial review jurisdictions. Given the prospect of substantial scrutiny and resistance, it may be prudent for state and territory governments to review approvals processes to ensure compatibility with Australia's commitment to reaching net zero emissions and clarity about the role of terrestrial NETs in achieving that commitment. A review of this sort was recommended in relation to the national renewable hydrogen strategy.[107]

The risks that terrestrial NETs pose to biodiversity conservation, water resources and competing land uses such as agriculture may be minimised by limiting the expansion of these activities to degraded or 'marginal' agricultural land rather than uncleared areas, and to areas close to existing electricity infrastructure and GHG sequestration sites.[108] Strategically siting new NETs projects in this way may also help to manage the complexity of approvals processes, for example by avoiding potential impacts on high value conservation areas and Aboriginal cultural heritage

107 COAG Energy Council Hydrogen Working Group, *Australia's National Hydrogen Strategy* (Report, 2019) 50–1 ('responsive regulation'), 32 (noting the need to 'review and reform underpinning regulatory legal frameworks, develop consistent approaches for: efficient supply chains and markets, ensure a supportive investment environment, robust training requirements and safety standards').

108 See, eg, 'Grantham Institute Briefing Paper' (n 50) 7 (noting that the quality and types of marginal land are diverse so it can be difficult to predict precisely how much of it is actually available and how productive BECCS activities may prove to be); Muhammad A Mehmood et al, 'Biomass Production for Bioenergy Using Marginal Lands' (2016) 9(1) *Sustainable Production and Consumption* 3 <https://doi.org/10.1016/j.spc.2016.08.003>; Peter A Turner et al, 'The Global Overlap of Bioenergy and Carbon Sequestration Potential' (2018) 148 *Climatic Change* 1:1–10.

sites, and minimising the risk of community concern about harm to other important values. However, existing land use planning and vegetation management laws do not necessarily ensure this.[109] A strategic assessment of the impacts of biological NETs on biodiversity and food production would allow for a planned approach that protects these values, but no Australian jurisdiction currently requires strategic assessment of a program of activities, instead operating at the level of assessment of specific projects or activities.

The Commonwealth *EPBC Act* allows for, but does not require, strategic landscape-scale assessment of programs of activity.[110] The operation of the *EPBC Act* in relation to specific biomass production proposals will depend on the ecological or heritage values of any site proposed for deployment. The presence of listed species or ecological communities, or proximity to and capacity to affect national or world heritage places, or Ramsar wetlands, would be critical factors in determining whether approval is required.[111] This means that some areas of clearing for forestry expansion or biomass production may require Commonwealth approval in addition to obligations under state/territory laws, while others would not.

Coastal blue carbon projects can deliver important co-benefits for biodiversity, flood mitigation and erosion control,[112] but conflicts are likely to arise where coastal blue carbon is promoted above competing land uses. There is no specific Commonwealth legislation dealing with the coastal zone other than the recognition of Ramsar wetlands as a matter of national environmental significance under the *EPBC Act*.[113] All coastal jurisdictions have some form of policy or legislation to guide decisions over coastal land uses, though none explicitly identify GHG sequestration as a coastal value.[114] In some jurisdictions, there will be tensions between coastal-specific measures and wider planning laws that protect existing uses of land.

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109 There are state-level strategic planning protections for high-value agricultural and conservation land in some states: see, eg, Queensland Government Department of Infrastructure, Local Government and Planning, *State Planning Policy* (Report, July 2017) 29–30; *State Policy on the Protection of Agricultural Land 2009* (Tas). The New South Wales Agriculture Commissioner has recently recommended the development of a State Significant Agricultural Land Use Planning Policy to provide guidance on how conflicts between agricultural and other lands uses should be resolved: see Daryl Quinlivan, *Improving the Prospects for Agriculture and Regional Australia in the NSW Planning System* (Report, 31 October 2021).

110 *Environment Protection and Biodiversity Conservation Act 1999* (Cth) pts 10 ('Strategic Assessments'), 12 ('Identifying and Monitoring Biodiversity and Making Bioregional Plans'). See McCormack, McDonald and Brent (n 71).

111 *Environment Protection and Biodiversity Conservation Act 1999* (Cth) pts 3 ('Requirements for Environmental Approvals'), 9 ('Approval of Actions').

112 See discussion and references in Part II(B), above.

113 *Environment Protection and Biodiversity Conservation Act 1999* (Cth) ss 16–17B. Except to the extent that the *Water Act 2007* (Cth) seeks to maintain environmental health of the Murray-Darling Basin, including at the mouth of the River Murray and in the coastal lagoon known as the Coorong, in South Australia (ie, section 86AA).

114 *Coastal Management Act 2016* (NSW); *Coastal Protection and Management Act 1995* (Qld); *Coast Protection Act 1972* (SA); *Marine and Coastal Act 2018* (Vic); Western Australia, Tasmania and the Northern Territory do not have special purpose coastal planning legislation but the Western Australian Government, *Coastal Zone Strategy* (Report, July 2021), *Tasmanian State Coastal Policy 1996* (Tas) and the Northern Territory Government, 'Coastal and Marine Management Strategy Northern Territory: 2019–29' (Strategy, 2019) are silent on the issue. The South Australian government has a blue carbon

2 Risks Relating to Engineered Capture Techniques

Some engineered NETs have significant environmental impacts in their own right, while others are relatively benign. Soil remineralisation, for example, would deliver co-benefits for existing cropland, and may therefore avoid conflicts over competing land uses raised by BECCs or afforestation. However, mineralisation requires the mining, grinding, transportation, and dispersal of rock at very large scales. Expansion of mining and quarrying operations creates its own impacts on air quality, water supply, local amenity and biodiversity and would therefore be regulated under Commonwealth and state/territory environmental, mining, planning and pollution control regimes.[115] Minimising the noise, amenity, use of chemicals and other environmental or workplace risks arising from the operation of engineered removal plants, including DAC and pyrolysis facilities to produce biochar falls within the purview of existing planning and environmental management laws.

The health impacts of applying biochar and rock dust to large areas of agricultural land also require management to avoid the prospect of long-term liability for human health impacts (particularly respiratory problems), as has occurred with asbestos exposure and is emerging for crystalline silica exposure. Workplace health and safety legislation in all jurisdictions contains a duty on all employers to provide safe workplaces. Development and adoption of, and compliance with, a model code of practice for the safe application biochar or rock dust could be used to demonstrate compliance with this duty of care. Many of the current model codes of practice provide a good starting point, including those relating to asbestos, respirable crystalline silica, and spray painting.[116]

It is possible that these risks could also be addressed under soil conservation or environmental management legislation, though in practice this approach seems unlikely. There is very little regulation of tilling practices in Australia. Soil conservation legislation in most jurisdictions allows for the issuance of 'soil conservation notices', or orders *requiring* a landowner to take (or not take) an action for the purposes of soil conservation or land protection.[117] In addition, it is possible for the application of material to farmland to be classified an environmentally relevant activity or otherwise required to obtain an environmental licence or approval under state environmental management and pollution control

strategy to protect and restore coastal ecosystems to enhance their capacity as a carbon sink: 'Blue Carbon', *Government of South Australia* (Web Page) <https://www.environment.sa.gov.au/topics/climate-change/climate-change-blue-carbon-strategy>.

115 Every state and territory has specific mining legislation as well as legislation governing environmental impact assessment, planning, and environmental management. See generally Gerry Bates, *Environmental Law in Australia* (LexisNexis, 10th ed, 2019).

116 Safe Work Australia, *Model Code of Practice: Spray Painting and Powder Coating* (Report, July 2020); Safe Work Australia, *Model Code of Practice: Managing the Risks of Respirable Crystalline Silica from Engineered Stone in the Workplace* (Report, July 2021); Safe Work Australia, *How to Manage and Control Asbestos in the Workplace: Code of Practice* (Report, July 2020).

117 See, eg, *Soil Conservation Act 1938* (NSW); *Catchment and Land Protection Act 1994* (Vic) s 20 ('General duties of land owners', including to conserve soil) and pt 5 ('Land management notices'); *Soil and Land Conservation Act 1945* (WA) pt V ('soil conservation notices'). Tasmania has not specific provisions relating to soil, but the *Nature Conservation Act 2002* (Tas) relates to the protection of land.

legislation.[118] The Queensland Government's attempts to manage agricultural chemical run-off into the Great Barrier Reef show that this can be done,[119] but high levels of opposition from the North Queensland sugarcane and other farming industries also show that this form of direct regulation is likely to opposed.[120] Incorporating environmental management practices that govern risks into the approved methodology for awarding credits may be the preferable technique. Combining incentives for practices conducted with necessary safeguards will likely have greater lasting effect.

Marine NETs raise different legal issues. The process of ocean de-acidification involves adding lime, carbonate minerals, olivine or other silicates to the ocean or coastal environment, while fertilisation involves the addition of iron or other nutrients. The legal and regulatory issues relating to sourcing, mining, and grinding these liming materials are the same as those outlined above for land-based enhanced weathering. The production, manufacture, energy and transport systems to produce and deliver nutrients over regular periods for fertilisation also require regulation. However, the application of these substances to marine environments means that these NETs must comply with international legal requirements relating to sea dumping and marine pollution.[121]

The *1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972* ('*London Protocol*')[122] is particularly relevant to the regulation of marine NETs. The aim of the *London Protocol* is to protect and preserve the marine environment from all sources of pollution.[123] While marine NETs are intended to improve atmospheric GHG levels, there are risks that some techniques may also harm the marine environment, which would be inconsistent with the aim of the *London Protocol*. The *London Protocol* prohibits 'dumping' of matter into the ocean (including within a state's coastal waters and Exclusive Economic Zone ('EEZ')) from vessels, aircraft, platforms and other human-made structures at sea.[124] The only exceptions to this rule are specifically listed in Annex 1, which does not include the substances for marine NETs, such as lime, carbonate minerals, olivine or other silicates for ocean de-acidification,

118 See, eg, *National Environment Protection Council Act 1994* (Cth); *National Environment Protection (Ambient Air Quality) Measure 1998* (Cth); *Protection of the Environment Operations Act 1997* (NSW) pt 5.4 ('Air pollution'); *Environmental Management and Pollution Control Act 1994* (Tas) s 53 ('Offence of causing environmental nuisance'); *Environment Protection Act 2017* (Vic) pt 3.2 ('General environmental duty'); *Environmental Protection Act 1986* (WA) pt V div 1 ('Pollution and environmental harm offences').

119 *Environmental Protection Act 1994* (Qld) ch 4A ('Great Barrier Reef protection measures').

120 Michael Gorey, 'Farmers Oppose New Reef Regulations', *Bundaberg Now* (Web Page, 8 April 2019) <https://www.bundabergnow.com/2019/04/08/farmers-oppose-new-reef-regulations/>.

121 For an analysis of these obligations, see Kerryn Brent, William CG Burns and Jeffrey McGee, *Governance of Marine Geoengineering* (Report, 2019).

122 *Protocol of 1996 to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972*, opened for signature 7 November 1996, 36 ILM 1 (entered into force 24 March 2006) ('*London Protocol*').

123 Ibid art 2.

124 Ibid art 1 para 4.1, 4.

or iron sulphate or other substances for ocean fertilisation.[125] If placement of these materials constitutes 'dumping', it is thus prohibited under the regime. Dumping does not include: 'placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this *Protocol*'.[126] Placement of material for research purposes, or deployment activities to enhance the ocean's uptake of CO_2 are for a purpose *other than mere disposal* so are likely to fall outside the definition of dumping.[127]

Parties to the *London Protocol* and *London Convention* have passed several non-binding decisions to help clarify whether ocean fertilisation is 'dumping' and therefore prohibited. In 2008, it was determined that ocean fertilisation activities are 'dumping' and prohibited unless they qualify as legitimate scientific research.[128] In 2010, a specific assessment framework was developed to help parties determine whether a proposal qualifies as legitimate scientific research.[129] In 2013, parties amended the *London Protocol* to include these rules,[130] but this amendment is not yet in force, and Australia has not ratified it, so its provisions are not binding.[131] The amendment only establishes rules for ocean fertilisation and currently does not apply to other marine NETs, such as ocean alkalinisation or de-acidification.[132] Clarification of the position of marine NETs under the *London Protocol* and *United Nations Convention on the Law of the Sea* is needed. To facilitate further research into marine NETs other than ocean fertilisation, it may be necessary to provide rules that expressly permit legitimate scientific R&D.

The *Environment Protection (Sea Dumping) Act 1981* (Cth) ('*SDA*') implements Australia's international obligations under the *London Protocol*, prohibiting the dumping of substances that are not listed in Annex 1 of the *London Protocol* in Australian territorial waters, or from Australian ships and ships loaded in Australia.[133] This prohibition will apply to ocean fertilisation activities

125 Brent, Burns and McGee (n 121) 37–8.

126 *London Protocol* (n 122) art 1 para 4.2.

127 Brent et al (n 70) 836–7.

128 *Report of the Thirtieth Meeting of the Contracting Parties to the London Convention and the Third Meeting of the Contracting Parties to the London Protocol*, 30th and 3rd mtgs, Agenda Item 16, LC 30/16 (9 December 2008, adopted 31 October 2008) annex 6 (*Resolution LC-LP 1 (2008) on the Regulation of Ocean Fertilization*). For an overview of these developments, see Jeffrey McGee, Kerryn Brent and William CG Burns, 'Geoengineering the Oceans: An Emerging Frontier in International Climate Change Governance' (2018) 10(1) *Australian Journal of Maritime and Ocean Affairs* 67 <https://doi.org/10.1080/18366503.2017.1400899>.

129 *Report of the Thirty-Second Consultative Meeting and the Fifth Meeting of Contracting Parties*, 32nd and 5th mtgs, Agenda Item 15, LC 32/15 (9 November 2010, adopted 14 October 2010) annex 6 (*Assessment Framework for Scientific Research Involving Ocean Fertilization*).

130 *Resolution LP.4(8) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and Other Marine Geoengineering Activities*, Agenda Item 15, LC 35/15 (adopted 18 October 2013) annex 4.

131 See Brent, Burns and McGee (n 121) 43–8; Brent et al (n 70) 836.

132 Brent, Burns and McGee (n 121) 44–5. See also Harald Ginzky and Robyn Frost, 'Marine Geo-Engineering: Legally Binding Regulation under the *London Protocol*' (2014) 8(2) *Carbon & Climate Law Review* 82.

133 *Environment Protection (Sea Dumping) Act 1981* (Cth) s 10A ('*SDA*').

if they qualify as dumping under the *London Protocol*, as discussed above.[134] It is the responsibility of the Commonwealth Environment Minister to make this determination for individual activities,[135] and the Minister is obliged under the *London Protocol* to adopt a precautionary approach.[136] Importantly, if the Minister decides that an activity qualifies as dumping, they cannot otherwise permit the activity.[137] As currently framed, the *SDA* could therefore significantly restrict ocean fertilisation and other marine NETs activities from taking place in Australia, or by Australian researchers/companies.[138] It may be necessary to create an exception in the sea dumping legislation to enable small-scale experimentation in order to evaluate the effectiveness and risks of this NET.

The *EPBC Act* will apply to marine NETs with potential for significant environmental impacts, although the uncertainty surrounding possible environmental impacts makes it hard to assess how applications for approval would be considered.[139] If ocean fertilisation or de-acidification are not prohibited by the *SDA* because they fall outside the definition of dumping, they will require a permit under the *EPBC Act* if likely to have a significant impact on Commonwealth marine areas, or other matters of national environmental significance.[140] Artificial upwelling and downwelling for carbon capture is also likely to trigger approval obligations under the *EPBC Act*. The *EPBC Act* enables the Minister to attach conditions to approval of activities with risks of significant environmental impacts, but it has limited capacity to implement an adaptive management approach to potentially risky activities.

3 Risks Relating to Engineered Storage Techniques

The risks posed by engineered storage options also vary by technology. BECCS requires the production of energy and the capture of the resulting CO_2. Construction and operation of new energy plants or modification of existing facilities for CO_2 capture will require compliance with existing regulations for siting, constructing, operating, and maintaining energy facilities, including environmental permits and licensing for land use, infrastructure development, energy generation, pollution, and workplace health and safety.[141] Some have suggested that third party certification of the sustainability of bioenergy production could be used to reduce regulatory burden,[142] but these mechanisms do not provide the strategic oversight of BECCS activities that is required in order to address the environmental and other risks associated with such approaches.

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134 For detailed analysis, see Brent et al (n 70) 836–7.
135 *SDA* (n 133) s 19.
136 *London Protocol* (n 122) art 3 para 1.
137 Brent et al (n 70) 837.
138 Ibid.
139 Ibid.
140 *Environment Protection and Biodiversity Conservation Act 1999* (Cth) ss 24, 24A(4) (‘*EPBC Act*’).
141 International Energy Agency, ‘Carbon Capture and Storage: Model Regulatory Framework’ (Information Paper, November 2010) (‘CCS Model Regulatory Framework’).
142 Climate Institute, *Moving below Zero: Understanding Bioenergy with Carbon Capture & Storage* (Report, 9 April 2014) 21.

Geological storage of CO_2 captured through BECCS or DACS involves underground injection of captured CO_2 to directly store or mineralize CO_2 through chemical processes. Geological storage requires identification of suitable capture facilities, transmission and injection of CO_2, and plans for plant decommissioning, including rules about monitoring, reporting, and liability transfer for the permanent/ long-term security of storage.[143] In the absence of national CCS legislation for landbased CO_2 transmission and storage, these activities will be subject to state-based CCS legislation and development, impact assessments and environmental management and pollution control licensing requirements.[144]

The requirements of these CCS laws differ across jurisdictions and there is a strong case for a nationally harmonised approach. Victoria, Queensland and South Australia each have regimes in place governing permanent storage of liquefied CO_2, primarily from coal and gas production, in underground reservoirs or geological formations.[145] Queensland and Victoria have implemented dedicated greenhouse gas legislation,[146] while South Australia has combined CCS with its regulation of petroleum and gas operations.[147] Each governs onshore injection requirements and prescribes procedures for site closure, and timeframes and reporting requirements for transferring or limiting ongoing liability for stored CO_2. While they do not yet apply to storage for NETs purposes, they could easily be applied or adapted to CCS associated with DACS or BECCS.

The regulatory requirements for the Gorgon liquefied natural gas ('LNG') project in waters off Western Australia constitute a third form of regulation for CO_2 storage in Australia. The Gorgon LNG project incorporates project-specific agreements as annexes to special purpose legislation – the *Barrow Island Act 2003* (WA).[148] This project-specific approach to regulating storage may be appropriate for one-off activities, but does not provide the kind of accountability (in substantive standards or procedural safeguards), nor the consistency or strategic approach that will be required if CO_2 sequestration was to play a greater role in Australia's national emissions reduction policy.

Exploratory work has already been conducted to identify potentially suitable storage sites under existing state CCS legislation.[149] Most sites that have been identified as geologically suitable for permanent storage are located offshore, but onshore sites have been identified in both Queensland and New South

143 'CCS Model Regulatory Framework' (n 141).

144 Commonwealth CCS legislation – specifically the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cth) ('*National Offshore Storage Act*') – only applies to transmission and storage sites for GHGs in Commonwealth offshore areas, see the discussion accompanying footnotes 154–6 for more detail.

145 The Greenhouse Gas Storage Bill 2010 (NSW) was not passed by the Parliament before it lapsed in December 2010, so there is no legislation to govern CO_2 storage in New South Wales.

146 *Greenhouse Gas Storage Act 2009* (Qld) ('*Greenhouse Gas Storage Act*'); *Greenhouse Gas Geological Sequestration Act 2008* (Vic).

147 *Petroleum and Geothermal Energy Act 2000* (SA) ('*Petroleum and Geothermal Energy Act*').

148 *Barrow Island Act 2003* (WA) schedules 1 and 2 incorporate the 'Gorgon Gas Processing and Infrastructure Project Agreement' and the '2013 Variation Agreement', respectively.

149 Section 30 of the *Greenhouse Gas Storage Act* lists the activities authorised under a GHG permit as including 'GHG storage exploration' and division 3 of the *Petroleum and Geothermal Energy Act*, which creates rules about applying for and granting 'gas storage exploration licences'.

Wales.[150] Precaptured CO_2 may be transported in small volumes by road, rail or ship and governed by transport, pollution and health and safety laws.[151] But at the scale anticipated for technologies such as BECCS and DACS, most CO_2 will be transported from capture to injection sites along dedicated pipelines. New dedicated pipeline networks are likely to be required and this too raises governance challenges.[152]

Guaranteeing the permanence of the storage and minimising risks associated with leakage of stored GHGs are key priorities of geological sequestration governance. The requirements for injecting, capping, monitoring, and reporting on the stability of stored CO_2 have been a key focus of legislation for CCS. The 'Carbon Dioxide Capture and Geological Storage Australian Regulatory Guiding Principles' ('Guiding Principles for CCS') support a nationally consistent approach to regulating CCS in federal, state and territory laws.[153] The 'Guiding Principles for CCS' provide a framework for assessment and approvals processes; storage site exploration, access and surface tenure over potential storage locations; monitoring and verification obligations for health, safety, and environmental protection; and liability and post-closure responsibilities. While they are not binding, it is expected that all Australian laws and policies will be consistent with them.

Some key legal reforms are needed for Australia's geological sequestration sector to mature. State and territory laws for transporting greenhouse gases by pipeline should be harmonised to support the construction and operation of CO_2 pipeline networks across state and territory boundaries.[154] Legal requirements for injecting CO_2, capping, and retiring CO_2 storage reservoirs and transferring liability post-closure – whether for onshore or offshore storage – should also meet the standards set out in the Commonwealth Government's 'Guiding Principles for CCS'.[155] Finally, environmental impact assessment and land-use planning laws and

150 'Investigating Greenhouse Gas Storage Sites', *Australian Government Department of Industry, Innovation and Science* (Web Page, 2018) <https://web.archive.org/web/20190321182859/https://www.industry.gov.au/funding-and-incentives/mining/mining/low-emissions-technologies-for-fossil-fuels/investigating-greenhouse-gas-storage>.

151 Samantha Hepburn, *Mining and Energy Law* (Cambridge University Press, 2015) 291–2 <https://doi.org/10.1017/CBO9781107480025>.

152 Ibid 292. Existing state laws regulate the transmission of CO_2 by pipeline. Constructing a pipeline that originates and terminates within a single state will typically require a pipeline licence. Section 46 of the *Petroleum and Geothermal Energy Act* authorises a pipeline licensee to operate, maintain and, if relevant, to construct a transmission pipeline. Approvals occur under land-use planning, conservation, environmental management and impact assessment laws. In the absence of nationally-harmonised laws, constructing a pipeline that crosses a state border will require approvals for each of those jurisdictions are also required.

153 Ministerial Council on Mineral and Petroleum Resources, 'Carbon Dioxide Capture and Geological Storage Australian Regulatory Guiding Principles' (Guide, 2005) ('Guiding Principles for CCS').

154 This may develop along the lines of the National Gas Rules (a framework for negotiating/arbitrating access to pipelines for natural gas across the country by the multiple service providers and pipeline operators – to maximise access and efficiency in the network (eg, Australian Energy Market Commission)).

155 'Guiding Principles for CCS' (n 153).

pipeline 'rights of way' provisions[156] will need to address cumulative and landscape issues arising from the pipeline network that will be required for large-scale storage.

Marine-based storage of CO_2 includes direct injection of CO_2 into deep ocean waters, placement on the ocean floor, and injection into sediment or into rock below the seabed. Most of the storage potential lies within Australia's Continental Shelf or Extended Continental Shelf, and thus falls under Commonwealth jurisdiction. The *London Protocol* prohibits direct injection of CO_2 into deep ocean waters and placement on the ocean floor because it involves the dumping of waste at sea and CO_2 is not listed as an exception under Annex 1.[157] This prohibition applies to activities in all Australian coastal waters, EEZ and the high seas.[158] Injection into sub-sea geological formations is a listed exception to the prohibition[159] and a 2009 amendment (not yet in force) allows parties to conduct CCS in sub-sea geological formations that cross state boundaries.[160]

In practice, the Commonwealth already has a sophisticated (and complex) regulatory regime for governing offshore transportation and injection of CO_2 into sub-sea geological formations, although it has had very little use to date. The *National Offshore Storage Act* and associated regulations[161] establish an approval process for transportation and injection of CO_2.[162] That process requires a Pipeline Licence for construction and operation of petroleum pipelines, including for the transmission of CO_2 in Commonwealth waters (three nautical miles to boundary of the EEZ), and a Greenhouse Gas Injection Licence for injection of CO_2 into an 'identified greenhouse gas storage formation'.[163] Victoria is the only jurisdiction with dedicated legislation governing injection and storage of CO_2 in state waters.[164] The Victorian legislation will need to be mirrored in each state to ensure consistency in respect of activities in state waters.

Negative emission hydrogen with ocean de-acidification involves alkalinisation of the ocean as a by-product of hydrogen production. It is possible that disposal of alkaline seawater associated with hydrogen production will fall outside the scope of the *London Protocol* because the definition of 'dumping' does not include: 'the disposal into the sea of wastes or other matter *incidental to*, or derived from the normal operations of vessels, aircraft, platforms or other man-made structures at sea and their equipment'.[165] If disposal of alkaline seawater were considered 'incidental' to the usual operation of hydrogen production, it may be exempt from

156 Hepburn (n 151) 292.

157 See discussion above at Part III(B)(3).

158 *London Protocol* (n 122) art 1 para 7.

159 Ibid annex 1 cl 4.

160 *Resolution LP.3(4) On the Amendment to Article 6 of the London Protocol* (adopted 30 October 2009) <https://www.imo.org/en/OurWork/Environment/Pages/CCS-Default.aspx>.

161 *National Offshore Storage Act* (n 144); *Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009* (Cth), *Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011* (Cth).

162 *National Offshore Storage Act* (n 144) pt 2.6 ('Pipeline licences'), ch 3 ('Regulation of activities relating to injection and storage of greenhouse gas substances').

163 Ibid pt 3.4.

164 *Offshore Petroleum and Greenhouse Gas Storage Act 2010* (Vic).

165 *London Protocol* (n 122) art 1 para 4.2.

the restrictions contained in the *London Protocol*, and therefore be beyond the reach of Australia's sea dumping legislation. However, the *Sea Installations Act 1987* (Cth) may also apply to offshore renewable hydrogen installations and give the Minister specific governance powers in relation to them. The purpose of this Act is to ensure the safe operation of sea installations, including those used for scientific activities.[166] While it no longer establishes permitting requirements (these were repealed in 2014), the Act allows the Minister to establish 'safety zones' to prohibit vessels from entering the area around installations.[167]

What is clear from this review of current state and Commonwealth laws governing NETs is the challenge arising from the diversity of GHG removal technologies. No single law governs all risks from all NETs. For some technologies, laws are already in place and provide a suitable framework for governing research, development and deployment, although most are complex and compliance is costly. For others, the law applies partially, but would benefit from amendment or explication through regulations or administrative guidelines. For a few technologies, especially in the marine environment, the law currently presents significant barriers to large-scale implementation. An effective regime to govern the upscaling of these technologies therefore requires technology-specific assessment of each NET. In the discussion below, we highlight some key reform priorities for establishing a legal framework that can both facilitate and govern NETs.

IV A NETS LAW REFORM AGENDA

There are some clear reform priorities for improving the facilitation and regulation of NETs. Starting internationally, an expectation that parties to the *Paris Agreement* develop separate targets in their NDCs for emissions reduction and GHG removal would help establish an imperative for domestic NETs. At the very least, a clear separation of NETs and emissions reduction commitments in NDCs can provide a foundation for separate targets and accounting in future. Australia should lobby for such an approach within negotiations under the *Paris Agreement*.

For NETs that are already proven and in the implementation stage, like those terrestrial NETs, the key challenge is to promote further uptake and provide mechanisms for resolving land use conflicts through effective strategic landscape planning. The Australian Government's provision of funding to landholders to undertake initial soil assessment work is a small example of such incentives. However, technology-specific subsidies of this sort are unlikely to produce stepwise advances in NETs uptake. Establishing a broad-based cap on emissions that is implemented through some form of trading or crediting mechanism – be it an expanded safeguard mechanism or a new GHG pricing mechanism – would significantly increase demand for GHG credits and is therefore essential to

166 *Sea Installations Act 1987* (Cth) s 3.
167 Ibid s 57.

facilitate NETs expansion. Creating this demand is a critical role for the Australian Government. In reforming the Safeguard Mechanism and implementing a framework to facilitate NETs, it will also be important to ensure comparability of NETs-produced credits and those from emissions reduction, to avoid the risks of mitigation deterrence.

Ensuring high levels of public trust in the credits generated by NETs is essential. This requires robust, verifiable, and internationally benchmarked GHG accounting rules that address the full life cycle of NETs activities. Some guidelines and standards have already been developed under the *UNFCCC* to guide national GHG accounting processes, but these require careful review to ensure that they address the issues of life cycle assessment, avoidance of double counting, ensuring permanence, and non-reversal.[168] Regular auditing of projects to ensure that they are delivering in the way that the rules intended is critical if the public is to have confidence in the legitimacy of NETs as a contribution to Australia's mitigation commitments.

The complexity of this task should not be underestimated, given that many technologies require calculation of life-cycle emissions from mining, processing, and transport of inputs to NETs processes. The GHG accounting models and methodologies applicable to the land sector are already complex; land managers need specialist legal and technical advice to evaluate their eligibility and comply with procedural and reporting requirements. Accounting methodologies will have to be extended or adjusted for each new technology, so there is a real risk that the already complex regulatory landscape will become even more burdensome.

The activities that earn emissions reduction or GHG removal credits also require nationally-consistent standards and methodologies. While it is tempting to propose a single law governing NETs activities, potentially along the line of the new scheme governing offshore electricity infrastructure,[169] this analysis suggests that the sheer diversity of capture and storage methods and combinations will necessitate a more heterogenous regulatory approach. Over time, it may be possible to simplify the regulatory burden for tried and tested approaches, but some level of cost and complexity seems unavoidable in the short term.

A review of state land use planning and environmental management laws is needed to enhance safeguards against the environmental and social risks of NETs activities. A joint national statement on the role of NETs should guide such a review. Without an agreed position on how NETs should contribute to Australia's net zero target, law reform could create or perpetuate perverse incentives to more cost-effective mitigation.

The role of CCS deserves special attention as a key component of multiple NETs. The current arrangements are both complex and costly. Despite detailed regulatory reviews associated with government liability for historical mine site rehabilitation, a consistent regulatory framework for the storage phase for CCS projects remains

168 Bert Metz et al, *Special Report on Carbon Dioxide Capture and Storage* (Report, 2005) 372–5; Tanzer and Ramírez (n 30).

169 *Offshore Electricity Infrastructure Act 2021* (Cth).

a priority.[170] Such a framework needs to include tools for mitigating against the risks of long-term liabilities for CCS, including bonds, levies and other financial obligations for post-site-closure stewardship and the transfer of liability.[171] The assessment, approval and operation of cross-border transport of CO_2 to storage sites, including geological sequestration or mineralisation sites, requires explicit attention. A national approach to assessment and approval of CO_2 transport across states and territories can ensure equity in the distribution of risks and benefits, including risks relating to leakage, storage failure and/or liability. Harmonised assessment, approval and operation requirements for cross-border transport of CO_2 would also create greater certainty for CCS proponents, including about the immediate and long-term availability of suitable storage sites.[172] Harmonised laws would also support strategic, cooperative planning for the future availability of the most suitable CO_2 storage sites and promote co-location of electricity generation, distribution and other infrastructure adjacent to CO_2 storage areas. It also has the best chance of reducing some of the cost and complexity of current regulatory regimes.

While the gaps in, and shortcomings of, existing laws governing the risks of NETs require attention, a key question is how, if at all, current laws should apply to R&D activities. To facilitate the R&D of new NETs activities, it may be necessary to vary the Climate Solutions Fund process to pay a premium for technology development, rather than focussing solely on least-cost emissions reductions.[173] This carries the risk, however, of diverting investment away from proven methods, so a preferable approach would be to offer new additional funding specifically for NETs R&D. Additional measures for guaranteeing sequestration permanence may also be required, particularly where significant risks of bushfire or other hazards threaten permanence. Appropriate additional measures might include obligations to manage fire hazards, re-plant and restore following loss (with associated insurance requirements), and allowances for risks of loss in accounting methods.

Where R&D is relatively small-scale and impacts likely to be manageable, there is an argument that activities should be exempted from, or subject to lower, regulatory requirements provided they are conducted in conformity with research protocols that address such risks.[174] For NETs that hold promise, but which require more R&D, it may be appropriate to permit small-scale field experiments using agreements that exempt otherwise applicable statutory obligations. The new regime established to enable the construction, installation, commissioning, operation,

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170 See 'CCS Model Regulatory Framework' (n 141) pts 6.9, 6.11, 6.12. See, eg, Petro Georgiou et al, House of Representatives Standing Committee on Science and Innovation, *Between a Rock and a Hard Place: The Science of Geosequestration* (Report, August 2007) ch 7 ('Legislative and regulatory framework'); Nicola Swayne and Angela Phillips, 'Legal Liability for Carbon Capture and Storage in Australia: Where Should the Losses Fall?' (2012) 29(3) *Environmental and Planning Law Journal* 189.

171 'CCS Model Regulatory Framework' (n 141) pt 6.

172 Including to strategically located 'hubs', adjacent to high-value CO_2 storage areas, where transmission, injection and other infrastructure can be co-located and operated most efficiently.

173 Honegger and Reiner (n 80).

174 Some laws already allow for this, though not specifically based on the activity being for research and development purposes. For example, the *EPBC Act* itself allows for determinations that activities will not have a significant impact provided they are undertaken in a particular manner: *EPBC Act* (n 140) s 77A.

maintenance, and decommissioning of offshore electricity infrastructure may be a useful starting point. Based on the *National Offshore Storage Act*, the *Offshore Electricity Infrastructure Act 2021* (Cth) prohibits offshore electricity activities in Commonwealth waters without a licence. Section 17 provides the Minister with powers to declare where such activity should occur, and the Act provides for the award of various categories of licence. Of note is the provision for award of a licence for small-scale research and demonstration of emerging technologies, for up to ten years.[175]

It is also essential to avoid technological lock-in or path dependency, and to build public confidence in the technologies themselves and the capacity of existing regimes to manage their risks. Clearly defining thresholds of scale and acceptable risk, and developing research protocols where none exist, can help avoid these risks. Policies governing research and climate adaptation interventions within the Great Barrier Reef Marine Park may provide a useful foundation for such protocols.[176]

V CONCLUSION

A portfolio of various NETs deployed at large scale will almost certainly be required for Australia to be on a plausible path to meeting a net zero commitment by 2050. Fortuitously, Australia has large landmass and one of the world's largest marine estates, so has a natural advantage for GHG removal not enjoyed by most other countries. However, a realistic pathway to net zero emissions will require very significant investment in R&D of immature technologies to identify viable candidates and improve their commercial viability and scalability. The Commonwealth Government already has a policy framework to support R&D, technology deployment, and commercialisation. These include the Emissions Reduction Fund, Australian Renewable Energy Agency, R&D Tax Credits, AusIndustry's Accelerating Commercialisation Grants, the Clean Energy Finance Corporation and the Australian Research Council. Additional investment through these mechanisms specifically for NETs R&D remains a priority, but deployment of NETs at scale will require sustainable economic incentives. International carbon trading opportunities under the *Paris Agreement* hold the greatest promise in this respect, buttressed by a strong domestic regulatory framework.

GHG accounting methods will be required at supply chain and sectoral levels to support the deployment of NETs in ways that deliver *net* negative emissions. Without such GHG accounting methods and coordination it will be very difficult to maintain social licence for the public expenditure required to transform NETs from

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175 Explanatory Memorandum, Offshore Electricity Infrastructure Bill 2021 (Cth) 2. However, while the *Offshore Electricity Infrastructure Act 2021* (Cth) establishes a system for site selection for offshore electricity infrastructure, without more detail it could not be said that it establishes the kind of systematic, strategic process of spatial planning that will be needed for NETs.

176 Great Barrier Reef Marine Park Authority, *Managing Research in the Great Barrier Reef Marine Park Guidelines* (Report, 4 October 2017); Great Barrier Reef Marine Park Authority, *Policy on Great Reef Interventions* (Report, December 2020); Great Barrier Reef Marine Park Authority, *Assessment and Decision Guidelines* (Report, 1 April 2019).

the R&D phase to large scale deployment. There will also need to be coordination of incentives for 'NETs hubs'. Similar to current hydrogen hub proposals, NETs hubs could support co-location of manufacturing, energy and GHG capture and storage facilities to reduce costs and the risks of new assets stranded in locations unable to support net negative supply chains.

Developing and deploying large-scale GHG removal technologies in Australia poses environmental and social risks which will straddle state jurisdictions, and in the case of marine NETs, potentially straddle international borders. A key challenge is that the diversity of NETs requires a correspondingly heterogenous approach to regulating for environmental protection, human health and safety. Evaluating and reforming existing laws to ensure they are fit for purpose will be an immense task. To ensure that R&D can progress in the meantime, R&D should be subject to special regulatory arrangements to facilitate identification of the most promising candidate technologies.

The scale of work required for large scale NETs in Australia may seem daunting. It would be naïve to suggest that reforms of the kind outlined above can be achieved while climate policy continues to be divisive. However, given Australia's potential for developing terrestrial and marine NETs and our modest mitigation efforts to date, NETs must be part of a path to net zero emissions at 2050. A robust and credible regime that builds confidence in NETs credits and ensures legal safeguards against environmental and social risks is an essential step towards this goal.