THE LEGAL FRAMEWORK FOR CARBON DIOXIDE REMOVAL IN CANADA

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Recent assessments of progress on greenhouse gas (GHG) emissions reductions suggest that efforts to reduce emissions are well below what is necessary to meet current global targets of 2 degrees Celsius, let alone 1.5 degrees Celsius above pre-industrial levels. Current Intergovernmental Panel on Climate Change models include significant amounts of carbon dioxide removal (CDR) from the atmosphere as necessary to meet the 2 degrees Celsius target. The models assume the availability of CDR technologies to contribute to climate goals, but significant uncertainties remain regarding the efficacy, costs, scalability, environmental impacts, and broader public acceptability of these technologies. In Canada, CDR technologies are a crucial element of Canada's long-term climate strategy towards achieving net-zero emissions by 2050. Still, little to no national policy attention has been paid to researching, assessing, and implementing CDR measures, including the necessary legal framework in which these technologies would operate.

This article provides an overview of Canada's existing legal framework that will apply to various CDR methods as they are developed. It examines the legal framework as it may apply to CDR measures collectively (particularly in consideration of how these technologies will be treated in Canada's broader climate framework), and individually. It aims to take stock of existing federal and provincial rules and assess the potential gaps that will need to begin to be addressed as Canada develops CDR capacities.

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I. INTRODUCTION

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) released a Special Report examining the impacts of global warming of 1.5 degrees Celsius, and the potential emission pathways to limit warming to 1.5 degrees Celsius.[1] The 1.5 degrees Celsius limit was identified in the *Paris Agreement* and represents the internationally agreed upon goal of limiting global average temperature increases to 1.5 degrees Celsius above pre-industrial levels, while holding the increase to well below 2 degrees Celsius.[2] One of the key findings of the Special Report is that all pathways consistent with 1.5 degrees Celsius contemplate the use of carbon dioxide removal (CDR)[3] over the twenty-first century.[4] Thus, in addition to reducing emissions, countries will also need to remove carbon dioxide (CO_2) from the atmosphere and permanently store it either biologically or geologically. The amount of CDR required would depend on the levels of reduction of greenhouse gas (GHG) emissions, particularly in the near term. Even in scenarios modelled to meet the less onerous target of 2 degrees Celsius, it is projected that CDR will have to play a significant role.[5] The IPCC's acknowledgment of the increasing importance of CDR for achieving climate goals is consistent with several other reports by international organizations and scientific bodies that have considered CDR to be the "least expensive and least disruptive" approach to achieve the *Paris Agreement* targets.[6]

In Canada, the salience of CDR is recognized in *Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy*, which identifies the need for CDR in the latter part of the century to meet Canada's long-term climate goals.[7] Notwithstanding the acknowledged

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1 Intergovernmental Panel on Climate Change, *Global Warming of 1.5°C, An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (Geneva: World Meteorological Organization, 2018), online: <www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf> [IPCC 1.5].

2 *Paris Agreement*, being an Annex to the *Report of the Conference of the parties on its twenty-first session, held in parties from 30 November to 13 December 2015--Addendum Part two: Action taken by the Conference of the parties at its twenty-first session, 12 December 2015*, UN Doc FCCC/CP/2015/10/Add.1, 55 ILM 740 (entered into force 4 November 2016) [*Paris Agreement*]. For a detailed discussion of the *Paris Agreement*, see Daniel R Klein et al, *The Paris Agreement on Climate Change: Analysis and Commentary* (New York: Oxford University Press, 2017). See also Daniel Bodansky, "The Paris Climate Change Agreement: A New Hope?" (2016) 110:269 AJIL 288.

3 The terms "greenhouse gas removal" (GGR), "carbon dioxide removal" (CDR), and "negative emission technologies" (NETs) are often used interchangeably. We use the term CDR in this article since at present, the focus of international and Canadian greenhouse gas removal is on carbon dioxide.

4 IPCC 1.5, *supra* note 1 at 19.

5 Sabine Fuss et al, "Betting on Negative Emissions" (2014) 4:10 Nature Climate Change 850 [Fuss et al, "Negative Emissions"].

6 National Academies of Sciences, Engineering, and Medicine, *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda* (Washington, DC: The National Academies Press, 2019) at 4 [National Academies Research Agenda]. See also United Nations Environment Programme, *The Emissions Gap Report 2017*, UNEPOR (2017) 1, online (pdf): <www.unep.org/resources/emissions-gap-report-2018> [UNEP 2017].

7 Environment and Climate Change Canada, *Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy*, Catalogue No 978-0-660-06577-9 (Ottawa: Environment and Climate Change Canada, 2016) at 9 [Environment and Climate Change Canada, 2016].

importance of these technologies amongst the scientific community to meeting Canadian and global climate goals, Canada has no clear policy strategy on their desirability, how they might be developed and implemented, or how they ought to be accounted for within the portfolio of climate responses in the medium and long-term.[8] The absence of a national strategy on CDR is concerning because there remains a great deal of uncertainty regarding the technological and economic feasibility of CDR and the environmental and other impacts of implementing such methods at the scales potentially required. Without a national strategy, interested parties are likely to be less willing to invest the time and capital required to establish the feasibility of these technologies and implement them in the context of Canada's legal framework. The need for greater policy certainty concerning CDR in the Canadian context was emphasized in a 2015 Carbon Management Canada (CMC) report on deep decarbonization pathways, which described CDR research as a "high priority frontier of Canadian climate policy knowledge."[9] Further research on CDR was also identified as a priority area in a 2020 Environment and Climate Change Canada science needs assessment.[10]

This article provides an initial assessment of the legal and policy framework relevant to CDR in Canada with a view to contributing to emerging discussions on the desirability and manner of incorporating CDR into Canada's climate strategy. Such an assessment is not a simple task because CDR is not a homogeneous class of technologies but rather uses diverse mechanisms to capture and then store CO_2 long-term.[11] One implication of this diversity is that it is unlikely for CDR to be regulated as an undifferentiated and wholly novel phenomenon. Instead, the regulatory landscape will likely involve existing laws of general application, such as carbon pricing regulations, pollution laws, environmental assessment processes, and the application and development of more specific legal requirements with the need to account for novel and emerging issues. At the same time, new climate technologies — particularly those involving large uncertainties and having the potential to transform and disrupt key social, political, economic, and environmental systems — require anticipatory governance that pays particular attention to, and incorporates, effective mechanisms for eliciting and adjudicating public interests and values.[12]

Active CDR projects are being advanced in Canada, involving both marine and terrestrial forms of CDR. The risks arising from the "wait-and-see" attitude adopted by regulators are not an abstract concern. In 2012, an unauthorized marine CDR experiment involving ocean fertilization was conducted off Canada's west coast. Materials were deposited into the ocean in an attempt to stimulate phytoplankton growth to promote fish stocks and biologically

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8 Neil Craik, "Developing a National Strategy for Climate Engineering Research in Canada" (2017) Centre for International Governance Innovation Papers No 153.

9 Chris Bataille, David Sawyer & Noel Melton, "Pathways to Deep Decarbonization in Canada" (2015) at 40, online (pdf): *Deep Decarbonization Pathways* <ddpinitiative.org/category/publication/page/2/#gallery-4>.

10 Environment and Climate Change Canada, *Climate Science 2050: Advancing Science and Knowledge on Climate Change*, Catalogue No En4-414/2020E-PDF (Ottawa: Environment and Climate Change Canada, 2020), annex 3.

11 The specifics of each of these technologies is discussed in detail, below at Part II.B.

12 Walter D Valdivia & David H Guston, "Responsible Innovation: A Primer for Policymakers" (2015), online: *Center for Technology Innovation at Brookings* <www.brookings.edu/wp-content/uploads/2016/06/Valdivia-Guston_Responsible-Innovation_v9.pdf>. See also Rider W Foley, David H Guston & Daniel Sarewitz, "Towards the Anticipatory Governance of Geoengineering" in Jason J Blackstock & Sean Low, eds, *Geoengineering Our Climate? Ethics, Politics, and Governance* (London: Earthscan, 2019) 223.

capture CO_2 through photosynthesis.[13] The incident caught Canadian officials flat-footed and demonstrated the inadequacy of Canada's marine protection laws to regulate controversial and potentially harmful CDR experiments. Advanced, systematic assessment of the regulatory and policy demands of CDR technologies, and Canada's readiness to address them, can minimize the risks associated with CDR and generate higher levels of public trust in the government's ability to assess and manage these risks which are a key component for fair and legitimate decision-making in an area that will likely be characterized by polarized views.

The analysis in this article is descriptive in the sense that we are not advocating for or against the adoption of any particular technology, or even of CDR more generally. Reliance on CDR in modelling scenarios to achieve the targets found in the *Paris Agreement* should not be taken as a signal of the inevitability of these technologies in the real world. There remain significant technological, economic, political, and social barriers to the development and large-scale implementation of CDR. However, it is clear that these responses to climate change are currently on the table as part of a portfolio of policy choices that decision-makers must evaluate, which in turn requires forethought into the kinds of legal rules and processes that will need to be put in place as CDR technologies and their impacts become better understood.

Because the discussions surrounding CDR are in their early stages, this article provides background on the current scientific and technical understanding of proposed CDR technologies, including their potential contribution to meeting international climate targets and the anticipated risks they may pose to social, political, economic, and environmental systems. Part II of this article provides an overview of some of the main forms of CDR that are currently being discussed and assessed by scientific and policy communities. Recognizing the vast and growing technical literature on CDR, our goal is to provide sufficient detail to allow readers to understand the potential regulatory and policy demands of these technologies. Our focus is on technological, as opposed to nature-based approaches, to CDR; consequently, we do not analyze forestry or blue carbon techniques. In Part III, we discuss the main governance requirements for CDR, as well as the existing international rules that are responding to those demands. Following this, in Part IV, we look more specifically at where CDR technologies may fit within Canadian climate policy, the jurisdictional issues that will determine which governments are empowered to take steps to address CDR, and the laws of general application affecting all CDR technologies. In Part V, we turn to the existing legislative requirements at the federal and provincial levels that specific CDR technologies may trigger. We chose to focus on Alberta as the provincial jurisdiction to examine, due to its physical and regulatory capacities in carbon capture and storage, making Alberta a potentially more likely jurisdiction to pursue CDR. We conclude in Part VI of this article with an overall assessment of Canada's readiness to govern the development and implementation of CDR, as well as associated challenges that are likely to arise along the way. Against this backdrop, we identify some near-term priorities that policy-makers ought to consider if Canada moves away from a climate policy dominated by emissions reduction and adaptation strategies towards the wider range of climate responses that will be required in order to move to net-zero emissions in the second half of this century.

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13 Neil Craik, Jason Blackstock & Anna-Maria Hubert, "Regulating Geoengineering Research Through Domestic Environmental Protection Frameworks: Reflections on the Recent Canadian Ocean Fertilization Case" (2013) 7:2 Carbon & Climate L Rev 117.

II. UNDERSTANDING CDR

A. CARBON DIOXIDE REMOVAL

Increases in global average temperatures are driven by the cumulative amount of GHGs in the atmosphere. CO_2, in particular, remains persistent in the atmosphere for very long periods of time (>200 years), meaning that there is a finite amount that can be released into the atmosphere without exceeding the global average temperature targets of between 1.5 degrees Celsius and 2 degrees Celsius. The IPCC and other climate modellers have used the strong linear relationship between temperature change and emissions to calculate the amount of CO_2 that can be safely emitted, referred to as a carbon budget. The IPCC estimates a remaining carbon budget (from the beginning of 2020) of approximately 400 gross tonnage (GT) CO_2 for a 67 percent chance of limiting warming to 1.5 degrees Celsius and approximately 500 GT CO_2 for a 50 percent chance.[14]

CDR technologies can contribute to achieving the Paris Agreement temperature goals because the effect of CO_2 removals from the atmosphere on climatic conditions is similar to not emitting those emissions in the first place.[15] In this regard, CDR is best thought of as closely tied to mitigation efforts in the sense that both emissions reductions and CDR measures seek to limit atmospheric GHG concentrations.[16] The critical difference between reductions and removals is that CDR technologies allow for removals to occur at different locations from emission sources and at a point later in time. Many modelling scenarios provide for exceedances in GHG levels beyond those that would meet the *Paris Agreement* temperature targets but then subsequently drawdown those amounts over time using CDR.[17] The resulting temperature exceedance is referred to as "overshoot ," which would require a period where global emissions would be net negative, meaning that more CO_2 would be removed from the atmosphere than is released.[18]

While some CDR technologies may have impacts similar to traditional emissions reduction methods, there are important differences. For example, some environmental consequences may be avoided by not emitting CO_2 in the first place, as compared to emitting CO_2 and subsequently removing it, especially since some impacts such as sea level rise or impacts to biodiversity may involve tipping points with irreversible consequences.[19] The ability to separate emissions and their removal to achieve GHG reduction targets also gives rise to the potential of exceeding safe levels of atmospheric GHGs without the guarantee that

14 Intergovernmental Panel on Climate Change, *Climate Change 2021: The Physical Science Basis, Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, UNWMOUR (2021) 4.

15 But see Kirsten Zickfeld et al, "Asymmetry in the Climate-Carbon Cycle Response to Positive and Negative CO_2 Emissions" (2021) 11:7 Nature Climate Change 613 (noting that negative emissions at large-scales are less effective at lowering atmospheric CO_2 than an equivalent amount of emissions reduction).

16 Matthias Honegger, Wil Burns & David R Morrow, "Is Carbon Dioxide Removal 'Mitigation of Climate Change'?" (2021) 30:3 RECIEL 327.

17 Oliver Geden & Stefan Schäfer, "'Negative Emissions': A Challenge for Climate Policy" (2016) 53 Stiftung Wissenschaft & Politik 1.

18 UNEP 2017, *supra* note 6; Fuss et al, "Negative Emissions," *supra* note 5; The Royal Society, "Geoengineering the Climate: Science, Governance and Uncertainty" (2009), online: <royal society.org/~/media/Royal_Society_Content/policy/publications/2009/8693.pdf> [The Royal Society, "Geoengineering the Climate"].

19 Secretariat of the Convention on Biological Diversity, CBD Secretariat, Update on Climate Geoengineering in Relation to the Convention on Biological Diversity: Potential Impacts and Regulatory Framework, CBD Technical Series No 84, UNEPOR (2016) at para 109.

those levels will be brought down. At present, there is considerable uncertainty about the technological, social, economic, and environmental feasibility of delivering CDR at the scales required.[20] This creates a "mitigation deterrence" risk, often referred to as a form of moral hazard, that states and other actors will limit their emissions reduction efforts in the near term relying on the ability of unproven technologies to remove GHGs at some future time.[21] This possibility has led some commentators to argue that the parties to the Paris Agreement ought to place limits on the amount of overshoot that can be collectively relied upon in setting and assessing emissions reduction efforts.[22]

CDR technologies must also be distinguished from other proposed climate responses aimed at limiting global average temperature increases through the large-scale reflection of sunlight away from the Earth's atmosphere — a grouping of technologies referred to as solar radiation modification or management (SRM, or solar geoengineering). In past studies, CDR and SRM approaches have been discussed together under the umbrella term of geoengineering (or climate engineering).[23] However, the specific technologies, incentive structures, potential impacts, and governance demands may be different, and these are increasingly treated in the scientific literature as distinct climate responses.[24] SRM technologies address the consequences of increased GHG emissions by affecting the Earth's radiative balance but do not affect the root cause of climate change from rising GHG concentrations in the atmosphere. In addition, SRM would not address non-temperature related impacts from increased atmospheric CO_2, such as ocean acidification.[25]

Estimates of the potential scale of CDR that must be delivered varies widely due to this figure's reliance on assumptions respecting the pace of emissions reductions, the degree of overshoot, and the costs of deploying various technologies. For 2 degrees Celsius pathways, estimates are in the range of 5–21 gross tonnage carbon dioxide per year ($GTCO_2$/yr) by the end of the century.[26] To put this in perspective, current levels of total CO_2 emitted annually are approximately 40 $GTCO_2$. While the bulk of CDR deployment would occur in the latter part of the century, most scenarios show deployment beginning between 2030 and 2040.[27]

The global distribution of the deployment of different CDR measures is uncertain, although it would depend partly on the suitability of natural conditions and resources for their deployment (for example, land availability for afforestation or geological storage potential). Following arguments relating to the distribution of mitigation burdens between countries more generally, it is reasonable to assume that developed countries, such as Canada, would have to take the lead in CDR development and delivery, given their higher levels of capacity and historic contributions to existing atmospheric levels of GHGs. Distributional considerations would also apply within countries, as different regions, states, and provinces have varying potential to develop and deploy CDR technologies.

20 *Ibid.*
21 Dominic Lenzi, "The Ethics of Negative Emissions," (2018) 1:7ed Global Sustainability 1.
22 Oliver Geden & Andreas Löschel, "Define Limits for Temperature Overshoot Targets" (2017) 10:12 Nature Geoscience 881. See also Shinichiro Asayama & Mike Hulme, "Engineering Climate Debt: Temperature Overshoot and Peak-Shaving as Risky Subprime Mortgage Lending" (2019) 19:8 Climate Policy 937.
23 The Royal Society, "Geoengineering the Climate," *supra* note 18.
24 IPCC 1.5, *supra* note 1; National Academies Research Agenda, *supra* note 6.
25 Royal Society, "Geoengineering the Climate," *supra* note 18.
26 Fuss et al, "Negative Emissions," *supra* note 5.
27 Kevin Anderson & Glen Peters, "The Trouble with Negative Emissions" (2016) 354:6309 Science 182.

Notwithstanding that there is a well-established argument in the literature that CDR measures will be a critical component of future climate change responses, there remain significant barriers to large-scale deployment.[28] For instance, land-based methods would compete with agricultural production and impact food systems, interfere with ecosystem functions, and may be constrained by nutrient and water availability. Ocean-based approaches are likely to have significant implications for ecosystem functions since many methods require the deposition of materials into the ocean environment.[29] The potential impacts of large-scale CDR implementation on energy, food, water, and ecosystems raises additional concerns respecting human rights implications.[30] In the Canadian context, the impact of CDR on Indigenous communities and the exercise of Aboriginal and treaty rights would require extensive consultation and possibly the consent of affected Indigenous groups.[31] There are also considerable uncertainties regarding the costs associated with various CDR technologies, which vary widely and are context-dependent.

B. CARBON DIOXIDE REMOVAL METHODS

CDR technologies rely on biological or chemical processes to capture CO_2 and store it geologically or within biological systems. The range of proposed CDR technologies are highly diverse and vary in their technological readiness, storage potential and longevity, their potential for, and barriers to, scalability, costs, environmental risks and co-benefits, and other socio-political and policy considerations.[32] None of these proposed technologies are currently ready to deploy safely and at the scales necessary to significantly contribute to the Paris Agreement targets. This section offers a high-level overview of key proposed CDR measures under consideration with a view to better understanding their regulatory and policy implications.

1. DIRECT AIR CAPTURE AND CARBON STORAGE (DACCS)

Direct air capture (DAC) removes CO_2 directly from the atmosphere using chemical processes that react with CO_2, followed by a subsequent process that recovers and concentrates the CO_2 for storage. In contrast to other conventional point source technologies that capture CO_2 from industrial emission streams, DAC technologies remove CO_2 directly from the ambient air, which contains CO_2 at much lower concentrations.[33] The captured CO_2 from the DAC process is then geologically stored over long timescales to achieve permanent removal. Carbon storage sites require certain geological characteristics, which are present

28 Pete Smith et al, "Biophysical and Economic Limits to Negative CO_2 Emissions" (2016) 6 Nature Climate Change 42 at 46. See also Phil Williamson, "Emissions Reduction: Scrutinize CO_2 Removal Methods" (2016) 530:7589 Nature 153 at 154.

29 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, "High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques," 98 GESAMP Reports & Studies 1, online: <www.unep.org/resources/emissions-gap-report-2018> [GESAMP].

30 William CG Burns, "The Paris Agreement and Climate Geoengineering Governance: The Need for a Human Rights-Based Component" (2016) 111 Centre for Intl Goverance Innovation 2 at 1– 2.

31 Discussed below at Part IV.B.2.

32 For a detailed summary see The Royal Society, "Greenhouse Gas Removal" (2018), online: <royal society.org/~/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf> [The Royal Society Report on CDR].

33 The former scrubs air with flue gas from 5–15 percent CO_2, whereas the latter filters air with a much lower concentration of 0.0039 percent CO_2. See e.g. KS Lackner, "Capture of Carbon Dioxide from Ambient Air" (2009) 176:1 European Physical J Special Topics 93.

in both onshore and offshore areas in Canada.[34] Canada has extensive experience developing carbon capture and storage (CCS) technologies, although commercial-scale CCS is still not operational in Canada.[35] Canada also has several ongoing DAC projects, including a demonstration plant in British Columbia.[36]

Current estimates suggest that DACCS will be expensive to implement due to its high capital costs and high energy requirements, as well as significant costs associated with CO_2 transport and storage.[37] However, even if relatively expensive, DACCS may still be cheaper than cutting emissions in energy-intensive sectors that are difficult to decarbonize, such as transport and aviation.[38] If DACCS is to result in overall reduction in net emissions, the energy requirements must be met with renewal sources, placing further pressures on limited renewal energy sources.

The environmental effects of DACCS technologies include high demands for energy, water, and raw materials, air pollution associated with fuel combustion, and the creation of industrial waste products from the DAC process.[39] When the CO_2 produced from the facilities is stored in geologic formations, there are also concerns that it will leak or release from the basin's margins.[40] In the event of leakage, geological storage may affect agriculture and other land uses in the area, including soil quality. Leakage will also affect the overall efficacy of the technique in achieving mitigation.[41] There are large uncertainties about the overall environmental impacts of DACCS. For example, a recent Royal Society report on CDR concludes that "[l]ife cycle environmental impact assessments for the different DACCS technologies are limited, with only one study published so far."[42]

34 International CCS Knowledge Centre, *Canada's CO_2 Landscape: A Guided Map for Sources & Sinks* (2021), online: <ccsknowledge.com/pub/Publications/CO2-Sources_&_Sinks_Map_Canada%20(2021-05-12).pdf>.

35 For example, the Alberta Carbon Trunk Line is the world's largest carbon capture and storage (CCS) project, which "consists of a 240 km pipeline which will gather, compress and store up to 14.6 million tonnes of CO2 per year, and inject this CO2 into depleted oil reservoirs" (Alberta Government, "Alberta Carbon Trunk Line," online: <majorprojects.alberta.ca/details/Alberta-Carbon-Trunk-Line/622>).

36 Carbon Engineering, "Our Story," online: <carbonengineering.com/our-story/>. See also Solid Carbon, "A Rock-Solid Climate Solution," online: <solidcarbon.ca>.

37 See generally Alain Goeppert et al, "Air as the Renewable Carbon Source of the Future: An Overview of CO_2 Capture from the Atmosphere" (2012) 5:7 Energy & Environmental Science 7833; Niall McGlashan et al, "High-Level Techno-Economic Assessment of Negative Emissions Technologies" (2012) 90:6 Process Safety & Environmental Protection 501; Geoffrey Holmes & David W Keith, "An Air-Liquid Contractor for Large-Scale Capture of CO_2 from Air" (2012) 370:1974 Philosophical Transactions Royal Society 4380.

38 Giulia Realmonte et al, "An Inter-Model Assessment of the Role of Direct Air Capture in Deep Mitigation Pathways" (2019) 10:3277 Nature Communications 1.

39 The Royal Society Report on CDR, *supra* note 32 at 60.

40 National Academies Research Agenda, *supra* note 6 at 224–27.

41 Adriano Vinca, Johannes Emmerling & Massimo Tavoni, "Bearing the Cost of Stored Carbon Leakage" (2018) 6:40 Frontiers in Energy Research 1.

42 The Royal Society Report on CDR, *supra* note 32 at 60.

2. BIOENERGY WITH CARBON CAPTURE AND STORAGE (BECCS)

BECCS is the CDR method that has been given the greatest amount of attention in emission scenarios.[43] Like DACCS, this technique combines a removal approach with CCS to achieve a net removal of CO_2. The first phase of the BECCS process, which entails producing "[b]ioenergy from biomass based power plants," is considered a "mature technology."[44] Carbon dioxide is removed by the growth of feedstock, which is then combusted to create energy. The CO_2 released through the combustion process is then captured and stored geologically. As discussed above, the CCS phase is still in development, though Canada is regarded as a global leader in the field. This expertise, combined with large-scale geological storage potential and significant amounts of available biomass, suggests that BECCS could be an option to help Canada reach its GHG emissions targets.[45] Nevertheless, BECCS still faces significant technological and economic bars to implementation, with the result that its viability at scale remains uncertain.[46] Currently, there are no BECCS projects underway in Canada.[47]

The required scale of BECCS gives rise to major concerns about environmental sustainability. The development of feedstock for bioenergy competes with other land uses, such as the production of food and biodiversity conservation.[48] It also raises concerns about increased air pollution from biomass burning,[49] adverse impacts on the global nitrogen cycle,[50] and on forest ecosystems from whole-tree harvesting and full removal of woody biomass,[51] as well as the integrity of CO_2 storage.[52] Expanded lifecycle analysis focusing on more than CO_2 may help improve understanding of the impacts of BECCS on the environment and other earth atmospheric systems and cycles.[53]

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43 IPCC 1.5, *supra* note 1, "Summary for Policymakers"; Asbjørn Torvanger, "Governance of Bioenergy with Carbon Capture and Storage (BECCS): Accounting, Rewarding, and the Paris Agreement" (2019) 19:3 Climate Policy 329 at 329–30.

44 The Royal Society Report on CDR, *supra* note 32 at 40.

45 Canada's large pulp industry makes BECCS a technology that could be an important technology for Canada's mitigation portfolio: see e.g. Henrik Karlsson & Lennart Byström, "Global Status of BECCS Projects 2010" (2011) at 39, online: <www.globalccsinstitute.com/archive/hub/publications/13516/gccsi-biorecro-global-status-beccs-110302-report.pdf>.

46 Daniel L Sanchez & Daniel M Kammen, "A Commercialization Strategy for Carbon-Negative Energy" (2016) 1:15002 Nature Energy 1.

47 Several small-scale BECCS projects are underway in the US: see e.g. Daniel L Sanchez et al, "Near-Term Deployment of Carbon Capture and Sequestration from Biorefineries in the United States" (2018) 115:19 Proceedings of the National Academy of Sciences of the United States of America 4875. In the UK, the former Drax coal plant is being converted for use as a BECCS facility that will isolate the CO_2 being produced after combusting biomass: *ibid*.

48 Alexander Popp et al, "Land-Use Futures in the Shared Socio-Economic Pathways" (2017) 42 Global Environmental Change 331.

49 *Ibid*.

50 The Royal Society Report on CDR, *supra* note 32 at 40.

51 British Columbia Ministry of Forests, *A Compilation of Forest Biomass Harvesting and Related Policy in Canada* (Technical Report 081) by Jean Roach & Shannon M Berch, (Victoria, British Columbia, 2014) at 2 [Technical Report 081].

52 The Royal Society Report on CDR, *supra* note 32 at 41.

53 *Ibid* at 40.

3. BIOCHAR PRODUCTION AND DEPOSITION

Biochar technology uses the application of charcoal or biomass-derived black carbon produced through pyrolysis to soil as a method to sequester carbon within the soil or other surfaces to which biochar material is applied.[54] Unlike carbon stored in biomass, the carbon stored in biochar is relatively resistant to decomposition. As a result, it will be released at a much slower rate and will continue to uptake carbon until saturated, approximately 10–100 years.[55] Biochar can also be used as a soil amendment to improve fertility while simultaneously sequestering CO_2 from the atmosphere.

Though biochar is a proven CDR method, it is not yet widely applied, in part, because of the costs and limited availability of pyrolysis facilities.[56] In Canada, various initiatives are underway to scale up biochar's use. For example, the Alberta Biochar Initiative was established "to develop and demonstrate technologies that will enable the large scale commercial deployment of biochar products and biochar applications."[57]

Biochar has a few recognized drawbacks. Human health risks include respiratory illnesses that may result from the fine ash associated with biochar, as well, some biochar contains heavy metals, volatile organic compounds, polycyclic aromatic hydrocarbons, and dissolved organic carbon.[58] From a climate perspective, because biochar materials are generally dark in colour, when applied in sufficient quantities to make the method most effective, they will darken the soil surface and ultimately, decrease surface albedo with potential warming consequences.[59]

4. ENHANCED WEATHERING

Enhanced weathering (EW) seeks to remove CO_2 from the atmosphere by spreading crushed silicate material, often sourced from olivine-rich basalt rocks, on top of soil or other surfaces to accelerate naturally occurring chemical reactions that capture carbon.[60] The application of silicate rock aims to accelerate natural mitigation processes by converting CO_2

54 Johannes Lehmann, John Gaunt & Marco Rondon, "Bio-Char Sequestration in Terrestrial Ecosystems – A Review" (2006) 11:2 Mitigation & Adaptation Strategies Global Change 403.

55 Pete Smith, "Soil Carbon Sequestration and Biochar as Negative Emission Technologies" (2016) 22:3 Global Change Biology 1315 [Smith, "Soil Carbon Sequestration"].

56 The Royal Society Report on CDR, *supra* note 32 at 35.

57 "Alberta Biochar Initiative (ABI)" (2018), online: *International Biochar Initiative* <biochar-international.org/regional/abi/>.

58 UK, Department for Environment, Food and Rural Affairs, and Department of Energy and Climate Change, "An Assessment of the Benefits and Issues Associated with the Application of Biochar to Soil" (Commissioned Report), by Simon Shackley et al (Edinburgh: University of Edinburgh School of Geosciences, 2010).

59 Smith, "Soil Carbon Sequestration," *supra* note 55 at 1318.

60 Peter Köhler et al, "Geoengineering Impact of Open Ocean Dissolution of Olivine on Atmospheric CO_2, Surface Ocean pH and Marine Biology" (2013) 8 Environmental Research Letters 1; Peter Köhler, Jens Hartmann & Dieter A Wolf-Gladrow, "Geoengineering Potential of Artificially Enhanced Silicate Weathering of Olivine" (2010) 107:47 Proceedings of the National Academy of Sciences of the United States of America 20228 [Köhler et al, "Geoengineering Potential"]; Lyla L Taylor et al, "Enhanced Weathering Strategies for Stabilizing Climate and Averting Ocean Acidification" (2016) 6 Nature Climate Change 402 [Taylor et al, "Enhanced Weathering Strategies"].

to a stable sequestered form in the soil.[61] The carbon is eventually stored in a solid mineralized form (carbonate minerals) with the potential for stable long-term storage.[62]

The use of EW is predicted to be most efficient in croplands when compared to its use on pastures and forested areas.[63] Pre-existing agricultural infrastructure provides a mechanism for spreading silicate mineral particles with the least disturbance and allows for water to be continuously applied through existing irrigation systems.[64] The land use and resource demands of EW are reduced by its application on existing cropland. However, if deployed at larger scales, EW would require large amounts of reactive silicate rocks, which would demand significant energy to mine, process, transport, and distribute.[65] The efficiency of this technology is also highly dependent on climatic conditions, and the characteristics of the soil and water over which the silicates are distributed.[66] EW has the greatest effect in more temperate regions because the reaction is accelerated by increasing temperatures and humidity, potentially limiting its application in Canada.[67]

Barriers to the deployment include a lack of knowledge about the adverse effects on the environment and human health, including the inhalation of small mineral particles which can cause lung ailments, such as silicosis, and, therefore, must be avoided during mineral processing and its application to land.[68] In addition, some minerals used in EW, such as olivine-rich rocks, contain high concentrations of heavy metals, such as nickel.[69] These may accumulate in soils and water, which is particularly concerning if deployed in crops meant for human consumption.[70] These risks require further assessment before the widespread use of EW is implemented.[71]

61 Robert A Berner, Antonio C Lasaga & Robert M Garrels, "The Carbonate-Silicate Geochemical Cycle and its Effect on Atmospheric Carbon Dioxide over the Past 100 Million Years" (1983) 283:7 American J Science 641.

62 European Academies Science Advisory Council, "Negative Emission Technologies: What Role in Meeting Paris Agreement Targets?" (EASAC Policy Report 35), (Germany: National Academy of Sciences Leopoldina, 2018) 1 at 29.

63 Jessica Strefler et al, "Potential and Costs of Carbon Dioxide Removal by Enhanced Weathering of Rocks" (2018) 13:3 Environmental Research Letters 1 [Strefler et al, "Potential Costs"].

64 *Ibid.*

65 Taylor et al, "Enhanced Weathering Strategies," *supra* note 60; Köhler et al, "Geoengineering Potential," *supra* note 60.

66 Hein FM ten Berge et al, "Olivine Weathering in Soil, and its Effects on Growth and Nutrient Uptake in Ryegrass (*Lolium perenne* L.): A Pot Experiment" (2012) 7:8 PLOS ONE.

67 Strefler et al, "Potential Costs," *supra* note 63 at 7.

68 The Royal Society Report on CDR, *supra* note 32 at 50; Marc B Schenker et al, "Pneumoconiosis from Agricultural Dust Exposure Among Young California Farmworkers" (2009) 117:6 Environmental Health Perspectives 988; Michael R Flynn & Pam Susi, "Engineering Controls for Selected Silica and Dust Exposures in the Construction Industry – A Review" (2003) 18:4 Applied Occupational & Environmental Hygiene 268.

69 Francesc Montserrat et al, "Olivine Dissolution in Seawater: Implications for CO_2 Sequestration Through Enhanced Weathering in Coastal Environments" (2017) 51:7 Environment Science & Technology 3960 at 3966.

70 Phil Renforth et al, "Contaminant Mobility and Carbon Sequestration Downstream of the Ajka (Hungary) Red Mud Spill: The Effects of Gypsum Dosing" (2012) 421–22 Science Total Environment 253 (Renforth et al considered the threshold amounts of olivine that could be used before the maximum allowable accumulation of heavy metals in the soil profile is reached. It was found that 95 tons of olivine per hectare of soil would maximize the Nickle limit, and 200 tons of olivine per hectare of soil would exceed the Chromium (Cr5+) limit).

71 The Royal Society Report on CDR, *supra* note 32 at 51.

5. OCEAN FERTILIZATION

Ocean fertilization seeks to enhance biological processes that mediate the sequestration of atmospheric CO_2 for long-term storage in the deep ocean (referred to as the "biological pump").[72] In this process, the production of carbon is fixed by photosynthetic algae (phytoplankton), which use sunlight and nutrients to convert dissolved inorganic carbon into organic matter. Much of this organic material is consumed by predators or redissolved in the upper ocean layers. However, some of the sequestered carbon sinks as organic matter to the deep ocean, where it is stored for centuries to millennia.[73] The efficiency of this process in promoting long-term carbon storage in the deep ocean is constricted by the nutrients available to support algal growth in surface waters.[74] Ocean fertilization attempts to increase the magnitude of the biological pump by promoting the growth of phytoplankton at the ocean surface through the addition of nutrients.[75] Most of the research has focused on the enrichment of nutrient-deficient surface waters of the open ocean through the direct delivery of nitrate, phosphate, or iron.[76] Researchers have conducted over a dozen in situ scientific iron enrichment studies in the oceans to date.[77] These studies have had variable success, in part, because of problems quantifying the efficiency of carbon drawdown.[78]

Large-scale deployment of ocean fertilization may have significant adverse impacts on the marine environment.[79] Changes in phytoplankton and bacterial communities as a consequence of large-scale nutrient enrichment has the potential to disrupt marine food webs at the surface, including fisheries, and may result in the growth of harmful algal blooms.[80] Additionally, the decomposition of the fertilized bloom may decrease oxygen levels in the ocean subsurface, with the potential to transgress critical thresholds for oxygen levels at the site of nutrient addition or further far afield.[81] Modelling studies also predict that large-scale fertilization over many years could create ocean "dead zones" from oxygen depletion, resulting in the deaths of marine organisms.[82]

While Canada has not authorized any ocean fertilization experiments, an unauthorized experiment was conducted off the coast of British Columbia in 2012, as described in the introduction.

72 Sallie W Chisholm, "Stirring Times in the Southern Ocean" (2000) 407:6805 Nature 685; Victor Smetacek et al, "Deep Carbon Export from a Southern Ocean Iron-Fertilized Diatom Bloom" (2012) 487:7407 Nature 313.

73 Chisholm, *ibid*.

74 Philip W Boyd et al, "Mesoscale Iron Enrichment Experiments 1993-2005: Synthesis and Future Directions" (2007) 315:5812 Science 612.

75 The Royal Society Report on CDR, *supra* note 32 at 44.

76 For a comprehensive discussion of the adverse environmental effects of ocean iron fertilization, see Doug Wallace et al, "Ocean Fertilization: A Scientific Summary for Policy Makers," Intergovernmental Oceanographic Commission, UNESCOOR (2010) 1. See also Secretariat of the Convention on Biological Diversity, "Scientific Synthesis of the Impacts of Ocean Fertilization on Marine Biodiversity," CBD Technical Series No 45 (2009) 11 [CBD Technical Series No 45].

77 Boyd et al, *supra* note 74.

78 The Royal Society Report on CDR, *supra* note 32 at 43.

79 Wallace et al, *supra* note 76; CBD Technical Series No 45, *supra* note 76.

80 Wallace et al, *ibid*.

81 *Ibid* at 9.

82 *Ibid* at 10; CBD Technical Series No 45, *supra* note 76 at 38.

6. OCEAN ALKALINITY ENHANCEMENT

Ocean alkalinity enhancement attempts to mimic natural weathering processes in the oceans that play a major role in reducing atmospheric CO_2 levels. The release of processed alkaline materials, such as calcium carbonate or lime, in ocean surface waters increases the buffering capacity of seawater as pH increases, promoting CO_2 uptake from the atmosphere and storage in the oceans by artificially increasing the concentration of positively charged calcium ions.[83]

Various alkaline minerals could be made to react with dissolved CO_2 to achieve carbon drawdown. One option involves the addition of calcium carbonate, which is present in large quantities in the form of limestone, and is easily dissolved in seawater. However, a major drawback of this approach is that this reaction is relatively slow and thus "likely irrelevant to mitigating more urgent excess CO_2 and surface ocean acidification problems."[84] A faster option would be to process limestone carbonate rocks to produce lime and CO_2. The lime is then dissolved in seawater to increase ocean alkalinity and promote the uptake of atmospheric CO_2 at the ocean surface.[85] However, the disadvantage of this process is that it requires significant amounts of energy, making it more expensive and possibly counterproductive if fossil fuels are used as an energy source for forcing the reaction to produce lime.[86]

The chemical reactions involved in ocean alkalinity enhancement are well understood. However, though the technique has been demonstrated in the laboratory, no large-scale field tests of any of the different approaches have been carried out to date.[87] Moreover, the long-term storage potential of carbon from ocean alkalinity enhancement remains uncertain due to the possibility of mineral precipitation, which would reduce the carbon carrying capacity of the water and reverse the CO_2 uptake.[88]

Scientists have identified a range of potential environmental impacts associated with ocean alkalinity enhancement. The technique relies on naturally occurring minerals and reactions that are considered to be "benign in principle."[89] However, the addition of alkaline substances could cause a local increase of pH in surface waters, with possible positive and negative effects on marine ecosystems. On the other hand, making the oceans more alkaline may reverse ocean acidification, which is another adverse consequence of rising atmospheric CO_2 levels on the marine environment.[90] Another obstacle is that depending on the alkaline minerals applied, massive quantities of limestone rock would be required to sequester even

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83 Phil Renforth & Gideon Henderson, "Assessing Ocean Alkalinity for Carbon Sequestration" (2017) 55:3 Reviews of Geophysics 636.

84 GESAMP, *supra* note 29 at 65; LDD Harvey, "Mitigating the Atmospheric CO_2 Increase and Ocean Acidification by Adding Limestone Powder to Upwelling Regions" (2008) 113:4 J Geophysical Research 1.

85 *Ibid*. See also Gideon Henderson, Ros Rickaby & Heather Bouman, "Decreasing Atmosphere CO_2 by Increasing Ocean Alkalinity: The Ocean Dimension: Would the Concept Work and What Would be the Environmental Consequences?" (2008), online: *University of Oxford, Department of Earth Sciences* and *The James Martin 21st Century Ocean Institute* <www.earth.ox.ac.uk/~gideonh/reports/Cquestrate_report.pdf>; Haroon S Kheshgi, "Sequestering Atmospheric Carbon Dioxide by Increasing Ocean Alkalinity" (1995) 20:9 Energy 915; Renforth & Henderson, *supra* note 83.

86 The Royal Society, "Geoengineering the Climate," *supra* note 18 at 14.

87 The Royal Society Report on CDR, *supra* note 32 at 56.

88 *Ibid* at 57.

89 The Royal Society, "Geoengineering the Climate," *supra* note 18 at 14.

90 GESAMP, *supra* note 29 at 67.

modest amounts of CO_2 using this technique. Intensive mining operations would, therefore, be required to supply the necessary raw materials. Consequently, the greatest environmental impact of this CDR technique would likely be terrestrial environmental impacts from mining operations. Conventional mining techniques are also energy intensive and predominantly rely on fossil fuels for conducting operations, processing materials, and transporting them to the delivery site. The CO_2 produced in these earlier stages of the life cycle of this technology would have to be taken into account when evaluating the net benefit of this marine CDR method.

III. GOVERNANCE OF CDR

A. GOVERNANCE DEMANDS

Before turning to specific instruments and processes that will likely influence the role of CDR as part of the wider portfolio of climate measures, it is useful to first consider in broad terms the principal governance demands that we expect to arise in relation to CDR.[91]

- *Research and development*: The maturity of CDR is technology specific, with some technologies being at experimental stages while others are at the demonstration or small-scale deployment stages. Key governance challenges include funding research and upstream innovation and then satisfying the high capital requirements of large-scale development. The need for capital militates in favour of private sector development, which suggests the need to integrate CDR into carbon market mechanisms. The governance and regulation of research also raise questions about the environmental ethics of in situ experiments and accountability, indicating that scrutiny of research oversight will be an important regulatory objective.[92]

- *Setting targets and distributing responsibilities to remove GHGs*: Determining the appropriate balance between emissions reductions and removals may be required to avoid possible over-reliance on CDR (and constraints on overshoot) in medium and long-term planning and assessments of progress towards the *Paris Agreement* goals. The distribution of burdens associated with CDR at international and national levels will likely give rise to divisive debates respecting equity and responsibility.[93]

- *Impact assessment at project and strategic levels*: Existing assessments of the viability of large-scale CDR indicate significant local, regional, and global impacts on environmental, economic, and social systems. These impacts will need to be assessed at multiple levels. The high potential for trade-offs and co-benefits from CDR technologies, as well as the need to integrate some CDR with other large-scale systems (such as energy systems), will require integrated assessments and long-

[91] MJ Mace et al, "Governing Large-Scale Carbon Dioxide Removal: Are We Ready?" (2018), online: *Carnegie Climate Geoengineering Governance Initiative* <www.c2g2.net/wp-content/uploads/C2G2-2018-CDR-Governance-1.pdf>.

[92] Anna-Maria Hubert, "A Code of Conduct for Responsible Geoengineering Research" (2021) 12:S1 Global Policy 82.

[93] Claire L Fyson et al, "Fair-Share Carbon Dioxide Removal Increases Major Emitter Responsibility" (2020) 10:9 Nature Climate Change 836.

term planning of related natural and human systems, as well as integration into development frameworks, such as the Sustainable Development Goals.[94]

- *Property rights and liability rules*: Ownership rules for subsurface geological formations for storage will be a key consideration for CCS. There may also be legal questions respecting ownership of, and responsibility for, other deposition related CDR methods, like biochar and enhanced weathering.[95] Liability rules will be needed to address accountability for harms arising from CDR activities and for leakage of CO_2 treated as permanent.[96]

- *Accounting*: Removals will need to be quantified using standard methods to track progress and assess ambition. The context-specific nature of many CDR technologies, especially those involving biological processes, poses challenges to creating quantifiable accounting methods and would require international co-operation. The deployment of CDR involving market mechanisms and the trading of credits would create further demand for establishing the fungibility of removal units and the ability to track those units to avoid double counting.

- *Monitoring/verification, including storage permanence*: In addition to accounting for removals, there will be a need for systems of monitoring and verification. The question of the permanence of removals is salient, as both biological and geological sequestration may be affected by subsequent actions or events, such as forest fires or geological disruptions.

- *Public consultation*: Public consultation is critical at all stages of CDR research, development, and deployment. As the social acceptability of large-scale CDR will influence the amount undertaken, consultation becomes a crucial aspect of countries being able to deliver on projected amounts of CDR. In the event that certain CDR technologies prove socially unacceptable, it is important to understand those limitations early, as the inability to deploy CDR would increase dependence on emissions reductions and also pose a greater risk that any overshoot goes unmitigated. Special consideration of the impact of CDR activities on the rights of Indigenous groups will require attention to processes that meet the specific legal obligations owed to Indigenous communities.

B. INTERNATIONAL LAW AND GOVERNANCE

Canadian law and policy will need to be responsive to the patchwork of international rules and processes relevant to CDR. The most important of these is likely to be the United Nations climate regime and, specifically, the *Paris Agreement*.[97] While CDR is not explicitly addressed as a distinct climate response under the *Paris Agreement*, it can be interpreted as

[94] Matthias Honegger, Axel Michaelowa & Joyashree Roy, "Potential Implications of Carbon Dioxide Removal for the Sustainable Development Goals" (2021) 21:5 Climate Policy 678.

[95] Nigel Bankes, "Pore Space Ownership in Western Canada," in Ian Havercroft, Richard Macrory & Richard Stewart, eds, *Carbon Capture and Storage: Emerging Legal and Regulatory Issues*, 2nd ed (Oxford: Hart, 2018) 203.

[96] Ian Havercroft, "Long-Term Liability and CCS" in Havercroft, Macrory & Stewart, *ibid*, 307.

[97] Neil Craik & William CG Burns, "Climate Engineering Under the Paris Agreement" (2019) 49:12 Environmental L Reporter News & Analysis 11113. See also Honegger, Burns & Morrow, *supra* note 16.

falling within the scope of the mitigation provisions, in particular, articles 4 and 5, which speak to "removals by sinks."[98] The term "sinks" is defined in the *UNFCCC* in very broad terms to include "any process, activity or mechanism which removes a greenhouse gas … from the atmosphere."[99] A central goal of the *Paris Agreement* is to achieve a balance between emissions and removals (emissions neutrality) by the second part of the century. However, the *Paris Agreement* does not specify how that balance is to be achieved, and without further guidance, states could potentially offset emissions with large amounts of CDR to satisfy their climate obligations.

Given the bottom-up structure of the *Paris Agreement*, nothing currently precludes states from relying on CDR measures as a part of their nationally determined contributions (NDCs) in order to meet their Paris obligations beyond afforestation and reforestation efforts, though to date, there is little evidence of states doing so.[100] The *Paris Agreement* also calls for states to develop "long-term low greenhouse gas emission development strategies," which are more amenable to identifying long-term intentions in relation to mitigation strategies.[101] A number of states, including Canada, have lodged strategies that include reference to the need to develop CDR approaches.[102]

The *Paris Agreement*, together with the overarching *UNFCCC* framework, provides little direction on the governance of CDR, and the substantive rules and process of NDCs currently leave key decisions respecting the amount of CDR undertaken and the balance between reductions and removals in the hands of individual states. However, a number of processes and mechanisms are likely to become important as CDR is ramped up. In particular, the *UNFCCC* has developed accounting methodologies for forest and land-use related removals, as well as for CCS.[103] If other forms of CDR are relied upon by states in their NDCs, they will need to develop standardized accounting methodologies through the *UNFCCC* to ensure consistency of reporting by states. The Paris Agreement acknowledges a continued role for market mechanisms, which are likely necessary to secure investment in CDR to promote innovation and large-scale development.[104] The transparency mechanism is also relevant to the monitoring, reporting, and verification of GHG removals claimed. Assessments of collective progress will likely be undertaken through the global stocktaking mechanism,[105] which provides an opportunity for states to consider the overall balance between reductions and removals, and to potentially track the technological readiness of CDR technologies in relation to their expected demand.

To date, the only binding international instrument that directly regulates CDR is found in amendments[106] to the *1996 Protocol to the Convention on the Prevention of Marine Pollution*

98 *Paris Agreement, supra* note 2, arts 4–5.

99 *United Nations Framework Convention on Climate Change*, 9 May 1992, 1771 UNTS 107 (entered into force 21 March 1994), art 1 [*UNFCCC*].

100 National Academies Research Agenda, *supra* note 6 at 249.

101 *Paris Agreement*, *supra* note 2, art 4(19).

102 Environment and Climate Change Canada, 2016, *supra* note 7.

103 Mace et al, *supra* note 91 at 17.

104 *Paris Agreement*, *supra* note 2, art 6.

105 *Ibid*, art 14.

106 The Eighth Meeting of Contracting Parties to the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, "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" (2013) at annex 4, annex 5, online: *International Maritime Organization* <wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/LCLP Documents/LP.4(8).pdf> [Resolution LP.4(8)].

by Dumping of Wastes and Other Matter, 1972.[107] Adopted in 2013, though not yet in force, the amendments regulate the placement of matter in the oceans for "marine geoengineering" activities. Ocean fertilization is the only marine geoengineering measure currently listed, but this list could be expanded in the future to include other techniques, such as ocean alkalinity.[108] The listing for ocean fertilization contains an exception to a general prohibition to allow for "legitimate scientific research," which in turn requires states to assess the activity in accordance with an assessment framework adopted by the parties to the *London Protocol.*[109] The effect is to prohibit ocean fertilization deployment and to require states to authorize experimental activity related to ocean fertilization, regardless of the potential environmental impact. The adoption of the amendment was, in part, a response to the unauthorized ocean fertilization that originated in Canada.[110] If the *London Protocol* amendment does enter into force, it will require changes to the ocean dumping provisions of the *Canadian Environmental Protection Act.*[111] The parties to the *London Protocol* have also adopted rules addressing carbon capture and storage in sub-sea geological formations, which may impact any DACCS or BECCS projects that utilize offshore geological storage.[112]

The parties to the *Convention on Biological Diversity* have adopted several non-binding decisions addressing ocean fertilization and geoengineering more generally.[113] The most salient provision invites the parties to ensure that "no climate-related geo-engineering activities that may affect biodiversity take place" until there is an adequate scientific basis to justify such activities and to assess their risks.[114] An exception is made for "small scale scientific research studies that would be conducted in a controlled setting."[115] Despite its hortatory character, the decision is significant in that it shows the depth of unease that the international community has in relation to geoengineering, including CDR. A more recent

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107 *1996 Protocol to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter*, (1997) 36 ILM 1 [*London Protocol*].

108 Discussed in Romany M Webb, Korey Silverman-Roati & Michael B Gerrard, "Removing Carbon Dioxide Through Ocean Alkalinity Enhancement and Seaweed Cultivation: Legal Challenges and Opportunities" (2021) Sabin Center for Climate Change Law, Columbia Law School Working Draft, online: <climate.law.columbia.edu/sites/default/files/content/Webb%20et%20al%20-%20Removing%20CO2%20Through%20Ocean%20Alkalinity%20Enhancement%20and%20Seaweed%20Cultivation%20-%20Feb.%202021.pdf>.

109 Resolution LP.4(8), *supra* note 106, at annex 4, art 1.3. See further, The Thirty-Second Consultative Meeting of the Contracting Parties to the London Convention and the Fifth Meeting of the Contracting Parties to the London Protocol, "Resolution LC-LP.2 (2010) on the Assessment Framework for Scientific Research Involving Ocean Fertilization" (2010), online (pdf): *International Maritime Organization* <www.imo.org/en/OurWork/Environment/Pages/AssessmentFramework-default.aspx> [Resolution LC-LP.2].

110 The 34th Consultative Meeting of the Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, LP-LC 34/15, "Statement of Concern Regarding the Iron Fertilization in Ocean Waters West of Canada" (2012) at annex 7.

111 *Canadian Environmental Protection Act*, SC 1999, c 33 [*CEPA*].

112 The First Meeting of Contracting Parties to the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, "Resolution LP.1(1) On the Amendment to Include CO_2 Sequestration in Sub-Seabed Geological Formations in Annex 1 to the London Protocol" (2006), online: *International Maritime Organization* <wwwcdn.imo.org/local resources/en/KnowledgeCentre/IndexofIMOResolutions/LCLPDocuments/LP.1(1).pdf>.

113 Convention on Biological Diversity, *Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at its Tenth Meeting, Decision X/33* , UNEP (2010) at para 8(w) [*COP Decision X/33*]; Convention on Biological Diversity, *Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at its Eleventh Meeting, Decision XI/20*, UNEPOR (2012) at para 16; Convention on Biological Diversity, *Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at its Thirteenth Meeting, Decision XIII/14*, UNEPOR (2016) [*COP Decision XIII/14*].

114 *COP Decision X/33*, *ibid* at para 8(w) [footnotes omitted] (note that the scope of the decision may not be as wide as it appears since to fall within the recommended moratorium, activities would need to be of a scale to affect biodiversity).

115 *Ibid.*

2016 Conference of the Parties decision suggests a shift in views, noting that "more transdisciplinary research and sharing of knowledge among appropriate institutions is needed in order to better understand the impacts of climate-related geoengineering on biodiversity and ecosystem functions and services, socio-economic, cultural and ethical issues and regulatory options."[116]

Finally, in 2019, a group of states attempted to have the United Nations Environment Assembly pass a resolution on "geoengineering and its governance." The resolution, which consisted of both CDR and SRM in tandem, sought the preparation of a further assessment of geoengineering technologies, as well as potential governance frameworks. Despite its modest objectives, the resolution failed to attract sufficient support and was ultimately pulled.[117] Canada was neither an active supporter of the resolution, nor one of its key opponents.

IV. CDR IN CANADA

A. CURRENT ROLE OF CDR IN CANADA'S CLIMATE STRATEGY

As noted above, Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy identifies the need for CDR in the latter part of the century, identifying large-scale afforestation and BECCS as possible approaches to achieve negative emissions.[118] The strategy references several decarbonization pathways studies that model scenarios that would enable Canada to meet its mid-century (2050) goal of reducing its net emissions by 80 percent from 2005 levels.[119] Both studies identify the need for CDR if Canada expects to achieve its 2050 emissions target. Even using optimistic assumptions respecting carbon pricing and technology development, CDR would be required. Both reports identified research on CDR as a key challenge that needs to be addressed in the short-term.[120] The Trottier Report specifically identifies BECCS and afforestation, as well as the increased use of wood products for carbon retention in buildings, as key areas for further research.[121] Since the amount of CDR required is dependent on the degree of emissions reductions, to the extent that Canada fails to meet its short and medium-term emissions reduction targets, there will be greater urgency to research, develop, and implement CDR measures.

The central policy framework for addressing climate change in Canada is the 2016 *Pan-Canadian Framework on Clean Growth and Climate Change*.[122] The *Pan-Canadian Framework* does not address CDR directly but does provide some important foundations. In particular, the framework's centrepiece, a national minimum carbon price, creates the basis

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116 *COP Decision XIII/14*, *supra* note 113 at para 5.

117 Franz Xaver Perrez, "The Role of the United Nations Environment Assembly in Emerging Issues of International Environmental Law" (2020) 12:14 Sustainability 1.

118 Environment and Climate Change Canada, 2016, *supra* note 7.

119 Trottier Energy Futures Project, "Canada's Challenge & Opportunity: Transformations for Major Reductions in GHG Emissions" (2016), online: *The Canadian Academy of Engineering* <cae-acg.ca/wp-content/uploads/2013/04/3_TEFP_Final-Report_160425.pdf> [Trottier Report]; Chris Bataille, Dave Sawyer & Noel Melton, *Pathways to Deep Decarbonization in Canada* (2015) CMC Research Institutes Working Paper.

120 Trottier Report, *ibid* at 14; Bataille, Sawyer & Melton, *ibid* at 40.

121 Trottier Report, *ibid*.

122 Government of Canada, *Pan-Canadian Framework on Clean Growth and Climate Change: Canada's Plan to Address Climate Change and Grow the Economy*, Catalogue No En4-294/2016E-PDF (Canada, 2016), online: <publications.gc.ca/collections/collection_2017/eccc/En4-294-2016-eng.pdf> [*Pan-Canadian Framework*].

for market-based approaches to net emissions reduction. The carbon pricing element was implemented by the Canadian federal government through the *Greenhouse Gas Pollution Pricing Act*.[123] The *Pan-Canadian Framework* identifies the potential for soils and forests to remove and store carbon but does not provide any specific policies.[124]

B. CONSTITUTIONAL ISSUES

1. DIVISION OF POWERS

The jurisdictional issues surrounding the regulatory authority over CDR will depend on the specific technology in question and the context of its development. As with most other matters involving the environment, energy, and natural resources, legislative responsibility is shared between the federal and provincial governments.[125]

The provinces are likely to have broad plenary authority over terrestrial-based CDR measures that occur entirely within a single province based on their legislative jurisdiction over natural resources, property and civil rights, public lands, and local undertakings.[126] Authority also arises from the provinces' ownership over CDR-related natural resources, such as forests and subsurface geological formations. For example, CDR methods such as DACCS and BECCS would be provincial responsibilities, as the air capture and bioenergy functions are likely to be local undertakings, while the storage will occur in geological formations under provincial authority. Biochar and terrestrial weathering that involve placing substances on or in private lands would also be subject to provincial authority.

Except for marine-based CDR activities, federal authority over CDR is more constrained. Ocean fertilization and ocean alkalinity methods, both of which involve the deposition of materials into the ocean, would most clearly fall under the federal government's authority over ocean dumping.[127] Here, the source of the federal government's authority is its residual jurisdiction under the national concern branch of the Peace, Order, and Good Governance (POGG) power, as was affirmed by the Supreme Court of Canada in *Crown Zellerbach*.[128] Offshore carbon storage is more complicated, but the seabed and subsoil beneath the seabed (unless within inland waters, which are part of the relevant province) are owned by the federal government.[129] Storage of material in the subsoil of the seabed would be included as a form of ocean disposal under *CEPA*. However, at present, there are no specific rules governing offshore CCS. The federal government would also have authority over terrestrial CDR activities that occur on federal lands.

The federal government would also be able to exercise jurisdiction over interprovincial or international undertakings. For example, it is conceivable that DACCS and BECCS facilities could involve a cross-boundary element, such as transporting captured CO_2 from a plant in one province for underground storage in another province. An example of this is

123 *Greenhouse Gas Pollution Pricing Act*, SC 2018, c12, s 186.
124 *Pan-Canadian Framework*, *supra* note 122 at 22–23.
125 See generally Dwight Newman, *Natural Resource Jurisdiction in Canada* (Halifax: LexisNexis Canada, 2013).
126 *Constitution Act, 1867* (UK), 30 & 31 Vict, c 3, ss 92(5), (10), (13), 92A, reprinted in RSC 1985, Appendix II, No 5.
127 *R v Crown Zellerbach Canada Ltd*, [1988] 1 SCR 401 [*Crown Zellerbach*].
128 *Ibid*.
129 *Oceans Act*, SC 1996, c 31, s 8(1).

the Weyburn-Midale CO_2 Monitoring and Storage project, which involved transporting CO_2 from North Dakota via a pipeline for storage in Saskatchewan, which was subject to the approval authority of the National Energy Board, now the Canada Energy Regulator.[130]

Indirectly, the federal government would also be able to exercise some regulatory control over elements of CDR projects that may have implications for other federal heads of power. The most salient here would be the triggering of federal environmental assessment requirements in the event that a planned CDR activity was a designated project that could impact a federally regulated component of the environment.[131] The federal government will also be able to shape CDR policy through its spending and taxation powers, which will support the incentive structure for CDR research and deployment through grants and tax credits.[132]

A more difficult question is the extent to which the federal government could exercise regulatory authority over CO_2 as a controlled substance or as part of a national scheme to address climate change, particularly through the GHG pricing mechanism. In relation to the former, CO_2 and other GHGs are identified as toxic substances under *CEPA*, and therefore, according to *CEPA*, are managed by the federal government.[133] The toxic substances provisions of *CEPA* were upheld by the Supreme Court of Canada as a valid exercise of the federal government's criminal law power in *R. v. Hydro-Québec*.[134] The federal government currently regulates the release of CO_2 in relation to certain fossil fuel-powered electrical generating facilities.[135] While the constitutionality of these regulations has not been challenged, regulations respecting renewable fuels enacted under *CEPA* were upheld as a valid exercise of the criminal power.[136]

The federal government's authority to legislate in relation to climate change has been the subject of recent challenges to the government's *Greenhouse Gas Pollution Pricing Act*[137] culminating in a 2021 decision from the Supreme Court of Canada, which upheld the fuel charge and output-based pricing system under the national concern branch of POGG.[138] The *GGPPA Reference* does not directly address CDR but may provide the federal government with authority to establish standards for CDR approaches where removals are used as offsets within a broader GHG pricing scheme. The *GGPPA* anticipated the need to establish common standards for offsets, although the offset regulation was not in place until after the reference was heard. It seems likely that one avenue for incentivizing CDR development will

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130 Petroleum Technology Research Centre, "Weyburn-Midale Project: The IEAG HG Weyburn-Midale CO_2 Monitoring and Storage Project," online: <ptrc.ca/projects/past-projects/weyburn-midale>.

131 *Impact Assessment Act*, SC 2019, c 28, s 7 [*IAA*]. The new *IAA* is subject to further constitutional challenge by the Province of Alberta. The constitutionality of federal impact assessment was upheld in *Friends of the Oldman River Society v Canada (Minister of Transport)*, [1992] 1 SCR 3.

132 Likely sources for funds include the *Net Zero Accelerator Fund* and the *CCUS tax incentives* announced in Canada's 2021 budget: "Creating Jobs and Growth: A Healthy Environment for a Healthy Economy (2021), online: <www.budget.gc.ca/2021/report-rapport/p2-en.html #chap5>.

133 *CEPA*, *supra* note 111 at part 5, s 64.

134 [1997] 3 SCR 213.

135 *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations*, SOR/2012-167; *Regulations Limiting Carbon Dioxide Emissions from Natural Gas-fired Generation of Electricity*, SOR/2018-261.

136 *Syncrude Canada Ltd v The Attorney General of Canada*, 2016 FCA 160.

137 *Greenhouse Gas Pollution Pricing Act*, SC 2018, c 12, s 186 [*GGPPA*].

138 *References re Greenhouse Gas Pollution Pricing Act,* 2021 SCC 11, on appeal from Saskatchewan, 2019 SKCA 40; Ontario, 2019 ONCA 544; Alberta, 2020 ABCA 74 [*GGPPA Reference*].

be to incorporate forms of CDR into the offset regulation—indeed, forestry management, a form of CDR, is identified in the federal offsets regulation.[139]

The scheme is addressed in greater detail below, but from a constitutional basis, this may become an area of tension between levels of government. First, the federal government will be able to exert considerable influence over CDR development by determining inclusion with the federal offset scheme or by allowing provincial offsets to be used with the federal scheme as a way to comply with emission requirements (with removals offsetting excess emissions), and through the setting of accounting protocols. There may also be concerns respecting the impact of provincial CDR policies impacting the overall stringency of the provincial regime, which could affect the eligibility of the province from the application of the *GGPPA* through the backstop mechanism.

The picture that emerges in relation to the governance of CDR is one that encourages co-operative federalism — an approach in keeping with the Supreme Court of Canada's approach to climate regulation more generally.[140] The federal government can still exercise a significant governance role through its spending and taxation powers, particularly in relation to supporting CDR research and development. In addition, the federal government would play a critical role in creating the conditions for innovation and scaling-up of CDR through the creation of national accounting and reporting standards for CDR and incorporating CDR into carbon pricing schemes, either directly or indirectly, through equivalent provincial schemes. At the same time, provinces would still be empowered to address those aspects of CDR that fall within their enumerated powers.

2. SECTION 35: DUTY TO CONSULT

One further constitutional consideration that may bear significantly on the development of CDR is the duty flowing from section 35 of the *Constitution Act, 1982* to consult and accommodate Aboriginal groups in relation to potential impacts on their Aboriginal and treaty rights.[141] There is ample scope for various applications of CDR to interfere with Aboriginal and treaty rights in both terrestrial and marine contexts, given the large-scale and perturbative nature of some CDR methods. Aboriginal consultation requirements have become a significant factor in relation to the approvals for other large-scale resource projects and would likely be a significant factor with respect to CDR as well.

It ought to be recognized that the potential scale of CDR activities could have profound cumulative impacts on Indigenous communities, requiring attention to the cumulative impacts of multiple projects and approaches.[142] This, in turn, may require consultation on upstream policy decisions that set the framework for CDR development. Section 35 rights are not limited to government decisions that have direct physical impacts on Indigenous

139 *Greenhouse Gas Offset Credit System Regulations (Canada)* (2021) C Gaz I, Vol 155, No 10, s 7(1)(a)(i) [*Credit System*].

140 *GGPPA Reference*, *supra* note 138 at para 50.

141 *Constitution Act, 1982*, s 35, being Schedule B to the *Canada Act 1982* (UK), 1982, c 11. The duty to consult was developed through a trilogy of Supreme Court of Canada cases: *Haida Nation v British Columbia (Minister of Forests)*, 2004 SCC 73; *Taku River Tlingit First Nation v British Columbia (Project Assessment Director)*, 2004 SCC 74; *Mikisew Cree First Nation v Canada (Minister of Canadian Heritage)*, 2005 SCC 69.

142 See e.g. *Taseko Mines Limited v Phillips*, 2011 BCSC 1675 at para 65; *Lameman v Alberta*, 2012 ABCA 59; *Lameman v Alberta*, 2011 ABQB 40.

communities and include obligations to consult on a broader range of policy instruments.[143] However, the framework for consultation outside the *IAA*[144] (which tends to focus on project level assessment) is less structured.[145] Of particular importance here are decision-making processes that seek to identify the amount of removals that can be delivered through CDR methods, which will affect the potential scale and intensity of activities and consequential impacts on land use.

A further related development is the embrace by both federal and provincial governments of the *United Nations Declaration on the Rights of Indigenous Peoples*,[146] which contains obligations requiring governments to receive Indigenous peoples' "free, prior and informed consent" in connection with decisions affecting their rights, interests, particularly in relation to projects involving their traditional territories.[147] The significance of the embrace of the *UNDRIP* by Canadian governments for processes of consultation and consent is still emerging, but the principle of consent strongly suggests the need for a highly collaborative approach to CDR developments affecting Indigenous rights and interests in Canada.

C. LAWS OF GENERAL APPLICATION

Given the divided jurisdiction over CDR and the diverse nature of the technologies themselves, there is no general law presently directed towards removals as a distinct regulatory object. The common aim shared by all CDR technologies to remove GHGs from the atmosphere is not likely sufficient to justify a comprehensive approach to the regulation of CDR technologies. Instead, regulation is likely to be technology-specific and involve the application of existing laws of general application to aspects of CDR.

1. REPORTING AND ACCOUNTING

Removals will be incorporated into national GHG accounting structures, the standards for which are driven by international processes and institutions. The *UNFCCC* already accounts for removals through sinks and reservoirs, and these standards are adopted and implemented by national governments to manage their reporting requirements under the international climate regime.[148] Standardization of accounting and reporting methods will be fundamental to commercialization and the integration of CDR technologies into carbon markets. Currently, in Canada, further, more precise standards find several sources, such as existing market structures and standards organizations.[149]

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143 The extension of the duty to consult to upstream policy decisions that "set the stage for further decisions that will have a *direct* adverse impact on land and resources": *Rio Tinto Alcan Inc v Carrier Sekani Tribal Council*, 2010 SCC 43 at para 47 [emphasis in original].

144 *IAA*, *supra* note 131.

145 See Part IV.B.3, below, for more on this topic.

146 *United Nations Declaration on the Rights of Indigenous Peoples*, GA Res 61/295, UNGAOR, 61st Sess, Supp No 53, UN Doc A/61/53 (2007) [*UNDRIP*].

147 *United Nations Declaration on the Rights of Indigenous Peoples Act*, SC 2021, c14; *UNDRIP*, *ibid*, arts 19, 32. See also *Declaration on the Rights of Indigenous Peoples Act*, SBC 2019, c 44.

148 These protocols have been developed in connection with the "[l]and use, land use change and forestry" (LULUCF) activities under the *Kyoto Protocol* and through the REDD+ programme. For an overview, see "Reporting and Accounting of LULUCF Activities under the Kyoto Protocol" (2022), online: *United Nations Climate Change* <unfccc.int/topics/land-use/workstreams/land-use-land-use-change-and-forestry-lulucf/reporting-and-accounting-of-lulucf-activities-under-the-kyoto-protocol>.

149 See for example methodologies developed by the American Carbon Registry on land use and carbon capture and storage: "Standards & Methodologies," online: <americancarbonregistry.org/carbon-accounting/standards-methodologies>.

The *Canadian Net-Zero Emissions Accountability Act* sets out a process for setting national targets from 2030 through to 2050, with the goal of achieving net-zero emissions by 2050.[150] The *Act* is process-oriented in that it obligates the Minister of Environment and Climate Change to set targets in a transparent and consultative manner, and to provide regular progress reports to Parliament on the ongoing implementation and effectiveness of its reduction plans. The intention is to align domestic policy with Canada's international commitments under the *Paris Agreement*, including requirements for progressively ambitious targets. The definition of "net-zero emissions" explicitly includes "anthropogenic removals of greenhouse gases from the atmosphere."[151] Thus, at a national policy level, the federal government anticipates a central role for removals in meeting its international and national climate goals. The key commitment is the preparation of a "greenhouse gas emissions reduction plan."[152] The focus here is on "reductions," suggesting that the required plan will focus on reducing emissions at source, not removals. However, the reduction plan has the scope to account for removals since any reduction target will be required to take into account GHG inventories and the key measures and strategies that will contribute to achieving net-zero emissions. The inclusion of removals as part of a broader strategy is reinforced by the inclusion of authority for the Governor in Council to specify methodologies regarding reporting greenhouse gas removals.[153] Thus, the regulations under the *Canadian Net-Zero Emissions Accountability Act* are likely to be a key source of developing accounting and reporting methodologies for removals.

The *Canadian Net-Zero Emissions Accountability Act* misses an opportunity to include provisions that would require the government to explicitly address removals as a distinct element, which may serve to increase the transparency of government reliance of removals and to provide opportunities for the assessment of the feasibility and desirability of removal strategies. A key governance requirement will be determining the appropriate balance between emissions reductions and removals, which is a policy choice that ought to be subject to public scrutiny and debate. A potential concern is the over-reliance on future removals, which results in less ambitious reduction commitments. Maximum transparency on each component of achieving net-zero emissions is consistent with the broader goals of the *Act*. The *Act* does provide for a Net-Zero Advisory Body that would include providing advice on reductions and removals and includes a mandate for public engagement, which could provide one avenue for public consultation on CDR policy.[154]

In addition to federal processes, the provinces may also have legislation of general application addressing emissions reductions and removals. For example, Alberta enacted the *Emissions Management and Climate Resilience Act*,[155] which provides for specific targets and reporting requirements for emitters within the province. The scope of the *EMCRA* includes removals through "sinks." However, the definition restricts sinks to "natural processes" and would appear to exclude certain forms of technology-driven CDR, such as

150 *Canadian Net-Zero Emissions Accountability Act*, SC 2021, c 22.
151 *Ibid*, s 2.
152 *Ibid*, s 9.
153 *Ibid*, s 26.
154 *Ibid*, s 20.
155 *Emissions Management and Climate Resilience Act*, SA 2003, c E-7.8 (formerly entitled the *Climate Change and Emissions Management Act*, Alta Reg 140/2007) [*EMCRA*].

DACCS.[156] The *EMCRA* provides for emission offset procedures that could be tailored for accounting and reporting of CDR activities.

2. CARBON PRICING

The *GGPPA* provides for the federal imposition of a carbon price through two principal mechanisms: a fuel charge that incorporates a price of carbon based on the carbon content of the fuel in question, and a charge on emissions from large emitters.[157] As discussed above, the federal system operates as a backstop and works where the carbon pricing systems within provinces and territories do not meet the federal bench stringency requirements. CDRs intersect with the federal and provincial plans through the potential to use removals as offsets for compliance purposes. Under the *GGPPA*, an emitter subject to emission restrictions may meet its requirements by reducing emissions to the required level or by purchasing surplus credits from emitters who exceed their reduction obligations or through other compliance units, which include offset credits issued under the regulation. Integration of CDR into carbon pricing schemes is likely to be a critical component in efforts to commercialize and scale up CDR activities through access to private capital.[158]

The federal government will be able to exercise control over CDR activities subject to the *GGPPA* by defining which activities are eligible to be considered federal offsets. The federal government has released offset regulations under the *GGPPA*, which further define the eligibility of offsets for registration under the *GGPPA*, including the requirement that the offset is subject to an existing federal offset protocol.[159] The regulation as drafted would likely address a number of key governance issues with respect to CDR, including verification and monitoring processes, issues respecting permanence through the creation of an environmental integrity account and the potential to reverse offset credits, and clarifying who will be responsible for cancelled credits. The development of protocols for many of the CDR methods will be complex, given the difficulties in calculating the amount of carbon successfully removed and the duration of the removal, particularly for biological sequestration methods. The protocols should account for the potential for leakage, which could include issues of non-permanence, the potential for CDR methods, such as forestry-related activities (in BECCS approaches), to create other GHGs,[160] and the potential impact on carbon uptake in adjacent systems. Protocol development will require dedicated research efforts and multi-jurisdictional co-operation.

Provinces will also have the ability to create their own offset programs, which would operate under provincial carbon pricing schemes. For example, Alberta operates an emissions offset system in conjunction with its *Technology Innovation and Emissions Reduction*

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156 *Ibid*, s 1 ("'sink' means (i) a component of the environment that removes or captures specified gases from the atmosphere through natural processes and includes, without limitation, plants and soil, and (ii) a geological formation or any constructed facility, place or thing that is used to store specified gases").

157 *GGPPA*, *supra* note 137, s 186.

158 Wilfried Rickels et al, "Integrating Carbon Dioxide Removal Into European Emissions Trading" (2021) 3 Frontiers in Climate 1.

159 *Credit System*, *supra* note 139.

160 Gabriel Popkin, "How Much Can Forests Fight Climate Change?" (2019) 565:7739 Nature 280 (also discusses the potential effects of the release of volatile organic compounds that are precursors to other GHGs).

Regulation,[161] which includes a protocol for CCS.[162] Because provinces have broad authority to develop their own offset systems and associated protocols, there is some potential for a patchwork of market-related CDR regulations across the country. The federal government will be able to influence this process through its equivalency determination under the *GGPPA*. Where, for example, a CDR protocol lacks environmental integrity, which affects the overall stringency of the provincial system, the federal government could impose federal requirements under the backstop on the basis that the provincial system no longer meets federal stringency requirements.[163] Given the decentralized structure of carbon markets in Canada, the integration of CDR into provincial offset schemes is a potential source of political tension and will require a degree of co-operation among levels of government and between the provinces to ensure stringency and fairness.

One aspect of carbon pricing of unique concern to CDR methods is that the carbon pricing systems in Canada anticipate an undifferentiated market in the sense that various credits are treated as fungible. Economically, the attractiveness of offsets is that they are available at a lower price than the marginal cost of abatement. Where CDR methods are less expensive than abatement or other forms of offsets not involving removals, then firms should prefer CDR. However, where CDR methods are more expensive, there will be no incentive for developers to invest in CDR technologies. Given the high cost associated with a number of CDR technologies that may be required to meet future net-zero targets, early incentives may require market interventions, such as subsidies or government commitments to purchase removals.[164]

In the same vein, it is also important to recognize that Canada must prepare for a net negative future, meaning that removals would need to be incentivized outside the context of offsetting emissions, again requiring a commitment to collective (likely government) procurement. While this may seem like a distinct issue, investment decisions for engineered solutions like DACCS or BECCS will likely require a degree of certainty beyond 2050.

3. IMPACT ASSESSMENT

Where planned activities present a risk to the natural environment, they may be subject to environmental impact assessment (EIA) requirements. EIA requirements are found in both federal and provincial law. As noted, the constitutional authority for the application of EIA laws to specific projects or activities is driven by the nature of the project and the types of impacts that may arise from the project. Consequently, a single project can be, and often is, subject to EIA requirements from both levels of government. Federal and provincial governments have negotiated co-operation agreements streamlining the EIA requirements for projects subject to multi-jurisdictional assessments.

161 Alta Reg 133/2019.

162 Alberta Environment and Parks, *Alberta Emission Offset System* (2022), online: <www.alberta.ca/alberta-emission-offset-system.aspx>; *Quantification Protocol for CO_2 Capture and Permanent Storage in Deep Saline Aquifers*, No 1 (Alberta: Carbon Offset Program, 2015) 65, online: <open.alberta.ca/publications/9780778572213>.

163 *GGPPA*, *supra* note 137, s 166(3).

164 Rickels et al, *supra* note 158. See also Chris Bataille & Caroline Lee, "Going Negative: Why Canada and the World Need Carbon Dioxide Removal, and How to Make it Happen" (6 July 2021), online (blog): *The Canadian Climate Institute* <climatechoices.ca/going-negative/>.

There is an increasing trend towards identifying project types or classes that are subject to assessment, as opposed to simply using a trigger based on the potential for harm. For example, the federal *IAA* designates projects in a regulation.[165] Under the *IAA,* there would still be residual discretion with the government to determine whether an assessment is required for designated projects.[166] In addition, there is further authority for the Minister of the Environment to require the assessment of an undesignated project.[167] The Alberta Environmental Assessment process follows a similar structure, which includes lists of mandatory and exempt projects.[168]

Given their early stages of development, specific CDR technologies have not been identified as designated projects. However, some elements of future CDR projects, such as pipelines and large industrial facilities, are subject to EIA laws.[169] Underground storage facilities may be subject to EIA laws depending on whether they meet the definition of a waste management facility, but are not unequivocally subject to EIA laws. One potential concern that arises is that CDR technologies, such as BECCS and DACCS, are comprised of distinct components, only some of which may be subject to EIA requirements. For example, the Quest Carbon Capture and Storage Project was subject to an EIA for the storage component of the project only.[170] There is often considerable agency discretion in determining the scope of the project and what is subject to an EIA, notwithstanding the functional connections between project elements.[171] There is a technology-specific assessment process for ocean fertilization (discussed below) that flows from the requirements of the *London Protocol*.[172] Other CDR methods such as biochar applications may require amendments to designated project lists if they are to be subject to EIA requirements.

Several other aspects unique to CDR indicate that special rules for assessment may be required. First of all, the novel and experimental nature of CDR raises a set of concerns that may not be adequately captured by EIA processes. This issue has several dimensions.[173] There may be experimental applications of CDR, such as small-scale field experiments for biochar or ocean-based removals that may not meet the typical EIA thresholds for triggering an EIA, but given their novel nature and potential for unforeseen impacts, may be usefully subject to assessment processes.[174] A lower threshold or even mandatory assessments of field experiments may be required to demonstrate to the public that any risks posed by CDR approaches are being thoroughly considered. For example, there is no harm-based trigger for ocean fertilization experiments under the *London Protocol's* Oceans Assessment, instead any activity that is classed as ocean fertilization, defined as "any activity undertaken by humans

165 *IAA*, *supra* note 131, s 2 (definition of designated project).
166 *Ibid*, s 16.
167 *Ibid*, s 9.
168 *Environmental Assessment (Mandatory and Exempted Activities) Regulation*, Alta Reg 111/1993.
169 *IAA*, *supra* note 131; *Physical Activities Regulations*, SOR/2019-285. There is often an element of scale involved in determining the applicability of EIA laws, such as only assessing pipelines of a certain minimum length or industrial facilities that meet minimum outputs.
170 Letter from Dallas Johnson to Kathy Penney (29 July 2010), Government of Alberta, Environmental Management Requiring EIA of Quest CCS Project, online: <open.alberta.ca/dataset/8c413a33-d90f-4b41-a68d-c9f73f0240aa/resource/1a4636d3-9326-4392-9fc7-877c39ae0b77/download/shell-quest-carbon-capt-and-storage-proj-eia-req-letter.pdf>.
171 See e.g. *MiningWatch Canada v Canada (Fisheries and Oceans)*, 2010 SCC 2.
172 Resolution LP.4(8), *supra* note 106.
173 See generally Anna-Maria Hubert & David Reichwein, "An Exploration of a Code of Conduct for Responsible Scientific Research Involving Geoengineering: Introduction, Draft Articles and Commentaries" (2015) Institute for Advanced Sustainability Studies Working Paper.
174 Neil Craik, "International EIA Law and Geoengineering: Do Emerging Technologies Require Special Rules?" (2015) 5:2 Climate L 111.

with the principal intention of stimulating primary productivity in the oceans,"[175] is subject to assessment regardless of predicted levels of risk.[176] Given the discretion granted to the Impact Assessment Agency in determining whether an assessment is conducted, guidance on addressing experimental CDR projects may be warranted.

Second, some of the concerns with CDR technologies differ due to their novel nature, which involves the potential ethical and social implications of moving towards large-scale CDR. Among the commonly noted concerns, there is a possibility that the development of CDR technologies may significantly deter or delay cuts in emissions and result in the reallocation of public and private funds towards removals, as opposed to reductions, a problem commonly referred to as "mitigation deterrence."[177] There are other potential interactions between CDR and other climate responses, such as the impact that large-scale biomass (forestry and BECCS) has on albedo and the potential for CDR-driven renewable energy requirements (for DACCS and biochar) to constrain other energy choices and drive up energy prices. Consequently, there is a need to assess CDR proposals in the context of Canada's other climate responses in an integrated fashion; an assessment that needs to be done at a policy, not project, level.

There may also be macro-level ecosystem implications as land-based CDR methods compete with other land uses, such as habitat and food production, and place further pressures on water and energy resources.[178] Scale becomes an important issue here. In order for CDR to make a meaningful contribution to climate goals, it must be undertaken at the multi-megatonne scale. Assessing scale-related concerns on a project-by-project basis may ignore or downplay these broader concerns given their abstract and more attenuated connection to specific projects. Strategic assessments, which provide for the assessment of government policies, plans, or programs, could be employed to address some of these concerns, so long as there is an underlying policy, plan, or program respecting CDR that can be the subject of an assessment.[179] The decision to conduct a strategic assessment is at the discretion of the Minister of the Environment and Climate Change.[180]

Another possible tool is the use of technology assessments. Technology assessment is an assessment tool that would consider the environmental, economic, social, and ethical implications of the development of a class of emerging technologies.[181] In Canada, there is no existing framework for technology assessments,[182] and the instances where technology assessments are undertaken have been on an ad hoc basis through institutions such as the Council of Canadian Academies.[183] The United States National Academy of Sciences has engaged in several large-scale assessments of geoengineering and CDR, in particular, as has

175 Resolution LP.4(8), *supra* note 106 at annex 4, art 1.1.
176 *Ibid*, art 6.
177 Nils Markusson, Duncan McLaren & David Tyfield, "Towards a Cultural Political Economy of Mitigation Deterrence by Negative Emissions Technologies (NETs)" (2018) 1 Global Sustainability 1.
178 *Ibid*.
179 *IAA*, *supra* note 131, s 95.
180 *Ibid*.
181 Daniel Sarewitz, "World View: Not by Experts Alone" (2010) 466:5 Nature 688.
182 The US had a legislated technology assessment process under the *Office of Technology Assessment Act, 1972*, Pub L 92-484. The Office of Technology Assessment was abolished in 1995.
183 "Canada's Carbon Sink Potential," (2022), online: *The Council of Canadian Academies* <cca-reports.ca/reports/canadas-carbon-sink-potential/> (the Council of Canadian Academies is currently undertaking a study assessing Canada's carbon sink potential).

the (United Kingdom) Royal Society.[184] Such assessments are not regulatory, but they can inform policy decisions respecting CDR technologies and their development. Additionally, these assessments can be structured to engage the public and thus have some potential to promote public understanding and trust in the underlying science and risk assessments associated with CDR technologies.

A final differentiating aspect of CDR is the risk-risk trade-off that such measures involve. CDR aims to better ensure that the global community can meet its target of keeping global average temperatures within the deemed "safe" limits of well below 2 degrees Celsius in line with the Paris targets. As currently understood through modelling, it is not likely that these targets will be met without the large-scale deployment of CDR technologies. Consequently, a failure to achieve sizable reductions through CDR poses a serious risk in itself, and thus any risks that are posed by the implementation of CDR must be considered in light of the risk posed by non-adoption. Legally, these kinds of trade-offs are anticipated under EIA legislation. For example, the *IAA* explicitly includes consideration of the project in question to "contribute to the Government of Canada's ability to meet its environmental obligations and its commitments in respect of climate change" as part of the assessment process.[185] However, such trade-offs have important distributive consequences as local communities may be asked to accept risks or impacts in order to provide a broader social benefit. Again, such dynamics are not uncommon in EIAs but do underscore the importance of public consultation and broad public acceptance of the social goals sought.

2. CO_2 AS A CONTROLLED SUBSTANCE

Another law with potential applications across technologies is the identification of CO_2 as a controlled ("toxic") substance under *CEPA*.[186] The listing of CO_2, which occurred in 2005, does not in and of itself create specific legal obligations, but rather allows the government to take steps to manage the adverse effects of the substance. As noted in connection with the discussion on the constitutional limitations related to *CEPA*, the federal government has broad authority to regulate CO_2 as emissions. The government has already done this with coal and natural gas electrical generating facilities by identifying emission standards that those facilities will be required to meet.[187] The clearest potential application of *CEPA* authority to CDR would be in relation to the development of regulatory standards controlling the permanent storage of CO_2 in connection with BECCS or DACCS projects, although it must be noted that, to date, the federal government has left this to the provinces in connection with CCS and enhanced oil recovery projects. Here, the concern is the unintended release of CO_2 from storage facilities, which may lead to regulations on the conditions of storage, reporting, and monitoring and duties in the event of an accidental release. As the permanence of CO_2 storage is a critical consideration for any credible system involving CCS, these would need to be addressed in any event.

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184 National Academies Research Agenda, *supra* note 6; The Royal Society Report on CDR, *supra* note 32.

185 *IAA*, *supra* note 131, s 22(i).

186 *CEPA*, *supra* note 111 at part 5, s 64 and Schedule 1.

187 *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations*, SOR/2012-167; *Regulations Limiting Carbon Dioxide Emissions from Natural Gas-fired Generation of Electricity*, SOR/2018-261.

V. CDR APPROACH SPECIFIC REGULATION

In addition to laws of general application, various federal and provincial laws and regulations may apply to specific CDR technologies and their development. Given the ensemble nature of most CDR technologies, the current regulatory framework is highly diffuse, where different elements of CDR approaches may come under different regulatory authority. For example, in the case of BECCS, the overall process of removing CO_2 consists of the growth and harvesting of biomass, its combustion to produce energy, the capture of CO_2 from that process, and then the transportation and sequestration of the captured carbon. While the carbon removal aspects of BECCS, such as the market incentives, accounting and reporting aspects, will likely be addressed in laws of general application, the specific impacts and regulation of the processes will be subject to a myriad of activity-specific laws. In many cases, the actual activity will be regulated with little or no differentiation from existing activities that currently operate as an element of the CDR process. Regulators will need to consider whether a combination of these activities or their changed purposes alters the current regulatory approach taken. Other technologies, such as ocean fertilization and ocean alkalinity, are sufficiently unique to require specific regulatory rules. In this section, we describe briefly the range of regulatory requirements that each technology may trigger. The discussion in this section is not intended to be comprehensive, but rather aims to provide a general sense of the range of issues currently subject to regulation.

A. DIRECT AIR CAPTURE AND CARBON STORAGE (DACCS)

There are two main components to DACCS projects and these are likely to be regulated independently of one another. The direct air capture (DAC) component would operate as an industrial facility and thus be subject to provincial environmental legislation covering process emissions and waste removal.[188] In order to operate in a carbon-efficient manner, DAC processes, which are energy-intensive, would have to draw their energy from renewable sources. At scale, there would be a need for multiple capture facilities, giving rise to land use issues, subject to provincial land use laws.[189] There are also land use issues and regulatory requirements that will be triggered by the need to transport CO_2 via pipelines from capture sites to storage locations. [190]

The carbon storage element is addressed by a comprehensive array of enactments, which, in Alberta, centres around the *Mines and Minerals Act* (as amended by the *Carbon Capture and Storage Statutes Amendment Act*), which covers incentives and funding, pore space ownership and tenure, permitting, and closure and post-closure liability.[191] The legislation and regulations are directed toward CCS from oil and gas activities, and would likely require modification to address the specific development demands of DACCS. However, the basic legislative architecture is largely in place. There is potential for competition between users of geological storage capacity, as storage may be used for DACCS, BECCS, and other CCS users, especially the upstream oil and gas industry, which will need to reduce its emissions

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188 *Environmental Protection and Enhancement Act*, RSA 2000, c E-12.

189 *Alberta Land Stewardship Act*, SA 2009, c A-26.8; *Public Lands Act*, RSA 2000, c P-40.

190 *Pipeline Act*, RSA 2000, c P-15.

191 *Mines and Minerals Act*, RSA 2000, c M-17, as amended by *Carbon Capture and Storage Statutes Amendment Act*, SA 2010, c 14.

dramatically as well as those engaged in enhanced oil recovery. This suggests regulators will need to pay attention to a fair and efficient system for the allocation of geological storage among user groups. The development of CCS regimes is less developed in other parts of Canada.

Different requirements would govern marine-based carbon storage. There is a proposed demonstration project in British Columbia that uses offshore renewable energy to drive a DAC process, with the captured CO_2 being transported via pipeline to offshore geological storage sites.[192] The offshore components trigger a variety of federal approval processes relating to siting and energy production.[193] Storage would be subject to the ocean dumping requirements of *CEPA*, as discussed above.[194] Canada has not implemented the marine CCS amendments under the *London Protocol* that would provide a process for CO_2 storage.[195] These amendments would likely need to take place to allow for the disposal of CO_2 in offshore areas, as CO_2 is not currently listed as a substance that could be disposed of under the existing rules.[196]

B. BIOENERGY WITH CARBON CAPTURE AND STORAGE (BECCS)

BECCS occurs in multiple phases, with different laws triggered by the biomass and bioenergy production and CCS phases. The carbon storage phase would be the same as for DACCS. The production of bioenergy will trigger legal or regulatory frameworks relating to the procurement and production of biomass feedstock and its combustion for energy.[197] Most policies, laws, and regulations applicable to forest biomass harvesting are present at the provincial level, given that more than 90 percent of Canadian Crown forested land is provincial Crown land.[198]

Every province in Canada has its own version of a "Forest Act," many of which were not drafted when forest biomass harvesting would be considered a typical forestry activity as defined in most of the provincial legislation.[199] Additionally, most provinces have conservation laws that promote sustainable forestry, and ecosystem and species protection practices.[200] Some of the restrictions that current legislation places on forest biomass

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[192] Solid Carbon, "A Rock-Solid Climate Solution" (2022), online: <solidcarbon.ca/>. For a legal analysis of the project see Romany M Webb & Michael B Gerrard, "The Legal Framework for Offshore Carbon Capture and Storage in Canada" (2021), online: *Sabin Center for Climate Change Law, Columbia Law School* <climate.law.columbia.edu/sites/default/files/content/Webb%20%26%20Gerrard%20-%20Offshore%20CCS%20in%20Canada.pdf>.

[193] *Canadian Navigable Waters Act*, RSC 1985, c N-22; *Canadian Energy Regulator Act*, SC 2019, c 28, s 10.

[194] *CEPA*, *supra* note 111, part 7, div 3.

[195] 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Protocol 1996), LC/LP. 1 *Notification of amendments to Annex 1 to the London Protocol 1996* (2006).

[196] *CEPA*, *supra* note 111, s 127.

[197] Technical Report 081, *supra* note 51 at 2.

[198] *Ibid* at 7.

[199] *Ibid* at 4, 8.

[200] *Wildlife Act*, RSA 2000, c W-10.

harvesting include the number of trees that must be left behind when harvesting biomass or the level of acceptable soil disturbance allowed during the harvesting process.[201]

At the federal level, Canada has introduced various guidelines and policy instruments to provide suppliers, consumers, and regulators with a consistent policy relating to the supply, use, and purchase of biomass for heat and energy applications.[202] Unfortunately, the federal government's policy framework was not created with CDR in mind, and would only apply to BECCS in a general sense. A similar policy would be a useful tool to guide the procurement of biomass for energy, while ensuring alignment with Canada's sustainability goals. Without a pre-established guide, proponents will have to rely on general legislation to determine how and where they procure biomass from, and, for example, would require compliance with forestry legislation such as the *Alberta Forests Act* and the Federal *Forestry Act* if procuring biomass through forestry practices.[203]

C. BIOCHAR AND ENHANCED WEATHERING

As a potential type of soil amendment, biochar and, to a lesser degree, enhanced weathering, fall within the ambit of the Federal *Fertilizers Act*.[204] The Canadian Food Inspection Agency (CFIA) is charged with the administration of the *Fertilizers Act* and its accompanying regulations.[205] The *Fertilizers Act* regards biochar as a "supplement," defined in the legislation as "any substance or mixture of substances, other than a fertilizer, that is manufactured, sold or represented for use in the improvement of the physical condition of soils or to aid plant growth or crop yields."[206] As a soil supplement, biochar must be registered prior to its sale or import into Canada. The CFIA also examines all unintended and potentially adverse effects of applying biochar and may impose disclosure requirements in connection with this process. There have been approximately a dozen biochar products registered with CFIA to date.[207]

The registration of a biochar product under the *Fertilizers Act* requires the completion of a compliance analysis and the submission of the Results of Analysis of the biochar being registered. This analysis must provide relevant information on levels of metals,[208] dioxins,

201 *Ibid* at 4; New Brunswick, Department of Natural Resources, Forest Biomass Harvesting, Policy No FMB 019 2008 (New Brunswick: Department of Natural Resources, 2008) at 1.1. (Currently, New Brunswick is the only province to implement a biomass policy. The Forest Biomass Harvesting Policy, implemented on 22 October 2008, was established to permit the harvesting of biomass from Crown lands while ensuring sustainable management of Crown forests.)

202 Natural Resources Canada, Solid Biofuels Bulletins 1–7.

203 *Forests Act*, RSA 2000, c F-22; *Forestry Act*, RSC 1985, c F-30.

204 *Fertilizers Act*, RSC 1985, c F-10.

205 *Fertilizers Regulations*, CRC, c 666.

206 *Fertilizers Act*, *supra* note 204, s 2 ("'supplement' means any substance or mixture of substances, other than a fertilizer, that is manufactured, sold or represented for use in the improvement of the physical condition of soils or to aid plant growth or crop yields").

207 Canadian Food Inspection Agency, "Registered Products List" (10 February 2022), online: <inspection.canada.ca/active/eng/plaveg/fereng/fereng_dbe.asp>.

208 *Ibid*. With respect to trace metals standards, proponents must provide results of analyses for the following 11 metals: Arsenic (As), Cadmium (Cd), Cobalt (Co), Copper (Cu), Chromium (Cr), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Selenium (Se), and Zinc (Zn). To demonstrate compliance with the CFIA Fertilizer Dioxin and Furan Standards, proponents must provide one set of TEQ dioxins and furans analyses.

and furans contained in the biochar.[209] Standard-setting for this field is complicated by the fact that biochar projects are complex, making it difficult to put a uniform bright-line value on what constitutes an unacceptable level of heavy metal or dioxin in every circumstance. Provincial soils legislation may also govern soil supplements, but there is little prescriptive control over activities analogous to biochar or enhanced terrestrial weathering.[210] Upstream production for biochar and mining for enhanced weathering will, of course, be subject to provincial legislation.

The use of biochar or enhanced weathering as a climate mitigation measure falls within the scope of the *EMCRA* as a "sink," which is defined as "a component of the environment that removes or captures specified gases from the atmosphere through natural processes and includes, without limitation, plants and soil."[211] Section 5 of the *EMCRA* provides that the Lieutenant Governor in Council may make regulations respecting emission offsets, credits, and sink rights for the purpose of achieving reductions in specified gas emissions.[212] Specifically relevant to CDR applications is the Governor's ability to regulate "governing standards and other requirements respecting the construction, development, operation, measurement and validation of sinks and emission offsets to meet specified gas emission targets,"[213] as well as the "allocation of physical and legal risks associated with emission offsets, credits and sink rights."[214]

D. OCEAN FERTILIZATION

Ocean fertilization is primarily regulated under Division 3 of Part 7 of *CEPA*.[215] In accordance with Canada's international obligations under the law of the sea, section 122.1 of *CEPA* declares that the aim of the Division is the protection of the marine environment, in particular, to implement the *London Convention*[216] and its *London Protocol*. *CEPA* regulates the disposal of substances at sea in ocean areas where Canada has sovereignty or jurisdiction,[217] by Canadian ships conducting disposal activities in marine areas within the sovereignty or jurisdiction of other states,[218] and in marine areas beyond national jurisdiction.[219] Canada is party to the more recent *London Protocol*, which adopts a highly-precautionary "reverse-listing" approach to the dumping of wastes and other matter at sea.[220] Accordingly, *CEPA* prohibits all disposal activities at sea unless the disposal is permitted in accordance with strict permitting requirements.[221]

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209 *Ibid*. See also *Fertilizers Act*, *supra* note 204, ss 5(1)(a)–(c); *Fertilizers Regulations*, *supra* note 205, s 2(1)(b) ("'novel supplement' means a supplement that is derived through biotechnology and has a novel trait; "Notification and Authorization of Novel Supplements" (s 23.1); "Registration" (s 5); and "Guaranteed Analysis" (s 15)).

210 *Soil Conservation Act*, RSA 2000, c S-15.

211 *EMCRA*, *supra* note 155, s 1(e)(i).

212 *Ibid*, s 5.

213 *Ibid*, ss 5, 60(1)(l).

214 *Ibid*, s 60(1)(m).

215 *CEPA*, *supra* note 111.

216 *1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter*, 29 December 1972, 1046 UNTS 120 (1975) [*London Convention*].

217 *CEPA*, *supra* note 111, s 125(1).

218 *Ibid*, ss 125(3)–(3.1).

219 *Ibid*, ss 125(2)–(2.1).

220 *Ibid*.

221 *Ibid*, ss 123–25.

CEPA does not expressly address ocean fertilization. However, Environment and Climate Change Canada (ECCC) has issued specific guidance which explains how *CEPA* applies to ocean fertilization activities. This guidance incorporates the *London Protocol's* 2008 and 2010 Resolutions on ocean fertilization into the *CEPA* legislative framework.[222] It clarifies that "[o]cean fertilization activities that fall within the definition of disposal under *CEPA* are considered to be disposal at sea and are not allowed without a permit."[223] Mirroring the definition of dumping in the *London Convention* and *London Protocol*, the meaning of "disposal" under the *Act* excludes "the placement of a substance for a purpose other than its mere disposal if the placement is not contrary to the purposes of this Division and the aims of the [*London*] *Convention* or the [*London*] *Protocol*."[224] Ocean fertilization falls within this definition since, although fertilizing substances are not introduced for the purpose of disposal, that is, to get rid of the material as waste, the intentional introduction of such substances may have adverse effects on the marine environment which is contrary to the objectives of the ocean dumping regime. Accordingly, the 2008 Resolution indicates that activities that do not qualify under the exception for legitimate scientific research be considered "contrary to the aims of the [*London*] *Convention* and [*London*] *Protocol*."[225] As such, Canadian citizens, Canadian ships, aircraft and platforms, and those loading material in Canada are not permitted to conduct ocean fertilization projects within waters under Canadian sovereignty or jurisdiction or on the high seas, unless they constitute legitimate scientific research. In order to be considered legitimate scientific research, the ECCC requires that projects be assessed using the 2010 Ocean Fertilization Assessment Framework.[226] The ECCC will review each completed assessment and render a decision.[227]

E. OCEAN ALKALINITY ADDITION

It is likely that, as with ocean fertilization, ocean alkalinity enhancement will fall under the *CEPA* rules on disposal at sea because the technology entails a deposition in ocean waters.[228] However, no specific international guidance or standards have been issued to date which would inform how the Canadian legislative framework will apply to this CDR technique. The meaning of "marine geoengineering" in the 2013 amendment of the *London Protocol* could in principle cover ocean alkalinity enhancement, which is defined as a "deliberate intervention in the marine environment to manipulate natural processes, including to counteract anthropogenic climate change and/or its impacts, and that has the potential to result in deleterious effects, especially where those effects may be widespread, long lasting or severe."[229] As noted above, however, ocean fertilization is currently the only marine geoengineering technique listed in the *London Protocol* amendment, though the amendment

222 *Ibid*.
223 Environment and Natural Resources, "Disposal at Sea: Ocean Fertilization Information for Research Community" (16 August 2017), online: <www.canada.ca/en/environment-climate-change/services/disposal-at-sea/publications/ocean-fertilization-information-research-community.html> [Canada, "Disposal at Sea"]. Note that there are currently no provisions for the permitting of ocean fertilization under *CEPA*.
224 *CEPA*, *supra* note 111, s 122(i).
225 The Thirtieth Meeting of the Contracting Parties to the London Convention and the Third Meeting of the Contracting Parties to the London Protocol, "Resolution LC-LP.1 (2008) on the Regulation of Ocean Fertilization" (2008).
226 Resolution LC-LP.2, *supra* note 109.
227 Canada, "Disposal at Sea," *supra* note 223.
228 Webb, Silverman-Roati & Gerrard, *supra* note 108.
229 Resolution LP.4(8), *supra* note 106, art 5bis.

is designed to allow for the addition of new marine geoengineering techniques as they became relevant.

GESAMP produced a report in 2019 on marine geoengineering activities, which discussed several marine CDR techniques including ocean alkalinity enhancement.[230] However, the *London Convention* and *London Protocol* have not yet responded to this study, nor have they adopted any resolutions or taken other actions to interpret the lawfulness of ocean alkalinity enhancement under the existing international rules.

Legal gaps and uncertainties at the international level necessarily impact the interpretation of *CEPA* in view of its stated scope and purpose.[231] Specifically, it is yet to be determined whether ocean alkalinity enhancement — being conducted either as a CDR strategy or for other purposes, such as to offset the impacts of ocean acidification — constitutes "disposal" under *CEPA*. It is likely that, given the potential for adverse impacts on the marine environment, Canadian regulators would adopt the same approach taken by the *London Convention* and *London Protocol* and reflected in the *CEPA* guidance on ocean fertilization. Accordingly, under *CEPA*, the addition of alkaline "substances" in the ocean would likely entail a "placement" for a "purpose other than its mere disposal."[232] In other words, the main interpretive question turns on whether the addition of alkaline materials would be "contrary to the purposes of this Division and the aims of the [*London*] *Convention* or the [*London*] *Protocol*."[233] In this regard, it is important to note, that even in the absence of express guidance from the *London Convention* and *London Protocol*, the overarching purpose of *CEPA* remains "to protect the marine environment, particularly by implementing the [*London] Convention* and the [*London*] *Protocol*."[234] Again, it is important to note the significance of international law, and the *London Convention* and *London Protocol* specifically, in determining the lawfulness of marine CDR activities in a Canadian context. However, even absent international guidance, ocean alkalinity related depositions could be interpreted domestically as being unlawful under *CEPA*, given that the overarching purpose of this Division is to protect the marine environment.

In the unlikely event that ocean alkalinity enhancement is deemed to be "disposal" under the Canadian legislation, then the salient question is whether alkaline substances would be prohibited, or, alternatively, whether they are likely to fall within the excepted list of wastes that may be considered for a permit. Consistent with the precautionary reverse-listing approach under the *London Protocol*, the disposal of substances at sea is only permitted for those substances listed in Part 5 of *CEPA* and where it is an environmentally preferable and practical alternative.[235] It is possible that substances used for ocean alkalinity enhancement could fall within the Part 5 exception, which allows for a permit to be issued for the disposal of "inert, inorganic geological material."[236] This interpretation is unlikely, however, since according to its plain meaning, "inert" refers to something being "without active chemical"[237]

[230] GESAMP, *supra* note 29.
[231] See discussion on ocean fertilization, above at Part V.D.
[232] *CEPA*, *supra* note 111, s 122(1)(i).
[233] *Ibid*.
[234] *Ibid*, s 122.1.
[235] *Ibid*, Part 6.
[236] *Ibid*, s 127 and Schedule 5. Cf *London Protocol*, annex I.
[237] *The Oxford English Dictionary*, *sub verbo* "inert."

— a description which does not seem applicable in the context of CDR given that the addition of alkaline substances is intended to alter ocean chemistry.

The fact that alkalinity addition may be conducted for different purposes other than CDR, such as to offset the impacts of ocean acidification on coastal shellfish farms, does not materially alter the interpretation and application of *CEPA*. Both examples likely entail deliberate "placements" of wastes at sea and thus would turn on the particular circumstances in relation to the wording of the exception for placement activities.

It is also important to consider the mode of application. *CEPA* rules on disposal at sea do not cover discharges from land-based sources such as pipes and outfalls, and, thus, proposals to apply alkaline substances locally via pipes on land are likely to be instead covered by the more liberal framework in Division 2 of Part 7 on protection of the marine environment from land-based sources of pollution. "[L]and-based sources" are defined in *CEPA* as "point and diffuse sources on land from which substances or energy reach the sea by water, through the air or directly from the coast."[238] The federal legislative scheme for "marine pollution" from land-based sources is highly discretionary.[239] According to section 121(1) of *CEPA*, "[t]he Minister may, after consultation with any other affected minister, issue environmental objectives, release guidelines and codes of practice to prevent and reduce marine pollution from land-based sources."[240] This guidance does not presently exist for ocean alkalinity addition or other CDR methods conducted from land.

VI. CONCLUSIONS AND FUTURE OUTLOOK

As a class of technologies, CDR is characterized by several important features that bear upon its regulation. First, CDR technologies are highly heterogeneous, making CDR more likely to be regulated as individual technologies or even as components of an ensemble of technologies that are combined to generate removals and storage. As currently emerging, this diversity is poised to result in a decentralized and possibly fragmented approach to CDR regulation in Canada. There are, however, a number of issues that likely require a more integrated approach, such as considering the extent to which Canada seeks to achieve emissions neutrality through reductions versus removals, the distribution of the burdens associated with removals across different parts of the country, and ensuring that new removal technologies and approaches are implemented with high levels of stringency. We anticipate that CDR technologies will also be subject to increasing international regulation requiring attention to compliance that may require central oversight.

The federal government has a number of regulatory mechanisms at hand that can promote coherence in regulation. In particular, the *Net-Zero Emission Accountability Act* could play a crucial role in tracking the distribution between emissions reductions and removals, and in facilitating a broader public discussion on the risks and benefits of committing to large-scale CDR activities. The *GGPPA* can also be used to impose national (and international) standards for CDR through the regulation of emission offsets, particularly stringency issues. The coordination of reporting and accounting standards is, in our view, a manageable regulatory challenge, not unlike the development of similar standards for emissions

238 *CEPA*, *supra* note 111, s 120.
239 *Ibid*.
240 *Ibid*, s 121(1).

reductions. What may prove to be more controversial is implementing any hard limits on the amount and timing of removals, particularly, if removals are used as a means to prolong high emissions activities, such as oil and gas development.

Second, CDR as a climate response is only meaningful when it is deployed at very large scales. The issue of scale requires a high degree of anticipation of the cumulative and systems level impacts of CDR as it scales up. The issue of cumulative impacts raises questions respecting the adequacy of federal and provincial impact assessment legislation, which is primary project focused, to effectively anticipate future impacts and provide for effective consultation mechanisms. The systems impacts are likely to be co-constitutive with CDR development, in the sense that CDR will impact energy, food and water systems, and those impacts will influence the viability and desirability of future CDR. Additionally, anticipatory governance is required to address distributive issues, such as which users will have access to geological storage or renewable energy.

The impacts from CDR at scale is also likely to have cross-technology implications, requiring an ability to assess technologies side by side, and in the context of policy choices that must consider a widening number of climate responses. Given the resource intensive nature of technology research and development, the Canadian government may want to focus on technologies that have greater net benefits in Canada, and eliminate technologies that are cost ineffective or too risky. We note that Canada does not have technology assessment processes, although we have indicated that the Council of Canadian Academies could play an important role in synthesizing knowledge on CDR development in Canada, particularly if debates on CDR become sites of contestation.[241]

Adequate Indigenous consultation presents some significant and unique challenges. The duty to consult has tended to focus on project impacts, and there are no clear processes to engage Indigenous peoples in a much broader discussion on CDR activities that impact traditional territories (both in the terrestrial and marine contexts). The extent of Indigenous rights in connection with subsurface sequestration activities and CDR activities occurring in marine areas remains unclear. If Canada continues to move towards a consent-based approach to resource policy affecting Indigenous rights and interests, early and ongoing consultation will be critical, as will the development of tools that generate benefits for Indigenous communities from CDR activities that affect their interests.[242] To date, there has been very limited discussions on the potential role that Indigenous communities could play in CDR development and no clear platform for these discussions.

[241] National Academies of Sciences are often characterized as boundary organizations that are adept at mediating the interface between science, society, and policy decisions, see e.g. David H Guston, "Boundary Organizations in Environmental Policy and Science: An Introduction" (2001) 26:4 Science, Technology, & Human Values 399.

[242] Government of British Columbia, "Atmospheric Benefit Sharing Agreements," online: <www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/consulting-with-first-nations/first-nations-negotiations/atmospheric-benefit-sharing-agreements> (one potential tool may be the expanded use of "atmospheric benefit sharing agreements" that have been used to structure forest offsets on traditional territories in British Columbia).

If there is a single, paramount message concerning the legal framework for CDR in Canada, it is the importance of seeing the regulatory forest through the trees. Governments can rely upon and adjust existing regulatory tools to management CDR projects at small and medium scales, but a failure to address the broader role of CDR in a portfolio of responses to climate change and to apply a high, perhaps unprecedented, level of foresight to the long-term implications of CDR development risks the development of disjointed approaches and potential legitimacy challenges if Canada locks itself into environmentally — and socially — unviable policy choices.

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