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ANNOTATED BIBLIOGRAPHY

The Emergence of Carbon Sequestration: An Introduction and Annotated Bibliography of Legal Aspects for CCS

NADINE R. HOFFMAN*

The burning of fossil fuels results in significant carbon dioxide emissions into the atmosphere. Carbon capture and storage (CCS) offers a way of safely storing emissions produced by large-scale industrial operations such as power plants, petroleum refineries, oil sands facilities, and manufacturing plants on or beneath the earth's surface. Many corporations and governments are interested in CCS as it allows for the continued use of fossil fuels while reducing harmful carbon dioxide emissions. Consequently, CCS has become an emerging, burgeoning industry. Terms used to describe the CCS process include carbon sequestration, biosequestration, geosequestration, carbon dioxide geosequestration, ocean sequestration, terrestrial sequestration, carbon dioxide sequestration, carbon dioxide storage, and carbon capture and disposal. Most commonly, this technique is referred to as carbon capture and storage or carbon capture and sequestration. CCS is used in this article to refer to all of these terms generally; authors in the annotated articles may use more specific terms depending on the process or location of the sequestered carbon dioxide being discussed.

CCS research and collaboration is underway in a wide range of disciplines, including law, economics, political science, science, and engineering; many larger collaborative projects are

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multidisciplinary. Research and development is necessary for the CCS industry to be successful in combating climate change in the short- and medium-terms. Many authors of articles referenced in this annotated bibliography suggest that governments and industry need to work together in order to combat climate change. This collaboration is necessary to ensure that CCS becomes a viable option to reduce greenhouse gas emissions and to help decrease their future effects on climate change.

CCS is the technological process of capturing carbon dioxide emissions and storing or sequestering these gases in physical formations in the ground for geologically significant periods of time. Storage of carbon dioxide usually takes place in natural formations on or beneath the earth. "There are four main types of geological storage/disposal sites: (1) depleted oil and gas reservoirs; (2) deep saline formations; (3) (unmineable) coal seams; and (4) salt caverns."¹ Other geological formations used for sequestration include forests, soil, oceans, and sinks.² Different processes are used to store the carbon dioxide, including photosynthesis and nutrient fertilization processes for oceans and forests as well as injecting gas into underground formations.³ With regard to climate change, the goal of CCS is to minimize carbon dioxide emissions into the atmosphere. Experts and policymakers anticipate that this process will help reduce the rate of global warming. Governments will have to balance the costs of tax incentives and funding of CCS with its economic and environmental benefits through planning, policy-making, legislation, and regulation. The first section of this article provides an overview of the legal aspects and issues arising from CCS, an interdisciplinary problem of increased importance as pilot projects proceed to develop this emerging industry. The second section contains an annotated bibliography of selected

1. Nigel Bankes, Jenette Poschwatta & E. Mitchell Shier, *The Legal Framework for Carbon Capture and Storage in Alberta*, 45 ALTA. L. REV. 585, 589 (2007).

2. See United Nations Framework Convention on Climate Change art. 1, para. 8, June 12, 1992, 1771 U.N.T.S. 107 [hereinafter UNFCCC] (defining 'sink' as "any process or activity which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.").

3. These issues are discussed at length in several papers included in the annotated bibliography that follows.

scholarly articles, followed by an unannotated bibliography of significant governmental and non-governmental reports.⁴ Most of the articles included in this selected bibliography discuss the relevant technical processes and locations for sequestration or storage as part of their background information. Despite the limited number of specific laws, regulations, and policies directly related to CCS processes, CCS developers are assisted by decades of natural gas injection and storage experience in the oil and gas industry. Many of the authors draw parallels or provide examples for other industries from the petroleum sector.

Several different types of sequestration in geological formations are currently underway. Each country concentrates on different methods based on their available formations. The use of plants or forests is often called biosequestration and is most developed in Australia. Storing carbon dioxide under the ocean's seabed is one type of biosequestration, referred to as ocean sequestration. Pilot projects using this technique have begun in Northern Europe, including in the United Kingdom.

Ocean sequestration projects inject carbon dioxide into the deep seabed within saline aquifers or depleted oil and gas reserves from offshore drilling. A more recent and controversial method of ocean sequestration relates to ocean fertilization, where nutrients such as nitrogen or phosphorous stimulate phytoplankton growth to convert carbon dioxide into organic carbon.⁵ Some policymakers consider carbon dioxide to be a form of hazardous waste in the marine environment. Methods for carbon dioxide disposal are controversial. CCS ocean sequestration methods are considered under Law of the Sea provisions primarily enunciated in the United Nations Convention on the Law of the Sea (UNCLOS).⁶ Marine sequestration is subject to a complex legal framework of local, national, regional, and international instruments. These

4. Reports were chosen based on citation patterns in the articles.

5. Rosemary Rayfuse, *Drowning our Sorrows to Secure a Carbon Free Future? Some International Legal Considerations Relating to Sequestering Carbon by Fertilising the Oceans*, 31 U. N.S.W. L.J. 919, 920 (2008), available at <http://www.austlii.edu.au/au/journals/UNSWLJ/2008/50.pdf>.

6. United Nations Convention on the Law of the Sea, Nov 16, 1994, 1833 U.N.T.S. 3. [hereinafter UNCLOS].

instruments deal with pollution, conservation, and marine environment issues.

The development of specific technologies for CCS is often cost prohibitive without governmental policy, legislative, regulatory and financial support. Governments attempt to provide a balance between the needs of their citizens, economic growth, industry, and the environment. International legal instruments such as the Kyoto Protocol⁷ to the United Nations Framework Convention on Climate Change (UNFCCC)⁸ have begun to address manufacturing processes and their resulting emissions. Nonetheless, there is much more to be done to provide a legal framework under which business can develop. Industry-government partnerships have been slow to progress, largely due to cost and various challenges associated with CCS operations. Governments must balance economic and social interests with liability issues for storing carbon. To date, however, environmental groups argue that governments have put business interests first and ignore the “polluter pays principle.”⁹ Many sources in this bibliography call for governments to create laws, regulations, and policies in order to encourage companies and researchers to develop necessary technologies and processes for effective CCS operations. Many of the articles include arguments for faster progression of these partnerships. One author goes so far as to state, “[t]he reality is that waiting until the future before acting, both by industry and government, is too late.”¹⁰ To this end, large corporations and governments are investing in related technologies and projects.¹¹ Industry has developed many of the technological processes as part of their research and

7. Kyoto Protocol to the United Nations Framework Convention on Climate Change, UN Doc. FCCC/CP/1997/7/Add.1 (Dec. 11, 1997); 37 I.L.M. 22 (1998) [hereinafter Kyoto Protocol].

8. UNFCCC, *supra* note 2.

9. Ross Ashcroft, *Carbon Capture and Storage: A Need for Re-Conceiving Property Interests and Resource Management in the Australian Legal System*, L. ASIA J. 70, 91 (2008).

10. *Id.*

11. See *R, D & D Projects Database*, IEA GREENHOUSE GAS R&D PROGRAMME, <http://co2captureandstorage.info/co2db.php> (last visited December 1, 2011) (providing for the International Energy Agency’s comprehensive list of worldwide CCS projects).

development, sometimes in cooperation with government and other researchers. Public-private collaboration on CCS technology development can be found in Australia and Norway where “these industries have received the benefit of highly subsidized research.”¹²

The next step for CCS development is the creation by governments and policymakers of a clear legal framework to regulate this new technology. Legal issues surrounding CCS relate to jurisdiction, transportation, short-term and long-term liability, real property rights for capture, injection and storage processes, monitoring and enforcement of agreements, risk management, the lack of legislative or regulatory frameworks and policies, competition, taxation, incentives such as carbon taxes and cap-and-trade systems, individual state responsibility, and state obligations in international law. As with oil and gas management in general, real property issues usually relate to the ownership of pore space as well as surface and sub-surface rights. Legal obligations of the parties relating to CCS matters include intellectual property, participation, monitoring, health and safety concerns, allowing for in situ testing, and permit granting.¹³

Initially, international organizations and non-governmental organizations addressed legal CCS issues by amending existing instruments (treaties, conventions, and protocols). Currently, all levels of government are beginning to legislate and regulate CCS, some through adapting existing laws and regulations while others are implementing new legislation and related policies. Regulation is needed for all steps of the CCS process, necessitating vigilant scrutiny over carbon dioxide pipelines and enactment of legislation specifically pertaining to the CCS industry.¹⁴ Most authors cited in the annotated bibliography identify and describe this as a necessity for all levels of government.

12. Ashcroft, *supra* note 9, at 77.

13. Ray Purdy, *The Legal Implications of Carbon Capture and Storage Under the Sea*, 7 SUSTAINABLE DEV. L. & POL’Y 22, 26 (2006).

14. David Schwartz, *The Natural Gas Industry: Lessons for the Future of the Carbon Dioxide Capture and Storage Industry*, 19 STAN. L. & POL’Y REV. 550, 573 (2008).

In addition to international organizations such as the International Energy Agency (IEA) and the United Nations, most regional, national and state/provincial governments, large corporations, and environmental groups are involved with CCS as a way to reduce carbon emissions. CCS-focused countries include Australia, Canada, China, Denmark, India, Japan, Norway, the United Kingdom, and the United States. Australia and the European Union were first to develop related policies and legislation for CCS, and consider themselves to be leaders in the reduction of carbon emissions.

The most advanced type of sequestration used by the petroleum industry in North America relates to enhanced oil recovery, underway since 1972. Under this process, carbon dioxide “is injected into an oil field in order to reduce the viscosity of the oil and to increase the amount [of oil] that can be recovered.”¹⁵ CCS may also provide a method for natural gas and coal bed methane to be recovered from unmineable coal beds. This form of CCS is popular due to available geological formations, appropriately combined with the possibility of transferring knowledge gained from oil and gas storage and acid gas disposal schemes. Most commonly, projects of this type in North America have used underground geological formations in depleted oil and gas wells and reservoirs. The regulation of this process is often cited as a lesson from the oil and gas sector to be learned by the new CCS industry.

Experts are not certain how long carbon dioxide can safely be sequestered. “As of yet, there are no guarantees that carbon dioxide sequestered underground will remain there or that long-term storage will be environmentally sound.”¹⁶ It is possible that “[g]eologically stored CO₂ [carbon dioxide] can migrate laterally, sometimes unpredictably, from its original storage location.”¹⁷ Despite this, CCS is considered in many of the sources selected in

15. Barry Barton, *Carbon Capture and Storage Law for New Zealand: A Comparative Study*, 13 N.Z. ENVTL. L.J. 1, 9 (2009).

16. Stephanie M. Haggerty, *Legal Requirements for Widespread Implementation for CO₂ Sequestration in Depleted Oil Reservoirs*, 21 PACE ENVTL. L. REV. 197, 216 (2003).

17. Will Reisinger et al., *Reconciling King Coal and Climate Change: A Regulatory Framework for Carbon Capture and Storage*, 11 VT. J. ENVTL. L. 1, 19 (2009).

this bibliography to be a reasonable short- to medium-term solution for the need to balance climate change with economic growth. “CCS reflects contemporary challenges in environmental law because it not only highlights the overriding importance of interdisciplinary cooperation, but it also requires competing environmental interests (e.g., air and water) to find legal solutions and make concessions to achieve common goals.”¹⁸

CCS proponents widely consider the technology to be a transitional process or “the best option among many bad options,” to be employed while newer technologies are developing to decrease emissions from fossil fuel use.¹⁹ Supporters state that CCS will enable a fundamental switch in the production and use of energy world-wide, as most greenhouse gases “have long atmospheric lifetimes — decades to thousands of years — compared to hours or days for most criteria air pollutants.”²⁰ Critics, on the other hand, suggest that CCS developments actually continue dependence on, and use of, fossil fuels without reducing emissions through efficiency improvements.

Although CCS as a whole is still a developing field, some aspects of the process have been underway for decades. The first sequestration attempt occurred in the United States in the 1930s, with waste injection into depleted oil and gas wells for disposal,²¹ prior to the enactment of federal legislation to protect underground sources of drinking water in 1974.²² The first formal intranational sequestration effort, known as the Guatemala Agroforestry Project,²³ commenced in 1988, with Applied Energy Services offsetting emissions from a new power plant they had constructed in the United States by planting fifty-

18. Purdy, *supra* note 13, at 26.

19. Alexandra B. Klass & Sara E. Bergan, *Carbon Sequestration and Sustainability*, 44 TULSA L. REV. 237, 245 (2009).

20. Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change, Carbon Sequestration, and Property Rights*, 2010 U. ILL. L. REV. 363, 372 (2010).

21. Haggerty, *supra* note 16, at 205.

22. Safe Drinking Water Act of 1974, Pub. L. 93-523, 88 Stat. 1661 (codified at 42 U.S.C. §§ 300f—300j-9 (2006)).

23. Fred Pearce, *Planting Trees for a Cooler World*, NEW SCI., October 15, 1988, at 21.

two million trees in Guatemala.²⁴ The experiences with injecting and storing natural gas in the petroleum industry and their available technologies are invaluable as background information for development of future sequestration projects.

The use of pipelines by the natural gas industry is another area identified in the literature for the burgeoning CCS industry to extrapolate from the oil and gas sector. This illustrates the need for careful monitoring. Pipeline management tactics provide a good example of the need to regulate a new CCS industry in a balanced manner, providing flexibility for the industry while enabling industry to operate effectively and grow.²⁵

Offshore and trans-boundary issues alongside the ongoing monitoring of storage facilities have been the focus of international law addressing CCS. The most relevant legal framework for ocean sequestration is set out in UNCLOS²⁶ and related instruments such as the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention),²⁷ the Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) of 1975,²⁸ and its associated protocol (London Protocol) of 1996.²⁹ The 1996 London Protocol was amended on November 27, 2006, to include sub-seabed geological formations. The 2007 amendments “remove pre-existing ambiguity about

24. Kelly Connelly Garry, *Managing Carbon in a World Economy: The Role of American Agriculture*, 9 GREAT PLAINS NAT. RESOURCES J. 18, 22 (2005).

25. See generally Robert R. Nordhaus & Emily Pitlick, *Carbon Dioxide Pipeline Regulation*, 30 ENERGY L.J. 85 (2007); see also Barton, *supra* note 15.

26. UNCLOS, *supra* note 6.

27. Convention for the Protection of the Marine Environment of the North-East Atlantic, Jan. 3, 2006, 2354 U.N.T.S. 67 [hereinafter OSPAR Convention].

28. Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Aug. 30, 1975, 1046 U.N.T.S. 120 [hereinafter London Convention].

29. Protocol to the Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Nov. 7, 1996, 36 I.L.M. 1 [hereinafter London Protocol].

whether this method for carbon dioxide isolation is permitted under international law.”³⁰

International environmental law is working to develop liability regimes while reminding States of their obligation “not to cause harm to the environment of another State.”³¹ In a discussion of state responsibility, Carr notes “the global climate is explicitly recognised . . . as a common concern of humankind. However, that does not yet imply specific legal obligations beyond cooperation.”³² Advocates see CCS as necessary to enable the creation of more sustainable solutions for future generations.

One of the most controversial aspects of CCS is carbon sinks, primarily due to their potential impact on climate change. Carbon sinks are often related to biosequestration, where carbon is sequestered in the air through photosynthesis using forests or farmland.³³ Benefits to countries allowing sinks and companies using them are unclear, though “sinks-based offsets may offer a cost-effective means to assist Canada and some other countries in bringing their net emissions within prescribed limits during the transition to a less carbon-intensive economy.”³⁴ As always, policies and political environments of individual nations affect international law.³⁵ Uncertainties about the use of sinks and their inclusion in the Kyoto Protocol was identified as a major reason for the United States’ lack of participation in the final Kyoto Protocol talks.³⁶

30. Ann Brewster Weeks, *Sub-seabed Carbon Dioxide Sequestration as a Climate Mitigation Option for the Eastern United States: A Preliminary Assessment of Technology and Law*, 12 OCEAN & COASTAL L.J. 245, 247 (2007).

31. Yvette Carr, *The International Legal Issues Relating to the Facilitation of Sub-Seabed CO₂ Sequestration Projects in Australia*, 14 AUSTL. INT’L L.J. 137, 149 (2007).

32. *Id.* at 153.

33. DEP’T OF THE ENV’T & HERITAGE, AUSTL. GREENHOUSE OFFICE, PLANNING FOREST SINK PROJECTS: A GUIDE TO LEGAL, TAXATION AND CONTRACTUAL ISSUES 53 (2005).

34. Steven A. Kennett, Arlene J. Kwasniak & Alastair R. Lucas, *Property Rights and the Legal Framework for Carbon Sequestration on Agricultural Land*, 37 OTTAWA L. REV. 173, 174 (2005).

35. Weeks, *supra* note 30, at 246-47.

36. Alexander Gillespie, *Sinks and the Climate Change Regime: The State of Play*, 12 DUKE ENVTL. L. & POL’Y F. 279, 301 (2003).

It is important for CCS-related legislation to be developed at different levels of government to ensure clarity through inter-governmental cooperation. This is particularly important as environmental law and regulation can occur under federal as well as state or provincial jurisdiction. In some countries, there are many potential administrative bodies that could have the authority to regulate CCS. Some sources in the attached bibliography discuss the use of existing administrative bodies, such as the Environmental Protection Agency (EPA) in the United States, versus creation of new bodies, such as the Carbon Dioxide Geosequestration Regulatory Working Group under the Ministerial Council on Mineral and Petroleum Resources in Australia. These bodies, described as one-way policymakers, can address long-term liability issues. Further, all levels of government and international organizations have different perspectives toward their policies, legislation, and regulations. Coordination at all levels will assist regulation over capture and injection processes, transportation, storage facilities, verification, and on-going monitoring of stored carbon dioxide. This cooperation, when combined with increased regulation, will provide guidance and lessen ambiguity in the CCS industry's early development.

Initially, CCS issues were added to existing legislation and regulations relating to hazardous waste disposal. CCS is beginning to have separate legislation and regulatory processes in some jurisdictions. These regulations are intended to protect human health as well as the environment in case of accidental releases of stored carbon dioxide. Future regulation needs to account for the various methods of sequestration used and their individual adaptations, applications, and risks. Uncertainties will be reduced for original adopters of CCS once these issues are addressed.³⁷ Australia and the United States have the most advanced legislation related to CCS, while many other governments, such as the European Union and Canada, are in the early stages of development.

37. Victor B. Flatt, *Paving the Legal Path for Carbon Sequestration from Coal*, 19 DUKE ENVTL. L. & POL'Y F. 211, 241 (2009).

Australia identified geosequestration as a priority with their 2004 energy strategy and eight-year plan outlined in *Securing Australia's Energy Future*.³⁸ They “confirmed that Australia’s abundant fossil fuel resources would remain the mainstay of energy production in this country for the foreseeable future.”³⁹ Since that time, Australia has created and amended the Commonwealth Offshore Petroleum Act⁴⁰ as appropriate legislation to allow the petroleum and CCS industries to co-exist. Specific guidelines and regulations for CCS use are under development.

Case law regarding CCS is limited at present. The benchmark case on this topic is *Massachusetts v. EPA*,⁴¹ where the United States Supreme Court ruled that “the EPA could regulate atmospheric carbon dioxide emissions as pollutants.”⁴² Most American experts argue that “[t]o protect both the environment and the nation, a comprehensive system of regulation, composed of general federal regulation and specific state-based regulation, should be created.”⁴³ The Waxman-Markey Bill,⁴⁴ passed by the House of Representatives in June 2009, is groundbreaking as it calls for significant investment in both energy-related technology and clean energy initiatives, “including up to sixty-billion dollars in carbon capture and sequestration technology.”⁴⁵ If this initiative ultimately becomes law, it will result in extensive growth of the CCS industry. In the

38. DEP'T OF THE PRIME MINISTER AND CABINET, SECURING AUSTRALIA'S ENERGY FUTURE (2004), available at <http://www.efa.com.au/Library/CthEnergyWhitePaper.pdf>.

39. James Fahey & Rosemary Lyster, *Geosequestration in Australia: Existing and Proposed Regulatory Mechanisms*, 4 J. EUR. ENVTL. PLAN. L. 287, 379 (2007).

40. *Offshore Petroleum Act 2006* (Cth) (Austl.).

41. *Massachusetts v. EPA*, 549 U.S. 497 (2007).

42. Jeffrey W. Moore, *The Potential Law of On-Shore Geologic Sequestration of CO₂ Captured from Coal-Fired Power Plants*, 28 ENERGY L.J. 443, 443 n.2 (2007).

43. Christopher Bidlack, *Regulating the Inevitable: Understanding the Legal consequences of and Providing for the Regulation of the Geologic Sequestration of Carbon Dioxide*, 30 J. LAND RESOURCES & ENVTL. L. 199, 199 (2010).

44. American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. (2009).

45. Chase E. Dressman, *CO₂Who?: Kentucky's Need to Statutorily Define Property Interests in Geologically Sequestered Carbon Dioxide*, 98 KY. L.J. 375, 395-96 (2009-2010).

meantime, CCS technologies are encouraged by the United States Department of Energy for power generation under the Energy Independence and Security Act of 2007.⁴⁶

The European Union is the best known multi-country, regional body, addressing CCS through the European Commission's *Community Guidelines on State Aid for Environmental Protection*⁴⁷ and the Directive on the Geological Storage of Carbon Dioxide.⁴⁸ These initiatives aim to integrate CCS into existing environmental legislation to provide a general framework for CCS. "The European Union is committed to the deployment of CCS as part of an aggressive strategy of reducing GHG [greenhouse gas] emissions [by 2020]."⁴⁹

Canadian policy and legislation regarding climate change mitigation is largely occurring at the provincial level, as provincial leaders have made it more of a priority than the federal government.⁵⁰ Alberta, the leading province for oil and gas operations, is the most advanced in CCS initiatives; they are considered "the benchmark for emissions from new electricity generation and new oil sands projects."⁵¹ Many public resources have been invested in the promotion and development of CCS processes, and have assisted in reducing emissions by manufacturing industries while continuing to foster economic growth.

CCS is an emerging initiative to combat climate change, with unknown possibilities for both short- and medium-term successes. Industry and governments must act cooperatively to ensure its success. Legal frameworks are under development locally,

46. Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492 (codified in scattered sections of 42 U.S.C.).

47. Community Guidelines on State Aid for Environmental Protection, 2001 O.J. (C 37) 3 (EC), *available at* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2008:082:0001:0033:EN:PDF>.

48. Directive 2009/31, of the European Parliament and of the Council of 23 April 2009 on the Geological Storage of Carbon Dioxide and Amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006, 2009 O.J. (L 140) 114 (EU), *available at* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF>.

49. Barton, *supra* note 15, at 17.

50. *Id.* at 11.

51. *Id.* at 10.

nationally, and internationally, which will foster the growth of CCS programs. Even though the CCS industry is in its infancy, technological processes for sequestering carbon are fairly advanced, with many projects in progress or in development around the world. The law needs to catch up with technology for the CCS industry to grow effectively, and for CCS to be successful in protecting the environment and humankind in the future. Further research and development into appropriate regulation of CCS operations and long-term liability for its processes continues to be necessary. Despite CCS advancements, industry and policymakers must not forget that CCS is a solution to provide researchers with time to find cleaner, more efficient energy sources for future generations while encouraging other sustainable development measures for lasting reduction in emissions. Finding a long-term solution “should remain an urgent and overriding goal.”⁵²

SELECTED ANNOTATED BIBLIOGRAPHY

This annotated bibliography provides a selection of published or forthcoming scholarly articles and intergovernmental reports. These reports focus on the legal aspects of CCS worldwide, concentrating on legislation and policy-making. To be selected, articles must have been included in a legal index or on the Legal Scholarship Network by June 2010. This bibliography excludes works focusing on emissions control and/or trade generally, as there are enough resources in those areas to warrant separate analysis. Books, chapters in books, and conference/workshop proceedings are excluded unless subsequently published as an independent scholarly article.⁵³

52. Jerneja Penca, *The 2006 “CO₂ Sequestration” Amendment to the 1996 London Protocol*, 24 INT’L J. MARINE & COASTAL L. 713, 725 (2009).

53. The following indices and databases were used to find articles: Index to Canadian Legal Literature (ICLL), AGIS Plus (Australian Government Information Service), LegalTrac, LexisNexis Environmental (available until July 2009), Legal Scholarship Network/Social Science Research Network (SSRN), Westlaw’s “JLR,” the various journals available through LexisNexis Quicklaw, Wilson’s OmniFile, and WorldCat.

International or Multi-Jurisdictional

- Anatole Boute, *Carbon Capture and Storage under the Clean Development Mechanism – An Overview of Regulatory Challenges*, 2 CARBON & CLIMATE L. REV. 339 (2008).

This article focuses on analysis of the Clean Development Mechanism of the Kyoto Protocol as a potential place for financial incentives for CCS in developing countries. The author provides an in-depth examination of the current regulatory framework, including competition between CCS and renewable energy or energy efficiency, permanence of emissions reductions, the need for adequate monitoring, and how emissions reductions are determined. The IEA Greenhouse Gas R & D Programme, an international collaborative research project,⁵⁴ and the International Panel on Climate Change (IPCC) guidance report, titled *2006 IPCC Guidelines for National Greenhouse Gas Inventories*,⁵⁵ are briefly discussed.

- INT'L ENERGY AGENCY & ORG. FOR ECON. CO-OPERATION AND DEV., LEGAL ASPECTS OF STORING CO₂: UPDATE AND RECOMMENDATIONS (2007), *available at* http://www.iea.org/textbase/nppdf/free/2007/legal_aspects.pdf.

This comprehensive and often cited report provides an in-depth overview of the main international legal issues pertaining to CCS, and offers five recommendations for further work and analysis. The report systematically examines the legal issues surrounding CCS as a way to lower greenhouse gas emissions into the atmosphere. It identifies categories of issues included under national regulations or policies and includes an extensive glossary, list of related websites, and technical statistics in appendices. This report is the product of research which began in 2004 at the IEA.

54. The IEAGHG was established as an Implementing Agreement under the IEA in 1991. See IEAGHG, www.ieaghg.org (last visited Nov. 30, 2010).

55. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2006 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES (2006), *available at* www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

- INT'L ENERGY AGENCY & ORG. FOR ECON. CO-OPERATION AND DEV., ENERGY TECHNOLOGY ANALYSIS: PROSPECTS FOR CO₂ CAPTURE AND STORAGE (2004), *available at* <http://www.gwpc.org/e-library/documents/co2/Report%20IEA%20CCS%20Prospects%2011-17-2004.pdf>.

Legal and other related issues surrounding CCS are compared with that of other technologies in this often cited intergovernmental report. This document provides an in-depth description of CCS as a viable process for climate change mitigation, an overview of worldwide CCS projects, and technical information on CCS. It also describes national and cross-boundary issues as well as international (largely marine) legal and regulatory frameworks. Also included in this report is a brief overview of carbon tax and emissions trading schemes and a useful appendix of definitions, abbreviations, and acronyms in easily understood terminology.

- INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, IPCC SPECIAL REPORT ON CARBON DIOXIDE CAPTURE AND STORAGE (2005), *available at* <http://www.ipcc-wg3.de/publications/special-reports/.files-images/SRCCS-WholeReport.pdf>.

This highly cited report is a summary for policymakers and includes technical information on various aspects of CCS. Literature published between 2001 and 2005 is assessed for many types of CCS, with the exception of biosequestration and ocean fertilization. This report provides a detailed technical overview of CCS and related processes, and calls for more research to be done on the risks, liability, legal, and regulatory issues of CCS. This report includes technical appendices as well as a fourteen-page glossary with acronyms and abbreviations.

- Jerneja Penca, *The 2006 "CO₂ Sequestration" Amendment to the 1996 London Protocol*, 24 INT'L J. MARINE & COASTAL L. 713 (2009).

This report describes in detail the process of adding the CO₂ Amendment to the 1996 London Protocol to the 1972 London Convention on the Prevention of Marine Pollution by Dumping of

Wastes and Other Matter,⁵⁶ and how these frameworks have the potential to clash with other areas of environmental law. This article outlines the law prior to the adoption of the CO₂ Amendment and provides a summary and analysis of developments surrounding the amendment. It also examines contentious aspects of the amendment including the Clean Development Mechanism, threats to marine environments, leakage from injection wells, sustainability, and liability. Seven relevant and well-known international instruments are discussed as to their mandates and appropriateness for CCS activities.

- Ray Purdy, *The Legal Implications of Carbon Capture & Storage Under the Sea*, 7 SUSTAINABLE DEV. L. & POL'Y 22 (2006).

This article explains the factors behind CCS, addressing its economical usefulness, commercial benefits to industry – particularly with emissions trading – and the potential for governments to meet climate targets required under the UNFCCC and Kyoto Protocol. The article includes an analysis of several studies conducted by the IPCC and the IEA, and the legal questions they pose for CCS use. The author addresses ambiguities for CCS under existing international legislation, concentrating on marine laws and potential amendments. Additionally, the European Union draft legislative proposal for CCS use, the inclusion of under the Clean Development Mechanism of the Kyoto Protocol, and the work of the Intersessional Legal and Related Issues Working Group on CO₂ Sequestration are described.

- Karen N. Scott, *The Day After Tomorrow: Ocean CO₂ Sequestration and the Future of Climate Change*, 18 GEO. INT'L ENVTL. L. REV. 57 (2005).

This article begins by describing CCS with respect to climate change through an international law framework, concentrating on the UNFCCC and oceanic storage under the international law

56. For the amendment, see Int'l Maritime Org. [IMO], *On the Amendment to Include CO₂ Sequestration in Sub-seabed Geological Formations in Annex 1 to the London Protocol*, IMO Assemb. Res. LP.1(1) (Nov. 2, 2006), available at http://www.imo.org/blast/blastDataHelper.asp?data_id=17614&filename=01.pdf.

of the sea. The author discusses international treaties, conventions, and protocols alongside states' rights and obligations, dumping, environmental impact statements, offshore installations, and ocean fertilization.

- TASK FORCE ON CARBON CAPTURE AND GEOLOGIC STORAGE, INTERSTATE OIL & GAS COMPACT COMM'N, STORAGE OF CARBON DIOXIDE IN GEOLOGIC STRUCTURES: A LEGAL AND REGULATORY GUIDE FOR STATES AND PROVINCES (2007), *available at* <http://www.gwpc.org/e-library/documents/co2/IOGCC%20Master%20CO2%20Regulatory%20Document%209-2007.pdf>.

This practical document is an important guide for states and provinces in Canada and the United States in preparing to use CCS technology. The authors of this report suggest modifying existing regulations for carbon dioxide, continuing research into ownership issues for storage rights, and an analysis of the Underground Injection Control program of the Safe Drinking Water Act⁵⁷ with respect to carbon dioxide storage in the United States. This report includes a model statute, rules and regulations, case law survey, and a bibliography in order to assist states and provinces in drafting a realistic framework for treating carbon dioxide as a resource, as opposed to a waste, in their legislation, regulations, and policies.

Australia and New Zealand

- Adam N. Andrews, *Picking Up on What's Going Underground: Australia Should Exempt Carbon Capture and Geo-Sequestration from Part IIIA of the Trade Practices Act*, PAC. RIM L. & POL'Y J. 407 (2008).

A comment on how CCS can be included in the Australian Trade Practices Act,⁵⁸ this article concentrates on how CCS should be exempt from the Act's section on access to facilities until the industry is more developed. This would encourage investment in CCS, and prevent unnecessary regulatory risks

57. Safe Drinking Water Act of 1974, 42 U.S.C. §§ 300f—300j-9 (2006).

58. *Trade Practices Act 1974* (Cth) pt IIIA (Austl.), *available at* http://www.austlii.edu.au/au/legis/cth/num_act/tpa1974149.

and burdens. The author questions real property rights and the potential monopoly of underground storage sites, predicts a future carbon tax and trade system, and discusses clean coal, and the use of private capital. This article also includes an outline of other relevant Australian legislation and regulatory issues.

- Ross Ashcroft, *Carbon Capture and Storage: A Need For Re-Conceiving Property Interests And Resource Management In The Australian Legal System*, L. ASIA J. 70 (2008).

This article provides a technical and historical overview of CCS. It analyzes non-legal areas of concern while concentrating on economic issues as well as laws in a wider context, regulation of land interests, and potential regulatory frameworks. The author touches on the Australian *Carbon Pollution Reduction Scheme: The Green Paper*,⁵⁹ common law principles, the Torrens system of land registration, compensation, ownership of carbon dioxide, and new legislation respecting real property. The article identifies property issues, the necessity of a legal framework, and includes further analysis of CCS alongside economic and social concerns as well as potential models for future legislation and regulation. The author concludes that we need to act now, rather than wait, in order to successfully adapt to climate change.

- DEP'T OF THE ENV'T AND HERITAGE, AUSTL. GREENHOUSE OFFICE, PLANNING FOREST SINK PROJECTS: A GUIDE TO LEGAL, TAXATION AND CONTRACTUAL ISSUES (2005).

A detailed sample agreement is included in this practical government publication, which also explains taxation processes, provides a detailed glossary of terms, and determines areas for potential liability. The bulk of this publication is to be used as a formbook as it includes a framework sales contract and detailed sample agreement for taxation respecting carbon sequestration rights intended for tailoring by specific states. This document includes a list of related government publications for further information and provides a history of existing state and commonwealth legislation in Australia, concentrating on the ownership rights surrounding sequestered carbon dioxide.

59. DEP'T OF CLIMATE CHANGE, COMMONWEALTH OF AUSTL., CARBON POLLUTION REDUCTION SCHEME: THE GREEN PAPER (2008).

- MINISTERIAL COUNCIL ON MINERAL AND PETROLEUM RES., DEPT OF RES., ENERGY AND TOURISM, CARBON DIOXIDE CAPTURE AND GEOLOGICAL STORAGE: AUSTRALIAN REGULATORY GUIDING PRINCIPLES 64 (2005) (Austl.).

This government report provides guiding principles for a consistent approach across Australia, including comparative assessments and recommendations, public consultation with many stakeholder groups, and a detailed implementation review for those planning or undertaking a CCS project. The authors set out objectives for the various necessary aspects of planning and implementing CCS projects. This document identifies the need for more detailed regulation and describes the legislative and regulatory process as of 2005 while providing background information, defining CCS, and briefly outlining legislation and regulation in Australian jurisdictions and international projects.

- Barry Barton, *Carbon Capture and Storage Law for New Zealand: A Comparative Study*, 13 N.Z. J. ENVTL. L.J. 1 (2009).

Beginning with an overview of CCS technology and processes, this article analyzes the role CCS can play as part of climate change initiatives for New Zealand. Examples of CCS use in Canada, Australia, the United States, and the European Union are critiqued. The author also analyzes legal topics relating to real property rights, CCS registration, regulation, similarities between CCS and oil and gas operations, and liability while focusing on the storage and disposal processes of CCS. New Zealand legislation is discussed at length, including relationships with legislation from other countries and desired characteristics of new law.

- Yvette Carr, *The International Legal Issues Relating to the Facilitation of Sub-Seabed CO₂ Sequestration Projects in Australia*, 14 AUSTL. INT'L L.J. 137 (2007).

This article discusses international legal issues relating to Australian sub-seabed sequestration projects. The author describes international obligations and their implementation from the perspective of state responsibility and civil liability. This article also outlines the existing state of the law, and

necessary changes for Australian legislation and regulatory frameworks in the short and long terms.

- Nicola Durrant, *Legal Issues in Biosequestration: Carbon Sinks, Carbon Rights and Carbon Trading*, 31 U. N.S.W. L.J. 906 (2008).

Including relevant definitions from the Kyoto Protocol, this article explains the credit system while concentrating on forest and agricultural sequestration methods used in biosequestration. The author describes how biosequestration projects raise legal questions, and contrasts the process for credit generation and carbon rights with carbon permits as temporary measures and permanent emissions reductions.

- Sandra Eckert & Richard McKellar, *Securing Rights to Carbon Sequestration: The Western Australian Experience*, 8 SUSTAINABLE DEV. L. & POL'Y. 30 (2008).

This article identifies the plantation industry for biosequestration over the past ten years as a sustainable industry to help with carbon offsets and re-vegetation initiatives. The article briefly describes carbon sequestration rights under property law, broad legislation and regulation principles, emissions trading, and carbon rights using examples from Western Australia. The authors include a chart for other Australian jurisdictions illustrating carbon rights and their enabling legislation. They also note that carbon rights have been part of contracts for over fifteen years and need separate registration under the Torrens system of land registration.

- Martin Edwards, *Interactions Between Petroleum Operations and Carbon Capture and Storage Options in Australian Offshore Waters*, 26 ENVTL. & PLAN. L.J. 152 (2009).

Risks and liabilities associated with CCS are described briefly in this article as part of existing and developing legislation in the Commonwealth of Australia. The author outlines how legislation will work and identifies expected regulatory directions under the amended Offshore Petroleum Act. This discussion includes an analysis of how CCS legislation will work with petroleum operations, and describes the adverse impact and

public interest tests. This article also outlines the process for states to develop their own legislation, regulations, and policies as part of this framework.

- James Fahey & Rosemary Lyster, *Geosequestration in Australia: Existing and Proposed Regulatory Mechanisms*, 4 J. EUR. ENVTL. & PLAN. L. 378 (2007).

The authors analyze Australian involvement with geosequestration at the international level, in the context of their in-depth overview of relevant Australian legislation by jurisdiction in this article. Key regulatory issues and sources of liability as well as constitutional and legislative powers to regulate onshore and offshore aspects of CCS are identified throughout. Responsibility and liability as derived from Australian common law, state and commonwealth legislation, and international law are also described. The authors identify proposed legislation, including draft amendments to the Offshore Petroleum Act.

- Samantha Hepburn, *Carbon Rights as New Property: The Benefits of Statutory Verification*, 31 SYDNEY L. REV. 239 (2009).

Discussing property law as a common law principle, this article critically examines forestry legislation validating CCS rights as property and tradable offsets in Australia. The author provides an overview of carbon sequestration rights legislation by state for the existing legislative regime, with commentary concentrating on forestry and the proposed Carbon Pollution Reduction Scheme. Property law issues are described as part of strategic approaches to climate change. The various terms used to describe carbon rights from different jurisdictions are clearly identified.

- Chris McGrath, *Regulating Greenhouse Gas Emissions from Australian Coal Mines*, 25 ENVTL. & PLAN. L.J. 240 (2008).

This article outlines the evolving responses respecting coal mines from a scientific and regulatory perspective through concentrating on the Great Barrier Reef and eight cases from Australia and the United States. The author uses the cases to

help explain why coal mines in Australia produce both direct and indirect emissions as they are regulated. He also provides an overview of climate regulation involving CCS.

- Rosemary Rayfuse, *Drowning our Sorrows to Secure a Carbon Free Future? Some International Legal Considerations Relating to Sequestering Carbon by Fertilizing the Oceans*, 31 U. N.S.W. L.J. 919 (2008).

This article focuses on ocean fertilization in domestic and international law. The author discusses the amount of carbon possible to be sequestered in an international legal framework, and notes relevant issues for Australia. She includes analysis of marine versus land-based pollution and sub-seabed sequestration for Australia and Norway. This article includes a brief discussion of transboundary effects, using Australia and the United States as examples, and a general discussion of carbon credits.

- Robin Warner, *Preserving a Balanced Ocean: Regulating Climate Change Mitigation Activities in Marine Areas Beyond National Jurisdiction*, 14 AUSTL. INT'L L.J. 99 (2007).

This article provides an examination of three climate change mitigation activities respecting the law of the sea and marine law beyond national jurisdiction. The author focuses on ocean sequestration within and beyond the national jurisdiction of Australia, and transnational environmental impacts. Potential options are discussed to strengthen environmental protection and lessen risks imposed beyond national jurisdiction, using the regulatory framework of international law in marine areas, international law principles, and the sovereign rights of coastal states. Relevant treaties, conventions, protocols, and regional agreements respecting the high seas, and guidance for states are outlined in detail. The author identifies the need for a national and international regulatory regime and strengthened accountability through declarations and binding instruments.

Canada

- Nigel Bankes, Jennette Poschwatta & E. Mitchell Shier, *The Legal Framework for Carbon Capture and Storage in Alberta*, 45 ALTA. L. REV. 585 (2007).

This article concentrates on legal issues associated with geological storage and disposal, particularly the injection and post-closure phases of CCS. The main barriers to CCS adoption as well as property, regulatory, and liability issues are identified with examples from Alberta, Canada, and on the international front. The authors suggest necessary changes to legislation in order to address regulatory issues such as the need for long-term monitoring. Natural gas storage, enhanced oil recovery, and acid gas disposal operations are described as analogous operations to CCS.

- MARY GRIFFITHS ET AL., CARBON CAPTURE AND STORAGE: AN ARROW IN THE QUIVER OR A SILVER BULLET TO COMBAT CLIMATE CHANGE? A CANADIAN PRIMER (2005).

This non-governmental report provides an analysis of CCS technology and processes with a section addressing policy issues at the provincial, federal, and international levels. The authors provide a brief discussion of specific legal issues from a Canadian perspective and include an extensive, useful glossary of terms.

- Steven A. Kennett, Arlene J. Kwasniak & Alastair R. Lucas, *Property Rights and the Legal Framework for Carbon Sequestration on Agricultural Land*, 37 OTTAWA L. REV. 171 (2005).

Biosequestration is described as an interim strategy for lowering greenhouse gas emissions in the short-term, while focusing on legal building blocks necessary to clarify real property rights respecting CCS. This article outlines six characteristics of real property rights regimes required to support CCS transactions. The authors call for a clear statutory basis for sequestration in Canada while using Australian legislation as an example for carbon rights. This article also contains a glossary of terms.

Europe and the United Kingdom

- Anton Ming-Zhi Gao, *The Application of the European SEA Directive to Carbon Capture and Storage Activities: The Issue of Screening*, 17 EUR. ENERGY & ENVTL. L. REV. 341 (2008).

Legislative issues associated with CCS technologies are addressed in this article, concentrating on the CCS Proposal,⁶⁰ the EIA Directive,⁶¹ and the SEA Directive⁶² by the European Commission. The author identifies the need for more European legislation to be ratified in order to regulate CCS and the emissions trading scheme as well as future applications and programs that should be included in regulation. This article includes a decision-making table to compare processes to the EIA Directive and government policy at all levels of government in the European Union. Relevant regulations, thresholds and exemptions for plans likely to have significant environmental effects, responsible authority, and transboundary transportation are also discussed.

- CLAIR GOUGH & SIMON SHACKLEY, TYNDALL CENTRE FOR CLIMATE CHANGE RESEARCH, AN INTEGRATED ASSESSMENT OF CARBON DIOXIDE CAPTURE AND STORAGE IN THE UK 256 (2005), *available at* http://www.tyndall.ac.uk/sites/default/files/t2_21.pdf.

60. *Proposal for a Directive of the European Parliament and of the Council on the Geological Storage of Carbon Dioxide and Amending Council Directives 85/337/EEC, 96/61/ED, Directives 2000/60/EC, 2001/80/EC, 2006/12/EC and Regulation (EC) No 1013/2006*, COM (2008) 18 final (Jan. 23, 2008), *available at* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0018:FIN:EN:PDF>.

61. Council Directive 85/337, 1985 O.J. (L 175) 40 (EC), *available at* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1985:175:0040:0048:EN:PDF>.

62. *Report from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions on the Application and Effectiveness of the Directive on Strategic Environmental Assessment (Directive 2001/42/EC)*, COM (2009) 469 final, *available at* <http://eur-ex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0469:FIN:EN:PDF>.

This frequently cited non-governmental report is an analysis of policy frameworks, business costs, and geological, environmental, technical, economic and social implications for CCS. It reviews current maritime and climate change laws related to the United Kingdom from an interdisciplinary and multidisciplinary perspective. The authors include a section on the legal aspects of CCS, including long-term monitoring, necessary regulatory framework, risk assessment, and liability. Like the IPCC report, this document builds upon the current ambiguous and unclear legal framework for CCS.

- CHRIS HENDRIKS ET AL., FIELD FOUND. FOR INT'L ENVTL. L. & DEV., *IMPACTS OF EU AND INTERNATIONAL LAW ON THE IMPLEMENTATION OF CARBON CAPTURE AND GEOLOGICAL STORAGE IN THE EUROPEAN UNION* (2005), *available at* http://pdf.wri.org/ccs_impact_of_eu_law_on.pdf.

An analysis of the environmental and safety risks of CCS, this report provides a comprehensive overview of CCS and related legal frameworks in international law and the European Union, and recommends necessary further legislative developments to address these risks. This report restricts its CCS parameters to geological storage and excludes ocean sequestration. The authors include an analysis of the costs and benefits of CCS technology, note the present lack of information on long-term CCS impacts, briefly address jurisdictional issues, and recommend a stand-alone framework rather than amendment of existing regulatory frameworks to include CCS. The report contains an extensive appendix of international instruments and a review of fifty-six international conventions, regional conventions, and European Union Directives respecting CCS activities.

- K. Kavouridis & N. Koukoulzas, *Coal and Sustainable Energy Supply Challenges and Barriers*, 36 *ENERGY POLY* 693 (2008).

The role of coal in Europe is the focus of this article. The authors evaluate challenges and barriers to cleaner coal power through use of CCS and emissions trading, while concentrating on the need to reassess policies relating to the security of European energy supply. The article expresses a legal framework for success which would maintain the balance of energy security

with economic requirements and environmental needs. The authors call for improved technologies and increased efficiency.

- Thomas M. Kerr, *Legal and Regulatory Developments: The Path Forward to Advance Carbon Dioxide Capture and Storage as a Climate Change Solution*, 11 INT'L ENERGY L. & TAX'N REV. 232 (2007).

Short-term and long-term issues in CCS policy are described at length in this article, including how some regulators are developing temporary rules for effective short-term operations in addition to comprehensive rules for long-term monitoring and verification of CCS projects. The article includes suggestions of how CCS can be included in the European Union's Emissions Trading Scheme as a climate change strategy to protect public health and the environment. The author recommends further legal work in the areas of cost recovery, transportation, storage, international efforts, jurisdiction, ownership, real property rights, liability, long-term carbon dioxide retention, monitoring and verification, intellectual property, marine environmental protection instruments, public participation, and national frameworks.

- Robert G. Lee, *Sub-Seabed Carbon Sequestration: Building the Legal Platform*, 30 LIVERPOOL L. REV. 131 (2009).

This article concentrates on ocean sequestration and addresses ocean bed capacities for CCS. The author notes activities pursuant to the Energy Act of 2008,⁶³ and discusses the clean coal consultation document prepared by AEA Technologies for the United Kingdom's Department of Energy and Climate Change.⁶⁴ The article incorporates reviews of technologies, an analysis of legal changes at the international, European Union, and United Kingdom levels, and an exploration of climate change as it pertains to marine protection. The author comments on how quickly legal change respecting CCS has occurred, despite unproven sustainability, due to enthusiasm for the technology

63. Energy Act, 2008, c. 32 (Eng.).

64. ATOMIC ENERGY AUTH. TECH., *FUTURE VALUE OF COAL CARBON ABATEMENT TECHNOLOGIES IN COAL AND GAS POWER GENERATION TO UK INDUSTRY: FINAL REPORT TO THE DEPARTMENT OF ENERGY AND CLIMATE CHANGE* (2010).

and its general political acceptance, and concludes that the viability of CCS depends on regulation and investment. Three mechanisms for CCS activities are described within the Clean Development Mechanism while analyzing the CCS Directive⁶⁵ and its provisions.

- Hans Vedder, *An Assessment of Carbon Capture and Storage Under EC Competition Law*, 29 EUR. COMPETITION L. REV. 586 (2008).

The European Commission's proposal for a directive on the geological storage of carbon dioxide⁶⁶ as well as competition law as it relates to CCS and the transportation of carbon dioxide is analyzed in depth in this article. State subsidies for research and facility construction, installations of CCS, financing of development and infrastructure, coal sector regulation including coal bed methane, and the draft environmental aid guidelines⁶⁷ from the European Commission are outlined. The author provides a detailed discussion of the effect of competition in enhanced oil recovery, gas storage markets, vertical integration in the energy sector, carbon capturers as customers, and access to transportation and storage under the proposed directive. The lack of legal certainty surrounding CCS is also noted.

- Hans Vedder, *An Assessment of Carbon Capture and Storage Under EC Competition Law*, 8 INT'L ENERGY L. REV. 307 (2008).

This article provides an in-depth analysis of the European Union competition and Kyoto Protocol obligations while investigating effects, identifying problems, and proposing solutions for integrating CCS into existing environmental legislation. State aid to finance CCS under European Union legislation and competition law under the proposed directive on

65. Directive 2009/31, *supra* note 48.

66. *Proposal for a Directive of the European Parliament and of the Council on the Geological Storage of Carbon Dioxide and Amending Council Directives 85/337/EEC, 96/61/ED, Directives 2000/60/EC, 2001/80/EC, 2006/12/EC and Regulation (EC) No 1013/2006*, *supra* note 60.

67. Community Guidelines on State Aid for Environmental Protection, 2008 O.J. (C 82) 1 (EU), *available at* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2008:082:0001:0033:EN:PDF>.

the geological storage of carbon dioxide⁶⁸ is also described. The author argues that CCS is considered unprofitable and may trigger government subsidies. A lack of legal certainty relating to the necessity of long-term investment commitments is also noted.

United States

- Owen L. Anderson, *Geologic CO₂ Sequestration: Who Owns the Pore Space?*, 9 WYO. L. REV. 97 (2009).

This article concentrates on issues and incentives surrounding enhanced oil recovery and sub-surface ownership from a property rights perspective. The author examines geological sequestration issues such as lack of existing policy, public acceptance, commercial viability, real property rights, and liability. Legal analogies from the Texas oil and gas industry are used to discuss issues of compensation, trespass, damages, sequestration, and temporary gas storage. Detailed appendices identify ownership of stored carbon dioxide and law related to pore space ownership in other state jurisdictions, and includes annotations of relevant legislation and case law from twelve other states.

- Les L. Baugh & William L. Troutman, *Assessing the Challenges of Geologic Carbon Capture and Sequestration: A California Guide to the Cost of Reducing CO₂ Emissions*, 9 SUSTAINABLE DEV. L. & POL'Y 16 (2009).

The authors propose mechanisms to manage risks associated with CCS while focusing on how California can adapt to initiatives implemented in other jurisdictions to reduce emissions using CCS technologies including processes, ownership of pore space, and potential liabilities. Risks discussed include liability, trespass, nuisance, negligence, and damages. New Australian and American technological initiatives for CCS are mentioned in this article, and ownership issues are noted for six states.

68. *Proposal for a Directive of the European Parliament and of the Council on the Geological Storage of Carbon Dioxide and Amending Council Directives 85/337/EEC, 96/61/ED, Directives 2000/60/EC, 2001/80/EC, 2006/12/EC and Regulation (EC) No 1013/2006*, *supra* note 60.

- Christopher Bidlack, *Regulating the Inevitable: Understanding the Legal Consequences of and Providing for the Regulation of the Geologic Sequestration of Carbon Dioxide*, 30 J. LAND RESOURCES & ENVTL. L. 199 (2010).

States at various stages of drafting and implementing CCS are identified, and their legislation is analyzed in this note. The author confirms the necessity for a strong balance of state and federal regulation, identifies legal issues likely to arise from CCS, and recommends governmental co-operation across jurisdictions. The article includes a regulatory proposal, identification of potential liability and real property rights issues, and a description of existing regulatory schemes under relevant law at the state and federal level. The establishment of an American primacy system for the EPA to allow states to administer federal programs is recommended; this system would be analogous to the Underground Injection Control program of the Safe Drinking Water Act.⁶⁹

- DEPT OF ENG'G & PUB. POL'Y, CARNEGIE MELLON UNIV., CARBON CAPTURE & SEQUESTRATION: FRAMING THE ISSUES FOR REGULATION: AN INTERIM REPORT FROM THE CCSREG PROJECT (2008).

This interdisciplinary project report frames issues for regulators to consider in order to augment regulations promulgated by the EPA. The compilers propose adaptation of regulations throughout projects in order to begin a consultative process for stakeholders creating draft language for future legislation. They identify existing pipeline regulations and jurisdictional issues while proposing necessary changes to legislation and regulation, as well as briefly describing industrial technologies and processes. Other themes of discussion in this report are access and real property rights, federal versus state authority in long-term stewardship, and liability. This report includes an appendix of regulatory and legislative developments in the European Union and Victoria, Australia, as well as American cap-and-trade legislative proposals.

69. Safe Drinking Water Act of 1974, 42 U.S.C. §§ 300f—300j-9 (2006).

- Thomas R. Decesar, Comment, *An Evaluation of Eminent Domain and a National Carbon Capture and Geologic Sequestration Program: Redefining the Space Below*, 45 WAKE FOREST L. REV. 261 (2010).

This Comment focuses on property rights and ownership respecting deep saline aquifers. Issues such as transportation, storage, compensation, takings, and pore space are analyzed. The author advocates for a national system for CCS regulation as part an EPA mandate. He believes that CCS is an emerging technology with potential to assist in reducing emissions, and argues that the EPA is the best place to create and monitor a regulatory scheme and issue permits for companies using CCS.

- Chase E. Dressman, Note, *CO_{who}? Kentucky's Need to Statutorily Define Property Interests in Geologically Sequestered Carbon Dioxide*, 98 KY. L.J. 375 (2009).

Kentucky property issues and associated legal concerns are the focus of this note. The author advocates for a new legislative response to existing ambiguous natural gas laws, rather than an extension of existing legislation and regulation to CCS. New legislation and regulations should require companies to demonstrate the extent of storage facilities, identify types of geological formations, and illustrate minimal weak points for potential future carbon dioxide leakage. The author discusses relevant case law and illustrates the need for Kentucky to adopt government assurances on the liability of stored carbon dioxide.

- Victor B. Flatt, *Paving the Legal Path for Carbon Sequestration from Coal*, 19 DUKE ENVTL. L. & POL'Y F. 211 (2009).

This article reviews existing and necessary legislation at the federal level under President Obama, including regulatory barriers for further discussion and research. The author proposes policies to address some legal issues, focusing on state versus federal administrative jurisdiction, liability, and real property

rights. New comprehensive federal legislation to work with the EPA and state regulators and clarification of jurisdictional terms for storage facilities is requested.

- Kelly Connelly Garry, *Managing Carbon in a World Economy: The Role of American Agriculture*, 9 GREAT PLAINS NAT. RESOURCES J. 18 (2005).

This article outlines how agriculture in the United States can help manage carbon through sequestration. The emergence of CCS in both national and global contexts is described in detail. The author provides a general overview of global warming and the possible reduction of greenhouse gases through forestry management and agricultural practices as well as how land can be adapted for CCS initiatives. Carbon credits and existing programs are also discussed.

- Alexander Gillespie, *Sinks and the Climate Change Regime: The State of Play*, 13 DUKE ENVTL. L. & POL'Y F. 279 (2002).

This article offers an explanation of why the UNFCCC Conference of the Parties talks collapsed when the United States left negotiations over the issue of carbon sinks. The pros and cons of the technical processes and IPCC recommendations are described in detail in this article. Bilateral projects between developed and developing countries are noted, with a concentration on forestry, biosequestration, and terrestrial sequestration methods of CCS. International agreements are analyzed generally with an in-depth discussion of changes in the UNFCCC, and related instruments such as the Kyoto Protocol, and Land Use, Land-Use Change and Forestry.

- Peter S. Glaser et al., *Global Warming Solutions: Regulatory Challenges and Common Law Liabilities Associated with the Geologic Sequestration of Carbon Dioxide*, 6 GEO. J.L. & PUB. POL'Y 429 (2008).

Legal issues relating to how and whether to regulate, determining ownership of carbon dioxide and geologic formations, and liability are addressed in detail in this article. The authors provide background information on technical aspects of CCS processes, risks, existing and future regulation, real property

rights, surface and sub-surface tort liability, future remedies, and *Massachusetts v. EPA*.⁷⁰ They note that the Underground Injection Control program of the Safe Drinking Water Act is insufficient for CCS due to a lack of sufficient monitoring alongside the process for new EPA rules, and propose the creation of a new regulatory regime for CCS use in the United States.

- Blayne N. Grave, Comment, *Carbon Capture and Storage in South Dakota: The Need for a Clear Designation of Pore Space Ownership*, 55.1 S.D. L. REV. 72 (2010).

This comment describes CCS, climate change, and sub-surface property rights for South Dakota. An overview of legislation is included, addressing the actions of three nearby states as well as the proposed EPA regulation of geological sequestration⁷¹ and the Interstate Oil and Gas Compact Commission (IOGCC) model act.⁷² The author argues that the EPA cannot determine storage rights, and explains that ownership of sub-surface storage space respecting property rights must be regulated in order to provide clarity for the CCS program.

- Stephanie M. Haggerty, *Legal Requirements for Widespread Implementation of CO₂ Sequestration in Depleted Oil Reservoirs*, 21 PACE ENVTL. L. REV. 197 (2003).

Beginning with a general overview of climate change and the impacts of fossil fuels, this article concentrates on carbon sequestration in geologic formations while describing CCS projects under the Underground Injection Control program of the Safe Drinking Water Act. The author provides recommendations for essential revisions to current statutes in the United States as well as to the UNFCCC, ultimately proposing that a new agency should be created to manage CCS activities at the federal level.

70. *Massachusetts v. EPA*, 549 U.S. 497 (2007).

71. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO₂) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43,492-01 (July 25, 2008) (codified at 40 C.F.R. pts. 144 & 146).

72. INTERSTATE OIL & GAS COMPACT COMM'N, 2004 MODEL UNDERGROUND GAS STORAGE PROVISIONS (2004), available at <http://www.iogcc.state.ok.us/Websites/iogcc/docs/ModelUGSAct-June2004.pdf>.

This article includes discussion of CCS and enhanced oil recovery processes and operations, economic feasibility and incentive programs, and environmental effects from potential leaks on health and drinking water.

- Delissa Hayano, *Guarding the Viability of Coal & Coal-fired Power Plants: A Road Map for Wyoming's Cradle to Grave Regulation of Geologic CO₂ Sequestration*, 9 WYO. L. REV. 139 (2009).

Wyoming's pioneering legislation is argued to be a step in the process of widespread adaptation of geologic sequestration in the United States. This article focuses on how it helps coal processing plants. The article describes five categories of CCS and analyzes CCS legislation in eleven states. The author argues that in developing statutory and regulatory frameworks, the drafters must keep the national interest in mind, noting that Wyoming's legislation lacks this scope, and identifies challenges, including real property rights, for legislators and regulators.

- K.E. Hughes & Richard E. Matheny, *The Carbon Capture and Sequestration Provisions of HR-2454: The American Clean Energy and Security Act of 2009*, OIL, GAS & ENERGY Q. 237 (Dec. 2009).

This article outlines the components and provisions of a national strategy and development of a legal and regulatory framework coordinated with existing federal and state laws. It concentrates on assessing the CCS aspects of the proposed American Clean Energy and Security Act of 2009⁷³ and the proposed CCS-related amendments to the Clean Air Act⁷⁴ and Safe Drinking Water Act.⁷⁵ The authors engage in an in-depth description of the new industry-funded Carbon Storage Research Corporation, including its mission to facilitate research and develop economically feasible and safe CCS technologies in order to manage climate change for future generations.

73. American Clean Energy and Security Act, H.R. 2454, 111th Cong. (2009).

74. Clean Air Act of 1970, 42 U.S.C. §§ 7401—671 (2006).

75. Safe Drinking Water Act of 1974, 42 U.S.C. §§ 300f—300j-9 (2006).

- Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change and Carbon Sequestration: Assessing a Liability Regime for Long-Term Storage of Carbon Dioxide*, 58 EMORY L.J. 103 (2008).

The balance between risks and benefits with potential legal liability for CCS projects is the focus of this article. The authors endeavor to clarify liability issues for the existing CCS industry and note the necessity for different rules relating to CCS projects in the short- and long-terms. The article provides an outline of liability under existing laws and policies, a summary of the role of federal and state governments, and a survey of mechanisms to ensure financial responsibility, in an attempt to guide policymakers on future liability issues. The authors concentrate on liability and funding issues using existing federal mechanisms to ensure timely compensation, as well as incentives for responsible risk management and the best American site selection.

- Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change, Carbon Sequestration, and Property Rights*, 2010 U. ILL. L. REV. 363 (2010).

This article looks at the role of real property rights in the development of the CCS industry, concentrating on sub-surface rights and pore space with oil and gas industry examples. The authors analyze mineral rights, private versus public ownership, physical and regulatory takings in the public interest, and just compensation. The article addresses proposed areas for federal legislation, and federal implementing authority for CCS use in the United States. A review of case law and legislation respecting air space, surface and sub-surface property rights, and federal versus state policies is included, as well as a comprehensive table of existing state legislation and regulation related to CCS and property rights.

- Alexandra B. Klass & Sara E. Bergan, *Carbon Sequestration and Sustainability*, 44 TULSA L. REV. 237 (2008).

This article analyzes two existing scientific studies identifying CCS as critical for reducing emissions and meeting growing energy needs, and concludes that there is little chance of

meeting necessary emission targets without CCS. The article identifies four existing CCS projects in the United States, and through this lens provides a detailed description of the role and sustainability of CCS. Potential risks involved with CCS are also discussed. The authors note public perception as an ongoing obstacle to CCS implementation and question its effects on drinking water. They also query whether CCS will delay more sustainable energy sources and foster continued dependence on coal, and discuss the impact of CCS on future generations.

- Philip M. Marston & Patricia A. Moore, *From EOR to CCS: The Evolving Legal and Regulatory Framework for Carbon Capture and Storage*, 29 ENERGY L.J. 421 (2008).

This article looks at existing policy and legislation in the United States for enhanced oil recovery projects as the model to create policies and laws respecting CCS. It includes an overview of existing state policy and legislation and current debates about regulation of the new CCS industry while using existing infrastructure. The authors discuss the model statute and rules drafted by the IOGCC, the process and legal framework of capturing and storing carbon dioxide from coal-fired power plants, jurisdictional status, regulation under state law, and the role and requirements of the EPA. Existing state CCS legislation from Texas, Wyoming, Mississippi, and Oklahoma is also identified.

- Jeffrey W. Moore, *The Potential of On-shore Geologic Sequestration of CO₂ Captured from Coal-fired Power Plants*, 28 ENERGY L.J. 443 (2007).

This article outlines the legislative and regulatory regime relating to CCS from a technical perspective, in light of *Massachusetts v. EPA*.⁷⁶ The author maintains that current laws do not adequately address CCS, and concludes that carbon dioxide injection should be considered for exemption from the Resource Conservation and Recovery Act's hazardous waste

76. *Massachusetts v. EPA*, 549 U.S. 497 (2007).

regulations.⁷⁷ Several statutes are analyzed in this article, using a risk-based regulatory approach.

- Larry Nettles & Mary Conner, *Carbon Dioxide Sequestration — Transportation, Storage, and Other Infrastructure Issues*, 4 TEX. J. OIL, GAS & ENERGY L. 27 (2008).

As regulations and legislation of CCS is in its infancy, this article includes a description of proposed EPA regulations, identifies sites for storage, describes different testing and monitoring requirements for fifty years following site closure, and describes the technical aspects of CCS. The authors argue the need for a “carbon revolution” for CCS and enhanced oil recovery to clarify real property rights respecting ownership and long-term liability. The article provides a brief explanation of the United States Geological Service studies relating to CCS, the role of states in the CCS implementation process, and CCS-related legislation in selected states.

- Robert R. Nordhaus & Emily Pitlick, *Carbon Dioxide Pipeline Regulation*, 30 ENERGY L.J. 85 (2007).

This article focuses on federal regulation of emissions and CCS, concentrating on carbon dioxide pipeline transportation in Texas and New Mexico. The authors provide background information, and discuss current United States federal and state law, areas for reform, and alternate regulatory frameworks. They also identify areas for further study and evaluation. Legal issues and examples addressed include transportation infrastructure, jurisdiction, enabling legislation, safety regulation, rate regulation, siting authority, nondiscriminatory access, and alternative regulatory frameworks.

- Patrick Parenteau, *Go Back, It's a Trap! On the Perils of Geologic Sequestration of CO₂* (May 27, 2009) (Vermont Law School Research Paper No. 09-19).

77. See Resource Conservation and Recovery Act, 42 U.S.C. §§ 6901—6987, 9001—9010 (2006); see also Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes, 53 Fed. Reg. 25,446 (July 6, 1988).

This author is not supportive of the coal industry, or of the use of CCS, due to its potential environmental and health effects. Concerns over CCS investment at the expense of renewable energy sources are detailed in this article, as the author questions whether carbon dioxide is a commodity, a waste, or both. The author outlines issues relating to capture, transport, storage and water use, economic issues, new manufacturing plants being built as capture-ready, regulatory issues, long-term liability, financial responsibility, cap-and-trade systems, public acceptance, and ethical implications. EPA technical issues are briefly identified as part of the discussion on the lack of a comprehensive regulatory framework for CCS and forthcoming legislation in three states.

- Will Reiseinger et al., *Reconciling King Coal and Climate Change: A Regulatory Framework for Carbon Capture and Storage*, 11 VT. J. ENVTL. L. 1 (2009).

Providing a framework for global climate change, this article describes technical details on CCS processes and incorporates a detailed outline of legal and regulatory barriers faced by CCS. A model regulatory framework to facilitate the development and growth of the CCS industry, including rules to govern real property rights, liability, and monitoring is presented. The author provides a survey of existing law and regulation as well as proposed state laws respecting CCS. Recommendations focus on property rights and a system to limit liability while encouraging private industry to develop CCS operations.

- David Schwartz, *The Natural Gas Industry: Lessons for the Future of the Carbon Dioxide Capture and Storage Industry*, 19 STAN. L. & POL'Y REV. 550 (2008).

This article presents an overview of the issue of ownership in the CCS industry, as well as economic feasibility of CCS use, and a discussion of how the industry will be regulated. The natural gas industry and its regulation are used as a case study in a description of legal issues surrounding pipelines, market centers, storage, and regulation. The author argues that retrofitting and storage of existing plants and technologies is the most necessary step in the CCS process, while noting continuing legal uncertainties over regulatory hurdles. This article concludes

with lessons learned from the natural gas industry as an analogy for CCS.

- Ann Brewster Weeks, *Subseabed Carbon Dioxide Sequestration as a Climate Mitigation Option for the Eastern United States: A Preliminary Assessment of Technology and Law*, 12 OCEAN & COASTAL L.J. 245 (2006).

This article questions the permissibility of sub-seabed sequestration under American and international law as part of an analysis of the international legal framework on ocean dumping under the London Protocol⁷⁸ Amendments and the Marine Protection, Research and Sanctuaries Act of 1972.⁷⁹ The article contains statistics describing emissions from the United States, and identifies the electricity industry as the major source of carbon dioxide emissions. An overview of recent policy and legislative directives is provided. The author calls for Congress to fix ambiguous language in existing legislation, and attempts to reconcile future carbon constraints by identifying various geological sequestration options and studies.

REPORTS WORTH NOTING

Several government, inter-governmental, or non-governmental reports are important to developing the legal framework of CCS as a climate change mitigation option. As these are more general in nature, they are listed below without annotation. Many are guidelines or technical documents, and often contain excellent glossaries and useful abbreviation or acronym guides.

GOV'T OF ALTA., TALK ABOUT CARBON CAPTURE & STORAGE (2009), *available at* http://www.energy.alberta.ca/Org/pdfs/FactSheet_CCS.pdf.

CARBON RIGHTS TASKFORCE, CONSERVATION COUNCIL OF W. AUSTL., CARBON RIGHTS IN WESTERN AUSTRALIA (2001).

⁷⁸ London Protocol, *supra* note 29.

⁷⁹ Marine Protection Research and Sanctuaries Act of 1972, 33 U.S.C. §§ 1401—45 & 16 U.S.C. §§ 1431—45 (2006).

DEPT OF THE ENV'T AND WATER RES., AUSTL. GREENHOUSE OFFICE, GREENHOUSE FRIENDLY FOREST SINK ABATEMENT PROJECTS (2007).

THE LAW SOC'Y OF W. AUSTL., CARBON RIGHTS: KYOTO AND BEYOND (2008).

HUGH SADDLER ET AL., GEOSEQUESTRATION: WHAT IT IS AND HOW MUCH CAN IT CONTRIBUTE TO A SUSTAINABLE ENERGY POLICY FOR AUSTRALIA? (2004).

Memorandum from Cynthia C. Dougherty, Director, EPA Office of Ground Water and Drinking Water & Brian McLean, Director, EPA Office of Atmospheric Programs, Using the Class V Experimental Technology Well Classification for Pilot Geologic Sequestration Projects – UIC Program Guidance (UICPG#83) (Mar. 1, 2007), *available at* http://www.epa.gov/ogwdw/uic/pdfs/guide_uic_carbonsequestration_final-03-07.pdf.

SONJA NOWAKOWSKI, MONT. ENERGY AND TELECOMMC'NS. INTERIM COMM., CARBON SEQUESTRATION STUDY: AN ANALYSIS OF GEOLOGICAL AND TERRESTRIAL CARBON SEQUESTRATION REGULATORY AND POLICY ISSUES (2008).

ELIZABETH A. BURTON ET AL., CAL. ENERGY COMM'N & DEP'T OF CONSERVATION, GEOLOGIC CARBON SEQUESTRATION STRATEGIES FOR CALIFORNIA: REPORT TO THE LEGISLATURE (2008).

MCKINSEY GLOBAL INST., THE CARBON PRODUCTIVITY CHALLENGE: CURBING CLIMATE CHANGE AND SUSTAINING ECONOMIC GROWTH (2008).

DEP'T OF CLIMATE CHANGE, COMMONWEALTH OF AUSTL., CARBON POLLUTION REDUCTION SCHEME: THE GREEN PAPER (2008).

ATT'Y GEN. DEP'T, COMMONWEALTH OF AUSTL., CARBON POLLUTION REDUCTION SCHEME: AUSTRALIA'S LOW POLLUTION FUTURE: WHITE PAPER: VOLUME 2 (2008).