Carbon Down Under—Lessons from Australia: Two Recommendations for Clarifying Subsurface Property Rights to Facilitate Onshore Geologic Carbon Sequestration in the United States

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> *Our situation is almost desperate; but there are some chances of deliverance, and it is these that I am considering. If at every instant we may perish, so at every instant we may be saved. Let us then be prepared to seize upon the smallest advantage.*
>
> Jules Verne[1]

I. INTRODUCTION

At current production rates, Australia will not exhaust its coal reserves until after the year 3023.[2] Although this fact bodes well for energy independence, coal-fired power plants account for approximately thirty percent of Australia's total greenhouse gas (GHG) emissions annually.[3] Similarly, the United States is the world's second largest producer of coal,[4] and more than thirty percent of domestic carbon dioxide (CO_2) emissions[5] are generated by coal-fired power plants.[6] Within the context

1. JULES VERNE, JOURNEY TO THE CENTER OF THE EARTH 219 (Sterling Publ'g 2007) (1864).

2. H.R. STANDING COMM. ON SCI. AND INNOVATION, BETWEEN A ROCK AND A HARD PLACE: THE SCIENCE OF GEOSEQUESTRATION 8–9 (Austl. 2007) [hereinafter BETWEEN A ROCK], *available at* http://www.aph.gov.au/house/committee/scin/geosequestration/report/fullreport.pdf. Australia houses 78,500 million tons of black coal reserves which, at current production levels, would last 215 years. *Id.* at 8. Additionally, Australia has 53,000 million tons of brown coal reserves, which, at current production levels, would last over 800 years. *Id.* at 8–9.

3. *Id.* at 9.

4. WORLD COAL INST., COAL FACTS (2008) [hereinafter WORLD COAL INST.], *available at* http://www.worldcoal.org/bin/pdf/original_pdf_file/coalfacts2008(04_06_2009).pdf.

5. Jeffrey W. Moore, *The Potential Law of On-Shore Geologic Sequestration of CO_2 Captured from Coal-Fired Power Plants*, 28 ENERGY L.J. 443, 446 (2007).

6. Other large sources of CO_2 emissions include natural gas-fired power plants, cement plants and oil refineries. CAL. ENERGY COMM'N, GEOLOGIC CARBON SEQUESTRATION STRATEGIES FOR CALIFORNIA, REPORT TO THE LEGISLATURE, CEC-500-2007-100-SF, at 5 (2007) [hereinafter CEC REPORT], *available at* http://www.energy.ca.gov/2007publications/CEC-500-2007-100/CEC-500-2007-100-SF.PDF.

of climate change,[7] such emissions are incongruent with the near-global consensus that anthropogenic GHG emissions must be drastically reduced and stabilized in order to avoid catastrophic climate changing repercussions.[8]

Mitigating anthropogenic emissions requires a suite of technologies and policies.[9] Carbon capture and sequestration (CCS) "has the flexibility to achieve [CO_2] reductions in many locations and major economic sectors."[10] Importantly, a type of CCS, geologic sequestration (GS), simply involves modifying *existing technology* to serve a new purpose.[11] In particular, CCS has the potential to mitigate GHG emissions from the sectors that contributed to the largest growth in emissions from 1970 to 2004.[12] Applying this technology to large point-source emitters[13] such as coal- and natural gas-fired power plants, cement plants, and oil refineries would significantly reduce emissions[14] and align with the global push toward climate stabilization.[15]

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7. *See* John C. Dernbach & Seema Kakade, *Climate Change Law: An Introduction*, 29 ENERGY L.J. 1 (2008) (discussing the emerging law of climate change); Shi-Ling Hsu, *A Realistic Evaluation of Climate Change Litigation Through the Lens of a Hypothetical Lawsuit*, 79 U. COLO. L. REV. 701 (2008) (analyzing possible future climate change litigation).

8. *See generally* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT 43–54 (2007) [hereinafter IPCC], *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (detailing information regarding the impacts of future climate change).

9. U.N. ENV'T PROGRAMME, DIV. FOR ENVTL. CONVENTIONS, CAN CARBON DIOXIDE STORAGE HELP CUT GREENHOUSE EMISSIONS?, A SIMPLIFIED GUIDE TO THE IPCC'S "SPECIAL REPORT ON CARBON DIOXIDE CAPTURE & STORAGE" 1 (2006) [hereinafter UNEP], *available at* http://www.unep.org/DEC/docs/CCS_guide.pdf.

10. CEC REPORT, *supra* note 6, at 6.

11. CCS technology is currently used in enhanced oil and gas recovery and enhanced coal bed methane production. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CARBON DIOXIDE CAPTURE AND STORAGE 261–63 (Bert Metz et al. eds., 2005) [hereinafter SPECIAL REPORT], *available at* http://www.ipcc.ch/pdf/special-reports/srccs/srccs_wholereport.pdf. This involves injecting CO_2 into mature wells in an effort to squeeze out the remaining gas or oil. *Id.* at 199. This technology has been utilized in Texas since the 1970s. *Id.*

12. IPCC, *supra* note 8, at 36. Aside from energy supply and industry (where CCS is feasible), transportation (where CCS is not feasible) was another large contributor. *Id.*

13. Anthropogenic GHG emissions have increased by 70% since pre-industrial times. *Id.* at 36, 50.

14. It may be argued that CCS is a coal-enabling technology. Because coal is abundant and inexpensive when compared to natural gas-fired power plants, nuclear power plants and renewable energy sources, it generates forty percent of the world's electricity. WORLD COAL INST., *supra* note 4. An immediate transition from coal to renewable electricity generation, for example, is unlikely to occur due to the cost differential.

15. As Socolow and Pacala conceptualized with their "wedge" approach to stabilization of CO_2 in the atmosphere, CCS could account for one "wedge" or the reduction of 25

Despite growing global attention that "CCS *could be* an important component of the broad portfolio of policies and technologies" needed to successfully address climate change at least cost,[16] large-scale deployment is unlikely in the current legal and regulatory vacuum. According to the Intergovernmental Panel on Climate Change (IPCC),[17] "CCS is technologically feasible" and could significantly reduce GHGs over the next century,[18] but not without a well-designed legal and regulatory framework.[19] Clearly identified property rights for geologic sequestration in subsurface formations[20] are central to such a framework. In particular, there must be a clear answer to the question: who owns the subsurface formations within which CO_2 will be sequestered indefinitely?

Since private investment in GS technology is not likely in the current legal vacuum, this comment concludes by recommending two regulatory approaches to allocate subsurface ownership rights and help facilitate GS in the U.S. The first recommendation is to follow the Victoria, Australia model and allocate GS-suitable subsurface formation property rights to the individual states. Alternatively, the second recommendation

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billion tons of carbon over fifty years. Robert H. Socolow & Stephen W. Pacala, *A Plan to Keep Carbon in Check*, SCI. AM., Sept. 2006, at 50–54. The difference between carbon emissions levels in 2056 under the business as usual scenario (14 billion tons per year) as compared with levels in 2056 if emissions are held constant at 2006 levels (7 billion tons per year) is divided into seven wedges. *See id.* Each wedge represents a reduction of 25 billion tons of carbon over fifty years. *Id.* at 53. One wedge is equivalent to the avoided emissions resulting from installing CCS technology at 800 large coal-fired power plants. *See id.*

16. UNEP, *supra* note 9, at 18 (emphasis added).

17. The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. Review by experts and governments is an essential part of the IPCC process. The Panel does not conduct new research, monitor climate-related data or recommend policies. It is open to all member countries of WMO [World Meteorological Organization] and UNEP [United Nations Environmental Programme].

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 16 YEARS OF SCIENTIFIC ASSESSMENT IN SUPPORT OF THE CLIMATE CONVENTION (2004), *available at* http://www.ipcc.ch/pdf/10th-anniversary/anniversary-brochure.pdf.

18. UNEP, *supra* note 9, at 17.

19. *Id.*

20. Subsurface formations include saline reservoirs, aquifers, pore space and other subsurface geologic formations suitable for geologic carbon sequestration. "Geologically speaking, aquifers are formations of sandstone, limestone and other porous rock deep in the earth. Such rock has many pores and the pores contain salty water, also called brine. The rock is permeable, which means water can be taken out and CO_2 and other gases can be injected." Cheryl Pellerin, Carbon Sequestration Technology Could Help Slow Global Warming (Dec. 14, 2004), http://www.america.gov/st/washfile-english/2004/December/20041214085757lcnirellep0.3161585.html.

requires amending state mineral law to specifically address GS-suitable subsurface formations as a new mineral resource.[21]

This comment's analysis requires a few necessary assumptions. First, the feasibility of large-scale deployment of geologic CCS technology for the purposes of permanently storing CO_2 is assumed.[22] Second, the establishment of a regulatory framework with incentives to mitigate or offset GHGs is assumed.[23] Third, the carbon-capture technology retrofitting of point-source emitters is assumed. And finally, the existence of infrastructure to transport supercritical CO_2 to a storage site is assumed.

This Comment contains five parts: Part I provides an introduction and overview to contextualize the need for CCS; Part II details the technology of GS; Part III is an overview of Australia's activities related to CCS—specifically, the Victorian model of GS regulation; Part IV discusses CCS-related activity in the United States and analyzes bodies of law that inform a discussion of subsurface property rights; and Part V synthesizes the prior sections and details two recommendations for the United States.

II. THE TECHNOLOGY OF CARBON CAPTURE AND SEQUESTRATION

Familiarity with the technical aspects of CCS is essential to properly understand the legal property rights interests implicated by GS. Three

21. This Comment is concerned with clarifying subsurface property rights as they relate to subsurface formations. Although it is beyond the scope of this Comment, clarifying ownership to subsurface formations will have the added benefit of facilitating identification of owners for the purposes of assigning liability for leakage and other environmental damage.

22. This appears to be a legitimate assumption in light of the three currently operational sequestration projects: Sleipner, Weyburn, and In Salah. *See infra* Part II.

23. In such a scenario, the government enforces penalties for GHG emissions greater than a certain established threshold, rendering CCS an appealing mitigation strategy. For example, in California the Air Resources Board's Proposed Scoping Plan has indicated that a cap and trade program is a possibility. CAL. AIR RES. BD., CLIMATE CHANGE PROPOSED SCOPING PLAN 27 (2008), http://www.arb.ca.gov/cc/scopingplan/document/psp.pdf. Without such a mandatory framework, the business-as-usual scenario results in unconstrained emissions. For the purposes of this analysis it is immaterial whether the framework ultimately pursued by the government takes the form of a "carbon tax" or implementation of a "carbon trading scheme." But it is important to note that the "credits" conferred to a firm for sequestering carbon via geologic sequestration are a separate issue from ownership issues surrounding subsurface formations that are suitable for such sequestration.

commonly understood approaches to CCS currently exist: terrestrial,[24] subseabed,[25] and geologic. In general, terrestrial sequestration involves utilizing vegetation and soil as carbon sinks[26] to result in the "net removal of CO_2 from the atmosphere or the prevention of CO_2 net emissions from the terrestrial ecosystems into the atmosphere."[27] Subseabed[28] sequestration generally involves injecting CO_2 into subseabed formations for storage.[29]

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24. Terrestrial sequestration is also known as biologic sequestration. For more information on Biologic and Agricultural sequestration, see generally Steven A. Kennett et al., *Property Rights and the Legal Framework for Carbon Sequestration on Agricultural Land*, 37 OTTAWA L. REV. 171 (2005–2006); Kelly Connelly Garry, *Managing Carbon in a World Economy: The Role of American Agriculture*, 9 GREAT PLAINS NAT. RESOURCES J. 18 (2005).

25. For more information on subseabed carbon sequestration, see generally Ray Purdy, *The Legal Implications of Carbon Capture and Storage Under the Sea*, 7 SUSTAINABLE DEV. L. & POL'Y 22 (2006). Amendments to the London Convention have created a basis "in international environmental law to regulate" CCS "in sub-seabed geological formations, for permanent isolation . . . ." Press Release, International Maritime Org., New International Rules to Allow Storage of CO_2 Under the Seabed (Feb. 9, 2007), http://www.imo.org/Newsroom/mainframe.asp?topic_id=1472&doc_id=7772. For an overview of the London Convention, see Tom Kerr, Energy Technology Office, International Energy Agency, Update on CCS International Legal & Regulatory Issues, slides 9–14 (2008), http://www.iea.org/textbase/speech/2008/tk_seeril.pdf.

26. A carbon sink is "a reservoir that absorbs or takes up released carbon from another part of the carbon cycle." Energy Information Administration, Glossary: Energy-Related Carbon Emissions, http://www.eia.doe.gov/emeu/efficiency/carbon_emissions/glossary.html (last visited Apr. 22, 2010).

27. U.S. Dept. of Energy, Terrestrial Sequestration Research, http://www.fossil.energy.gov/programs/sequestration/terrestrial/index.html (last visited Apr. 22, 2010).

28. Another proposed sequestration method involves:

> [T]he introduction of liquid CO_2 from ships or pipelines . . . [for] CO_2 dispos[al] at depths greater than 3000m [in the ocean] is expected to sink and form a 'lake' on the seabed . . . [however] assumptions that disposal in this manner would lead to effective [long-term] isolation of CO_2 from the atmosphere over very long time-scales may be flawed.

PAUL JOHNSTON ET AL., OCEAN DISPOSAL/SEQUESTRATION OF CARBON DIOXIDE FROM FOSSIL FUEL PRODUCTION AND USE: AN OVERVIEW OF RATIONALE, TECHNIQUES AND IMPLICATIONS 7 (1999), *available at* http://archive.greenpeace.org/politics/co2/co2dump.pdf. "[B]ecause of ocean currents and local supersaturation, a large fraction of the injected CO_2 will be released to the atmosphere after a few hundred years." Kurt Zenz House et al., *Permanent Carbon Dioxide Storage in Deep-Sea Sediments*, 103 PROC. NAT'L ACAD. SCI. 12291, 12291 (2006), *available at* http://www.pnas.org/content/103/33/12291.full.pdf. However, the risks of such a method are high and "offshore disposal, where CO_2 is stored directly in the seas, is . . . no longer seen as a politically acceptable or favored method of disposal." Purdy, *supra* note 25, at 22. Additionally, dissolving CO_2 in the ocean is thought to result in ocean acidification. Science Daily.com, Ocean Acidification: Another Undesired Side Effect of Fossil Fuel-Burning (May 24, 2008), http://www.sciencedaily.com/releases/2008/05/080521105251.htm.

29. For an analysis of the legal implications of subseabed sequestration, see generally 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, 245 (2007).

And finally, GS involves injecting CO_2 into subsurface formations for storage.

GS is a three-step process: "capture, transport and storage."[30] Step one is "separation of CO_2 from industrial and energy-related sources"; step two is "transport to a storage location"; and step three is "long-term isolation from the atmosphere."[31] Of these three steps, this comment focuses solely on a subset of the third: the subsurface formations within which CO_2 will be stored indefinitely.

For GS, CO_2 is first captured at the point source[32] of emissions.[33] Next, it is purified[34] and compressed to a supercritical state where it maintains properties of both a liquid and a gas.[35] Finally, the supercritical CO_2 is injected at least 800m (2625 ft) below the surface of the earth where it is to remain sequestered indefinitely.[36] Current estimated underground capacity ranges between 1157 and 4017 billion metric tons within the United States and Canada[37] and approximately 740 billion

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30. UNEP, *supra* note 9, at 8.

31. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, IPCC SPECIAL REPORT, CARBON DIOXIDE CAPTURE AND STORAGE, SUMMARY FOR POLICY MAKERS, A SPECIAL REPORT OF WORKING GROUP III OF THE IPCC 3 (2005), http://www.ipcc.ch/pdf/special-reports/srccs/srccs_summaryforpolicymakers.pdf.

32. A point source is an emitter. *See* UNEP, *supra* note 9, at 2, 8. For example, cement and oil refineries and natural gas and coal-fired power plants are point-source emitters. *See id.*

33. There are four main types of CO_2 capture systems: industrial process streams, post-combustion, pre-combustion and oxyfuel combustion. *See generally* SPECIAL REPORT, *supra* note 11, at 108.

34. Moore, s*upra* note 5, at 452.

35. *Id*.

36. Memorandum from Cynthia C. Dougherty, Director of Office of Ground Water and Drinking Water & Brian McLean, Director of Office of Atmospheric Programs to Water Management Division Directors, Air Division Directors & EPA Regions I to X, Using the Class V Experimental Well Technology Classification for Pilot Geologic Sequestration Projects, UIC Program Guidance (UICPG #83) 8 (March 2007), *available at* http://www.epa.gov/ogwdw000/uic/pdfs/guide_uic_carbonsequestration_final-03-07.pdf. Note, however, that in July of 2008 the EPA proposed Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells Proposed Rule for public review and comment. Press Release, Env'tl Protection Agency, EPA Lays Groundwork for Promising Technologies to Help Mitigate Climate Change (Jul. 15, 2008), *available at* http://yosemite.epa.gov/opa/admpress.nsf/0/D35B72DFE481043B85257487005E47CD. It appears as though the EPA contemplates that class VI Wells will be for large-scale deployment of CCS and be required to go through the UIC permitting process. *See infra* Part IV.B.

37. NAT'L ENERGY TECH. LABORATORY, DEPT. OF ENERGY, CARBON SEQUESTRATION ATLAS OF THE UNITED STATES AND CANADA 13–15 (2007) [hereinafter CARBON ATLAS], http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlas/ATLAS.pdf.

metric tons in Australia.[38] By comparison, a single "wedge," as contemplated by Socolow and Pacala, represents the reduction of 25 billion metric tons of carbon over fifty years.[39] This represents the potential to store up to 160 "wedges" of CO_2 in just the United States and Canada alone.[40] GS represents a significant opportunity for GHG mitigation should the technology be implemented on a widespread scale.

There are three main options for geologic carbon sequestration: depleted oil and gas reservoirs, un-mineable coal seams, and saline formations.[41] This comment focuses solely on saline formations.[42] Saline formations[43] represent the world's most abundant sequestration option,[44] especially in the United States (80–93%)[45] and Australia (94%).[46] According to the IPCC, worldwide capacity is sufficient to store "tens to hundreds of years of CO_2 emissions at current levels."[47] And "saline

38. BETWEEN A ROCK, *supra* note 2, at 33. Additionally, 94% of feasible geological storage capacity in Australia is in deep saline aquifers. *Id.* at *x*. By comparison, Australia is projected to emit 837 million tons of CO_2 annually. *Id.* at 9. Tonnes are equivalent to metric tons; for consistency, metric tons will be used throughout the Comment. Metric System of Measurement: Interpretation of the International System of Units for the United States, 63 Fed. Reg. 40338 (July 28, 1998), *available at* http://ts.nist.gov/WeightsAndMeasures/Metric/upload/SIFedReg.pdf.

39. Socolow & Pacala, *supra* note 15, at 52.

40. Author's calculations. High range of U.S. and Canadian capacity (4017 billion metric tons) divided by one "wedge" as contemplated by Socolow and Pacala (25 billion metric tons). *Id.*

41. Sierra Club, The Basics of Carbon Capture and Sequestration 1 (Apr. 2008), http://www.sierraclub.org/energy/factsheets/basics-sequestration.pdf.

42. Since saline formations have the most significant GS capacity in Australia and the United States, it is the author's opinion that most attention will be paid to establishing the legal framework surrounding them. Since coal seams and depleted oil and gas fields are typically already "owned," it is unlikely that ownership questions of first impression will arise with the deployment of GS in those locations. Additionally, saline formations comprise somewhere between 919–3724 billion metric tons of storage capacity, whereas depleted oil and gas fields and coal seams combined account for only 238.5–293.7 billion metric tons of possible storage capacity. CARBON ATLAS, *supra* note 37, at 13–15. Note: author calculated statistics by aggregating the "low" estimates as the "low" end of the range and aggregating the "high" estimates as the "high" end of the range.

43. "More research is needed . . . at this point, little is known . . . ." Sierra Club, *supra* note 41, at 1; BETWEEN A ROCK, *supra* note 2, at 32 ("CO_2 storage in saline formations . . . [is] considered to be the most promising location for long-term underground storage of CO_2. CSIRO, [Commonwealth Scientific and Industrial Research Organization] universities and other parties . . . are currently engaged in . . . research on the use of saline aquifers for long-term, permanent storage.").

44. Nat'l Energy Tech. Lab., Dept. of Energy, Carbon Sequestration Technology Roadmap and Program Plan 2007 at 1 (2007) [hereinafter NETL], http://www.netl.doe.gov/technologies/carbon_seq/refshelf/project%20portfolio/2007/2007Roadmap.pdf.

45. Author's calculations based upon data from CARBON ATLAS, *supra* note 37, at 13–15.

46. BETWEEN A ROCK, *supra* note 2, at *x*.

47. UNEP, *supra* note 9, at 6.

formations . . . are considered to be the most promising location for long-term underground storage of CO_2."[48] However, "much less information is known about the potential for saline formations to store and immobilize CO_2" permanently.[49]

Site characterization[50] for GS is of paramount importance[51] because of the risk of leakage.[52] A GS well must be drilled to a depth of at least 800m[53] (2625ft) below the crust of the earth. This results in risks including groundwater contamination, seismic activity, lateral migration, and other phenomena that could facilitate release of the sequestered carbon. As such, the International Energy Agency says, "potential storage

48. BETWEEN A ROCK, *supra* note 2, at 32.

49. NETL, *supra* note 44, at 22.

50. Site characterization is defined as, "confirming the appropriateness of a site for CO_2 storage through evaluations of surface area land use, the site's geology and hydrogeology, its capacity to store the desired amounts of CO_2, flow characterisation [sic] in the injection reservoir and the underlying layers, and identifying possible pathways for leakage." Int'l Energy Agency, Legal Aspects of Storing CO_2: Update and Recommendations 17 (2007), http://www.iea.org/textbase/nppdf/free/2007/legal_aspects.pdf.

51. According to the International Symposium on Site Characterization,

> [b]efore selecting a site, the geological setting must be characterized to determine if the overlying cap rock will provide an effective seal, if there is a sufficiently voluminous and permeable storage formation, and whether any abandoned or active wells will compromise the integrity of the seal . . . . Moreover, the availability of good site characterization data is critical for the reliability of models.

International Symposium, Site Characterization for CO_2 Geological Storage 1 (Mar. 20–23, 2006), http://www.epa.gov/ogwdw/uic/pdfs/page_uic_berkeley_summary.pdf.

52. The purpose of GS is to isolate CO_2 from the earth's atmosphere for an indefinite amount of time. Leakage of CO_2 from a GS site defeats this purpose by releasing CO_2 into the atmosphere. Although highly unlikely, the release of a significant plume of CO_2 could be catastrophic. For example, in Cameroon on August 21, 1986 through *a naturally occurring event*, a:

> CO_2-rich cloud was expelled rapidly from the southern floor of Lake Nyos [which is a lake formed over a volcano]. It rose as a jet with a speed of about 100 km per hour. The cloud quickly enveloped houses within the crater that were 120 meters above the shoreline of the lake. Because CO_2 is about 1.5 times the density of air, the gaseous mass hugged the ground surface and descended down valleys along the north side of the crater. The deadly cloud was about 50 meters thick and it advanced downslope at a rate of 20 to 50 km per hour. This deadly mist persisted in a concentrated form over a distance of 23 km, bringing sudden death to the villages of Nyos, Kam, Cha, and Subum . . . .

How Volcanoes Work, Lake Nyos,http://www.geology.sdsu.edu/how_volcanoes_work/Nyos.html (last visited Apr. 22, 2010).

53. Dougherty & McLean, *supra* note 36, at 8.

sites will need to be carefully selected and managed in order to minimi[z]e any chance of CO_2 leakage."[54]

The U.S. Department of Energy (DOE) estimates that the area of contamination "from an injection of one million tons of CO_2 per year in a deep saline formation for 20 years could be spread over a horizontal area of 15 square miles or more."[55] However, the IPCC characterizes the risks of GS as "comparable to the risks in similar existing industrial operations such as underground natural-gas storage and enhanced oil recovery."[56] According to the IPCC, "well-selected geological formations are likely to retain over 99% of their storage over a period of 1,000 years."[57]

A suitable potential GS reservoir has two main characteristics. First, it is "composed of porous rock saturated with brine."[58] The porous rock provides the space into which the CO_2 is injected and immobilized by capillary[59] forces.[60] Second, and more importantly, the formation would be "capped by one or more . . . impermeable rock formations" which serve to trap the injected CO_2[61] by acting as a physical barrier to vertical migration.[62]

Although no large-scale commercial GS sites yet exist, there are three currently functioning CCS projects. These projects are not utilizing CCS for GHG mitigation purposes. Instead, each of these projects is linked to either natural gas production or enhanced oil recovery: Sleipner West Gas Field (Sleipner), Weyburn Oil Field (Weyburn), and In Salah (In Salah).[63] Since 1996, the Sleipner project[64] in the North Sea has

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54. Int'l Energy Agency, Greenhouse Gas Research & Dev. Programme, Storing CO_2 Underground 7 (2007), http://www.ieaghg.org/docs/general_publications/storingCO.pdf.

55. NETL, *supra* note 44, at 27.

56. UNEP, *supra* note 9, at 15.

57. *Id.*

58. NETL, *supra* note 44, at 22.

59. Capillary force refers to the "adhesive force that holds a fluid in a capillary or a pore space. Capillary force is a function of the properties of the fluid, and surface and dimensions of the space. If the attraction between the fluid and surface is greater than the interaction of fluid molecules, the fluid will be held in place." Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO^2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43492, 43493 (July 25, 2008).

60. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, THE FUTURE OF COAL, AN INTERDISCIPLINARY STUDY: OPTIONS FOR A CARBON-CONSTRAINED WORLD 44 (2007) [hereinafter FUTURE OF COAL], *available at* http://web.mit.edu/coal/The_Future_of_Coal_Summary_Report.pdf.

61. NETL, *supra* note 44, at 22.

62. FUTURE OF COAL, *supra* note 60, at 44.

63. UNEP, *supra* note 9, at 10.

64. Interestingly, the Norwegian state oil and gas company Statoil voluntarily established the CCS in order to avoid a Norwegian CO_2 emissions tax. According to the Statoil website, CCS:

injected CO_2 into a saline formation 800m below the seabed to avoid a carbon tax resulting from enhanced gas production.[65] At least 7 million metric tons of CO_2 were injected in Sleipner's first nine years of operation and the formation's lifetime storage capacity is expected to be at least 20 million metric tons.[66] The Weyburn project in North America[67] injects CO_2 into a carbonite reservoir for enhanced oil recovery purposes.[68] Similar to Sleipner, Weyburn is also expected to store 20 million metric tons over the project's lifetime.[69] Finally, the In Salah project[70] in Algeria has been separating CO_2 from natural gas and injecting it "into a sandstone reservoir . . . 1800m" below the surface since 2004.[71] This reservoir is expected to store 17 million metric tons of CO_2 over its lifetime.[72]

CCS is a bridging technology,[73] not a permanent solution to air pollution. It is most appealing to coal-fired power generators subject to

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> represents a relatively expensive approach. [Because] [g]enerally speaking, a coal- or gas-fired power station which converted to this disposal method [CCS] would see its costs rise by 50–80 per cent. However, the Sleipner West licensees would have had to pay NOK 1 million [$140,870 USD] per day in Norwegian carbon dioxide tax had they released the greenhouse gas to the air. Injecting the [CO_2] costs about the same, and the solution is more environment-friendly.

Carbon Dioxide Storage Prized, Statoil.com,http://carbonsequestration.us/News &Projects/htm/Statoil-Sleipner-12-18-2000.html (last visited Apr. 22, 2010).

65. UNEP, *supra* note 9, at 10.

66. *Id.*

67. The project is actually "located in the Williston Basin, a geological structure extending from south central Canada into the US." *Id.*

68. *Id.* There are two Weyburn projects; the first is a commercial enhanced oil recovery project and the second is the International Energy Agency (IEA) GHG Weyburn–Midale CO_2 Monitoring and Storage project. Sheri Gagnon, *Background: What to do About CO_2*, CANADIAN GEOGRAPHIC, Jan.–Feb. 2008, http://www.canadiangeographic.ca/magazine/jf08/indepth/. Weyburn was designed to be, "the world's largest full-scale, in-the-field study of CO2 storage in a commercial EOR [enhanced oil recovery] operation." Int'l Energy Agency, IEA GHG Weyburn–Midale CO_2 Monitoring & Storage Project, Sixth Annual Conference on Carbon Capture & Sequestration 3 (May 7–10, 2007), http://www.netl.doe.gov/publications/proceedings/07/carbon-seq/data/papers/p2_177.pdf.

69. IEA Greenhouse Gas R&D Programme, International Weyburn Carbon Dioxide Monitoring Project, http://www.co2captureandstorage.info/project_specific.php?project_id=98 (last visited Apr. 22, 2010).

70. S*ee generally* BP China English, Carbon Capture and Storage, http://www.bp.com/sectiongenericarticle.do?categoryId=9012195&contentId=7024392 (last visited Apr. 22, 2010).

71. UNEP, *supra* note 9, at 10.

72. *Id.*

73. Dr. Julio S. Friedman, Leader, Carbon Management Program, Lawrence Livermore National Laboratory, Livermore, Reducing Emissions in California Through Carbon Capture

mandatory GHG mitigation targets because it represents the opportunity to continue exploiting coal reserves for power generation without the corresponding emissions. However, a lack of mandatory targets providing an economic incentive and the absence of GS-specific regulation makes it unlikely that Australian or U.S. firms will voluntarily participate in the costly research and development required to establish CCS technology.

III. THE AUSTRALIAN LEGAL FRAMEWORK FOR GS

Australia is the largest coal exporter in the world.[74] Black coal is the largest domestic export commodity. In 2005 alone, this export was valued at roughly $24 billion dollars.[75] For Australia, GS presents an opportunity to reconcile and benefit from their recent ratification of the Kyoto Protocol,[76] rising global pressure to mitigate emissions,[77] and the contemporaneous rising demand for least-cost[78] energy production. Just

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and Sequestration, Featured Presentation at the Climate Change Conference in San Francisco (Aug. 4, 2008) (characterizing CCS as "a bridging technology, not a long-term solution to decarbonized energy").

74. BETWEEN A ROCK, *supra* note 2, at 9.

75. *Id.* Amount cited is in Australian dollars. For conversion, visit XE, The World's Favorite Currency Site, www.xe.com.

76. Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, 37 I.L.M. 22; *see also* Press Release, Parliament of Australia, Prime Minister Ratifying the Kyoto Protocol, Dec. 3, 2007, *available at* http://parlinfo.aph.gov.au/parlInfo/download/media/pressrel/215P6/upload_binary/215p61.pdf;fileType=application%2Fpdf#search=%22ratifying%20the%20kyoto%22.

> [T]he Kyoto protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in December of 1997 . . . [and] provided a legal framework that addressed the issue of global climate change and placed quantifiable obligations upon sovereign States to decrease their levels of greenhouse gas emissions . . . [t]his . . . framework established the beginnings of a global emissions trading system . . . .

Renee Garner, *Regulating a National Emissions Trading System Within Australia: Constitutional Limitations*, 3 MACQUARIE J. INT'L & COMP. ENVTL. L. 83, 83 (2006).

77. In 2004, Rosemary Lyster commented that in "[l]ooking to the future, it is reasonable to predict that domestic and international lobbies will be increasingly vociferous in their demands that the Australia government . . . regulate properly the greenhouse gas emissions from the stationary energy sector . . . ." Rosemary Lyster, *Common but Differentiated? Australia's Approach to Global Climate Change*, 16 GEO. INT'L ENVTL. L. REV. 561, 591 (2004). While it is not possible to tell whether it was external or domestic pressure, it is worth noting that Prime Minister Rudd's first official act in office was to sign the Protocol. Anita Talberg, *Background Note, The Kyoto Protocol Accounting Rules* (2009), http://www.aph.gov.au/Library/Pubs/BN/2008-09/KyotoAccRules.htm#_ ftnref1.

78. Peter Christoff, *Can the Invisible Hand Adjust the Thermostat? Carbon Emissions Trading and Australia*, in CLIMATE LAW IN AUSTRALIA 82, 91–92 (Tim Bonyhady & Peter Christoff eds., 2007) ("The Australian economy (in particular the stationary energy sector) is highly dependent on cheap fossil fuels, and further substantial investment in the development of coal- and gas-fired power stations is intended and supported by State and federal policy.").

as in the United States, there is no federal level legislation addressing GHG mitigation. Also like the United States, Australia's prior focus encouraged "voluntary actions and other 'soft' incentives for industry to reduce its carbon output."[79] However, Prime Minister Rudd's signature of the Australian Kyoto ratification instrument as his first act of government signals a philosophical change.[80]

A. An Overview of Relevant Australian Property Law

U.S. and Australian property law is descended from a shared English heritage.[81] Just as in the United States, the law in this area is not static; it has evolved to accommodate technological advances.[82] For example, Australian property law was modified to limit a surface owner's right to airspace above the land "to a reasonable height to allow for modern day use of airspace by aeroplanes [sic]."[83] However, there is one point of significant divergence. In Australia, "'ownership' of all land is vested in the States."[84] This is known as "radical title" or "ultimate title."[85] In contrast to the American understanding of real property ownership,[86] under the Australian regime, a person does not own land, but simply an estate or interest in it.[87]

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79. JAQUELINE PEEL, LEGAL STUDIES RESEARCH PAPER NO. 269: THE ROLE OF CLIMATE CHANGE LITIGATION IN AUSTRALIA'S RESPONSE TO GLOBAL WARMING 90, 90 (2007).

80. Talberg, *supra* note 77.

81. Donna R. Christie, *A Tale of Three Takings: Taking Analysis in Land Use Regulation in the United States, Australia, and Canada,* 32 BROOKLYN J. INT'L L. 343, 343 (2007).

82. MINTER ELLISON, CARBON CAPTURE AND STORAGE REPORT TO THE AUSTRALIAN GREENHOUSE OFFICE ON PROPERTY RIGHTS AND ASSOCIATED LIABILITY ISSUES 30 (Austl. Greenhouse Office 2005).

83. *Id.*

84. *Id.* at 27.

85. *Id*.

86. The fee simple estate is the most commonly understood legal concept of ownership in the United States. This estate is defined as "compris[ing] the greatest ownership interest in property recognized by the law . . . The owner can dispose of the land as he or she pleases, and it will descend to the owner's heir at death or according to the terms of the owner's will." ROGER BERNHARDT & ANN M. BURKHART, REAL PROPERTY IN A NUTSHELL 48 (4th ed. 2000).

87. JOYCEY TOOHER & BRYAN DWYER, INTRODUCTION TO PROPERTY LAW 36 (4th ed., Reed Int'l Books Austl. 2002) (1987).

Traditionally, there are two types of estates in Australia: freehold estates and estates less than freehold.[88] "Freehold estates include the fee simple, fee tail and life estate."[89] Generally, the owner of a freehold estate is regarded as controlling three sets of rights: the surface of the land, the air space above the land, and the subsurface to the center of the earth.[90] Property rights relating to ownership are primarily a state concern, and there is variation among the jurisdictions.[91] Within this context, the next few sections will examine Australia's regulatory approach to addressing ownership of subsurface formations suitable for GS.

B. Commonwealth-Level GS Activity

In 2005, Australia took the global lead[92] in GS with the release of the Ministerial Council on Mineral and Petroleum Resources' (MCMPR's) *Carbon Dioxide Capture and Geological Storage: Australian Regulatory Guiding Principles* (Australian Guide).[93] In the absence of Commonwealth-level legislation, the Australian Guide was designed to "facilitate a nationally consistent approach to the application of Carbon Capture and Geological Storage."[94] Since environmental regulation and ownership of all land is vested in the States,[95] the absence of direct federal CCS–related

88. *Id.* "Non-freehold estates are of indefinite duration and are typically measured in weeks, months or years." ELLISON, *supra* note 82, at 27.

89. TOOHER & DWYER, *supra* note 87, at 36; ELLISON, *supra* note 82, at 27.

90. ELLISON, *supra* note 82, at 30.

91. *Id*.

92. NIGEL BANKES & JENETTE POSCHWATTA, AUSTRALIAN LEGISLATION ON CARBON CAPTURE AND STORAGE: A CANADIAN PERSPECTIVE 5 (2008), http://www.ucalgary.ca/oncampus/online/june26-08/ISEEE.pdf.

93. MINISTERIAL COUNCIL ON MINERAL AND PETROLEUM RES., CARBON DIOXIDE CAPTURE AND GEOLOGICAL STORAGE: AUSTRALIAN REGULATORY GUIDING PRINCIPLES (2005) [hereinafter AUSTL. GUIDE], *available at* http://www.ret.gov.au/resources/Documents/ccs/CCS_Aust_Regulatory_Guiding_Principles.pdf. In November 2008, Australia enacted the Offshore Petroleum Amendment (Greenhouse Gas Storage) Act 2008. This is the world's first regulatory framework for regulation of offshore CCS. Jessica Davies, *Australia Passes Legislation Creating "World First" Framework for Regulating CCS*, CLIMATEINTEL.COM, Nov. 19, 2008, http://climateintel.com/2008/11/19/australia-passes-legislation-creating-%E2%80%9Cworld-first%E2%80%9D-framework-for-regulating-ccs/#more-357.

94. AUSTL. GUIDE, *supra* note 93, at 4.

95. ELLISON, *supra* note 82, at 27; *see also* Garner, *supra* note 76, at 91 ("Traditionally, environmental powers rest primarily with the States and Territories . . . [t]here are no commonwealth powers over industrial pollution, manufacturing or mining which may have provided the foundation for Commonwealth Direct regulation of emissions produced in these industries . . . .").

legislation is expected. As a result, individual Australian states have been active in enacting, or at least proposing, CCS related legislation.[96]

With respect to the legal implications of GS, the Australian Guide illuminates the interstices of a legal, regulatory, and jurisdictional Gordian knot.[97] Environmental powers are shared between the Commonwealth and the states and territories.[98] In the Australian Guide, the MCMPR reaffirms that "onshore lands are principally regulated under State property laws."[99] The MCMPR references the underlying concepts of mining and petroleum law in the Australian Guide[100] and recommends amending existing government regulations rather than creating an entirely new regulatory regime.[101]

There is no Commonwealth-level GS regulation.[102] Instead, the Commonwealth endeavored to bring attention to the crucial issues in designing a regulatory framework: consistency, certainty, and clarity of

96. PEEL, *supra* note 79, at 95. The Government of Western Australia enacted the Carbon Rights Act 2002 three years before the Australian Guide was released. New South Wales created the "world's first mandatory carbon trading scheme" by enacting the NSW/ACT Greenhouse Gas Reduction Scheme (GGAS). Martin Wilder & Monique Miller, *Carbon Trading Markets: Legal Considerations*, in CLIMATE LAW IN AUSTRALIA, *supra* note 78, at 74. GGAS commenced on January 1, 2003. Greenhouse Gas Reduction Scheme, http://www.greenhousegas.nsw.gov.au/ (last visited Apr. 22, 2010). On November 5, 2008, the Victorian parliament passed the Greenhouse Gas Geological Sequestration Bill 2008. With the passage of the Bill, "Victoria . . . bec[a]me the first Australian state to pass stand alone legislation enabling the onshore injection and permanent storage of [CO_2] and other greenhouses gases." Press Release, Minister of Energy & Res., Historic Carbon Capture and Storage Bill Passes Through Parliament (Nov. 5, 2008), http://www.premier.vic.gov.au/newsroom/5247.html; *see infra* Part III.B. In the United States, California enacted Assembly Bill 32, the California Global Warming Solutions Act of 2006, which states that "in developing its plan, the state board [responsible for implementation of Assembly Bill 32] shall identify opportunities for emission reductions measures . . . including . . . carbon sequestration projects" CAL. HEALTH & SAFETY CODE § 38561(f) (2009).

97. AUSTL. GUIDE, *supra* note 93, at 26–27.

98. PEEL, *supra* note 79, at 94.

99. AUSTL. GUIDE, *supra* note 93, at 26–27.

100. *Id.* at 31–32.

101. Interestingly, this approach is consistent with the conclusion reached by the Interstate Oil and Gas Compact Commission [IOGCC] in the United States. IOGCC GUIDE, *infra* note 144, at 9.

102. In the offshore context of CCS, the Commonwealth has followed its own advice and released proposed legislation covering offshore CCS in the form of a "comprehensive set of amendments to the . . . *Offshore Petroleum Act* . . . designed to proved an enabling framework for objective-based regulation for CCS in offshore (Commonwealth) waters." BANKES & POSCHWATTE, *supra* note 92, at 5. The Commonwealth has authority to regulate three nautical miles beyond the shoreline. AUSTL. GUIDE, *supra* note 93, at 27.

rights. In the Australian Guide, the MCMPR addresses the complementary nature of uncertainty in the industry and centrality of property rights in observing that,

> [due to] the likely costs and long periods of operation of CCS projects, operators will require a high degree of certainty about access to a selected injection site before they will be willing to invest . . . . This need to clearly identify relevant parties' rights and obligations is a key consideration . . . .[103]

Guidance to the states is further crystallized by the comment that "proprietary rights and access for each stage of a CCS project relating to the surface and sub-surface need to be clear."[104] Ultimately, the MCMPR advocates thorough consideration of all issues surrounding GS, uniformity and consistency of regulation, and utilizing amendments to current regulatory systems based upon established mining and petroleum law.[105]

Three regulatory scenarios involving property rights are outlined by the MCMPR in the Australian Guide.[106] First, under "status quo" regulation, CCS site ownership transpires through the use of "contract, commercial and property law."[107] However, one weakness with this scenario is the lack of directly applicable legal precedents to guide resolution of "issues that might arise between owners of the land, owners of the CCS stream, and suppliers of the CCS stream."[108] Under scenario one, the landowner receives pore space allocation in proportion to surface ownership and retains "veto rights to block site access."[109] This results in "costly and time consuming" negotiations with all parties holding ownership interests in the land.[110] Additionally, the risk of "competing claims" to reservoirs results in uncertainty in the absence of "clear proprietary rights . . . relating to the . . . subsurface."[111] Therefore, this option is not the most efficient regulatory device for GS.

The second scenario is "self-regulation." The MCMPR suggests the establishment of a "code of conduct . . . to govern access and property rights"[112] by utilizing industry standards from areas such as mining and petroleum law, and existing legislation could be useful in resolving

103. AUSTL. GUIDE, *supra* note 93, at 26.
104. *Id.*
105. *Id.*
106. *Id.*
107. *Id.* at 28.
108. *Id.*
109. *Id.*
110. *Id.*
111. *Id.*
112. *Id.* at 29.

disputes.[113] However, the MCMPR also notes that the risk of competing claims and "relative immaturity of CCS technology" render self-regulation premature.[114]

The third and most appealing scenario involves amendment of existing legal frameworks to accommodate GS.[115] The MCMPR acknowledges the increased level of "complexity and compliance cost" resulting from this approach.[116] However, because scenarios one and two are not appropriate for all potential storage sites and "increase industry uncertainty," scenario three's transparency provides "certainty and specifically define[d] property rights in relation to CCS,"[117] rendering it the "the preferred option."[118]

C. State-Level Action and the Victorian Model

Australian States have enacted CCS-related legislation without specifically addressing or creating a regulatory structure for onshore GS activities.[119] For example, Western Australia enacted *The Carbon Rights Act 2003* (W.A. Act) "to provide for the creation and effect of certain interests in land in relation to the effects of carbon sequestration from . . . the atmosphere . . . ."[120] The W.A. Act defines "carbon sequestration" as "absorption from the atmosphere of carbon dioxide by land or anything on land; and the storage of carbon *in land* or in anything on land."[121]

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113. *Id.*
114. *Id.*
115. *Id.* at 30.
116. *Id.*
117. *Id.* at 31.
118. *Id.* at 32.
119. BETWEEN A ROCK, *supra* note 2, at 91.

> There are . . . existing state and federal laws and regulations with relevance to various aspects of CCS. At the state level, the *Queensland Petroleum and Gas (Protection and Safety) Act 2004* and the *South Australian Petroleum Act 2000*, for example, "provide for the transport by pipeline and storage in natural reservoirs of substances including [CO_2]." At the Commonwealth level, environmental laws relevant to CCS include: the *Environmental Protection and Biodiversity Conservation Act 1999*; the *Environment Protection (Sea Dumping) Act 1981*; and the *Offshore Petroleum Act 2006*.

Id.

120. Carbon Rights Act, 2003 No. 38 (W. Austl.), *available at* http://www.slp.wa.gov.au/pco/prod/FileStore.nsf/Documents/mrdocument:4798p/$file/carbnrightsact2003_00-00-02. pdf?openelement (last visited Apr. 22, 2010).
121. *Id.* pt. 1(3)(a)–(b) (emphasis added).

This definition appears to cover GS but does not specify it exactly. Instead, the W.A. Act establishes a structure by which "carbon rights" are created, registered, and conveyed. The W.A. Act does not address ownership of geologic formations within which the CO_2 is to be sequestered.

The emphasis of the W.A. Act is not on GS. Instead, it creates tradable value in biologic sequestration and soil sinks.[122] According to a pamphlet prepared by the Government of Western Australia, "[c]arbon rights are a potential new source of income for owners of land *on which* vegetation or soils accumulate carbon from the atmosphere."[123] This pamphlet minimizes the W.A. Act's potential application to GS because it addresses only land "on which" sequestration takes place rather than "in land" as the text of the W.A. Act contemplates. This resulting lack of clarity increases the regulatory and legal uncertainty. It is unclear whether the W.A. Act will require amendments to clarify its applicability to GS.

With the passage of *The Greenhouse Gas Geological Sequestration Act 2008* (Victorian GS Act) on September 9, 2008, Victoria[124] became the first Australian state to enact[125] "legislation enabling the onshore injection and permanent storage of [CO_2]."[126] In accordance with the recommendations of the Australian Guide, the Victorian GS Act's framework is generally based on a familiar industry model, the Victorian Petroleum Act 1998.[127] However, the Victorian GS Act was created as "stand-alone legislation [in part] because: Greenhouse gas storage formations are [considered] a new resource."[128]

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122. "The *Carbon Rights Act 2003* establishes a statutory basis for the ownership and protection of *carbon rights*, in order to facilitate trading." STATE OF W. AUSTL. CARBON RIGHTS IN WA—A NEW INTEREST IN THE LAND 1 (2005), http://www.agric.wa.gov.au/objtwr/imported_assets/content/sust/carbon_rights.pdf. The Government further explains that, "[t]he commercial benefits of *carbon rights* only arise because of legal agreements that place restrictions or caps on greenhouse gas [GHG] emissions from industries and make storage of carbon a legitimate way of offsetting those emissions." *Id.* at 3.

123. *Id*. at 1 (emphasis added).

124. Notably, Victoria remains a leader in environment-related legislation. *See* GEOFFREY SAWER, THE AUSTRALIAN AND THE LAW 200-01 (Penguin Books 1972). In 1970 it was the first Australian State to enact environmental legislation with its Environmental Protection Act 1970. *Id.*

125. Press Release, Minister for Energy and Resources, State of Vict., Historic Carbon Capture and Storage Bill Passes Through Parliament (Nov. 5, 2008), http://www.premier.vic.gov.au/component/content/article/5247.html.

126. Press Release, Minister for Energy and Resources, State of Vict., Victoria Leads Australia With Carbon Capture and Storage Bill (Sept. 9, 2008), http://www.premier.vic.gov.au/component/content/article/4704.html.

127. *Id.*

128. *Id.*

The new regulatory regime created by the Victorian GS Act was designed to encourage development of GS.[129] Its goal is unambiguous and clearly stated: it endeavors to "facilitate and regulate the injection of greenhouse gas substances into underground geological formations for the purpose of permanent storage of those gases . . . ."[130] Most importantly, two important issues are resolved in the Victorian GS Act. First, it defines "underground geological storage formation," and second, it provides for clear allocation of property rights in subsurface formations.[131]

The choice of a flexible definition of subsurface formations reflects the Victorian government's forward-looking approach. The Victorian GS Act increases regulatory certainty because it clearly identifies and defines "underground geological storage formation."[132] The definition includes "any seal or reservoir of an underground geological formation" and "any associated geological attributes or features of an underground geological formation."[133] Because storage formations are considered a new resource, this definition facilitates a certain flexibility of interpretation. This definition is clear and specific yet allows for unanticipated future changes or technological advances.

Ownership of subsurface formations is unequivocally allocated to the Crown by the Victorian GS Act. The text reads, "the Crown owns all underground geological storage formations below the surface of any land in Victoria."[134] Because title to all Australian land is vested in the states[135] and all third parties with interests in land are merely tenants,[136]

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129. Vict. Parl. Deb. (Hansard), Legis. Assemb. 56th Parl., 1st Sess., (2008) 3674 (Batchelor, Minister for Energy and Resources, Second Reading Speech), *available at* http://www.parliament.vic.gov.au/downloadhansard/la_2008.htm (select "Book 12" under "Revised Book" for the month of September).

130. Greenhouse Gas Geological Sequestration Act, 2008, Pt. 1, Div. 1(1) (Vict.), *available at* http://www.legislation.vic.gov.au/ (follow "Victorian Statute Book" hyperlink; then follow "2008" hyperlink; then follow "Greenhouse Gas Geological Sequestration Act 2008" hyperlink; then select.pdf file).

131. *See generally id.* (creating a system of exploration and injection leases and banning GS activities from certain wilderness sites).

132. *Id.*

133. *Id.* pt. 1 § 3.

134. *Id.* pt. 2 § 14.

135. ELLISON, *supra* note 82, at 27 (citing Mabo v. Queensland II (1992) 175 C.L.R. 1.).

136. SAWER, *supra* note 82, at 174–75. For an overview of the doctrines of "tenure" and "estates" see generally TOOHER & DWYER, *supra* note 87. Although the concept of native title is beyond the scope of this analysis, the issue may further complicate endeavors to secure rights in Australian subsurface formations since native title is "extinguished where the

the Victorian Government is within its authority to include this provision. The clear allocation of subsurface formation ownership to the government establishes a monopoly on the "new resource" of underground formations. This monopoly eliminates the risk of one surface owner blocking storage in an entire formation[137] and ensures more efficient administration of the statute.[138] Additionally, the GS industry is relieved of the cautious necessity of extensive negotiations with every party who *may* have an interest in a specific formation, however remote. Instead, the GS industry is confronted with a single, predictable owner, the government.

The Victorian GS Act increases certainty in the burgeoning GS industry and provides a partial model for GS regulation because it clearly defines underground geologic formation and allocates subsurface property rights. This increased certainty reduces perceived industry risk and lowers transaction costs resulting in a positive signal of clarity and certainty to the burgeoning GS industry that is currently lacking in the United States.

IV. FEDERAL-LEVEL GS ACTIVITY IN THE UNITED STATES

The United States produces three times as much coal as Australia.[139] Like Australia, there is no enacted federal legislation[140] related to global warming prevention or CCS.[141] There are, however, three important GS-related developments in the United States, although none specifically address subsurface formation ownership. First, the Interstate Oil and Gas Compact Commission (IOGCC)[142] released the *Storage of Carbon*

Crown appropriates Crown land for public purposes." *Id.* at 7. The seminal case on native title is Mabo v. Queensland II (1992) 175 C.L.R. 1. *Id.* at 5.

137. *See supra* text accompanying note 109.

138. However, it remains to be seen how the existence of subsurface formations that cross state borders will be handled. A.M. Warburton & J.A. Grove, et al., *Geosequestration Law in Australia,* in CLIMATE LAW IN AUSTRALIA, s*upra* note 78, at 148–49.

139. WORLD COAL INST., s*upra* note 4.

140. On January 28, 2009, the U.S. House of Representatives passed a bill as part of the American Recovery and Reinvestment Act that includes two significant provisions relating to CCS: $2.4B in appropriations for CCS technology and tax credit increases for energy research including CCS. UNITED STATES CARBON SEQUESTRATION COUNCIL, SEQUESTRATION NEWS 1 (Feb. 2, 2009),http://www.southwestcarbonpartnership.org /_Resources/PDF/SequestrationNews_February%202_2009.pdf.

141. Elizabeth C. Brodeen, *Sequestration, Science and the Law: An Analysis of the Sequestration Component of the California and Northeastern States' Plans to Curb Global Warming,* 37 LEWIS & CLARK ENVTL. L. 1217, 1217 (2007).

142. According to the IOGCC's website, "the Commission's member states have established effective regulation of the oil and natural gas industry through a variety of programs designed to gather and share information, technologies and regulatory methods." Interstate

Dioxide in Geologic Structures: A Legal and Regulatory Guide for States and Provinces (IOGCC Guide) in September of 2007.[143] Second, the Environmental Protection Agency (EPA) has proposed a rulemaking for a GS-specific well classification under the Underground Injection Control (UIC) program in anticipation that the Safe Drinking Water Act (SDWA)[144] will cover GS. And third, the DOE is funding geologic sequestration pilot programs across the country.[145]

A. The IOGCC Guide

The IOGCC is "a multi-state government agency . . . work[ing] to ensure [the] nation's oil and natural gas resources are conserved and maximized . . . ."[146] The IOGCC Guide shares several concepts similar to the Australian Guide. First, the IOGCC "envision[s] . . . a substantially consistent system for the geologic storage of CO_2 regulated at the state . . . level in conformance with national and international law and protocol."[147] Second, similar to the cooperative federalism seen in the Australian Guide, the IOGCC concludes that the "jurisdiction, experience, and expertise of states" render them "the most logical and experienced regulators" of GS.[148] And third, the IOGCC observes that current regulatory frameworks might be modified to accommodate GS.[149]

Oil and Gas Compact Commission, About Us [hereinafter IOGCC Website], http://www.iogcc.state.ok.us/history (last visited Apr. 22, 2010).

143. According to the *IOGCC Guide*, the "report was prepared as an account of work sponsored by an agency [the Department of Energy] of the United States Government. . . . The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof." INTERSTATE OIL AND GAS COMPACT COMMISSION, STORAGE OF CARBON DIOXIDE IN GEOLOGIC STRUCTURES: A LEGAL AND REGULATORY GUIDE FOR STATES AND PROVINCES 2 (2007) [hereinafter IOGCC GUIDE], http://groundwork.iogcc.org/sites/default/files/2008-CO2-Storage-Legal-and-Regulatory-Guide-for-States-Full-Report.pdf.

144. *See* 42 U.S.C.A. § 300h–300h-8 (West 2009).

145. As a result of the recent enactment of the American Recovery and Reinvestment Act (Federal Stimulus Bill) over $8B in federal funds now support CCS technology. *Flurry of US State, Federal Policies Advance CCS*, CARBON CAPTURE JOURNAL, Feb. 20, 2009, http://www.carboncapturejournal.com/displaynews.php?NewsID=344&PHPSESSID=fp4t1fj6f62msb5jlfb8mllb66.

146. IOGCC Website, *supra* note 142.

147. IOGCC GUIDE, *supra* note 143, at 4.

148. *Id.* at 3.

149. *Id.*

The IOGCC concludes that the varying legal treatment of subsurface pore space among states can be reconciled by "clearly identifying the surface owner as the person with the right to lease pore space for storage . . . ."[150] However, the model statute does not clearly identify such ownership rights. Instead, the statute recommends that the state regulating agency approve "use of a reservoir as a storage facility . . . after public notice and hearing."[151] Property rights are only obliquely referenced by the requirement that the state regulating agency find "[t]hat a good faith effort has been made to obtain the consent of a majority of the owners having property interests affected by the storage facility. . . ."[152]

A footnote to the model statute explains that an "amalgamation of property rights is absolutely necessary to properly permit, construct and operate a . . . [GS] project."[153] Similar to the Victorian GS Act which reserves rights in all subsurface formations to a single owner, the Crown, the IOGCC model statute invokes eminent domain to solve the fragmentation problem.[154] The eminent domain clause provides in part that "any storage operator is hereby empowered . . . to exercise the right of eminent domain . . . to acquire all surface and subsurface rights and interests necessary or useful" to operate a storage facility.[155] Although this may appear to be a simple and efficient solution, the model statute does not address issues of just compensation that most certainly would provide the basis for substantial litigation. The IOGCC recognizes the requirement of clear ownership rights to facilitate GS, but perhaps fails to take into consideration the risk of prohibitive litigation costs associated with such broad authority for eminent domain.

B. EPA's Proposed Class VI Well Rulemaking

The EPA published notification of a proposed rulemaking entitled *Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells*

150. *Id.* at 22.
151. *Id.* at 33 (citing the Geologic Storage of Carbon Dioxide Model Statute, §§ 3(a) and 3(a)(2)).
152. *Id.* (citing the Geologic Storage of Carbon Dioxide Model Statute, § 3(a)(2)).
153. *Id*. at 33 n.3.
154. *See supra* Part III.A.
155. IOGCC GUIDE, *supra* note 143, at 33 (citing the Geologic Storage of Carbon Dioxide Model Statute, § 5(a)).

(EPA's Proposed Well Requirements) on July 25, 2008.[156] This rulemaking proposes creation of a Class VI Well for GS.[157] However, the EPA's Proposed Well Requirements are narrowly focused on the permitting issues associated with drilling wells for GS. This is an important step in the overall process of establishing GS as a viable industry, but the proposed rule will only apply to "owners or operators of [GS] wells."[158] The owner or operator of a well is not necessarily the same party with ownership of the subsurface formation. Therefore, this proposed rule applies once ownership rights in the subsurface have been established.

C. The WESTCARB Pilot Program

Although there is no federal legislation relating to GS, significant funding has been provided by the DOE for pilot projects through regional partnerships. In the fall of 2003, the DOE formed seven[159] Regional Carbon Sequestration Partnerships, "tasked with determining the most suitable technologies, regulations, and infrastructure needs for

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156. *See* Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, 73 Fed. Reg. 43492 (proposed July 25, 2008) (to be codified at 40 C.F.R. pt. 144, 146).

157. At present, only pilot projects may be permitted under the existing regulatory scheme as a Class V Well. *See generally* Dougherty & McLean, *supra* note 36, at 6. Pilot projects may be drilled after obtaining a "Class V—experimental technology well" permit. *Id*. at 5. Most class V wells are "shallow disposal systems." U.S. Envtl. Prot. Agency, Class V Wells, http://www.epa.gov/safewater/uic/class5/index.html (last visited Apr. 22, 2010). Since GS requires relatively deep wells, Class V is an awkward fit for GS. For an excellent analysis of the awkward fit of GS into the UIC Program and recommended modifications (before the proposed CCS well classification), see Moore, *supra* note 5, at 462–65. Additionally, there is currently no UIC well classification that covers *commercial*- scale deployment of GS technology and as such, commercial-scale GS wells cannot legally be drilled under the UIC Program. It has been proposed that Congress could remedy this obstacle "by exempting GS from the UIC program—as it did for natural gas storage—and create an entirely new regulatory regime for GS." Peter S. Glaser et al, *Global Warning Solutions: Regulatory Challenges and Common Law Liabilities Associated with the Geologic Sequestration of Carbon Dioxide*, 6 GEO. J. L. & PUB. POL'Y 429, 437 (2008).

158. Press Release, U.S. Envtl. Protection Agency, EPA Lays Groundwork for Promising Technologies to Help Mitigate Climate Change (July 15, 2008), http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceceeac8525735900400c27/d35b72dfe481043b85257487005e47cd!OpenDocument.

159. For more information on the Regional Carbon Sequestration Partnerships, see NatCarb, Regional Carbon Sequestration Partnerships, http://www.natcarb.org/Atlas/partners.html (last visited Apr. 22, 2010).

carbon capture and sequestration in different regions of the U.S. and Canada."[160] An example of one of the partnerships is WESTCARB,[161] located in California and now in Phase III[162] of the pilot program. Phase III is a ten-year, large-volume CCS pilot project funded by the U.S. Department of Energy and undertaken by the California Energy Commission (CEC), Clean Energy Systems (CES), and various other parties in Kern County, California.[163] The pilot project will "inject 250,000 tons of CO_2 per year for four years into a . . . saline formation about 7,000 feet beneath a new . . . powerplant."[164]

One of the primary purposes of WESTCARB III is to "address and provide important information for evolving institutional, regulatory and legal frameworks—[to] 'frame the debate.'"[165] CES owns the land upon which the new powerplant will be built and below which the CO_2 will be sequestered.[166] However, since ownership rights are clear, the WESTCARB pilot project will not likely inspire much discussion of subsurface formation ownership.

V. STATE LAW IN THE UNITED STATES—THE CALIFORNIA EXAMPLE

Due to the enactment of Assembly Bill 32,[167] it is of specific importance that WESTCARB III will be located in California.[168] By

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160. *Id.*

161. West Coast Regional Carbon Sequestration Partnership, CO_2 Sequestration, http://www.westcarb.org/ (last visited Apr. 22, 2010).

162. WESTCARB Phase III is also known as the "Kimberlina Test Facility." WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP, PHASE III FACTSHEET 1, http://www.westcarb.org/pdfs/PhaseIII_%20Factsheet.pdf.

163. Press Release, California Energy Commission, California Awarded $65 Million to Fight Global Warming Carbon Sequestration and Storage to Be Studied at Bakersfield Pilot Site (May 6, 2008), *available at* http://www.energy.ca.gov/releases/2008_releases/2008-05-06_global_warming.html.

164. West Coast Regional Carbon Sequestration Partnership, *supra* note 161.

165. Terry Surles, WESTCARB Development Director, Hawaii Natural Energy Institute/Calif. Inst. For Energy & Environment, presentation at the WESTCARB Annual Business Meeting (Nov. 27, 2007).

166. Telephone Interview with Alex Heney, Media Relations, Clean Energy Systems, in Sacramento, Cal. (Dec. 10, 2008).

167. California Global Warming Solutions Act, CAL. HEALTH & SAFETY CODE §§ 38500–38599 (West 2007).

168. To the extent that climate change is considered air pollution, it is primarily a state concern. With the Enactment of the Air Quality Act of 1967, Congress expressly stated "that air pollution prevention . . . and air pollution control at its source is the primary responsibility of States and local governments." Air Quality Act of 1967, 42 U.S.C 7401(a)(3) (2007); *see also* Huron Portland Cement Co. v. City of Detroit, 362 U.S. 440,

law, California must reduce its GHG emissions to 1990 levels by 2020.[169] Tasked with implementation of this ambitious effort is the California Air Resources Board (CARB).[170] In the *Climate Change Proposed Scoping Plan*, CARB specifically addresses geological storage of carbon and comments that, "while more research and development needs to occur, California should support . . . near-term advancement of the technology . . . ."[171] Without a well-designed legal and regulatory system for CCS, this call for "support" is ineffective.

California has the opportunity to lead the United States and further the goals of Assembly Bill 32 by recognizing a clearly established property right in subsurface geologic formations. In California, real or immovable property consists of land among other things.[172] Further, land is defined as,

> The material of the earth, whatever may be the ingredients of which it is composed, whether soil, rock or other substance, and includes free or occupied space for an indefinite distance upwards as well as downwards, subject to limitations upon the use of airspace imposed . . . . [173]

Subsurface formations appear to fit squarely into the California definition of land because the best-suited GS sites are comprised of porous rock beneath a solid cap rock. However, application of these statutes to GS is cumbersome and unenlightening at best.

The Ninth Circuit adheres to the figurative principle of ownership from the heavens to the center of the earth,[174] constrained only by the ability to exert dominion over the property.[175] Dominion over property results from: (1) exclusive possession; and (2) reclamation from "the general mass of the earth."[176] However, "without possession, no right . . .

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446 (1960) ("Congressional recognition that the problem of air pollution is peculiarly a matter of state and local concern is manifest in this [1955] legislation.").

169. CAL. AIR RES. BD., *supra* note 23, at ES-1.

170. *Id.*

171. *Id.* at 116–17. CARB is contemplating a place for CCS within a larger, proposed carbon trading scheme. This is evidenced by CARB's emphasis on the need to, "ensure an adequate framework is in place to provide credit for CCS projects when appropriate." *Id.* at 117.

172. CAL. CIV. CODE § 658 (2009).

173. *Id.* § 659.

174. Hinman v. Pac. Air Lines Transp. Corp., 84 F.2d 755, 757 (9th Cir. 1936) ("Th[e] formula 'from the center of the earth to the sky' . . . [is] a figurative phrase to express the full and complete ownership of land . . . .").

175. *Id.* at 758.

176. *Id.*

can be maintained."[177] Because subsurface formations are large and lack discrete boundaries, reducing them to "exclusive possession" is impossible without purchasing large tracts of land. Additionally, the value of subsurface formations is in their storage capacity or pore space. Pore space is nothing more than "space" and cannot be "reclaimed" from the earth. Therefore subsurface formations fall squarely outside of the definition of "property" under a Ninth Circuit analysis.

Most modern cases reaffirm the "center of the earth" concept of property ownership,[178] especially in California. However, a few cases outside of California illustrate a shift toward a more relaxed standard as new technologies have stretched the limits of the imagination. For example, an Ohio court explains that "ownership rights in today's world are not so clear-cut as they were before the advent of airplanes and injection wells."[179] Perhaps there is room for modification of the "center of the earth" theory as technology evolves.

A. Airspace Law

Airspace law illustrates the malleability of property rights when confronted by technological innovation. GS is an innovative and desirable technology that illuminates the previously uncontemplated economic value of subsurface formations. Just as courts were confronted with airspace rights and the desirability of commercial air travel, subsurface formation ownership coupled with the desirability of GHG mitigation is a legal issue of first impression. How far do these property rights extend, now that their sudden usefulness has been established?

Historically, fragmentation of airspace risked impeding air transit. Recognizing exclusive ownership in the column of upper airspace above surface property would necessitate extensive negotiations for a single flight path or risk myriad trespass suits. Exclusive ownership would give millions of landowners "virtual veto power" over airplane travel in direct contravention of the public good.[180] To counter this risk, Congress

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177. *Id.* (holding that "the very essence and origin of the legal right of property is dominion over it. Property must have been reclaimed from the general mass of the earth, and it must be capable by its nature of exclusive possession. Without possession, no right in it can be maintained.").

178. John G. Sprankling, *Owning the Center of the Earth*, 55 UCLA L. REV. 979, 991 (2008).

179. Chance v. BP Chem., Inc., 670 N.E.2d 985, 992 (Ohio 1996) (discussing ownership of state waters beneath surface property).

180. Sprankling, *supra* note 178, at 1029–30 (discussing the Supreme Court's rejection of the "heavens to the center of the earth" theory of ownership in U.S. v. Causby, 328 U.S. 256, 261 (1946)).

gave the public freedom of transit in the upper airspace.[181] In 1946, the U.S. Supreme Court addressed this issue and explained:

> The air is a public highway, as Congress has declared. Were that not true, every transcontinental flight would subject the operator to countless trespass suits. Common sense revolts at the idea. To recognize such private claims to the airspace would clog these highways, seriously interfere with their control and development in the public interest, and transfer into private ownership that to which only the public has a just claim.[182]

Property rights in airspace are therefore limited to the extent the airspace is reasonably used by a surface property owner.[183]

By analogy to airspace rights, Congress and the courts have spoken to the ownership issues raised by GS. Both airspace and the subsurface are a public good. Desirable goals are furthered through public use of both the airspace and the subsurface. Until the advent of the commercial airplane, it was unimaginable that the upper airspace could be so imminently useful. Similarly, prior to global awareness of climate change and the subsequent evolution of mitigation technologies, very little contemplation of the usefulness of subsurface formations had transpired. Rather than force protracted negotiations with myriad landowners, Congress may choose to establish the greater public good of GHG mitigation strategies and reserve the subsurface formations solely for public use. However, landowners would still be able to negotiate site access and well locations.

Although this airspace analogy is persuasive and efficient, following Victoria's lead in reserving all rights in subsurface formations to the government will be challenged on constitutional grounds in the United States. A typical property owner will not find a use for the upper airspace because there is no economic incentive to do so. A landowner receives no value from permitting a commercial aircraft to cross the slice of upper airspace above her property. However, in the context of GS there is a strong economic incentive to negotiate use of subsurface formations for sequestration activities. Firms subject to mandatory emissions reductions will be willing to pay for GS if it is cheaper than paying penalties associated with failing to meet a mandatory emissions reduction target. Property owners will negotiate with these firms if they

181. BERNHARDT & BURKHART, *supra* note 86, at 385.
182. U.S. v. Causby, 328 U.S. 256, 261 (1946).
183. BERNHARDT & BURKHART, *supra* note 86, at 385.

expect to profit. If the U.S. Government owns all subsurface formations, firms will only have to negotiate with a single entity; but property owners will be deprived of their ability to profit. This approach will not be well received because of the volume and magnitude of takings proceedings coupled with the complex task of providing just compensation[184] for the "taking" of subsurface property rights.

B. Water Law

A subcategory of subsurface formations is the saline aquifer. This type of formation presents the largest possible storage capacity in the United States and Canada.[185] This vast, unused resource suffers from a lack of case law on point with regard to ownership.[186] In contrast to injection of a substance into the ground for storage, the legal focus in this area has typically been on ownership of the water itself for consumption.[187]

Current law does not distinguish between saline aquifer and "freshwater aquifer."[188] As a result, both are treated identically under the law despite marked differences.[189] Where freshwater aquifers are a great resource and storage location for groundwater, the saline aquifer is essentially useless to human beings. Saline aquifers contain water that is diffuse, briny, and contains myriad dissolved compounds. It is illegal for freshwater aquifers to be used for GS under the SDWA because injected CO_2 would contaminate groundwater.[190] Injection of CO_2 into saline aquifers poses no such threat to groundwater and yet is treated identically to freshwater aquifer contamination.

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184. There are various issues related to quantification of actual damages and just compensation to the property owner. Since the government would own all subsurface formations, it will be difficult to quantify the value of a subsurface formation in the absence of a market reference price. Furthermore, government ownership of such a substantial amount of property would result in significant exposure to lawsuits ranging from groundwater contamination to liability under the Comprehensive Environmental Response, Compensation, and Liablity Act of 1980. 42 U.S.C. §§ 9601–9675 (2006).

185. *See supra* text accompanying notes 48–49.

186. MARK A. DE FIGUEIREDO, PROPERTY INTERESTS AND LIABILITY OF GEOLOGIC CARBON DIOXIDE STORAGE: A SPECIAL REPORT TO THE MIT CARBON SEQUESTRATION INITIATIVE 9 (2005).

187. *Id.*

188. *Id.*

189. *Id.*

190. "All injection must be authorized under either general rules or specific permits. Injection well owners and operators may not site, construct, operate, maintain, convert, plug, abandon, or conduct any other injection activity that endangers USDWs [underground sources of drinking water]." U.S. Envtl. Prot. Agency, Basic Information About Injection Wells, http://www.epa.gov/ogwdw000/uic/basicinformation.html (last visited Apr. 22, 2010).

As a result, state water law may govern ownership of subsurface saline formations[191] due to improper categorization with freshwater aquifers used to store groundwater. Groundwater is stringently regulated under the SDWA[192] and may have an influence on saline formation ownership.[193] The exact nature of this influence is unclear because groundwater law is not designed to address subsurface formation ownership.[194]

Water law is an awkward fit for GS because its sole concern is water rights, not the real property ownership rights associated with where the water is located. Specifically, water law is not directly applicable to GS because "state groundwater law has generally arisen in the context of withdrawals from valuable freshwater aquifers rather than injections into the largely valueless saline aquifers."[195] Although GS involves sequestering CO_2 within water-saturated subsurface formations, water law provides no regulatory guidance regarding ownership of the formations themselves.

The people of California own all water located within the state[196] and it provides an example of regulatory silence regarding ownership of subsurface formations. Section 10752(a) of the California Water Code defines groundwater as "all water beneath the surface of the earth within the zone below the water table in which the soil is completely saturated with water, but does not include water which flows in known and definite channels."[197] The briny water within a saline aquifer is covered by this definition but not the subsurface formation itself.[198]

If the people own all water, it logically follows that saline formations are also the property of the people. However, state "ownership" of groundwater is understood to be ownership "in a regulatory, supervisory

191. FIGUEIREDO, *supra* note 186, at 8; Glaser et al., *supra* note 157, at 439 ("[deep saline aquifer] formation ownership will likely be determined by state groundwater law.").
192. 42 U.S.C.A. § 300h –300h-8 (West 2009).
193. FIGUEIREDO, *supra* note 186, at 3.
194. For example, *EPA's Proposed Well Requirements* do not address subsurface formation ownership. *See supra* text accompanying note 157.
195. Glaser et al., *supra* note 157, at 439.
196. CAL. WATER CODE § 102 (2009).
197. *Id.* § 10752(a) (2009).
198. Although it is beyond the scope of this Comment, it is interesting to note that once CO_2 is injected into the subsurface formation and sequestered in the pore space and/or dissolved in the briny water, it may be considered "groundwater" for purposes of California Water Law.

sense . . . not . . . in a possessory, proprietary sense."[199] Clearly the state does not have possessory ownership rights in groundwater, but the California Supreme Court has explained that neither does the surface owner. The California Supreme Court construed section 102 to mean that a property owner did not own the "groundwater, surface water, and aquifers on and surrounding" his property.[200] If the state does not have possessory ownership and the surface owner does not own aquifers beneath his property, it is not clear that any party owns a proprietary interest in California groundwater.[201]

Amending the current definition of "groundwater" to specifically exclude saline aquifers resolves the ambiguous applicability of water law to GS. However, such an amendment does not clarify ownership rights. Merely establishing that GS reservoirs are *not* subject to water law does not provide any information regarding the reservoir's owner. Additionally, California enacted the Safe Drinking Water and Toxic Enforcement Act through initiative in 1986.[202] This measure requires some of the most stringent regulations in the nation with regard to toxic chemicals and groundwater contamination. The perceived risks of groundwater contamination resulting from GS activities will likely inspire significant public attention and concern. As a result, the legislature is not likely to exclude saline aquifers and in the absence of a separate GS regulatory regime, the applicability of water law to GS will remain unsettled.

C. Property Rights—Defining the Mineral Estate

Subsurface formations suitable for GS are currently a legally unrecognized mineral resource. Amending existing mineral law to

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199. State v. Super. Ct. of Riverside County, 93 Cal. Rptr. 2d 276, 287–88 (Ct. App. 2000).

200. AIU Ins. Co. v. Super. Ct. of Santa Clara County, 799 P.2d 1253, 1261 (1990).

201. Presuming water law applies to GS for the purpose of entertaining an analogy, California subscribes to the "correlative rights rule" with regard to groundwater. FIGUEIREDO, *supra* note 186, at 10. Setting direct subsurface ownership rights issues aside and presuming water law would apply, this rule "holds that a land owner may use groundwater in proportion to its surface ownership." Glaser et al., *supra* note 157, at 439. This concept has been "extended by the doctrine of mutual prescription [to] allocat[e] water by comparing reasonableness of use based on such factors as custom, social utility, safe yield, and need." FIGUEIREDO, *supra* note 186, at 10–11 (citing City of Pasadena v. City of Alhambra, 207 P.2d 17, 33 (1949)). Applying this rule to GS would permit landowners to store GS in subsurface formations in proportion to their ownership of the surface. Certainly GS provides "social utility" in the form of reduced GHG emissions. However, determining one landowner's degree of "need" for GS beneath his property could prove difficult. There is a risk that various landowners with a profit motive might attempt to show a greater "need" to store more carbon beneath their property through litigation.

202. CAL. HEALTH & SAFETY CODE §§ 25249.5–25249.13 (2009).

create a new mineral right in subsurface formations instantly results in a familiar regulatory framework and body of common law applicable to GS by analogy.

There is no single definition of "mineral estate."[203] In fact, courts have generally considered the meaning of "mineral estate" to be uncertain and indefinite.[204] A suitable subsurface GS formation includes two basic requirements covered by this broad, cross-categorical characterization of "other minerals": porous rock and cap rock. This elastic definition of "other minerals" has allowed courts to "accommodat[e] substances that *rather recently have acquired greatly increased economic value*."[205] Subsurface formations are not "substances." However, large-scale deployment of GS renders the previously valueless subsurface formations an important resource, thereby greatly increasing their economic value. Since courts have historically expanded or narrowed the mineral estate from time to time,[206] judicial or legislative expansion to accommodate subsurface formations presents an excellent option for regulation.

In the Australian Guide, the MCMPR recommends that GS-specific legislation take the form of amendments to existing oil and gas law rather than the whole cloth creation of a new regulatory regime.[207] In the absence of legislative direction, courts will construct a place within the mineral estate for ownership of subsurface formations.

Categorizing a subsurface formation as a "mineral" turns on the definition of "substance." Merriam-Webster defines "substance" as "matter of particular or definite chemical constitution."[208] The term "mineral rights" often contemplates substances that stretch this traditional understanding. For example, "gravel, clay, granite, sandstone, coal, lignite, surplus salt water, iron ore . . . uranium, fissionable materials, subterranean water, helium, carbon dioxide,[209] and geothermic matter such as hot

203. RICHARD W. HEMINGWAY, THE LAW OF OIL AND GAS 8 (3d ed. 1991).
204. *Id.* at 11.
205. *Id.* (emphasis added).
206. *Id.*
207. AUSTL. GUIDE, *supra* note 93, at 32.
208. Merriam-Webster OnLine, http://www.merriam-webster.com/dictionary/substance (last visited Mar. 6, 2009).
209. HEMINGWAY, *supra* note 203, at 9. Because it is beyond the scope of this Comment, we must set aside the question of whether a mineral estate owner, in conveying his grant of "oil, gas and other minerals" would be interpreted as conveying any CO_2 that had been sequestered beneath his property.

water and steam . . ." have been considered "all other minerals."[210] Subsurface formations are a substance because they are comprised of porous rock with "particular chemical constitution."[211]

Subsurface formations are a separate mineral estate interest because they meet the most common requirements examined by courts in deciding the issue. Subsurface formations reasonably could be found to "possess [the] exceptional characteristic or peculiar property"[212] of being suitable for GS. Such suitability might then be found to give the subsurface formation "a special value apart from the land itself."[213] Further, subsurface formations are not "traditionally associated with surface ownership, or . . . considered essential or beneficial to the utilization of the surface of the land."[214] As a result, subsurface formations assimilate nicely into the current body of mineral law.

D. Oil and Gas Law

Subsurface formations such as GS-suitable saline formations are large and do not have discrete boundaries because they are permeable rock formations.[215] As a result, concurrent injection of CO_2 into the same formation is likely to result. Similar to oil and gas law,[216] it is difficult to determine from which location among many the CO_2 stored within a subsurface formation originated. Where oil and gas law focus on extraction—and sometimes storage—of a valuable commodity, GS involves capture of a pollutant and its injection into the earth. Therefore, any examination of oil and gas law as an analogy requires it to be applied in reverse to GS.

In oil and gas law, for example, the fundamental "rule of capture" assigns title to oil and gas drained from beneath another's property to the party who produced it.[217] In GS activities this rule would assign title to a subsurface formation by the first person or entity to discover and inject CO_2 into it. Alternatively, California follows the minority, "non ownership"

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210. *Id.*
211. *See supra* text accompanying notes 58–62.
212. HEMINGWAY, *supra* note 203, at 12.
213. *Id.*
214. *Id.* at 12–13.
215. *Id.*
216. "Oil and gas are fugacious; they may move from place to place within sedimentary rock. In addition, oil and gas are fungible; it is difficult to determine whether a certain MCF of gas or barrel of oil produced has been drawn from under one tract of land or another." JOHN S. LOWE, OIL AND GAS LAW IN A NUTSHELL 8 (3d ed. 1995).
217. *Id.* at 9.

theory of oil and gas.[218] This theory holds that "the owner of oil and gas rights [does] not own oil or gas until it [has] been controlled by capture in a well."[219] Therefore, if subsurface formations exist below surface property, the surface owner has the right to sequester carbon, but not until she actually starts doing so. Either approach is an effective means of allocating ownership rights in subsurface formations but neither addresses the fragmentation problem.

Under California oil and gas law, the fragmentation problem is addressed through mandatory pooling agreements. The concept of pooling "usually describes the joining together of tracts [of land] in order to receive a drilling permit under the applicable well spacing rule for the area."[220] Considering a subsurface reservoir to be a "pool" for the purposes of this analogy, California's mandatory pooling statute could be modified to address GS. Landowners could also voluntarily pool their property rights to a single subsurface formation and negotiate storage fees in proportion to their surface ownership.

Mandatory pooling can be required in California to "prevent waste" and increase "recovery of oil or gas,"[221] and is a model for amalgamation of property rights for GS purposes. Additionally, the California Public Resources Code specifies that "a well spacing plan apply[ing] to the surface and *subsurface* of a designated pool . . . [may require that] all or certain specified parcels of land shall be included in [the] pooling . . . agreement."[222] Presuming there will be GS well spacing requirements, for example, a mandatory pooling requirement could force surface landowners to combine their interests in the same subsurface formation. This would streamline storage access negotiations. Additionally, such a pooling agreement could help ensure that only a single well is drilled over a specific subsurface formation and reduce the risk of competing interests from multiple wells sequestering carbon in the same geologic formation.

218. *Id.* at 29.
219. *Id.* at 28.
220. Bruce M. Kramer, *Compulsory Pooling and Unitization: State Options in Dealing With Uncooperative Owners*, 7 U. UTAH J. ENERGY L. & POL'Y 255, 255 n.1 (1986).
221. CAL. PUB. RES. CODE § 3609 (2009).
222. *Id.* (emphasis added).

E. Natural Gas Storage

The storage of natural gas[223] appears to be the most likely applicable analogy to GS because of the technical similarities.[224] However, there are two main points of distinction:[225] natural gas storage is exempt from the UIC program under the SDWA,[226] and natural gas is a valuable commodity. By contrast, the EPA's Proposed Well Requirements signal that EPA contemplates jurisdiction[227] over GS wells. Additionally, stored CO_2 is essentially pollution; the value is in the subsurface formation's ability to sequester it. However, similarities related to risk of groundwater contamination and technological storage specifications warrant further examination.

It is not likely that GS will be exempted from the UIC if the EPA's Proposed Well Requirements become a formal rule because CO_2 is not a "natural gas." Determinations of administrative agencies in interpreting

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223. To be clear, CO2 is not considered a natural gas under the Underground Injection Control Program, nor under the Safe Drinking Water Act. Moore, *supra* note 5, at 462. The purpose of this analysis is to examine regulation that may be the nearest available model, by analogy, for GS of CO_2.

224. *Compare* JAMES E. MIELKE & JOSEPH P. RIVA, JR., CONGRESSIONAL RESEARCH SERVICE REPORT FOR CONGRESS: UNDERGROUND STORAGE OF NATURAL GAS iii, CRS-4 (Cong. Research Service: The Library of Cong. 1988) ("Storing natural gas underground involves containing the gas within the pore structure of a large volume of porous and permeable rock enclosed by an impermeable cap rock."), *with supra* text accompanying notes 60–64 (a suitable potential GS reservoir "is composed of porous rock" and "capped by one or more . . . impermeable rock formations.").

225. There is another point of distinction worth mentioning. Natural gas is piped interstate and is therefore regulated at the federal level by the Federal Energy Regulatory Commission (FERC). At this juncture, it is premature—although not impossible—to assume that FERC will have jurisdiction over GS activities. It remains to be seen whether storage locations will require interstate transport of CO_2 or whether large subsurface formations will cross state lines and trigger FERC jurisdiction.

226. 42 U.S.C. § 300h(d)(1)(B)(i) (2006).

227. Since GS sequesters CO_2 that would otherwise be emitted into the air and covered under the provisions of the Clean Air Act (CAA), it is likely that the EPA will have authority to regulate GS activities. 42 U.S.C. §§ 7401–7671(q) (2006). The U.S. Supreme Court's landmark decision in *Massachusetts v. EPA* held that it is within the authority of the EPA under the CAA to regulate CO_2 emissions from new motor vehicles "in the event [EPA] forms a 'judgment' that such emissions contribute to climate change." 549 U.S. 497, 528 (2007). Although not directly on point, the *Massachusetts* case provides support that the EPA will likely have authority to regulate CO_2 emissions if found to contribute to climate change. On December 15, 2009, EPA published an endangerment finding for six greenhouse gases including CO_2. Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 66496 (Dec. 15, 2009).

and implementing federal legislation are given deference by the courts.[228] With respect to CO_2, the Tenth Circuit upheld a decision by the EPA "to regulate the disposal of [CO_2] waste fluids—including underground injection."[229] Specifically, the court "upheld the administrative interpretation that [CO_2] is not 'natural gas' within the meaning" of well classifications in the code of federal regulations.[230]

Despite the likelihood that CO_2 will not be exempt under the SDWA, it is still helpful to examine the current state of natural gas storage law. The complexities of underground natural gas storage are best illuminated by Kuntz' recommended approach to securing such rights:

> Because the cases on [this] subject are few in number and are not in harmony, when a subsurface stratum is acquired for storage purposes, the grant should be taken from the person having the right to extract the particular substance to be stored, the surface owner and the owner of any other mineral rights. Prudence also dictates that grants be secured from mineral owners of any separate strata not acquired whose rights of access might be impaired, from owners of various surface interests and from owners of easements or other similar interests whose rights might be impaired in some way.[231]

This recommendation provides an illuminating roadmap through the complexities inherent in subsurface property rights related to GS from a contractual perspective. Despite the complexities, the GS industry may take solace in the existence of a functioning natural gas storage industry. Although the law in this area is complex, it is not prohibitive—with the proper economic incentives. The existence of "special statutory provisions for condemnation of subsurface structures for gas storage" in various

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228. When a court reviews an agency's construction of the statute which it administers, it is confronted with two questions. First, always, is the question whether Congress has directly spoken to the precise question at issue. If the intent of Congress is clear, that is the end of the matter; for the court, as well as the agency, must give effect to the unambiguously expressed intent of Congress. If, however, the court determines Congress has not directly addressed the precise question at issue, the court does not simply impose its own construction on the statute, as would be necessary in the absence of an administrative interpretation. Rather, if the statute is silent or ambiguous with respect to the specific issue, the question for the court is whether the agency's answer is based on a permissible construction of the statute.

Chevron U.S.A., Inc. v. Natural Res. Def. Council, 467 U.S. 837, 842–43 (1984).

229. Arco Oil & Gas Co. v. Envtl. Protection Agency, 14 F.3d 1431, 1437–38 (10th Cir. 1993) (citing 40 C.F.R. § 144.6 (West 1993)).

230. *Id.* at 1437.

231. 1 EUGENE KUNTZ, A TREATISE ON THE LAW OF OIL AND GAS 75 (1987).

states[232] may provide a model for regulating GS[233] because current regulatory frameworks could be amended to cover GS.

F. Eminent Domain[234] and Condemnation

The IOGCC model statute suggests eminent domain proceedings to acquire ownership of subsurface formations where there is a fragmentation issue.[235] Taking this suggestion a step further would be to follow the Victorian model[236] and render subsurface formations state property.[237] With such a monopoly, the state government may best be able to regulate GS. Where the subsurface formations cross state borders and injection sites are present in each state, the mingling of CO_2 in the reservoir is a function of interstate commerce. As a result, establishment of a uniform system of state-based administration under federal direction provides regulatory oversight of GS operations, and is consistent with the notion of dual sovereignty inherent in the UIC program authorized by the SDWA.[238]

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232. *Id.* at 77–78.

233. For an excellent analysis of major issues related to federal condemnations for underground natural gas storage rights that outlines issues that will likely also be faced by GS including valuation and extent of property owner's rights to subsurface geologic formations, see generally Steven D. McGrew, *Selected Issues in Federal Condemnations for Underground Natural Gas Storage Rights: Valuation Methods, Inverse Condemnation, and Trespass*, 51 CASE W. RES. L. REV. 131 (2000).

234. The focus of this Comment is on determining initial ownership rights. Since eminent domain can only be addressed "once ownership issues have been determined" full eminent domain analysis is beyond the scope of this Comment. Mark A. de Figueiredo, *Property Interests and Liability of Geologic Carbon Dioxide Storage*, *in* CARBON CAPTURE AND SEQUESTRATION: INTEGRATING TECHNOLOGY, MONITORING, AND REGULATION 243, 244 (Elizabeth J. Wilson & David Gerard eds., 2007).

235. *See supra* text accompanying notes 156–157.

236. *See supra* text accompanying note 136.

237. Notably, state ownership of subsurface formations would also alleviate the issue of subsurface trespass inherent in private ownership. Further, the issue of permanent long-term storage of the sequestered CO_2 could be remedied by enacting legislation similar to the Nuclear Waste Policy Act, 42 U.S.C. §§ 10101–10270 (2006). This Act transferred ultimate title of nuclear waste to the Federal Government as it was determined that "Federal ownership and management of such [a] site is necessary or desirable in order to protect the public health and safety, and the environment." 42 U.S.C. § 10171(b)(1)(C) (2006). With a finite end to liability for sequestered carbon, it is more likely that firms would invest in the technology. For a detailed discussion of a CCS-specific liability regime, see 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).

238. 42 U.S.C.A. § 300h-1 (West 2009). The relationship between federal and state governments under this type of program is characterized as "dual sovereignty." James R. May, *Of Happy Incidents, Climate, Federalism, and Preemption*, 17 TEMP. POL. & CIV. RTS. L. REV. 465, 471 (2008). State primacy is preserved through the power to implement

Should Congress express its intent that states pursue condemnation of subsurface formations for GS purposes, it would be at the behest of the states to amend existing law or create a new statutory regime. In California, for example, the Public Utilities Code permits condemnation of "any property necessary for the construction and maintenance of" a gas or electric plant.[239] Further, the 1975 Law Revision Commission explains that,

> Section 612 grants an "electrical corporation" (defined in Section 218) the right of eminent domain to acquire property necessary for the construction and maintenance of its electric plant. "Electric plant" is defined in Section 217 to mean in substance all property devoted to public use in the production, generation, transmission, delivery, or furnishing of electricity for light, heat, or power. Thus, Section 612 authorizes condemnation of any property necessary to carry out the regulated activities of the electrical corporation.[240]

To facilitate GS, the Public Utilities Code could be amended to include GS formations as "property devoted to public use" that is "necessary to carry out" the GHG mitigation goals from Assembly Bill 32.

What comprises a "public use" is largely dependent upon specific facts and circumstances and requires a case-by-case inquiry.[241] Further, "public use" has been defined as "a use which concerns the whole community or promotes the general interest in its relation to any legitimate object of government."[242] Most relevant to GS is that a public use "may extend to matters of public health, recreation and enjoyment."[243] Nothing would appear more appropriate as a "public use" than GHG mitigation. Climate change concerns a "whole community" and has dire implications with regard to "public health, recreation and enjoyment."

Broadening the doctrine of eminent domain in this respect is not politically feasible in the United States without public acceptance of the exigencies of climate change. The public is frustrated by "the legal confusion engulfing the definition of public use and legal setbacks for

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and enforce standards while the Environmental Protection Agency retains the power to set federal "technology-based performance standards." *Id.*

239. CAL. PUB. UTIL. CODE § 612–613 (2009).

240. CAL. L. REVISION COMM'N, THE EMINENT DOMAIN LAW 1001, 1017–18 (1975), *available at* http://clrc.ca.gov/pub/Printed-Reports/Pub118.pdf.

241. City of Oakland v. Oakland Raiders, 646 P.2d 835, 841 (1982) (citing Fallbrook Irrigation Dist. v. Bradley, 164 U.S. 112, 159–60 (1896)).

242. *Id.* (quoting Bauer v. Ventura County, 45 Cal.2d 276, 284 (1955)).

243. *Id.*

advocates of private property rights in courts around the nation. . . ."[244] This has resulted in "an ever-increasing public outcry against many, if not most, exercises of eminent domain."[245] Condemning subsurface formations for GS would be the largest eminent domain action in U.S. history. As such, any attempt would likely be met with constitutional challenges, additional cost-prohibitive litigation, and just compensation costs. Although this approach would clearly allocate property rights, this approach will not succeed without a tidal sea change in public opinion.

VI. RECOMMENDATIONS AND CONCLUSION

There is no obvious solution to clarifying ownership rights in subsurface formations suitable for GS. Through federal-level guidance and individual state action, Australia is cultivating a regulatory and legal environment to help invite GS investment and increase confidence in the industry. Combining these international developments with current U.S. law and guidance can provide a partial model for future action in the United States and crystallize the need for the clear identification of subsurface property rights.

Australia and the United States differ in many respects yet share some important similarities. Both countries have significant coal reserves, are heavily dependent on coal-fired power generation, and are becoming more cognizant of the need to take action to reduce GHG emissions. Additionally, both the MCMPR and IOGCC observe that clarity with regard to subsurface ownership rights is essential in the development of a regulatory regime for GS.

The recommendation most congruent with settled U.S. law and the American respect for private property follows the approach suggested in both the Australian Guide and the IOGCC Guide. This approach involves amending existing statutes to directly address subsurface formation ownership in the context of GS. In this scenario, the federal government issues guidance to the states with the same goal as the MCMPR in the Australian Guide: a consistent national approach to GS legislation. Although ownership rights are allocated to the surface owner, states maintain ultimate discretion in choosing a regulatory approach. This results in different legal regimes for each state jurisdiction and requires firms to negotiate with every party with any interest in the subsurface.

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244. Alberto B. Lopez, *Weighing and Reweighing Eminent Domain's Political Philosophies Post-*Kelo, 41 WAKE FOREST L. REV. 237, 240 (2006).
245. *Id.*

Although costs would be higher under this approach, courts have confronted and successfully resolved analogous legal issues of first impression, and a body of common law would develop.

The second recommendation is more efficient but less politically feasible. Following the Victorian model, ownership of subsurface formations is allocated to individual states as a public good. Although it goes against the grain of the American appreciation for personal property, a government monopoly on subsurface formations increases predictability and reduces transaction costs. Under this regime, firms interested in GS would be required to negotiate with a single owner—the state—rather than all parties with any interest in the subsurface. The resulting clarity of ownership rights in combination with a standardized government negotiation process significantly increases certainty in the industry. The success of this approach turns on public opinion regarding the relative importance of mitigating GHG emissions and the government's ability to defend against constitutional challenge and provide just compensation.

GS presents novel subsurface ownership issues that must be addressed in any related U.S. regulatory framework. Predictability and certainty in this regard will provide regulatory clarity and encourage investment in what is currently a legal and regulatory vacuum. GS could provide one of the many small advantages necessary to mitigate GHG emissions. Yet without clearly established property rights inspiring certainty in the industry, we can be certain only that the GHG mitigation potential of large-scale GS deployment will remain unrealized.