Findings and Recommendations by the California Carbon Capture and Storage Review Panel

December 2010

Contents

Abbreviations and Acronyms

ARB – California Air Resources Board
ARRA – American Recovery and Reinvestment Act of 2009
CAA – Clean Air Act
CEC – California Energy Commission (also Energy Commission)
CEQA – California Environmental Quality Act
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
CPUC – California Public Utilities Commission
DOE – U.S. Department of Energy
DOGGR – Division of Oil, Gas and Geothermal Resources
DOT – Department of Transportation
EJ – Environmental Justice
Energy Commission – California Energy Commission
EOR – enhanced oil recovery
EPS – Emissions Performance Standard
FERC – Federal Energy Regulatory Commission
GHG – greenhouse gas
GS – geologic storage
LGP – loan guarantee program
MOU – Memorandum of Understanding
MRR – mandatory reporting regulation (ARB) or rule (U.S. EPA)
MRV – monitoring, reporting, and verification
NGA – Natural Gas Act
NSR – New Source Review
PHMSA – Pipeline and Hazardous Materials Safety Administration
PIER – Public Interest Energy Research
PSD – Prevention of Significant Deterioration [program]
SIP – State Implementation Plan
SDWA – Safe Water Drinking Act
UIC – underground injection control
USDW – underground sources of drinking water
EPA – U.S. Environmental Protection Agency
WCI – Western Climate Initiative
WESTCARB – The West Coast Regional Carbon Sequestration Partnership

Executive Summary

California's Greenhouse Gas Reduction Requirements

To stem the effects of global warming, the Global Warming Solutions Act of 2006 (Assembly Bill 32,[1] or AB 32), commits California to (1) the achievement of a statewide greenhouse gas (GHG) emissions limit by 2020 based upon emission levels in 1990, and (2) the adoption of rules and regulations to "achieve the maximum technologically feasible and cost-effective" GHG emission reductions from specified sources or source categories. AB 32 followed Executive Order S-3-05,[2] in which the Governor of California established three emission reduction targets: (1) by 2010, reduce GHG emissions to 2000 levels; (2) by 2020, reduce GHG emissions to 1990 levels; and (3) by 2050, reduce GHG emissions to 80 percent below 1990 levels. These goals are consistent with U.S. goals as reflected in the Copenhagen Accords[3] and the recent United Nations Climate Change Conference agreements in Cancun.[4]

The major sources of GHG emissions identified by the California Air Resources Board (ARB) are the transportation, electric power, industrial, commercial and residential, and agricultural sectors. While several long-lived gases contribute to GHG emissions, by far the dominant GHG in the State is carbon dioxide (CO_2) emitted from the combustion of fossil fuels used for transportation, electric power generation and industrial operations. Deep reductions in CO_2 emissions are thus required to meet California's commitments under AB 32.

Toward this end, considerable efforts are being focused in California on improving end-use energy efficiency and increasing the amount of electricity produced from renewable energy resources. These measures, as well as other mitigation options such as sustainable biofuels and smart growth, reduce the consumption of fossil fuels and will thus play important roles in California's energy future. Nonetheless, fossil fuels, including oil for transportation and natural gas for electricity production, will constitute a substantial component of California's emissions for some time to come. In order to utilize fossil fuels and meet the 2050 GHG emissions reduction goal, it will be necessary to deploy additional technologies. Carbon capture and storage (CCS) is a technology that may need to be deployed on a significant scale to curb CO_2 emissions from power plants and industrial sources.

Creation of the Carbon Capture and Storage Review Panel

Recognizing the importance of CCS for California's industrial and electricity sectors, the California Public Utilities Commission (CPUC), California Energy Commission (Energy Commission), and the Air Resources Board (ARB) created a CCS Review Panel in February 2010. The Panel, composed of experts[5] from industry, trade groups, academia, and environmental organizations, was asked to:

1. Identify, discuss, and frame specific policies addressing the role of CCS technology in meeting the State's energy needs and greenhouse gas emissions reduction strategies for 2020 and 2050.

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[1] http://www.leginfo.ca.gov/cgi-bin/postquery?bill_number=ab_32&sess=0506&house=B&author=nunez
[2] http://www.dot.ca.gov/hq/energy/ExecOrderS-3-05.htm
[3] http://unfccc.int/documentation/documents/advanced_search/items/3594.php?rec=j&priref=600005735#beg
[4] http://unfccc.int/2860.php
[5] Appendix B in *Draft White Papers: Carbon Capture and Storage in California - Prepared by the Technical Advisory Team in support of The California Carbon Capture and Storage Review Panel*, California Institute for Energy and Environment, Berkeley, CA, December 2010.

2. Support development of a legal/regulatory framework for permitting proposed CCS projects consistent with the State's energy and environmental policy objectives.[6]

The Panel held five public meetings on April 22, June 2, August 18, October 21, and December 15, 2010,[7] to arrive at its findings and recommendations. These meetings were designed to solicit input from technical experts and key stakeholders and to allow the Panel to deliberate in an open, public setting.

During the time that the Panel was meeting and deliberating, other significant events occurred on the international, federal, and state levels. The recent international meeting in Cancun of the Conference of Parties to the U.N. Framework Convention on Climate Change recognized that CCS "is a relevant technology for the attainment of the ultimate goal of the Convention and may be part of a range of potential options for mitigating greenhouse gas emissions" and prescribed specific conditions and modalities for its eligibility under the Clean Development Mechanism.[8] The federal government recently completed a multi-agency task force study that emphasized the importance of CCS for reducing GHG emissions and identified measures to help facilitate its use.[9]

Additionally, the United States Environmental Protection Agency (EPA) recently issued new regulations under the Underground Injection Control (UIC) Program for the injection of CO_2 into subsurface formations[10] for the purpose of sequestration, as well as a subpart to the Greenhouse Gas Reporting Rule[11] for annual reporting of emissions from geologic sequestration projects. These regulations by EPA are designed to safeguard underground sources of drinking water and to provide for the monitoring, reporting, and verification of injected CO_2, and releases, if any. To a large extent, the rules for the new Class VI injection wells under the UIC program clarified a number of issues and needs identified by the Panel in its deliberations by defining the minimum requirements for implementing a CCS project. Nonetheless, a number of key issues facing CCS projects in California remain to be resolved.

What are the Key Issues Facing CCS Projects in California?

The Panel identified a number of key legal and regulatory issues that require greater clarity and possible legislative action before CCS can be broadly deployed as a GHG mitigation measure under state laws and policies to reduce CO_2 emissions. Key questions include:

1. Will CCS be eligible to meet the requirements of AB 32 or other relevant California laws and policies?

2. Is there a clear regulatory framework and related permitting pathway for CCS projects in California?

3. Are there clear agency rules that would allow for early CCS demonstration projects in the State?

4. What additional considerations must be addressed and resolved to allow for the deployment of CCS?

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[6] Appendix A in *Draft White Papers: Carbon Capture and Storage in California.*
[7] http://www.climatechange.ca.gov/carbon_capture_review_panel/meetings/index.html
[8] http://unfccc.int/files/meetings/cop_16/application/pdf/cop16_cmp_ccs.pdf
[9] http://fossil.energy.gov/programs/sequestration/ccs_task_force.html
[10] http://water.epa.gov/type/groundwater/uic/class6/gsclass6wells.cfm
[11] http://www.epa.gov/climatechange/emissions/subpart/rr.html

Key Findings and Recommendations

The Panel deliberated on the issues enumerated above and put forth the following key findings and recommendations for consideration by the three principal agencies and the legislature. The body of this report provides more extensive background discussions of these key findings and recommendations, which were adopted at the Panel's final public meeting on December 15, 2010. As part of this issue analysis, a companion report, *Draft White Papers: Carbon Capture and Storage in California,* which contains extensive appendices, was also developed.[12]

Key Findings:

1. There is a public benefit from long-term geologic storage of CO_2 as a strategy for reducing GHG emissions to the atmosphere as required by California laws and policies.
2. Technology currently exists for the safe and effective capture, transport, and geological storage of CO_2 from power plants and other large industrial facilities.
3. High costs, inadequate economic drivers, remaining uncertainties in the regulatory and legal frameworks for CO_2 storage, and uncertainties regarding public acceptance are barriers to the near-term deployment of commercial-scale CCS projects in California.
4. There is a need for clear rules under AB 32 regarding the treatment of CO_2 emission reductions from CCS projects involving capped and uncapped emission sources.
5. Multiple state and federal agencies are currently responsible for permitting CCS projects in California.
6. There is a need for clear, efficient, and consistent regulatory requirements and authority for permitting all phases of CCS projects in California, including CO_2 capture, transport, and storage.
7. Standards are needed to ensure the safe and effective operation of geologic storage projects.[13]
8. Consistent requirements are needed for monitoring, measuring, verifying, and reporting injected CO_2, and releases, if any, and for GHG accounting protocols necessary to comply with federal and state laws and policies to reduce CO_2 emissions.
9. There is a need to establish clear financial responsibility for the stewardship of geologic storage sites during the (a) operating phase; (b) post-injection (pre-closure) monitoring phase; and (c) post-closure phase.[14]

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[12] *Draft White Papers: Carbon Capture and Storage in California - Prepared by the Technical Advisory Team in support of The California Carbon Capture and Storage Review Panel*, California Institute for Energy and Environment, Berkeley, CA, December 2010.

[13] EPA's recently promulgated UIC Class VI rule and subpart RR of the Greenhouse Gas Reporting Rule both apply to California geologic sequestration sites and go a long way toward establishing regulatory requirements for such sites. Nonetheless, gaps remain under those programs and the need exists for California to address those gaps.

[14] We note that the new EPA rules for UIC Class VI injection wells specify requirements for the operating and post-injection (pre-closure) phases, but not the post-closure phase. Since EPA rules are considered minimum requirements under Section 1421(b) of the Safe Drinking Water Act, the State should clarify whether it will adopt more stringent requirements for the phases covered by EPA rules.

10. The right to use subsurface pore space for geologic storage needs to be clarified.
11. There is a need to address any potential environmental justice aspects of CCS projects.
12. There is a need for increased public understanding of CCS benefits and risks.
13. Absent new initiatives, economic barriers to early CCS deployment will delay the technological learning needed to drive down the costs of CCS.

Recommendations:

To ensure that CCS can play a role in meeting California's requirements for GHG emission reductions:

1. The State should recognize appropriately regulated CCS as a measure that can safely and effectively reduce atmospheric emissions of CO_2 from relevant stationary sources, including power plants and other industrial sources. To that end, and conditioned on compliance with all applicable federal and state requirements, ARB should: (a) for capped sources under AB 32, recognize CO_2 sequestered by CCS projects as having not been emitted to the atmosphere (with the result that an allowance is not required to be held for each ton of CO_2 that is captured and geologically stored) and define accounting protocols for sequestered CO_2; and, (b) for uncapped sources under AB 32, decide whether offset protocols for CCS projects within the State should be adopted.

To address regulatory and permitting issues related to CCS projects:

2. The State should evaluate current EPA regulations and determine which, if any, State agency should seek "primacy" for permitting Class VI wells under the UIC program.
3. The State should designate the California Energy Commission (Energy Commission) as the lead agency under the California Environmental Quality Act (CEQA) for preventing significant environmental impacts in CCS projects (both new and retrofit projects).
4. The State should clarify that the State Fire Marshall is indeed the lead agency for regulating the safety and operation of intrastate CO_2 pipelines.
5. The Energy Commission should consult with the responsible permitting agencies in carrying out its responsibilities as the CEQA lead agency for CCS projects. Specifically, the Energy Commission should:
    a. Designate the Division of Oil, Gas and Geothermal Resources (DOGGR) to be the responsible agency for activities related to the subsurface.
    b. Coordinate the development of performance standards for CCS sites that would include design requirements and other operational measurements consistent with the goals of protecting the groundwater and preventing emissions of CO_2 to the atmosphere.
    c. Designate the California Air Resources Board as the responsible agency for air-related aspects of CO_2 monitoring, reporting, and verification (MRV) requirements.
    d. Designate the State Fire Marshall as the responsible agency for CO_2 pipelines.
    e. Designate the State Water Board as the responsible agency for impacts to water quality.

f. Designate other agencies as appropriate.

To address key legal issues and uncertainties related to CCS projects:

6. The State should consider legislation establishing an industry-funded trust fund to manage and be responsible for geologic site operations in the post-closure stewardship phase. In addition, California should proactively participate in federal legislative efforts to enact similar post-closure stewardship programs under federal law.

7. The State legislature should declare that the surface owner is the owner of the subsurface "pore space" needed to store CO_2. The legislature should further establish procedures for aggregating and adjudicating the use of, and compensation for, pore space for CCS projects.

8. The State should consider whether legislation is needed to extend to CO_2 transportation infrastructure for CCS projects the current authority for acquiring the rights of way for the siting of transportation infrastructure for natural gas storage projects.

To ensure the safe, equitable, and cost-effective use of CCS in California:

9. It should be State policy that the burdens and benefits of CCS be shared equally among all Californians. Toward this end, the permitting authority shall endeavor to reduce, as much as possible, any disparate impacts to residents of any particular geographic area or any particular socio-economic class.

10. The Panel endorses the need for a well-thought-out and well-funded public outreach program to ensure that the risks and benefits of CCS technology are effectively communicated to the public.

11. The State legislature should establish that any cost allocation mechanisms for CCS project should be spread as broadly as possible across all Californians.

12. The State should evaluate a variety of different types of incentives for early CCS projects in California and consider implementing those that are most cost-effective.

Introduction

The Role of Carbon Capture and Storage (CCS) in Meeting California's Climate Reduction Goals

Carbon capture and storage (CCS) refers to technologies that are capable of achieving significant reductions in CO_2 emissions from power plants and other large industrial sources using fossil fuels and/or biomass. CCS includes the capture, or removal, of CO_2 within the plant and its subsequent compression, transport, and injection into a geological formation that prevents its release to the atmosphere.

Research, development, and commercialization of CCS have been underway for many years, with major international conferences concerning this technology being held since the early 1990s. Knowledge and practical project experience on this technology has greatly expanded. In 2005, for example, the IPCC issued a Special Report on CCS which reflects the substantial body of evidence, knowledge, and peer-reviewed literature on the subject. In that report, the IPCC affirmed the effectiveness of CCS, concluding that based on observations from existing projects, engineered and natural analogues, and analytical models, "the fraction [of CO_2] retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years. For well-selected, designed and managed geological storage sites, the vast majority of the CO_2 will gradually be immobilized by various trapping mechanisms and, in that case, could be retained for up to millions of years."[15]

Together with other measures, the safe and effective deployment of CCS technologies is an important option in the portfolio of mitigation measures to achieve California's GHG emission reductions under AB 32. For power plants that do not use natural gas, it is also the only option for meeting CO_2 emission limits under the Emissions Performance Standard established in 2006 under Senate Bill 1368. These requirements apply to new or renewed long-term contracts to purchase electricity from baseload facilities owned by, or under long-term contract to, publicly or investor-owned utilities. Such sources must meet a GHG emission performance standard of 1,100 lbs CO_2 per megawatt-hour (MWh)—a standard that effectively requires CCS for any coal-based electricity.

Of particular relevance to California is the fact that CCS is also capable of greatly reducing the carbon footprint of new and existing power plants burning natural gas. While such plants emit less CO_2 than coal-burning plants, their emissions will need to be addressed as well in order to meet California's 2050 reduction goal of 80 percent below 1990 levels. CCS can provide a high level of abatement at these plants. CCS is also capable of controlling CO_2 emissions from California oil refineries—and has been identified by refiners as a key option in reducing emissions from their facilities—as well as other industrial facilities, including plants producing hydrogen and low-carbon transportation fuels. CCS can also provide a pathway to de-carbonize the transportation sector through the use of electric vehicles that utilize low-carbon power.

Studies by a broad range of governmental and non-governmental organizations show that CCS is a critical component of a cost-effective strategy for achieving stringent global GHG emission reductions. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) recognizes that

[15] IPCC, 2005: *IPCC Special Report on Carbon Dioxide Capture and Storage*, Prepared by Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

more stringent greenhouse gas stabilization levels indicate that a wider portfolio of technologies including CCS is needed.[16] The International Energy Agency (IEA) has estimated that CCS could contribute one-fifth of global reduction efforts by 2050, while without CCS overall costs to halve CO_2 emissions levels by 2050 increase by 70%.[17] A recent study by the National Research Council also shows that CCS can play a prominent role in cost-effective strategies to reduce U.S. GHG emissions by 80 percent below current levels by 2050.[18]

California's situation differs from the national and global circumstances in that it relies less on coal to meet its energy needs, and the transportation sector accounts for a much higher portion of its total emissions. Nonetheless, the requirements of AB 32 pose a major challenge for de-carbonizing California energy sources. A portfolio of mitigation options that includes CCS would thus provide California with greater certainty of achieving its long-term emission goals, and of doing so at the lowest cost. CCS has already been identified as a mitigation option in the State. CCS is recognized as a compliance option under the implementing rules for the Emissions Performance Standard under SB1368 by the CPUC and the Energy Commission. California's Low Carbon Fuel Standard (LCFS) acknowledges that CCS may be eligible as a control measure to lower the carbon intensity of fuels including crude oil and the resulting gasoline and diesel products. ARB's *Climate Change Scoping Plan*[19] (December 2008) recommended that "California should both support near-term advancement of the technology and ensure that an adequate framework is in place to provide credit for CCS projects when appropriate." Further, ARB, at its meeting on December 16, 2010, adopted California's cap-and-trade program and also adopted a resolution "to initiate a public process to establish a protocol for accounting for sequestration of CO_2 through geologic means and recommendations for how such sequestration should be addressed in the cap and trade program."[20]

California is a member of the West Coast Regional Carbon Sequestration Partnership (WESTCARB), which is led by the California Energy Commission. Established in 2003, WESTCARB is a public-private collaboration of over 90 organizations devoted to characterizing regional carbon sequestration opportunities in seven western states and one Canadian province. WESTCARB's work includes conducting technology validation field tests, identifying major sources of CO_2 in its region, assessing the status and cost of technologies for separating CO_2 from process and exhaust gases, and determining the potential for storing captured CO_2 in secure geologic formations. The State should continue to guide and support the federally funded WESTCARB Regional Sequestration Partnership Program.

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[16] Technical Summary in *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, page 41.
[17] IEA, Technology Roadmap: Carbon Capture & Storage. http://www.iea.org/papers/2009/CCS_Roadmap.pdf
[18] *Limiting the Magnitude of Future Climate Change.* America's Climate Choices Panel on Limiting the Magnitude of Climate Change, Board on Atmospheric Sciences and Climate Division on Earth and Life Studies, National Research Council of the National Academies, Washington, D.C., 2010.
[19] California Air Resources Board, December 2008, Climate Change Scoping Plan: A Framework for Change, http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.
[20] http://www.arb.ca.gov/cc/capandtrade/capandtrade/draft%20resolution.pdf

What Are the Impediments to Using CCS Technology?

CCS technology is being deployed to a limited extent today and could be more broadly deployed in the near future. For this to happen, however, targeted policy action is needed to address some key barriers. The eventual success of CCS as a mitigation option, and its timely deployment, will depend on whether those barriers are addressed swiftly. Long lead times for project development mean that the State must act now to ensure that CCS contributes to the GHG reduction goals for 2020 and beyond.

First, to justify capital investments in CCS technology, private industry needs to know that California law and regulation will recognize safe and effective CCS as a means of satisfying the state's GHG emission reduction goals. ARB's recent resolution indicates that some clarity has been provided and that details will be forthcoming. Further, if CCS is to play a role in achieving California's GHG reduction goals, a coherent regulatory and permitting framework must be in place. The framework should clearly establish the roles and authorities of the involved state agencies, allow for an efficient permitting process, recognize the value of emission reductions from CCS, and serve the public's interest in assuring climate change mitigation goals are met while protecting human health and the environment.

Second, absent new initiatives, economic barriers alone will impede the early deployment of CCS because its current cost typically exceeds the implicit or explicit "carbon price" associated with near-term (2020) GHG reduction requirements. At the same time, it is also widely expected that technological learning will drive down the future costs of CCS. Thus, there is urgency in beginning to deploy CCS prior to 2020 in order to minimize the costs of meeting California's 2050 climate goals, where CCS is projected to play a more prominent role in achieving cost-effective emission reductions. Given the economic uncertainty, the State should consider the creation of an industry-funded trust fund to cover the costs for geologic site monitoring in the post-closure stewardship phase. California should proactively participate in federal efforts to develop post-closure stewardship programs. Once federal legislation is enacted, the State should consider how to transition the State's fund into the federal one.

Third, despite the status of the technology, the risks and benefits of CCS are not yet well understood by the public, stakeholders, and policymakers. This can have a profound impact on the adoption of policies, the siting of projects, and the pace at which CCS technology is deployed to reduce GHG emissions in California.

AB 32 and Its Applicability to Carbon Capture and Storage

The major policy driver for CCS technology development in California was the enactment of the Global Warming Solutions Act of 2006 (Assembly Bill 32,[21] Chapter 488, Statutes of 2006). This landmark legislation declares global warming to be a serious threat to California's environment and economy. The law requires a reduction in statewide GHG emissions to 1990 levels by the year 2020. In addition, Executive Order S-3-05 signed June 1, 2005, set a 2050 greenhouse gas reduction target of 80 percent below 1990 levels.

Under AB 32, the California Air Resources Board (ARB) is the lead agency for developing a comprehensive, multi-year program to reduce GHG emissions in California. Under its authority, ARB is establishing regulations, programs, and reporting requirements, including:

- The Low-Carbon Fuel Standard requiring a 10 percent reduction in the carbon intensity of liquid transportation fuels by 2020
- Mandatory reporting requirements for major GHG emitters
- Specific GHG reducing measures
- A cap-and-trade program (announced on December 16, 2010) that allows the trading of emission allowances or offset credits among participants in the emerging carbon market

The *Climate Change Scoping Plan*[22] by ARB recognized the role of CCS as a long-term (post-2020) strategy. Its potential role and initial deployment prior to 2020 are not discussed. CCS is specified by ARB as an option for lowering the carbon intensity of high carbon intensity crude oil. However, the Scoping Plan does not measure the potential GHG reductions from this technology, nor does it provide a reporting mechanism for measuring CO_2 emission reductions from CCS technology. Thus, even though ARB voted on December 16, 2010, "to initiate a public process to establish a protocol for accounting for sequestration of CO_2 through geologic means and recommendations for how such sequestration should be addressed in the cap and trade program," it is not yet clear how CCS developers will be given credit for carbon reductions under ARB's mandatory reporting regulation or under the State's cap-and-trade program.

Based on its deliberation of these issues (see the supporting report *Draft White Papers*[23]*)* and on testimony received, the Panel offers the following findings and recommendation:

Key Findings:

- There is a public benefit from long-term geologic storage of CO_2 as a strategy for reducing GHG emissions to the atmosphere as required by California laws and policies.
- Technology currently exists for the safe and effective capture, transport, and geological storage of CO_2 from power plants and other large industrial facilities.
- There is a need for clear rules under AB 32 regarding the treatment of CO_2 emission reductions from CCS projects in capped and uncapped emission sources.

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[21] http://www.leginfo.ca.gov/cgi-bin/postquery?bill_number=ab_32&sess=0506&house=B&author=nunez
[22] California Air Resources Board, December 2008, Climate Change Scoping Plan: A Framework for Change, http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.
[23] Appendix M in *Draft White Papers: Carbon Capture and Storage in California*.

Recommendation:

- The State should recognize appropriately regulated CCS as a measure that can safely and effectively reduce atmospheric emissions of CO_2 from relevant stationary sources, including power plants and other industrial sources. To that end, and conditioned on compliance with all applicable federal and state requirements, the ARB should: (a) for capped sources under AB 32, recognize CO_2 sequestered by CCS projects as having not been emitted to the atmosphere (with the result that an allowance is not required to be held for each ton of CO_2 that is captured and geologically stored) and define accounting protocols for sequestered CO_2; and, (b) for uncapped sources under AB 32, decide whether offset protocols for CCS projects within the State should be adopted.

Permitting CCS Projects in California

There is no single lead agency for the permitting of CCS projects in California. The current permitting process involves a multitude of federal, state, regional, and local agencies, each with its unique authorities and regulatory requirements. Often, the agencies act independently of one another, and permitting timeframes are not always closely coordinated. Multi-agency permitting can be time-consuming and costly for CCS developers, but can ensure that environmental safeguards are in place for such projects.

In addition, gaps exist in how California regulations apply to geologic CCS projects, especially CCS projects that do not involve Enhanced Oil Recovery (EOR). Some of these gaps have been addressed by EPA in its recent rulemaking on Class VI wells for CCS. Other gaps can be addressed by establishing a Memorandum of Understanding (MOU) among state agencies, and by an application from a designated state regulatory agency to obtain "primacy" over CCS injection wells under EPA rules. An MOU can improve coordination among state agencies, especially where there is overlap or the potential for duplication of regulatory requirements. An MOU can also serve to designate the lead agency and clarify the regulatory jurisdiction of different agencies.

Any legal or regulatory framework that is established for permitting CCS projects should be clear and transparent. It should provide needed guidance to project developers on specific regulatory requirements. In addition, such a framework should balance the need for regulatory certainty with the need to protect public health and safety and the environment. Such a framework should aim to:

- Maintain consistency in state permitting requirements for all types of geologic CCS projects
- Clarify the respective roles and boundaries of each of the agencies while reducing regulatory uncertainty
- Define specific regulatory requirements that provide guidance for early geologic CCS projects, until a permanent statutory or regulatory framework is established

The California Energy Commission's 12-month process for licensing electric power plants incorporates the requirements of state, local, or regional agencies into its "one stop" permitting process. The Energy Commission coordinates its review of the facility with other permitting agencies to ensure consistency between their requirements and its own conditions of certification. In the case of a power plant project that involves CCS, the Energy Commission considers the environmental impacts of the entire facility and incorporates permit conditions to ensure that the CO_2 injection process is conducted in an environmentally safe manner.

DOGGR has the authority to regulate EOR projects using different types of injectants, but does not currently have the authority to assume the role of permitting geologic sequestration projects where enhanced recovery is not taking place. Under current law and regulation, DOGGR regulates the drilling and operation of wells that are classified as Class II wells under authority delegated from the EPA. DOGGR sets requirements for any subsurface injection of fluids for enhanced recovery of oil or natural gas, or for fluids that are brought to the surface in connection with conventional oil or natural gas production.

EPA is the lead agency for the Underground Injection Control (UIC) program. EPA has delegated its authority for Class II wells (EOR projects) to DOGGR. Through its recent rulemaking, EPA can delegate similar authority to a state agency for permitting Class VI wells, a new class of injection wells for

geologic sequestration projects established by the "Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells," published in the Federal Register on December 10, 2010.[24]

Based on its deliberation of these issues (see the supporting report *Draft White Papers*[25]*)* and on testimony received, the Panel offers the following findings and recommendations:

Key Findings:

- Multiple state and federal agencies are currently responsible for permitting CCS projects in California.
- There is a need for clear, efficient, and consistent regulatory requirements and authority for permitting all phases of CCS projects in California, including CO_2 capture, transport and storage.

Recommendations:

- The State should designate the California Energy Commission as the lead agency under the California Environmental Quality Act (CEQA) for preventing significant environmental impacts in CCS projects (both new and retrofit projects).
- The State should clarify that the State Fire Marshall is indeed the lead agency for regulating the safety and operation of intrastate CO_2 pipelines.
- The Energy Commission should consult with the responsible permitting agencies in carrying out its responsibilities as the CEQA lead agency for CCS projects. Specifically, the Energy Commission should:
    - Designate the Division of Oil, Gas and Geothermal Resources (DOGGR) to be the responsible agency for activities related to the subsurface.
    - Coordinate the development of performance standards for CCS sites that would include design requirements and other operational measurements consistent with the goals of protecting the groundwater and preventing emissions of CO_2 to the atmosphere.
    - Designate the California Air Resources Board as the responsible agency for air-related aspects of CO_2 monitoring, reporting, and verification (MRV) requirements.
    - Designate the State Fire Marshall as the responsible agency for CO_2 pipelines.
    - Designate the State Water Board as the responsible agency for impacts to water quality.

      Designate other agencies as appropriate.
- The State should evaluate current EPA regulations and determine which, if any, State agency should seek "primacy" for permitting Class VI wells under the UIC program.

[24] 75 Fed Reg 77230 (12/12/10).
[25] Appendix N in *Draft White Papers: Carbon Capture and Storage in California.*

Permitting and Regulation of Intrastate Carbon Dioxide Pipelines

Developing a CO_2 pipeline transportation infrastructure between capture and sequestration sites may encounter challenges in technology, cost, regulation, policy, rights-of-way, and public acceptance. Such an infrastructure already exists for natural gas and CO_2 pipelines, therefore the challenges are not anticipated to be major barriers to deployment. The areas addressed below are safety, siting, and rate regulation of intrastate CO_2 pipelines in California.

Safety

CO_2 pipelines should continue to be regulated as they currently are under the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration. No new regulatory structure is needed. The State Fire Marshal could implement these requirements using existing authority. If it is concluded that legislative clarification is needed, the authority should be accomplished by adding CO_2 transportation pipelines to the State Fire Marshal's authority.

Siting

CCS-related site access rights could be legislatively addressed through a relatively small change to the language in existing statutes that provide authority for natural gas storage. The legislative action would be to amend the current language to include CCS. The authority in existing California law for underground natural gas storage condemnation is in the CPUC. A few extra steps would be needed to include such language in the statutory authority of the Energy Commission. A memorandum developed by the Panel's technical advisory committee titled "Establishing Eminent Domain Authority for Carbon Storage in California,"[26] provides sample amendments that would extend condemnation authority to carbon sequestration facility operators following the natural gas storage model. There are pros and cons to legislative action in this area, and such legislation should be approached with caution due to the public interests and sensitivities. However, legislation authorizing the use of eminent domain for CO_2 pipelines would likely further the implementation of carbon sequestration to the extent it does not lead to opposition against projects.

Rate regulation

CO_2 pipelines' rates and services should be left to commercial contracts, primarily because of uncertainty as to who will own and operate such facilities, and what business model the providers of these services will use. In addition, early pipeline projects are likely to be designed for exclusive use of pipeline capacity by a project developer as part of an integrated capture/transport/storage project. Regulatory action on rates could add complexity for these early projects without significantly furthering the implementation of carbon sequestration.

Based on its deliberation of these issues (see the supporting report *Draft White Papers*[27]*)* and on testimony received, the Panel offers the following finding and recommendations:

[26] Appendix S in *Draft White Papers: Carbon Capture and Storage in California.*
[27] Appendix I in *Draft White Papers: Carbon Capture and Storage in California.*

Key Finding:

There is a need for clear, efficient, and consistent regulatory requirements and authority for permitting all phases of CCS projects in California, including CO_2 capture, transport, and storage.

Recommendations:

- The State should clarify that the State Fire Marshall is indeed the lead agency for regulating the safety and operation of intrastate CO_2 pipelines.
- The State should consider whether legislation is needed to extend to CO_2 transportation infrastructure for CCS projects the current authority for acquiring the rights of way for the siting of transportation infrastructure for natural gas storage projects.

Standards and Reporting Requirements for Geological CO_2 Storage Projects

The regulation of geological CO_2 storage (GS) sites must ensure both the safety of CCS operations and the permanence of CO_2 sequestration. This will require regulations and standards for permitting GS sites, as well as requirements for monitoring, reporting, and verification (MRV) during site operation.

Standards for the permitting and operation of a GS site would have to first define what constitutes a geologic storage project for purposes of CCS, and explicitly distinguish it from a project whose sole purpose is enhanced oil recovery (EOR) or enhanced gas recovery.

While the general objective of GS standards is to ensure the permanence of carbon storage, a requirement such as the ongoing need to demonstrate with a high degree of confidence that a site would retain 99 percent or more of the injected CO_2 for 1000 years would be problematic as an ongoing performance requirement because it could not strictly be met short of elaborate site monitoring for 1000 years. However, such a requirement could function effectively as a site screening and design requirement. Thus, the concept advocated by the Panel is one of performance standards which, if met, would be consistent with the expectation of storage permanence and safety. The standards would include defined performance measures, design requirements, procedures, monitoring requirements, and other specified measures consistent with the policy goals of preventing CO_2 emissions to the atmosphere, while protecting human health and the environment (including groundwater and other valued resources). Performance standards for GS operations would also include the ability to undertake specified mitigation and remediation measures should leaks or other performance issues arise during the course of operations.

In the context of geologic CO_2 storage, MRV requirements refer to activities for collecting and reporting data about the characteristics and performance of GS projects. The primary purposes of MRV will be to verify that projects perform as expected—that ecosystems, local populations, livestock, and natural resources such as groundwater and recoverable oil and gas are protected, that damages from seismicity do not result from injecting CO_2, and that the proposed storage of CO_2 emissions is achieved.

There are available measurement techniques for detection of leakage and the overarching approaches for combining these techniques into a monitoring program. The major components to be addressed by monitoring in GS projects include: (1) injection rates and pressure, (2) injection well integrity, (3) subsurface distribution of the CO_2, and (4) the local environment.

Many of the measurement technologies for monitoring GS are drawn from other applications such as the oil and gas industry, natural gas storage, disposal of liquid and hazardous waste in deep geologic formations, groundwater monitoring, safety procedures for industries handling CO_2, and ecosystem research. These established practices provide numerous measurement approaches and options—a monitoring toolbox—which enables development of tailored, flexible monitoring programs for GS.

Practical and cost-effective approaches to MRV will rely on a combination of measurements and model predictions, tailored to the geological attributes and risks of specific storage sites. Many current GS projects involve research elements to further develop or adapt existing measurement tools to the characteristics of CO_2 storage or to test new techniques. This research aims to enhance our understanding of GS, lower costs, gain lessons learned from field testing, and expand the options of an already robust monitoring toolbox.

The inherent variability in geologic environments calls for flexibility in the MRV methods used, types and numbers of parameters measured, and the temporal and spatial frequency of their measurement. A consistent monitoring policy across different government regulatory entities will be essential to enable project developers to build unified, tailored monitoring programs that will allow GS projects to move forward in a cost- and time-effective manner, while ensuring protection of the public, the environment, and natural resources.

In November 2010, EPA finalized requirements for GS wells, including the development of a new class of wells (Class VI), under authority of the U.S. Safe Drinking Water Act's Underground Injection Control (UIC) Program.[28] These requirements are designed to protect underground sources of drinking water (USDWs).

In a complementary rulemaking issued under the U.S. Clean Air Act, EPA finalized reporting requirements for GS sites under the federal GHG reporting program.[29] This subpart to the national Greenhouse Gas Reporting Rule (subpart RR) requires GS sites to report their air emissions (if any) while also complying with EPA-approved "Monitoring, Reporting and Verification" (MRV) plans. While just a reporting requirement, the purpose of the federal subpart RR rule is to enable EPA to gather data that is expected to confirm that geologic sequestration results in permanent storage.

Together, the federal Class VI rule and subpart RR rule, which apply to California GS sites, provide for substantial regulation of storage sites. However, some regulatory gaps may remain, as follows: (1) because the federal UIC Class VI rule is intended to only protect USDWs, other environmental and mineral rights receptors in California are left unprotected; (2) the federal subpart RR reporting rule, because it is only an emissions reporting rule, arguably fails to establish binding legal requirements regarding atmospheric emissions of CO_2 from GS sites; and (3) although both the federal Class VI and subpart RR reporting rule contain detailed requirements related to MRV and related requirements, California (and specifically, ARB) needs to review these federal rules and likely adopt its own MRV requirements to ensure compliance with programs established under AB 32.

Based on its deliberation of these issues (see the supporting report *Draft White Papers*[30]*)* and on testimony received, the Panel offers the following findings and recommendation:

Key Findings:

- Standards are needed to ensure the safe and effective operation of geologic storage projects.
- Consistent requirements are needed for monitoring, measuring, verifying, and reporting injected CO_2, and releases, if any, and for GHG accounting protocols necessary to comply with federal and state laws and policies to reduce CO_2 emissions.

Recommendation:

The recommendations presented earlier under "Permitting CCS Projects in California" effectively address the findings related to standards and reporting requirements for GS projects.

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[28] http://water.epa.gov/type/groundwater/uic/class6/gsclass6wells.cfm
[29] http://www.epa.gov/climatechange/emissions/subpart/rr.html
[30] Appendices G and Q in *Draft White Papers: Carbon Capture and Storage in California*.

Ownership and Use of Pore Space for CO_2 Storage

There are no established rules in California that govern ownership or use of subsurface pore space for carbon sequestration under private and state lands. Yet, carbon sequestration cannot occur absent the right to inject and store CO_2. Therefore, in order for carbon sequestration to play a role in achieving California's climate goals, ownership of pore space rights needs to be clarified and statutory procedures need to be established for the acquisition of pore space rights. Furthermore, statutes can clarify which parties retain ownership of and liability for injected CO_2. Uncertainty about these issues creates risks for investors and landowners that will delay or prevent development of carbon sequestration projects in California if they remain unaddressed.

There are three basic approaches to acquiring pore space rights for carbon sequestration that have been discussed in recent years: 1) a traditional private property approach, 2) a limited private property approach, and 3) a public resource approach. Each approach has positives and negatives that would impact the rights of property owners, the rights of early movers in carbon sequestration development, the economics of carbon sequestration projects, and the level of regulatory infrastructure and public resources required.

A full analysis of these options that weighs the benefits and challenges of each option is provided in Appendix J of *Draft White Papers: Carbon Capture and Storage in California.* Here we present a brief summary of each option.

Traditional Private Property Approach

The traditional private property approach is premised on the long-standing common law rule that the surface owner owns the subsurface, subject to considerations such as the dominance of the mineral estate. This approach, which has been codified in law by some states already, recognizes that the right to use the pore space for the injection and sequestration of CO_2 is a property right that must be acquired from the property owner in return for payment. The traditional private property approach would require legislation that:

- Allocates ownership of pore space (e.g., to the surface owner or to the mineral rights owner)
- Defines ownership and liability for injected CO_2
- Allows for unitization and/or eminent domain to acquire pore space, including pore space owned by state and local governments

Limited Private Property Approach—CCSREG Concept

Instead of an absolute right to pore space, some commentators have suggested that landowners' rights to deep formations are not absolute. The limited private property approach would require legislation that:

- Establishes the process by which pore space property rights are adjudicated

- Defines a "fair" threshold at which a property right to pore space is recognized (e.g., "non-speculative economic interest" in the CCSReg Project's model legislation)[31]
- Allows for eminent domain of recognized pore space rights, including pore space containing minerals and pore space owned by state and local governments

Public Resource Approach

Aquifer storage and recovery law could serve as a model for a third approach, a public resource approach, at least for carbon sequestration in saline formations. This approach would require legislation that:

- Recognizes saline formations as public resources for the purposes of sequestration projects
- Authorizes a public agency to either conduct sequestration operations or to permit private entities to conduct sequestration operations on the public's behalf

Based on its deliberation of these issues (see the supporting report *Draft White Papers*[32]*)* and on testimony received, the Panel offers the following finding and recommendation:

Key Finding:

- The right to use subsurface pore space for geologic storage needs to be clarified.

Recommendation:

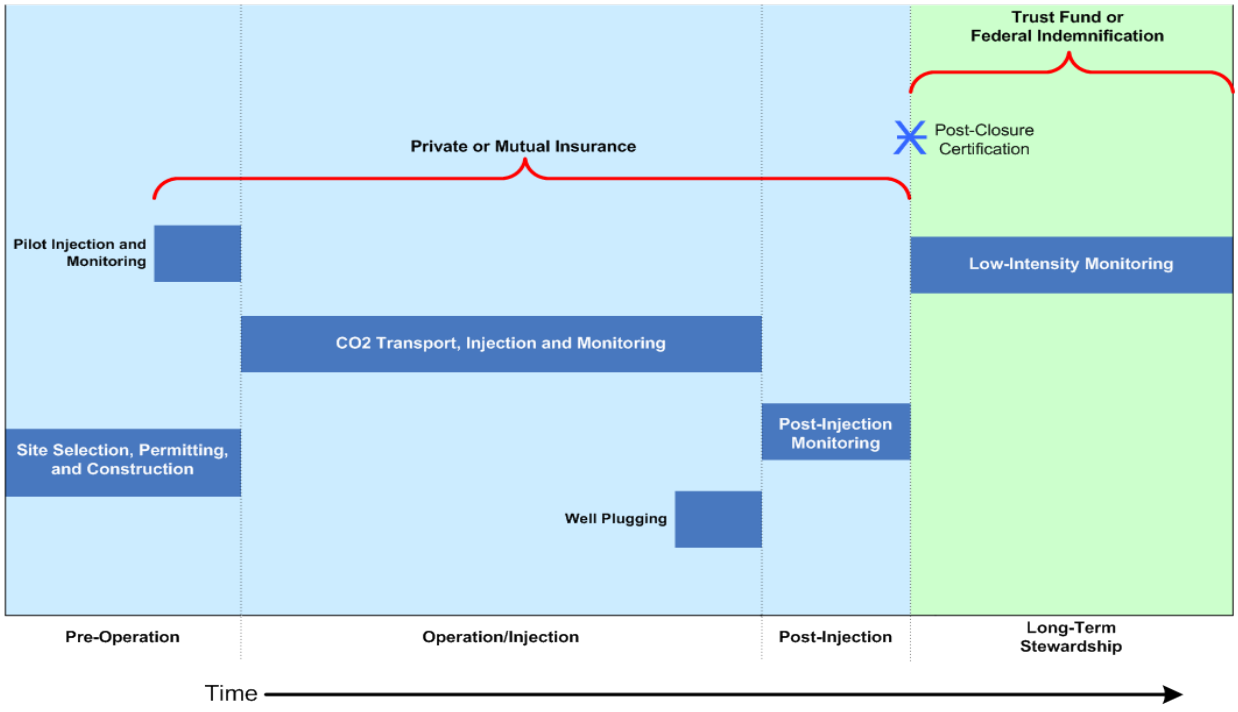
- The State legislature should declare that the surface owner is the owner of the subsurface "pore space" needed to store CO_2. The legislature should further establish procedures for aggregating and adjudicating the use of, and compensation for, pore space for CCS projects.

[31] CCSReg Project, "Model Legislation: The Carbon Capture and Sequestration Regulatory Act of 2010," May 19, 2010, available at http://www.ccsreg.org/pdf/CCS_Draft_Leg_05192010.pdf
[32] Appendix J in *Draft White Papers: Carbon Capture and Storage in California*.

Long-Term Stewardship and Liability of Geological Storage Sites

Long-term stewardship refers to how and by whom the actual post-closure operations of a CCS project will be undertaken in the long-term. Long-term liability is a legal concept involving the issue of who is or will be financially responsible for a project and for any damages attributed to that project following closure. At this stage there are no federal post-closure stewardship or liability requirements, although legislative proposals to establish such requirements have been introduced. In the absence of any new legislation, established liability regimes and responsibilities apply to projects.

Although the risk profile of geologic storage sites is typically expected to be highest during the injection phase when pressures in the subsurface are highest, it is important to monitor the performance and safeguard the integrity of projects after an injection site is closed. Because CO_2 must stay permanently stored, it is widely considered prudent from an environmental and public safety perspective to task a governmental entity with site stewardship obligations commencing with the post-closure phase.



To that effect, the State may wish to consider criteria for site closure that establishes that the CO_2 is trapped and is expected to remain so, and that the operational phase may safely be terminated. These criteria should be consistent with Class VI UIC regulations for CCS that EPA finalized on November 22, 2010.

To the question of who bears the residual legal and financial liability beyond what the stewardship agency and trust fund cover, we note competing factors. Liability relief for operators could create moral hazard that jeopardizes the safety and performance of projects, and could be at odds with public acceptance of CCS technology. In addition, calls for liability relief do not seem consistent with the widely accepted, manageable risks of CCS based on today's best science. Nonetheless, many of the private entities likely to utilize CCS as a mitigation option have professed reluctance to invest in CCS technology in the face of

seemingly unknown financial risks. As such, lack of liability relief might act as a deterrent to the development of some projects. In addition, companies do not last forever, but may be bought and sold or may declare bankruptcy. A recourse gap may therefore arise after the demise of a company, depending on the successorship of its management and assets, which could undermine the goal of good site stewardship and public confidence in projects.

Based on its deliberation of these issues (see the supporting report *Draft White Papers*[33]*)* and on testimony received, the Panel offers the following finding and recommendation:

Key Finding:

- There is a need to establish clear financial responsibility for the stewardship of geologic storage sites during the, (a) operating phase; (b) post-injection (pre-closure) monitoring phase; and (c) post-closure phase.[34]

Recommendation:

- The State should consider legislation establishing an industry-funded trust fund to manage and be responsible for geologic site operations in the post-closure stewardship phase. In addition, California should proactively participate in federal legislative efforts to enact similar post-closure stewardship programs under federal law.

[33] Appendix P in *Draft White Papers: Carbon Capture and Storage in California*.
[34] We note that the new EPA rules for UIC Class VI injection wells specify requirements for the operating and post-injection (pre-closure) phases, but not the post-closure phase. Since EPA rules are considered minimum requirements under Section 1421(b) of the Safe Drinking Water Act, the State should clarify whether it will adopt more stringent requirements for the phases covered by EPA rules.

Considerations of Environmental Justice

The Environmental Justice (EJ) movement addresses the statistical reality that people who inhabit the most polluted environments are commonly people of color and the poor. Poorer communities, which often co-exist in proximity to facilities that have historically had negative environmental impacts, can be in line to host more of these types of facilities. Studies of these communities have shown that they exhibit higher levels of illness, disease, and premature deaths than do other areas.

Concerns of EJ communities often pertain to large industrial facilities such as power plants, refineries, cement plants, chemical plants, as well as truck and ship traffic, and issues associated with dumping and incineration sites. Fossil fuels figure significantly in EJ concerns because of impacts to air, land, and water associated with their extraction or production, the emissions from their refining and combustion, and their waste byproducts (e.g., coal ash and petroleum coke). EJ activists advocate moving away from the extraction and use of fossil fuels, and transitioning to sustainable alternatives.

EPA defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."

According to a presentation given before the Panel,[35] EJ advocates would expand EPA's definition to include "the avoidance of disproportionate environmental impacts on communities of low income residents and people of color, including:

- Cumulative health impacts on a region or community
- Fair and equitable use of government spending
- Health considerations sharing equal consideration with economic interests
- Long-term sustainability issues
- Fixing the health problems of dirty air and finding co-benefits of reductions in GHG emissions

Based on its deliberation of these issues (see the supporting report *Draft White Papers*[36]*)* and on testimony received, the Panel offers the following finding and recommendation:

Key Finding:

There is a need to address any potential environmental justice aspects of CCS projects.

Recommendation:

It should be State policy that the burdens and benefits of CCS be shared equally among all Californians. Toward this end, the permitting authority shall endeavor to reduce, as much as possible, any disparate impacts to residents of any particular geographic area or any particular socio-economic class.

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[35] http://www.climatechange.ca.gov/carbon_capture_review_panel/meetings/2010-06-02/presentations/CCS_vs_Environmental_Justice_Document.pdf

[36] Appendix L in *Draft White Papers: Carbon Capture and Storage in California*.

CCS Public Outreach in California

In developing policies for CCS, California's agencies will want to use transparent processes and provide multiple opportunities for public input. Sufficient time and resources should be allocated to support an inclusive outreach effort to ensure that the benefits and risks of CCS are communicated in ways that are accessible to a wide variety of audiences. Companion efforts to further public education on CCS will be essential to meaningful public engagement.

Based on its deliberation of these issues (see the supporting report *Draft White Papers*[37]*)* and on testimony received, the Panel offers the following finding and recommendation:

Key Finding:

There is a need for increased public understanding of CCS benefits and risks.

Recommendation:

The Panel endorses the need for a well thought-out and well-funded public outreach program to ensure that the risks and benefits of CCS technology are effectively communicated to the public.

[37] Appendix K in *Draft White Papers: Carbon Capture and Storage in California.*

Incentives to Accelerate CCS Deployment in California

Although many GHG stabilization studies forecast CCS to be a major contributor to GHG emissions reduction, especially in the period after 2020, CCS is not practiced in an integrated, commercial manner today at the scale necessary to make meaningful reductions in man-made GHG emissions. Thus, governments and regulatory bodies have been acting to accelerate CCS technology development, demonstration, and early deployment through public policies and financial incentives.

Financial incentives to encourage investment in CCS tend to address one of three cost centers: capital cost, financing cost, and operating cost. For example, the federal government has offered investment tax credits and U.S. Department of Energy (DOE) cost share grants to reduce capital costs, DOE loan guarantees to reduce financing costs (and increase the likelihood of financial closure), and per-ton sequestration tax credits and accelerated depreciation to reduce net operating costs.

State government incentives can also address these cost centers through programs similar to those offered by the federal government. One rationale for California "topping off" federal CCS incentives is the recognition that costs for land, labor, materials, and utilities tend to be higher in California than the national average (by perhaps 20 percent overall), and thus a higher total value of incentive may be needed here to engender the desired degree of market response. In addition, states can offer credits or exemptions to taxes uniquely imposed at the state/county level, such as property taxes. California currently offers, for example, a property tax exemption for certain investments in renewable energy technologies. Given California's current budget challenges and the myriad approaches available for incentives, the State should evaluate its options to encourage early CCS projects in California and consider implementing those expected to be the most effective.

Utility rate regulation is another area where states traditionally have jurisdiction. The CPUC has authority over cost recovery for power plants built or owned by investor-owned utilities, and for long-term power purchase contracts by investor-owned utilities from plants developed and operated by independent generators. CPUC can approve "above market" costs for power from CCS-equipped plants deemed to be in the public interest, although such above-market costs may adversely affect regulated utilities' competitiveness in the retail electric market because California consumers have access to non-utility energy service providers. Because the CPUC has jurisdiction over only a portion of the State's electricity service providers, the Legislature would need to establish cost allocation mechanisms for power plant CCS projects to socialize any reasonable above-market costs to all Californians, so that utility customers alone do not bear the cost for the public-interest benefit of CCS application. The Legislature adopted such an approach for the California Solar Initiative.

Because CCS increases the variable operating cost of power plants, they may be temporarily uncompetitive in traditional dispatch models relative to plants without CCS, particularly in the era immediately after GHG regulations take effect, when allowance price caps and/or other measures limit the price of CO_2 emission allowances. In California, a power generation operator could coordinate directly with the Independent System Operator to prevent dispatch curtailment for fossil power plants with CCS by obtaining a "must run" designation for such units.

Finally, if any portion of annual GHG allowances is distributed via auction, a portion of the resulting revenue may be targeted to clean energy technology demonstrations (including CCS). This approach is being pursued in Europe. Bonus allowances for early CCS adopters have also been proposed as a means to offset competitive challenges in the years immediately following application (e.g., proposed Waxman-Markey federal legislation in 2008). ARB could design the California cap-and-trade program such that

allowance value is used to encourage early applications of CCS either through allowance allocation schemes or through distribution of allowance auction proceeds.

Based on its deliberation of these issues (see the supporting report *Draft White Papers*[38]*)* and on testimony received, the Panel offers the following finding and recommendations:

Key Finding:

- Absent new initiatives, economic barriers to early CCS deployment will delay the technological learning needed to drive down the costs of CCS.

Recommendations:

- Legislature should establish that any cost allocation mechanisms for CCS projects should be spread as broadly as possible across all Californians.
- The State should evaluate a variety of different types of incentives for early CCS projects in California and consider implementing those that are most cost-effective.

[38] Appendices G and H in *Draft White Papers: Carbon Capture and Storage in California.*

California Carbon Capture and Storage Review Panel

Carl Bauer, Panel Chairman
Retired Director National Energy
Technology Laboratory
South Park, Pennsylvania

Sally Benson, Director
Global Climate & Energy Program (GCEP)
Stanford University, California

Kipp Coddington, Partner
Mowrey Meezan Coddington Cloud LLP
Washington, DC

John Fielder, President
Southern California Edison
Rosemead, California

John King, Chairman
North American Carbon Capture & Storage Association;
Environmental Implementation Manager Royal Dutch Shell
Calgary, Canada

Kevin Murray, Managing Partner
The Murray Group
Los Angeles, California

George Peridas, Scientist
Natural Resources Defense Council
San Francisco, California

Catherine Reheis-Boyd, President
Western States Petroleum Association
Sacramento, California

Edward Rubin, Professor
Department of Engineering & Public Policy
Carnegie Mellon University
Pittsburgh, Pennsylvania

Dan Skopec, Chair
California CCS Coalition
San Francisco, California