EXHIBIT 2

CALIFORNIA
ENERGY
COMMISSION

GEOLOGIC CARBON SEQUESTRATION STRATEGIES FOR CALIFORNIA

THE ASSEMBLY BILL 1925 REPORT TO THE CALIFORNIA LEGISLATURE

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Executive Summary

Assembly Bill 1925 (Blakeslee), Chapter 471, Statutes of 2006, passed unanimously by the California Legislature, is designed to assess the present level of development of carbon capture and sequestration and its potential application for meeting California's climate change mitigation goals. This bill directs the California Energy Commission, in coordination with the Department of Conservation, to prepare a report for the Legislature that contains:

> …recommendations for how the state can develop parameters to accelerate the adoption of cost-effective geologic sequestration strategies for long-term management of industrial carbon dioxide.[1]

Carbon capture and sequestration options include any process that "captures" carbon dioxide (CO_2) and stores, or sequesters, it away from the atmosphere for the purpose of mitigating climate change that is caused by atmospheric CO_2 build up. Three approaches can capture and sequester carbon: terrestrial, geologic, and oceanic. Of these, the first and second can be used in California. Terrestrial carbon sequestration involves changing the management of forests, rangelands, agricultural lands, and wetlands so that these ecosystems naturally capture and store more CO_2 and/or emit less. Geologic sequestration involves using gas separation technologies to capture CO_2 from large point sources, such as power plants, cement factories, or refineries, and inject it deep underground.

Commercial-scale application of geologic carbon sequestration, the focus of AB 1925, requires not only technological readiness, but also the construction and implementation of appropriate regulatory and statutory frameworks. Particular challenges exist for geologic sequestration because it potentially cuts across the jurisdictions of several state and federal agencies and because of its uniquely long-term nature, potentially extending to hundreds, or even thousands, of years for storage.

With respect to geologic sequestration, the relevant topics to assess the state's readiness, as called out by the AB 1925 legislation and as identified by experts on the development of carbon capture and sequestration, are:

- Potential for geologic storage in the state
- Capture technologies
- Site characterization
- Monitoring and verification
- Risks and risk management

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[1] http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_1901-1950/ab_1925_bill_20060926_chaptered.pdf

- Remediation and mitigation
- Economic considerations
- Regulatory and statutory issues

Subject matter experts contributed white papers that serve as the technical foundation for this report to the Legislature, which devotes a chapter to each of these topics. The Energy Commission also is publishing the white papers as chapters in a separate document through its Public Interest Energy Research Division. Development of this report involved a process of two public workshops and presentations at technical and community meetings that engaged state agencies, other experts in various aspects of geologic sequestration, a range of stakeholders, and the public.

While technical challenges remain, the primary barriers to progress with initial geologic sequestration projects in the state lie within the statutory and regulatory arena. Demonstration projects and further technical evaluations and studies are needed, in part to guide development of regulations and statutes that are appropriate for carbon capture and sequestration. Demonstration projects, in particular, also should provide opportunities to engage stakeholders and for public education on carbon capture and storage. Many of the main areas of concern cut across topic areas and the discussion below is presented in that context. Each topic chapter of this report also includes specific suggestions not reiterated here.

Potential for Geologic Sequestration

The first step in geologic sequestration entails modifying large industrial plants, such as power plants, oil refineries, and cement plants, to separate CO_2 from process or exhaust gases. The CO_2 must then be delivered (generally via pipeline) to a storage site and injected deep underground into geologic formations that will prevent the injected CO_2 from re-entering the atmosphere for hundreds to thousands of years.

In California, suitable geologic formations include depleted or near-depleted oil and gas reservoirs and saline formations (rocks containing non-potable salty water). These targets are common in deep sedimentary basins, places where sand and mud have accumulated to great thickness over many millions of years and lithified into rock. These types of layered rocks are potentially good storage sites because they have the capacity to hold or trap large amounts of CO_2 in the pore spaces of sand layers, while overlying impermeable mud rock layers form good seals that prevent the gas from escaping upward.

Preliminary studies of the geology of the state identified a large storage resource potential, but more detailed site-specific characterization of the subsurface geology will be needed in many areas. Preliminary estimates of saline formation CO_2 storage capacity for the 10 largest sedimentary basins is between 75 and 300 metric gigatons of CO_2; for oil and gas fields, preliminary estimates are on the order of 3.5 and 1.7 metric gigatons of CO_2, respectively. There

is a generally favorable correspondence within the state between locations of emission point sources and sites for geologic storage.

The existence of appropriate infrastructure and expertise, as well as economic factors, favor development of early carbon capture and sequestration projects in affiliation with CO_2-enhanced oil recovery projects in oil and gas fields. To date, the high cost of acquiring CO_2 from out-of-state sources has been a barrier to adoption of carbon dioxide-enhanced oil recovery in the state. Economic and regulatory studies need to establish the relationship between captured CO_2 cost and demand for this CO_2 for enhanced oil recovery and to evaluate the regulatory and statutory issues that would facilitate enhanced oil recovery operations that could store substantial quantities of CO_2. These projects, in turn, could provide important datasets to facilitate carbon capture and sequestration development. For example, two new power plants in California, the proposed BP-Rio Tinto-Edison Mission Energy petroleum coke gasification project in Carson (Los Angeles County) and the Clean Energy Systems oxy-combustion plant in Kimberlina (Kern County) include designs for CO_2 capture, with the prospect that the CO_2 may be sold for commercial purposes, including enhanced oil recovery. Given that economic factors favor the combination of carbon capture and sequestration with enhanced oil recovery and that many early carbon capture and sequestration projects will likely be of this type, it is important to better understand the conditions necessary to assure proper operation and oversight of these types of projects.

While early carbon capture and sequestration projects may take advantage of the opportunities for storing CO_2 in affiliation with CO_2-enhanced oil recovery projects in depleted oil and gas fields, they will not be sufficient to accommodate all of the CO_2 that must be captured from various industrial sources to enable California to meet its long-term goals for reducing greenhouse gas emissions. Commercial application of geologic sequestration in California will require use of the state's ample saline formations. Although CO_2 storage in saline formations will resemble storage in oil or gas reservoirs, the saline formations of California have not been extensively studied in the manner of oil- and gas-containing formations. These studies must be done.

Demonstration projects of CO_2 storage in saline formations at volumes and over time periods sufficient to evaluate their suitability as CO_2 storage sites also will be critical. The research and pilot projects being conducted by the WESTCARB partnership have begun the work needed to gather data and better understand saline formation storage capacity and trapping mechanisms, but more efforts are required. Data shared by operators of initial commercial projects will also improve our understanding.

The amount of CO_2 that can be sequestered annually by geologic storage is limited by the number of point sources that can be economically captured. For example, power plant emissions, based on the greenhouse gas inventory, totaling about 107 million tons of CO_2 per year, could in theory all be geologically sequestered. However, the true rate at which carbon capture and sequestration can be deployed depends on many factors, including a more detailed

understanding of the storage resource and the pace of transport infrastructure development, chiefly pipeline networks.

Geologic carbon capture and sequestration can mitigate only that part of emissions associated with large single point sources, such as smoke stacks on factories or power plants. In contrast, transportation fuel emissions, California's largest sector source at about 190 million tons of CO_2 per year, consists of millions of small mobile sources, making capture impractical. However, plans for CO_2 reduction in the transportation sector include use of lower net carbon fuels, such as ethanol, which is made at fermentation-based production plants that are amenable to CO_2 capture and geologic sequestration.

Locations of the largest CO_2 point sources by type appear to match well with geologic storage sites for key areas of the state: the Los Angeles Basin, the Bakersfield area, and the San Francisco–Sacramento area. In total, some 30 industrial facilities produce over 1 million metric tons of CO_2 emissions per year. Most are natural gas-fired power plants, along with several oil refineries and cement kilns. The few coal- and petroleum coke-fired power plants in California are relatively small because they are mostly non-utility generators built as cogeneration qualified facilities.

Where large industrial sources amenable to CO_2 capture do not overlie suitable geologic CO_2 storage sites, CO_2 will have to be transported to storage sites via pipelines, trucks, trains, ships, or barges. For the large quantities of CO_2 that must be handled for sequestration, pipelines are clearly the most economic. The technical, economic, safety and permitting aspects of CO_2 pipeline transport are relatively well understood because of the many pipelines in the U.S. for the large-scale transport of CO_2 for use in enhanced oil recovery. The costs and complexity of building CO_2 pipeline infrastructure in California will depend on the proximity of CO_2 sources to preferred storage sites, available rights-of-way, the surface terrain, and current surface uses. The impacts of these factors on transport feasibility and costs must be quantified.

Based on this assessment, the report recommends the following actions:

- Improve characterization of the geologic CO_2 storage potential in the state, particularly for saline formation storage, and facilitate demonstration projects for CO_2 storage in saline formations.
- To facilitate carbon capture and sequestration infrastructure, evaluate the cost and other issues associated with pipeline development to link industrial CO_2 sources to preferred storage sites.
- Evaluate the potential in the state for use of captured CO_2 for enhanced oil recovery.

Capture Technologies and Economics

Large industrial sources of CO_2 usually do not generate emissions of high purity CO_2 at pressure. These sources include natural gas–fired power plants, cement plants, and oil refinery

furnaces and boilers. Instead, the CO_2 is present in fairly dilute concentrations in their combustion exhaust or process flue gas streams. With current technologies, capture of CO_2 out of flue gas is costly. However, with respect to underground storage capacity use, energy for compression, and other costs, it would be prohibitive to inject the full flue gas stream into deep geologic formations. Therefore, CO_2 capture generally requires separation of CO_2 from other gases. Three approaches are currently available to capture CO_2 from large power plants and other industrial CO_2 sources: post-combustion, pre-combustion, and oxyfuel combustion.

Carbon capture and sequestration costs are mainly due to increased capital and internal energy needs associated with concentrating the CO_2 to a pure stream, compressing it to high pressure, and for transportation, if required. In general terms, CO_2 capture economics favor large point sources near good geologic storage sites. The economics also favors low cost fuels due to the increased energy use for CO_2 capture. CO_2 capture economics also generally favors fuels high in carbon that generate relatively higher concentrations of CO_2 in flue gas streams prior to CO_2 capture. Therefore, the costs of CO_2 capture generally are higher for natural gas-fired plants than for coal-fired plants. For either fuel type, costs per ton of CO_2 removed are higher for smaller plants than for larger plants.

Assessing the economics of carbon capture and sequestration is very challenging today, in part because no policy exists to establish a price for CO_2 in the marketplace. Additional complicating factors include the large run-up in the last several years of costs for process equipment and piping worldwide, as well as a "first-of-a-kind" premium for carbon capture and sequestration facilities. Factoring in these parameters, preliminary estimates result in CO_2 capture and compression costs on the order of $50 to $90 per metric ton of CO_2 removed, by far the largest part of the entire cost of carbon capture and sequestration.

From an economic standpoint, several "targets of opportunity" with respect to carbon capture and sequestration in California should be considered. One is the use of captured CO_2 for enhanced oil recovery, which places a value of about $20/metric ton on CO_2. The other is industrial processes with high concentrations of CO_2 in process or exhaust streams, which make these applications viable economically. Examples include fermentation processes such as those used in ethanol production, older hydrogen plants in oil refineries and chemical plants, and natural gas processing facilities. For these plants, where a high purity stream of CO_2 is produced as part of the industrial process, the capture cost will be small, and the primary expense will involve CO_2 drying and compression for injection. It is important to note that when CO_2 capture and storage is used with biomass feedstocks, there is opportunity for double reductions—in effect, "net-negative" emissions. CO_2 capture and storage from biomass is usually most effective via co-processing waste biomass whenever available at large fossil fuel facilities with CO_2 capture to achieve essential economies of scale and high annual investment utilization.

The challenge for CO_2 capture is to reduce costs and energy use relative to other CO_2 reduction options such as end-use efficiency improvement, renewables, and nuclear power. New and

improved technologies being developed for CO_2 capture aim to reduce capital costs and the energy requirements for solvent regeneration. Over time, the economics of CO_2 capture are expected to improve due to technology refinements, success with novel technologies, and "learning-by-doing" to enhance capital utilization and efficiencies through commercial-scale applications.

Based on this assessment, the report recommends the following actions:

- Advance capture technologies and invest in research and development to improve the economics and efficiencies of CO_2 capture systems for major industrial sources.

Site Characterization, Monitoring and Verification, Risks, Remediation and Mitigation

From the initial design stages to post-closure, carbon capture and sequestration projects will have greater operational success and public acceptance if site characterization, monitoring and verification, risk assessment and management, and remediation and mitigation planning are integrally linked. Careful site selection and certification will form the foundation for successful long-term geologic sequestration by ensuring that CO_2 storage sites are reviewed for sufficient capacity, geologic features for secure storage, accessibility to pipelines, and other factors conducive to a technically successful project. Projects also should be designed to assure protection of the health and safety of workers, the public, and the environment which requires that the risks of the project be assessed and managed. For carbon capture and sequestration, risk derives primarily from the potential for releases of captured gases through all phases of operation, including capture, transportation, and subsurface storage. Monitoring and verification are essential to demonstrate that geologic storage is safe for the public and local communities, does not create significant adverse local environmental impacts, and is effective as a greenhouse gas control technology. Finally, remediation and mitigation procedures must be in place to cover the possibility of CO_2 leakage, out of the storage formation, during pipeline transport, or from injection activities, that could affect public health, the environment, or economic interests.

Siting of geological storage projects requires substantial subsurface characterization. However, available data and cost limit the detail, degree of quantification, and precision of characterization. The degree of site characterization should reflect the goals of the project stakeholders and be appropriate to the subsurface and surface character of the site(s) under consideration. In general, site characterization information should be sufficient to

- Identify sites with low overall risk and high chance of short- and long-term success
- Provide a technical basis for decision making for financing and insurance
- Provide data for planning, including safe and successful operations
- Design and deploy monitoring and verification tools

- Quantify and manage risk.

Existing technology and conventional data sets readily meet these goals.

Surface characterization is also an important component of site characterization. The infrastructure itself, including pipelines and monitoring equipment, has environmental and societal impacts that must be considered, including evaluation of impacts on sensitive species and other wildlife and cultural and environmental justice issues. Local land uses and structures, including pre-existing subsurface structures such as mines or basements, should be identified and their associated risks considered. Topography and prevailing meteorologic conditions must be characterized to understand the potential impact of any significant CO_2 leak.

A CO_2 storage project must be compatible with previous, current, and future uses of the site. In particular, in oil or gas producing areas, the distribution and condition of wells affect the potential for reservoir leakage. Storage projects also could influence future utilization of water and mineral resources in the area.

Proper site characterization is critical to proper risk assessment. Dividing the process of carbon capture and sequestration into above-ground and below-ground components aids in risk assessment for carbon capture and sequestration. Pre-injection risk assessment is associated with releases from surface facilities and engineered systems for separating, compressing and transporting CO_2; post-injection is focused on potential impacts of releases from wells and storage reservoirs. Predicting the future course of events at a carbon sequestration site is particularly challenging because the site must retain injected CO_2 for at least hundreds of years to be effective at mitigating greenhouse gas emissions. These timescales are short compared to geologic timescales, but very long compared to the timescales of typical risk assessments and to existing datasets for any geologic phenomena.

One of the most important purposes of monitoring and verification is to confirm that the project is performing as expected; monitoring also is needed to ensure that natural resources, such as groundwater and recoverable oil and gas, are protected and that natural ecosystems, local populations, and livestock are not exposed to unsafe concentrations. Various monitoring techniques can verify the amount of CO_2 stored, track the CO_2 plume underground, and check for potential leakage from the storage formation or to the surface. Monitoring instrumentation must be reliable, economical, and capable of detecting low-level leakage while having sufficient range to register major leaks. Currently available equipment is more than adequate to meet the needs for monitoring CO_2 injection rates, wellhead and formation pressures, and occupational safety. However, CO_2 measurement and monitoring approaches suited to the large areas and long time-scales relevant to geologic sequestration need further evaluation and refinement, perhaps best done through demonstration projects. Determining pre-injection subsurface conditions, as well as natural background levels of CO_2, is also critical to understanding project performance. Without an adequate baseline, it may not be possible to distinguish storage-related changes in the environment from natural variations. For most CO_2 storage projects, the

monitoring baseline should be obtained during the pre-injection site characterization phase of the storage project.

All sites, even those with optimal features, must be assessed for potential human health and safety and environmental risks during the operational and post-operational phases of a project. Safety procedures to limit these risks and leakage response procedures will be needed. Experience with storing CO_2 in geological formations suggests that the inherent risks and potential quantities of CO_2 leakage will likely be minimal. However small the risk, CO_2 leakage can result from human error, natural hazards, or other unknown factors. Procedures are needed to cover the possibility of CO_2 migrating out of the storage formation(s) or other releases that might occur during pipeline transportation or injection activities that could affect public health, the environment, or economic interests. Analogous industries, such as natural gas storage and enhanced oil recovery, should be studied to rigorously evaluate the potential application of their remediation and mitigation procedures to geologic sequestration. However, further efforts are needed to address CO_2 monitoring, leak detection, and mitigation and remediation at greater spatial and time scales than those necessary for enhanced oil recovery operations. Priorities for continued research include procedures for identifying and addressing a failure in the reservoir seal or caprock; materials selection and construction procedures to achieve a "thousand-year well"; and the cost-effective means for securely reworking or plugging wells in a CO_2 storage environment.

From these discussions, there is a clear need to develop consistent and integrated frameworks and protocols for carbon capture and sequestration site characterization, risk assessment, monitoring and verification requirements, and mitigation and remediation planning. Currently no consensus or standard exists for these factors regarding the criteria required to adequately or even minimally address the potential concerns of operators, regulators, and other stakeholders. Considerable relevant experience is available from the oil and gas industry, natural gas storage, and underground injection of wastes. Flexibility to tailor carbon capture and sequestration frameworks to the specific geological and geographic attributes of a storage site would be beneficial. It may also be appropriate to establish a minimum set of requirements.

Based on this assessment, the report recommends the following actions:

- Develop integrated site characterization, monitoring and verification, and risk assessment protocols for CO_2 storage sites.
- Evaluate options and existing capabilities to respond to carbon capture and sequestration leakage events, including remediation and mitigation planning.

Statutory and Regulatory Issues

For carbon capture and sequestration, as for any new technology or industry, it is important that legal and regulatory standards be established to protect the public, the environment, and the state's resources and, at the same time, be designed to facilitate technical innovation and

advancement. In California, as elsewhere, carbon capture and sequestration-specific regulatory and statutory frameworks do not yet exist. This report provides a review of this issue, for the purpose of assessing how current frameworks may apply to carbon capture and sequestration implementation in the state. It is not a formal legal analysis of the statutes and regulations relevant to carbon capture and sequestration. Given the complexities of the regulatory and statutory frameworks that have been identified as potentially applying to carbon capture and sequestration, a robust follow-up analysis seems warranted to establish the potential impact of including carbon capture and sequestration under existing statutes and regulations and of the effect on existing frameworks of any new carbon capture and sequestration-specific regulations and statutes.

Regulatory continuity is an important goal for the frameworks that will be established for carbon capture and sequestration. It is possible, under current regulations, for authority to become split along the lines of reservoir type and along pre-injection (surface) and post-injection (subsurface) activities. Because of the potential to affect existing industries, particularly enhanced oil recovery operations, the ramifications of different regulatory options must be studied. Ideally, a single authority should regulate the injection, storage, and monitoring of CO_2 into all potential geologic reservoirs. Another area of complexity is the interplay among ownership interests and provisions for the public good and how these diverse interests should be accommodated for the purposes of long-term geologic CO_2 storage.

A key uncertainty is the issue of liability. While the operational risks associated with transportation, injection, and storage of CO_2 have been successfully managed for many years, there is major concern with sources of liability during the post-closure phase of carbon capture and sequestration, given that no time limitations have been established, making the term in effect, unending. For industry, the concerns associated with this open-ended liability include the consequent inability to obtain insurance for the project, the potential to incur remediation costs related to CO_2 migration and/or leakage at some point in the distant future, and the disincentive that these potential costs may have on investment today in CO_2 geologic storage.

Based on this assessment, the report recommends the following action:

- Rigorously evaluate statutory and regulatory uncertainties and options for regulatory frameworks appropriate for CCS.

Education and Public Participation

Worldwide, the heightened level of activity on geologic sequestration research and applications reflects a growing consensus across a range of stakeholders for the need to incorporate carbon capture and sequestration into mitigation steps to combat climate change.

A well-trained workforce to select and certify CO_2 storage sites, install carbon capture and sequestration infrastructure, manage operations, and respond to leakage events is critical to

protecting public health, safety, and the environment and to ensuring the overall success of carbon capture and sequestration projects. Regulators who oversee geologic sequestration applications may need additional training.

Public outreach activities must provide accurate information to help the public weigh the benefits and risks, as well as the safety and mitigation measures that may be taken to manage risks. Public support and participation will be a key factor in the success of early geologic sequestration projects, which should openly share information to demonstrate that long-term storage of CO_2 can be accomplished safely.

As is also true for other new technologies in the early stages of deployment, there is generally little public awareness and understanding of carbon capture and sequestration. Even though CO_2 capture and storage is a public good in contributing to global climate change mitigation, the perceptions, risks to, and benefits for the local public and communities should be acknowledged and addressed through efforts to openly share carbon capture and sequestration knowledge and pertinent project-specific information.

Based on this assessment, the report recommends the following actions:

- Facilitate training of necessary personnel.
- Encourage public participation and education.

CHAPTER 11: Conclusions

While technical challenges remain, the primary barriers to progressing with initial geologic sequestration projects in the state lie within the statutory and regulatory arena. However, demonstration projects and further technical evaluations and studies are needed, in part to guide development of regulations and statutes that are appropriate for CCS. Demonstration projects, in particular, also should provide opportunities to engage stakeholders and for public education on carbon capture and storage. The following information summarizes the primary conclusions and makes recommendations from this report's main topics.

Potential for Geologic Sequestration

Improve geologic characterization of the storage potential in the state, particularly for saline formation storage, and facilitate a demonstration project for CO_2 storage in a saline formation.

While preliminary studies of the geology of the state identify a large storage resource potential, more detailed site-specific characterization of the subsurface geology will be needed in many areas with sequestration potential. Preliminary estimates of saline formation CO_2 storage capacity for the 10 largest basins is between 75 and 300 metric gigatons of carbon dioxide (GT CO_2); for oil and gas fields, preliminary estimates are on the order of 3.5 and 1.7 GT CO_2, respectively. There is reasonably good agreement within the state between locations of emission point sources and sites for geologic storage.

While early projects may take advantage of the opportunities for doing CO_2 storage in affiliation with CO_2-EOR projects in depleted oil and gas fields, they will not be sufficient to accommodate all of the CO_2 that will have to be captured from various industrial sources to enable California to meet its long-term goal for reducing greenhouse gas emissions. Thus, commercial application of geologic sequestration in California will require use of the state's ample saline formations. Although CO_2 storage in saline formations will resemble storage in oil or gas reservoirs, the saline formations of California have not been extensively studied in the manner of oil- and gas-containing formations. These studies must be done.

Demonstration projects of CO_2 storage in saline formations at volumes and over time periods sufficient to evaluate their suitability as CO_2 storage sites also will be critical. The research and pilot projects being conducted by the WESTCARB partnership have begun the work needed to gather data and better understand saline formation storage capacity and trapping mechanisms, but more efforts are required.