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# California's Policy Approach to Develop Carbon Capture, Utilization and Sequestration as a Mitigation Technology

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**Abstract**

While California has been at the forefront in adopting an aggressive climate change mitigation policy, it has taken a more measured and tentative approach toward creating an enabling policy and a regulatory framework for carbon capture, utilization and sequestration (CCUS) technologies to contribute to greenhouse gas (GHG) reductions. In 2005, Governor's Executive Order S-3-05 required that California reduce GHG emissions to 1990 levels by 2020 and to 80% below 1990 levels by 2050. In 2006, State Assembly Bill 32 codified the 2020 goal into law. In 2006, the California Legislature required two California agencies, the California Energy Commission and the Department of Conservation, to produce a report recommending how the state could facilitate commercial adoption of geologic sequestration from industrial sources. In 2010, three state agencies, the Energy Commission, Public Utilities Commission, and Air Resources Board, convened the California Carbon Capture and Storage Review Panel to make recommendations on specific policy, institutional, and regulatory changes necessary for California to enable commercial-scale carbon capture and geologic storage projects. Since 2006, several legislative bills have been introduced to establish regulatory authority, liability, and address pore space ownership issues, but none have made it into law.

To meet the state's aggressive targets, especially the 2050 goal, will nevertheless require widespread adoption of CCUS technologies, according to studies by the California Council on Science and Technology. California contributes 7.5% of the total GHG emissions in the USA, or 1.8% of global GHG emissions. Over half of this currently is from point sources, but that proportion will increase as the state pursues electrification of the transportation sector. Trajectories of future GHG emissions growth suggest mitigation technologies must be implemented at rates on the order of 10-20 million tonnes of GHGs removed per year.

The cap-and-trade system recently adopted in California to address the GHG reduction mandates of Assembly Bill 32 would seem to encourage pursuit CCUS technology projects by industrial emitters, but uncertainties preclude developing viable business cases. Uncertainty includes a lack of data on the costs of capture and storage and the lack of cap-and-trade accounting protocols for CCUS technologies. Although these protocols are scheduled to be developed, they will lag the initialization of cap-and-trade in 2012.

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**Nomenclature**

| | |
|---|---|
| CCUS | Carbon capture, utilization and sequestration |
| CEC | California Energy Commission |
| CARB | California Air Resources Board |
| CPUC | California Public Utilities Commission |
| DOE | U.S. Department of Energy |
| DOGGR | California Division of Oil, Gas, and Geothermal Resources |
| EOR | Enhanced oil recovery (using $CO_2$) |
| GHG | Greenhouse gas |
| WESTCARB | West Coast Regional Carbon Sequestration Partnership |

## 1. Introduction

It has frequently been asserted that a major barrier to commercialization of carbon capture, utilization and sequestration (CCUS) technologies in the United States is the lack of climate legislation at the U.S. federal level that would regulate or place a value on carbon, thereby providing industry with an incentive or requirement to mitigate $CO_2$ emissions. California has been at the forefront in adopting an aggressive climate change mitigation policy and is poised in 2013 to put cap-and-trade into practice. Furthermore, numerous studies done to determine how California can meet its emissions reductions goals have shown that CCUS technology is requisite. Nevertheless, California has yet to see concrete advancement toward commercial-scale CCUS projects. This paper briefly summarizes the history of CCUS projects and related policy in California with the aim of understanding what factors beyond climate policy might be critical path barriers to CCUS technology adoption.

## 2. California's Greenhouse Gas Reduction Policies

California contributes 7.5% of the total greenhouse gas (GHG) emissions in the USA, or 1.8% of global GHG emissions. In 2005, Governor's Executive Order S-3-05 required that California reduce GHG emissions to 1990 levels by 2020 and to 80% below 1990 levels by 2050. In 2006, State Assembly Bill 32 codified the 2020 goal into law and gave the California Air Resources Board (CARB) the authority to adopt appropriate measures to assure that the state met that goal (For measures adopted, see [1]). Many laws were subsequently passed to facilitate reaching the 2020 goals. For example, SB 1368 sets an emission performance standard for long-term power purchase contracts.

California policy makers have taken a more measured and tentative approach toward CCUS technologies. In 2006, the California Legislature required two California agencies, the California Energy

Commission (CEC) and the Department of Conservation, to produce a report recommending how the state could facilitate commercial adoption of geologic sequestration from industrial sources [2]. In 2010, three state agencies, the Energy Commission, Public Utilities Commission, and Air Resources Board, convened a panel [3] to make recommendations on specific policy, institutional, and regulatory changes necessary for California to enable commercial-scale carbon capture and geologic storage (CCS) projects. Since 2006, several legislative bills have been introduced to establish regulatory authority, liability, and address pore space ownership issues, but none have been passed into law. No legislation has been enacted to address the 2050 goals.

State agencies and industry have taken advantage of federal opportunities to further CCUS technology through U.S. Department of Energy (DOE) programs: Hydrogen Energy California (HECA) received a grant to construct an IGCC plant that would use petcoke to produce hydrogen and electricity, and capture $CO_2$ for enhanced oil recovery (EOR) in a nearby oilfield in California's Central Valley; C6 Resources, LLC, a subsidiary of Shell Oil Company, received American Recovery and Reinvestment Act (ARRA) funding to perform a scoping study to capture and store refinery $CO_2$ emissions in the San Francisco Bay Area; the CEC and Lawrence Berkeley National Laboratory (LBNL) were awarded a regional carbon sequestration partnership (West Coast Regional Carbon Sequestration Partnership, WESTCARB) to characterize the potential in the western region of the U.S. and Canada for geologic and terrestrial sequestration; Terralog Technologies was awarded a grant to study the geologic sequestration potential of the Wilmington Basin, offshore from the Los Angeles area; Clean Energy Systems was awarded funds to develop and test an oxy-fuel combustion technology for power generation that emits pure $CO_2$ and water, eliminating the need for costly capture technologies. Numerous grants for laboratory or modeling research related to capture or geologic storage have also been made to National Laboratories and universities in the state. Terrestrial and geologic conceptual or pilot field studies have been funded through WESTCARB, the Energy Commission and other agencies.

California's ambitious climate change mitigation program has given it a leadership position for exploring CCUS in the western United States during the past decade, and in so doing it has generated a wealth of data about sequestration potential [4] [5]. Table 1 summarizes some of the major CCUS and related policy and industrial activities in the state since 2003 that form a strong, but not yet comprehensive platform from which to launch a viable CCUS industry.

Table 1: Summary of CCUS policy and related activities in or affecting California since 2003

| Year | Activity |
|---|---|
| **2003** | The CEC, with LBNL, wins a competitive DOE solicitation to form WESTCARB. The first phase of the project focuses on characterizing geologic and terrestrial storage options in the western U.S. and Canada, from Alaska to Arizona. |
| **2005** | California Governor's Executive Order S-3-05 establishes three GHG reduction goals for the state. |
| **2005** | WESTCARB initiates the second phase of the project focusing on pilot-scale demonstrations of geologic and terrestrial storage, while continuing geologic characterization activities. |
| **2006** | California Assembly Bill 32 passes, directing CARB to establish methods to meet the 2020 reduction goal. |
| **2006** | California Assembly Bill 1925 passes, requiring the CEC and the Department of Conservation to produce a report making recommendations to facilitate adoption of CCS by industrial emitters. |
| **2006** | California Senate Bill 1368 establishes $CO_2$ emissions limits for power purchased for long term contracts. |

| | |
|---|---|
| **2006** | California Assembly Bill 705 stranded (not passed into law), gives permitting and regulatory authority of CCS projects to the California Division of Oil, Gas and Geothermal Resources (DOGGR, a division of the Department of Conservation). |
| **2007** | WESTCARB initiates the third phase of the project to develop a commercial-scale demonstration project in California with an industry partner. |
| **2009** | HECA wins a competitive DOE ARRA solicitation to construct an IGCC plant producing hydrogen, electricity, and $CO_2$ for EOR in southern California. |
| **2009** | C6 Resources wins a competitive DOE ARRA solicitation to perform a scoping study of a CCS project for geologic storage of refinery emissions in northern California. |
| **2010** | The U.S. President establishes the Interagency Task Force on CCS to develop a coordinated federal plan to overcome barriers to deployment of CCS within 10 years and bring 5-10 commercial demonstration projects online by 2016. |
| **2010** | The U.S. Environmental Protection Agency issues new Underground Injection Control (UIC) Program regulations for injection of $CO_2$ for the purpose of sequestration and adds a subpart to the Greenhouse Gas Reporting Rule for annual reporting of emissions from geologic sequestration projects. |
| **2010** | Three state agencies establish the California CCS Review Panel to provide recommendations to remove policy, regulatory and institutional barriers to CCS. |
| **2010** | CARB approves the cap-and-trade program, which includes CCUS as an option to meet GHG emissions reductions. |
| **2012** | Senate Bill 1139 held (not passed), which would give permitting and regulatory authority of CCUS projects associated with EOR to DOGGR. |

## 3. Methods for Meeting GHG Reduction Goals

Numerous approaches, such as energy efficiency, renewables, and performance standards, have been enacted into law and methodologies for meeting these standards have been developed by CARB to meet the 2020 goal. For example, the Governor signed into law a mandate that 33% of utilities' generation portfolio must be from renewables; CARB adopted a low-carbon fuel standard; and incentives for electrification of the transportation sector have been established. CARB and other state agencies have done studies which demonstrate that the 2020 goal can be met through such methodologies. Generally, it is assumed that CCUS technology will not be sufficiently widely deployed to play a major role in meeting 2020 goals, in spite of the fact that approximately 40% of the state's emissions currently are from static point sources amenable to carbon capture technologies from a technical or engineering standpoint. However, California's in-state fossil fuel electricity generation uses natural gas, not coal, which would make $CO_2$ capture costs for these facilities exceptionally high. As the state pursues electrification of the transportation sector to meet the 2020 goal, the proportion of GHG emissions from the power generation sector will rise as emissions from the transportation sector fall.

Cap-and-trade is the primary mechanism by which various industrial sectors will be forced to meet emissions targets. To date, CCUS technologies are not included in protocols that provide the mechanisms for industry to meet their compliance obligations. Plans are to include CCUS protocols in the 2015-2016 timeframe.

The California Council on Science and Technology (CCST), among others, has studied various scenarios of energy usage growth and carbon emissions reduction technologies that would meet the 2050 goal [6] [7]. These studies show that to meet the state's 2050 goal will require widespread adoption of CCUS technologies. Figure 1 shows actual and projected trends in sector emissions with the 2020 and

2050 goals superimposed. A simple linear trajectory of reducing emissions indicates that mitigation technologies must be implemented at rates on the order of 10-20 million tonnes of $CO_2$ equivalent (10-20 $MtCO_{2e}$) removed per year to meet 2050 goals.

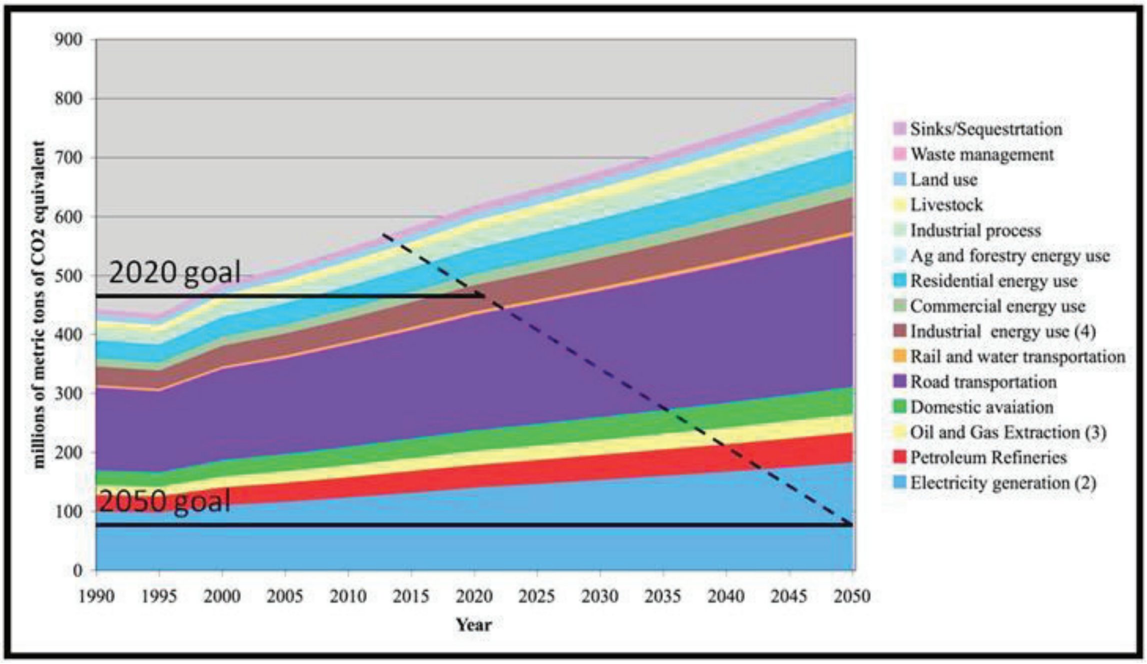


Figure 1: California's actual and projected greenhouse gas emissions 1990-2050 with 2020 and 2050 reduction goals trajectory to 2050 shown [8].

This rate of 10-20 $MtCO_{2e}$ is equivalent to completely eliminating the emissions each year of a few of California's largest industrial point sources: natural gas combined cycle (NGCC) power plants, refineries or cement plants (Figure 2). Unlike most states or countries, California's major power plants are fueled by natural gas rather than coal. California, however, does import about 20 percent of its power from coal plants in other western states. The emissions associated with this imported electricity are counted in the state's emissions inventory. Because of California Senate Bill 1368, which forbids California utilities from entering long term power purchase agreements if generator emissions exceed 500 kg (1100 pounds) of $CO_2$ per MWh (approximately the emissions of an efficient natural gas-fired plant), the electricity imported from the current out-of-state coal-fired sources will have to be replaced by other, low-carbon generation facilities unless the coal-fired plants adopt CCUS.

The CCST studies indicate that meeting the 2050 goals will require nearly complete elimination of emissions from the electricity sector and possibly the additional use of geologic storage on emissions from biomass sources to create "net-negative" emissions [7]. California's electricity demand is currently about 300 TWh and by 2050 it is projected to be 1,200 TWh if no mitigating measures are taken in a business-as-usual projection [6]. Greenblatt and Long [7] calculate that with extreme energy efficiency measures and extensive implementation of renewable generation, the 2050 demand can be constrained to 500 TWh, allowing for additional energy demand for CCUS. To meet the 2050 GHG emissions goal of 77 $MtCO_{2e}$ (see Figure 1), over the next four decades California must aggressively pursue CCUS measures to counter slippage in renewable and energy efficiency goals. Nuclear is not an option because under present law, California cannot build any new nuclear plants. An increase in wind and solar generation, the growing renewable sources, will also require a more robust baseload generation to compensate for the inherent intermittency, even anticipating advances in storage technology. About 38% of California's GHG emissions are produced by the transportation sector and, in order to reduce this sector's emissions, there are ambitious goals to electrify this sector, requiring additional low- and zero-carbon generation.

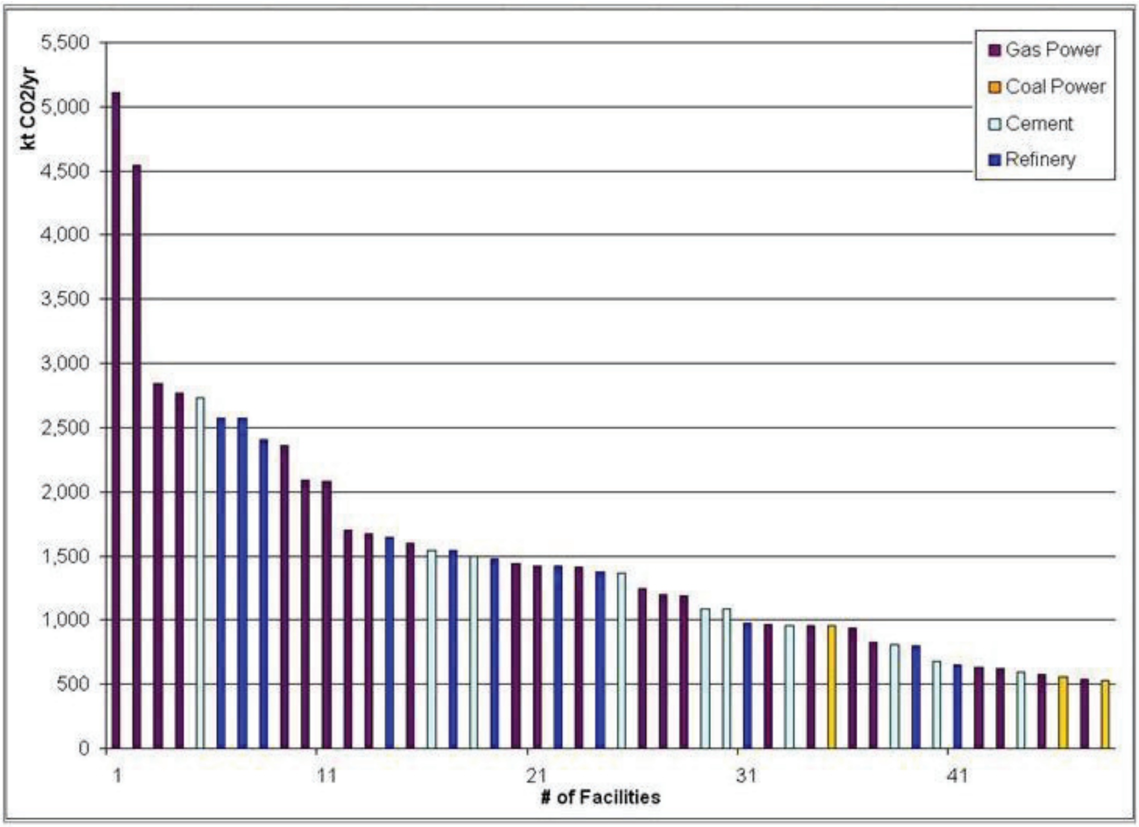


Figure 2: Sizes of emissions from California's 50 largest point sources: natural gas power plants, refineries and cement plants [2].

## 4. Discussion

California's experience makes it clear that other drivers are necessary beyond the drivers of climate policy that creates a value and market for carbon via cap-and-trade and significant research findings demonstrating the necessity of including CCUS technology in the portfolio of technologies used to meet GHG reduction targets. With caps to be set in 2013, it is as yet unclear what value carbon will attain, but given the long lead times for CCUS to become a viable mitigation option, it appears that, even with the addition of substantial government support, industry stakeholders, with few exceptions, remain unwilling to invest in CCUS technology.

To make a business case for CCUS requires economic certainty over the long term. Changes in other factors must occur to address the imbalance between the cost of sequestration versus achieving reductions via other methods. Stakeholders frequently include the following factors when explaining decisions not to pursue CCUS options: the large initial capital investment required by present commercially available capture technologies; the lack of cap-and-trade protocols for CCUS; the lack of incentives for CCUS in power purchase agreements necessary for financing; the lack of supporting infrastructure to provide captured $CO_2$ at reasonable cost for enhanced oil recovery or other utilization options.

Breakthroughs in capture technology to substantially reduce the cost appear to be requisite to facilitate widespread CCUS adoption. When cap-and-trade protocols are developed for CCUS in 2015-2016, that problem will potentially be solved. However, protocols may in themselves create issues for stakeholders that may continue to impede CCUS adoption.

Policy can address the relative status of CCUS compared to other low- or zero-carbon power technologies such as renewables. Approval of power purchase agreements for electricity generated with CCUS could follow similar processes as were used to incentivize adoption of renewables. Similarly, preference in loading orders for power generation with CCUS could be implemented.

Finally, the lack of pipeline infrastructure impedes growth of industry demand for $CO_2$ for enhanced oil recovery. Public investment at the state or federal level is probably necessary to build this infrastructure. However, demand for and the price of $CO_2$ obtained depends highly on the price of oil. At costs of one million to several million dollars per mile, a pipeline infrastructure would be a long term and large public investment. Such an investment should not be considered without serious analysis of whether sufficiently high oil prices can be sustained through 2050 and beyond. If the decarbonization of the world's economy, particularly the transportation sector, results in substantial reductions in oil demand, that industry would be unwilling to pay for $CO_2$ for enhanced oil recovery.

We conclude that the commercialization of CCUS technology in California requires several factors beyond the state's current climate policy and carbon compliance policy. First, breakthroughs are needed in methods for capture or power generation that reduce the cost of producing pure $CO_2$ streams. Second, policy should include CCUS in the same contexts it has used to advance other low- or zero-carbon technologies as well as resolve legal and regulatory issues unique to CCUS, such as long-term liability, pore space ownership, accounting for sequestered $CO_2$, and streamlined permitting. Third, the investment of public dollars through federal or state funding of projects or infrastructure seems to be required, but should be done carefully to assure the public receives long term value from its investment.

To meet demand projections, grid reliability requirements, and GHG emissions goals, CCUS will be necessary for many power generation facilities. Consequently, a utility sector CCUS commercial demonstration project is deemed necessary in California over the next few years [9] to show not only technical and fiscal feasibility, but also that regulatory and legal mechanisms are functional. Such a project would ensure that issues have been addressed such that additional projects can follow and become operational by 2050.

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