An Action Plan for Carbon Capture and Storage in California: Opportunities, Challenges, and Solutions

A Presentation on the Study Results by the Project Executives
Professor Sally Benson, Stanford University
Melanie Kenderdine, Energy Futures Initiative
October 26, 2020
The Energy Futures Initiative (EFI) advances technically grounded solutions to the climate crisis through science-based analysis, thought leadership, and coalition-building. Under the leadership of Ernest J. Moniz, the 13th U.S. Secretary of Energy, EFI conducts rigorous research to accelerate the transition to a low-carbon economy through innovation in technology, policy, and business models. www.energyfuturesinitiative.org

The Stanford Center for Carbon Storage uses a multidisciplinary approach to conduct fundamental and applied research to address critical questions related to CO₂ storage in geologic formations. The center also conducts technoeconomic and policy/regulatory assessment of CCS projects. www.sccs.stanford.edu

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EFI and Stanford wish to thank the following individuals for contributing subject-matter expertise during the development of this study. Their participation does not imply endorsement of the analysis approach or conclusions.

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Maximizing the value of CCS for meeting the state’s economywide decarbonization goals affordably and equitably

Motivating the private sector to decarbonize

Enabling economic and reliability benefits from existing industries and power generation

Assessing social equity and community benefits from CCS

Unlocking new clean energy industries and jobs
Significant Challenges for Utility Scale Battery Storage

Study Approach and Framing

The Need For CCS

Opportunities

Challenges

Action Plan

An Action Plan for Carbon Capture and Storage in California: Opportunities, Challenges, and Solutions
California’s Economy-Wide Climate Goals

- **2017 Emissions**: 424 MtCO\(_2\)e
- **2020 Goal**: Equal to 1990 Emissions Level
  - **427 MtCO\(_2\)e**
- **2030 Goal**: 40% Reduction from 1990 Emissions Level
  - **256.2 MtCO\(_2\)e**
- **2045 Goal**: Carbon Neutrality & Net-Negative Emissions Thereafter
  - **2050**

**Emissions (MtCO\(_2\)e)**

- **Electricity**
- **Industry**
- **Transportation**
- **Buildings**
- **Agriculture & Forestry**
- **Recycling and Waste**
Renewable Generation Goals

- 33% renewable generation by 2020
- 50% renewables by 2026
- 60% renewables by 2030
- 100% carbon-free electricity by 2045
- 40% emission reduction (AB 32 economy wide goal of 40% reduction from 1990 level)

On track to meet 2020 and 2030 goals

Source: California Energy Commission, staff analysis November 2018
California’s Energy System and the Role of CCS

Source: https://flowcharts.llnl.gov/
California’s Day Time Electricity Mix

**Current supply** AS OF 20:45

- **Renewables** 8.4% (2,048 MW)
- **Natural gas** 37.4% (9,082 MW)
- **Large hydro** 9.3% (2,250 MW)
- **Imports** 35.6% (8,641 MW)
- **Batteries** 0.0% (0 MW)
- **Nuclear** 9.3% (2,264 MW)
- **Coal** 0.0% (10 MW)
- **Other** 0.0% (0 MW)

**Current renewables** AS OF 20:45

- **Solar** -0.0% (-1 MW)
- **Wind** 23.6% (483 MW)
- **Geothermal** 41.4% (848 MW)
- **Biomass** 12.9% (264 MW)
- **Biogas** 8.8% (181 MW)
- **Small hydro** 13.3% (273 MW)
California’s Night Time Electricity Mix

Current supply AS OF 20:45

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Hourly trends in solar and wind capacity factors in CA for 2017 aligned to normalized variation in hourly load relative to peak daily load


What CCS Can Do For California: Support for Grid Reliability, Variable Renewable and Climate Targets

Enable continued reliability benefits from clean firm power generation...
Favorable Policy Aspects for Decarbonizing Fossil Fuels in California

- California Low Carbon Fuel Stanford
  - CO₂ Storage Protocol
- Federal 45Q tax credit for CCUS
  - $35/tonne CO₂ for CO₂-EOR
  - $50/tonne for saline formation storage

Low Carbon Fuel Standard: 20% reduction in the carbon intensity of transportation fuels by 2030
Credit prices in the LCFS Market

Source: https://www3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm
60 Mt/Yr CO₂ Emissions Could Be Avoided with CCS

Policy Incentives
- LCFS at $100/ton
- 45Q tax credit
What CCS Can Do for California?

Emissions Reduction Potential from CCS in California

- Approx. 15% of state’s total CO₂ emissions
- 65% greater than all emissions from in-state power generation
- 44% greater than emissions from the entire buildings sector
- 84% greater than all emissions from the agriculture sector
- 66% greater than emissions from all heavy-duty vehicles

Source: Adapted from CARB, 2020
What CCS Can Do for California: Enabling New Clean Energy Industries and Jobs

...Unlock new, potentially multi-billion-dollar clean energy industries, creating new jobs in the process.

Enable Carbon Dioxide Removal/Direct Air Capture and CO₂ Utilization Industry

Similarities with CCS

- Improved process energy efficiency
- Lifecycle analyses
- Low-carbon capture requirements/systems
- Low-carbon heat
- Geologic storage
- Material manufacturing & scale-up
- Novel: catalysts; membranes; solvents; sorbents
- Simulation
- Sensors and controls

Translate Oil and Gas Skillsets to CCS Industry Job

Support Development of A Hydrogen Economy

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<td>Applying industry expertise to CCUS technologies for direct air capture (DAC) and bioenergy with carbon capture and storage (BECCS)</td>
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“The oil and gas industry...[w]as a major employer and leading economic drive in California responsible for 368,100 jobs in 2015, or 1.6 percent of California’s employment, with almost $66 billion in total value-added, contributing 2.7 percent of California’s state product.” - LA County Economic Development Corporation

- Half of ports’ drayage fleet (5,000 trucks)
- Entire ports’ electricity requirement (50MW/h)
- 80% of SCG’s petroleum refiner demand
- 10% of SCG’s residential gas demand (as blend)
- CO₂ sequestration equivalent to half an average coal plant emissions