CCST EXPERT BRIEFING SERIES:
Toward a Disaster Resilient California

TECHNOLOGICAL PATHWAYS for Carbon Sequestration in California

Briefing held **MARCH 2021**

One Pager

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Photo: Hellisheidi Geothermal Power Plant in Iceland demonstrates processes to capture CO_2 emissions for long-term geologic storage. | Carbfix, photo by Arni Saeberg

BACKGROUND

- Anthropogenic **carbon emissions** are a leading cause of **climate change**.
- California has set an ambitious goal of being **carbon neutral** by 2045.
- A combined approach of reducing carbon emissions and **increasing carbon sequestration**—capture and long-term storage of CO_2—can help California reach its goals.
- CO_2 can be sequestered using either natural or **technological pathways**.
- Technological pathways use machines to **capture CO_2** from air or water using chemical reactions.
- Captured CO_2 can then be injected into geologic reservoirs or converted into stable materials for **long-term storage**.

REDUCING ATMOSPHERIC CO_2 LEVELS
to Mitigate Climate Disasters

Over the past several hundred years, human activities such as fossil fuel use and land use changes have dramatically increased the amount of carbon dioxide (CO_2) in the atmosphere. The resulting impacts to the global climate pose a grave threat to society and the environment due to more frequent and severe disasters such as destructive storms, droughts, and wildfires.

In an effort to limit the impacts of climate change, California has taken action to reduce CO_2 emissions and increase CO_2 sequestration to achieve net-zero emissions statewide by 2045 and negative emissions—more CO_2 sequestered than emitted—thereafter.

BENEFITS
of Carbon Sequestration

1. **Remove** legacy emissions from past anthropogenic sources.
2. **Offset** continued emissions from difficult to decarbonize sectors.
3. **Improve** resilience to climate change.

Technologies to sequester carbon have been successfully used in in other states for enhanced oil recovery and in other countries for long-term carbon storage to mitigate climate change (figure). California currently does not have any active carbon capture and storage projects in operation, but several projects are in varying stages of planning.

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SELECT EXPERTS

The following experts can advise on technological carbon capture and storage pathways:

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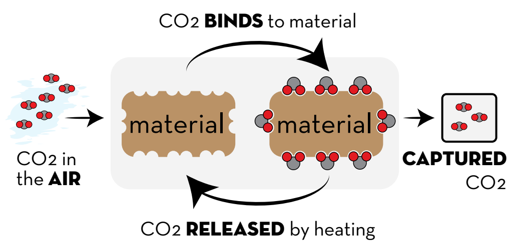
TECHNOLOGIES FOR CARBON CAPTURE AND LONG-TERM STORAGE

1



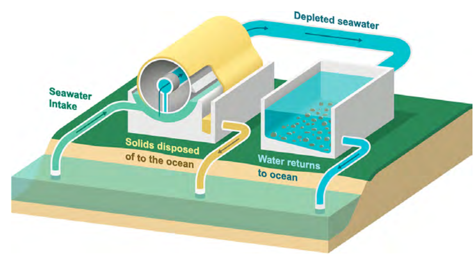
Example: Solid metal-organic materials bind CO_2 from the air and then release the CO_2 when heated, allowing the CO_2 to be captured and the materials to be re-used.

Figure: Modified from Nature 2015, 519, 303

DIRECT AIR CAPTURE

Machines with specialized materials can directly capture CO_2 from the air using chemical reactions. Direct air capture (DAC) technologies can be used to extract CO_2 from the ambient atmosphere or from point sources of emissions such as fuel combustion or industrial processes.

2



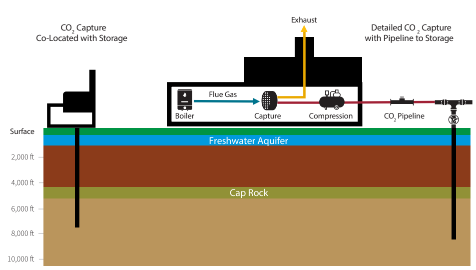
Example: Researchers are studying pathways to deploy DOC machines at coastal facilities paired with mineralization of captured CO_2 to create carbonate rocks for stable, long-term storage.

Figure: From Sust. Chem. & Eng. 2021 9 (3), 1073-1089

DIRECT OCEAN CAPTURE

Emerging research is exploring direct ocean capture (DOC) technologies to extract CO_2 from seawater using chemical reactions. Because the natural carbon cycle maintains a balance of CO_2 between the ocean and the atmosphere, removal of CO_2 from seawater induces the ocean to absorb more CO_2 from the air to re-establish an equilibrium.

3



Example: Depleted fossil fuel fields—such as those in the Central Valley that previously stored carbon in the form of oil or natural gas—can be good candidates for long-term CO_2 storage.

Figure: Energy Futures Initiative and Stanford University 2020.

STORAGE IN RESERVOIRS

Captured CO_2 can be injected into underground, geologic formations for long-term storage (figure). The most promising sites are those that minimize the risk of underground water contamination, induced seismicity, and CO_2 leakage back to the atmosphere.

4

Examples: Manufacturing processes that incorporate captured CO_2 into concrete for use as a building material (figure).

Photo: Concrete block made with injected waste CO2 (Sant Lab, UCLA)

STORAGE IN MATERIALS

Captured CO_2 can be processed into stable materials that provide for long-term storage. Some of these materials can then be utilized in valuable products providing an economic pathway to offset the costs of the carbon sequestration process.