CCST EXPERT BRIEFING SERIES

A Carbon Neutral California: The Role of Negative Emissions in Meeting the State's Climate Goals

Briefing held **FEBRUARY 2020**

One Pager

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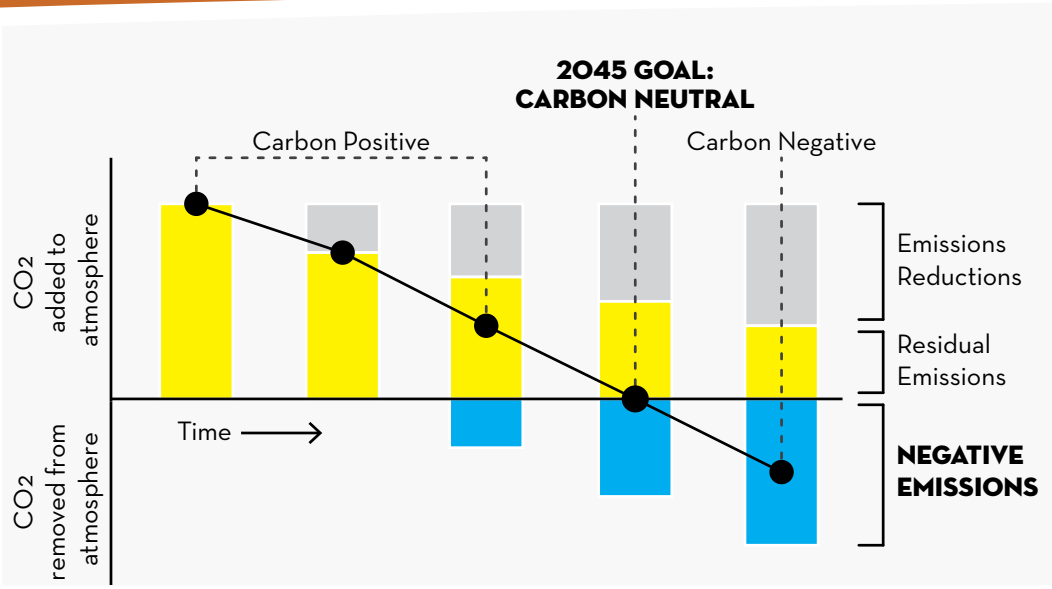

Figure: Examples of net carbon emissions scenarios (black trendline), modified from LLNL 2020

BACKGROUND

- Anthropomorphic **carbon emissions** are a leading cause of **climate change**.
- California has set an ambitious goal of being **carbon neutral** by 2045.
- The State has made considerable progress in **reducing carbon emissions** through increased renewable energy production and electrification.
- However, **residual carbon emissions** from some economic sectors, including transportation and industry, are still predicted to persist in 2045.
- **Negative Emissions** - the physical removal of carbon dioxide (CO_2) from the atmosphere - can be used to **offset** residual emissions sources to achieve **carbon neutrality**.

REMOVAL AND LONG-TERM STORAGE OF ATMOSPHERIC CO_2

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 air resulting in climate change. In an effort to limit global warming, the State has taken action to reduce net emissions of CO_2.

Net CO_2 emissions can be reduced by reducing the rate at which CO_2 is added to the atmosphere or by increasing the rate at which CO_2 is removed from the atmosphere.

CO_2 can be removed from the atmosphere and stored using either technological or natural pathways. Technological pathways rely on chemical reactivity to capture CO_2 from the air for storage in geologic basins or use in products (e.g. biochar or cement).

Negative Emissions Pathways

1. **Natural -** management of natural and working lands to increase CO_2 uptake and carbon storage by plants and soil.
2. **Waste Biomass -** capture of CO_2 emitted from waste biomass during conversion to beneficial products.
3. **Direct Air Capture -** removal of CO_2 directly from the air using chemical reactions.

Natural pathways rely on photosynthesis by plants to capture CO_2 from the air for long-term storage in the ecosystem (e.g. soils or woody biomass).

Experts are working to identify and implement negative emissions pathways in California to meet the State's climate goals.

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SELECT EXPERTS

THE FOLLOWING EXPERTS CAN ADVISE ON NEGATIVE EMISSIONS:

SARAH BAKER, PHD
Research Staff
Lawrence Livermore National Lab
baker74@llnl.gov
Office: (925) 422-3811

EXPERTISE: AVAILABLE PATHWAYS FOR NEGATIVE EMISSIONS IN CALIFORNIA

DICK CAMERON
Director of Land Science
The Nature Conservancy
dcameron@tnc.org
Office: (415) 203-5734

EXPERTISE: LAND MANAGEMENT AND CONSERVATION FOR CARBON STORAGE

JEFFREY LONG, PHD
Professor
UC Berkeley
Lawrence Berkeley National Lab
jrlong@berkeley.edu
Office: (510) 642-0860

EXPERTISE: DESIGN OF NEW MATERIALS FOR DIRECT AIR CAPTURE OF CARBON

SARAH SALTZER, PHD
Managing Director
Stanford Center for Carbon Storage
sarah.saltzer@stanford.edu
Office: (650) 721-3174

EXPERTISE: CARBON MANAGEMENT AND LONG-TERM GEOLOGIC STORAGE

CCST Contact: sarah.brady@ccst.us

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EXAMPLES OF NEGATIVE EMISSIONS PATHWAYS

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NATURAL PATHWAYS

Natural and working lands provide opportunities to serve as a net carbon sink for the State by increasing the uptake and storage of carbon in forests, woodlands, wetlands, and soils. These pathways can also provide many co-benefits including enhanced ecosystem services and resilience.

Examples:

- Agricultural practices that increase carbon uptake of soil.
- **Photo:** Restoration to replace trees that have been lost due to wildfire or land use changes.

Photo: Lassen Volcanic National Park (NPS)

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TECHNOLOGICAL PATHWAYS

Machines with specialized materials can act like a sponge to directly capture CO_2 from the air. The captured CO_2 can then be transfered to long-term storage. When paired with renewable energy, geothermal heat, or natural gas with carbon capture this can result in negative emissions.

Example:

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

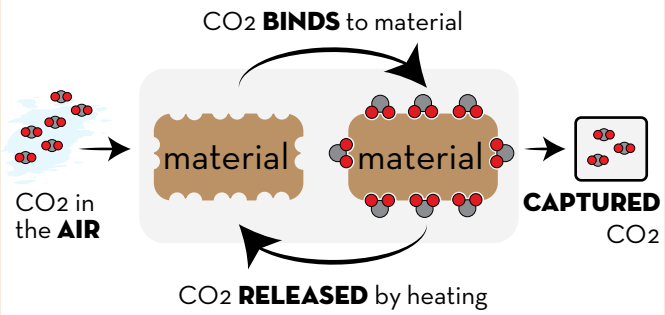

Figure: Modified from Nature 2015, 519, 303

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GEOLOGIC STORAGE

Once carbon has been captured from the atmosphere it must be transferred to a long-term storage option to achieve negative emissions. CO_2 can be injected into underground, geologic formations for long-term storage. The most promising sites are those that minimize the risk of underground water contamination, induced seismicity, and CO_2 leakage back to the atmosphere.

Examples:

- Depleted fossil fuel fields - that previously stored carbon in the form of oil or natural gas - can be good candidates for long-term CO_2 storage.
- **Figure:** The Central Valley provides the largest potential geologic CO_2 storage capacity (green layer) in California.

Figure: WestCARtB

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