



ROADS TO REMOVAL

OPTIONS FOR CARBON DIOXIDE REMOVAL IN THE UNITED STATES

First-of-its-kind national study identifies county-by-county opportunities in all 50 states that, if fully implemented, could result in the removal of 1 billion metric tonnes of CO₂ and 440,000 jobs.

Key Findings

California's largest contribution to removing CO₂ can be from municipal trash, plus forest and agricultural wastes. Keeping this carbon from returning to the air solves two problems: less landfill and water runoff contamination, and less smoke pollution from fires.

Near Term Opportunities

- Thinning overstocked forests and expanding use of agricultural cover crops are cost-efficient, ready-to-go opportunities for CO₂ removal.
- Public health benefits from air and water quality improvements.

Longer Term Investments

- New jobs in carbon management can re-employ skilled workforces.
- Nearly every Central Valley county has good, affordable geologic CO₂ storage potential, with adjacent skilled workforce.
- Direct air capture with co-located renewable energy and geologic storage is possible but will require balancing high energy costs and land use constraints.

CALIFORNIA OPPORTUNITIES



▶ Northern Forests

- Forest management and forest biomass (Trinity, El Dorado)

▶ Central Valley

- Cover crops and perennial field borders (Merced, King), agriculture biomass and geologic CO₂ storage (Fresno, Kings, Kern)

▶ Westcoast Cities and Southern Desert

- Municipal solid waste diverted for CO₂ removal (Los Angeles county)

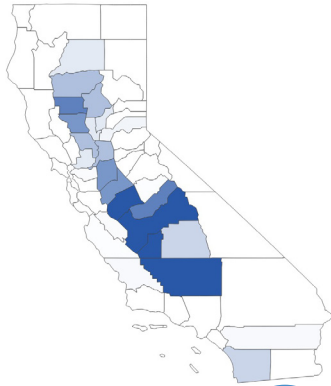
BY THE NUMBERS

CO₂ Removal Capacity in California

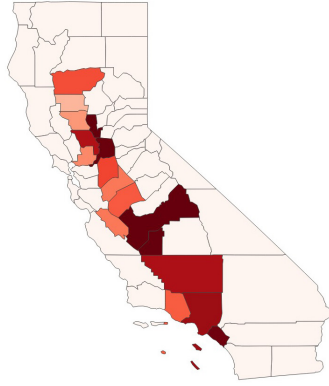
Direct air capture with storage	82M tonnes CO ₂ /year potential
Geologic Storage	30,000 sq-mi (18% of state) \$4.50-\$17.90/tonne CO ₂ (Central Valley)
Soils	11M tonnes CO ₂ e by 2050 <\$40/tonne CO ₂ e
Biomass carbon removal and storage	180M tonnes CO ₂ /year \$78/tonne CO ₂ average cost 9M tonnes of H ₂ (via gasification)

By implementing methods that remove CO₂ from the air, communities big and small can create new jobs, improve air and water quality, increase our resilience to a changing climate, and protect life and property.

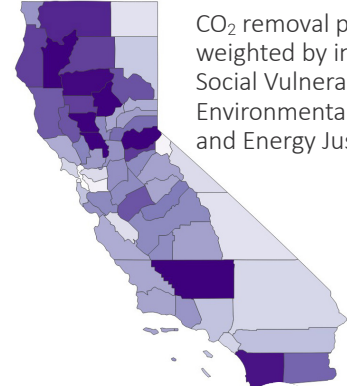
COUNTY-LEVEL RESULTS



Direct Air Capture with Storage



Geologic CO₂ Storage Potential



Environmental and Socioeconomic Benefits

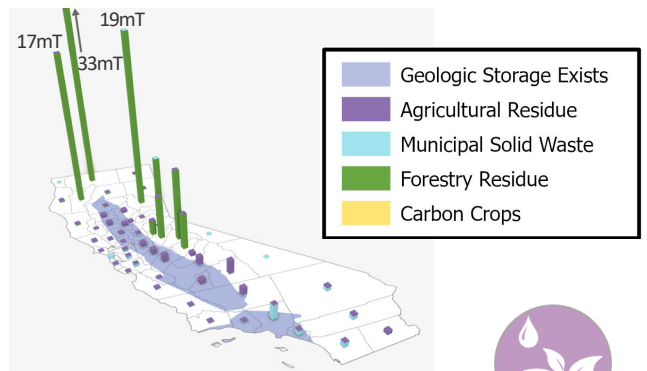


CO₂ removal potential weighted by indices of Social Vulnerability and Environmental, Equity, and Energy Justice

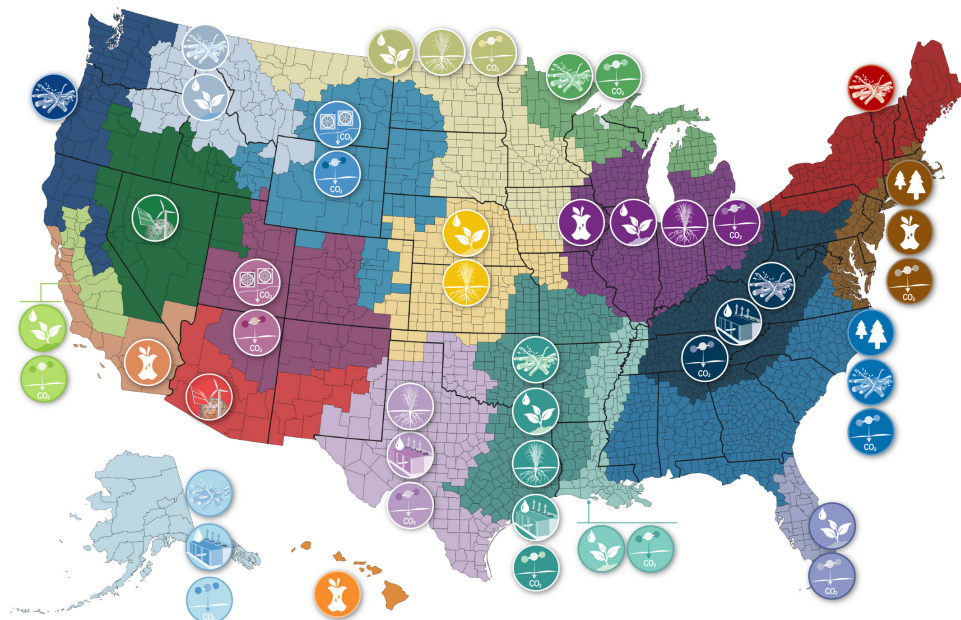
Renewable Energy & DACS: A full buildout of direct air capture and storage capacity could provide more than 20,000 direct jobs and an additional 240,000 indirect jobs.

Win for water quality: Perennial field borders and cover cropping in the California Central Valley have both high CO₂ removal potential and high opportunity to improve local water quality.

Win for air quality: Biomass carbon removal and storage (BiCRS) in the Central Valley can remove large amounts of agricultural residue that would otherwise be burned, removing a major area health hazard.



Wastes available for 'BiCRS' —Biomass Carbon Removal and Storage



Every region has a story.

Every region has an opportunity.

Roads to Removal Partners:

- Lawrence Livermore National Laboratory
- Oak Ridge National Laboratory
- Lawrence Berkeley National Laboratory
- University of Texas at Austin
- North Carolina State University
- University of California, Berkeley
- Colorado State University
- Indiana University Indianapolis
- Yale University
- University of New Hampshire
- Iowa State University
- Michigan State University
- University of Pennsylvania

To learn more about each carbon dioxide removal pathway go to Roads2Removal.org