



CCS in the U.S. Energy Ecosystem and Policy

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Carbon Capture and Storage (CCS) & Carbon Dioxide Removal (CDR) Are Essential for Net Zero by 2050

1970's

- CO₂-EOR
- CO₂ sourced from natural and industrial sources

1990's

- Norwegian Sleipner Offshore CO₂ Capture and Storage Project

2000's

- IPCC Special Report on Carbon Capture and Storage
- Government research support for Carbon Capture and Storage

2010's

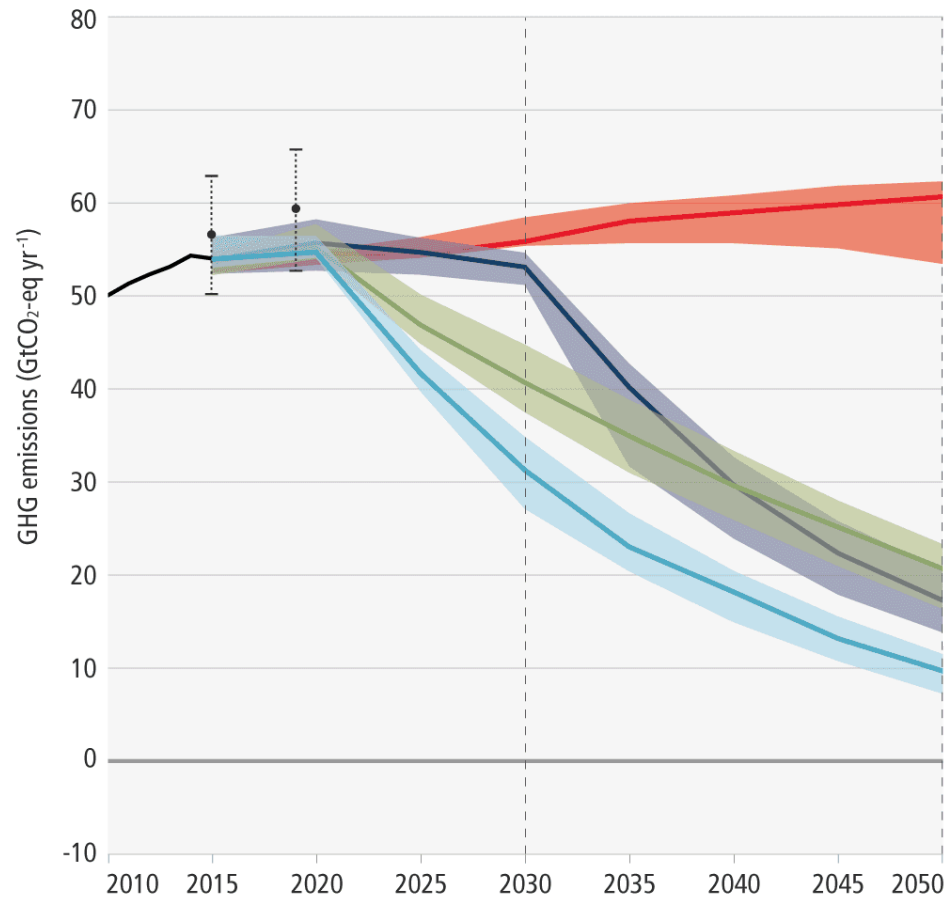
- Recognize "hard-to-abate" sectors of the economy need CCS
- Net zero is required to stabilize warming
- Carbon dioxide removal is needed
- Accelerating deployment of Carbon Capture, Storage, and Utilization

2020's

- Large scale demos
- Incentives drive deployment

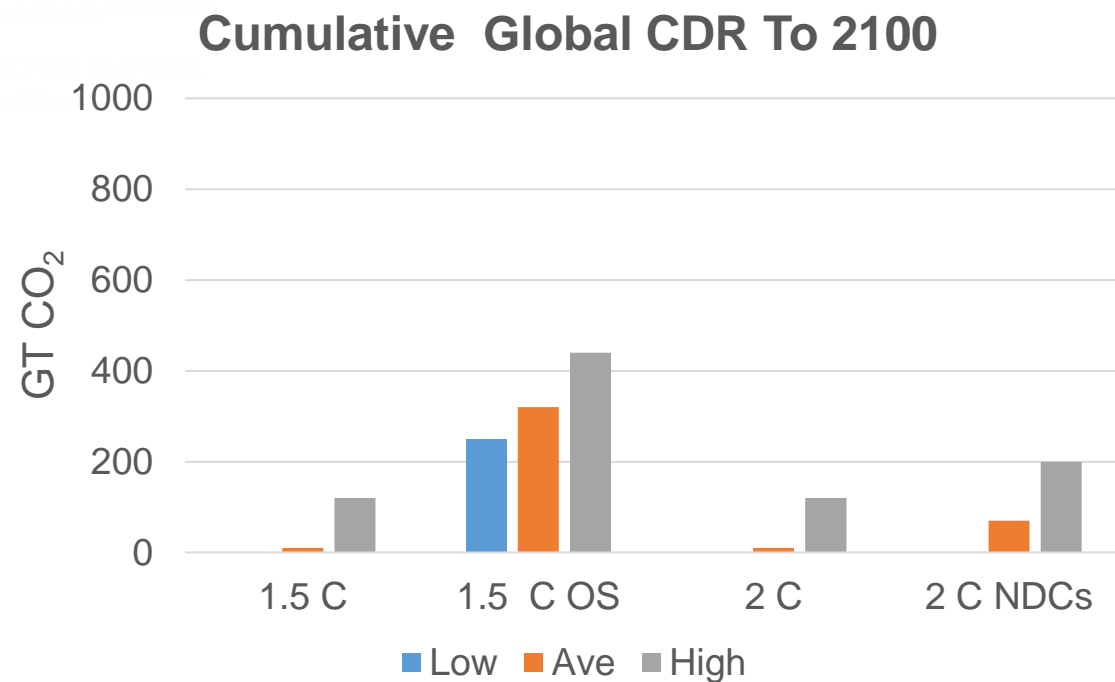
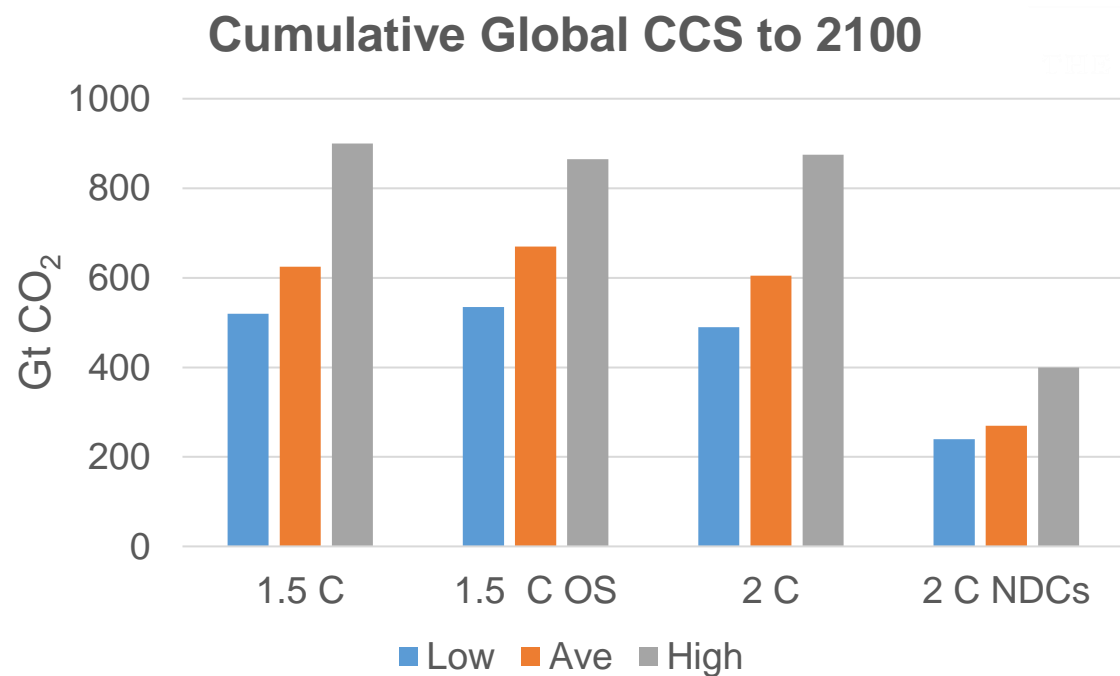


Rapid and Large Emission Reductions are Needed to Limit Warming to Less Than 1.5 to 2 °C



IPCC, Working Group III, April 2022

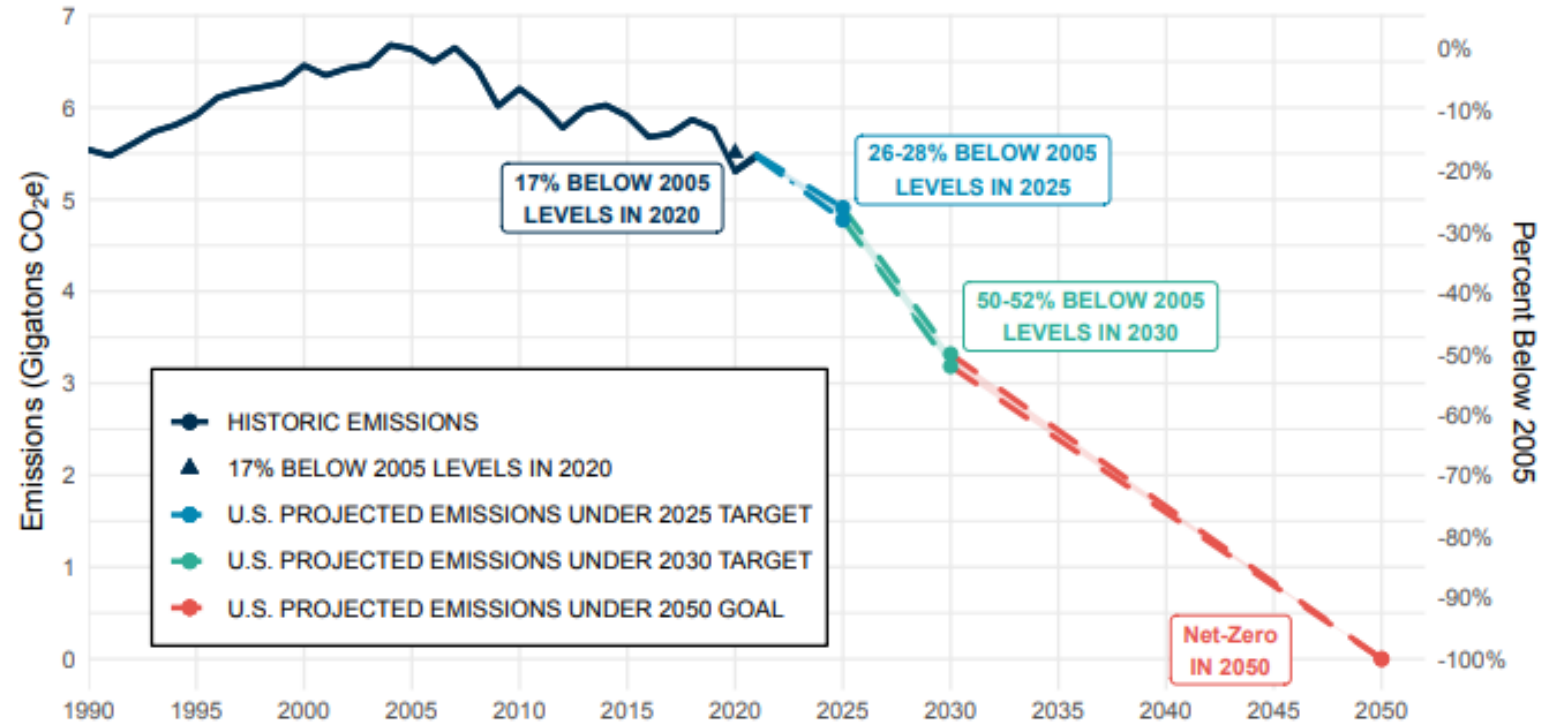
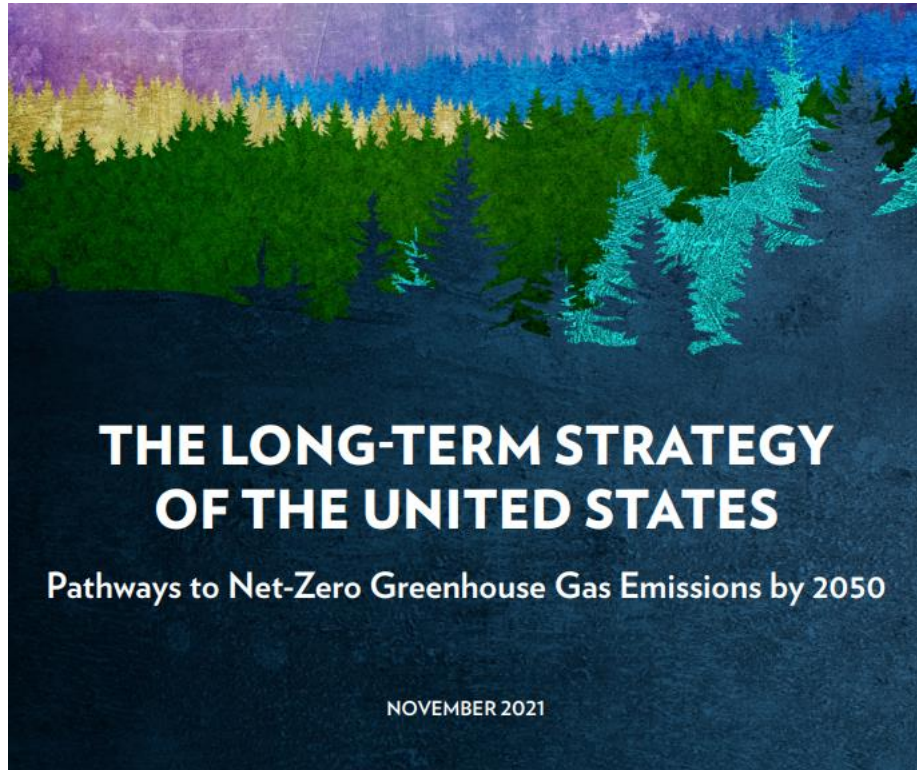
Carbon Capture, Utilization, and Storage (CCS) & Carbon Dioxide Removal (CDR) are Necessary to Meet Emission Reduction Goals



IPCC, Working Group III, April 2022



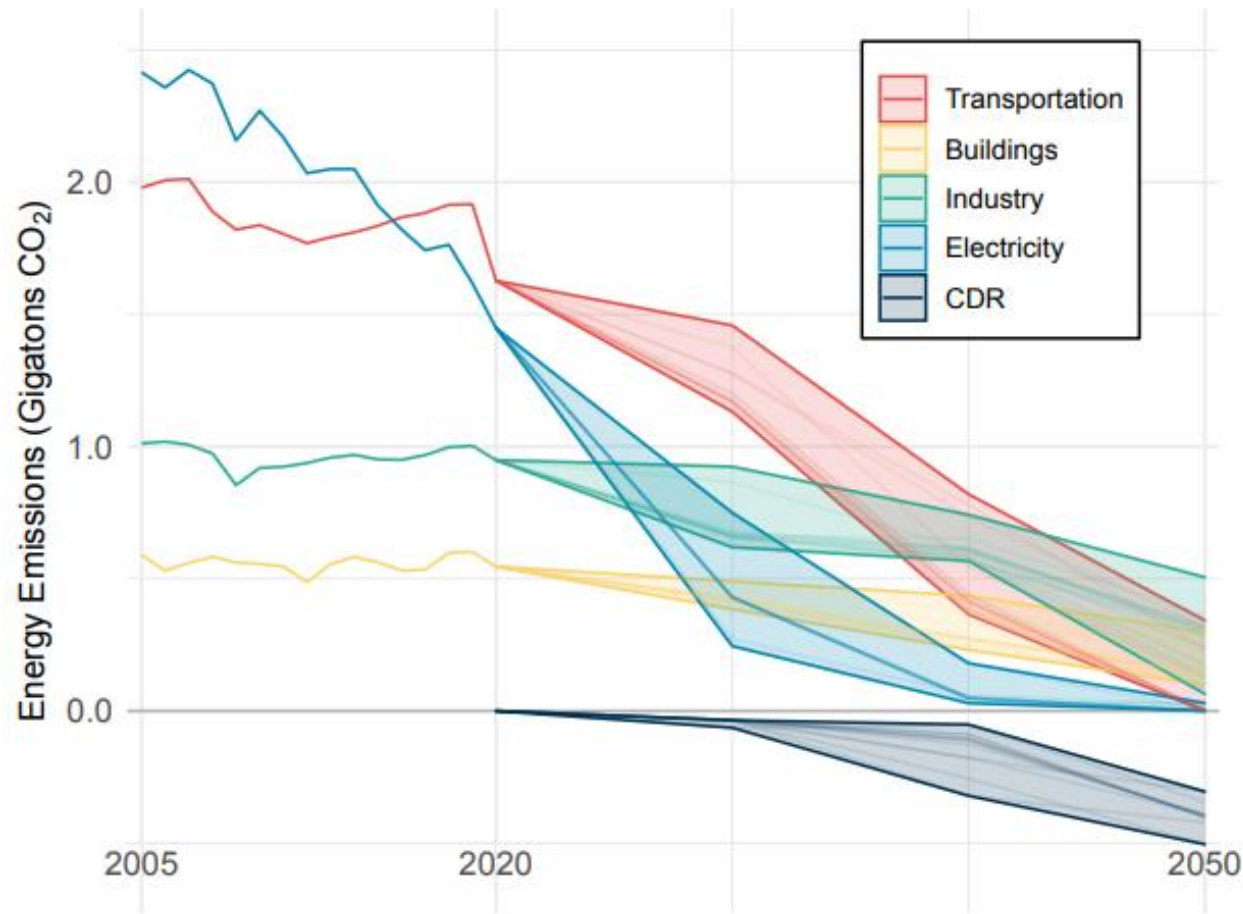
The U.S. National Long Term Climate Strategy Maps Out Pathways to Net Zero By 2050



U.S. Long Term Climate Strategy: Domestic Climate Policy Office and the State Department, 2021



Sectoral Pathways to Net Zero 2050 Include CCS and CDR



Transportation

- H₂ from natural gas & CCS
- Biofuels with CCS

Buildings

- H₂ from natural gas & CCS

Industry

- CCS for steel, cement, ammonia, and chemicals
- H₂ from natural gas & CCS

Electricity

- Natural gas or coal & CCS
- Biomass plus CCS
- H₂ from natural gas & CCS
- H₂ from biomass & CCS

U.S. Long Term Climate Strategy: Domestic Climate Policy Office and the State Department, 2021

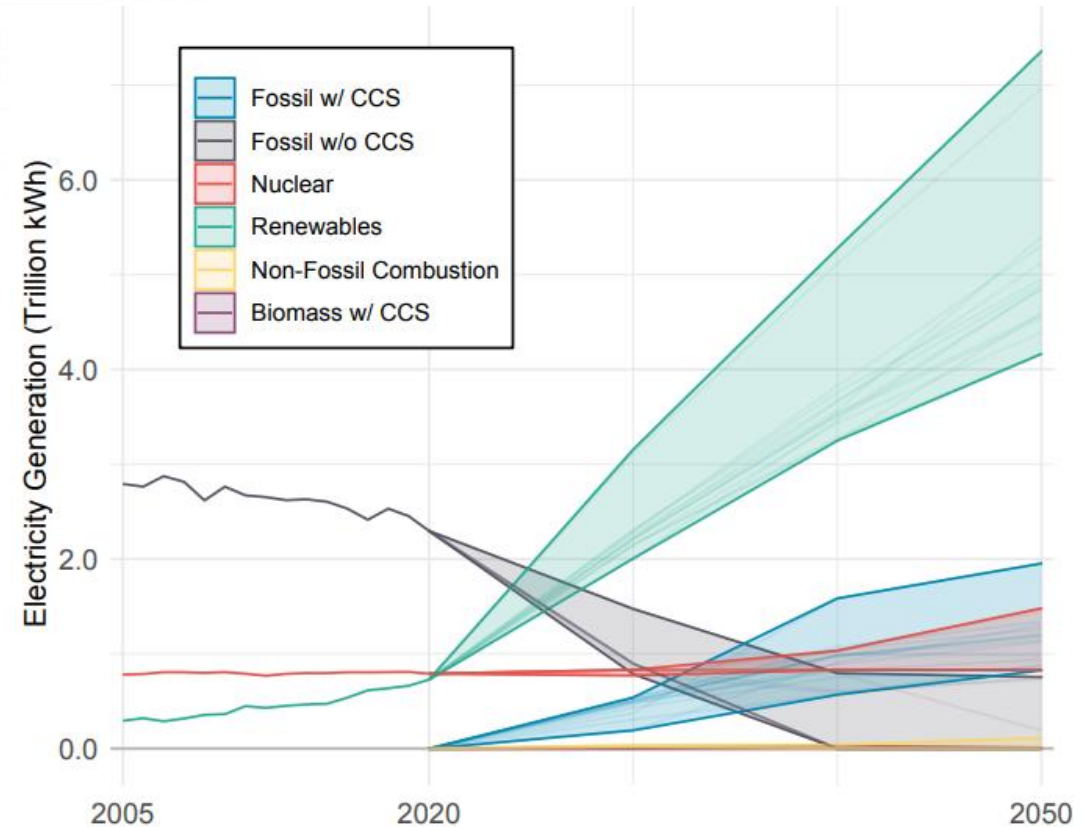




Multiple Synergistic Actions Result in Cost Effective Net Zero Solutions

Electricity Sector

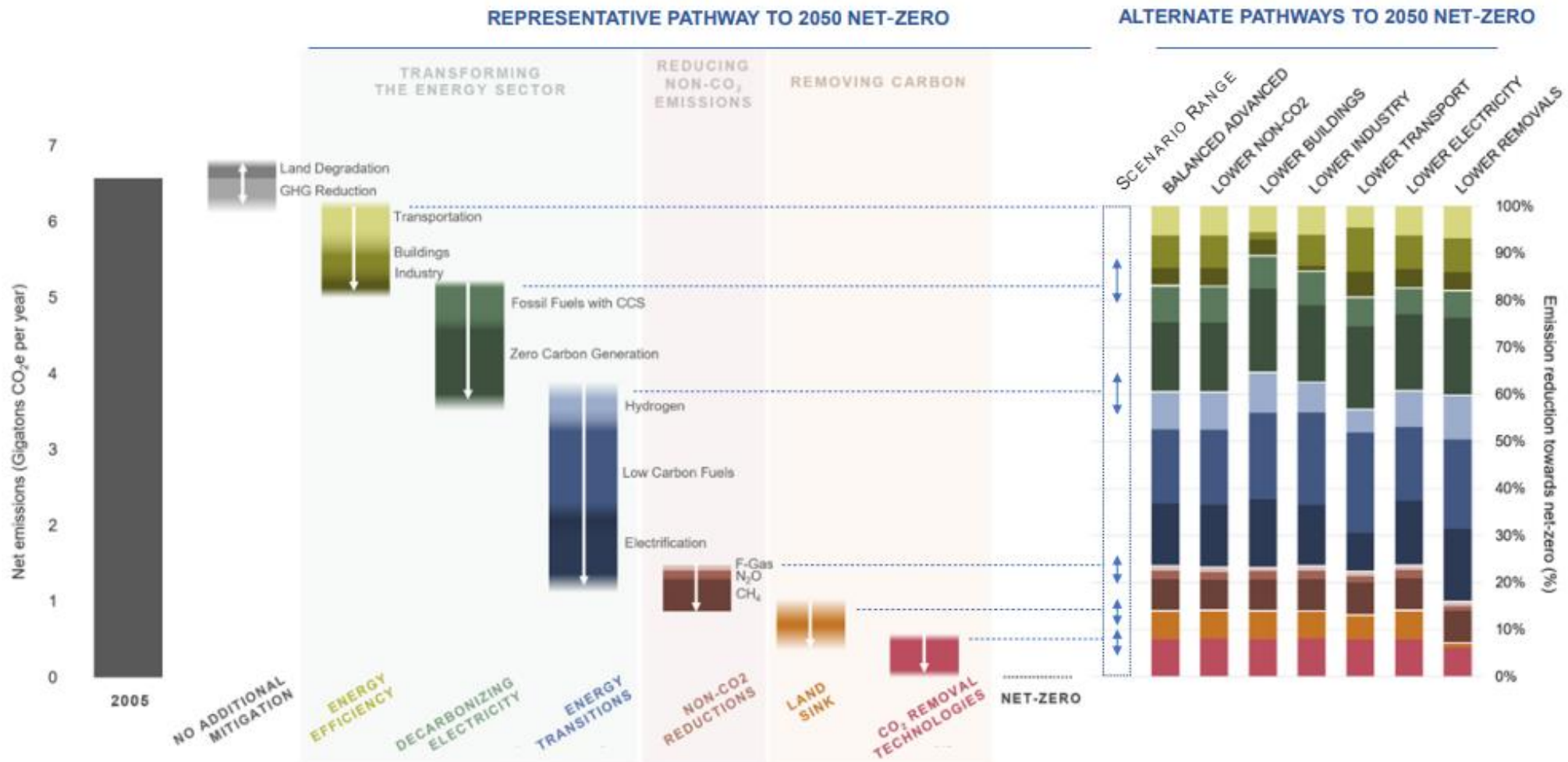
- Renewables
- Energy storage
- “Clean-firm power”
 - Nuclear fission
 - Natural gas or coal with CCS
 - Bio energy with CCS (BECCS) provides electricity and CDR
 - Renewable gas
 - H₂



U.S. Long Term Climate Strategy: Domestic Climate Policy Office and the State Department, 2021



CCS/CDR provide 10-20% of Emission Reductions



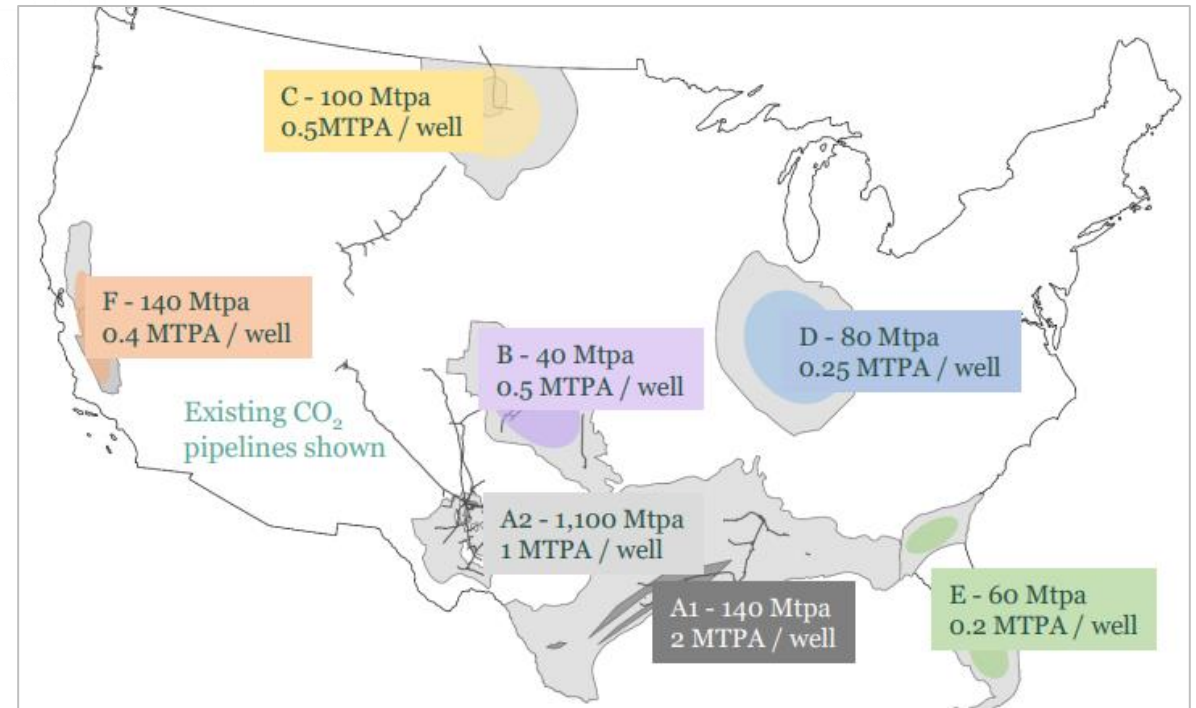
U.S. Long Term Climate Strategy: Domestic Climate Policy Office and the State Department, 2021



Bottoms-Up Modeling Confirms the Important Role of CCS/CDR

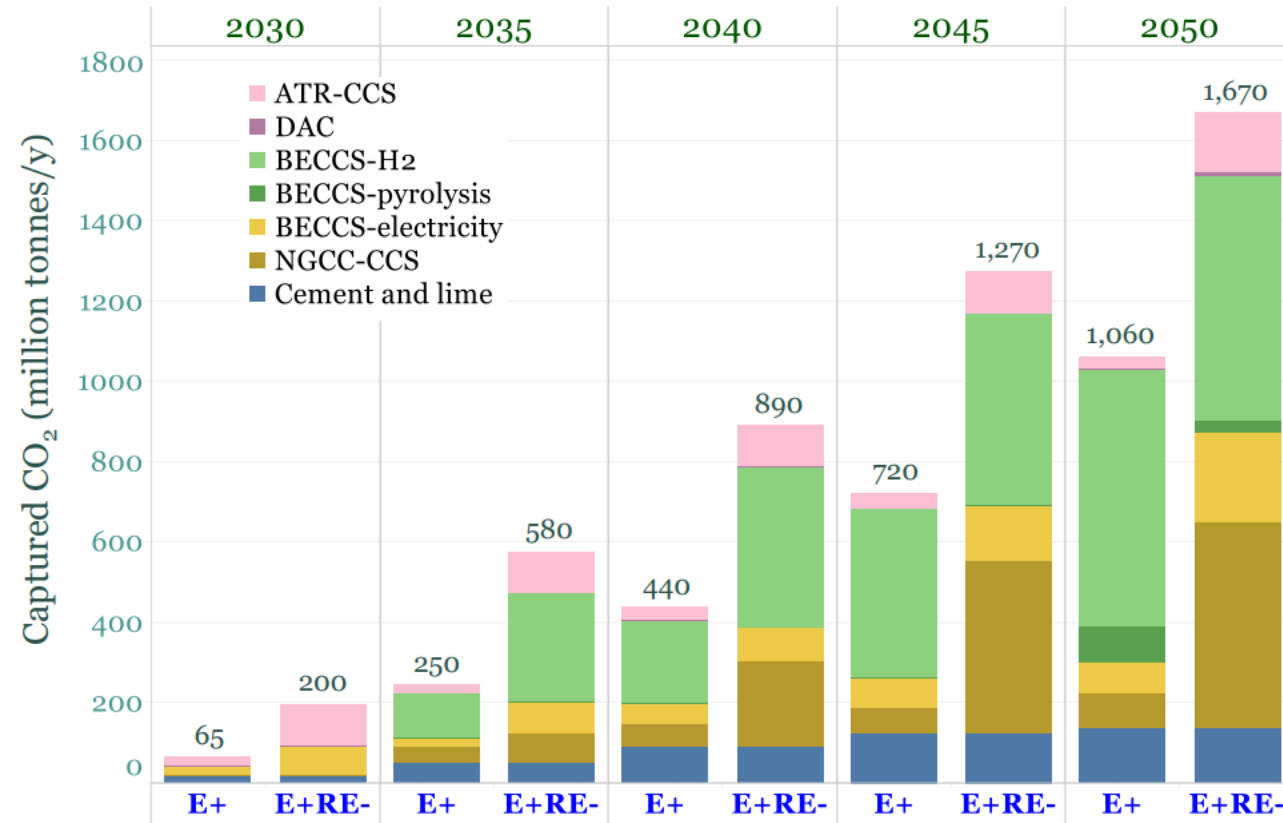


<https://netzeroamerica.princeton.edu/the-report>





U.S. Energy System Requires Growing Deployment of CCS for a Wide Variety of Energy Applications

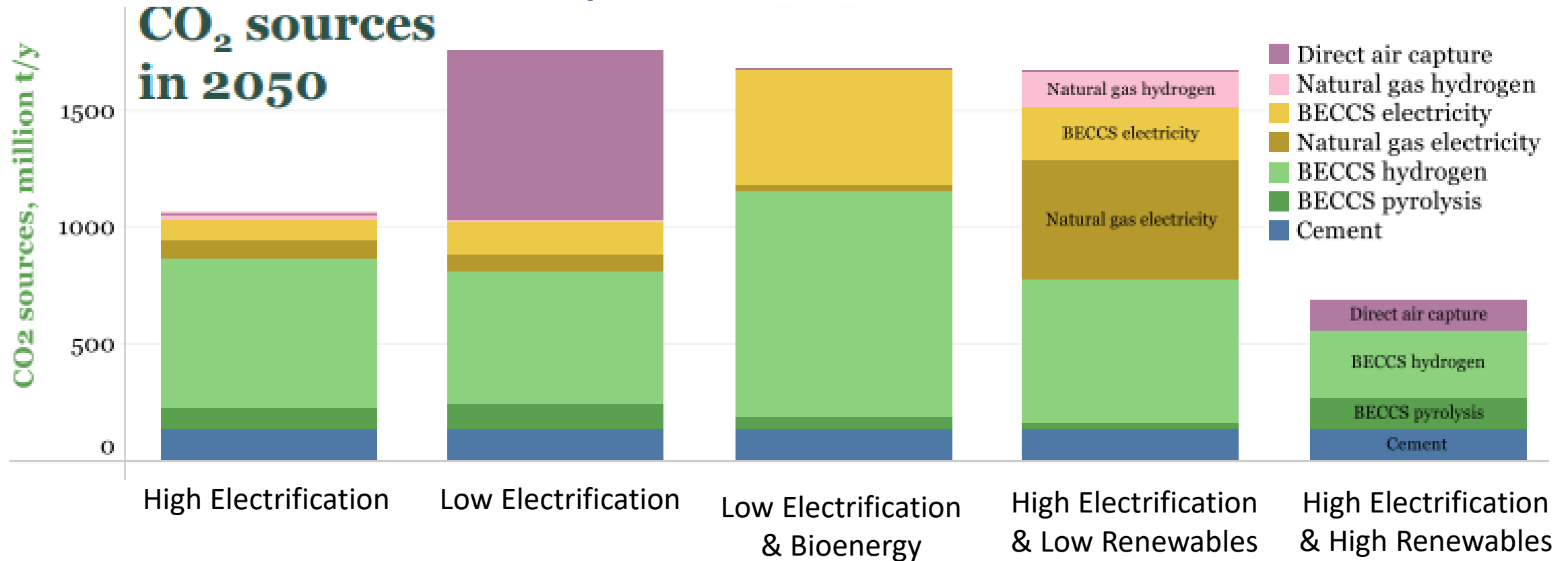


[https://netzeroamerica.princeton.edu/img/Princeton%20NZA%20FINAL%20REPORT%20SUMMARY%20\(29Oct2021\).pdf](https://netzeroamerica.princeton.edu/img/Princeton%20NZA%20FINAL%20REPORT%20SUMMARY%20(29Oct2021).pdf)





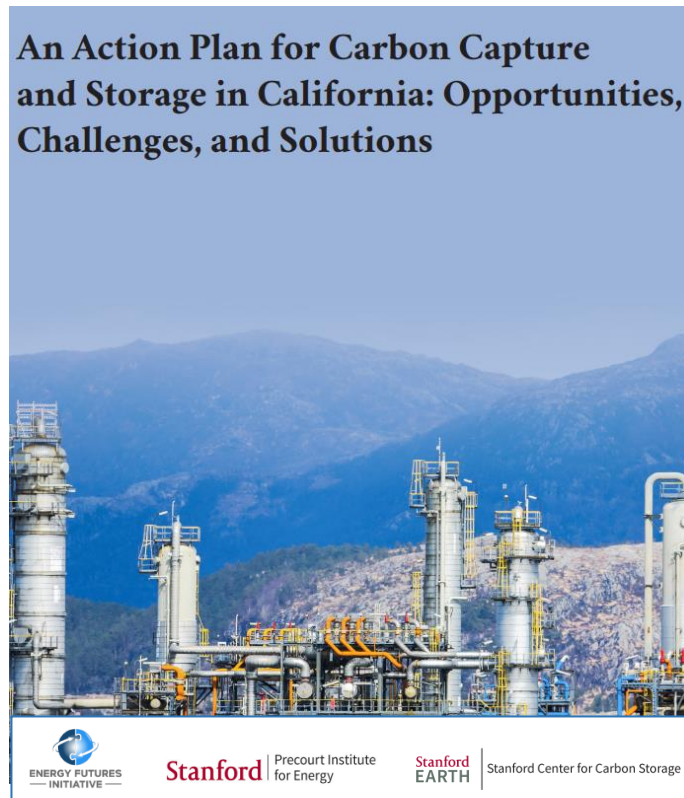
Large Amounts of Carbon Capture and Storage are Anticipated for All Scenarios



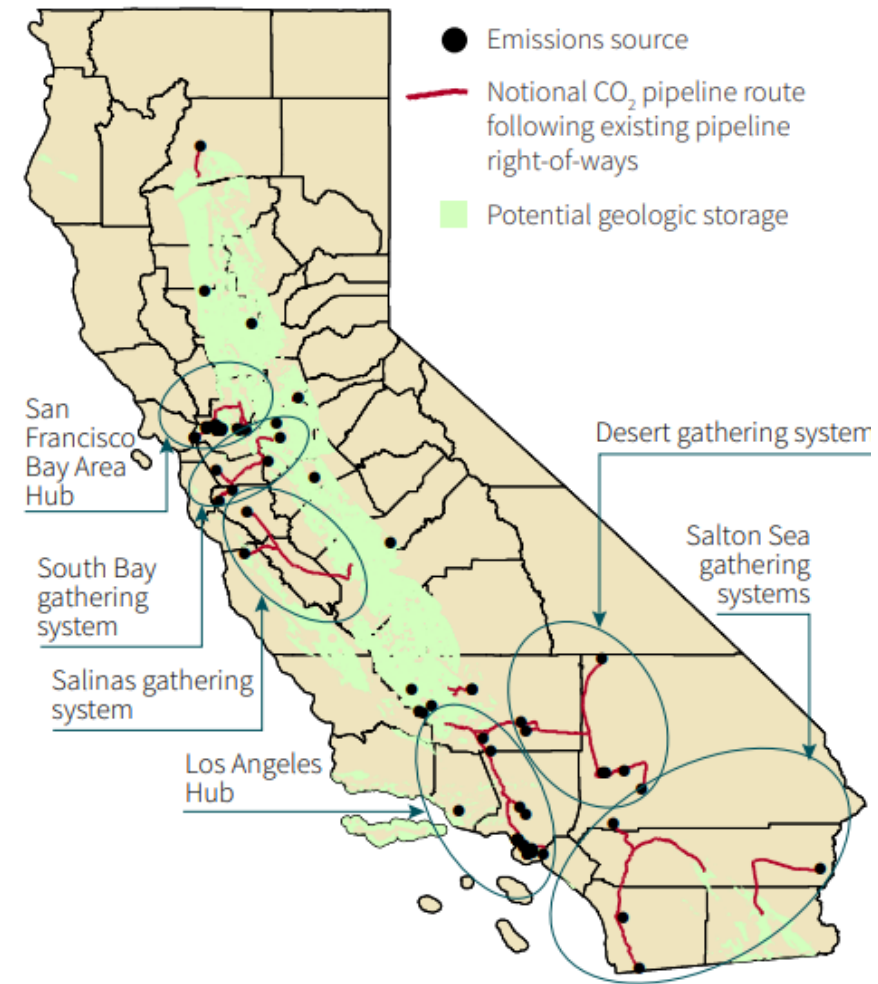
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State-Level Technoeconomic Assessment of the Role CCS



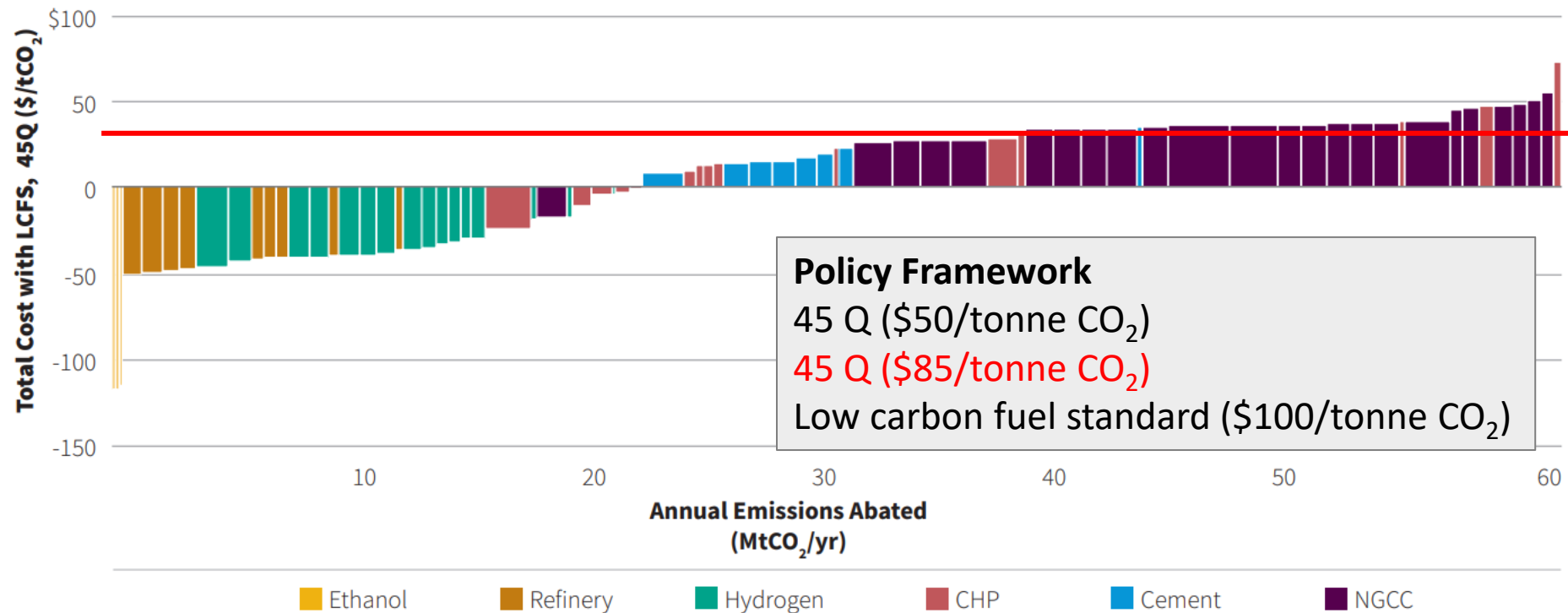
<https://sccs.stanford.edu/ccs-in-ca/full-report-form>





With Current Policy Frameworks, Some Applications of CCUS Are Cost Competitive Today, More in the Future

MARGINAL ABATEMENT CURVE BY FACILITY



<https://sccs.stanford.edu/ccs-in-ca/full-report-form>





In short... it's time to get going

- Carbon capture and storage & carbon dioxide removal are needed for Net Zero 2050
- Expected to contribute between 10-20% of needed emission reductions
- Pathways to net zero are uncertain, but CCS plays an important role in all of them
- Contributes to emission reductions in every energy sector
- Cost reductions and technology maturation are needed to realize the full potential
- Addressing justice and equity concerns must be a central part of project planning and implementation
- Now's the time to begin scaling up

