

State of the Science

An Overview of CO₂ Removal (CDR) Strategies from a California Perspective



March 19th, 2024

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*An Overview of CO₂ Removal
(CDR) Strategies from a
California Perspective*

TL;DR



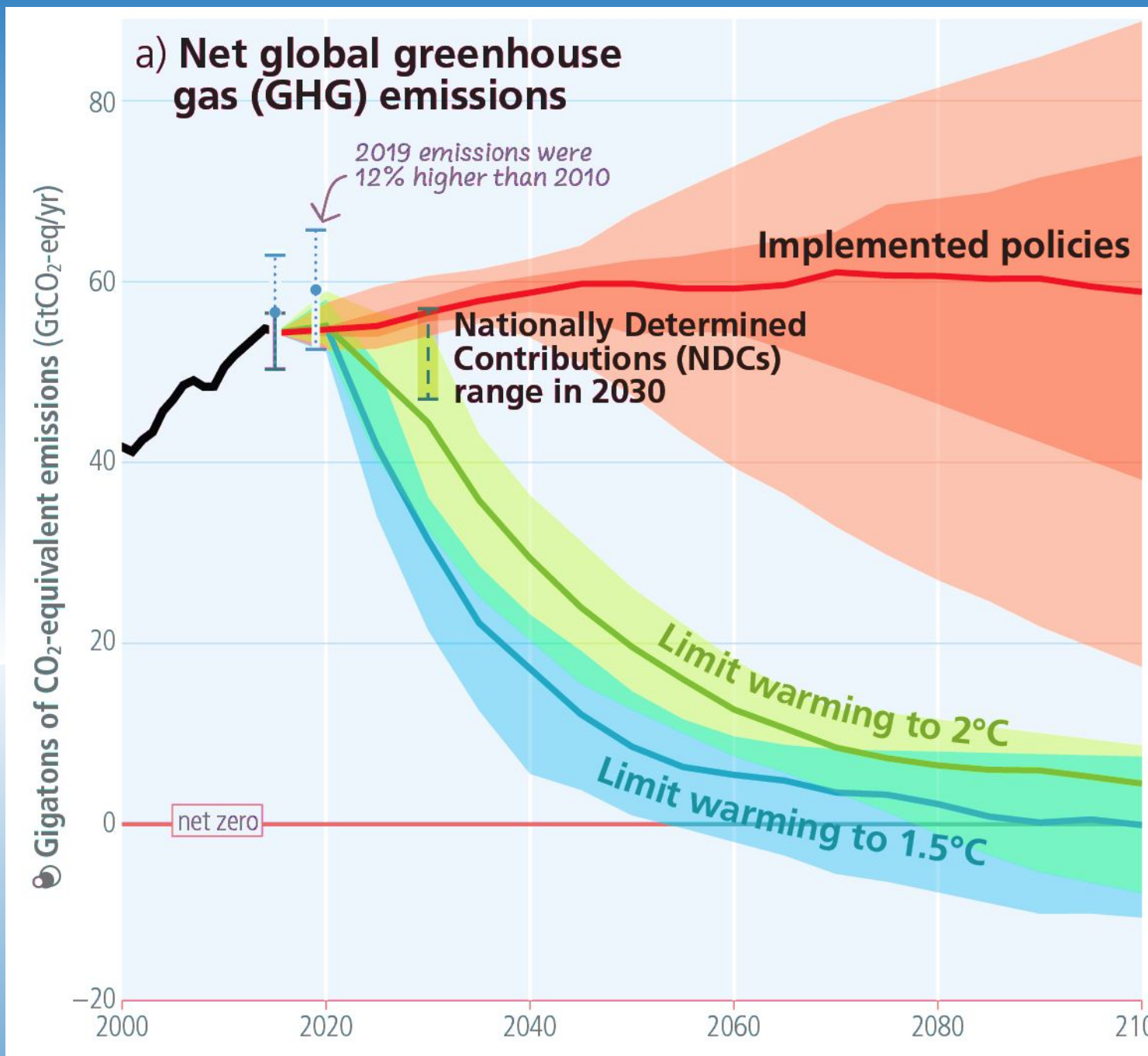
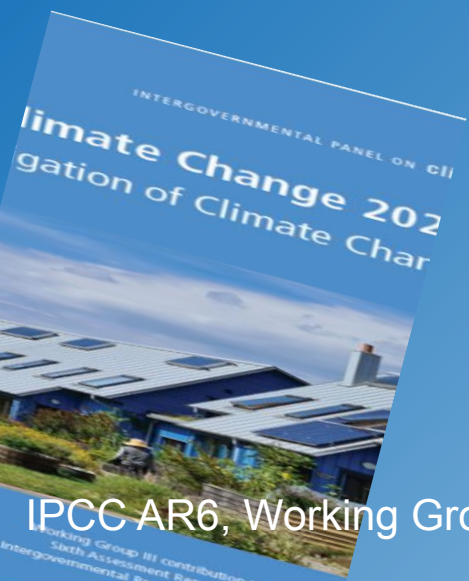
March 19th, 2024

We haven't
decarbonized
yet...

why bother with
CO₂ removal?

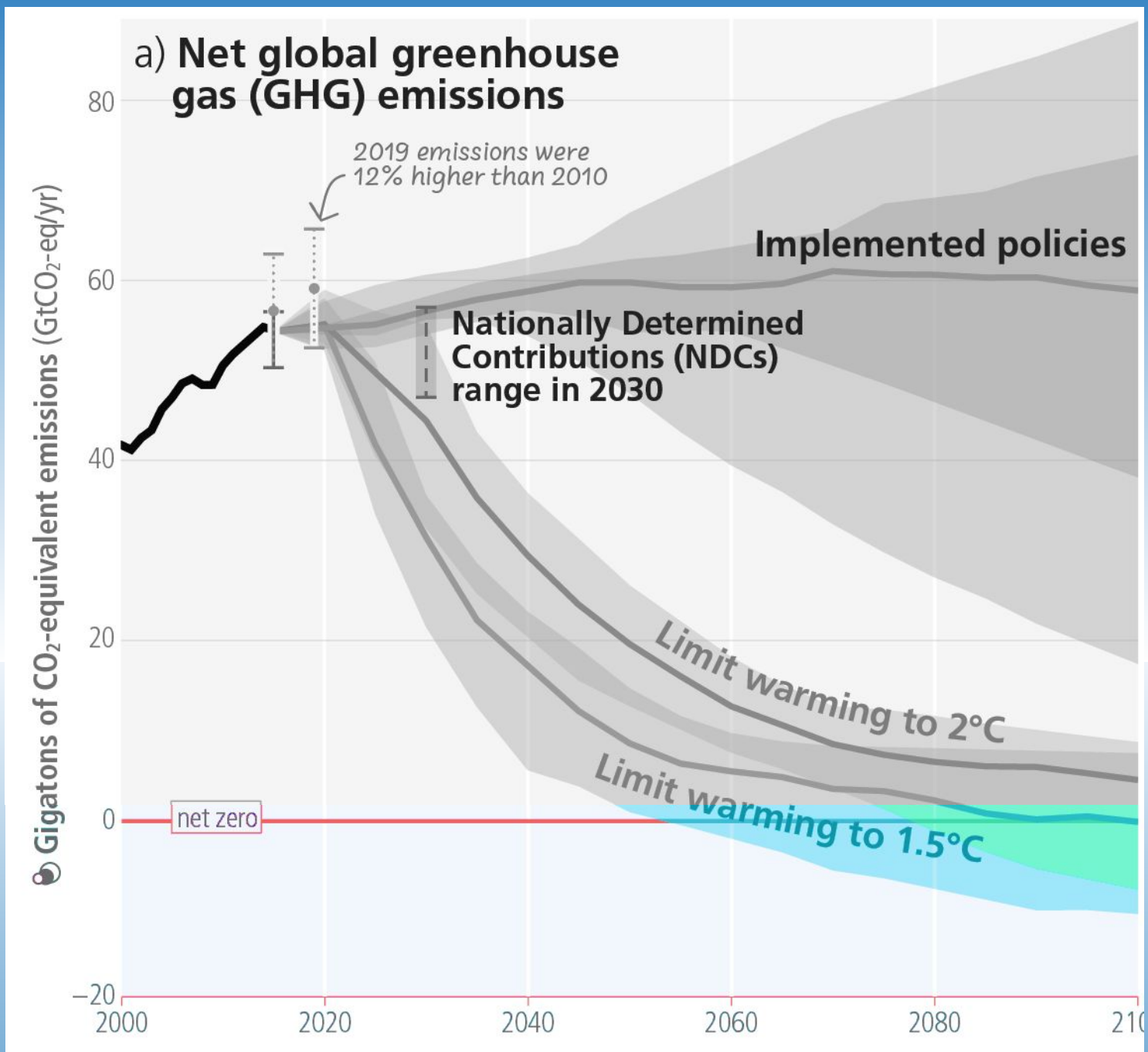
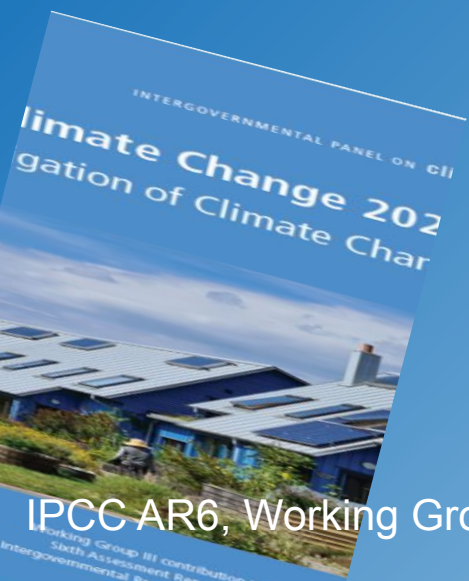
why bother with CO₂ removal?

- Rapid, deep and immediate reductions now!

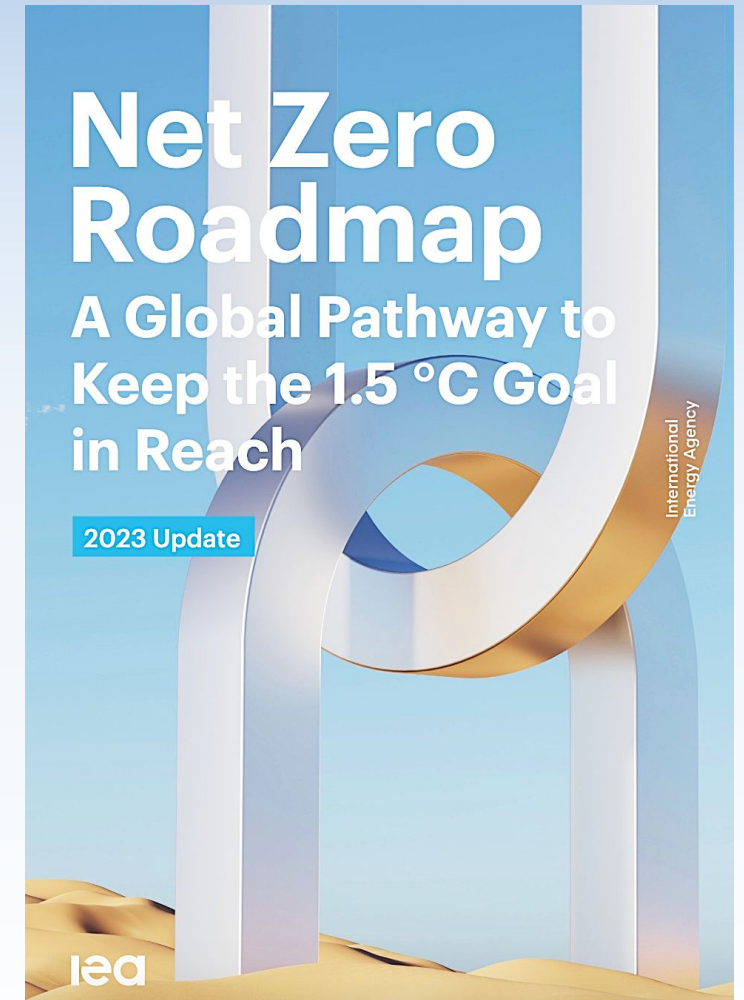


why bother with CO₂ removal?

- Rapid, deep and immediate reductions now!
- 1.5 °C now requires going carbon negative
 - i.e. CO₂ removal (CDR)

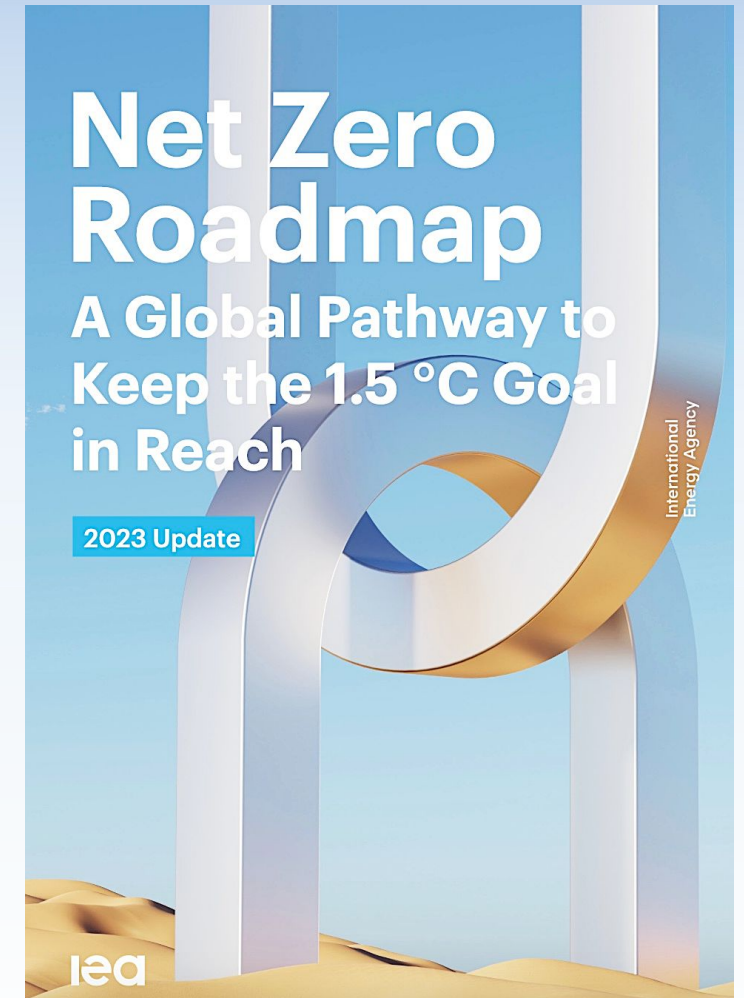


Globally, 1.5°C is Possible



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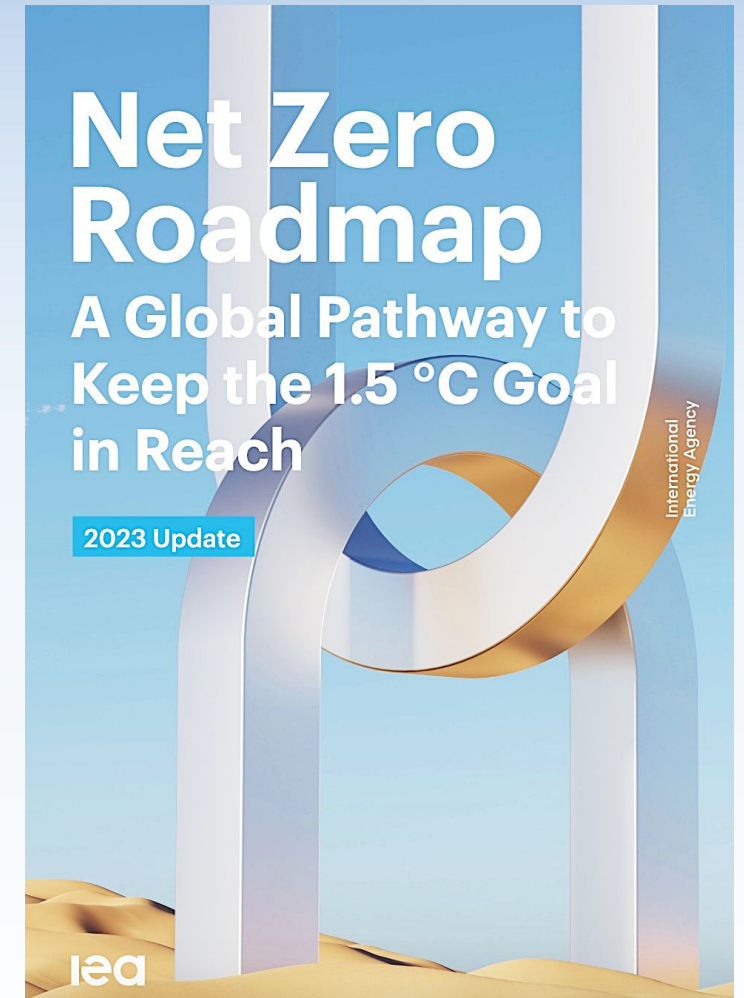
□ But it's **HARD!**



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□ But it's **HARD!**

- 3x green energy supply by 2030
- 2x fuel efficiency
- No new unabated coal plants
- Cut methane (CH₄) emissions by 75%
- Transmission networks increase by 30% year-over-year till 2030
- Increase clean energy budget in developing countries by \$3 trillion (200%)



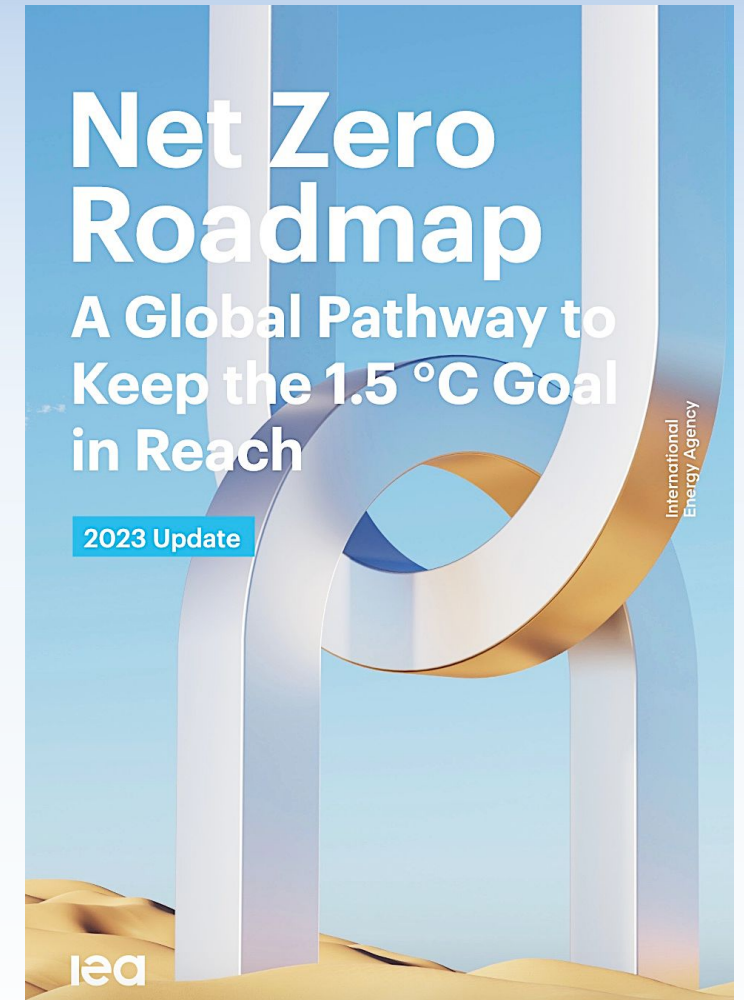
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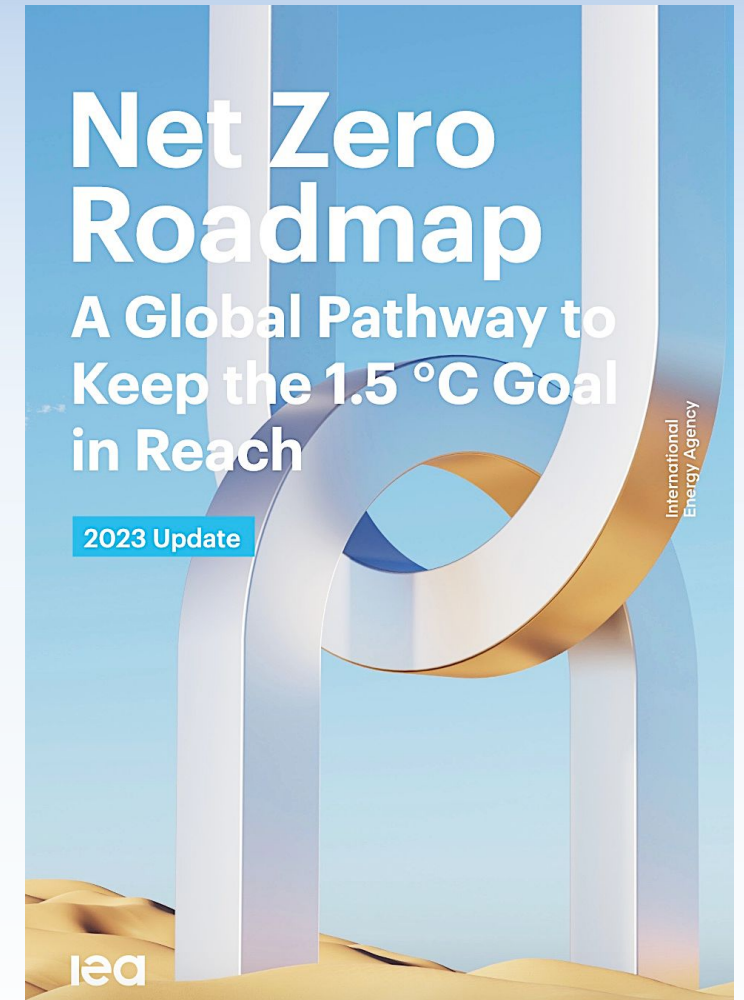
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□ “Technologies to capture CO₂ from smokestacks and the atmosphere”



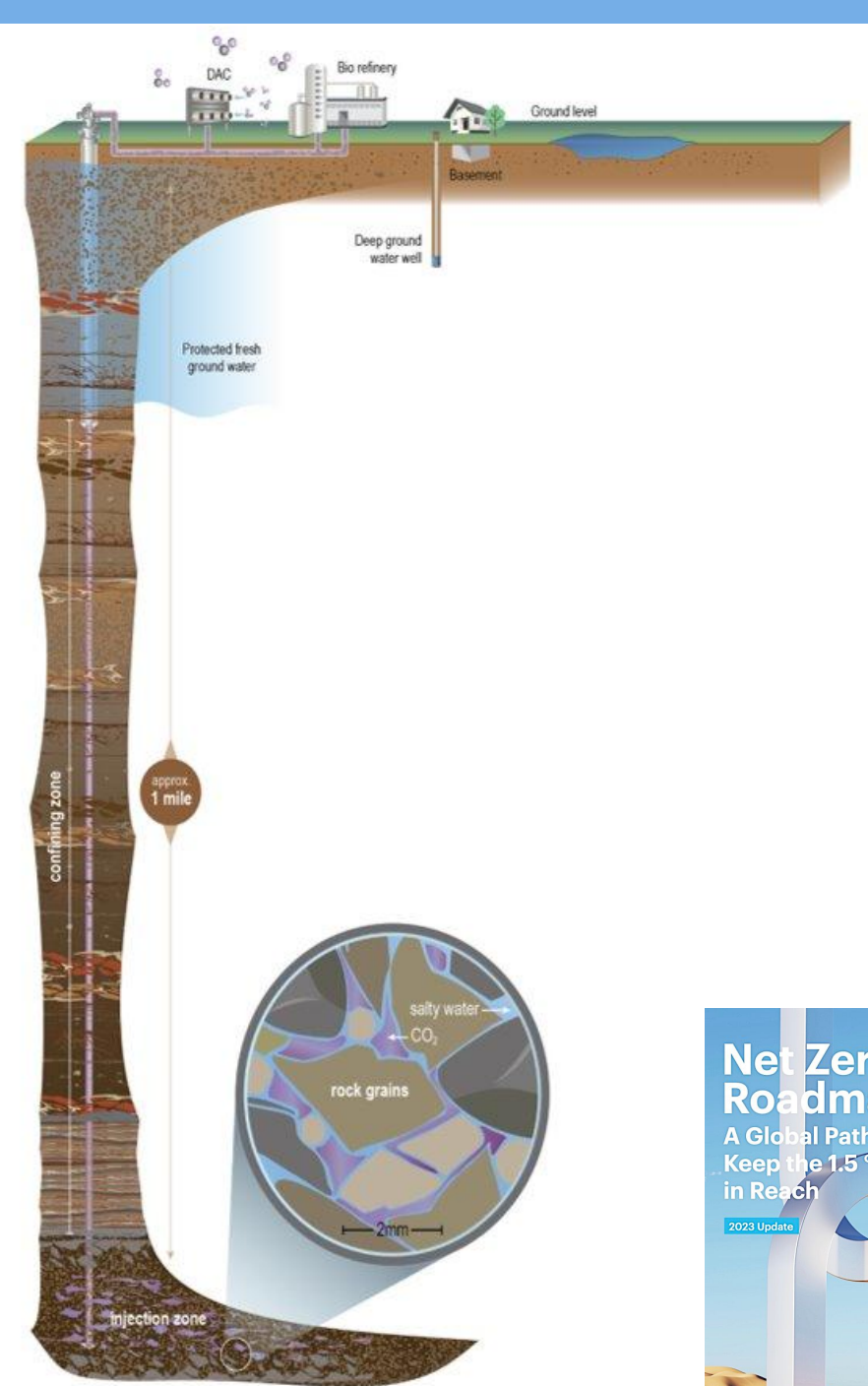
After you remove CO₂, you
have to store it
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□ Deep, porous rock layers

- Way, way below aquifers
- Only when there is a 'caprock'



**Net Zero
Roadmap**
A Global Pathway to
Keep the 1.5 °C Goal
in Reach

2023 Update

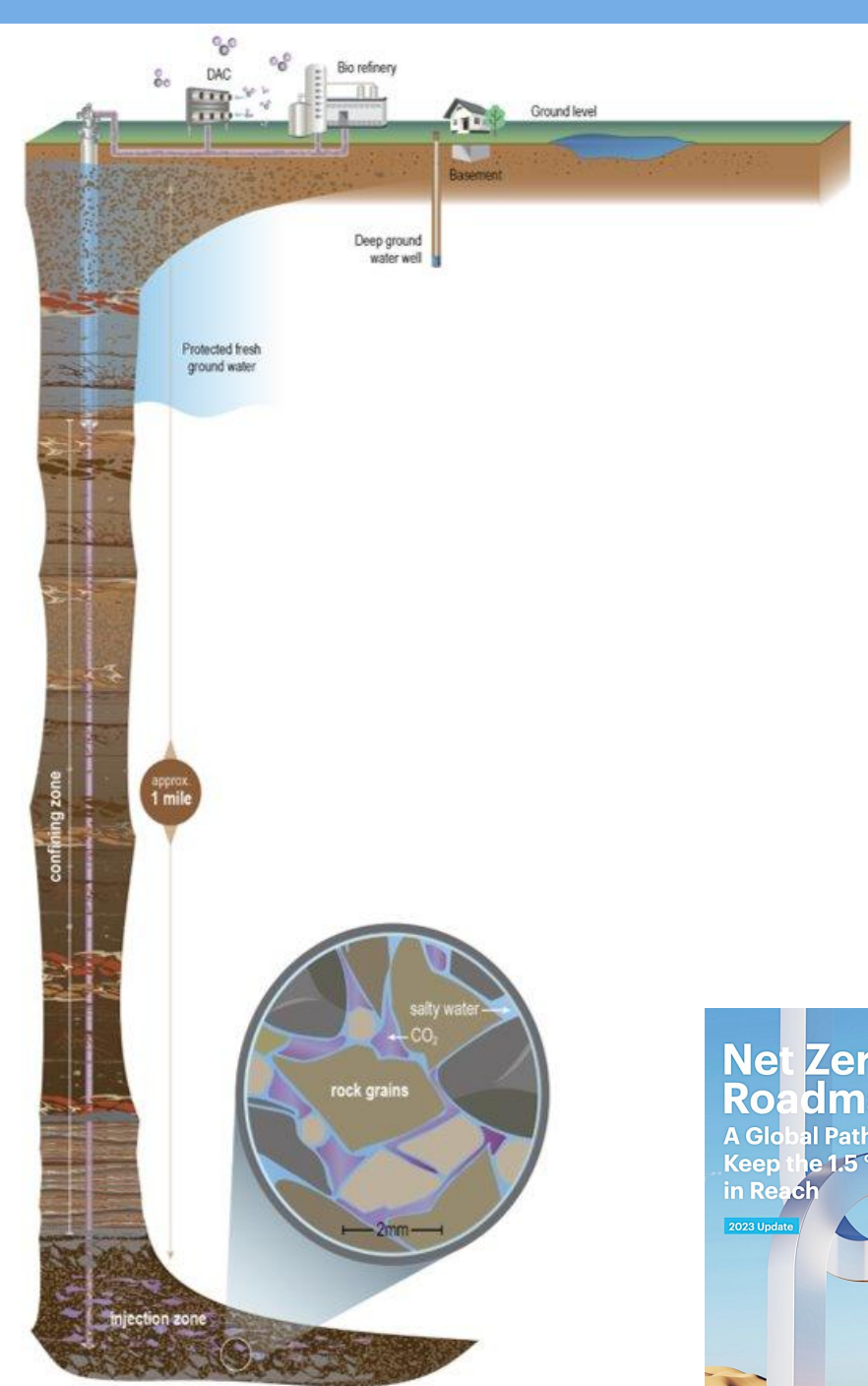
iea

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□ Current projects, globally, have capacity to store ~40 million tonnes CO₂



Net Zero Roadmap
A Global Pathway to Keep the 1.5°C Goal in Reach

2023 Update

ica

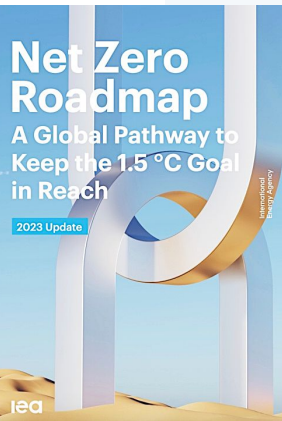
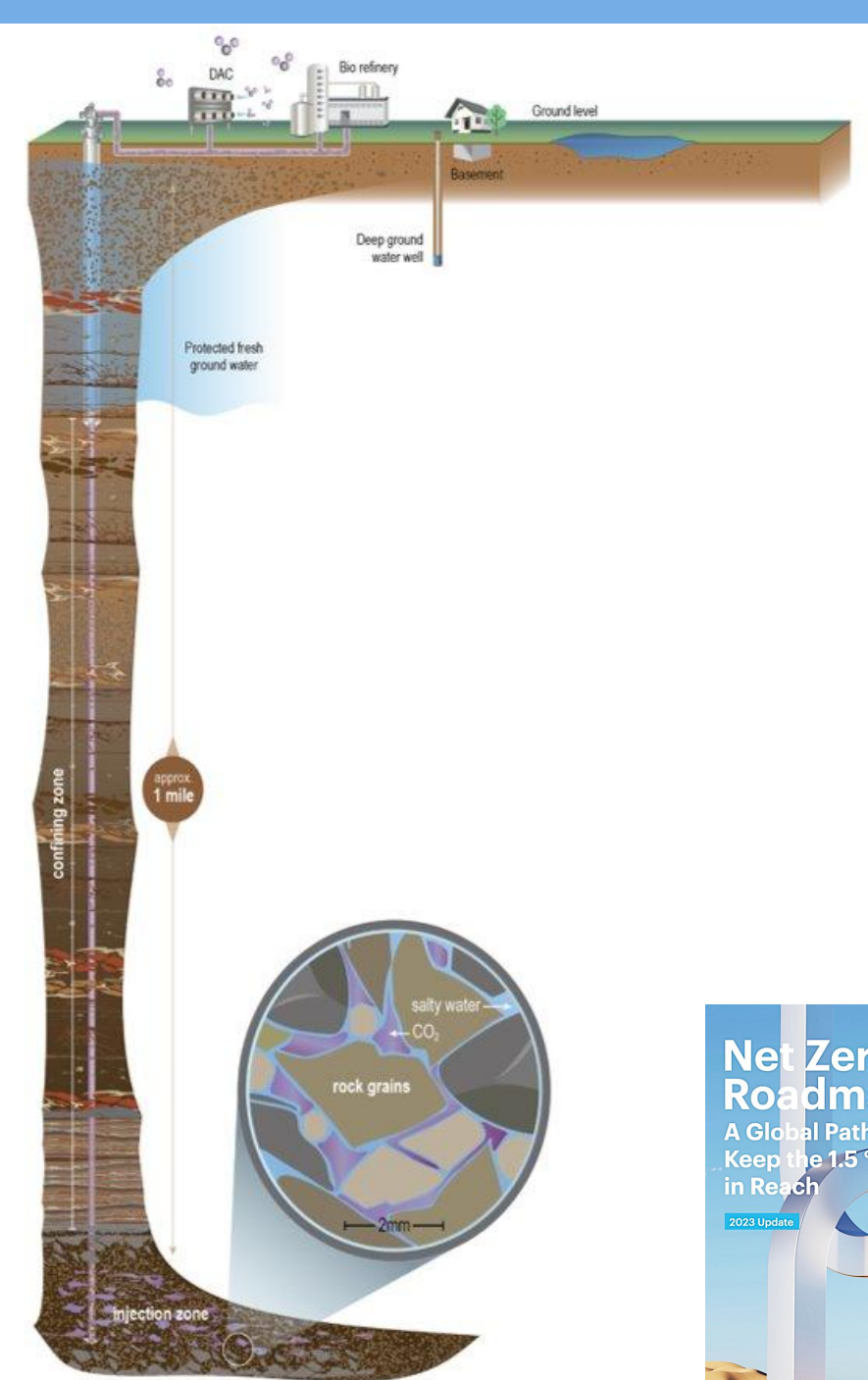
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□ Current projects, globally, have capacity to store ~40 million tonnes CO₂

□ We need 100 billion tonnes CO₂ by 2060 to reach 2 °C



Carbon Capture and Storage (CCS) is different than CO₂ Removal (CDR)

- **CCS = capturing CO₂ before
it can go into the air**

CARBON CAPTURE



"SCRUBS" CO₂ FROM A
POINT SOURCE LIKE
A POWER PLANT

Carbon Capture and Storage (CCS) is different than CO₂ Removal (CDR)

- **CCS = capturing CO₂ before it can go into the air**
- **CDR = taking CO₂ out of air**

CARBON REMOVAL



"SUCKS" EXISTING CO₂
FROM AIR RATHER THAN
PREVENTING AT THE SOURCE

CARBON CAPTURE



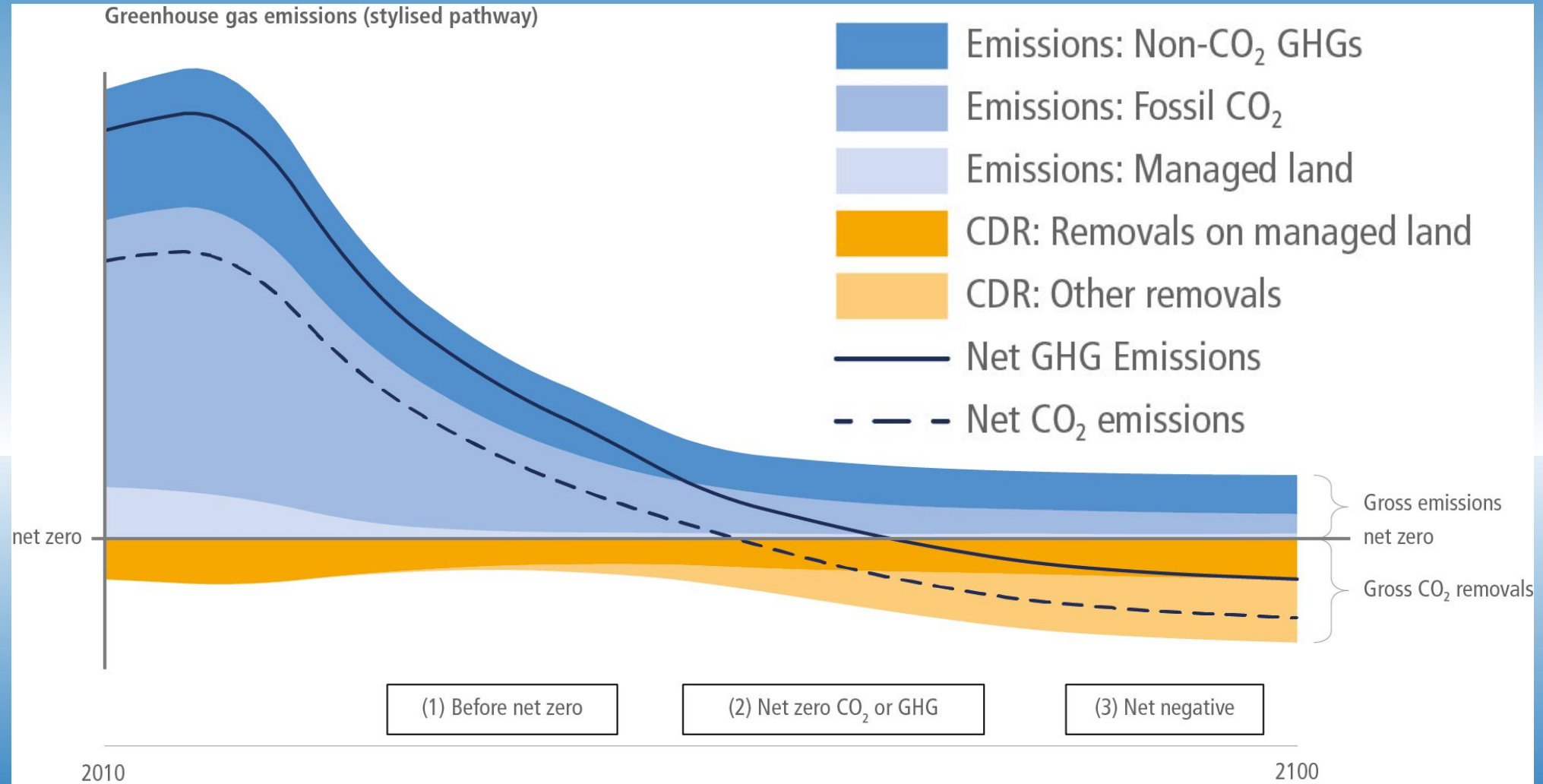
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Let's Say We Succeed.

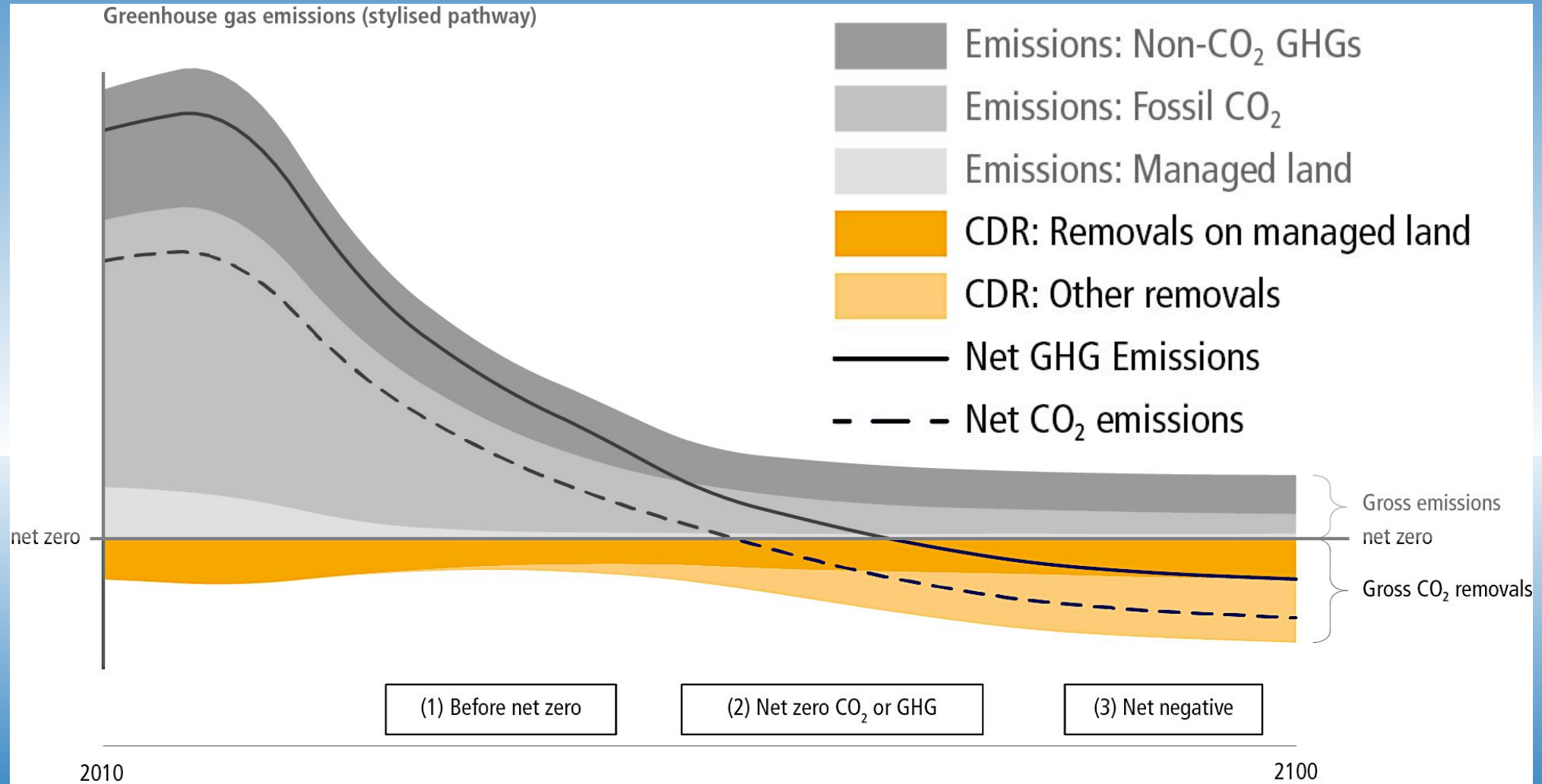
Let's Say We Succeed.

All Countries, Including US,
Must Reach 'Net Zero'

'Net Zero' implies some amount of carbon removal

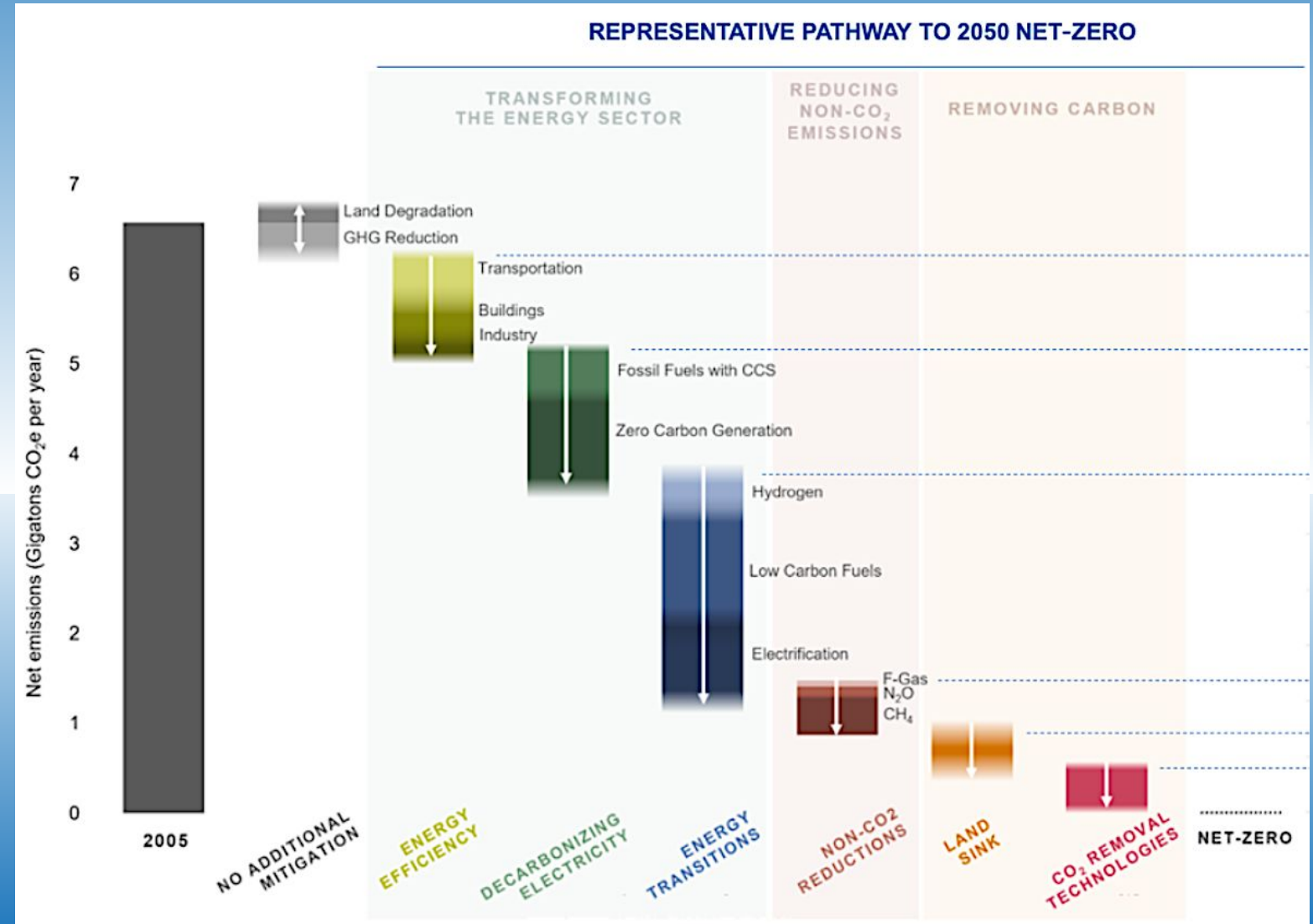


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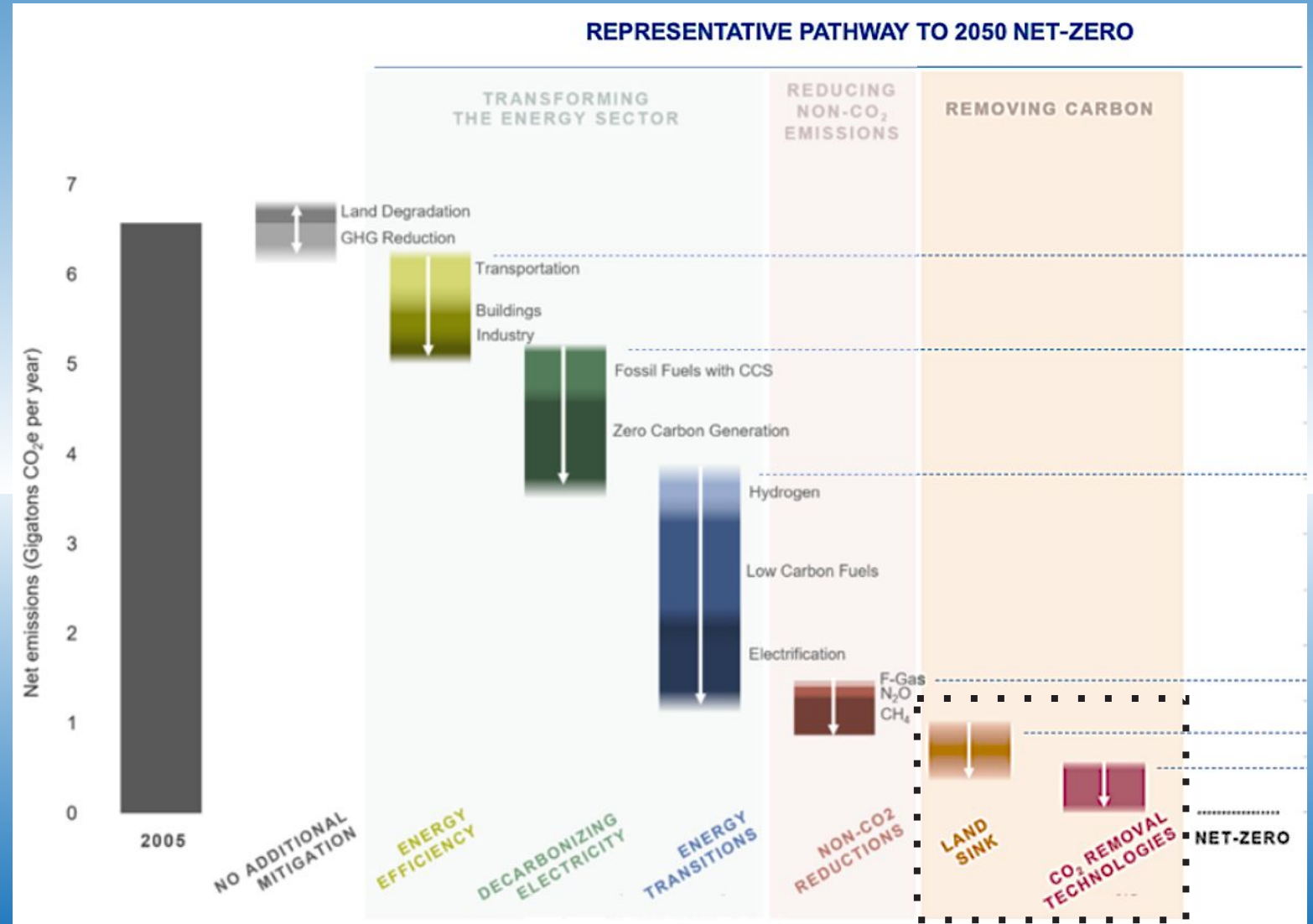


Nationally, what do we need to do to reach 'net zero?'

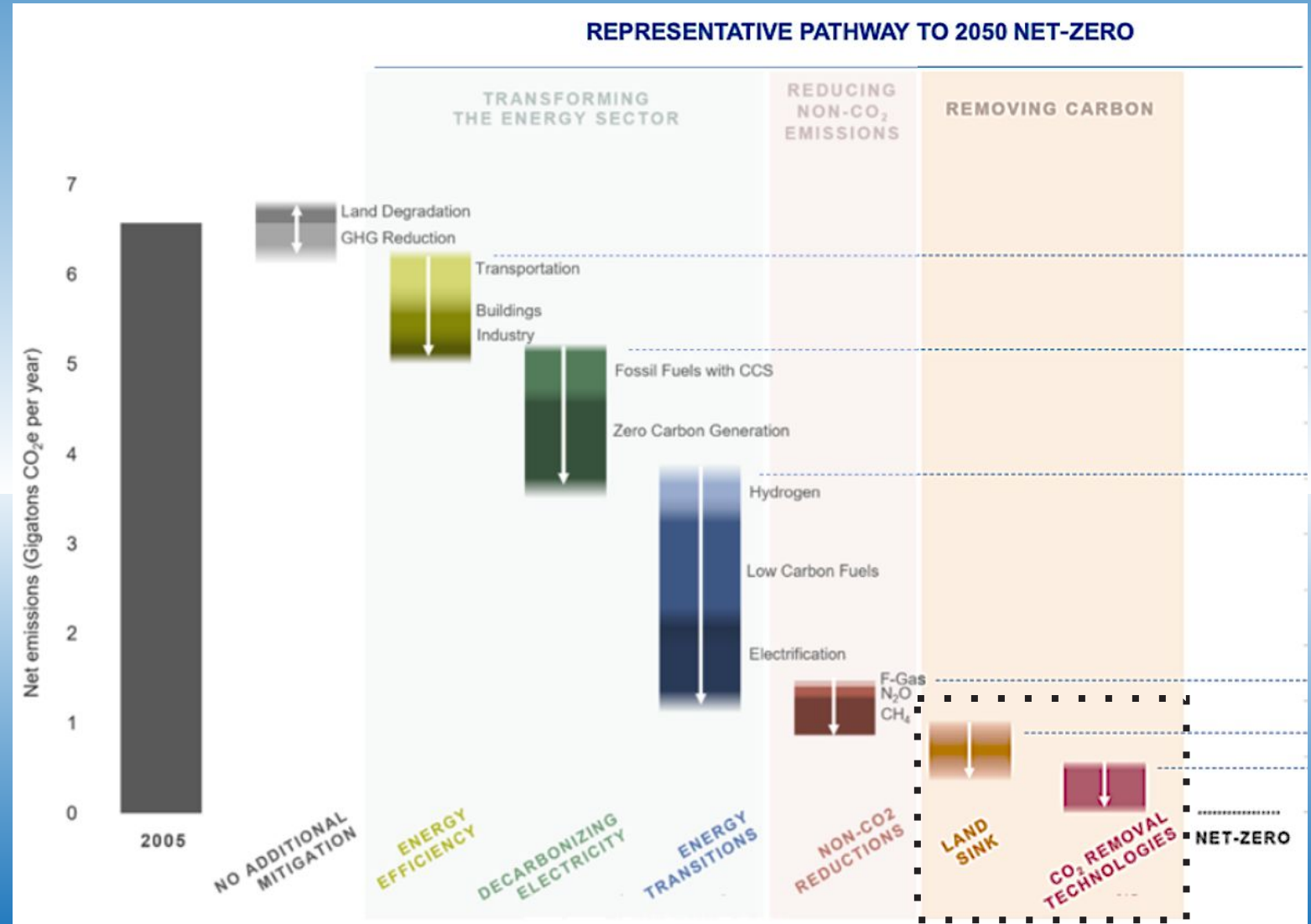
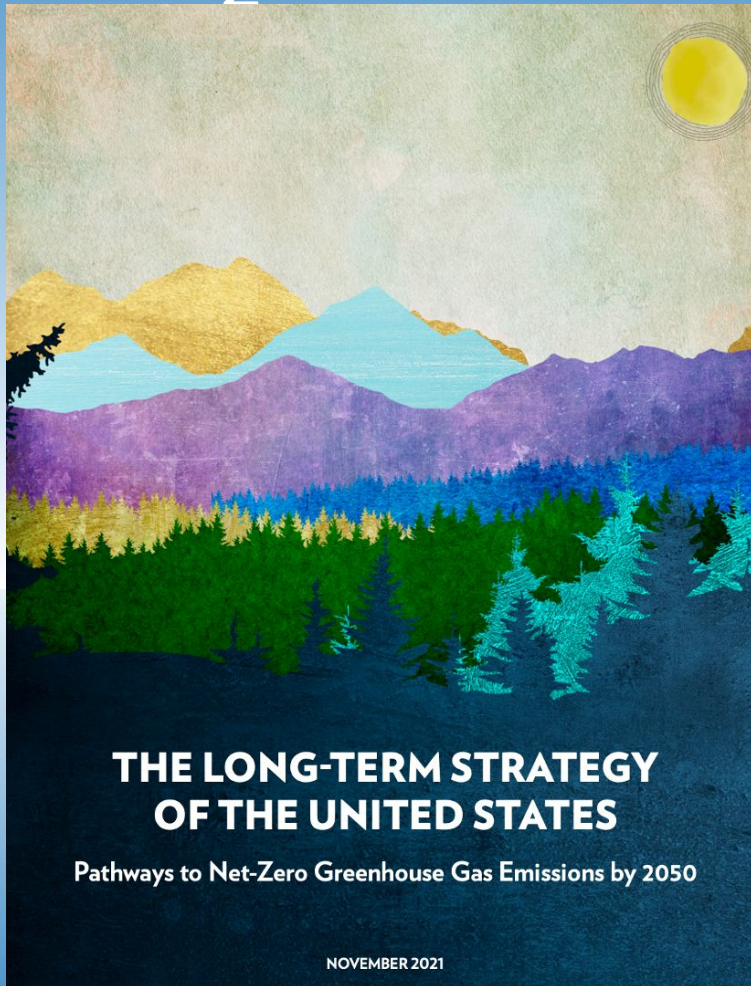
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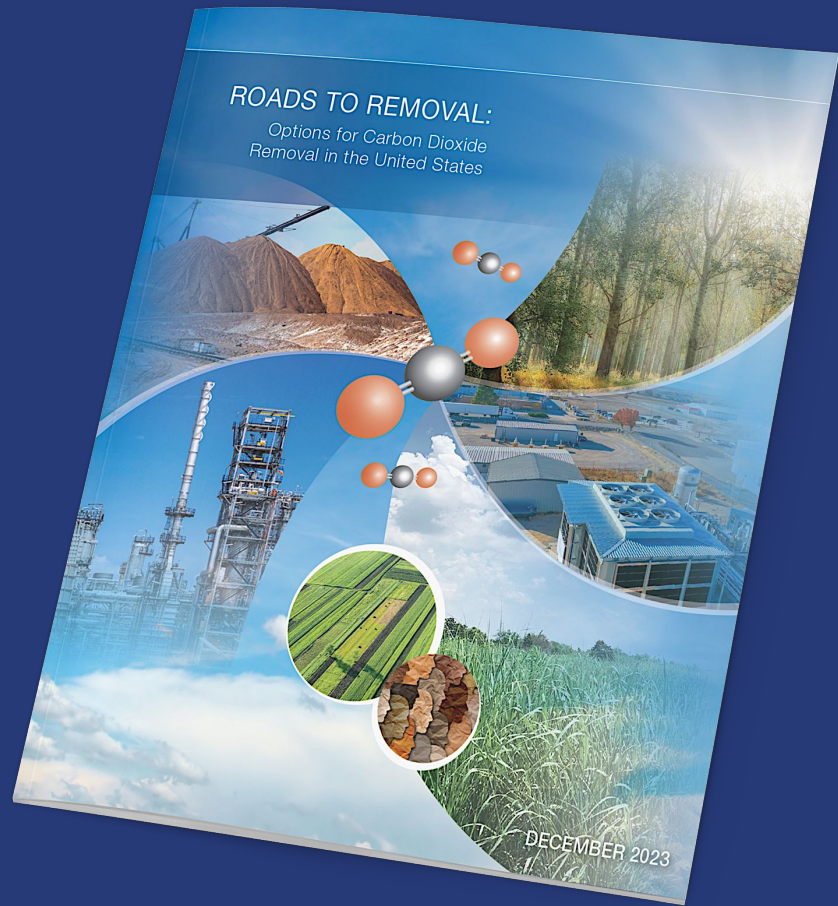
CO₂ Removal (CDR) Needed for Final 10 – 20%



The US Needs to Remove ~1 Billion Tonnes of CO₂



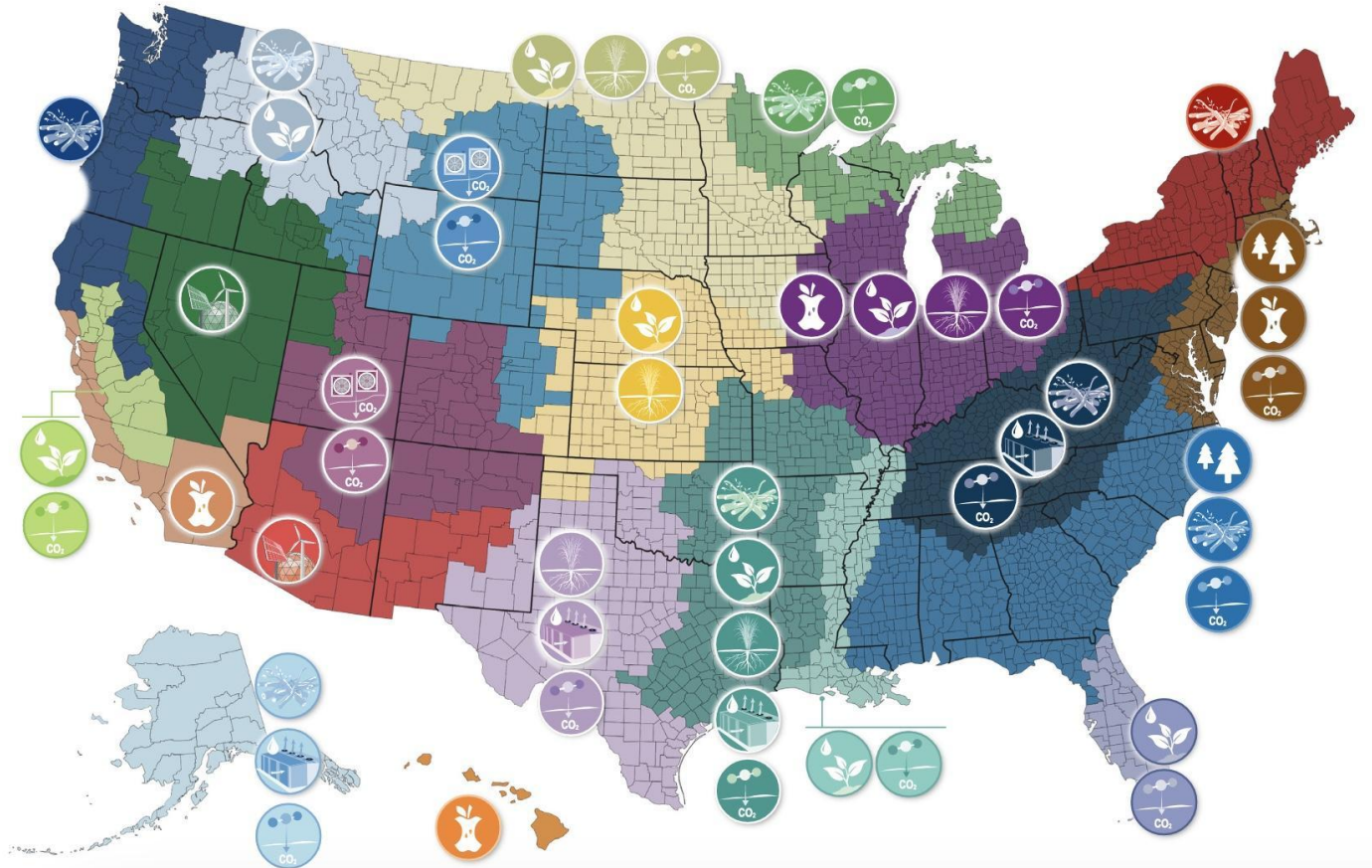
Can We Remove 1 Billion Tonnes?



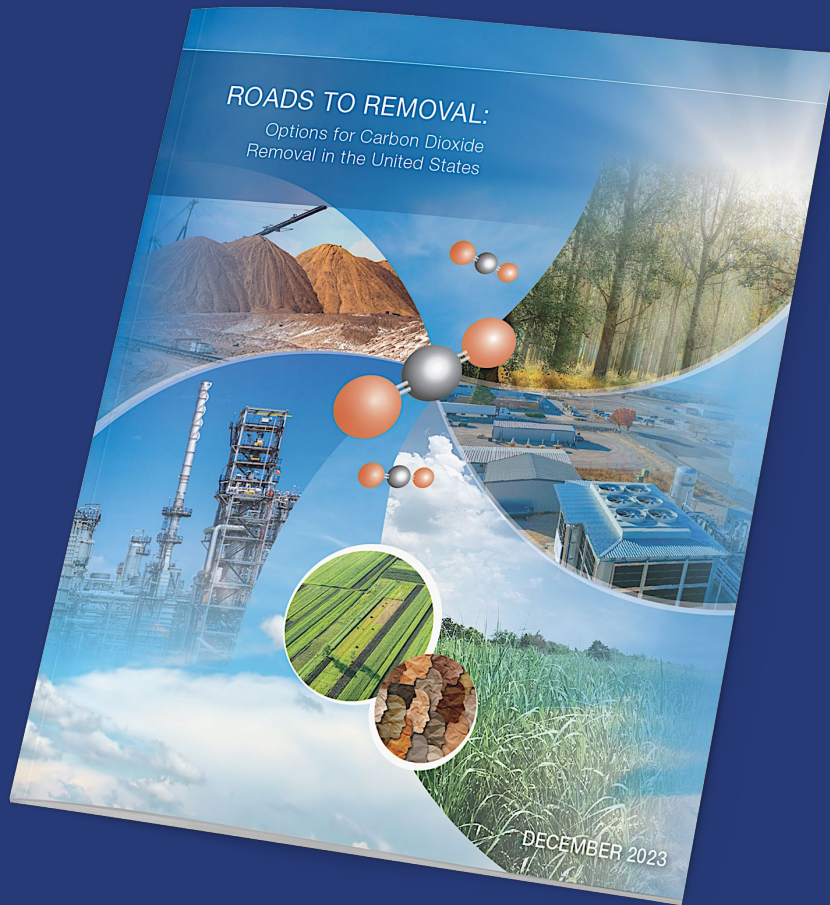
Yes, We Can.



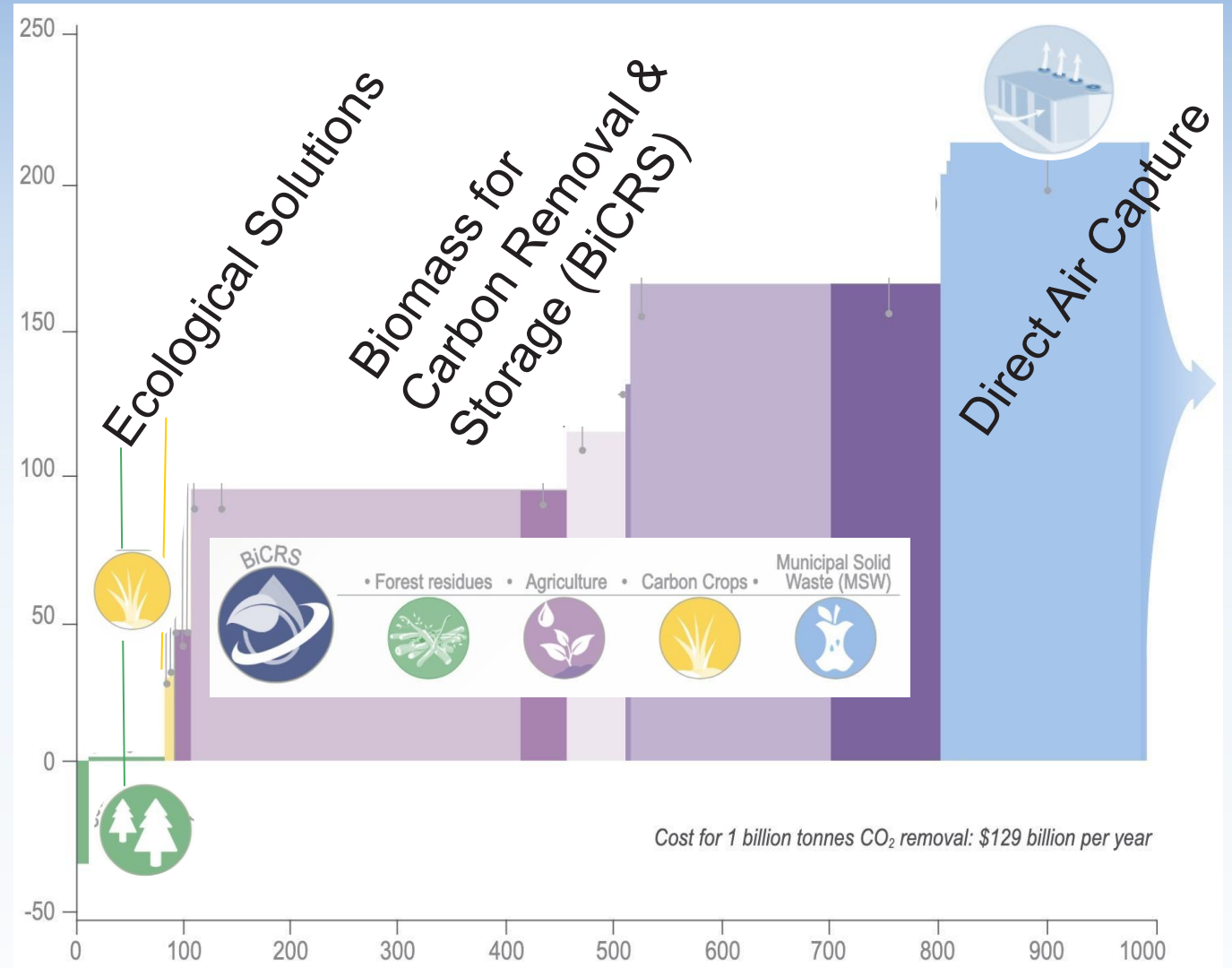
-  Forest Management
-  Forest Biomass
-  Municipal Solid Waste
-  Agricultural Residues
-  Cropland Soils
-  Solvent DACS
-  Adsorbent DACS
-  Geologic Storage
-  Renewable Energy



Yes, We Can.

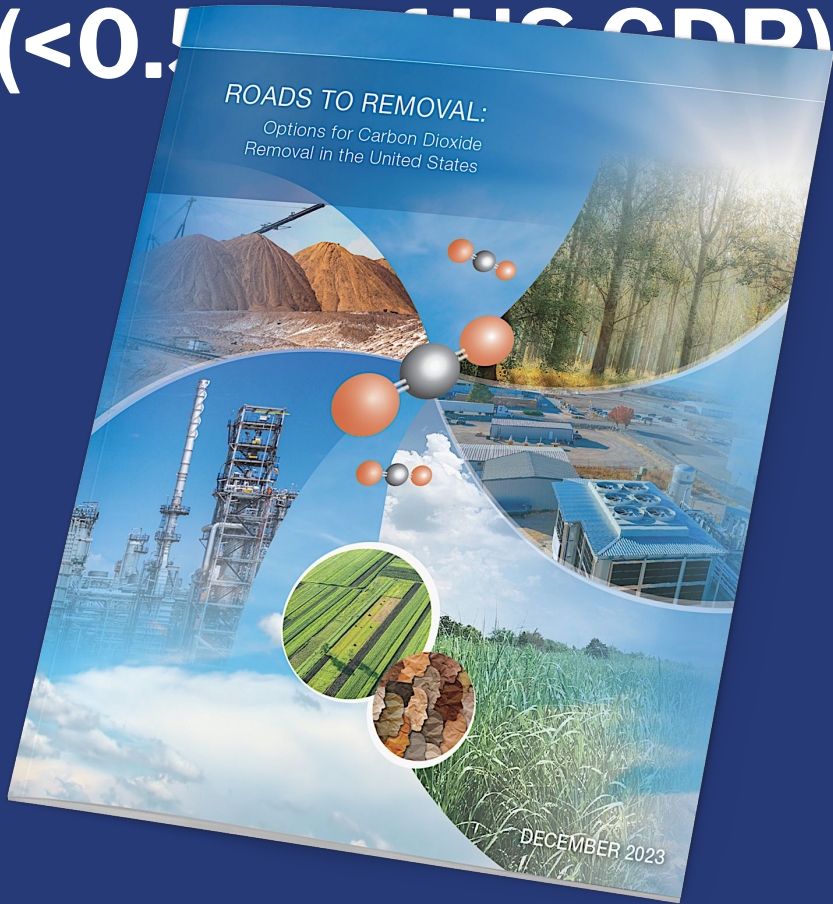


Cost (\$ / tonne)

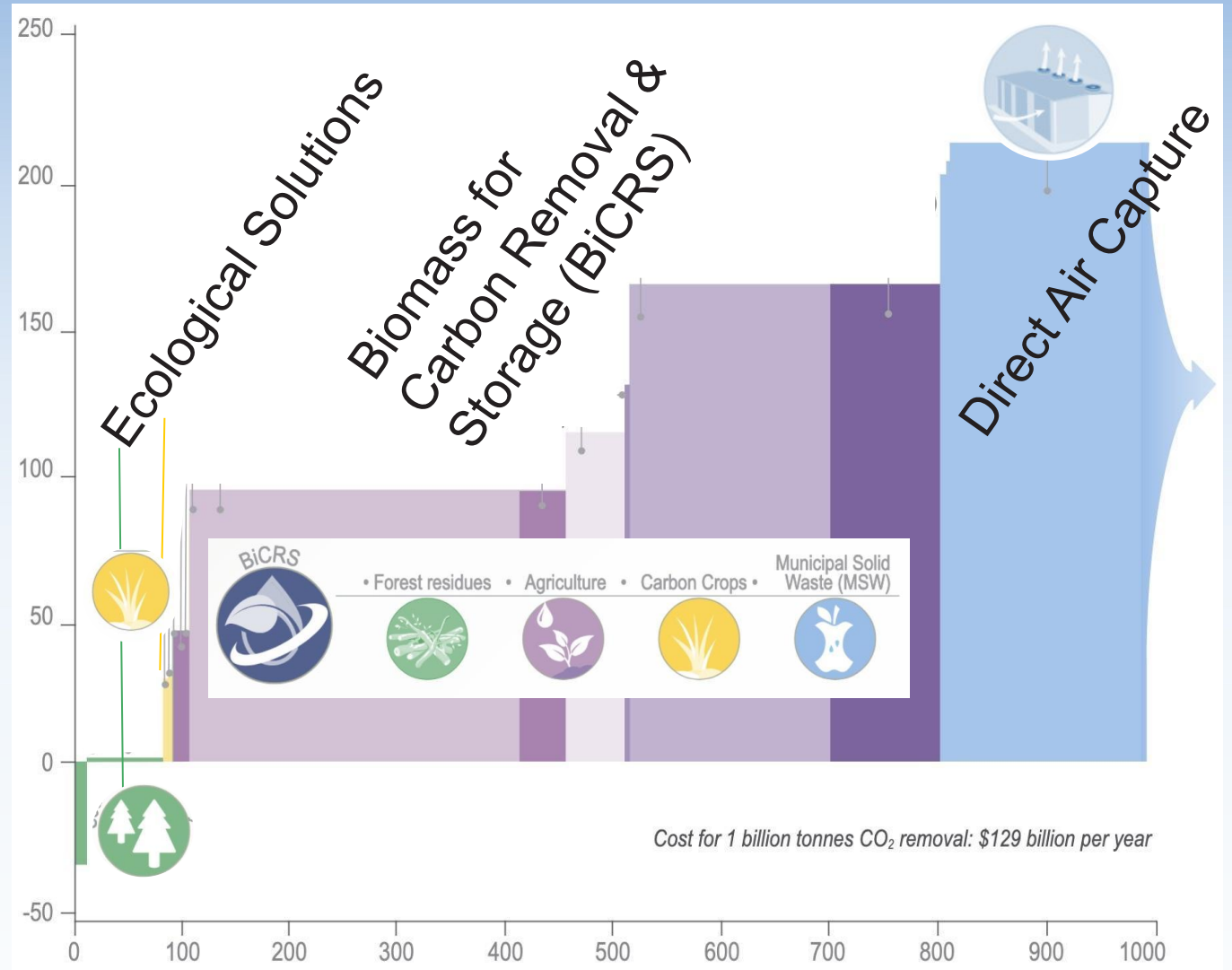


Million tonnes CO₂ per Year

~\$130
Billion/year
(<0.5% of US GDP)

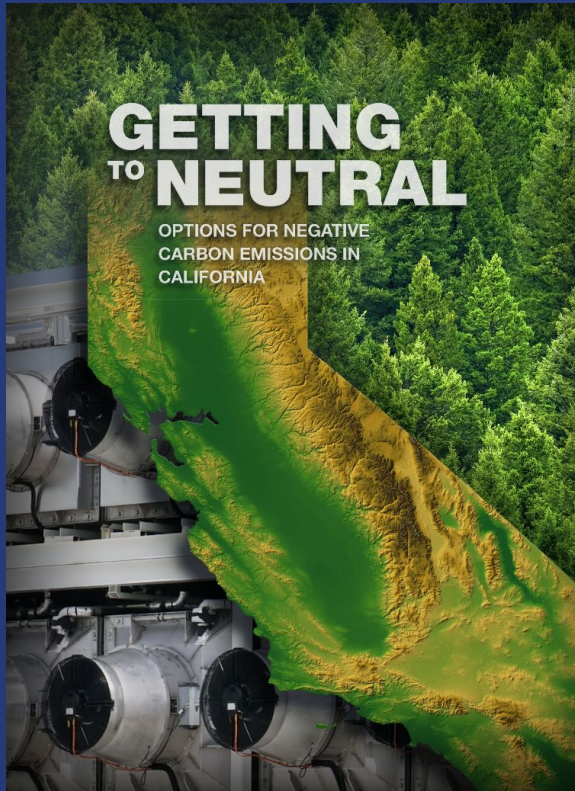


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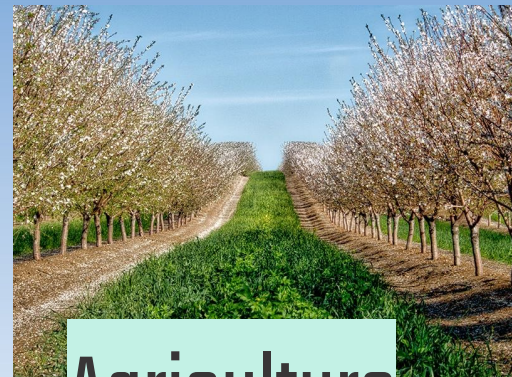
California targeted 125 MT/year of CDR



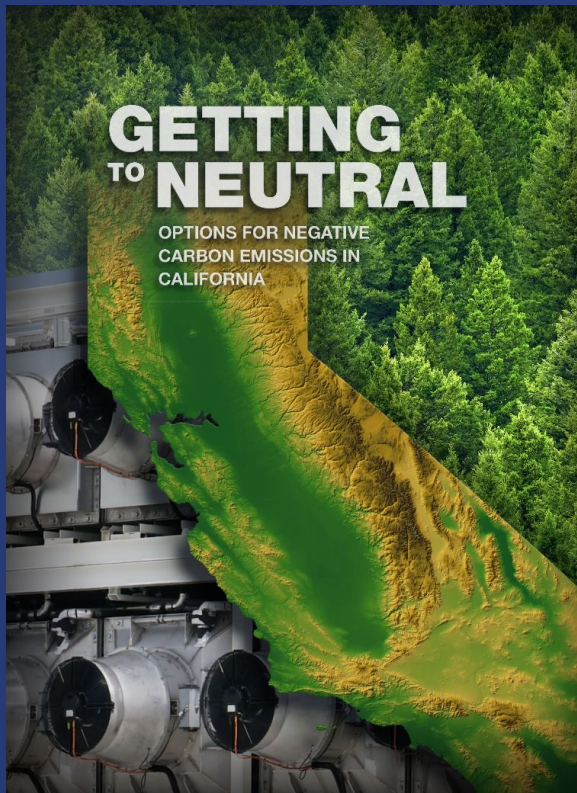
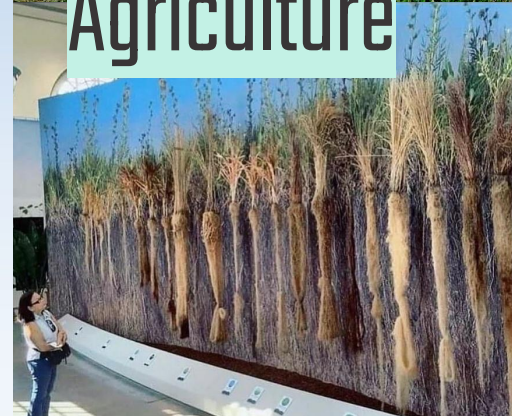
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Forests



Agriculture



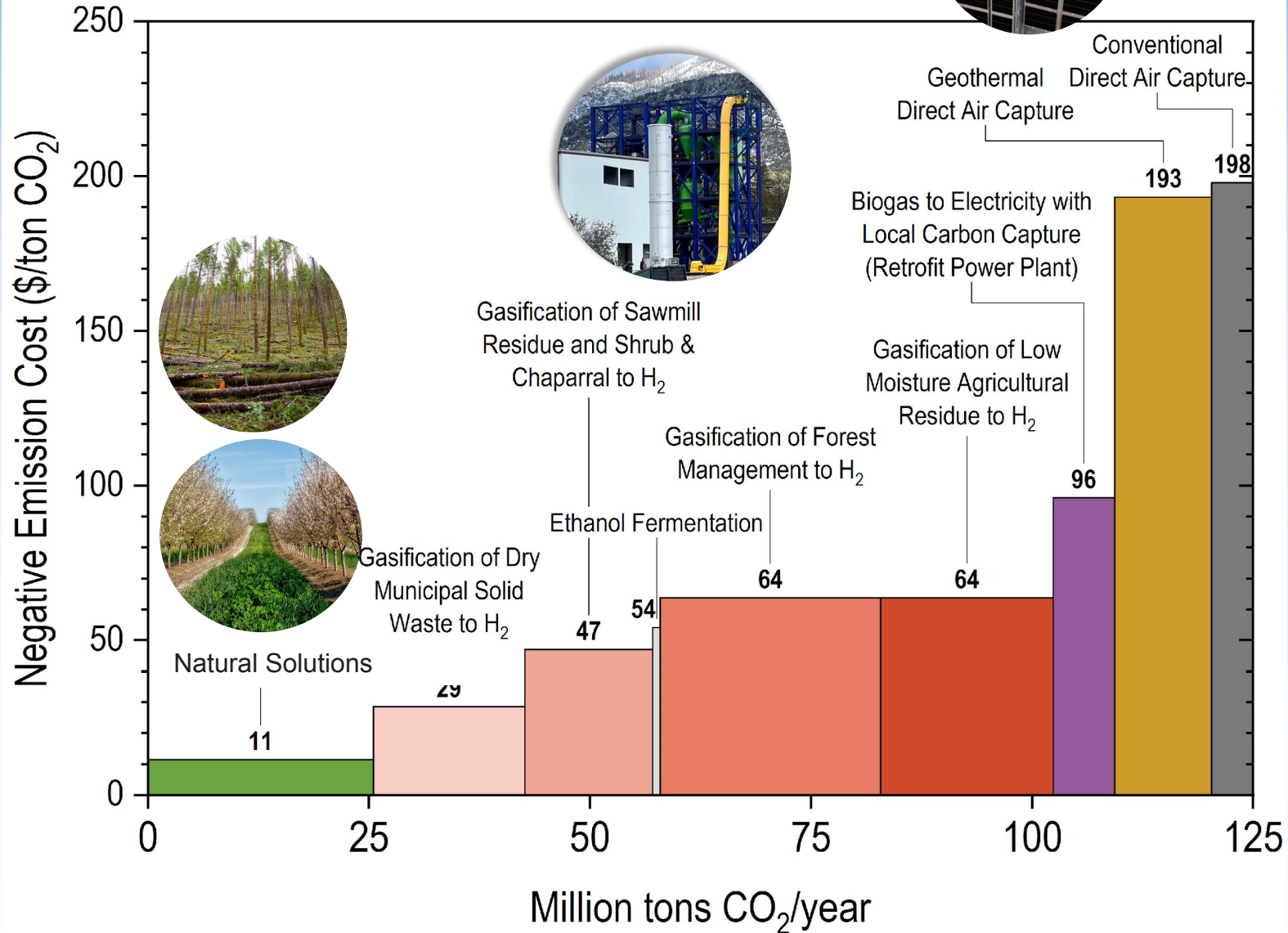
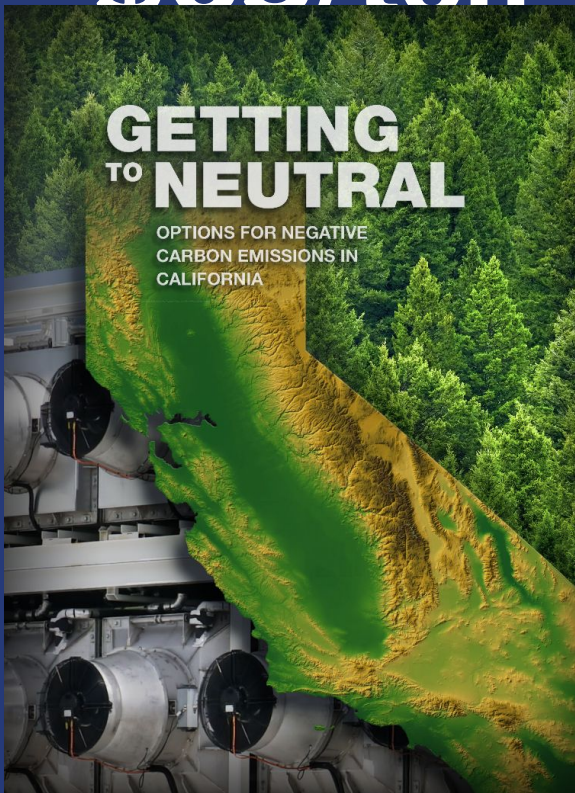
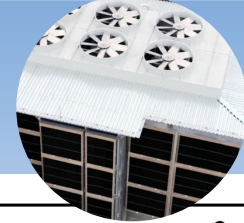
Biomass



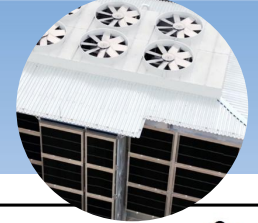
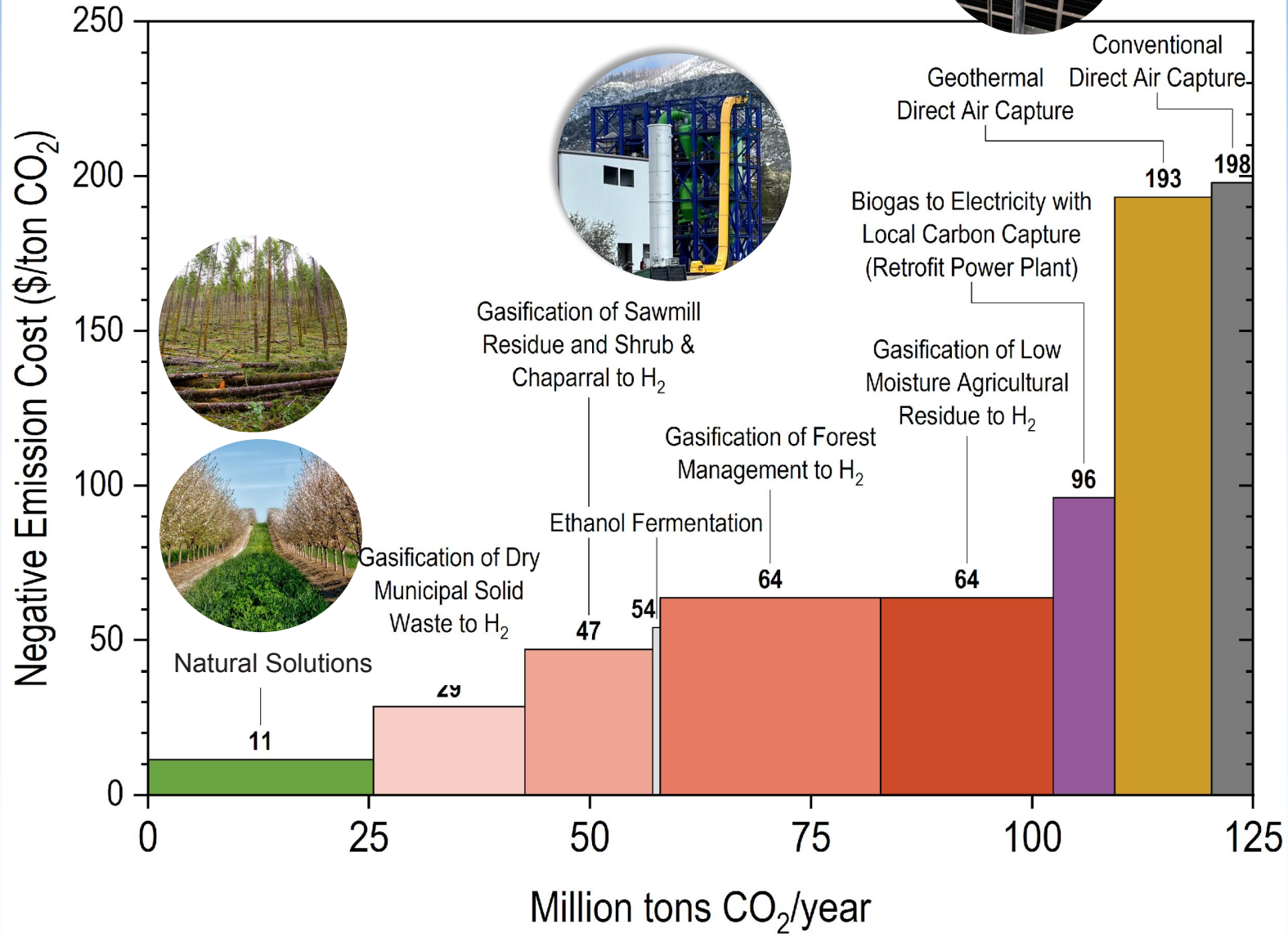
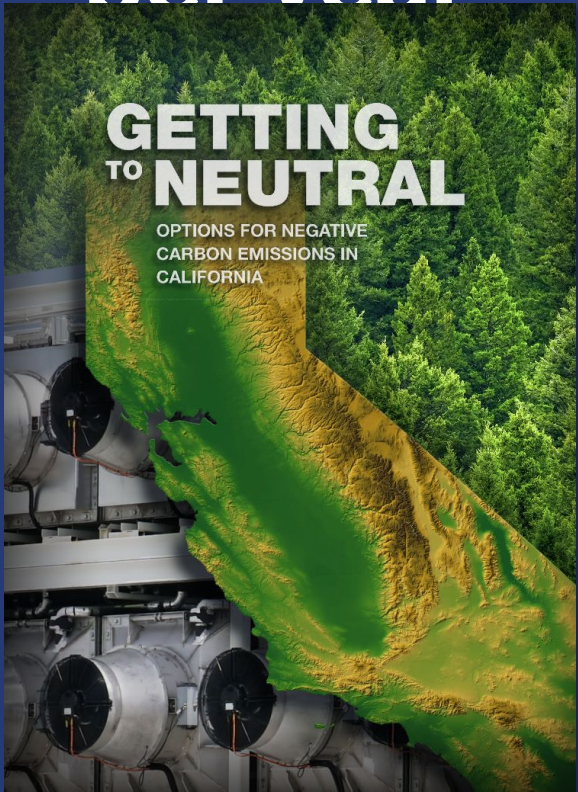
Direct Air
Capture



California's most affordable path to 125 MT/year ~\$65/ton

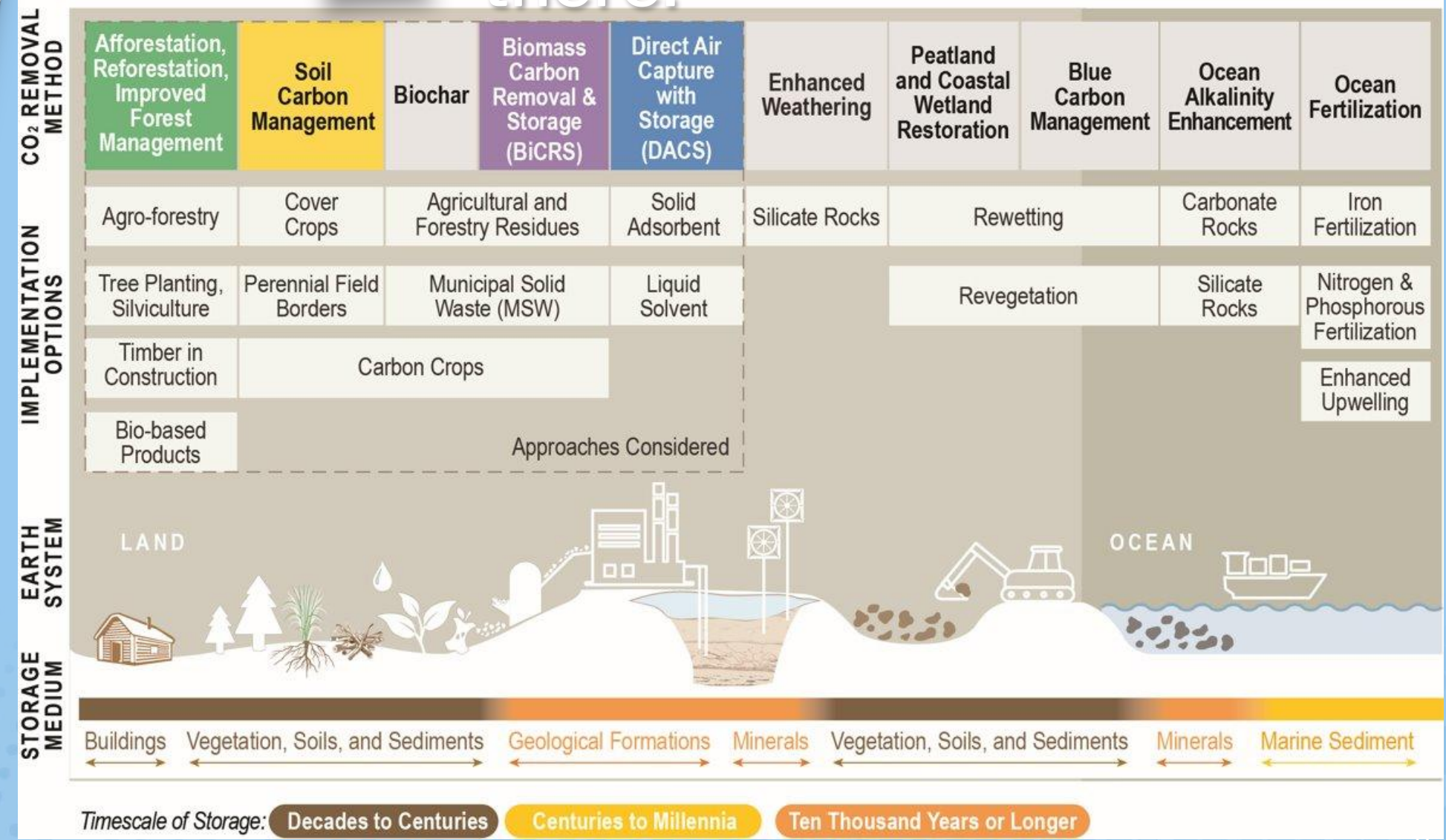


Less than \$10 billion
(0.4% of CA GDP)
per year

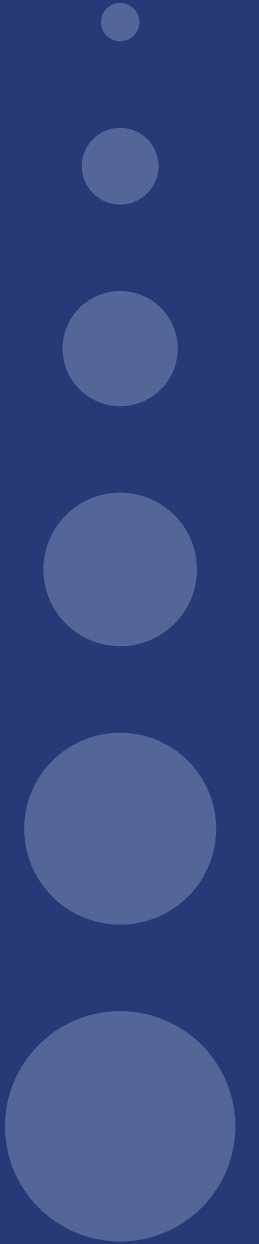




Plenty other options out there!



In Summary...



State of the Science:

- We need to decarbonize now,
- We also need to start removing CO_2
- California can accomplish
 - 20% of CDR needs with ecological CDR
 - 80% with geologic CO_2 storage

CARBON REMOVAL



"SUCKS" EXISTING CO_2
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PREVENTING AT THE SOURCE

Thank You

