Engineered Solutions to Carbon Dioxide Removal

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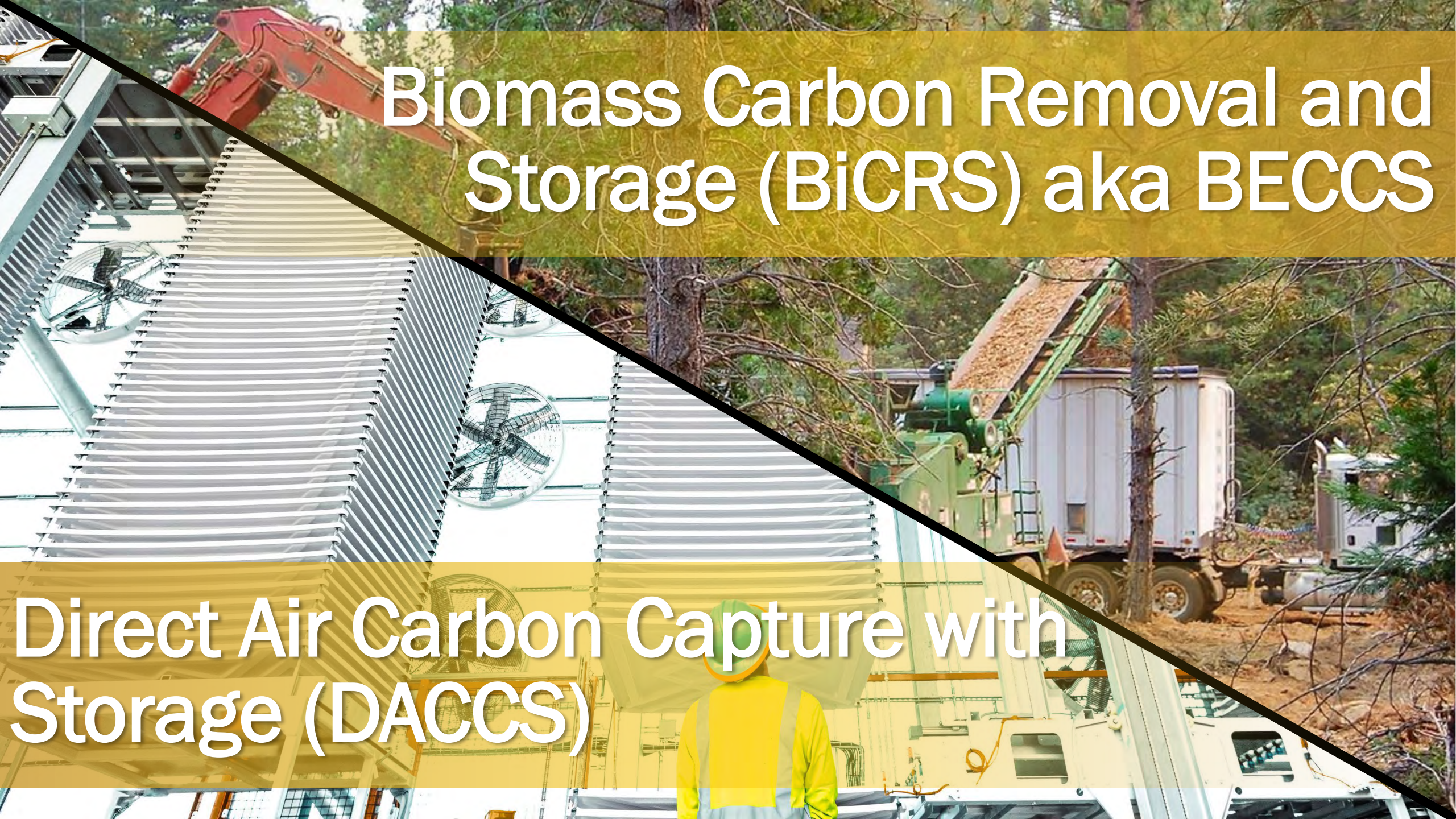
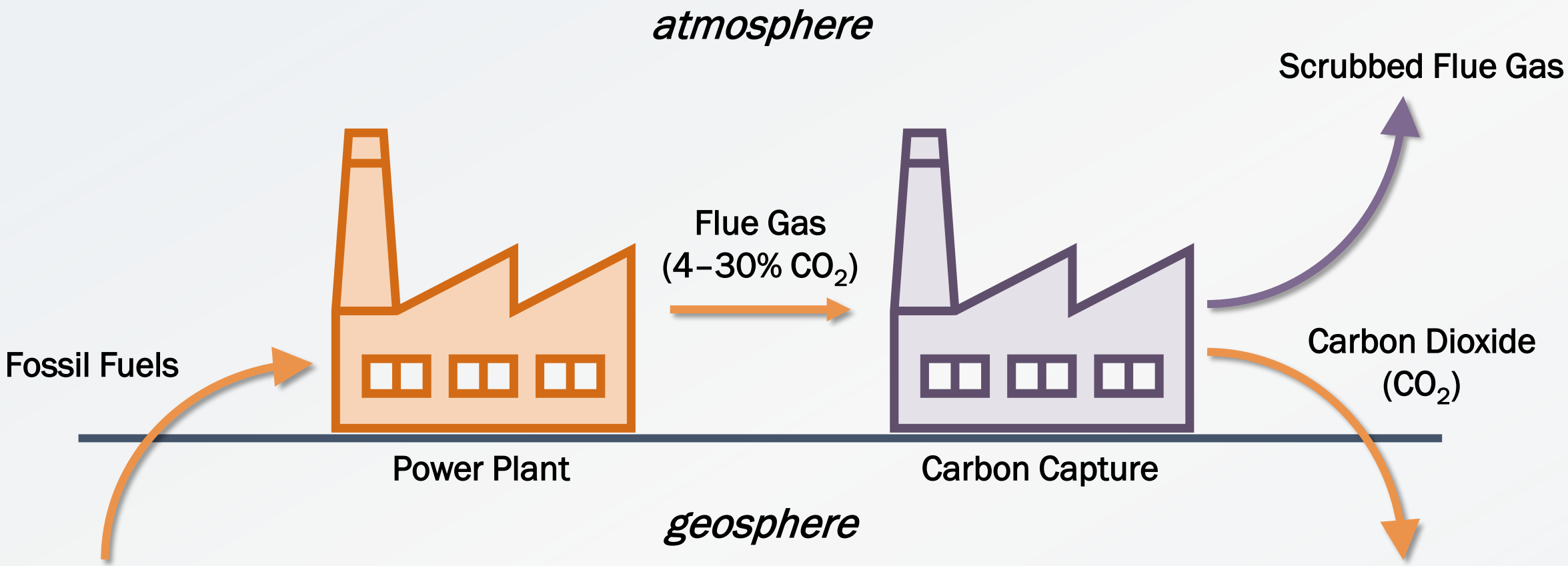
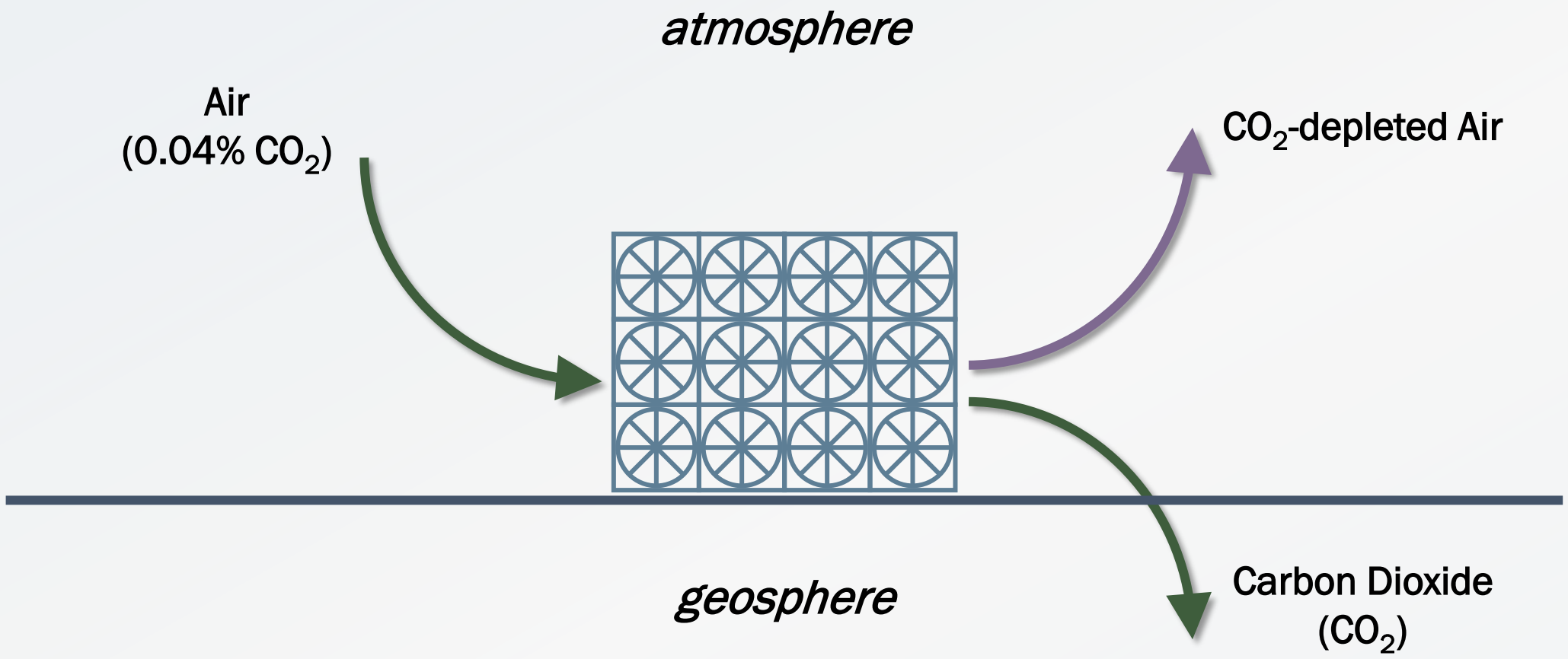

Biomass Carbon Removal and Storage (BiCRS) aka BECCS
Direct Air Carbon Capture with Storage (DACCS)

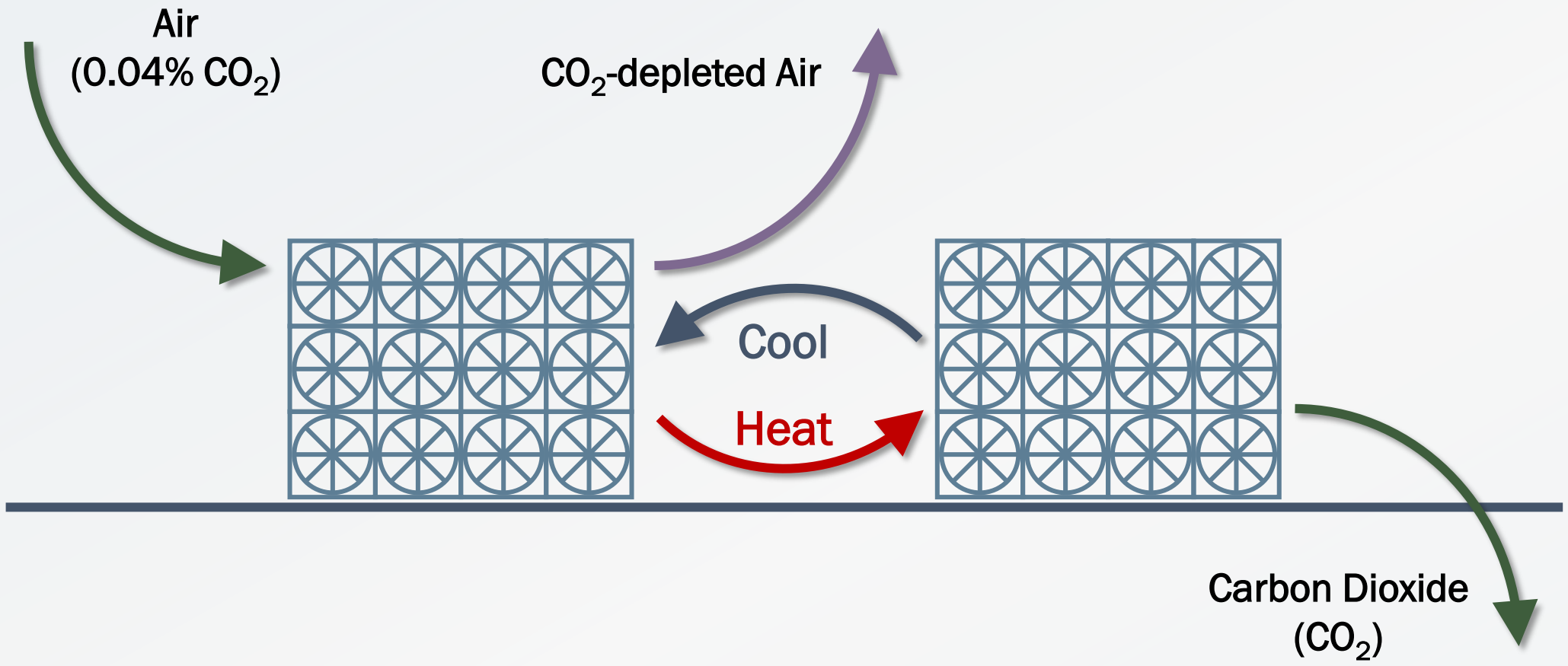
Carbon capture on fossil-based point sources results in reduction of greenhouse gas emissions, not carbon dioxide removal



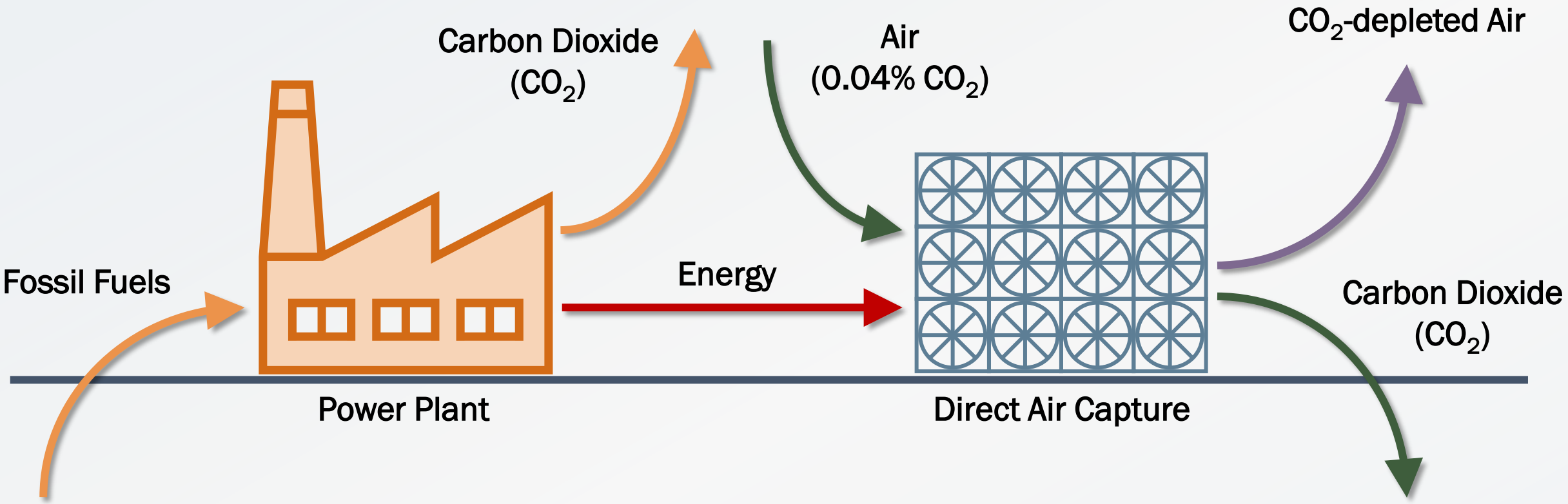
Direct air capture, with carbon sequestration, removes carbon from the atmosphere, potentially resulting in net carbon removal



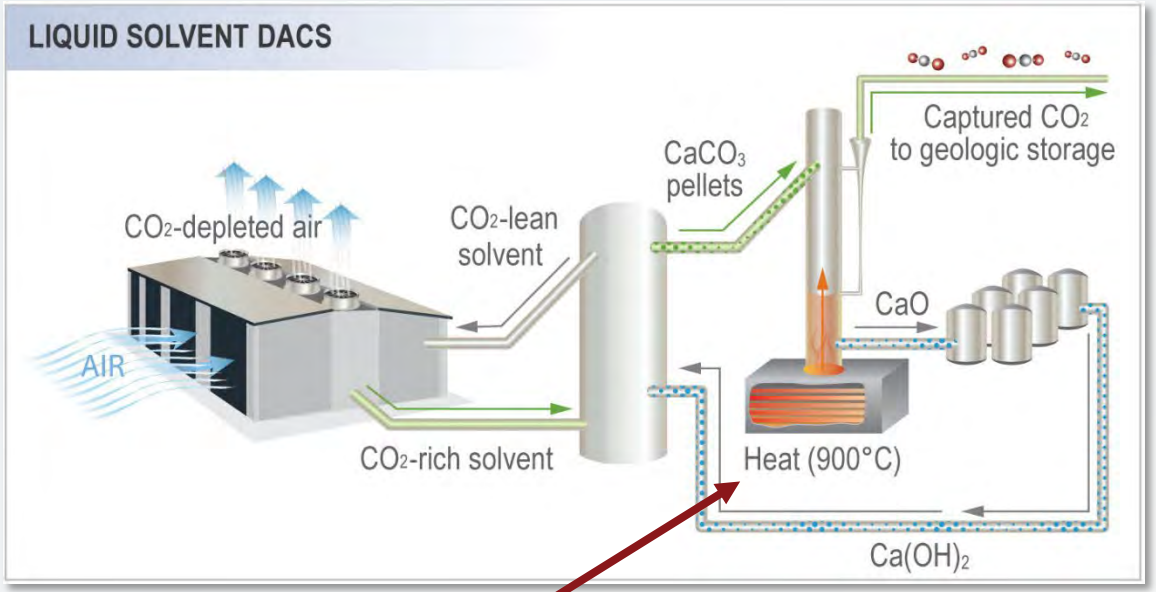
In a direct air capture system, the material used to absorb CO_2 from the atmosphere is regenerated so it can be reused



The energy source for DACCS can dictate the carbon dioxide removal potential — low-carbon energy sources are required

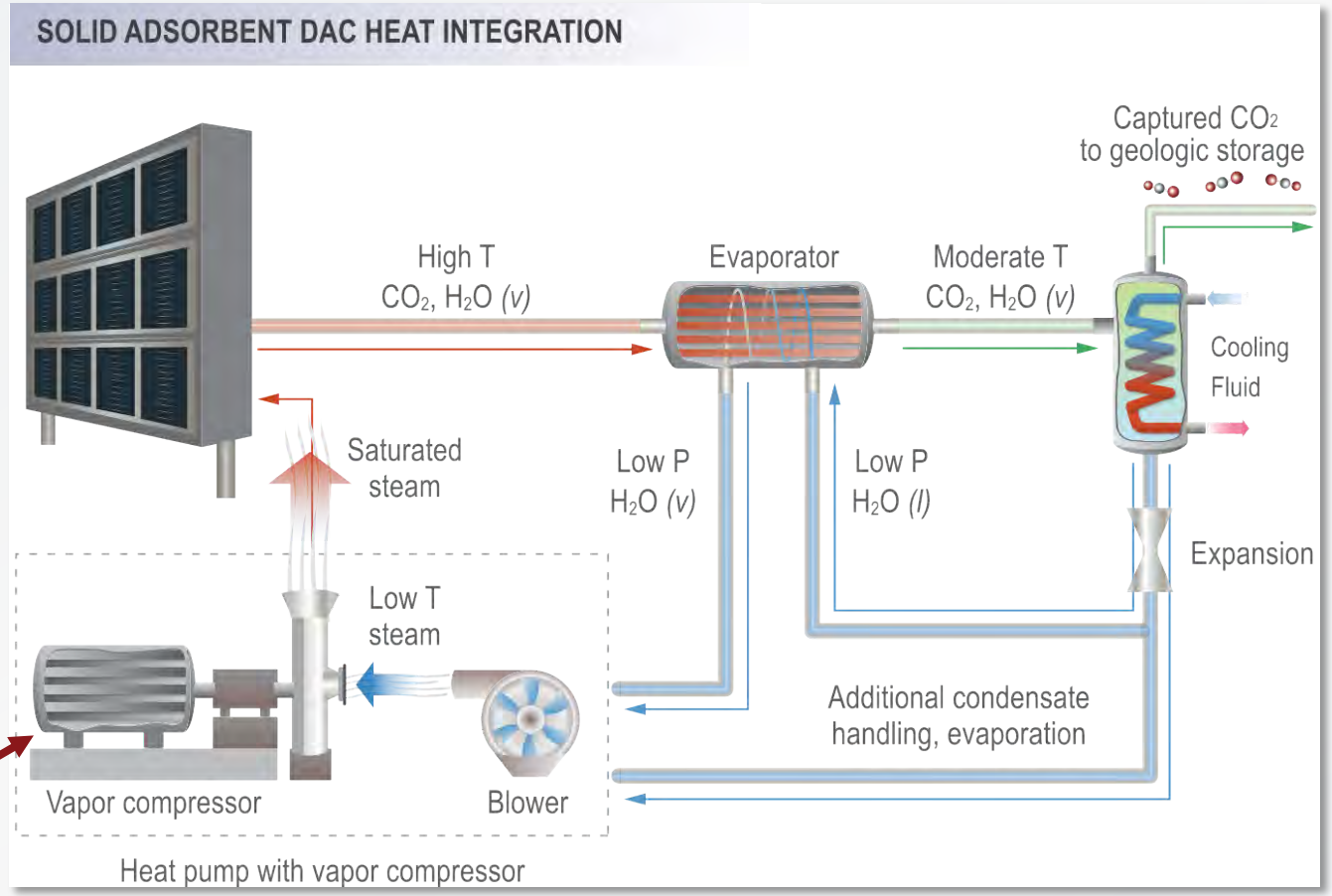


There are many types of DACCS processes, distinguished by the material used for capture and method of regeneration

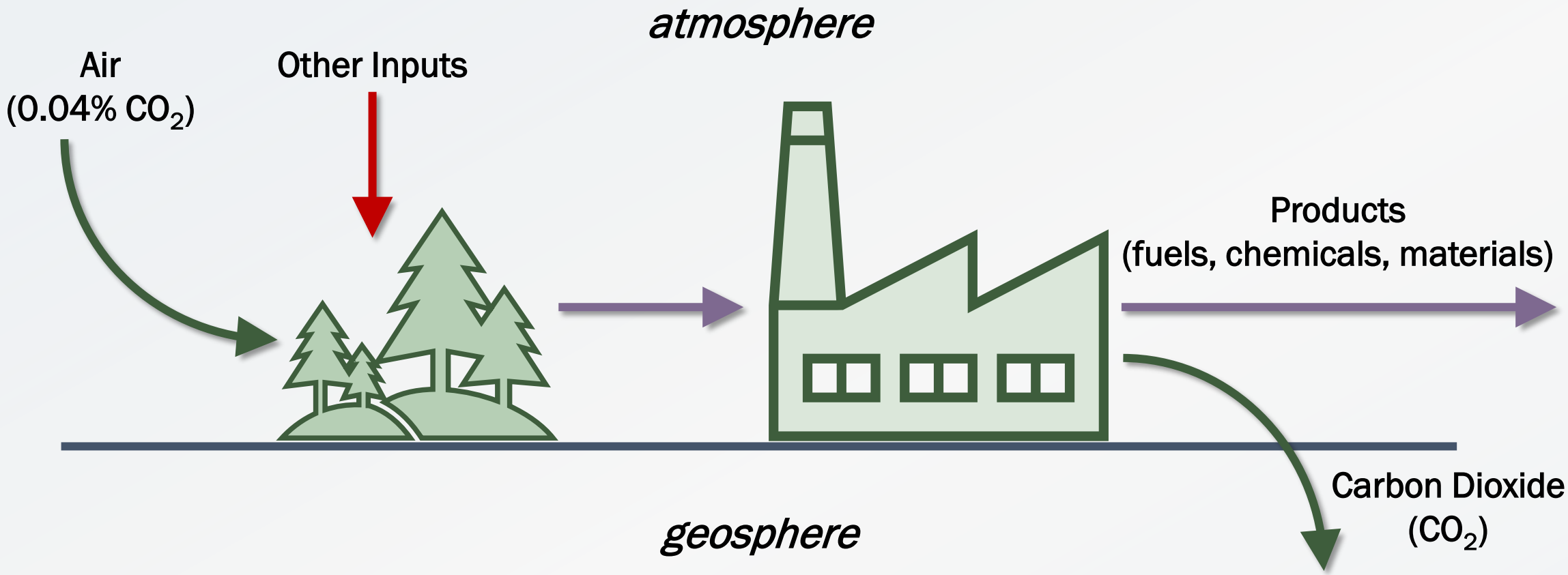


Natural gas combustion

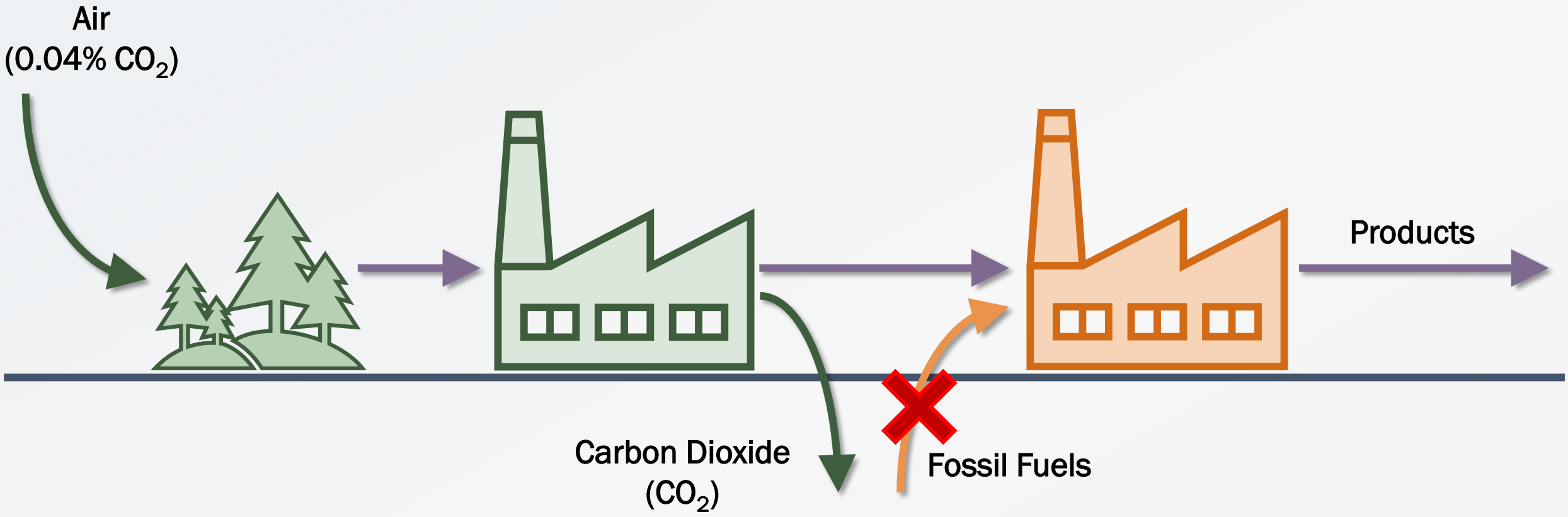
(Renewable) electricity



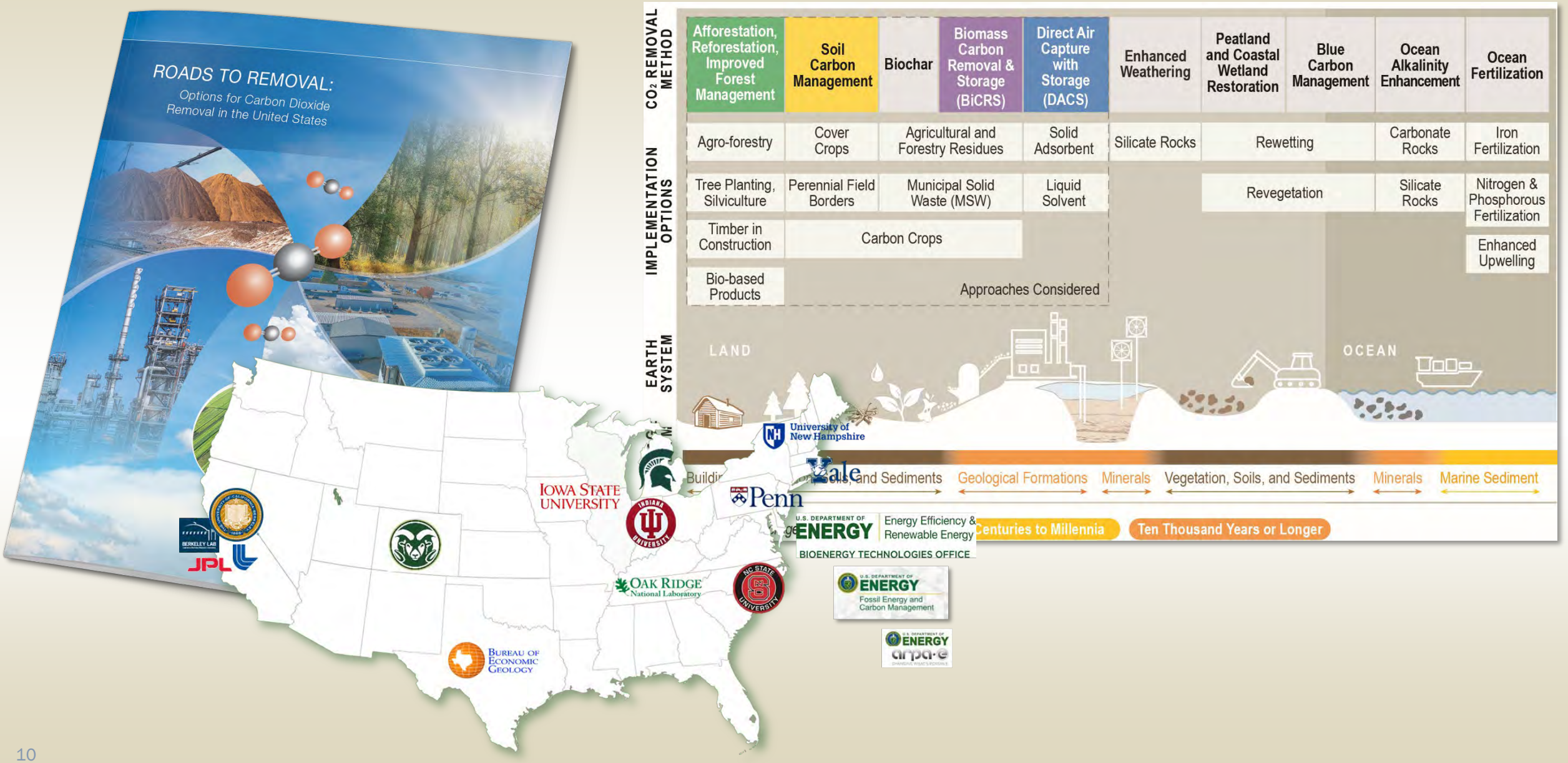
Performing carbon capture with biomass upgrading/conversion processes can result in net carbon removal, depending on inputs



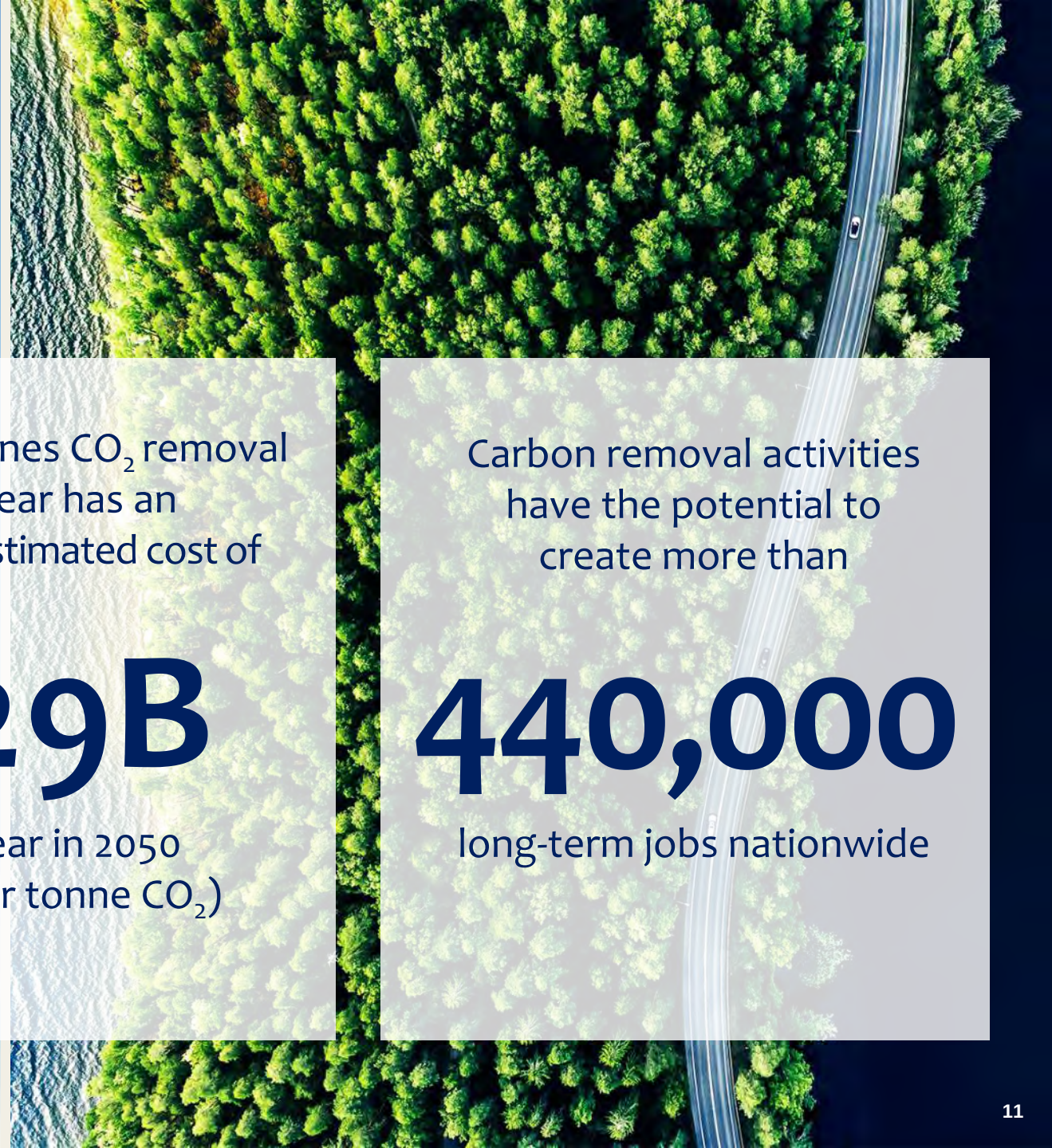
Displacing fossil-derived products counts as avoided emissions, not carbon dioxide removal, unless the product stores carbon durably



We examined options for carbon dioxide removal in the United States



Achieving US National Carbon Removal Goals is Possible



The United States can remove at least

1B

tonnes of CO_2 per year by 2050 using demonstrated technologies

1 billion tonnes CO_2 removal per year has an average estimated cost of

$129B

per year in 2050 ($129 per tonne CO_2)

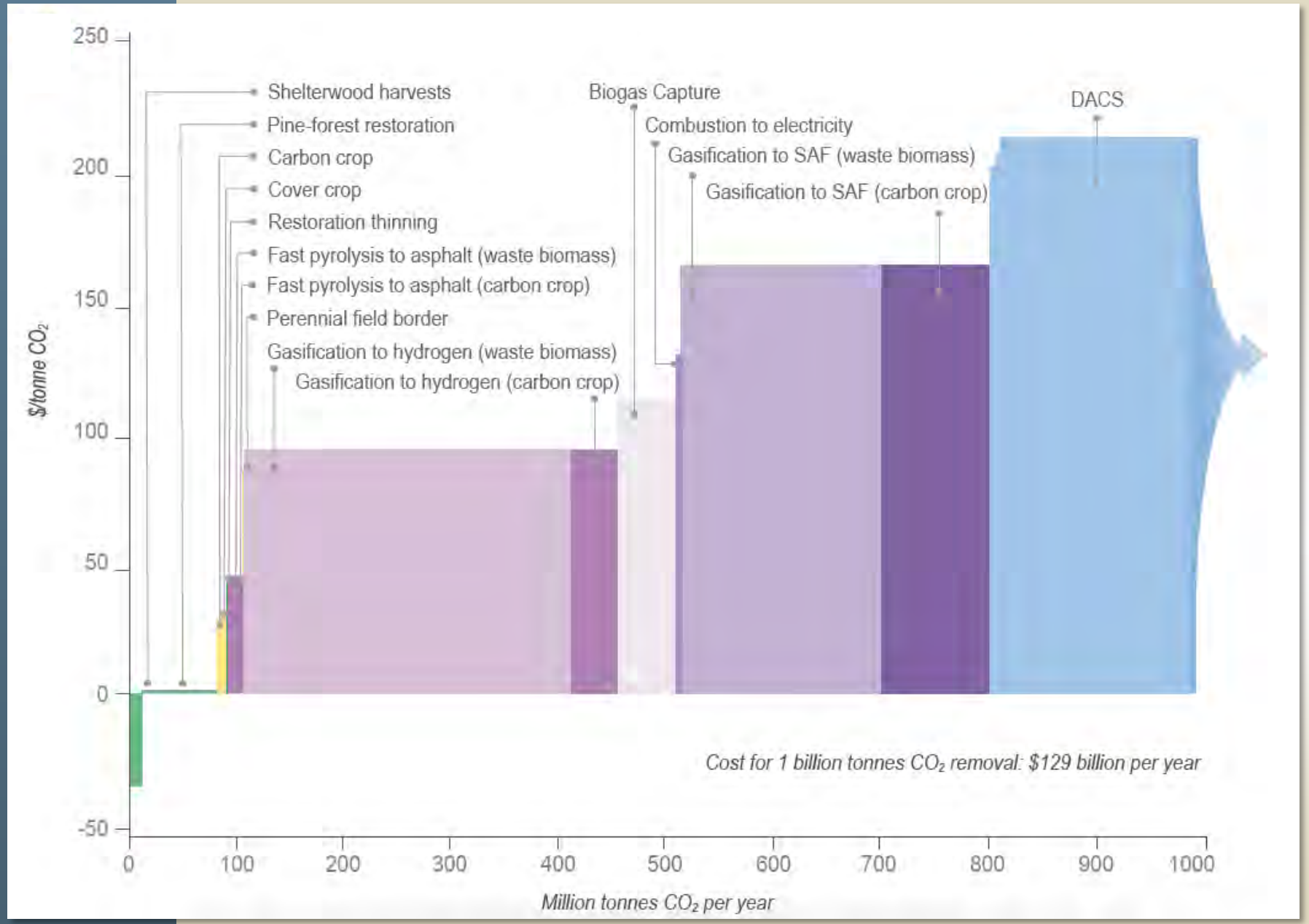
Carbon removal activities have the potential to create more than

440,000

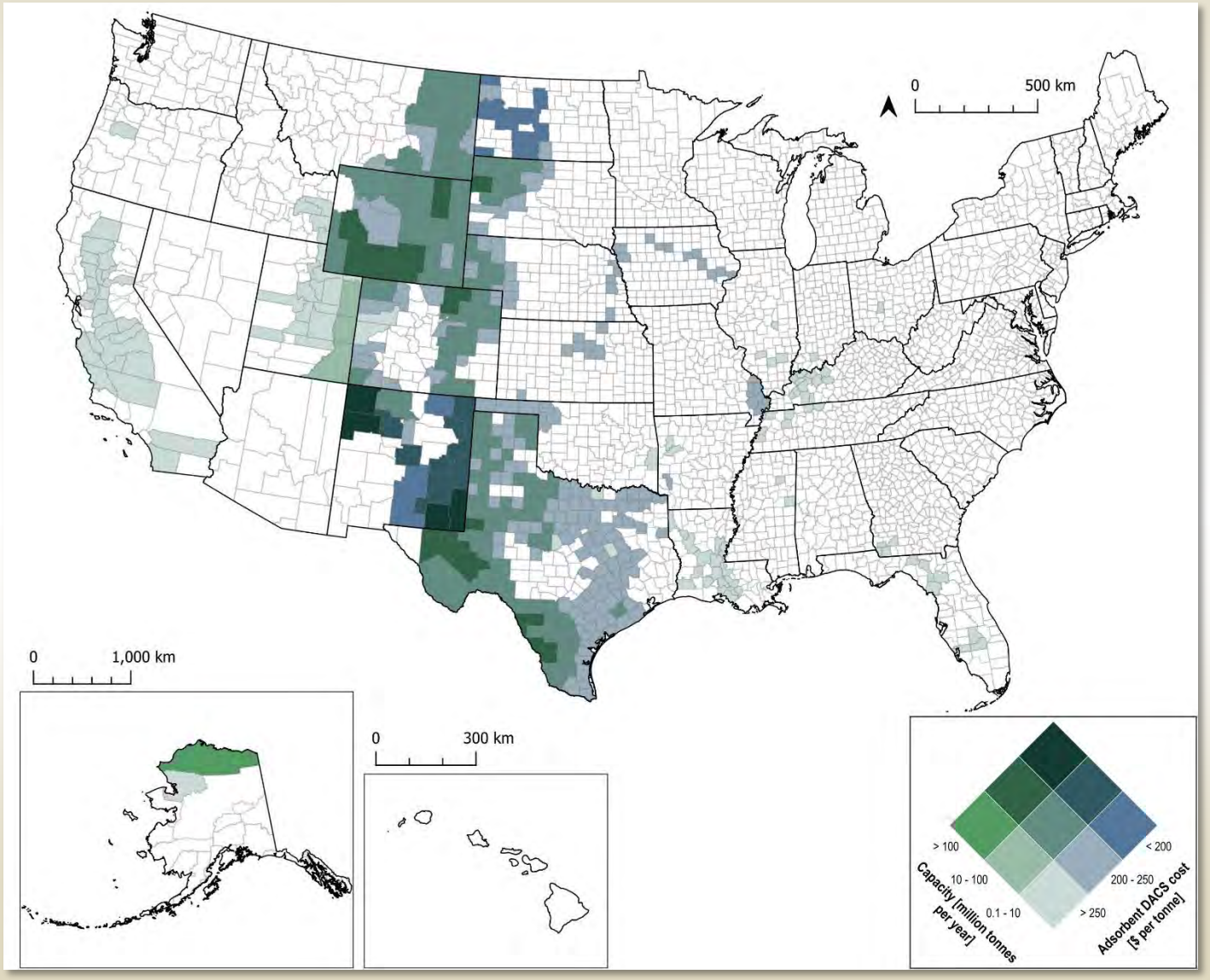
long-term jobs nationwide

What it will cost

- We have more CO_2 removal capacity than we will need
- 'Extra' removal capacity allows each region to make choices that match local needs

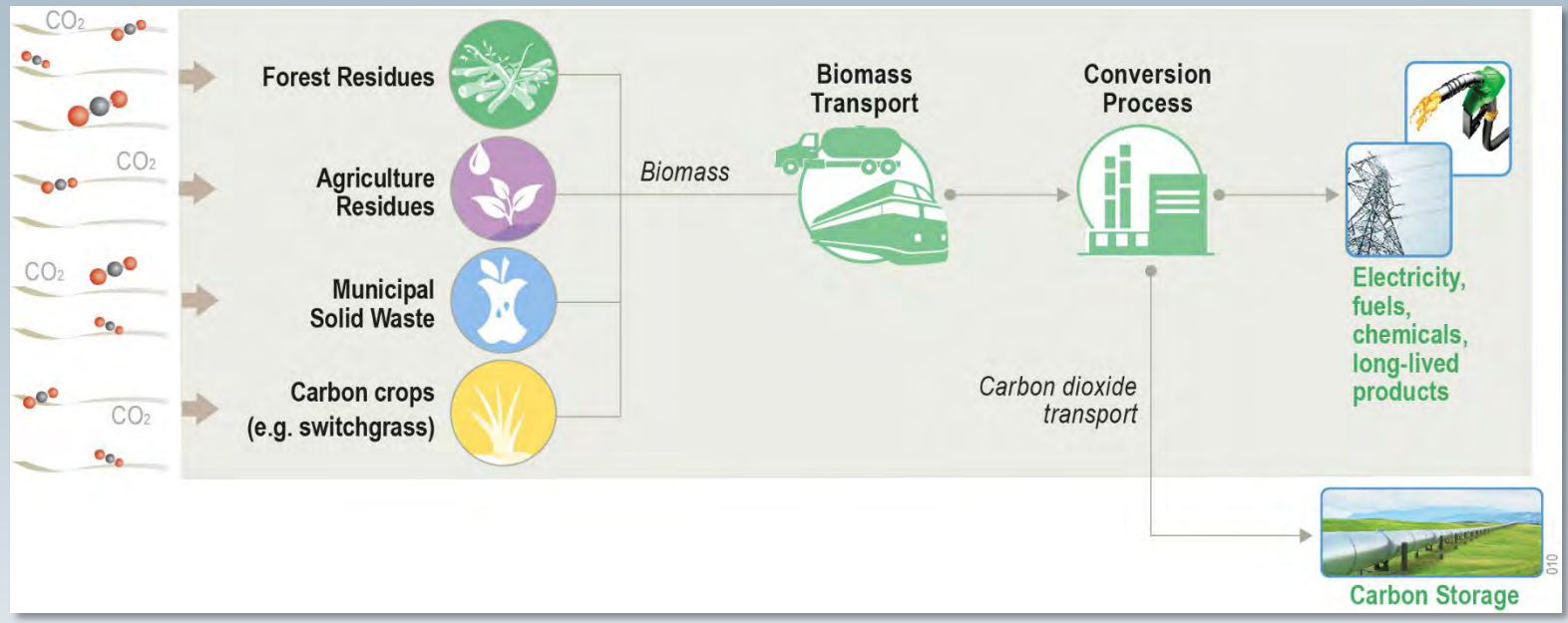


Opportunities for gigatonne-scale DACCS deployment exist in the western United States collocated with geologic storage formations



Using organic wastes, we can remove millions of tonnes of CO_2 per year

- Targeted areas with biomass (feedstock), good geologic storage, & regional co-benefits
- Avoided land where we grow food
- In-depth technical-economic analysis for 27 mature biomass conversion pathways
- Would require ~300 new biorefineries across the USA



700-900 million tonnes CO_2 year, at <$100/ton

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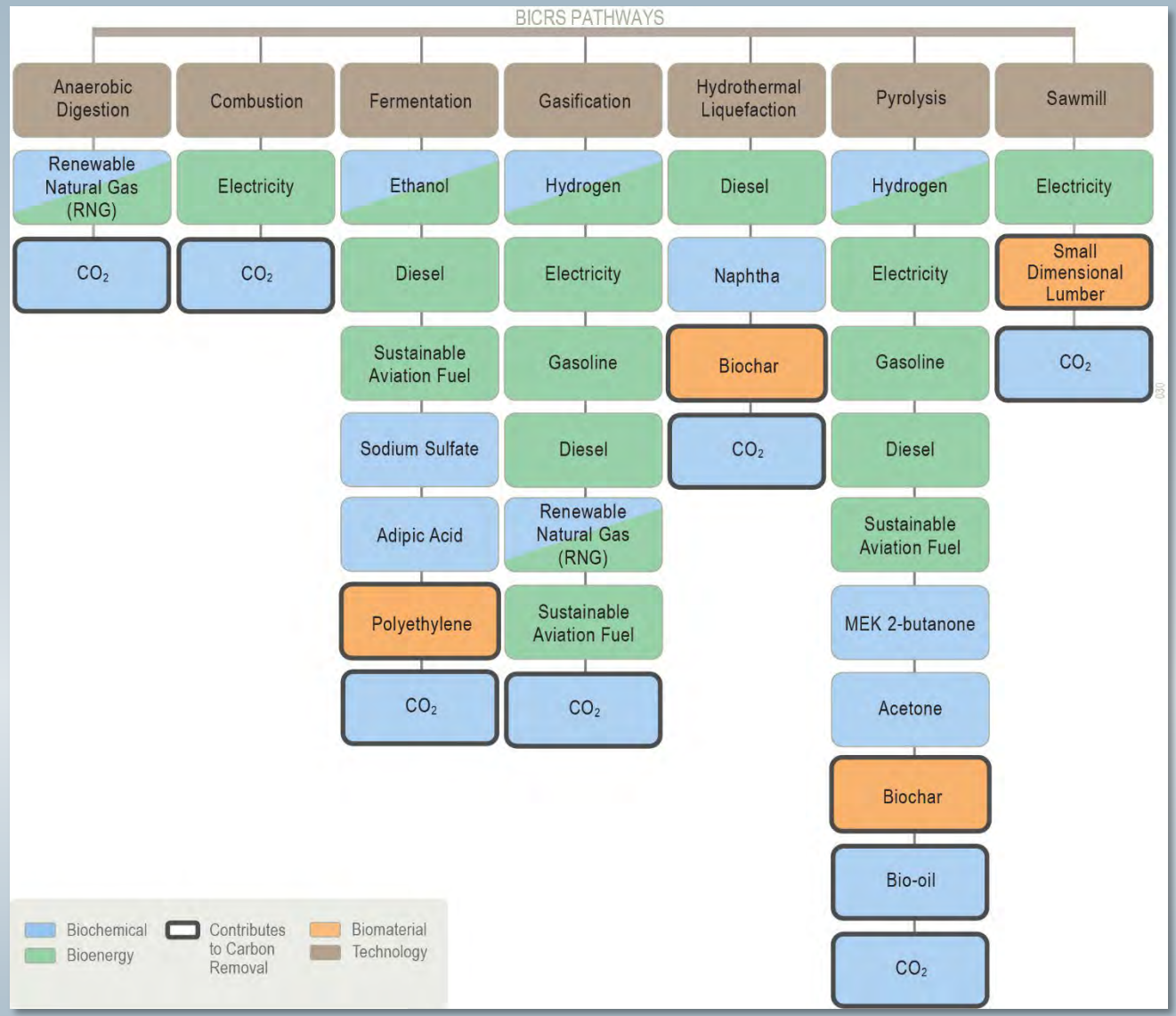
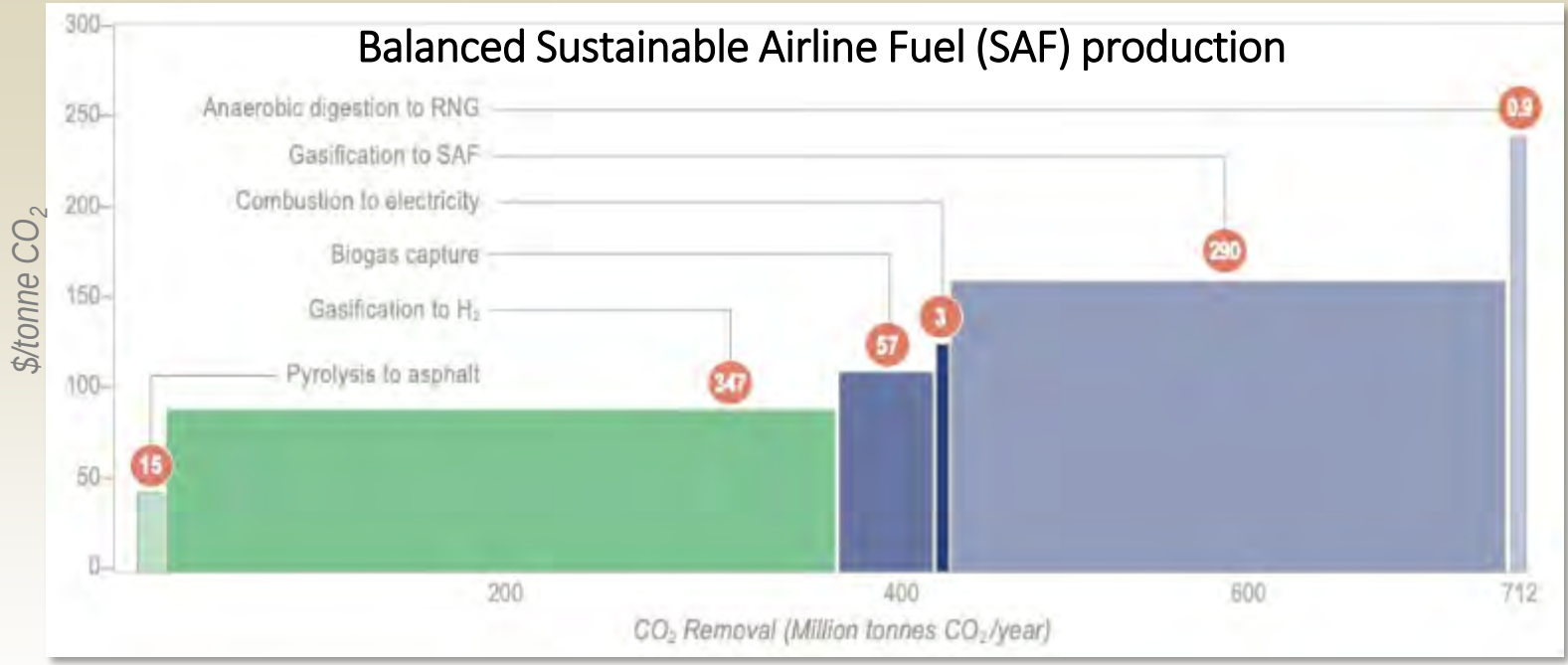
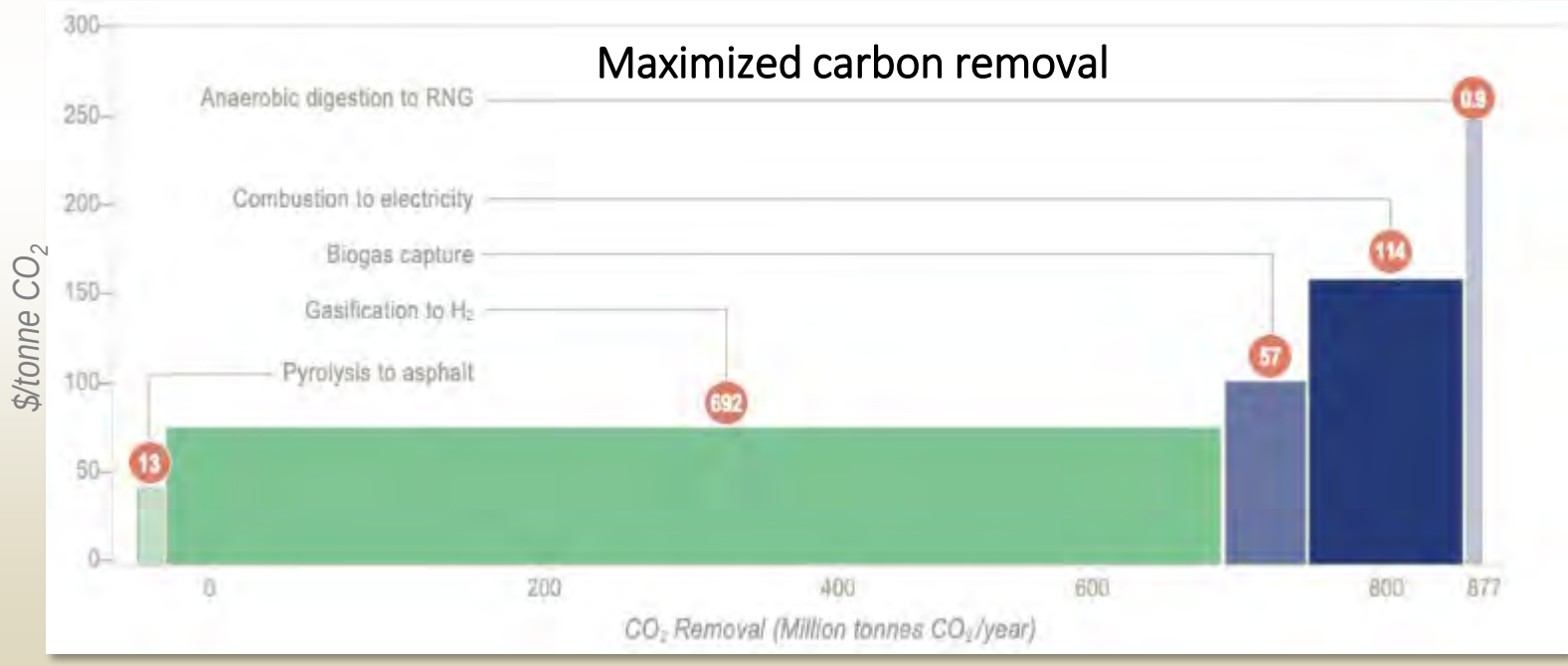


27 unique biomass conversion pathways

Biomass Carbon Removal and Storage (BiCRS) can be customized to prioritize essential products OR to maximize carbon removal

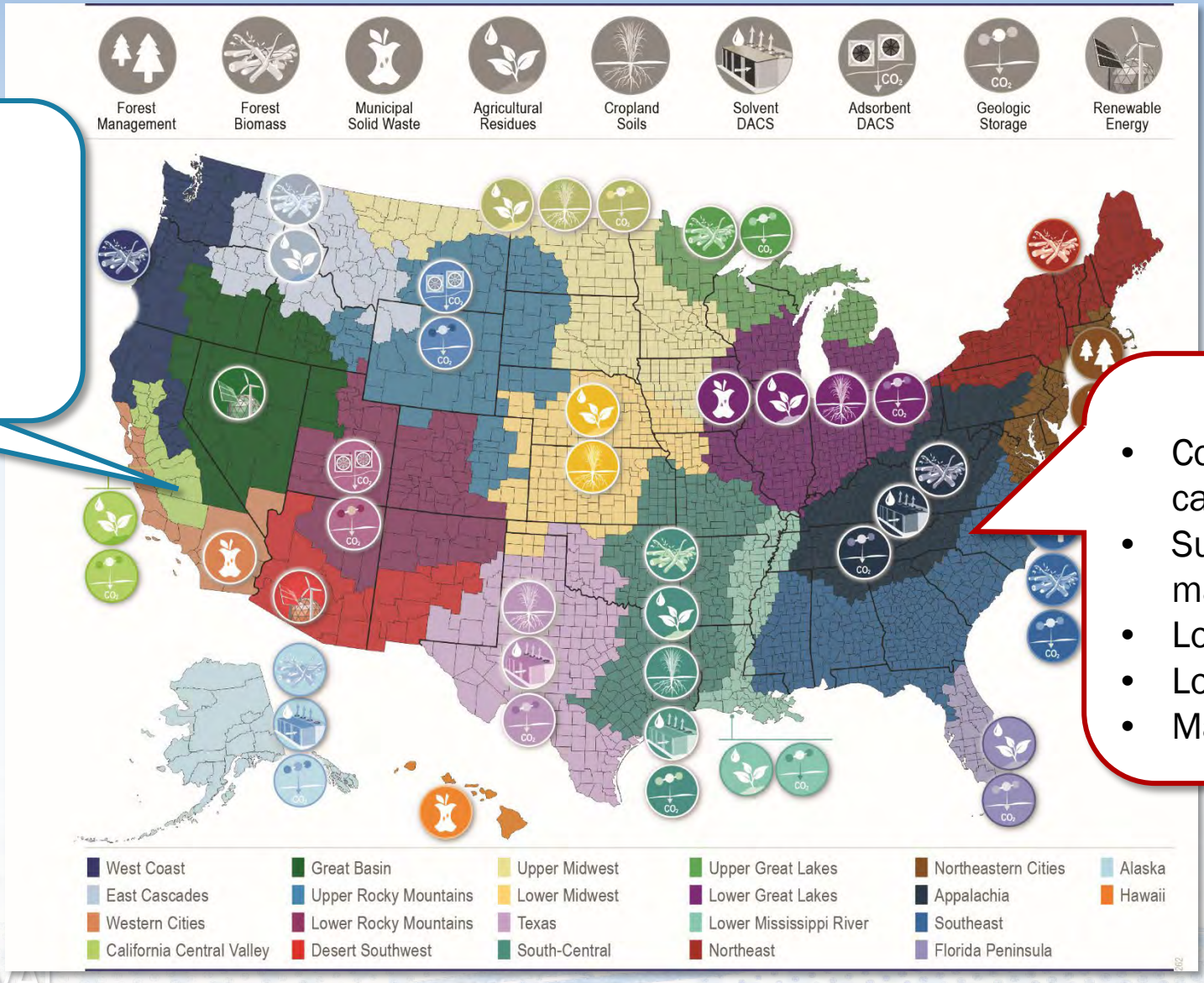




Every US Region Has a Story and an Opportunity

<u>CA Central Valley</u>

- Substantial waste biomass for BiCRS
- Local geologic storage
- Cover crops and perennial field borders



<u>Southeast</u>

- Cover crops and perennial carbon crops
- Sustainable forest management
- Long-lived wood products
- Logging residue for BiCRS
- May need to transport CO_2

THANKS

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THE LLNL CARBON INITIATIVE

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