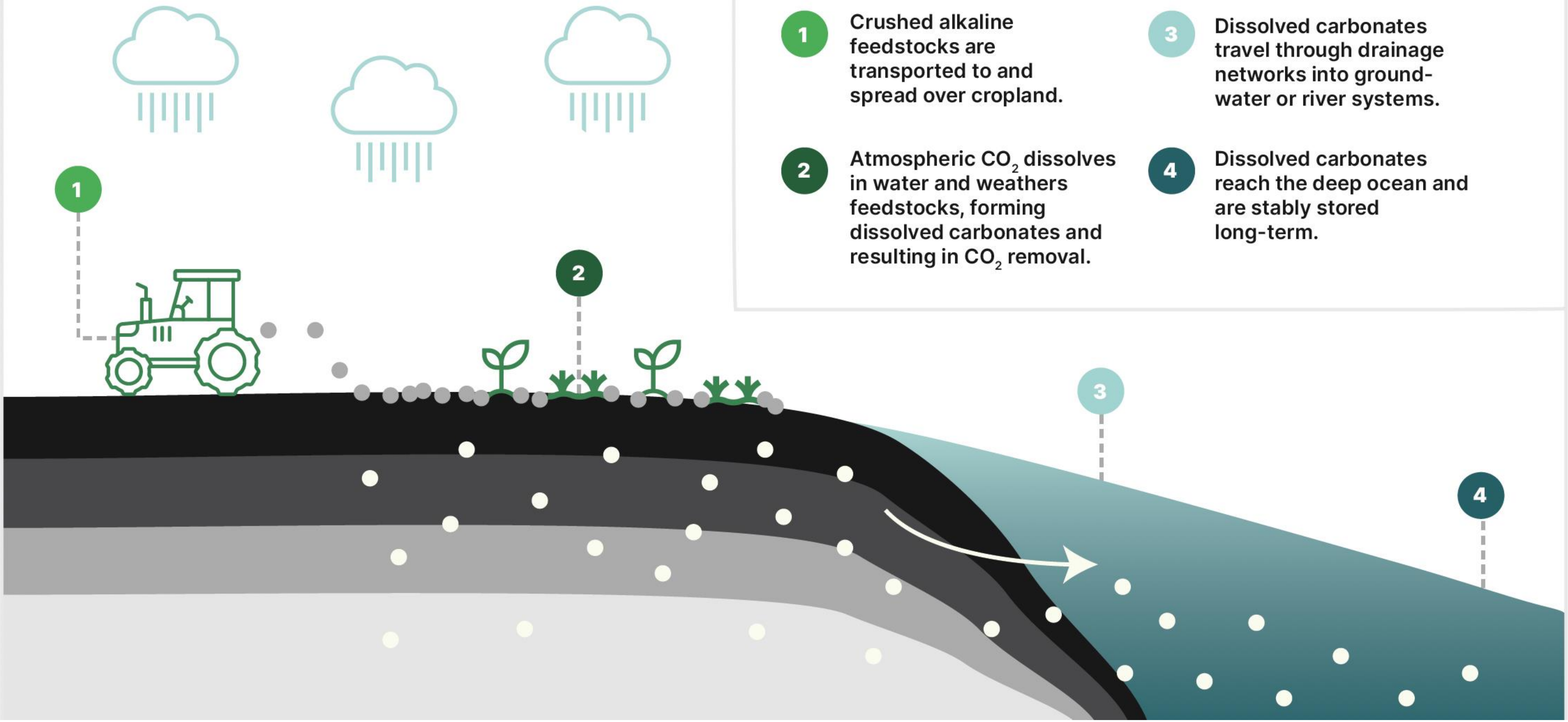
Enhanced rock weathering process

1. Crushed alkaline feedstocks are transported to and spread over cropland.
2. Atmospheric CO_2 dissolves in water and weathers feedstocks, forming dissolved carbonates and resulting in CO_2 removal.
3. Dissolved carbonates travel through drainage networks into ground-water or river systems.
4. Dissolved carbonates reach the deep ocean and are stably stored long-term.

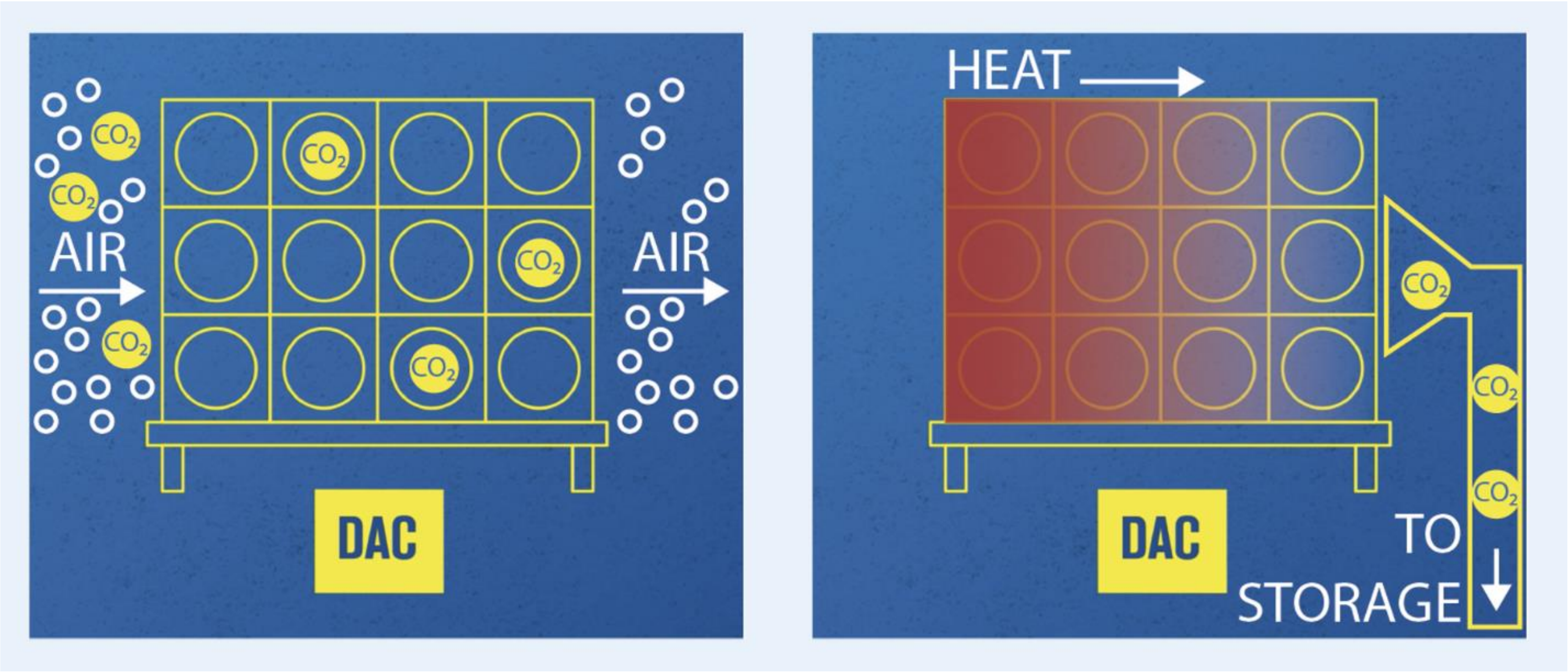


Penn Engineering

Table 2. Comparison of feedstocks with potential for use in ERW cropland projects

Feedstock	Ultramafic rocks (peridotites and serpentines)	Mafic rocks (basalt)	Fly ash	Concrete waste and cement kiln dust
Source	Mined for purpose or for production of nickel, chromium, or diamonds	Mined for purpose or for production of copper	Industrial waste	Industrial waste
Major geographies for production	Global[12]	Global[13]	Global; China responsible for half of annual production with legacy stockpiles available globally[14]	Global[15]
Global availability	Abundant; most-reactive minerals (e.g., brucite) are more rare[16]	Widespread; about 10 times more abundant than ultramafic rocks[17]	About one Gt/yr production; expected to decrease with decline of coal	Widespread; concrete production expected to Increase 12–15% up to 2050[18]

Direct air capture (DAC) removes CO_2 from the atmosphere



DAC is energy intensive

With today's technologies, it takes between **2 and 3 MWh** of energy per tonne of CO_2 removed, and that split is roughly 80% thermal energy.
For DAC to make sense, that energy must be low carbon.

CDR method	Status (TRL)	Cost[1] (USD tCO_2^{-1})	Mitigation potential[1] ($GtCO_2\ yr^{-1}$)	Risk and impacts	Co-benefits	Trade-offs and spillover effects
Improved forest management	8–9	Insufficient data	0.1–2.1	If improved management is understood as merely intensification involving increased fertiliser use and introduced species, then it could reduce biodiversity and increase eutrophication.	In case of sustainable forest management, it leads to enhanced employment and local livelihoods, enhanced biodiversity, improved productivity.	If it involves increased fertiliser use and introduced species it could reduce biodiversity and increase eutrophication and upstream GHG emissions.
Biochar	6–7	10–345	0.3–6.6	Particulate and GHG emissions from production; biodiversity and carbon stock loss from unsustainable biomass harvest.	Increased crop yields and reduced non-CO_2 emissions from soil; and resilience to drought.	Environmental impacts associated particulate matter; competition for biomass resource.
Direct air carbon capture and storage (DACCS)	6	100–300 (84–386)	5–40	Increased energy and water use.	Water produced (solid sorbent DAC designs only).	Potentially increased emissions from water supply and energy generation.
Bioenergy with carbon capture and storage (BECCS)	5–6	15–400	0.5–11	Inappropriate deployment at very large scale leads to additional land and water use to grow biomass feedstock. Biodiversity and carbon stock loss if from unsustainable biomass harvest.	Reduction of air pollutants, fuel security, optimal use of residues, additional income, health benefits, and if implemented well, it can enhance biodiversity.	Competition for land with biodiversity conservation and food production.
Enhanced weathering (EW)	3–4	50–200 (24–578)	2–4 (<1–95)	Mining impacts; air quality impacts of rock dust when spreading on soil.	Enhanced plant growth, reduced erosion, enhanced soil carbon, reduced soil acidity, enhanced soil water retention.	Potentially increased emissions from water supply and energy generation.

Where to learn more?

cdrprimer.org