From Zero to Hero: How to make the Carbon Management Challenge an ambitious lever in the climate fight

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The Carbon Management Challenge (CMC)[1] has set a goal of reaching a minimum of 1 billion tonnes per year of geological carbon dioxide storage by 2030. While in line geological storage required in the International Energy Agency's Net Zero pathway[2], there is concern this may be a distraction from the imperative of reducing fossil fuel emissions. Here we show that, if presented in terms of an accelerating Geologically Stored Fraction, the CMC could represent the first phase of a progressive transition to Geological Net Zero by mid-century, consistent with the goals of the Paris Agreement.[3]

The Geologically Stored Fraction is the fraction of carbon dioxide still produced from fossil fuels and industrial processes that is captured, either at source or recovered from the atmosphere, and committed to permanent geological storage.[4] Achieving a durable halt to global warming requires this Geologically Stored Fraction to be increased to 100%, a state known as Geological Net Zero.[5] Measures promoting biosphere recovery must be additional to, not instead of, achieving this geological carbon balance, due to the limited capacity of the biosphere to absorb geological-origin carbon dioxide in a warming world.

The current global Geologically Stored Fraction is approximately 0.1% and has not increased significantly in recent years. Scenarios that limit warming close to 1.5°C show this fraction rising at a steadily accelerating rate to reach 100% shortly after mid-century (see Figure, panel c). This acceleration is achieved by simultaneously reducing carbon dioxide production (panel a) and increasing carbon dioxide removal to geological storage (panel b). The relative contributions of reductions versus removals depend on the scenario, but this accelerating stored fraction is a feature of all Paris-compliant scenarios.

To reach Geological Net Zero in the 2050s, the Geologically Stored Fraction must accelerate, on average, by 0.2% per year from now on. This means achieving a 0.1% stored fraction in year 1, 0.4% in year 2 (an increase of 0.3%), 0.9% in year 3 (an increase of 0.5%), and so on. If this acceleration begins in 2024 and is maintained over the next three decades, the Geologically Stored Fraction would reach 3.6% in 2030, 40% in 2044 and 100%, or Geological Net Zero, around 2055.

Annual global carbon dioxide production from fossil fuels and industry is approximately 35 billion tonnes. For the CMC goal to represent a Geologically Stored Fraction of 3.6%, carbon dioxide production would have to be reduced to 28 billion tonnes annually by 2030. More ambitious subsequent reductions require less storage (purple dotted lines), while less ambitious reductions require more storage (orange lines), to achieve the same Geologically Stored Fraction. Both paths yield rapid and sustained reductions in emissions (production minus storage).

If framed as a commitment to a sustained acceleration of the Geologically Stored Fraction, the CMC goal of 1 billion tonnes annually by 2030 is consistent with a complete global phase-out of unabated fossil fuel use by the mid-2050s. This represents a simple and verifiable goal that would stop fossil fuel production and use from causing further global warming within a generation. Combined with ambitious but achievable goals to reduce global carbon dioxide production, investment in nature-

based solutions, and reductions of other greenhouse gas emissions such as methane, this would limit peak warming close to 1.5°C.

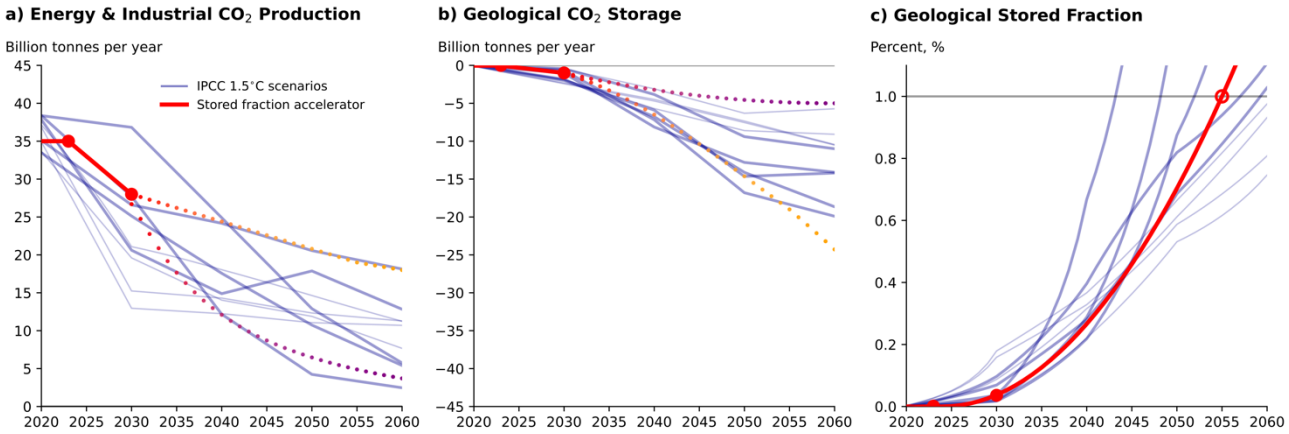

Figure: Demonstration that the CMC 2030 goal is consistent with technology-neutral IPCC 1.5°C scenarios if framed as the beginning of a steady acceleration of Geologically Stored Fraction. (a) CO_2 produced from energy and industrial processes in 1.5°C-compatible scenarios from the IPCC's AR6 (blue)[6], CMC goal (red), and two potential post-2030 extensions (dotted). (b) Ramp-up of geological CO_2 storage showing trade-off between faster reductions in CO_2 production (purple) versus faster ramp-up of geological CO_2 storage (orange). (c) Geologically stored fraction in 1.5°C scenarios (blue) and a quadratically rising extension to the CMC (red). Note that thinner lines refers to scenarios which do not reach geological net zero before 2060, and thinker lines to scenarios which do reach geological net zero before 2060 (c). The red dots show key milestones in CMC's geologically stored fraction: the present day, the CMC goal of 1 $GtCO_2$/year CO_2 storage by 2030, and the date of geological net zero in 2055.

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