Dissent on XPRIZE carbon removal for Vaulted Deep by Jessica Strefler

The XPRIZE jury has decided to award the main prize to Mati, and runners-up prizes to NetZero, Vaulted Deep, and UNDO. As a member of the jury, I share and support most of that decision. However, although I respect the insights and decision of my fellow jury members, I feel compelled to express a dissenting opinion regarding the award for Vaulted Deep.

As outlined in the XPRIZE carbon removal competition guidelines, the award seeks to recognize solutions that can pull carbon dioxide directly from the atmosphere or oceans and sequester it durably and sustainably. To win the prize teams must demonstrate CO2 removal at the kilotonne per year scale, model costs at the megatonne per year scale, and present a plan to sustainably reach gigatonne per year scale in future. In my view, Vaulted Deep met the first two criteria, but their concept cannot be scaled sustainably.

Vaulted Deep takes organic materials and sequesters it geologically to permanently remove the carbon, so-called biomass burial. This can be done with a variety of feedstocks; for XPRIZE they focused on manure. If the solution works as expected, it would sequester 100% of the organic carbon, thus being much more efficient for carbon removal than other solutions using biogenic feedstocks like biochar or bioenergy combined with carbon capture and storage. However, it would use none of the embodied energy.

Under certain circumstances, this solution can help making the current agricultural system more sustainable. For example, in localities where large amounts of manure are produced in high concentration and can thus not all be used as fertilizer for the surrounding farms, simply because the amount exceeds the demand in the area that can reasonably be reached. Another sustainable option would be the removal of contaminated wastes, that cannot be used in any other way.

However, in my view this solution can be either sustainable or scalable, but not sustainably scalable. Scaling this approach to the gigatonne per year level would require several billion tonnes of biomass. While there may be enough manure globally, most of it is left on pastures and would have to be made available for sequestration (https://openknowledge.fao.org/server/api/core/bitstreams/f0cebfdd-725e-4d7a-8e14-3ba8fb1486a7/content). There may be difficulties in collecting this manure, and also suitable geological storage space would have to be co-located, but the major problem lies with sustainability.

Even in the current energy and land system, scaling biomass burial to the gigatonne scale would require taking feedstocks away from other uses like fertilizer or energy. This problem is exacerbated in a future where the world moves towards a carbon-neutral economy – and only then carbon removal makes sense. In such a carbon-neutral economy, a large share of the current demand for fossil oil and gas can be avoided, for example via electrification (Luderer et al., 2022, https://doi.org/10.1038/s41560-021-00937-z). Yet some demand for liquid and gaseous fuels will remain, mainly for aviation, shipping, and feedstock for the chemical industry, as well as for high-temperature heat or residual power demands in an otherwise fully renewable electricity system (Luderer et al., 2018, https://doi.org/10.1038/s41558-018-0198-6). To reach carbon neutrality, these fossil fuels would either have to be replaced with bioenergy or synthetic fuels, or their emissions would need to be offset by carbon removal.

However, the production of carbon-neutral synthetic fuels requires large amounts of energy and hydrogen, which is currently scarce and expensive, and will likely remain so for the coming decades (Odenweller and Ueckerdt, 2025, https://doi.org/10.1038/s41560-024-01684-7), leading to high costs and uncertain availability of synthetic fuels (Ueckerdt et al., 2021,

https://doi.org/10.1038/s41558-021-01032-7). As a consequence, the vast majority of transformation pathways that reach carbon neutrality rely to some extent on bioenergy. In a carbon-neutral economy, bioenergy will therefore most likely become an ever more valuable resource, with high value for both its energy content as well as its carbon content. At the same time, sustainable biomass will remain scarce, as it requires arable land and resources as water, nitrogen, and phosphorus, and competes with food and feed production. In essence, we can either continue to use fossil fuels and offset the emissions, or use biomass to replace fossil fuels, or aim to harvest both the energy and carbon value of bioenergy. Given the scarcity and high value of bioenergy, this path would be the most effective. Taking away billions of tonnes every year without recycling the nutrients and without using the embodied energy would result in increased demand for chemical fertilizer and the continued use of fossil fuels to meet hydrocarbon demands. Therefore, biomass burial may present a sustainable, meaningful application for a small subset of biomass that is not useable in any other form. However, this will remain a niche case.

I call for a more careful consideration of the use of the scarce and valuable resource that biomass presents and therefore do not support awarding an XPRIZE to Vaulted Deep.

I offer this dissent with the utmost respect for the jury, from the perspective of an integrated assessment of energy and land system transformation. I hope this viewpoint can be of value for the continued debate on biomass and carbon removal.

The views expressed in this letter are solely those of the author and do not reflect the views of my employer.