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Why we need the ‘and’ in ‘CO₂ utilization and storage’

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While research is still needed to answer scientific and technical questions about CO₂ Capture and Storage (CCS), it is largely economic and political forces rather than technical issues that have prevented widespread deployment of CCS over the last decade. Meanwhile, the energy-climate crisis continues as fossil-fuel use grows, causing atmospheric concentrations of CO₂ to increase, along with global atmospheric temperatures and the associated measurable and costly impacts on Earth's climate. Given the current economic and political state of affairs, it is natural to look for ways other than storage (sequestration) by which mankind can decrease greenhouse gas (GHG) emissions. With CO₂ accounting for approximately 70% of the GHG radiative forcing from among the other main GHGs (CH₄, N₂O, CF₄, C₂F₆, SF₆, and HFC-23, 134a, and 152a), and with abundant fossil-fuel-combustion point sources of CO₂ available, it makes sense to focus on reducing net emissions of CO₂ by any and all means.

With direct injection into the ground for permanent sequestration currently considered expensive and lacking popular support, many people concerned about energy and climate have turned to studying utilization of CO₂ – so-called CO₂ Capture, Utilization, and Storage (CCUS). In fact, the annual CCS conference held for several years now in Pittsburgh changed its name this year to the 11th Annual Conference on Carbon Capture Utilization & Sequestration. Currently, CO₂ is used beneficially for a large number of purposes in the chemical, pharmaceutical, food and beverage, agricultural, healthcare, environmental, energy resource extraction, pulp and paper, electronic, metals, and fire safety industries.^{1,2} In the area of energy resource extraction, the oil industry injects millions of tonnes of CO₂ per year for enhanced oil recovery (CO₂ - EOR). While much of the current utilization demand makes use of CO₂ as is, vast amounts of CO₂ are also converted into a variety of useful products such as urea (fertilizer), formic acid (preservative for animal feed), and syngas (fuel). Although there exist many potential large-scale uses for CO₂, the current demand is dwarfed by the potential supply from anthropogenic sources (mostly fossil fuel combustion), and projections of increased fossil-fuel use make it difficult to envision utilization ever solving the energy-climate crisis. For example, Song³ estimated the total potential US demand for CO₂ in the chemical and materials industries at approximately 6 MtCO₂/yr, approximately the output of a 750 MW coal-fired power plant. CO₂-EOR within the USA currently uses a lot more CO₂ than do the chemical and material industries, approximately 48 Mt CO₂/yr,³ or the output of six 1-GW coal-fired power plants. Urea production in the USA is the largest single use at 120 Mt CO₂/yr.² Meanwhile, the current US power plant CO₂ emissions are estimated to be about 3 Gt CO₂/yr, or about 15 times larger than the current US utilization rate of approximately 200 Mt CO₂/yr. Moreover, it deserves mention here that the vast majority of CO₂ used for EOR comes from natural CO₂ reservoirs rather than anthropogenic sources. While we can envision policies arising from concern for climate that will motivate greater utilization of anthropogenic CO₂, this greater utilization rate will occur in a future with potentially much larger rates of CO₂ emissions, assuming that global projections of increased demand for energy and its modes of generation are correct.

Despite the raw numbers and what they reveal about the imbalance between today's CO₂ utilization and anthropogenic emissions, increasing CO₂ utilization is still a worthy goal. The fact is we need to start reducing CO₂ emissions in every way we can. The problem of global anthropogenic GHG emissions of approximately 30 Gt CO₂/yr is so large that it demands solutions from every corner of Earth. For example, off-setting electricity production from coal by greater use of nuclear and renewable energy sources is an effective CO₂ emissions mitigation strategy, but utilization can potentially reduce CO₂ emissions even more than these fuel-substitution approaches.⁴ And there is hope for large increases in utilization. First, increased application of CO₂-EOR, along with a large-scale switchover to anthropogenic

sources of CO₂ used for EOR, could drastically increase that sector's efficacy in reducing anthropogenic emissions. In addition, there are new sectors being studied, such as the use of CO₂ as a cushion gas for energy storage.⁵ Granted, if our energy supply remains dominated by fossil fuels used as they are today, even these relatively large sub-surface uses will remain dwarfed by combustion-related emissions. But there are also promising demonstrations of the use of CO₂ in making cement,⁶ a potentially game-changing approach given the vast and growing 3.3 Gt/yr global market for cement used in concrete. Related approaches to carbonation and mineralization for CCS were presented in the last issue of Volume 1 of this journal (see Zevenhoven⁷ for an overview).

So while utilization will not contribute a large amount to reducing anthropogenic CO₂ emissions in the near future, it remains a critically important area, because it does not rely solely on policy decisions that can be influenced by a fickle economy. Rather, it relies on technological breakthroughs and market competitiveness. That is not to say that policies cannot help increase the scale of utilization, but rather that CO₂ utilization can stand on its own, as demonstrated by the wide variety of current uses. While increased research and publication emphasis on utilization is welcomed (e.g., through publications in this journal), we need to remember that the large long-term potential mitigation of CO₂ emissions provided by underground CO₂ storage⁸ will be needed as long as fossil fuels are used as they are today, requiring that we keep the 'and' in 'utilization and storage'.

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