frontiers | Frontiers in Sustainability

TYPE Editorial
PUBLISHED 07 January 2025
DOI 10.3389/frsus.2024.1527055

OPEN ACCESS

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RECEIVED 12 November 2024
ACCEPTED 03 December 2024
PUBLISHED 07 January 2025

CITATION
Reis-Machado AS, Nunes AVM and Nunes da Ponte M (2025) Editorial: Current and emerging trends in CO_2 utilization towards the global challenge of sustainability. *Front. Sustain.* 5:1527055. doi: 10.3389/frsus.2024.1527055

Editorial: Current and emerging trends in CO_2 utilization towards the global challenge of sustainability

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KEYWORDS

CO_2 utilization, synthetic fuels, CO_2 mineralization, net zero emissions, sustainability assessment (SA)

Editorial on the Research Topic
Current and emerging trends in CO_2 utilization towards the global challenge of sustainability

CO_2 utilization as a sustainable and secure supply of carbon has gained renewed interest. This is clearly evident from the large number of recent scientific papers published on the subject. At the same time, the field is going through a fast evolving scenario, with several industrial initiatives taking place, mainly on new pilot scales or demonstration units.

This Research Topic (RT) analyses the fundamental need of methodological harmonization for sustainability assessment of CO_2 utilization. In order to address global sustainability development goals, a balance among the three pillars of sustainable development, i.e., economic, environmental, and social is necessary. Furthermore, it illustrates current strategies that can be adopted by industry to reach Near Zero Emissions Scenario (NZE) in three important sectors, namely in the production of surfactants, in the production of fuels on the hard to electrify heavy goods transportation and in construction materials based on biomass wastes and CO_2 mineralization. Emerging research trends that will define the role of CO_2 in the future of the global economy are described.

In the first article, Newman and Styring highlight the importance to harmonize CCU sustainability assessments in order to guide R&D investments toward sustainable processes, products and supply chains. In addition to environmental and economic analyses, societal issues were recently included in the assessments, forming the triple helix framework (McCord et al., 2021). In this paper, the different methodologies were reviewed. While combined Life Cycle and Techno-Economic Assessments have reached maturity, societal sustainability assessment still presents significant challenges, due to qualitative data and scarcity of quantitative inputs and analysis methodology. Future work should achieve methodological harmonization in sustainability evaluation of CCU projects integrating societal sustainability assessment.

The need to screen several chemical pathways before a process is adopted to assure sustainable production is becoming more evident. Several attempts have been made using different analysis frameworks. In the second paper, Platt and Styring showed the wide potential for green Linear Alkylbenzene Sulfonate (LAS) production. They used different building blocks by constructing a tree diagram based on literature search and technology evaluation, highlighting the need for a short form sustainability screening. Work in this direction is for instance the work of Limleamthong et al. (2016). They developed a new approach based on Data Envelopment Analysis (DEA) for the multi-criteria screening of molecules, according to techno-economic and environmental aspects identifying the most efficient chemicals,. This method allows establishing improvement targets for the chemicals found to be inefficient to guide research efforts in green chemistry. Establishing indicators is another avenue that is being pursued (Schakel et al., 2017).

In the third paper (Styring et al.) illustrate how the alternative fuel dimethyl ether (DME) is promising to address global sustainability goals. They analyze for the first time Power-to-DME against policy requirements. This study addresses a sector that significantly contributes to atmospheric CO_2 emissions. Transport emissions grew at an annual average rate of 1.7% from 1990 to 2022, faster than any other end-use sector except for industry which grew at the same rate. To get on track with the 2050 Near Zero Emissions Scenario (NZE) CO_2 emissions must fall by more than 3% per year to 2030.[1] When compared with fossil diesel, DME reduces NO_x, SO_x and particulate emissions (Semelsberger et al., 2006). It offers also the advantage of being easily adapted for use in conventional automotive engine systems. The analysis shows that use of DME achieves greenhouse gas (GHG) emission savings of at least 70%, meeting the criteria set up in the RED II directive.

Cement is an essential material and its production and use is highly energy and materials intensive. The most common form of cement is Portland cement, about 93–97% of which consists of a material called clinker. Clinker is formed when the raw material limestone burns at a high temperature in a cement kiln generating CaO and CO_2. Cement emissions intensity has remained relatively stable since 2018 (0.6 t CO_2 per ton of cement produced). To get on track with the NZE Scenario, emissions must fall by an average of 3% annually through to 2030 (IEA50). Clinker substitution and adoption of green fuels will be key to put this Industry on track. In this context, in the third paper (Tripathi et al.) links two sectors of significant emissions, the hard to abate CO_2 emissions of the cement industry and the emissions from burning woody biomass to energy plants estimated to be 1.2 Gt CO_2e/y, accounting for ~2.3% of global emissions (Bailis et al., 2015) projected to be 2 Gt CO_2e by 2050 (Booth, 2018) in a "end-of-waste" strategy toward a circular economy supported by the European Commission (2011). This work exploits the ability biomass ashes to mineralize CO_2 gas and partially replace cement in mortars and shows that the additions of the different type of ashes need to be optimized for material's best performance.

A potential for saving 82.5 Mt of CO_2/150 Mt of ash incorporated as cement replacement was estimated.

Despite the promise of CCU technologies, many important sectors are not on track with NZE scenarios. This is a matter of serious concern, needing more efforts at all levels to further develop and implement these technologies.

1 IEA50. Available at: https://www.iea.org/energy-system/industry/cement (accessed September 2024).

Author contributions

ARM: Writing – original draft, Writing – review & editing. AN: Writing – review & editing. MNP: Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The authors acknowledge FCT (Fundação para a Ciência e a Tecnologia, I.P.) under the projects of the Associate Laboratory LAQV REQUIMTE LA/P/0008/2020 doi: 10.54499/LA/P/0008/2020 UIDP/50006/2020 doi: 10.54499/UIDP/50006/2020 UIDB/50006/2020 doi: 10.54499/UIDB/50006/2020 LA/P/0037/2020, UIDP/50025/2020, and UIDB/50025/2020 of the Associate Laboratory Institute of Nanostructures, Nanomodelling and Nanofabrication—i3N, CO2RED, doi: 10.54499/PTDC/EQU-EPQ/2195/2021 and the project M-ECO2—Industrial cluster for advanced biofuel production, Ref. C644930471-00000041, co-financed by PRR—Recovery and Resilience Plan of the European Union (Next Generation EU).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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