Electrochemical Ocean-Based CDR Methods: At a Glance

Electricity can be used to remove carbon dioxide from seawater by driving well-understood chemical reactions that either liberate carbon dioxide gas from the seawater for capture and sequestration, or alter seawater's chemical balances to enable it to store more CO_2 than it naturally would.[62] Following these reactions, treated seawater is returned to the ocean, where it will then absorb more carbon dioxide from the atmosphere.[63]

Potential Scale of Carbon Storage: Electrochemical CDR requires large quantities of reactants, seawater, and energy. To remove 0.001 to 0.002 gigatonnes of CO_2 per year (GtC yr^{-1}) electrochemically would require treatment of as much water as currently goes through every desalination plant in the world.[64] Removing just 0.5 (GtC yr^{-1}) per year electrochemically would also require scaling up current worldwide acid production by a factor of about two, or base production by a factor of seven.[65] In terms of energy, removing 1 (GtC yr^{-1}) per year electrochemically would require 2,000 terawatt-hours of electricity per year, or 20 percent of the projected increase in global annual electricity supply by 2040.[66] To contribute to emissions mitigation, electrochemical CDR approaches would have to rely on renewable energy. For some methods, substantial new infrastructure would also be needed to produce and transport reactants or reaction products.

Technical Readiness: Electrochemical CDR has been demonstrated only at prototype scale.[67] There have been no pilot projects or field trials for this technology.[68] The energy needed to pump water and extract carbon dioxide is a significant limitation on electrochemical CDR, but combining this technique with ocean thermal energy conversion, offshore wind facilities, or desalination plants could decrease infrastructure and operating costs.[69]

Potential Risks and Benefits (Social and Environmental): The environmental risks and benefits associated with electrochemical ocean capture of carbon have not been researched.[70] As with existing power and desalination plants, seawater intakes can pose a risk to many marine organisms.[71] Electrochemical CDR techniques would also cause local pH and chemical equilibrium changes to seawater, which could affect marine life and ecology depending on rates, magnitudes, areas, and timescales of change.[72]

Outstanding Questions: Technological developments like improved ion membranes used to help remove CO_2 , corrosion-proof materials, and installations robust enough for the ocean environment will be required to reduce costs for upscaling this technology.[73] Environmental impacts and co-benefits, like the production of hydrogen or chlorine gas during electrochemical ocean capture of carbon, need to be researched.[74] While verification of CDR by direct CO_2 removal from seawater is relatively straightforward, verification by methods that electrochemically alter ocean chemistry (e.g., by creating alkalinity) is likely to be more challenging. As with all marine CDR techniques, verification of these methods would require analysis of total CO_2 emissions associated with building and operating facilities and supplying them with electricity or raw materials.

---

[62] National Academies of Sciences, Engineering, and Medicine (hereinafter NASEM), *A Research Strategy for Ocean-Based Carbon Dioxide Removal and Sequestration* (Washington, D.C.: National Academies Press, 2021), https://doi.org/10.17226/26278.

[63] Ibid.

[64] Ibid.

[65] Ibid.

[66] Ibid.

[67] See, for example, Charles-Francois de Lannoy et al., "Indirect Ocean Capture of Atmospheric CO_2, Part I: Prototype of a Negative Emissions Technology," *International Journal of Greenhouse Gas Control* 70 (March 2018): 243–53, https://doi.org/10.1016/j.ijggc.2017.10.007.

[68] Joint Group of Experts on the Scientific Aspects of Marine Geoengineering Techniques (hereinafter GESAMP), *High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques* (London: International Maritime Organization, 2019), http://www.gesamp.org/publications/high-level-review-of-a-wide-range-of-proposed-marine-geoengineering-techniques .

[69] De Lannoy et al., "Indirect Ocean Capture"; GESAMP, *High Level Review.*

[70] NASEM, *A Research Strategy.*

[71] Thomas M. Missimer and Robert G. Malivab, "Environmental Issues in Seawater Reverse Osmosis Desalination: Intakes and Outfalls," *Desalination* 434 (2018): 198-215, https://doi.org/10.1016/j.desal.2017.07.012.

[72] NASEM, *A Research Strategy.*

[73] NASEM, *A Research Strategy*; De Lannoy et al., "Indirect Ocean Capture."

[74] NASEM, *A Research Strategy.*