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Direct Air Capture and Ocean Storage with Hydrogen Production

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With its vast capacity to store carbon, the ocean offers a promising opportunity for atmospheric carbon dioxide removal (CDR). In this talk, we present a pathway and the mass balances for scalable CDR using seawater as both the source of reactants and as the reaction medium via electrolysis through the *Equatic* process. This process applies an electric potential to split seawater into H^+ and OH^-ions, generating acidity and alkalinity. Additionally, it produces gaseous co-products, oxygen and hydrogen. The resulting alkalinity, generated through a "continuous electrolytic pH pump", leads to the instantaneous precipitation of calcium carbonate ($CaCO_3$) and magnesium hydroxide ($Mg(OH)_2$). The carbonate solids are stored on land, whereas the catholyte slurry containing magnesium hydroxide is re-equilibrated with atmospheric CO_2 within the plant, forming bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions. This results in the trapping, and hence durable (at least ~10,000 years) immobilization of CO_2 that was originally dissolved in water (3%), and that is additionally drawn down from the atmosphere (97%). Taken together, these actions result in the net removal of 4.6 kg of CO_2 per m^3 of seawater catholyte. The result of this engineered process is the discharge of modified seawater back into the marine environment. Therefore, the Measurement, Reporting, and Verification (MRV) strategy is divided into two parts: ISBL (inside battery limits) and OSBL (outside battery limits). ISBL measurements quantify CDR based on the difference in the chemical composition of the inlet and outlet streams. On the other hand, OSBL monitoring and modeling will assess if the discharge plume, as it mixes with ambient seawater, results in carbon loss that could reverse the CDR achieved ISBL. The OSBL carbon budget could be either positive or negative, depending on the discharge composition and its interactions with the marine environment. Therefore, this framework determines the necessary measurements to fully characterize CDR during both the engineered process and in the resulting discharge plume. Autonomous and laboratory-based methods, including a constrained model of carbon tracking as the process discharge is diluted into the surrounding seawater, are considered.