Solar-powered Direct Air Capture: Techno-economic and Environmental Assessment

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Direct air capture of CO_2 (DAC) has gained attention in recent years as a promising negative emissions technology. Although the largest DAC testing facilities currently focus on carbon capture and storage, companies and research institutions are also developing concepts for carbon capture and utilization. However, for DAC to become an enabler for carbon neutral fuels and chemicals, not only the cost of captured CO_2 must decrease, but also the associated greenhouse gas emissions. The source of these emissions depends on the DAC technology. In the case of liquid solvent or high-temperature direct air capture (HT-DAC), most emissions are caused by the combustion of fuels to calcine carbonates. Since this reaction requires very high temperatures (around 900 °C for calcium carbonate), its decarbonization can be challenging. Among the available renewable energies, concentrated solar power (CSP) is the only one that can directly provide large quantities of heat at such high temperatures. Therefore, coupling a CSP-powered solar calciner with the available HT-DAC technology seems to be an interesting possibility. In this presentation, an integration of both technologies is proposed and analyzed with a techno-economic and environmental assessment that allows the comparison with a baseline HT-DAC plant. Additionally, due to the nature of sites with abundant solar resources, special attention is paid to the impact of harsh environmental conditions on the DAC process.