Technological advances in carbon dioxide capture & utilization (CCU)

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Recent years have seen a sharp rise in the share of renewable energy production. This renewable power usually often leads to energy surplus. Storage (batteries, water pumping or hydrogen production) have been proposed to exploit this surplus. One of the novel alternatives is to use excess electricity to convert CO_2 into organic chemicals and fuels. Growing rapidly, now comprise approximately 25% of the global electricity capacity is now comprised of renewable energy sources, thus providing great opportunity for CO_2 reduction (CO2R). The International Renewable Energy Agency (IRENA) estimated at the end of 2018 the installed global renewable energy generation across wind, solar, hydroelectric, and other sources to be 2351 GW. CO2R pathways can utilize electricity directly in the conversion step or indirectly via other energy carriers (e.g., H_2) in the so called Power-to-X approach. Most common conversion pathways include electrochemical, bioelectrochemical, plasma and thermochemical conversion. Non-reductive routes which are commercially mature such as enhanced oil recovery, food and beverage, and concrete curing also exist. While the latter have a higher relative level of maturity, they provide fewer opportunities for electricity utilization compared to reductive routes. The electrochemical CO_2 reduction provides a viable option for reducing anthropogenic CO_2 emissions, while at the same time closing the carbon cycle, by selectively converting CO_2 to fuels/chemicals. While reduction to CO or formic acid only requires two proton-coupled electron transfers, the reduction of CO_2 to ethylene or ethanol consumes 12 electrons. Currently, CO, ethylene, and formate are considered as best possible option as each has been synthesized electrochemically with partial current densities >100 mA cm^2, often considered as commercially relevant current density, at a faradaic efficiency >60%. For the indirect route, methanol and methane are at high current TRL (i.e., low technical barriers to formation) and high achievable rates of formation. In this presentation, along with a general overview of CCU, VITO's research on CO_2 conversion using bioelectrochemical and electrochemical approach will be presented.