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Climate-Benign Direct Air CO_2 Capture, Utilization, and Storage (DACCUS)

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Transitioning towards a carbon managed energy infrastructure is essential to mitigate climate change. Negative emission technologies, such as direct air CO_2 capture (DACC), together with renewable energies will likely to be necessary components in the effort to slow, stop, reverse the flow of carbon dioxide (CO_2) to the atmosphere. The DACC process requires heat and electricity to capture CO_2 from the ambient air, the sources of which may not be climate-benign. We present an approach that combines DACC, long-term CO_2 storage, and geothermal energy production: a climate-benign direct air capture, carbon utilization, and storage (DACCUS). The CO_2 captured from the ambient air, is geologically stored in sedimentary basins, and circulated to the surface in a closed system to extract the available geothermal heat. The produced heat can be used directly or converted to electricity by a power plant and used in the DACC process. We investigate the performance of DACCUS systems, including sensitivity analyses of key parameters, such as the sorbent regeneration temperature (80-120°C), the outlet temperature the CO_2 stream from the DACC (70-22°C), and reservoir permeability ($1x10^{-15}$-$1x10^{-11}$ m^2), among others. The results indicate that DACCUS has a promising potential for using the CO_2 from DACC to produce process energy requirements. For example, with a regeneration temperature of 100°C and a DACC outlet temperature of 70°C, reservoirs with depths equal or above 3.5 km, and geothermal temperature gradients equal or above 35°C/km, can provide sufficient wellhead temperatures. In addition, the maximum DACC capacity for those temperatures increases considerably for reservoir permeability up to $5x10^{-14}$ m^2, and can provide the make-up CO_2 for that which migrates outside of the region in the aquifer where CO_2 is circulated between the subsurface and the surface. Costs estimates for DACC are \$500–600/tCO_2. While also the cost of the integrated system is important, the integration with CO_2-geothermal production could yield substantial savings for DACC (\$0.64M - \$30.6M annually of avoided electricity costs).