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USING GEOLOGIC CO_2 STORAGE FOR ENHANCED GEOTHERMAL ENERGY AND WATER RECOVERY AND ENERGY STORAGE

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Reductions in CO_2 emissions at a scale consistent with limiting the increase in the global average temperature to below 2ºC above pre-industrial levels requires a range of measures, including increased use of renewable and low-carbon energy and reduced CO_2 intensity of fossil energy use, with each of these measures having major deployment barriers. The variability of the predominant renewable resources (wind and solar) requires major advances in utility-scale diurnal-to-seasonal energy storage. Base-load energy, such as nuclear, that cannot be cycled during periods of over-generation will have difficulty co-existing on electric grids with a large presence of variable renewables. Major deployment barriers for CO_2 capture, utilization, and storage (CCUS) in saline reservoirs include: (1) net cost (after accounting for utilization benefits); (2) water intensity of CO_2 capture, and (3) overpressure, which is fluid pressure that exceeds the original reservoir pressure due to CO_2 injection, because it drives key storage risks: induced seismicity, caprock fracture, and CO_2 leakage.

We present a synergistic approach to CCUS in sedimentary basins designed to address each of these deployment barriers. Our approach uses the huge fluid and thermal storage capacity of the subsurface, together with overpressure driven by CO_2 storage, to harvest, store, and dispatch energy from subsurface (geothermal) and surface (solar, nuclear, fossil) thermal resources, as well as excess energy from electric grids. Captured CO_2 is injected into saline reservoirs to store pressure, generate artesian flow of brine, and provide a supplemental working fluid for efficient heat extraction and power conversion. Concentric rings of injection and production wells create a *hydraulic divide* to confine the stored pressure, CO_2, and thermal energy below the caprock seal that overlies the CO_2 storage reservoir. This energy storage can take excess power from the grid and excess/waste thermal energy from thermal power plants, and dispatch that energy when it is demanded and thus enable higher penetration of variable renewables, while utilizing thermal energy that would otherwise be wasted. CO_2 stored in the subsurface functions as a cushion gas to provide enormous pressure-storage capacity and displace large quantities of brine, which will flow under artificially-created artesian pressure up production wells. Geothermal power generated from produced CO_2 and brine and energy-storage applications may generate enough revenues to compensate for (or to even exceed) CO_2 capture and storage costs.

To address the CCUS deployment barrier of overpressure, we apply a pressure-management strategy that diverts a portion of the produced brine once a target overpressure is reached at the injection wells. The target overpressure is that determined to be low enough to reduce the risk of induced seismicity, caprock fracture, and CO_2 leakage. Diverted brine is available for beneficial consumptive use, such as for power-plant cooling, or it can be used to generate fresh water using desalination technologies, such as reverse osmosis. The benefit of water generation can be particularly valuable in water-stressed regions. Our analyses indicate that only a small portion (< 5% unless CO_2 is stored at a very high rate) of the produced brine needs to be diverted for the injection wells to remain below the target overpressure. Because the required recovery factor for desalination is relatively small (<5%), a wide range of brine composition can be amenable to economic treatment.

Our approach has several advantages over conventional (e.g., hydrothermal) and enhanced geothermal energy systems (EGS). CO_2 is a very efficient geothermal working fluid. Combined with the benefits of harnessing the overpressure driven by CO_2 storage and the greater lateral extent, permeability, and porosity of sedimentary basins, compared to hydrothermal upflows or artificially-created EGS reservoirs, it allows for much greater spacing between injection and production wells. This efficient use of wells enables utilizing resources with lower temperatures than those of typical geothermal systems, resulting in wider deployment potential. The added benefit of bulk energy storage (BES) creates an arbitrage opportunity that enhances economic viability. Our analyses show that BES achieved by time-shifting the parasitic load of pressurizing our system does not reduce the efficiency of driving fluid recirculation; hence our approach is more efficient than other BES technologies, such as lithium-ion batteries or pumped hydro. Because the primary cost of BES is that associated with oversizing the pumps for fluid reinjection, the capital cost is much less than that of other BES approaches. Moreover, the huge capacity of the subsurface can enable seasonal energy storage, while most other approaches are limited to diurnal storage.

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