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# Development and planning for carbon dioxide (CO2) capture, utilization, and storage (CCUS) infrastructure in geothermal reservoirs

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(1) IPCC. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., et al., Eds.; Cambridge University Press: Cambridge, United Kingdom and New York, NY, USA, 2014. (2) Adams, B. M.; Kuehn, T. H.; Bielicki, J. M.; Randolph, J. B.; Saar, M. O. A comparison of electric power output of CO2 Plume Geothermal (CPG) and brine geothermal systems for varying reservoir conditions. Appl. Energy 2015, 140, 365–377. (3) Middleton, R. S.; Bielicki, J. M. A scalable infrastructure model for carbon capture and storage: SimCCS. Energy Policy 2009, 37 (1), 1052–1060.

**DEVELOPMENT AND PLANNING FOR CARBON DIOXIDE ($CO_2$) CAPTURE, UTILIZATION, AND STORAGE (CCUS) INFRASTRUCTURE IN GEOTHERMAL RESERVOIRS**

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$CO_2$ emissions from human activities are a substantial contributor to climate change.[1] To reduce $CO_2$ emissions on a large scale, $CO_2$-reduction technologies such as $CO_2$ capture and storage (CCS) will need to be competitive with current energy technologies.[1] CCS systems are costly due to the equipment, construction, and energy needed to capture $CO_2$, transport it via a pipeline network, and inject it into deep saline aquifers. In $CO_2$ capture, utilization, and storage (CCUS) systems, the $CO_2$ is used to produce an economically viable product which could reduce the cost of a CCS system. One option is to use the sequestered $CO_2$ as a heat extraction fluid in sedimentary basin geothermal reservoirs ($CO_2$-Geothermal); $CO_2$ extracts heat more efficiently than naturally existing geo-fluid (e.g., brine).[2] $CO_2$-Geothermal would require construction of a geothermal power plant in addition to the infrastructure requirements of CCS. The viability of $CO_2$-Geothermal and CCS in saline aquifers will depend on the infrastructure needed to capture, transport, and inject $CO_2$ from point sources into reservoirs. Despite the additional costs for building and operating a $CO_2$-geothermal power plant, $CO_2$-Geothermal systems could offset the costs of CCS-Saline through the sale of the electricity generated from the geothermal energy.

To compare the viability of CCS-Saline and $CO_2$-Geothermal, we used the *SimCCS* (scalable infrastructure model for CCS) geospatial-optimization, engineering-economic model[3] to determine the infrastructure requirements and supply curves for each technology. *SimCCS* optimizes integrated CCS networks by deciding where and how much $CO_2$ to capture, where to build pipelines, and where and how much $CO_2$ to inject into the reservoir. We adapted *SimCCS* to include the levelized cost of electricity for $CO_2$-Geothermal power plants, which will depend on heat flux and aquifer temperature, permeability, porosity, depth, thickness, and $CO_2$ storage capacity. In an application in Colorado and Louisiana, we collected geothermal, aquifer, and $CO_2$ storage data from the National Geothermal Data System and NATCARB. We chose Colorado and Louisiana as case studies for comparing $CO_2$-Geothermal and CCS-Saline due to the presence of a relatively high heat flux in the Denver and Gulf Coast Basins, aquifers that are capable of storing substantial amounts of $CO_2$, and coal-fired power plants present within the state. $CO_2$ emission rates and locations of coal-fired power plants in Colorado and Louisiana were compiled from EPA data. The costs of $CO_2$ capture at power plants were estimated using the Integrated Environmental Control Model. The costs for CCS-Saline were used as a baseline to compare the supply curves and determine the efficacy of $CO_2$-Geothermal.

The results show that $CO_2$-Geothermal could be profitable and substantially reduce the cost of CCS-Saline systems. $CO_2$-Geothermal is first deployed where storage reservoirs have a higher heat flux resulting in more centralized networks, whereas the networks for CCS-Saline are more decentralized. The results also show that the viability of CCS-Saline and $CO_2$-Geothermal varies with the $CO_2$ storage rate. These results plus future detailed cost and network estimates will be helpful for planners and policy makers to compare technologies such as CCS-Saline and $CO_2$-Geothermal and make informed decisions on $CO_2$-reduction technologies and trajectories.

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**References**

(1) IPCC. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., et al., Eds.; Cambridge University Press: Cambridge, United Kingdom and New York, NY, USA, 2014.

(2) Adams, B. M.; Kuehn, T. H.; Bielicki, J. M.; Randolph, J. B.; Saar, M. O. A comparison of electric power output of CO2 Plume Geothermal (CPG) and brine geothermal systems for varying reservoir conditions. *Appl. Energy* **2015**, *140*, 365–377.

(3) Middleton, R. S.; Bielicki, J. M. A scalable infrastructure model for carbon capture and storage: SimCCS. *Energy Policy* **2009**, *37* (1), 1052–1060.