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Synergies Between Carbon Capture, Utilization and Sequestration and Geothermal Power in Sedimentary Basins

By Anna Littlefield and Eric Stautberg

To achieve a rapid and effective energy transition, society will need to widely deploy both existing and emerging technologies and tools. Mitigating the emissions of greenhouse gases while maintaining the world's growing demands for energy will require these to deployed at great pace and scale. Natural synergies exist between two such technologies: carbon capture utilization and sequestration (CCUS) projects and geothermal power generation from hot sedimentary aquifers. The overlapping technical and operational components of these projects underline an opportunity for cost savings and accelerated deployment. Both technologies also share many of the skills, investments, and project cycles from existing oil and gas operations—making them ripe for transitions.

In CCUS projects, CO_2 is initially captured either directly from the air (Direct Air Capture, DAC) or from an emitting point source, such as a power plant. This CO_2 is then compressed and transported via pipelines to a site where it can safely be injected into a subsurface reservoir for permanent storage. Sedimentary basins across the world possess reservoirs viable for injection, representing immense volumetric storage capacity for CO_2. The most recent report from the IPCC makes it clear that CCUS is a critical tool, not only for industrial processes for which emissions are hard-to-abate, but also for reaching mitigation goals with expediency.

Geothermal, in contrast, is a power generating process that avoids creating emissions by utilizing the natural heat flow from the earth to generate electricity. While historically this technology has been concentrated in areas with high volcanic heat flow, there is a push to deploy geothermal in sedimentary basins across the United States that were not previously considered viable for geothermal development. Advances in drilling technologies and well completion techniques from the oil and gas sector are now being applied to exploration and development of low temperature (100-150 °C) geothermal resources in these sedimentary basins. Geothermal projects can be established by drilling new wells or re-purposing existing oil and gas wells and can either use brine or a working fluid such as CO_2.

Despite the recent crescendo of conversation, attention and funding directed towards the fields of CCUS and geothermal, the operational mechanisms for both depend on technologies that have been utilized for decades. For different reasons, both industries also face challenges in scaling up and establishing economically viable projects. These challenges highlight the importance of utilizing all reasonable options for optimizing projects, including co-development and spatial overlap.

In the United States, the Gulf Coast basins possess ideal geologic characteristics for both geothermal exploration and CCUS development. Thick, permeable reservoir successions are ideal for storing high volumes of CO_2, while water saturations and temperatures are optimal for geothermal energy. This subsurface setting, prime for both industries, underlines the potential for significant spatial overlap for facilities and co-development of projects, lowering costs for each. Proximity to a high concentration of emitting sources and existing infrastructure may also benefit project economics.

Depending on the well design, geothermal operations may utilize either an open loop system-- where hot brines are brought to the surface and pass through a binary cycle power plant -- or a closed loop system where fully cased wells extract heat from the subsurface, with no direct interaction with reservoir fluids. The latter depends on a working fluid such as CO_2, natural or halogenated hydrocarbons, or ammonia. CO_2 has been proposed as an ideal working fluid because of its high latent heat capacity and good convective properties. Co-developing geothermal that utilizes CO_2 and CCUS projects benefits both efforts operationally by utilizing existing CO_2 infrastructure and lowering transportation expenses. Additionally, electricity generated from geothermal can be used to power CCUS facilities and operations on site.

CO_2 plume geothermal is an even more explicit opportunity for overlap between the two industries. When CO_2 is sequestered in the subsurface for long term storage, the naturally elevated reservoir temperatures are enhanced by the buoyancy-driven convection of CO_2. This heat capacity and natural convection creates an ideal target for geothermal exploration. With a symbiotic system like this, energy generation on site and efficiencies for both projects can be augmented.

Another important aspect of the energy transition are the implications for the nation's workforce. Lessons learned from a shrinking coal industry and the associated economic impacts have led to a focus on a just transition for an anticipated decline in fossil fuel demand. A geothermal and CCUS workforce would share similarities with each other, and more importantly with the oil and gas industry which already boasts an immense and highly skilled work force. At every level, from wellsite operations to technical exploration efforts, similar roles will exist in CCUS and geothermal industries as do for the oil and gas industry. The preservation and re-purposing of this skilled labor force is of equal importance in ensuring that a successful transition is a collective success.

The aggressive goals set by private industry and government bodies alike to decarbonize and pivot our energy systems to low-carbon sources will require an all-hands-on-deck approach with respect to emerging energy technologies and skilled labor. Geothermal represents a clean and sustainable energy alternative, while CCUS addresses both existing atmospheric CO_2 and difficult-to-decarbonize industries that will require longer periods of transition. While challenges will certainly exist with co-developing two highly technical industries, collaborative efforts have the potential to provide long term cost savings and accelerate project development. Both industries are well-positioned for overlap that will strengthen their viability as key pillars in the future energy landscape. Exploring other complimentary technologies, project efficiencies and workforce synergies will be critical in accelerating global energy transitions.

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Anna Littlefield is the Program Manager for Carbon Capture Utilization and Sequestration for the Payne Institute at the Colorado School of Mines. As a current PhD student in the Mines geology department, her research focuses on the geochemical impacts of injecting CO2 into the subsurface as well as the overlap of geotechnical considerations with policy-making. Anna joins the Payne Institute with 8 years' experience in the oil and gas industry, where she worked development, appraisal, exploration, new ventures, and carbon sequestration projects. Her academic background is in hydrogeology with an M.S. in geology from Texas A&M University, and a B.S. in geology from Appalachian State University. Anna is passionate about addressing both the societal and technical challenges of the energy transition and applying her experience to advance this effort.

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Eric Stautberg is a PhD student in the Mudrocks and Tight Oil Characterization Research Consortium in the Department of Geology and Geological Engineering at Colorado School of Mines. His current research is focused on identifying sedimentary geothermal play types on the Texas Gulf Coast and developing exploration methods to help characterize and evaluate geothermal resources for power generation. Prior to Colorado School of Mines, Eric worked in the oil and gas industry for 7 years as an exploration geologist, prospecting and drilling wells in multiple Gulf Coast basins and the Permian Basin. He has a M.S. in Geological Sciences from the University of Texas at El Paso where his research was focused on carbonate sedimentology and stratigraphy and a B.S in Geology from Texas A&M University. Eric is applying subsurface exploration methods from the oil and gas sector to help bring geothermal energy to regions of the U.S. without previous geothermal energy development.

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