November, 2021

Subsurface Carbon Energy Storage (CES) in legacy Oil and Gas Reservoirs for Zero Carbon Electric Grids

Executive Summary

GeoSierra has adapted its multi-azimuth propped vertical sand plane technology[1] to be an effective method for sub-surface closed cycling of supercritical carbon dioxide (sCO_2) in legacy oil and gas reservoirs to develop a large scale, efficient, robust Carbon Energy Storage (CES) scheme to achieve zero carbon electric grids. Excess electricity generated from renewables is stored as potential energy, by pumping the sCO_2 from the shallow reservoir down to the deep reservoir, in which the sCO_2 has sufficient residence time to be heated to the deep reservoir temperature before being produced for electrical generation. The CES scheme in the legacy oil and gas reservoirs around Bakersfield, CA is a net generator of electricity, i.e. it generates 20% more electricity in the generation mode than it consumes in the storage mode from the renewables, due to the high efficiency of sCO2 as a subsurface working fluid and the ambient temperature of the deep reservoir. The CES scheme's capacity can be dynamically configured to accommodate large seasonal changes in renewable generated electricity. For example, during icing conditions, wind powered electrical generation can fall off dramatically, requiring a robust CES scheme, to match supply to demand. The multi-azimuth sand planes, propped with garnet sand, see Figure 1b), enables the CES scheme to achieve the high injection and production flow rates to be commercially viable on electrical generated revenue alone.

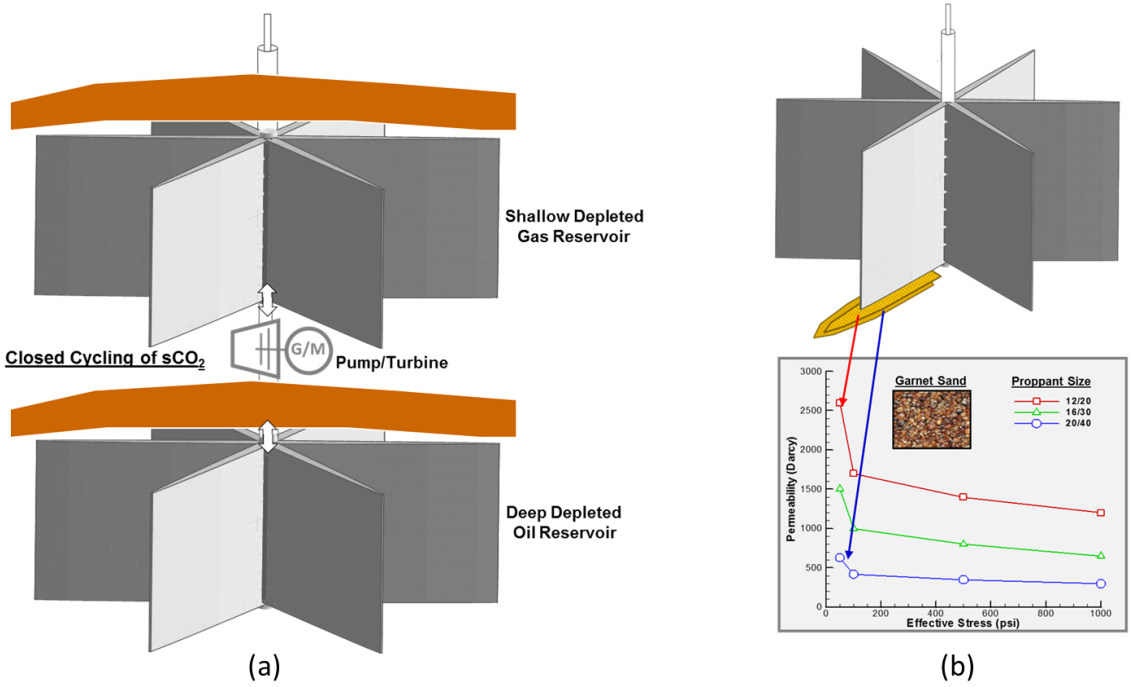

Figure 1. Subsurface Carbon Energy Storage, a) Closed Cycling of Supercritical Carbon Dioxide between Shallow and Deep Reservoirs, and b) Multi-Azimuth Garnet Sand Propped Well.

1. Hocking, G., T. W. Cavender, J. Person and T. Hunter. 2012. "Single-Well SAGD Field Installation and Functionality Trials", Paper presented at the SPE Heavy Oil Conference Canada, Calgary, Alberta, Canada, June 2012. doi: https://doi.org/10.2118/157739-MS.

The CES scheme not only has electrical generated revenue, but also revenue from a carbon storage tax and from additional oil recovered by gravity drainage. The turbidite reservoirs around Bakersfield have a low vertical permeability limiting primary pressure depletion oil recovery to 35% of OOIP; whereas, the installed vertical multi-azimuth sand planes enable gravity drainage thus increasing oil recovery to ~70% of OOIP, albeit at a slow rate. The turbidite reservoirs around Bakersfield are anelastic, and thus can't be fracture enhanced by conventional hydraulic fracturing. These reservoirs are ideal for the multi-azimuth sand plane technology, since the reservoir anelasticity ensures the self-propagating fluidized inclusions remain on azimuth. To achieve a zero carbon electric grid, California would require 25,000MWe of CES, which could easily be accommodated in the turbidite reservoirs around Bakersfield.

The patented multi-azimuth sand plane technology was jointly developed by GeoSierra and Halliburton, with GeoSierra having the exclusive rights to the technology outside hydrocarbon recovery field of use, and the non-exclusive rights along with Halliburton in the field of use of hydrocarbon recovery. GeoSierra have developed an open hole completion procedure for the multi-azimuth sand plane technology that is currently patent pending. Each multi-azimuth well consists of six (6) multi-azimuth highly permeable propped sand planes installed at varying azimuths throughout the reservoir thickness, thus minimizing the impact of low vertical permeability and geological heterogeneities on the CES system performance. The garnet sand proppant is chemically and mechanically stable under high temperatures in the presence of sCO_2, and has an extremely high in-place permeability. A schematic of the subsurface CES scheme is shown in Figure 2.

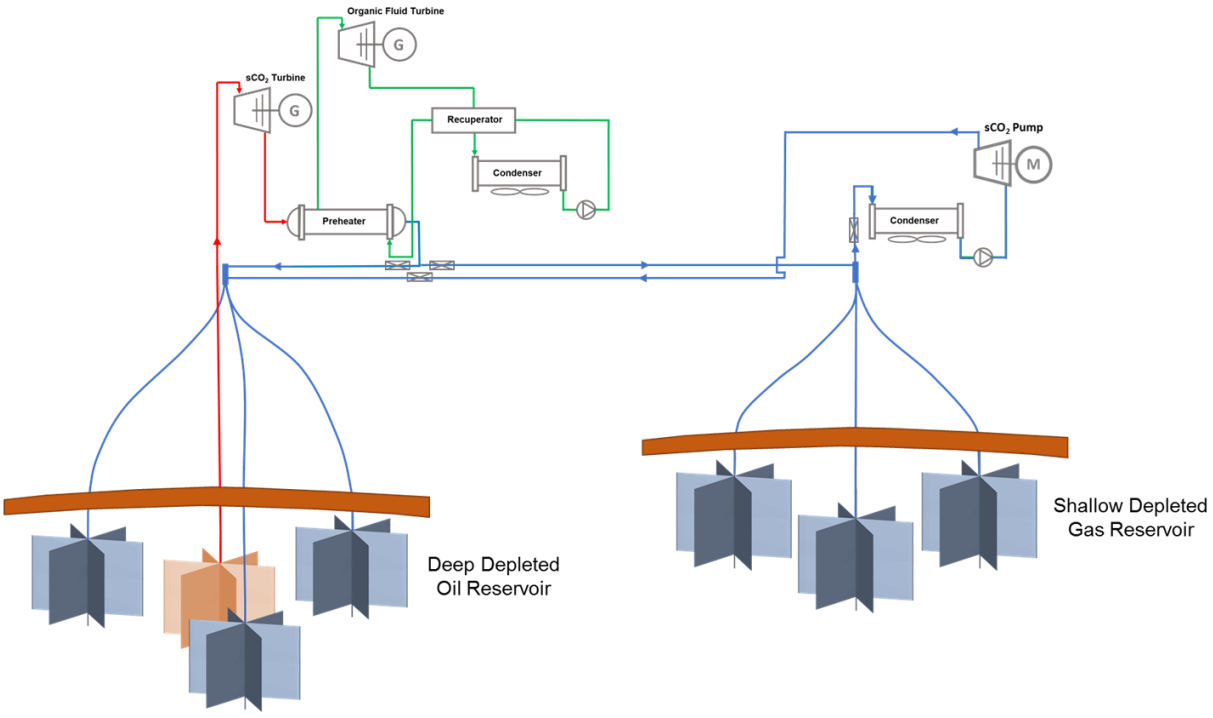

Figure 2. Schematic of Subsurface Carbon Energy Storage Scheme, with the Dynamic Capability of Modifying the Storage/Generation Capacity.