Techno-economic tradeoffs of CO_2 fluid in geothermal plant

Y. Al hararmi[1], *A. Menefee*[2], *B. Schwartz*[3], *M. Poplawski*[4], *A. Alfarhan*[5]

Department of Energy and Mineral Engineering, Penn State, University Park, PA [1,2,3,5]

Department of Civil Engineering, Michigan Technological Univeristy [4]

Introduction

- Geothermal power is considered one of the most consistent forms of renewable electricity.
- Traditionally, water is used as a circulating fluid for heat extraction and subsequent power production, but it has been proposed that CO2 can be circulated through porous, permeable formations to produce geothermal power while storing CO2, also known as CO2 plume geothermal (CPG).
- In this study, we conduct a techno-economic analysis comparing the use of water and CO2 as a circulating fluid in porous geothermal reservoirs.
- We include capital and operating costs for each fluid, as well as production tax credits for renewable electricity generation and CO2 storage credits through the 45Q tax amendment.
- We conduct Monte Carlo simulations on all possible combinations of inputs, resulting in 3,072 cost outputs for each fluid. In the median 50% of outputs, the average rate of return is 20% for a CO2 project and 22.9% for water, while the average NPV is 42.3% greater for water than for CO2.

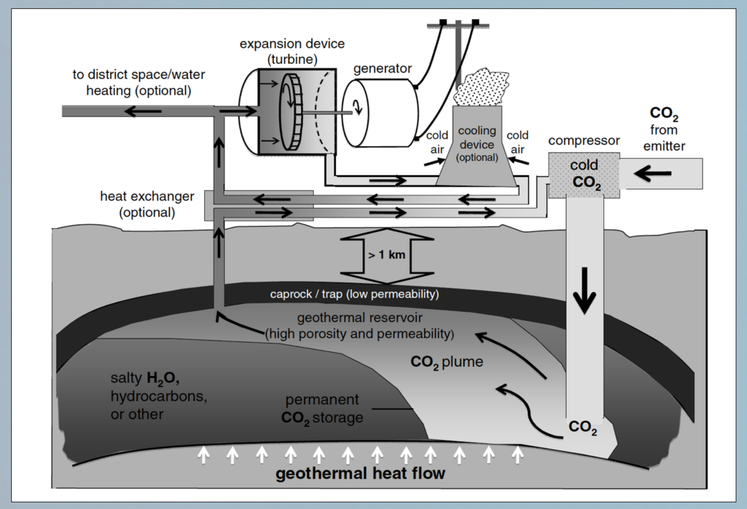

Figure 1. simplified implementation of CPG

Methods

- In the following, an economic cashflow model was implemented for both conventional geothermal powerplant as well as CPG.
- Various variables were employed on both costs and revenue in the techno-economic analysis.
- We use MATLAB and Excel to compute project costs and conduct Monte Carlo simulations.

Input	Geothermal plant	***CPG***
Site CAPEX	Site from DOE (2.5 – 5.5 KW]	Same
Transport CAPEX	0	$2 million – $100 million
Site OPEX	5% of CAPEX	LC – CO_2 compress / transport $30-$60/ton CO2
Mass of CO_2 sequestered in tons	0	21000 t CO_2 / MW capacity
Working power	10MW – 20MW	(20%-50%)(10M-20M)
PTC	$0.025/KWh	$0.025/KWh
45 Q CO_2 credit	-	($35-$85)
Electricity sales	$0.09-$0.14 kwh	
Commercial tax rate	22%	22%
Project life	30 years	30 years

Table . Parameters used on the simulation

- A case study was conducted that examines the proposed use of CPG geothermal powerplant in California as a supporting alternative to conventional geothermal powerplant.
- The study focuses on geothermal powerplants with depth ranging from (3-10km) that offers adequate reservoir temperatures.
- The case study has taken into consideration that CC(U)S plants are located within 200 miles from the Geysers..

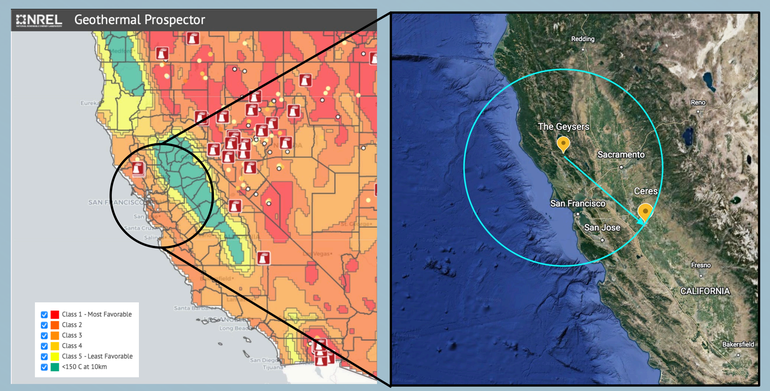

Figure 2. heat map of California

Results

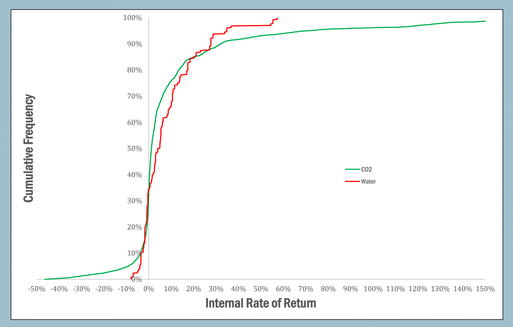

Figure 3

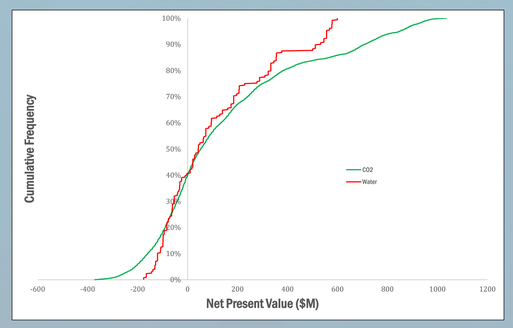

Figure 4

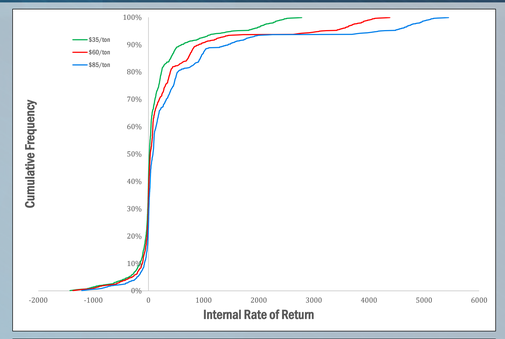

Figure 5

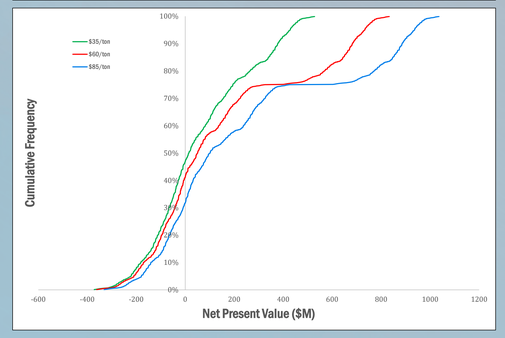

Figure 6

Conclusion

- These results suggest using CO2 as a replacement fluid to water could be an economically viable and sustainable means of geothermal power production.
- Moreover, CPG has the potential of generating electricity from wasted CO2 and can be used in regions where water is a limited resource.

Future work

- Extend this technology to aging oil and gas reservoirs.
- More detailed site studies on CO2 capture technologies and availability in the region of geothermal reservoir.
- In addition, extend studies on transporting and optimizing CO2 to increase the efficiency and harness maximum heat.

References

Randolph, J. B., & Saar, M. O. (2011). Coupling carbon dioxide sequestration with geothermal energy capture in naturally permeable, porous geologic formations: Implications for CO2 sequestration. *Energy Procedia*, *4*, 2206-2213.

Adams, B. M., Vogler, D., Kuehn, T. H., Bielicki, J. M., Garapati, N., & Saar, M. O. (2021). Heat depletion in sedimentary basins and its effect on the design and electric power output of CO2 Plume Geothermal (CPG) systems. *Renewable Energy*, *172*, 1393-1403.

Gupta, N., & Vashistha, M. (2016). Carbon dioxide plume geothermal (CPG) system-a new approach for enhancing geothermal energy production and deployment of CCUS on large scale in India. *Energy Procedia*, *90*, 492-502.

Bedre, M. G., & Anderson, B. J. (2012). Sensitivity analysis of low-temperature geothermal reservoirs: Effect of reservoir parameters on the direct use of geothermal energy. *TrGRC*, *36*, 1255-1261.

Moran, Sean, Lauren Collins, and David Cole. "Clean Energy Tax Proposals in Biden's New 'Build Back Better' Framework: Insights: Vinson & Elkins Llp." Vinson & Elkins, November 2, 2021. https://www.velaw.com/insights/clean-energy-tax-proposals-in-bidens-new-build-back-better-framework/.

US Department of Energy. (n.d.). Geothermal fags. Energy. gov. Retrieved July 22, 2022, from https://www.energy.gov/eere/geothermal/geothermal-faqs

Google Earth. (2022). Google Earth. https://earth.google.com/web/@38.19236897,-120.62859667,121.8573975a,1439948.67663994d,35y,-0.0000071h,0t,0r

PennState College of Earth and Mineral Sciences

John and Willie Leone Family Department of Energy and Mineral Engineering