Geothermal Energy: Mining the Oil Sands While Sequestering CO2

INTRODUCTION

What is our technology?
- Utilizing an Enhanced Geothermal System (EGS) to heat water through a heat exchanger [1]
- Store CO2 by using CO2 as the EGS working fluid [2]
- Combine both technologies to provide hot water for separating bitumen from oil sands in surface mining operations.
- Natural gas normally burned is conserved, results in reductions of CO2 emissions on top of the CO2 stored

What is an Enhanced Geothermal System (EGS)?
- High pressure working fluid is pumped down into a reservoir of fractured impermeable rock to extract heat
- Alberta has reservoir temperatures of 120°C at depths of 5km around Fort McMurray area [5]
- This temperature is adequate for the hot water used in separating bitumen from the oil sands in surface mining operations [5]

METHODOLOGY

Process
- Implementation starts in 2020 with a single pilot plant
- 100 MW capacity is added yearly, each plant is 1.5 PJ (48 MW) and sequesters 286,000 tCO2/year [2]
- Geothermal implementation stops at 2038 as CanESS model shows leveling off of energy demand from adequate capacity [4]

Assumptions
- CO2 does not react with rock in reservoir
- Infinite CO2 storage capacity for reservoir
- Operations of geothermal plant is CO2 emission free
- Plants operate at 100% capacity

METHODOLOGY

RESULTS

➢ Diesel consumed from trucks used in extraction process remains constant
➢ Increase in electricity demand and emissions for EGS. Results from energy needed to capture and compress CO2, 43 kWh/tCO2 and 61 kWh/tCO2 respectively [3] (more info in discussion)
➢ Reduction in natural gas consumption and emissions for both EGSs with net emissions of the CO2 EGS System found to be 0.21 tCO2e per barrel in the year 2060

➢ Electrical demand increased by 100 MWe in 2060
➢ Increased electricity use of 28.6 TWh overall
➢ EGS projected to relieve 57.1PJ of natural gas demand
➢ 1,820 PJ of natural gas saved overall
➢ Total projected storage of CO2 in 2060 expected to be 8.6 Mt CO2e
➢ Overall storage is projected to be 268 Mt CO2e
➢ A total net reduction of 346Mt of CO2e is predicted

➢ With our proposed model, an EGS with H2O as the working fluid would reduce total emissions by 78 Mt CO2e
➢ If CO2 is used as a working fluid, storage of the CO2 results in a further reduction of 268 Mt CO2e
➢ During the year 2060, the reference scenario predicts emissions of 223 Mt CO2e
➢ H2O EGS would reduce emissions to 19.8 Mt CO2e
➢ CO2 EGS reduces emissions further to 11.4 Mt CO2e

DISCUSSION

Challenges
This study is limited by the unknown interactions CO2 will have with our EGS reservoirs. This interaction is important and requires further study as they determine the specific storage capacity. Storage capacity of the reservoir will depict how much CO2 we can actually sequester. For simplicity, we assumed an infinite storage capacity which is unrealistic and thus inflated our CO2 storage values.

Due to lack of applicable data, our group used values for the capture and compression energy needed for CO2 to provide a base value for the amount of electrical energy required for the pumps. However, we anticipate the true value to be higher as we are pumping the CO2 down 5km wells and back to the surface. Complications also need to be resolved on the possibility of keeping our CO2 as a liquid throughout injection and extraction.

EGS also has locational issues as extracted heat cannot be piped over large distances without large heat losses. The EGS wells would need to be localized to the mining area to retain the extracted heat.

Finally, our model does not account for the emissions associated with setting up a EGS plant. The most carbon intensive processes include drilling and fracking of the reservoirs. Thus, further analysis must be conducted in order to obtain a full life cycle assessment of the emissions reduced.

CONCLUSIONS

The oil sands in Alberta are a large contributor to greenhouse gas emissions and provide a unique opportunity to utilize geothermal energy to minimize the impact. This can be achieved from an EGS system with CO2 as the working fluid to provide the hot water required in separating bitumen from the oil sands for surface mining operations. CO2 is used as it can be simultaneously stored underground and thus further reduces emissions. Although this unproven technology has some limitations, our model showed reduction of emissions by 9.9 Mt CO2e per year by 2038. 79% of the reductions result from the storage of CO2. Once again, these are optimistic values as further research and deeper analysis is required to account for the challenges associated with the technology.

ACKNOWLEDGEMENTS

Thank you Dr. D. Layzell, Dr. B. Straatman, and Dr. H. Hamza for your guidance throughout our project along with whatif? Technologies for their CanESS model. Additional thanks to our advisors for their support.

REFERENCES