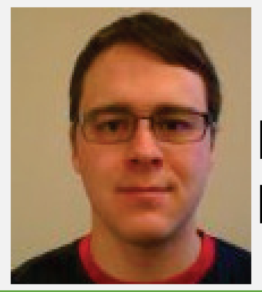
Geothermal Energy: Mining the Oil Sands While Sequestering CO_2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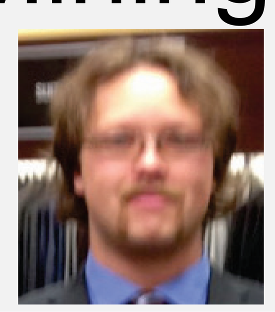
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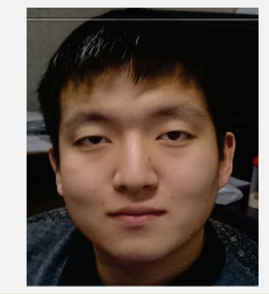
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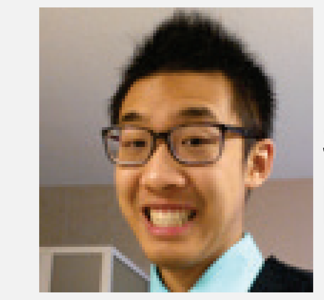
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INTRODUCTION

What is our technology?

- Utilizing an Enhanced Geothermal System (EGS) to heat water through a heat exchanger [1]
- Store CO_2 by using CO_2 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 CO_2 emissions on top of the CO_2 stored

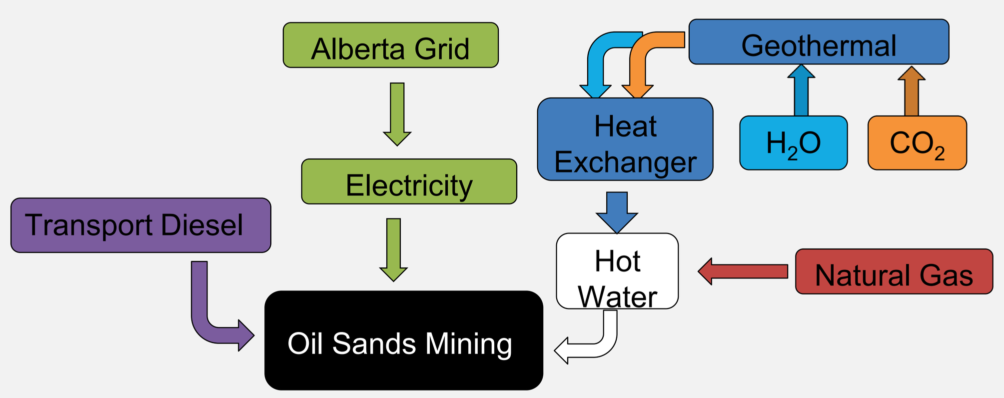


Figure 1: Logic flow of our proposed system model

Note: Normally H_2O is used as working fluid in an EGS. We modelled both scenarios separately to compare emission reductions.

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]

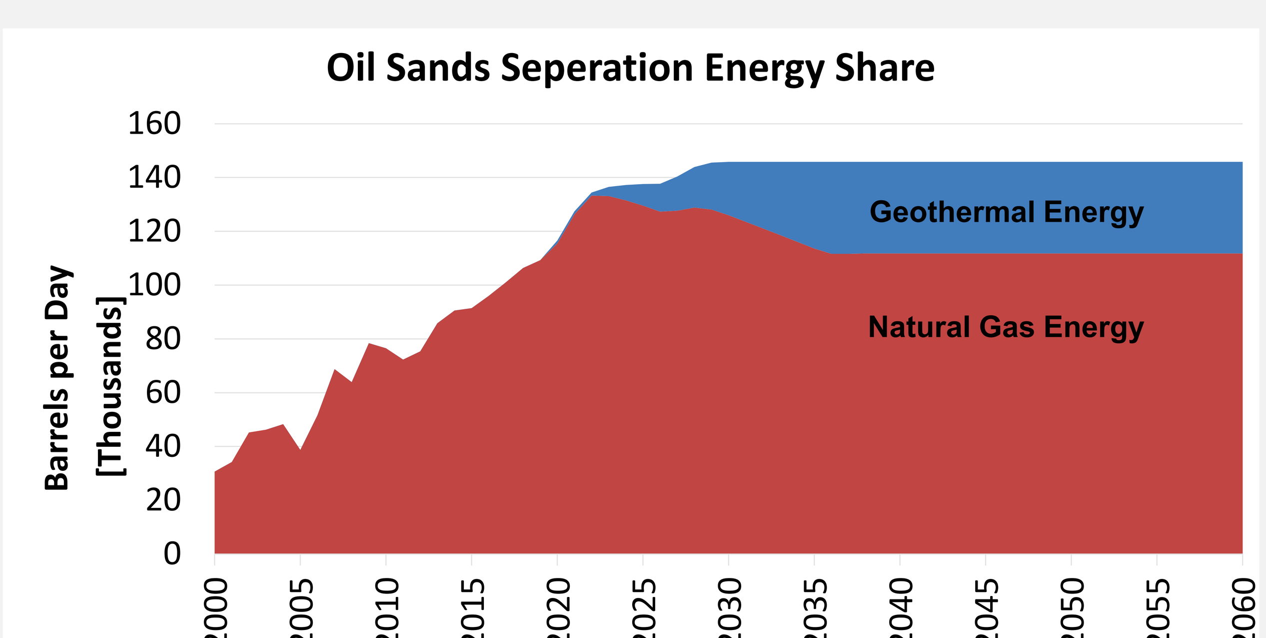
METHODOLOGY

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 tCO_2/year [2]
- Geothermal implementation stops at 2038 as CanESS model shows leveling off of energy demand from adequate capacity [4]

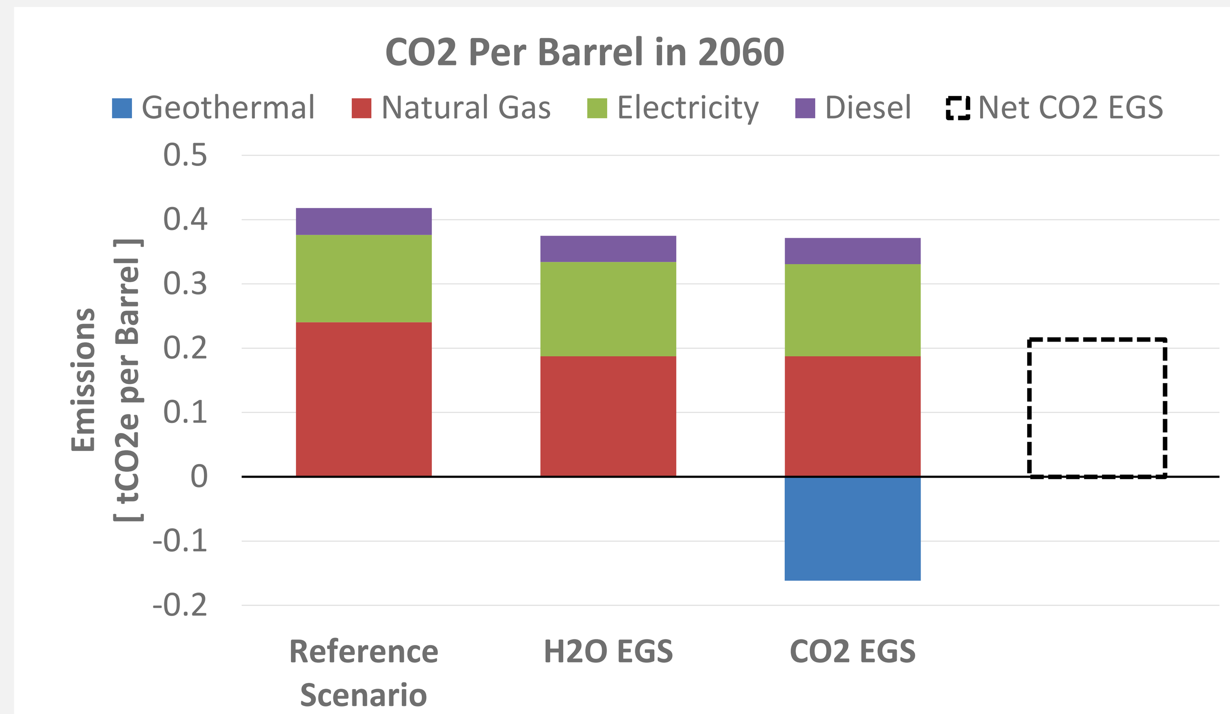
Assumptions

- CO_2 does not react with rock in reservoir
- Infinite CO_2 storage capacity for reservoir
- Operations of geothermal plant is CO_2 emission free
- Plants operate at 100% capacity

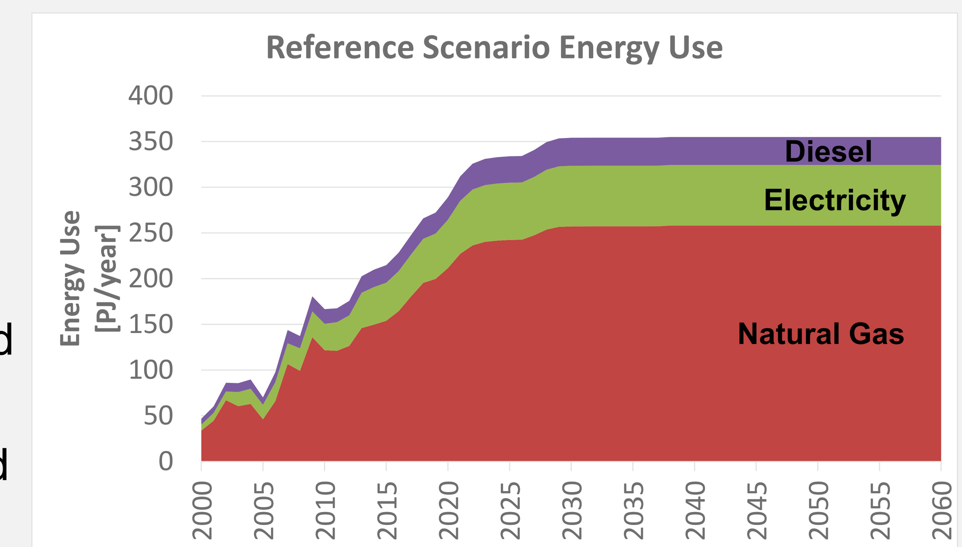


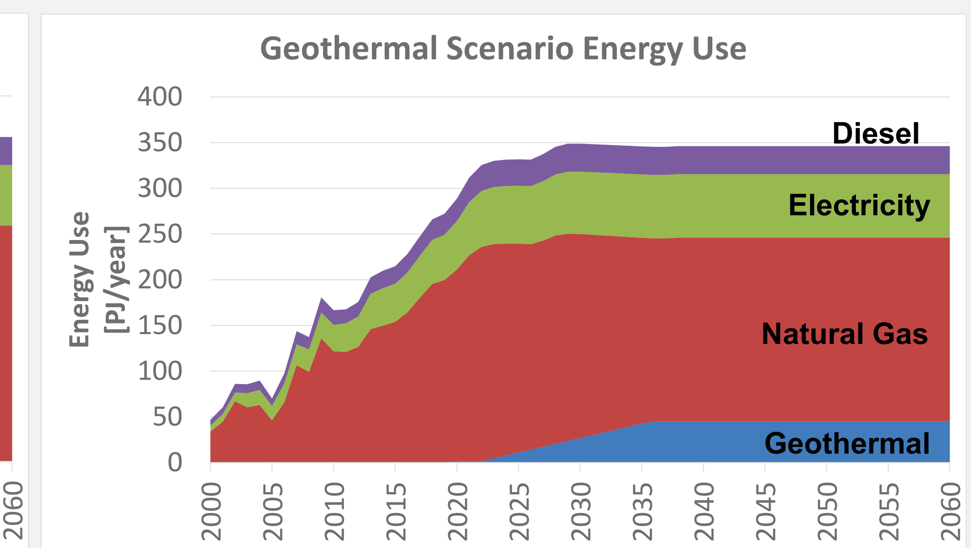
Note: System is not fully replacing existing natural gas infrastructure

RESULTS

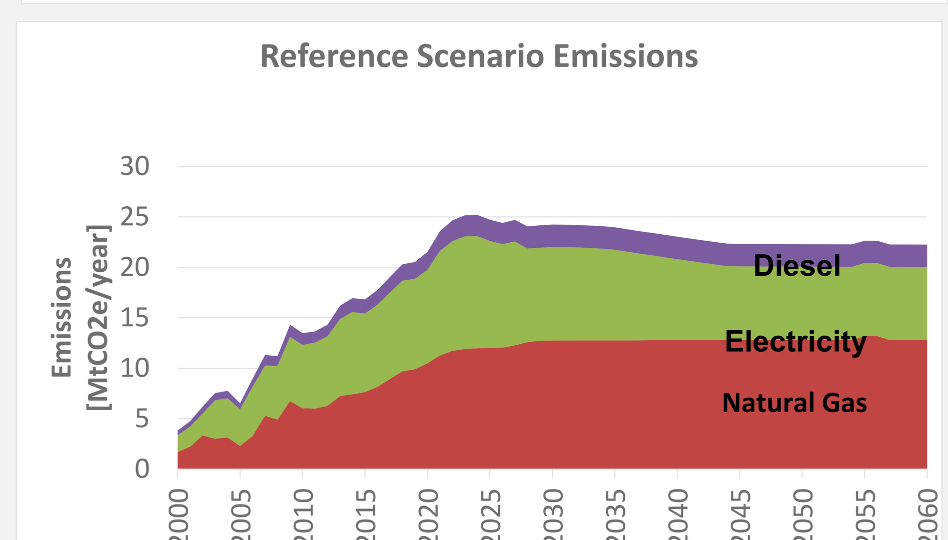


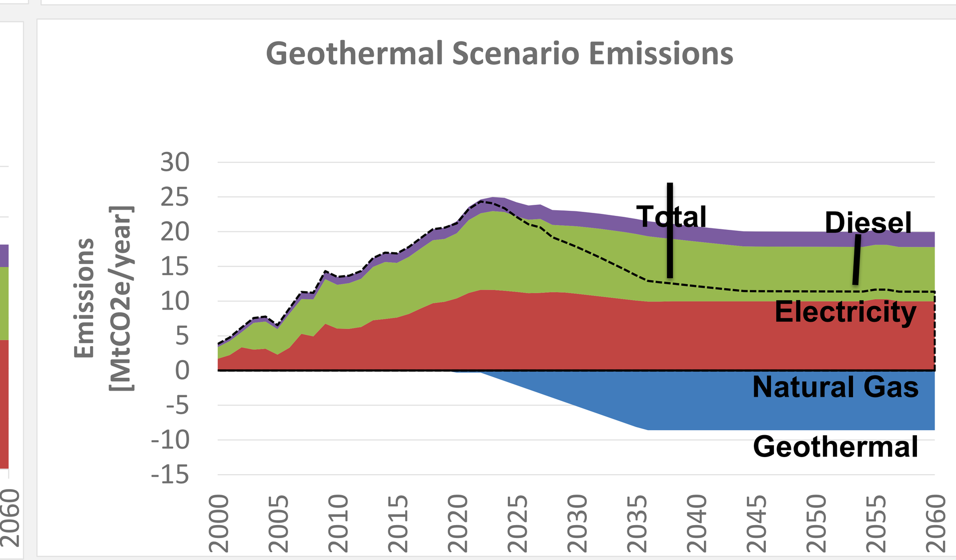
- Diesel consumed from trucks used in extraction process remains constant
- Increase in electricity demand and emissions for EGS. Results from energy needed to capture and compress CO_2, 43 kWh/tCO_2 and 61 kWh/tCO_2 respectively [3] (more info in discussion)
- Reduction in natural gas consumption and emissions for both EGSs with net emissions of the CO_2 EGS System found to be 0.21 tCO_2e per barrel in the year 2060



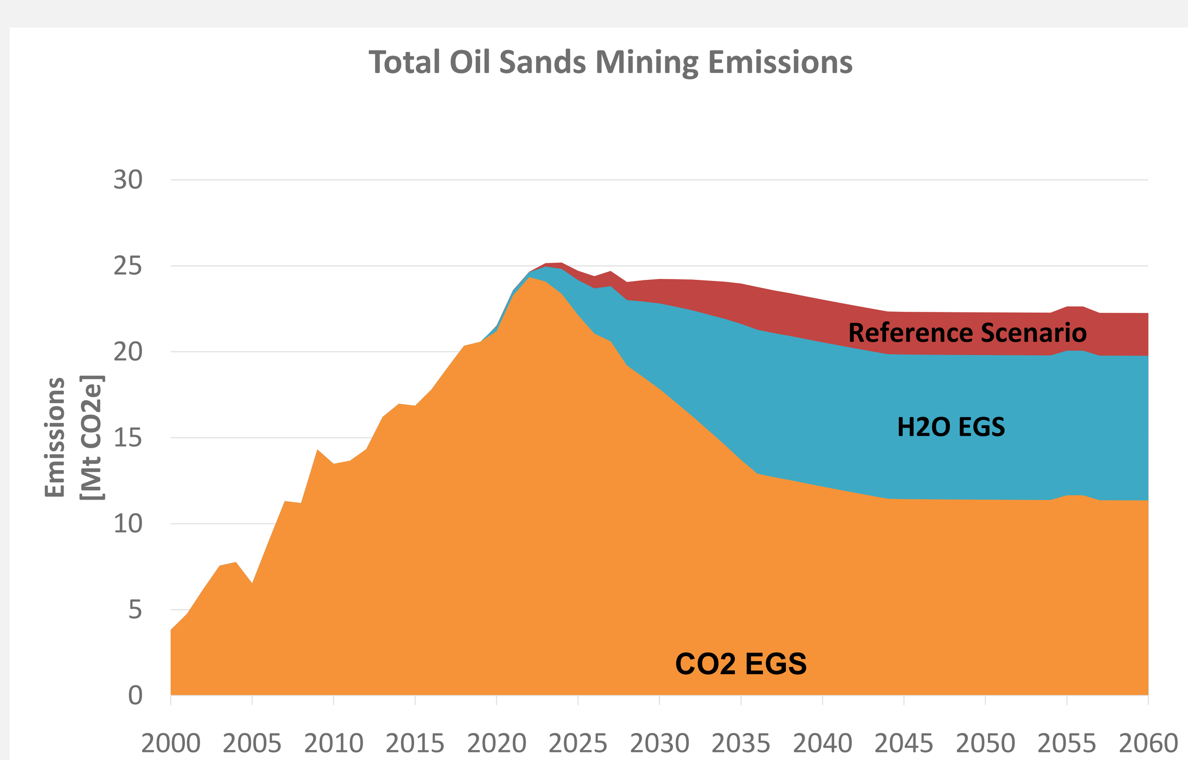


- Electrical demand increased by 100 MWe in 2060
- Increased electricity use of 28.6 TWh overall
- EGS projected to relieve 57.1PJ of natural gas demand in 2060
- 1,820 PJ of natural gas saved overall





- Total projected storage of CO_2 in 2060 expected to be 8.6 Mt CO_2e
- Overall storage is projected to be 268 Mt CO_2e
- A total net reduction of 346Mt of CO_2e is predicted



- With our proposed model, an EGS with H_2O as the working fluid would reduce total emissions by 78 Mt CO_2e
- If CO_2 is used as a working fluid, storage of the CO_2 results in a further reduction of 268 Mt CO_2e
- During the year 2060, the reference scenario predicts emissions of 22.3 Mt CO_2e
- H_2O EGS would reduce emissions to 19.8 Mt CO_2e
- CO_2 EGS reduces emissions further to 11.4 Mt CO_2e

DISCUSSION

Challenges

This study is limited by the unknown interactions CO_2 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 CO_2 we can actually sequester. For simplicity, we assumed an infinite storage capacity which is unrealistic and thus inflated our CO_2 storage values.

Due to lack of applicable data, our group used values for the capture and compression energy needed for CO_2 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 CO_2 down 5km wells and back to the surface. Complications also need to be resolved on the possibility of keeping our CO_2 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 intense 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 CO_2 as the working fluid to provide the hot water required in separating bitumen from the oil sands for surface mining operations. CO_2 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 CO_2e per year by 2038. 79% of the reductions result from the storage of CO_2. Once again, these are optimistic values as further research and deeper analysis is required to account for the challenges associated with the technology.

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