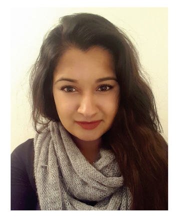
Heat Recovery From Depleted SAGD Reservoirs

To Generate Green Electricity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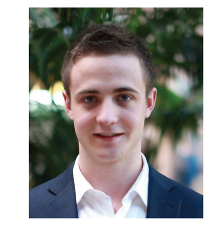
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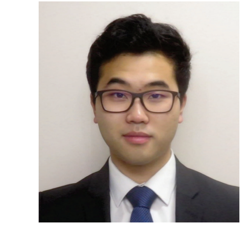
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INTRODUCTION

After 6 years of SAGD operation, roughly 50% of injected heat is left underground [1]. By injecting water into the heated region, 25% of the injected heat could be recovered via produced hot water [1].

Harnessing this leftover heat with an organic Rankine cycle (ORC) to produce GHG free electricity will offset the net carbon emissions of the grid.

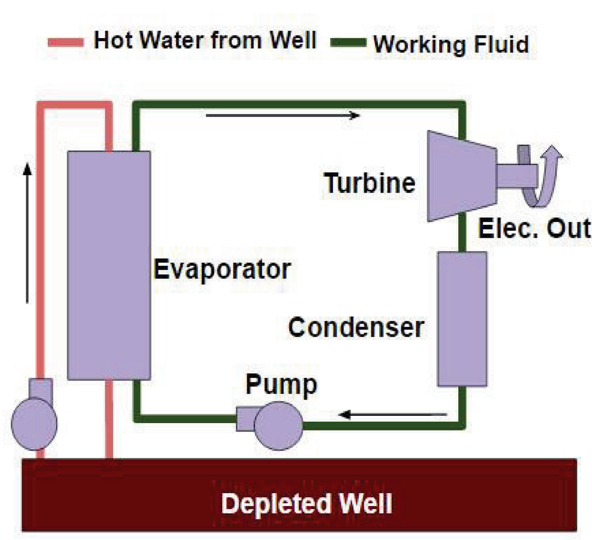


Fig.1. Schematic of an Organic Rankine Cycle

METHODS

- Each 33 000 bpd SAGD facility is assumed to have 6 well pads, each with 8 well pairs.
- Well pairs produce for 6 years then undergo 3 years (worst case) to 5 years (best case) of heat recovery depending on the heat recovery rate.
- Electricity generated per well pair is equal and scalable.
- Annual emission reduction is calculated using the yearly electricity generation and the carbon intensity of Alberta's electrical grid.

Fig. 2. Produced Water Temperature Profile

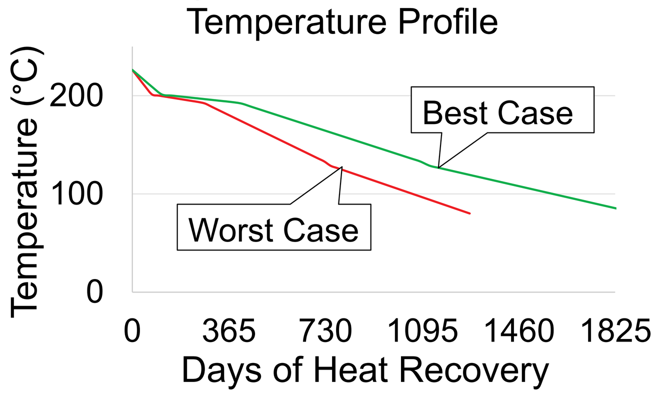


Table 1. ORC Efficiency

Year	% (Worst Case)
1	18.72
2	17.52
3	12.48

Fig. 3. Daily ORC Output

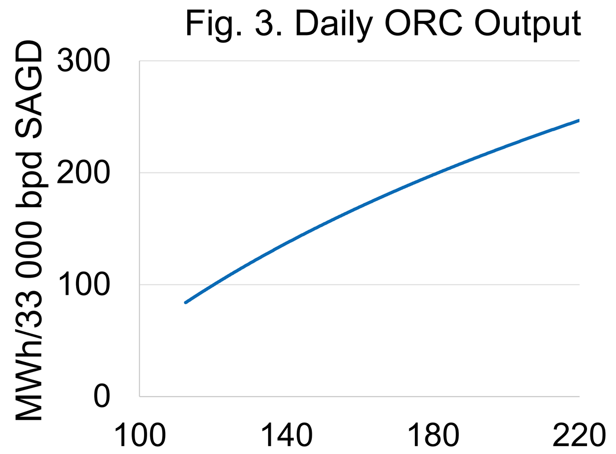
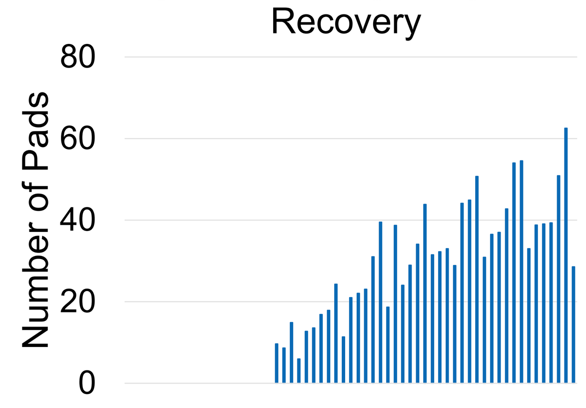
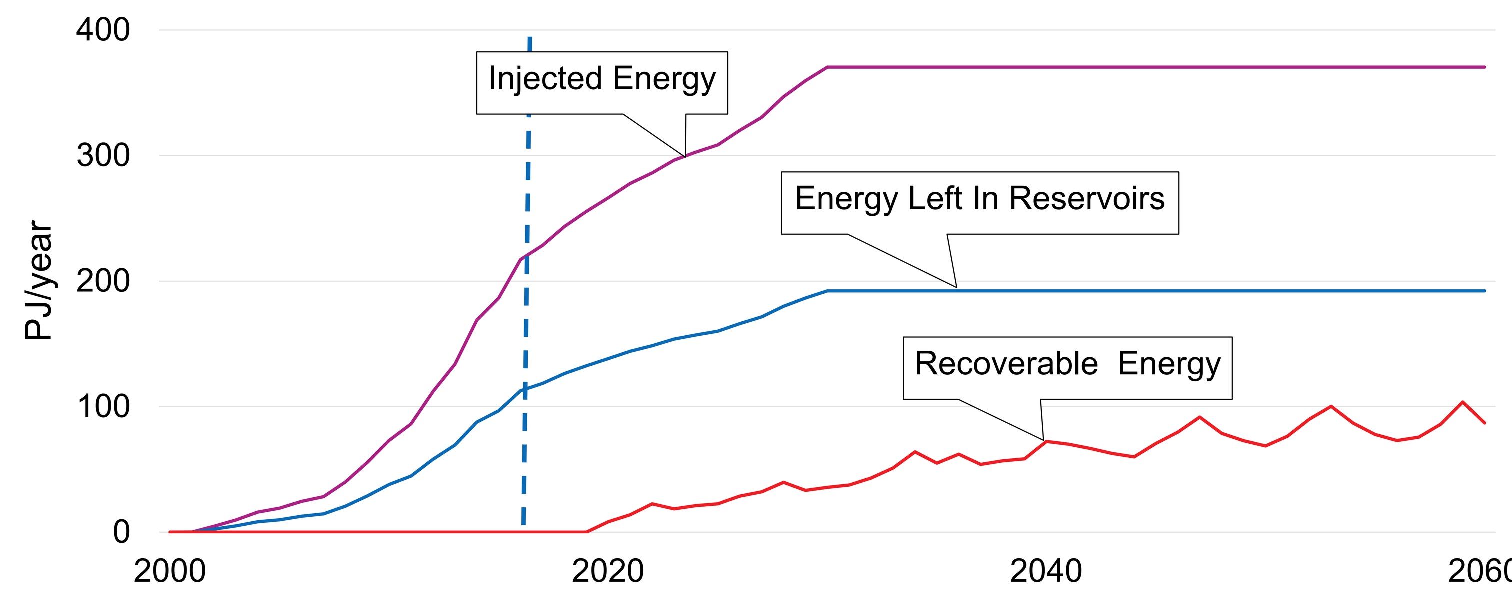


Fig. 4. Pads Beginning Heat Recovery



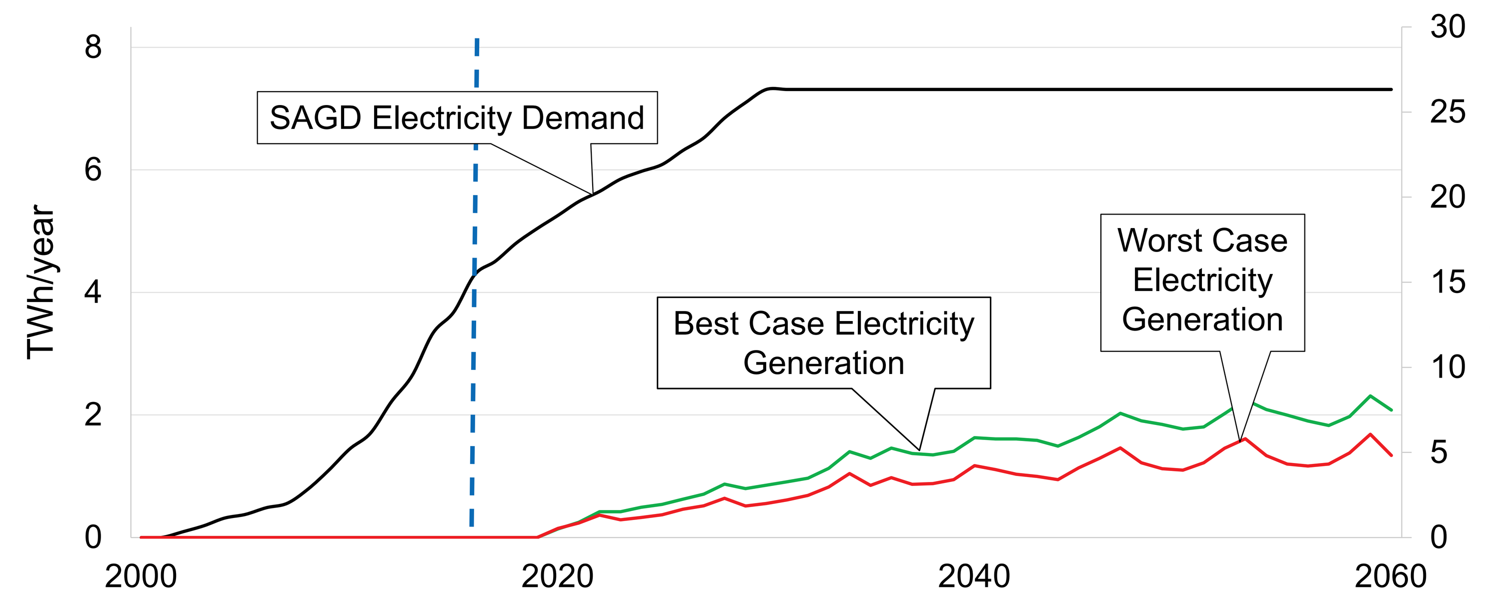
ALTERNATIVE SCENARIO RESULTS

Heat Recovery
Recoverable energy from produced hot water shown is the worst case [1].



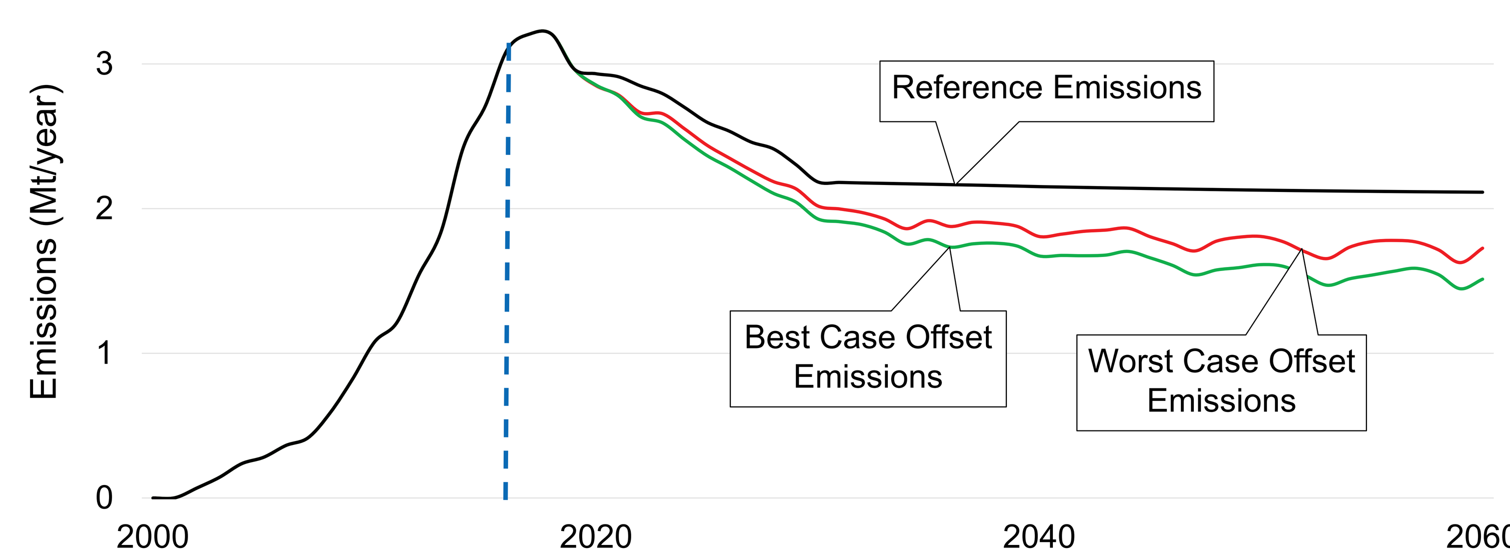
- Peaks in recoverable energy are due to irregular ORC project additions shown in Fig. 4.

Electricity Generation
Best and worst case scenarios based on heat recovery rates shown in Fig. 2.



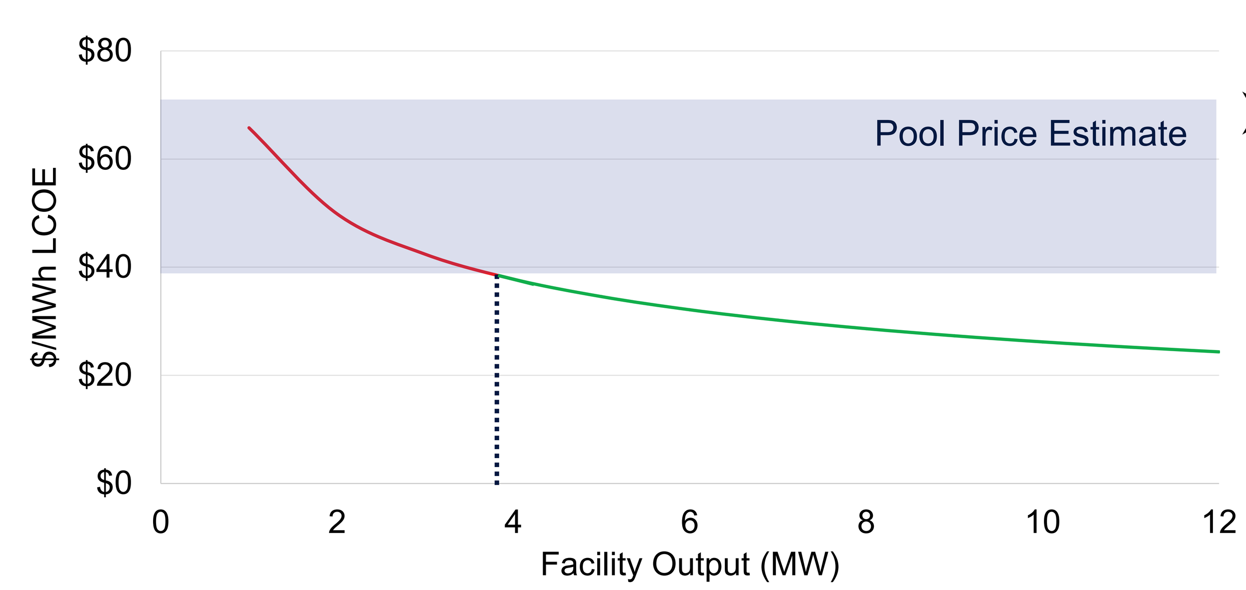
- 1.3 to 2.0 TWh/year (4.7 to 7.2 PJ/year) can be generated by 2060.

Emission Offset
Reference emissions are due to SAGD electricity import.



- Decline in emissions from imported power due to coal phase-out [3].
- Emissions can be offset by 0.39 to 0.58 Mt/year by 2060.

Economics
The levelized cost of electricity (LCOE) of ORCs is based on a range of MW outputs in Northern Alberta. A range of pool prices are considered. The blue region is an estimated nominal Alberta pool price for the next 10 years [6][7].



- If the facility output is such that the LCOE is below the pool price of electricity, heat recovery is profitable.

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[7] E. Derouane, Sustainable strategies for the upgrading of natural gas, 1st ed. Dordrecht: Springer, 2005.

DISCUSSION

Heat recovery from depleted SAGD wells can produce between 1.3 and 2.0 TWh/year of electricity by 2060. This corresponds to a GHG emission reduction of between 0.39 and 0.58 Mt/year by 2060 which represents 19-28% of emissions associated with electricity use in the SAGD sector. Due to the declining carbon intensity of the Alberta electrical grid, this technology should be implemented as soon as 2020 to have the greatest impact on reducing emissions.

This study was limited in that heat recovery was based on an isolated well pair [1]. More accurate heat recovery estimates should be based on modelling a depleted SAGD pad or reservoir.

The high cost of implementing an organic Rankine cycle will likely be the greatest challenge to the adoption of this technology. Updating the current SAGD approval process to mandate heat recovery after completion of SAGD production would cause earlier adoption of waste heat recovery.

CONCLUSIONS

Electricity generated from depleted SAGD heat recovery can reduce emission associated with electricity use in the SAGD sector by up to 28%. However the technology will be held back by its high cost of implementation, possibly requiring that a heat recovery plan becomes a requirement for approval for new SAGD operations.

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