Eavor-Loop for Combined Heat and Power at the University of Calgary: A Techno-Economic Analysis

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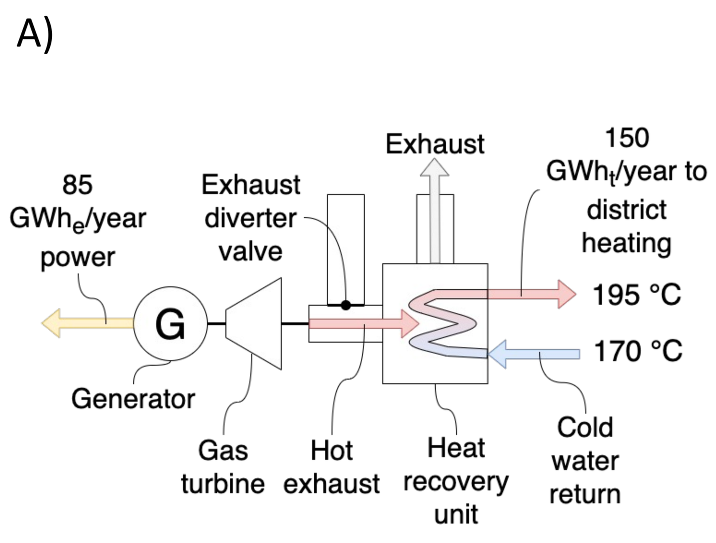
UNIVERSITY OF CALGARY
Campus as a Learning Lab

Background and Introduction

- Eavor-Loop™ is a multi-leg closed-loop advanced geothermal system capable of producing industrial-scale heat for district heating or electricity via an Organic Rankine Cycle (ORC) power plant with zero greenhouse gas (GHG) emissions [1].
- Energy for the University of Calgary main campus is currently supplied by a 14 MW natural gas turbine producing combined heat and power (CHP) connected to a district heating system.
- Eavor-Loop™ energy could reduce the carbon intensity of the University of Calgary's energy system, integrate into the existing district heating infrastructure, and support the university's climate commitment of a carbon-neutral campus by 2050 [2].

Purpose: *Assess the technical and economic feasibility of Eavor-Loop™ for CHP at the University of Calgary.*



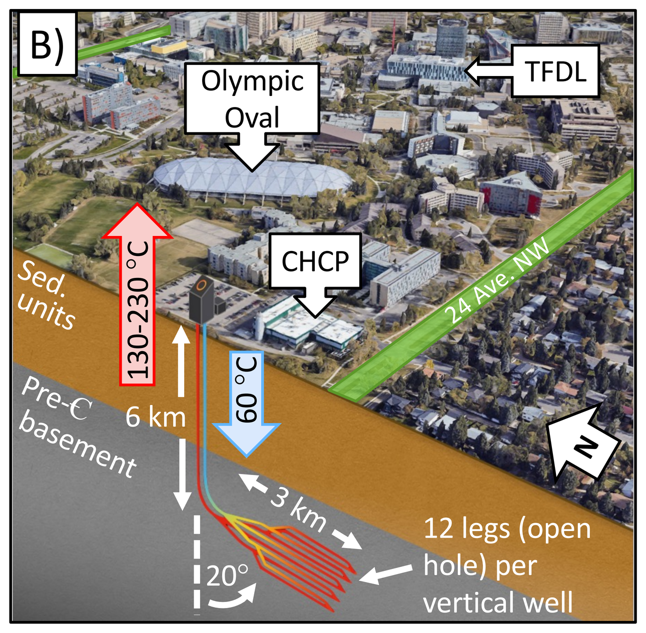


Figure 1: A) Schematic of existing natural gas cogeneration system for CHP. B) Schematic of proposed Eavor-Loop [3] on University of Calgary main campus with design parameters; CHCP: Central Heating and Cooling Plant with Eavor-Loop integration into district heating system; TFDL: Taylor Family Digital Library.

Methodology and Assumptions

- Performance of the natural gas cogeneration system (base case) and Eavor-Loop cases were modelled to determine feasibility of Eavor-Loop to replace the base case for CHP.
- Geothermal gradient (30 °C/km and 60 °C/km) and drilling cost assumptions ($200/m to $600/m open hole leg) from a previous techno-economic study of Eavor-Loop [4].
- Long term thermodynamic performance simulated using Eavor Technologies modelling assuming pseudo-steady state operation to estimate average lifetime energy output.

Methodology:

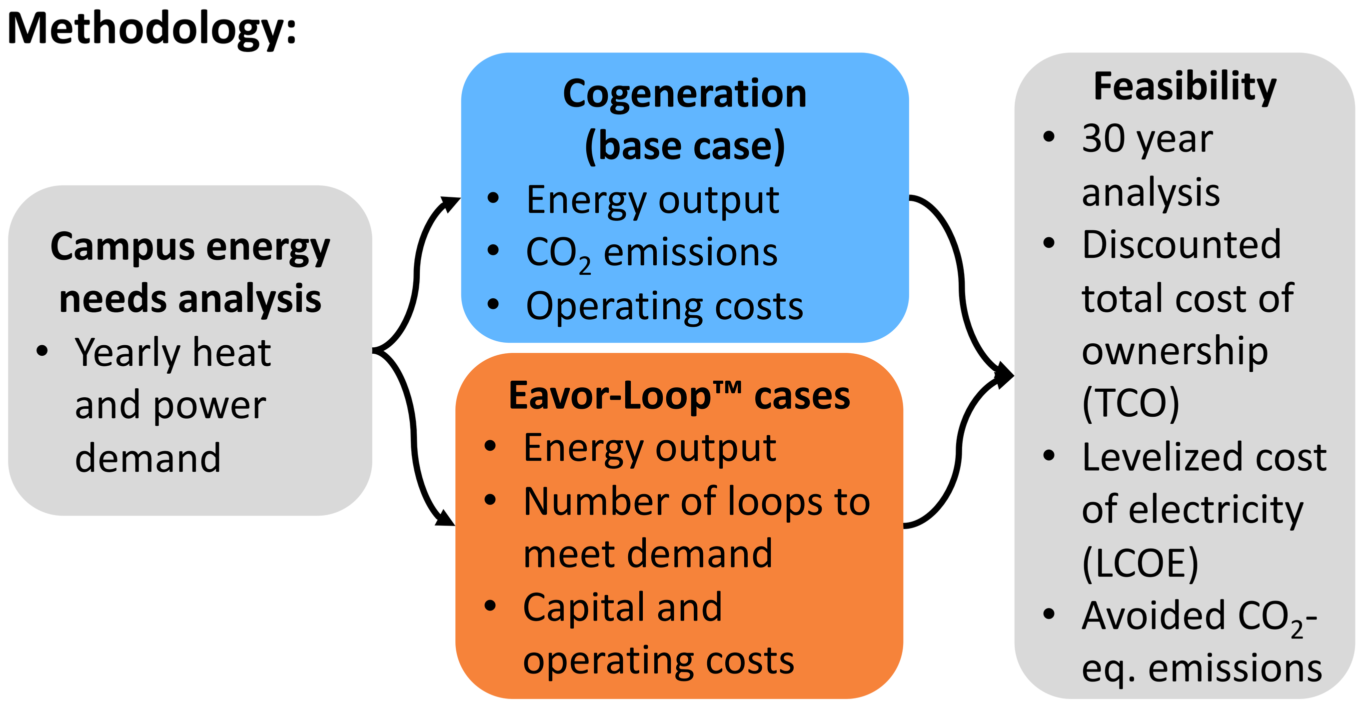


Figure 2: Analytical framework for the techno-economic analysis of Eavor-Loop for CHP.

Results

Cumulative discounted costs:

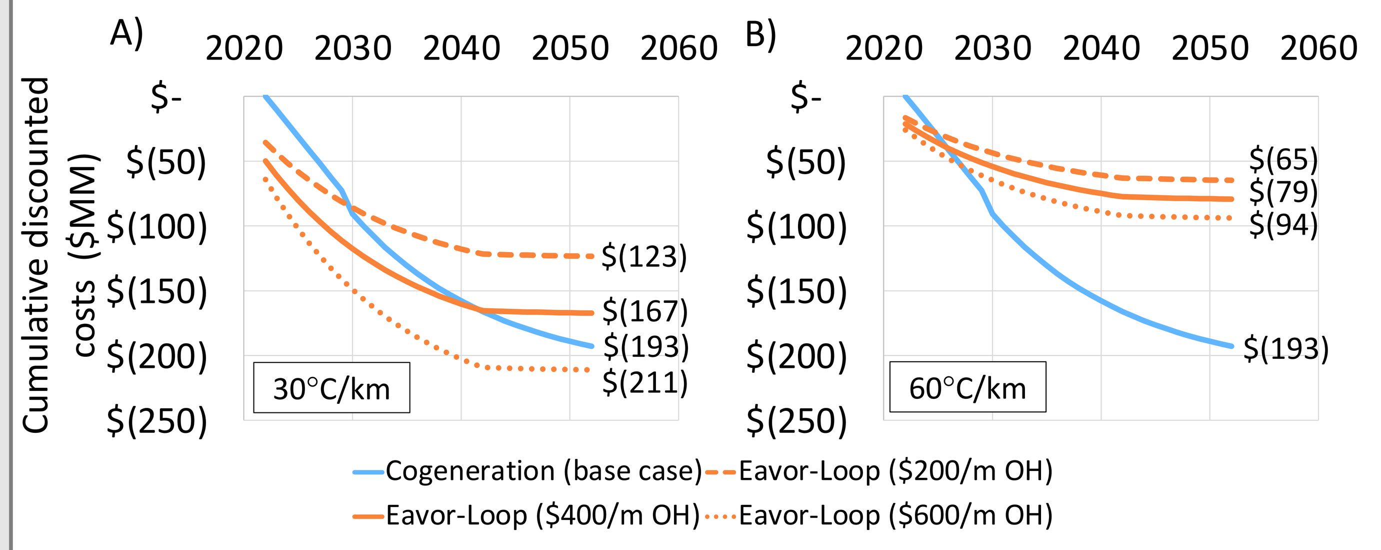


Figure 3: OH: Open hole drilling cost. A) Cumulative costs in millions for a 30°C/km geothermal gradient with 4 Eavor-Loops required to meet demand. B) Cumulative costs for a 60°C/km geothermal gradient with 1 Eavor-Loop required to meet demand. TCO for each case in parentheses. All cost figures at 8% discount rate.

Economic and environmental performance:

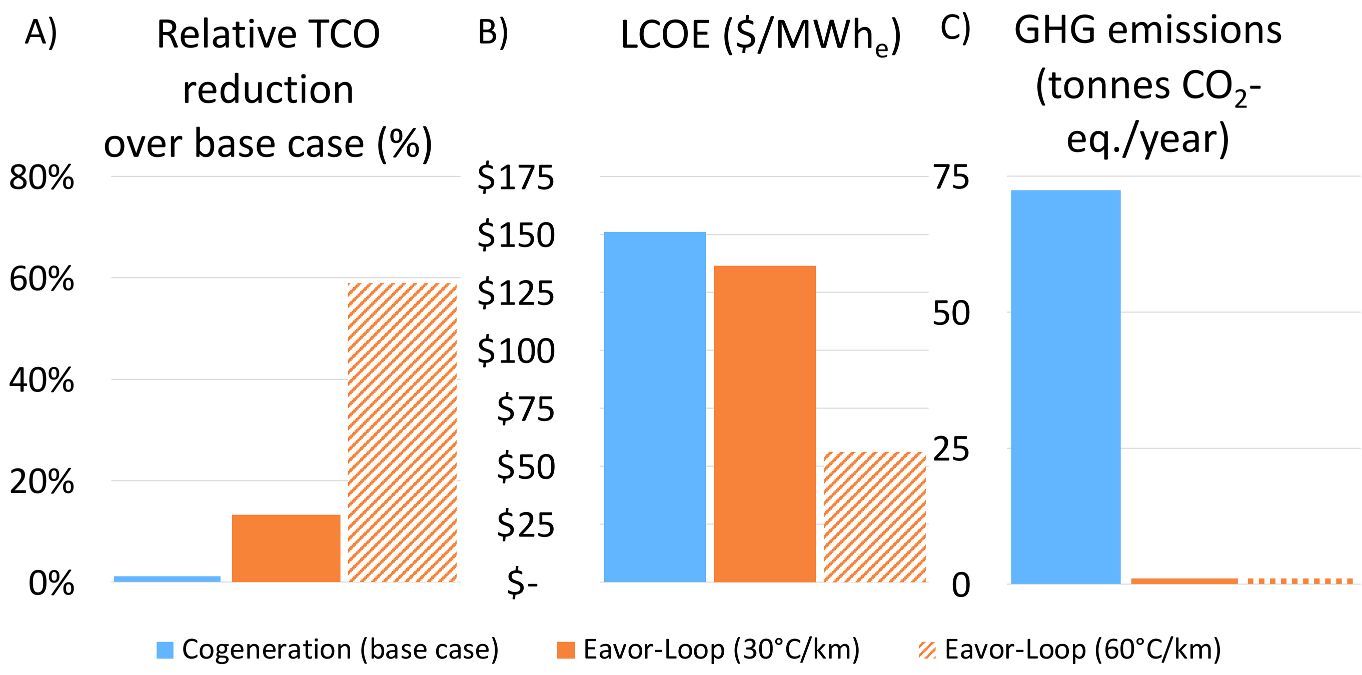


Figure 4: Comparison of A) Relative TCO reduction over base case; B) Levelized cost of electricity, calculated for Eavor-Loop cases with total thermal output in electrical equivalent units; and C) Yearly GHG emissions for the cogeneration base case and Eavor-Loop cases. Eavor-Loop cases assume $400/m open hole drilling cost. All cost figures at 8% discount rate.

Undiscounted cost breakdown:

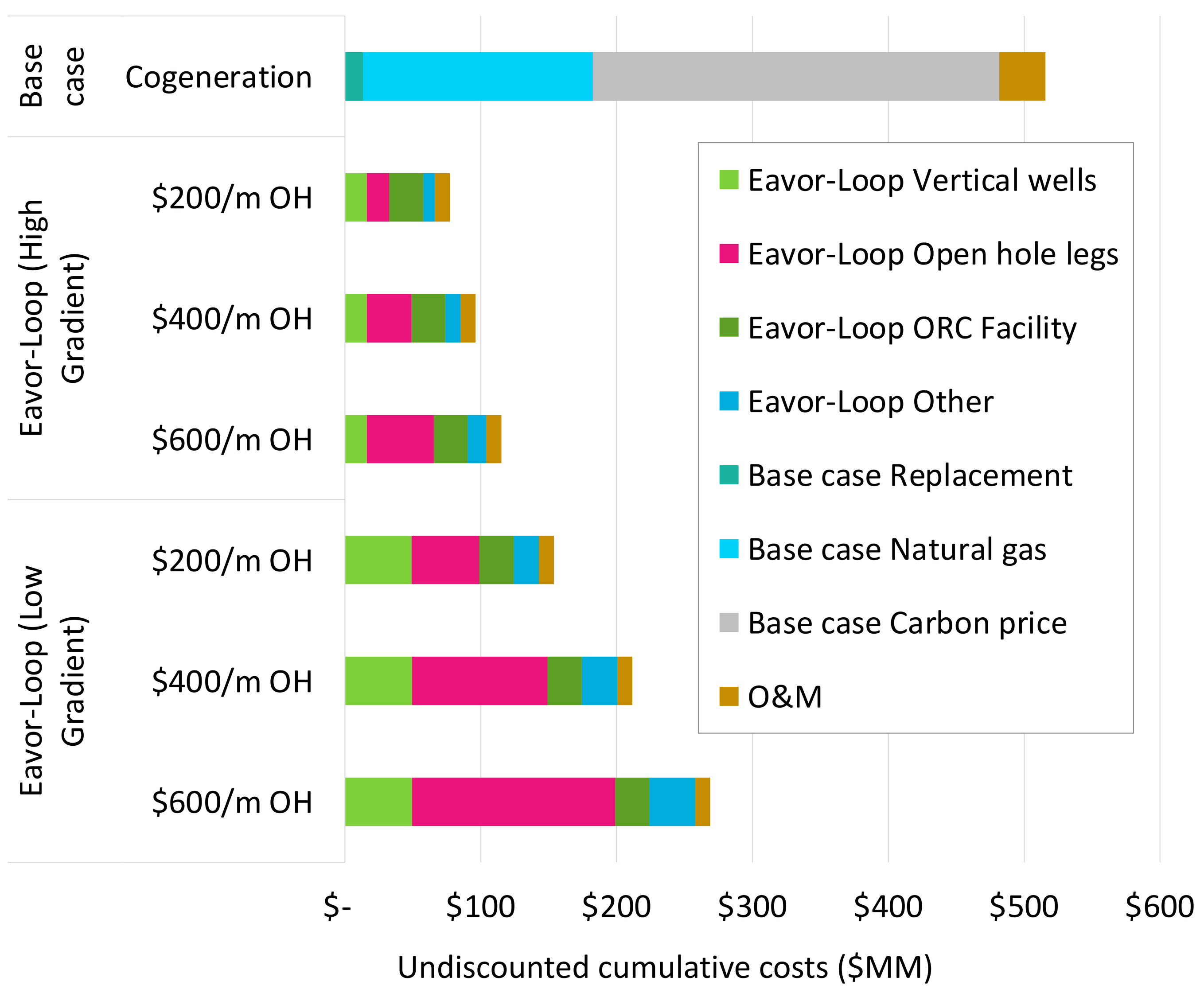


Figure 5: OH: open hole. Cumulative undiscounted cost items in millions over the analysis period for base and Eavor-Loop cases. Base case costs prorated for additional power sales revenue.

Sensitivity Analysis

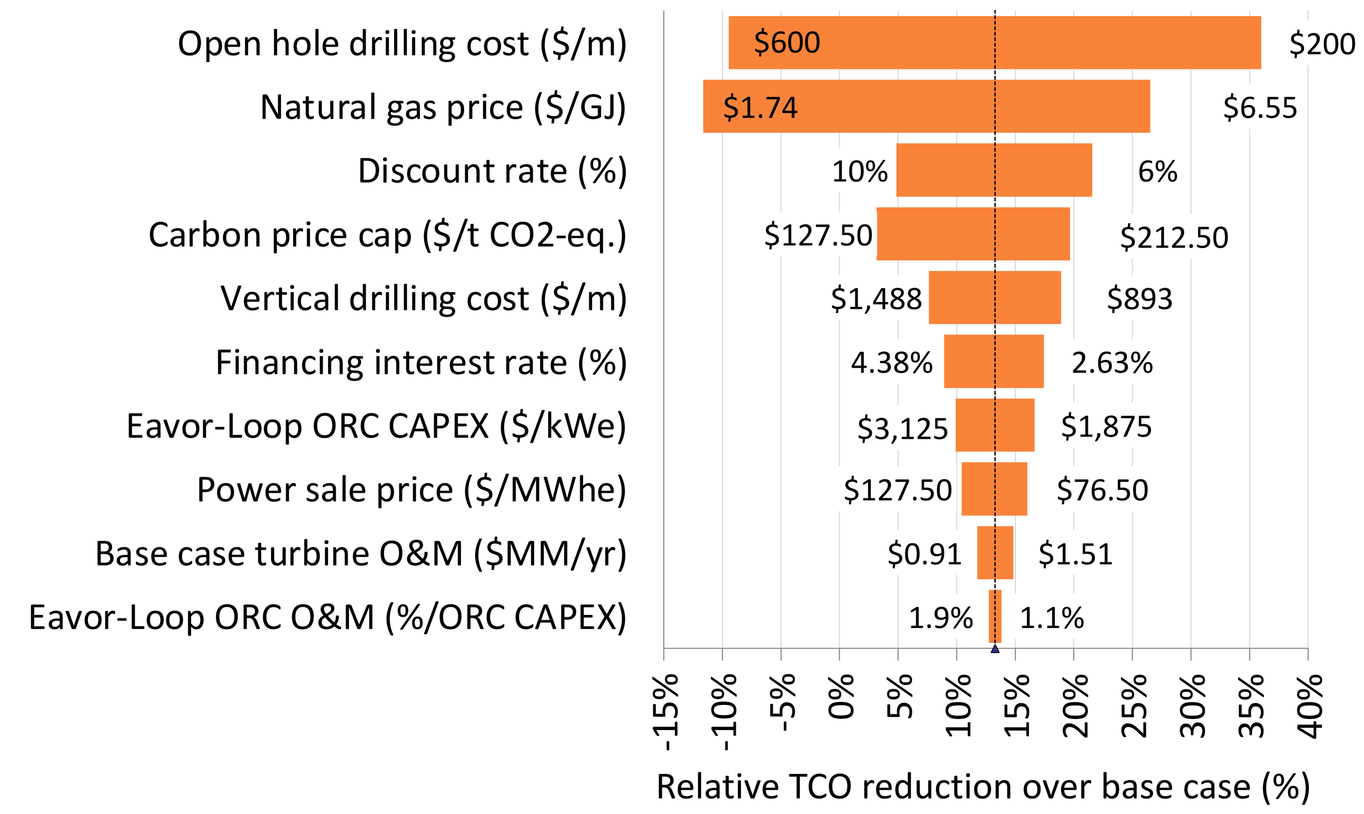


Figure 6: Relative TCO reduction of 30°C/km Eavor-Loop over base case. High and low sensitivity ranges shown next to each bar.

Conclusions

- Eavor-Loop has economically feasible TCO over the base case with a 30°C/km gradient and open hole drilling costs of $400/m or less.
- 30°C/km gradient Eavor-Loop with $400/m open hole drilling cost corresponds to 13% reduction in TCO over base case and a competitive LCOE of $137/MWh$_e$.
- 4 loops are needed to meet demand with 30°C/km gradient; 60°C/km gradient requires only 1 loop and significantly reduces TCO.
- Eavor-Loop cases result in 39% yearly reduction in total GHG emissions from the University of Calgary compared to 2017 [2]; 2.17 megatonnes of CO_2-eq. avoided over project lifetime.
- Economic feasibility is heavily dependent on open hole drilling cost due to extensive drilling required to construct the number of legs necessary to meet demand.

Future Work

- Modelling seasonal fluctuations in heat demand and the effect on Eavor-Loop power and heat production.
- Incorporating geological data for the Calgary region to refine drilling cost estimates and geothermal gradient assumptions.

References

[1] Eavor Technologies Inc. (n.d.). *Technology*. Retrieved January 16, 2022, from https://www.eavor.com/technology/

[2] University of Calgary. (2018). *2019 Climate action plan*. https://www.ucalgary.ca/live-uc-ucalgary-site/sites/default/files/teams/138/FINAL%20Climate%20Action%20Plan%202019.pdf

[3] Adapted from Eavor Technologies Inc.

[4] Beckers, K. F., & Johnston, H. E. (2022). Techno-economic performance of Eavor-Loop 2.0. *47th Workshop on Geothermal Reservoir Engineering*, 1–14.

Acknowledgements

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