Geothermal Initiatives at the University of Calgary

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ABSTRACT

To help meet net-zero 2050 goals set forth by the sustainability plan at the University of Calgary, a middle-deep geothermal heating and cooling system, based on a series of multilateral closed-loop horizontal wells, is proposed. As part of this, a demonstration project is proposed test system performance and is presented herein.

INTRODUCTION

The University of Calgary main campus is currently heated and powered by a combined heat and power system that consists of a natural gas turbine for electricity production and a combination of heat recovery units and supplemental natural gas boilers to provide hot water for the district energy system. The campus is currently developing a sustainability strategy to become net-zero by 2050 and has identified a district scale geo-exchange system with thermal energy storage and thermal energy recovery sources as a potential replacement system. The geothermal research team is proposing a deeper, closed-loop, geothermal heating system to reduce the number of wellbores and improve system performance. This work builds upon earlier work exploring a 7-9km deep closed-loop geothermal heat and power system (Barry-Hallee, 2022).

CURRENT SYSTEM

The current district energy system consists of a district energy network operating at 200^{o}C. A 14 MW natural gas turbine generates electricity for the campus as well as the heat necessary to drive the thermal network. Supplemental boilers are used during cold snaps to supplement heat generation. In the summer, cold water from the Bow River is used to provide cooling within the same network. Supply temperature is typically 200^{o}C and return temperature is 175^{o}C. Each individual building has a heat exchanger that provides the necessary hot water to provide heating and domestic hot water. Buildings operate at 65^{o}C to 95^{o}C, depending on the age of the building. Typical peak heating loads are around 54 MW_{th}, the total annual heat demand is around 150 GW_{th} per year, and annual electricity demand is around 90 GW_{e}.

PROPOSED GEOTHERMAL REPLACEMENT

Several systems have been proposed to replace the heating, the heating and cooling, and the heating and power requirements of the campus. These can be summarized as:

1. Geoexchange. Utilizing a borehole array drilled to 150 metres depth, along with heat recovery systems, solar thermal heat capture and thermal storage, 100% of the campus heating and cooling loads can be replaced. However, the borehole array will require 4,000 – 5,500 boreholes.

2. Ultradeep closed loop. Barry-Hallee (2022) estimated that two deep Eavor-Loops, each with 12 legs, drilled to 7 km depth, could provide 100% of the electricity and heating demand of the campus. This system would require 100's

km of wellbore in granitic basement rock, however, is expected to cost 30 – 50% less than the total natural gas plus carbon tax costs for the next 30 years.

3. Middle-deep closed loop. A new proposal is being developed that proposes a closed loop system landed in the Viking at 2400 metres where formation temperatures are expected to be between 55°C and 65°C. Either a co-axial system or a U-loop system would be able to provide 5 to 15°C delta temperature between the inlet and outlet at flow rates of up to 2000 m^3/day (approximately 500 kW to 1 MW per horizontal. With 20-35 horizontals, coupled with high temperature heat pumps to boost the temperature the 95°C needed by buildings, this system sounds like a good compromise between a geo-exchange system and an ultra deep system. Additionally, deeper H_2S zones may be avoided. During the summer, the heat pumps may be run in reverse and heat could be injected underground at 65°C to 75°C, enabling seasonal heat storage.

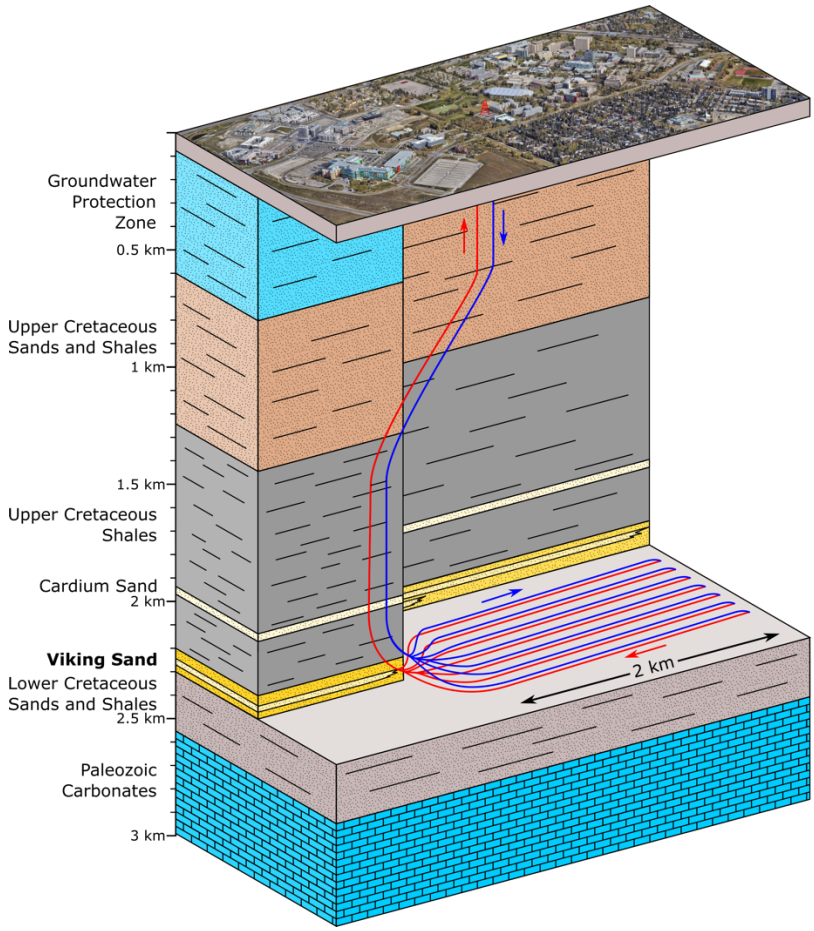

Figure 1 A schematic of a potential middle-deep geothermal heating and cooling system for the University of Calgary main campus.

THE OPPORTUNITY

There is a potential to demonstrate this system on campus as part of a pilot project with several wells and high temperature reversible heat pumps providing heating and cooling to a defined zone of campus.

THE POTENTIAL PILOT

The pilot will consist of three phases:

1. An urban geophysical survey of the subsurface under the campus, likely conducted as a series of student projects in geophysics.

2. Drilling of a test well to understand geology and geothermal gradients. This well would be completed as an instrumented observation well with DAS/DTS fibre and potentially a string of geophones.

3. Drilling of the horizonal wells, with as co-axial closed loop wells to eliminate the need for two drilling rigs, or as a series of U-loops (Eavor-Loops).

As the pilot becomes confirmed, we will be seeking industrial partners.

STAY TUNED!

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REFERENCES

Barry-Hallee, N. (2022). Eavor-Loop™ Geothermal for Combined Heat and Power at the University of Calgary: A Techno-Economic Analysis (Master's project). University of Calgary, Calgary, AB.