Novel Modelling Approach to Geothermal Greenhouse Agriculture for Indigenous Food Sovereignty in the Yukon

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Summary

Food security and Indigenous food sovereignty affect the physical, mental and socio-economic health of communities, particularly in Arctic and Subarctic Canada. Northern communities whose independence relies on traditional hunting, fishing and food-gathering have been impacted hard by changes in climate and ecosystem health. Extreme cold conditions, extended distances to power grids and a short growing season make these communities particularly vulnerable. Geothermal energy extracted from internal planetary heat is a low-carbon form of energy-on-demand and offers a solution to the high cost of plant-based food production and transportation for people residing in the north.

This paper and presentation model the feasibility of greenhouse agriculture supported by geothermal energy to improve food security in the Yukon, where the limiting factor for economical food production is adequate energy to maintain the temperature, light and humidity needed for plant growth. Two greenhouse designs are proposed to maximize production through year-round use or, alternatively, reduce energy consumption and support growth of plants for only 10 months of the year. These designs were developed by constructing a multifaceted model to better understand the scientific and anthropological complexity of the project.

Background

The challenges associated with affordable, nutritious food security for Indigenous communities in Northern Canada have been documented for decades (Loring & Gerlach, 2015). In 2007, the *United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP)* Articles 20, 24, 25, 26 and 29 speak to this fundamental right, and all of its provisions are summed up in Article 43 *"The rights recognized herein constitute the minimum standards for the survival, dignity and well-being of the Indigenous peoples of the world."* In 2008, the *UN's Food and Agriculture Organization (FAO)* convened to discuss the causes, consequences and solutions to rising threats to global food security.

The energy source-of-choice for remote communities in northwestern Canada for heat, transportation and electricity is diesel fuel. It is reliable and maintenance of the generators and vehicles it powers is well understood by residents. Geothermal energy is an advancing technology that is becoming more familiar to Canadians through emerging initiatives by Eavor Technologies, DEEP Corp., and the Fort Nelson First Nation Clarke Lake Project to name a few. The Canadian Geothermal Energy Association (CanGEA) in collaboration with the Geological Survey of Canada have identified numerous regions in northern and western Canada with vast geothermal potential (Figure 1).

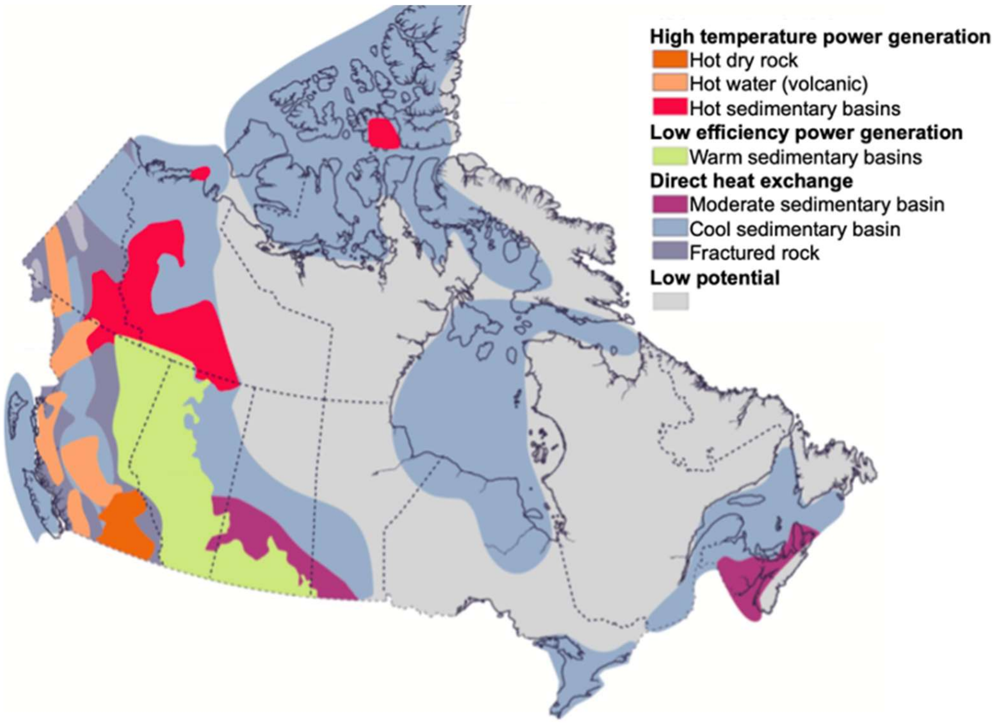

Figure 1. Distribution of geothermal potential in Canada based on end use. Data source: Geological Survey of Canada. Modified from CanGEA (https://www.cangea.ca/location.html).

Multifaceted Model

In a first-order feasibility study, greenhouse **economics** is modelled, using the main sources and sinks of energy and estimated crop yields. A heated greenhouse (10 month growing season) is compared to a containerized system (year-round growing season). The model demonstrates how geothermal greenhouses become cost competitive within 4-20 years depending on energy source, without the carbon dioxide emissions of a design supported by diesel-power. **Productivity** of the greenhouse designs is correlated with the nutritional requirements of nearby communities to predict the impact on food security per capita. Geothermal **energy source** options considered include: "new" heat from a purpose-drilled borehole for a ground-source heat pump, and "waste" heat from an existing nearby geothermal power plant. Results indicate that greenhouses attached to a 3–5-megawatt power plant can provide up to one million servings of vegetables yearly to nearby communities and outperform a diesel-heated greenhouse within 4 years (Figure 2).

Model findings are used to design two different styles of greenhouse with differing thermal characteristics. A heat balance calculation is performed at three different site locations in Yukon to estimate the monthly heating needs over a 12-month period (Figure 3). Estimated food production from each greenhouse and its economic cost (according to the model) are compared with the current cost of produce from local vendors to evaluate the benefit to consumers.

Contributing Complexities

A life-cycle analysis comparing the energy expenditure and carbon dioxide (CO_2) emitted to the atmosphere when residents buy shipped-in produce at the closest grocery store, as opposed to locally grown produce a geothermal-powered greenhouse.

This talk reviews the legislative and regulatory barriers faced by community-based geothermal projects, including greenhouse agriculture. It also reports on potential funding sources currently available that could offset the initial high capital costs of geothermal infrastructure.

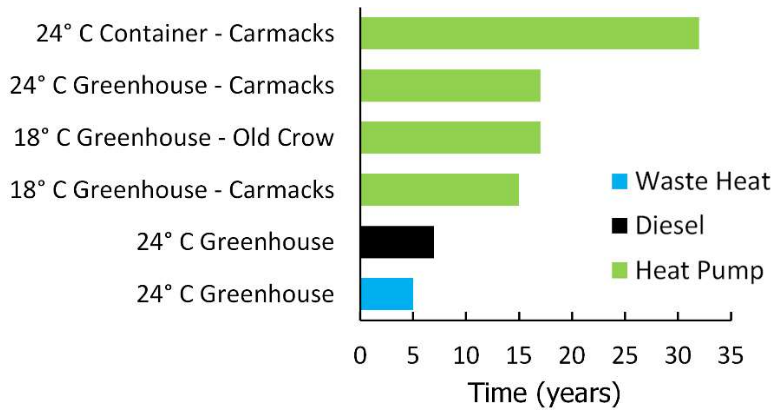

Figure 2. Return on investment (in years) from greenhouses constructed in northern (Old Crow) and southern (Carmacks) Yukon, where temperatures of 18°C and 24°C are maintained, utilizing either waste geothermal heat, a borehole heat-pump or a diesel generator. Results are from heat and economic models.

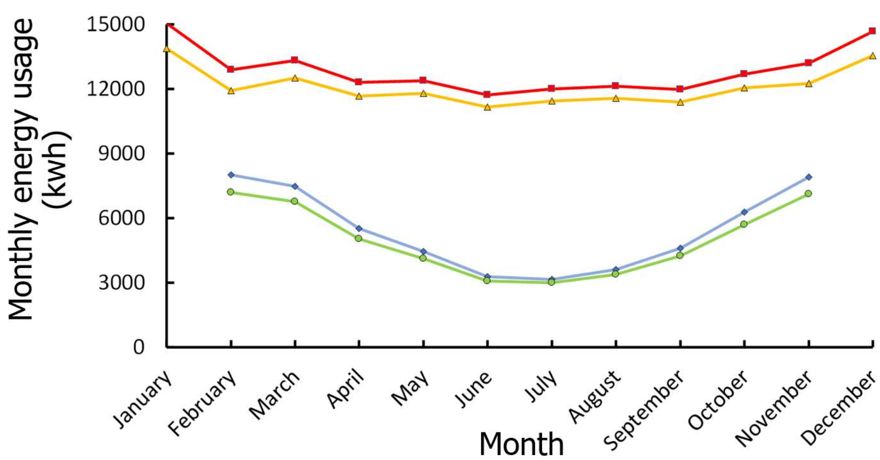

Figure 3. Energy requirements (estimated monthly in kilowatt-hours) for prism and cone greenhouse designs with and without access to solar radiation

Conclusions

Model findings estimate that a community-run greenhouse with an extended growing season can provide 15,000 servings of vegetables to nearby communities yearly, at half the cost to consumers. Using waste heat from a nearby geothermal plant could heat roughly 100 of these greenhouses, potentially providing over a million servings, at a 60% reduction in costs to consumers. These findings do not consider the benefits and limitations associated with the installation of a geothermal power plant nearby.

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References

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