ENGR 478: Course Project Alternative Energy System For Remote Communities

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Fort Liard, Northwest Territories

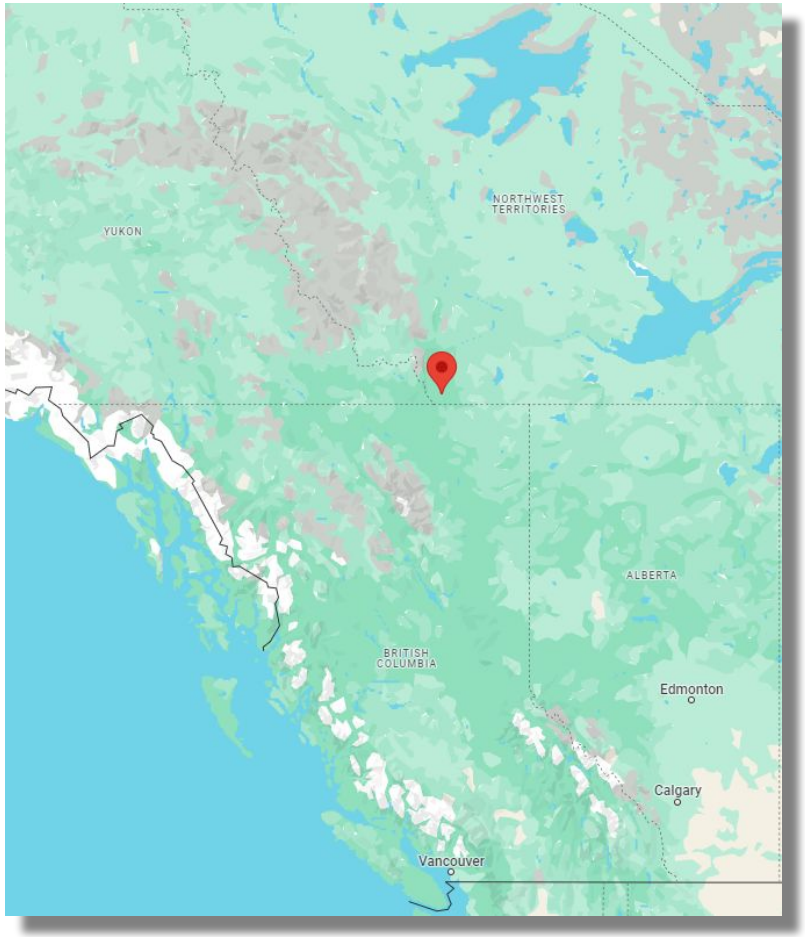
https://spectacularnwt.com/communities/dehcho/fort-liard/

Location and Population

Location: **South western corner of NWT**

Access: **By road via Liard Highway**

Population: **542 (NWT Bureau of Statistics, 2019)**



Community Energy Requirements and Sources

Current Provider: NTPC

NORTHWEST TERRITORIES POWER CORPORATION

https://www.ntpc.com/

Source: The Atlas of Canada - Remote Energy Database
https://atlas.gc.ca/rced-bdece/en/index.html

Community Energy Requirements and Sources

Current Community Power Profile:

Main Power Source: **Diesel**

Required Generating Capacity: **1,320 kW**

Annual Fossil Fuel Generation: **2,279,000 kWh / year**

Annual Fuel Consumption Rate: **212,773 L / year**

Annual Fuel Cost: **397,886 $ / year**

Annual Fuel Consumption Rate: **212,773 L / year**

Annual GHG Emissions: **575,948 kg CO_2 / year**

https://www.ntpc.com/capital-projects

Sustainable Energy Project: Requirements

1. Annual GHG emissions less than or equal to 25% of the current emissions

2. Capital cost less than the 10-year operating cost of the current power system

3. Annual operating cost less than or equal to the current operating cost

4. Total generating capacity must meet or exceed current generating capacity

Sustainable Energy Project

Requirements For Fort Liard, NT

1. New GHG Emissions **< 158 ton CO_2 / year**
2. Capital Cost **< $ 3,978,860**
3. Annual Operating Cost **< 195,751 $ / year**
4. Generating Capacity **> 1320 kW**

Potential Sustainable Energy System Solutions

Solution #1

Geothermal Energy Plant

https://energyeducation.ca/encyclopedia/Geothermal_power_plants

Solution 1: Geothermal

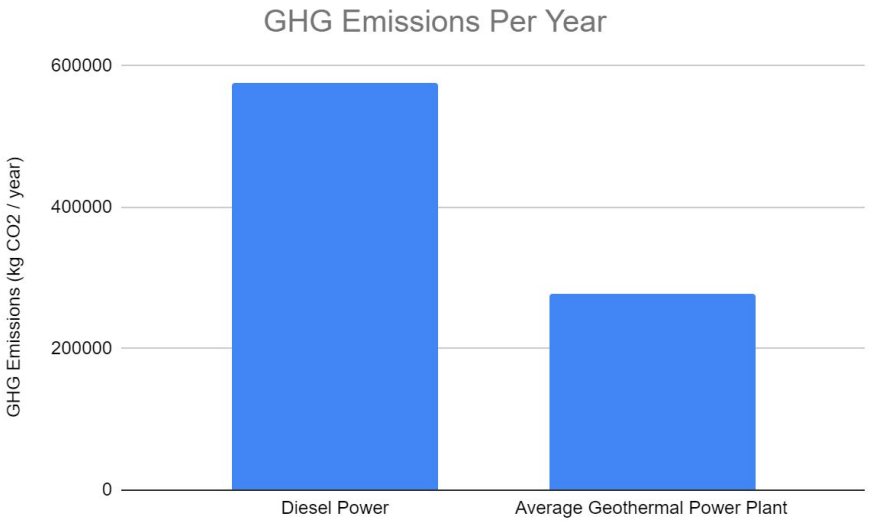
Requirement 1: Annual GHG Emissions

Based on data collected by the World Bank in 2017 (Fridriksson et al.) the average Geothermal Power Plant emits **122 g CO_2 / kWh**

Given Fort Liard has an annual energy requirement of **2,279,000 kWh / year**

The proposed Geothermal Power Plant would **most likely** emit: **278,038 kg CO_2 / year**

This **does not** meet the requirement proposed earlier of 25% of original emissions



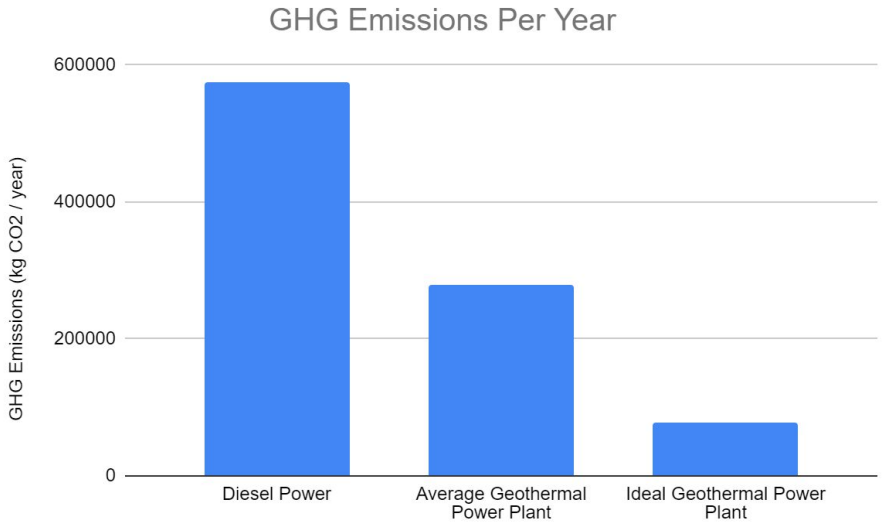
Solution 1: Geothermal

Requirement 1: Annual GHG Emissions

However, the least emissive plant reported by the World Bank emits **34 g CO_2 / kWh**

With this emission, our Geothermal Plant would create: **77,486 kg CO_2 / year**

This **does** meet the requirement for the Sustainable Energy Project (13% of original emissions)



Solution 1: Geothermal

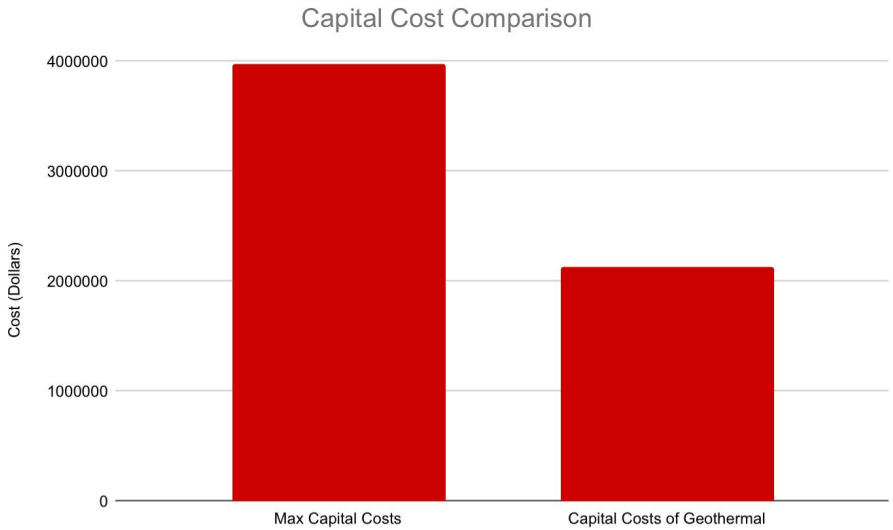
Requirement 2: Capital Cost

The minimum depth of well in Fort Liard is **2,500 meters**

Assuming a drilling cost of **850 $ / metre**

The capital cost of installing a Geothermal well is: **$ 2,125,000**

Geothermal Solution **does meet capital cost requirement**



Solution 1: Geothermal

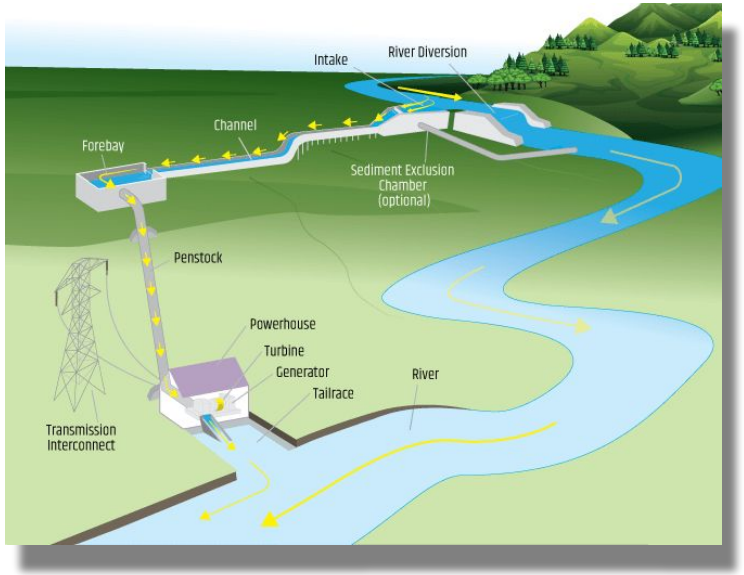
Project Feasibility

A study was done to check the feasibility of geothermal for Fort Liard by NRCAN and it was determined that the ground was not suitable (Thomas et al. 2023)

Even though it is well within the capital cost requirement we must find another option for our renewable energy project because it is not possible to use geothermal in the fort liard area

Solution #2

Run-of-River Hydro Power System

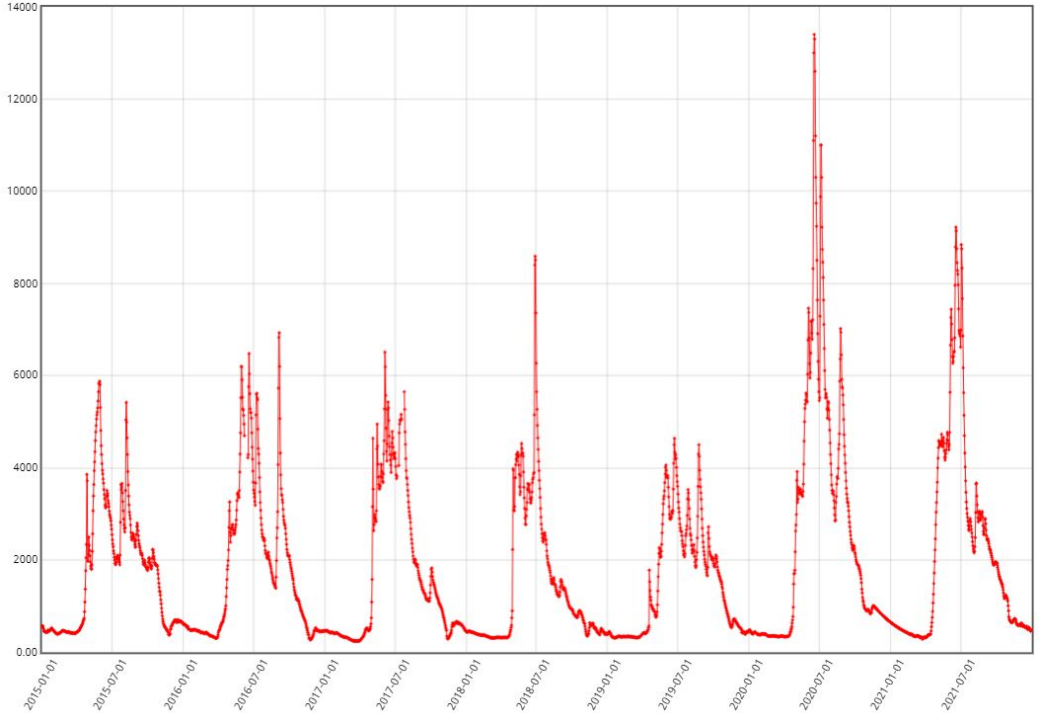


https://www.energy.gov/eere/water/types-hydropower-plants

River Overview

- Facility will be placed on **Liard River**
- Total head delivered: **2 metres**
- Estimated Minimum Flow: **300 m^3/s**

Flow and head estimates based on data provided by NRCan Water Office from 2015-2021 shown to the right



Solution 2: Run-of-River Hydro

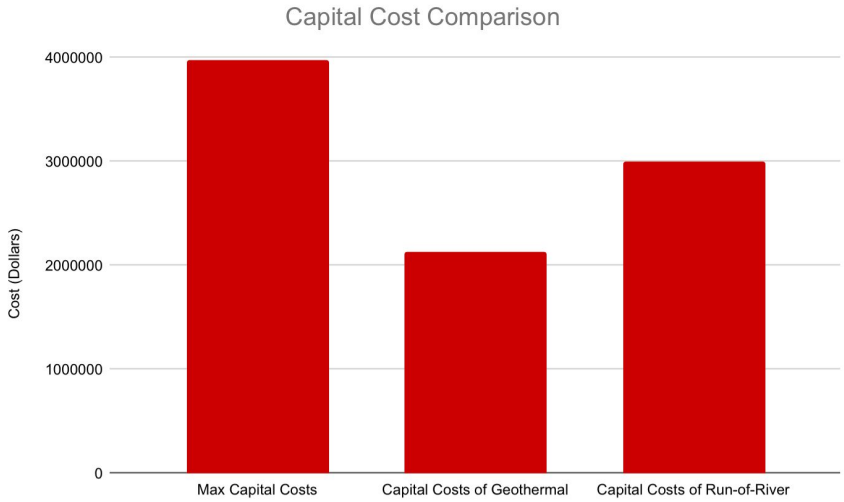
Requirement 1: Annual GHG Emissions

- Diesel generators are already onsite so will be kept as a back-up system in case the ROR hydro facility has down time especially in winter
- This will be operated less than 25% of the year
- The ROR hydro generation plant itself will have **0 GHG emissions per year**
- Hydro plant will be heated to prevent freezing in winter

Solution 2: Run-of-River Hydro

Requirement 2: Capital Costs

- Capital cost must be less than the 10 year operating cost of the current system ($3.98 million)
- Estimated cost is $1500/kW with a generation capacity of 2000 kW means a Capital Cost of: **$3.0 million**



Solution 2: Run-of-River Hydro

Requirement 3: Operating Costs

- We assumed that the operating costs are ~3% the capital cost
- Operating cost per year: **~$90000**
- The biggest O&M costs per year will be maintenance of the equipment

Solution 2: Run-of-River Hydro

Requirement 4: Generating Capacity and Turbine Specifications

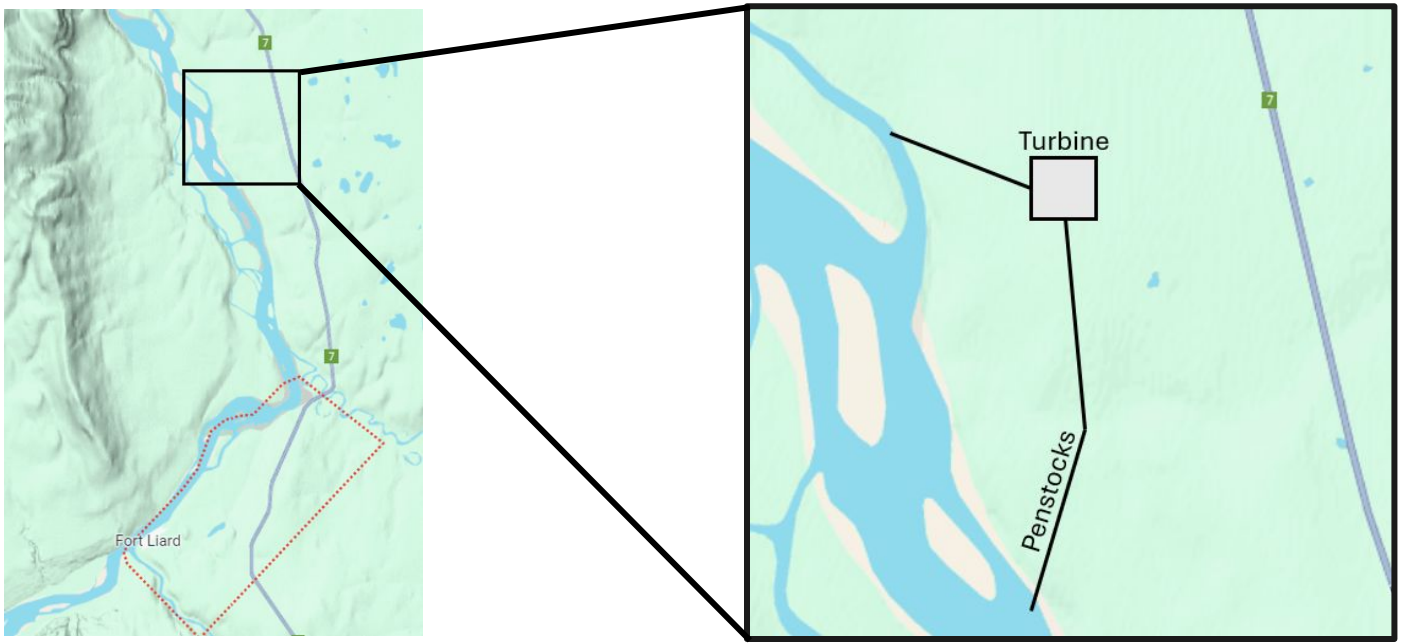
- Total Generating Capacity: **2000 kW**
- Availability Factor: **100% (Including Diesel Backup)**
- Maximum Turbine Volume Flow Rate: **110.80 m^3/s**
- Output Variability: Since maximum turbine flow is only 37% of minimum river flow, variability is not dependent on the river. Output variability is due to power demand and will likely only reach peak demand in cold winter months.
- Turbine Type: **Kaplan**
- Turbine Blade Diameter: **5 metres**
- Turbine Speed: **43.78 rpm**
- Turbine Specific Speed: **4.96 rad**

System Feasibility Overview

Specification	Threshold	Our System	Pass/Fail
GHG Emission Reduction	158 ton CO_2 / year	~20 ton CO_2 / year	Pass
Capital Cost	$ 3,978,860	$ 3,000,000	Pass
Operating Cost	195,751 $ / year	90,000 $ / year	Pass
Generating Capacity	1320 kW	2000 kW	Pass

Solution 2: Run-of-River Hydro

Equipment Location



References

Fridriksson, Thráinn, et al. “Greenhouse Gas Emissions from Geothermal Power Production .” *The World Bank*, PROCEEDINGS, 42nd Workshop on Geothermal Reservoir Engineering, 13 Feb. 2017.

Thomas, G., Terlaky, V., and Raymond, J. 2023 Liard Geothermal Reservoir Project Update. 51st Annual Yellowknife Geoscience Forum — Abstract Volume, p. 43-44; Northwest Territories Geological Survey, Yellowknife, Northwest Territories