Renewable energy, demand side management, and diesel efficiency

Arctic Sustainable Energy Research Conference

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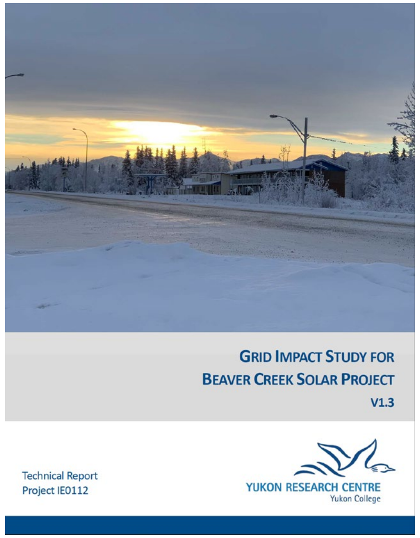
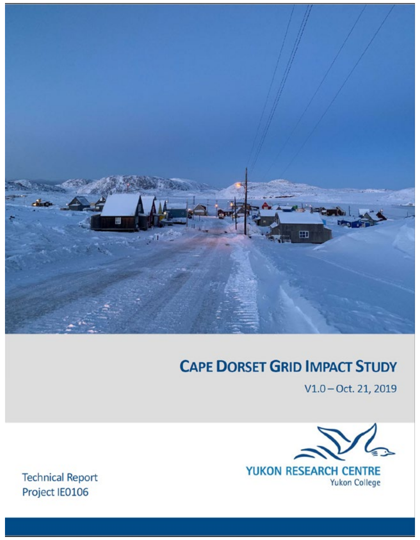
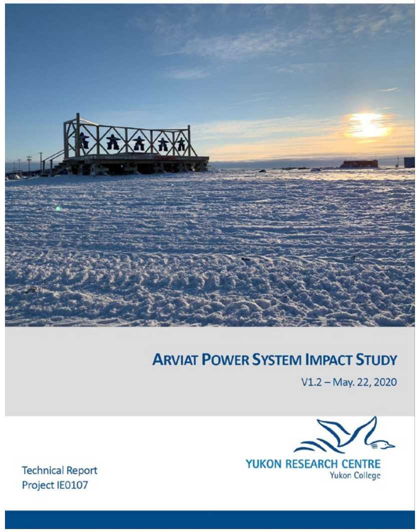
Purpose of presentation

- Highlight bottlenecks of integrating renewable generation
- Identify how battery systems can address those bottlenecks, as well as some challenges that we face in Canada
- Highlight other solutions that are being studied to reduce our dependency on fossil fuels, such as demand-side management and variable speed generators







Power System Impact Study Teams

- This presentation is the cumulation of experience from the Northern Energy Innovation research teams over the past 5 years, contributing to our Power System Impact Studies (PSIS):
- Leads: Jason Zrum, Spencer Sumanik, Simon Geoffroy-Gagnon, Michael Ross
- Contributors: Geoffrey Cartwright, Mariam Jacob, Sinan Bulut, Rosamond Tutton, John Ross, Eric Labrecque, Felix Mercure, Joe Collier, Patrick Giles, Jamie McLeish, Sasha Lachance, Tarek Bos-Jabbar, Noah Sternbergh, Esmee Smit-Anseeuw, Dmitri Pulido, Sara Thompson, Andris Krumins, Tanvir Rahman, Chiyo Aihoshi, Joshua Beckett

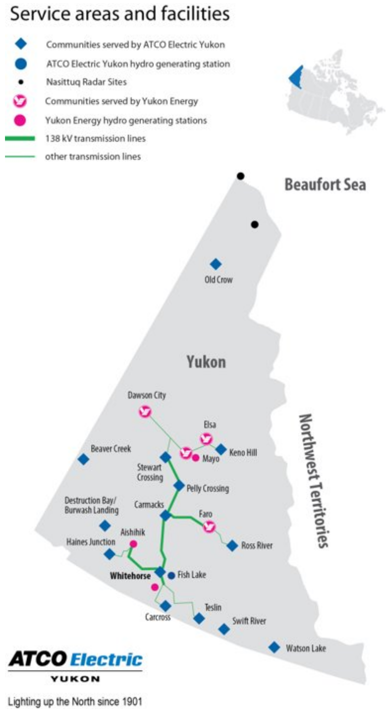
Background: Electric power in the Canadian territories

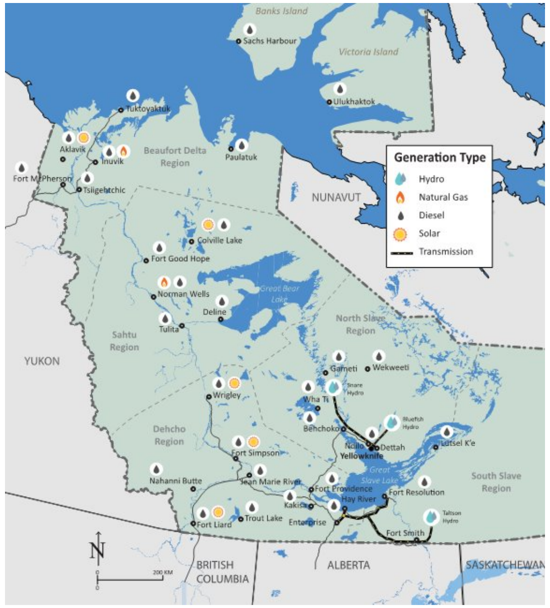
- No power system is connected to the north American interconnected system
- 55 isolated diesel-powered communities
- 31 connected to local isolated grid
- 3,8678,271 km^2, 13,604 people
- If it were a country, the Canadian territories would be the 7th largest country in the world with a population density less than that of the Sahara desert … ***by a factor of over 10*** (0.03 ppl/km^2 vs 0.4 ppl/km^2)

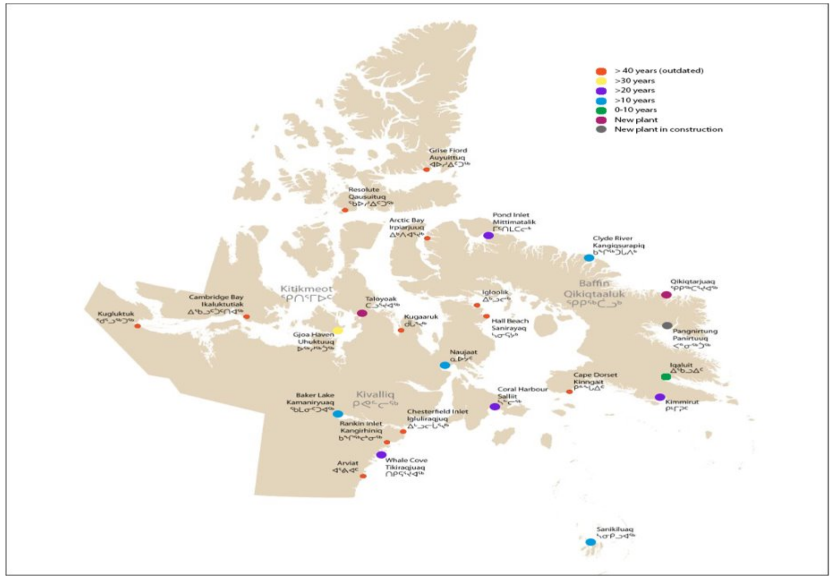
Image: Standing Senate Committee on Energy, the Environment and Natural Resources: Powering Canada's Territories, 2016

Background: Electric power in the Canadian territories

- Yukon: 1 hydro interconnected system, 5 diesel-powered communities
- Northwest Territories: 2 hydro interconnected systems, 25 fossil-fueled powered communities
- Nunavut: 25 diesel-powered communities

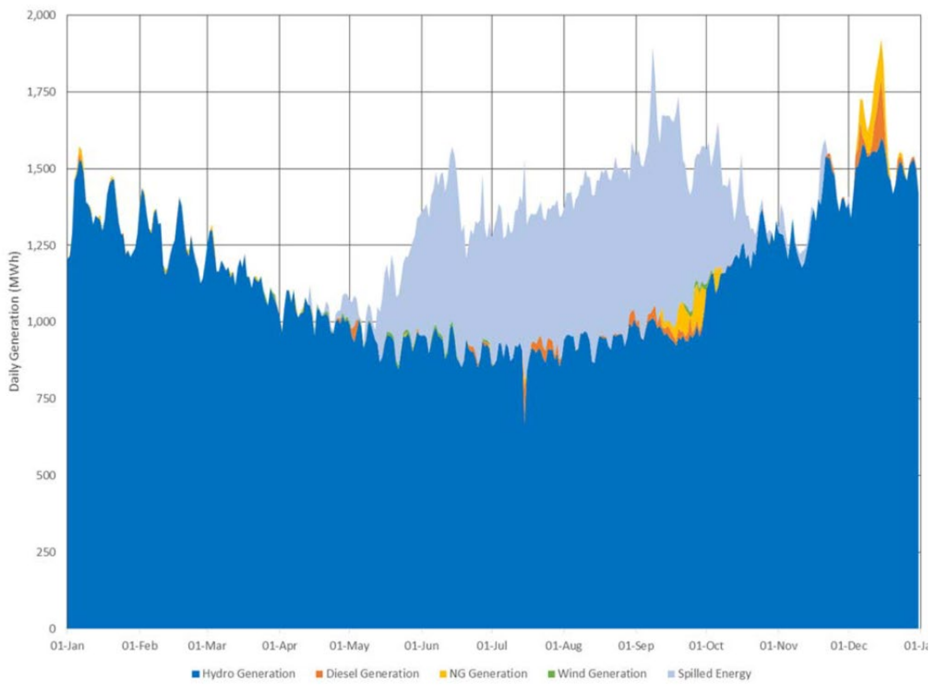






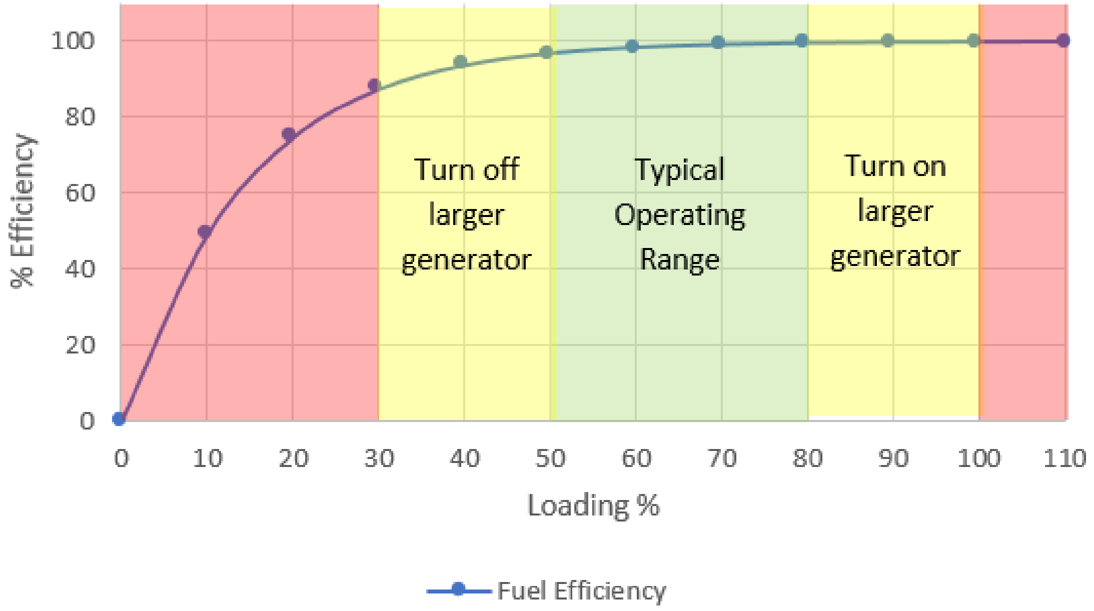
Clarification on capacity vs energy

- *Can we go 100% wind or 100% solar?*
- The infrastructure must meet both the capacity and the energy needs of the community.
  - The capacity refers to the maximum power requirement of the community. Reliable, controllable, and dispatchable power must be available to meet the power demand of the community to keep the system balanced
  - The energy needs of the community must be addressed through reserve requirements (long-term and operating reserves).
- *Power in = power out* at all times
  - A challenge without power import/export capabilities

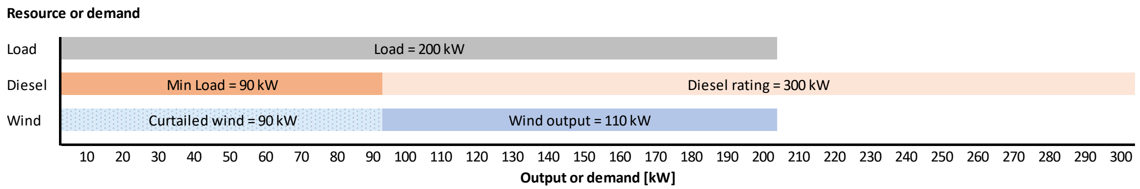


Common bottlenecks of renewable integration

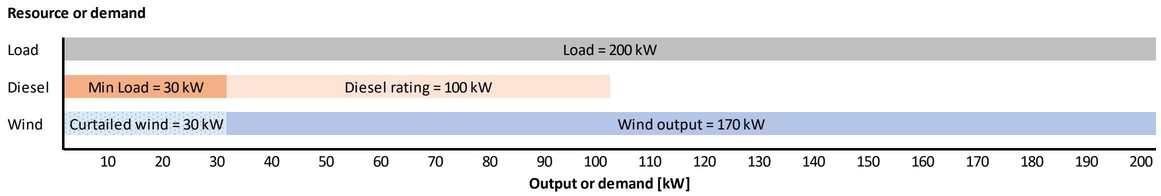
- Double edge sword of having a large or small “smallest generator”
  - A “large” smallest generator will have a larger minimum loading constraint, dependent on system load and can change from year to year
    - Underloading issue
  - A “small” smallest generator will have less operating reserve, determined by the power rating and dispatch logic
    - Operating Reserve issue



Case 1: “large” smallest generator (limited by underloading)

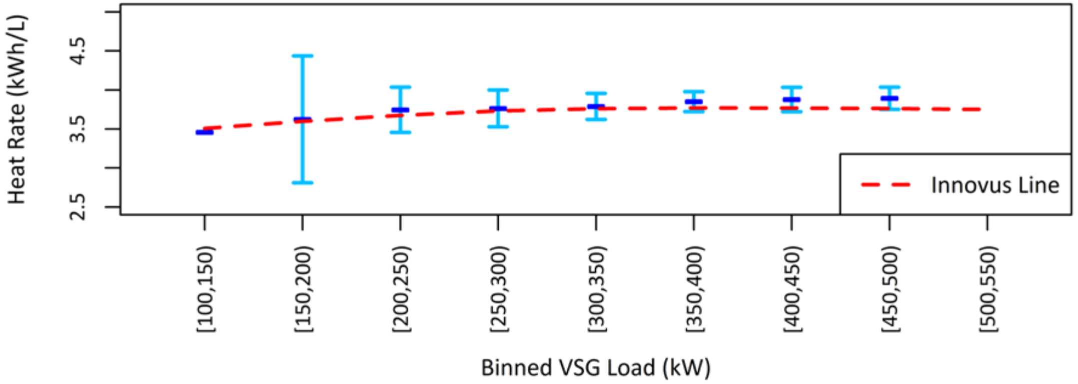


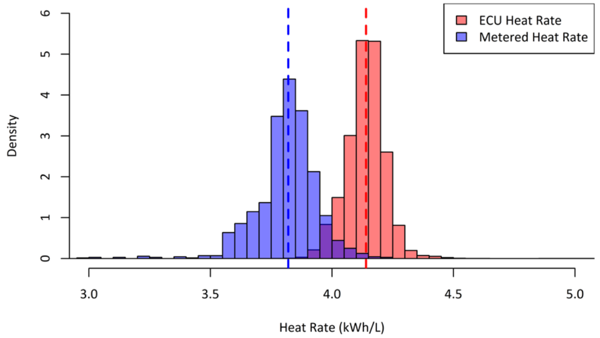
Case 2: “small” smallest generator (limited by operating reserve)



Variable speed generation as an option

- A Variable Speed Generator (VSG) has the promise of steady fuel efficiency across multiple loadings, as well as lower the minimum loading constraint to less than 10% of its rated capacity
- VSGs operate under the principle of a diesel generator's variable ac output rectified to a dc link and then inverted to 60 Hz ac
  - Analogous to a Type 4 wind turbine, but the prime mover is an internal combustion engine that can operate at an optimal rpm for a given power output
- More data are necessary to conclusively validate the efficiency and low loading characteristics of the VSG in Aklavik





Role of energy storage

- Battery storage systems:
  - Don’t have a minimum loading constraint
  - Can offer up and down reserve (depending on capacity and state of charge)
  - Is dispatchable based on its state-of-charge
  - However, it is not a net generator
- Energy storage systems can operate in PQ (current) or Vf (voltage) control mode
  - PQ control dispatches the real (P) and reactive (Q) power. It injects current into the system in synch with the measured voltage
  - Vf control mode sets the frequency (f) in isochronous control and regulates the voltage (V) through the power balance
- Diesel off reductions can account for up to 60% of diesel reduction (Łutsël K’é) from the base case of no renewables

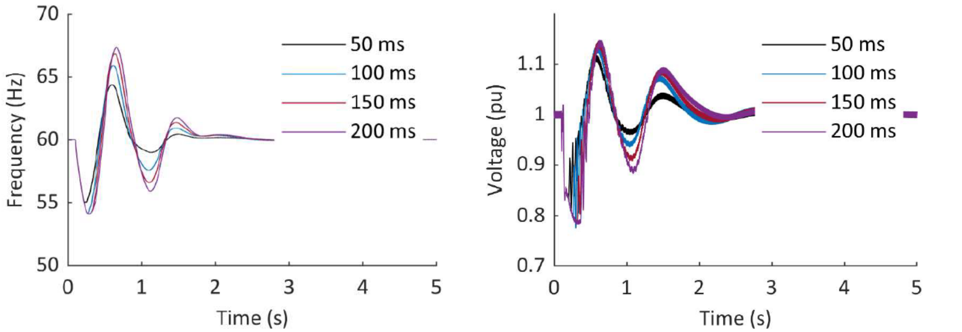


Figure 31: Dynamic response of GD3 for simulation case 2B-5 with varied time delay on GE1 power reference.

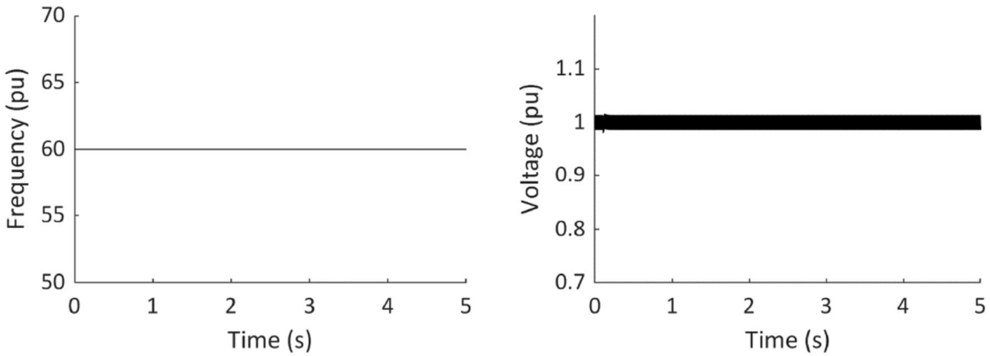
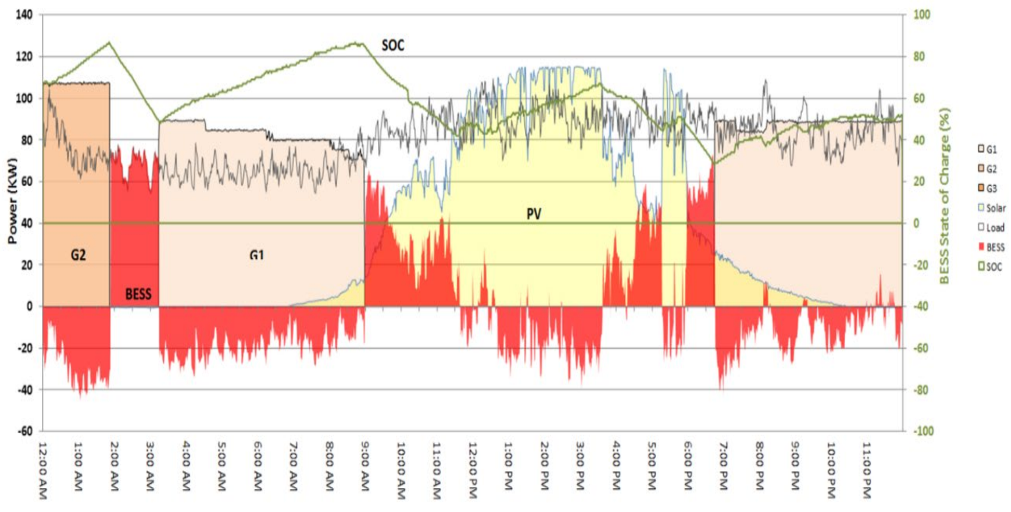


Figure 38: Dynamic response of GE1 for simulation case 2B-7.

Control strategies for battery systems

1) Diesel on at all times (existing Łutsël K’é System)
2) Diesel can turn off with the ESS operating in isochronous mode for periods of time (Old Crow Solar Project)
3) ESS always operating in isochronous control, diesel turns on to charge battery (Colville Lake)



Colville Lake BESS System - 2017/04/18

Who owns and controls the battery?

- The utility must be in control of and often must also own the isochronous resource(s) that regulates the voltage and frequency, and provides the necessary adequacy for the system
- Often times, utilities can't purchase a battery outright since the utility board may not approve of the large capital purchase (they are overseeing the best interest of the rate payer)
- Does the community want to be a regulated utility? Does the community want to be responsible for fixing any issue in the system if things go wrong?
- This is an ownership, financial, policy, risk, and regulatory issue.

Seasonal storage opportunities – pumped hydro

- Yukon Energy Corporation is planning on pursuing a pumped hydro facility at Moon Lake (White Pass)
- This can enable the Yukon to store excess solar and hydro in the summer to deliver it during the winter peak

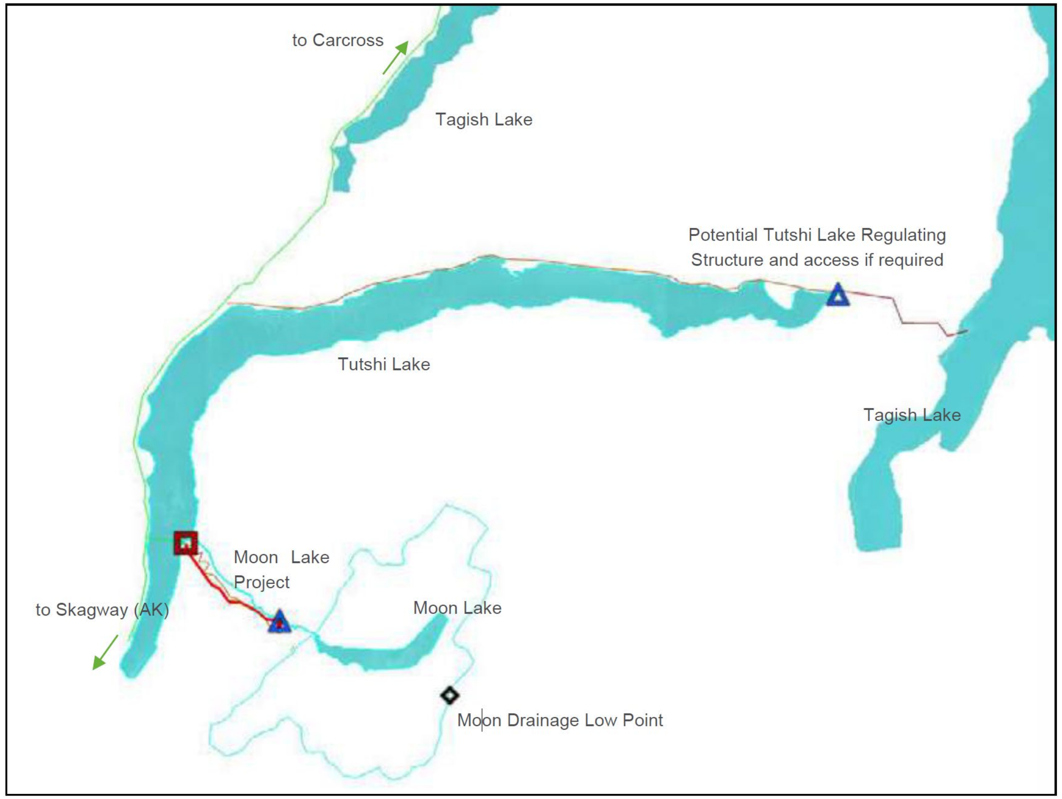
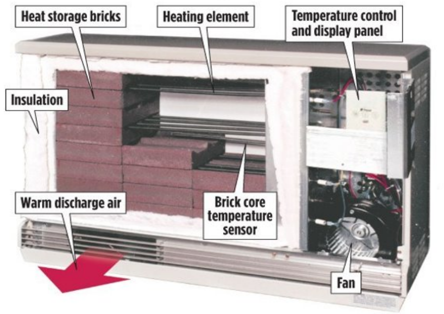


Figure 1.1 Tutshi-Moon Project

Demand-side management opportunities – electric thermal storage

- Modify the *power in = power out* equation by controlling power out
- In partnership with Yukon Conservation Society, YukonU, Yukon Government, ATCO Electric Yukon, and Yukon Energy Corporation are pursuing a pilot project to install 40 ETS units in residents' homes to reduce the Yukon's winter peak
- This diurnal technology is meant to help reduce the peak through load shifting by storing thermal energy during non-peak times and dissipating the heat when it is needed

Electric thermal storage heater



Source: Steffes Heating Systems   STAFF GRAPHIC | JEFF WOODBURY

10 High priority research questions
How effective are ETS units at reducing the Yukon's winter peak?
What regulatory or infrastructure changes would need to be made for adoption and wide implementation in the Yukon?
How effective are ETS units as controllable, predictable, dispatchable resources?
What is the best ETS control approach for peak reduction without producing a secondary peak?
Will occupants experience a disruption in their comfort levels?
What would the GHG emission reduction be from ETS implementation, and what would the heating fuel usage reduction be?
How would wide-spread ETS implementation affect residential load power factor/quality?
Can ETS help mitigate the black start load of the system by delaying when it charges after a power outage?
What is the added value of controlling the ETS units in aggregate?
What are the value streams for integrating ETS units in diesel-powered communities?

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