Getting to Deep Decarbonization

Kivalliq Hydro Fibre Case Study

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UNIVERSITY OF ALBERTA

Energy Systems Signature Area

www.ualberta.ca/energy-systems

The University of Alberta is located on Treaty 6 territory, a traditional gathering place for diverse Indigenous peoples including the Cree, Blackfoot, Métis, Nakota Sioux, Iroquois, Dene, Ojibway/ Saulteaux/Anishinaabe, Inuit, and many others whose histories, languages, and cultures continue to influence our vibrant community.

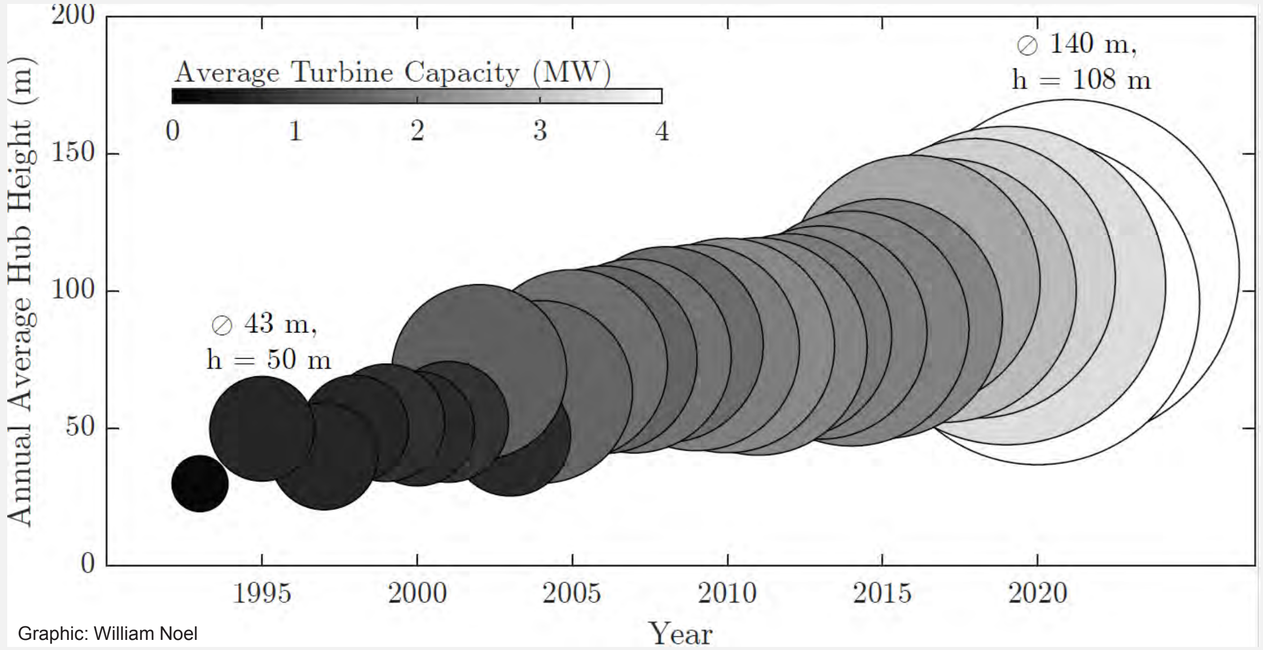
Disclaimer

- The research presented here is not on behalf of the Kivalliq Inuit Association, any of its subsidiaries, or intended to speak on behalf of the communities or the KHFL project
- Data used for this analysis is publicly available and was used as a case study for examining electrification of heating in northern contexts

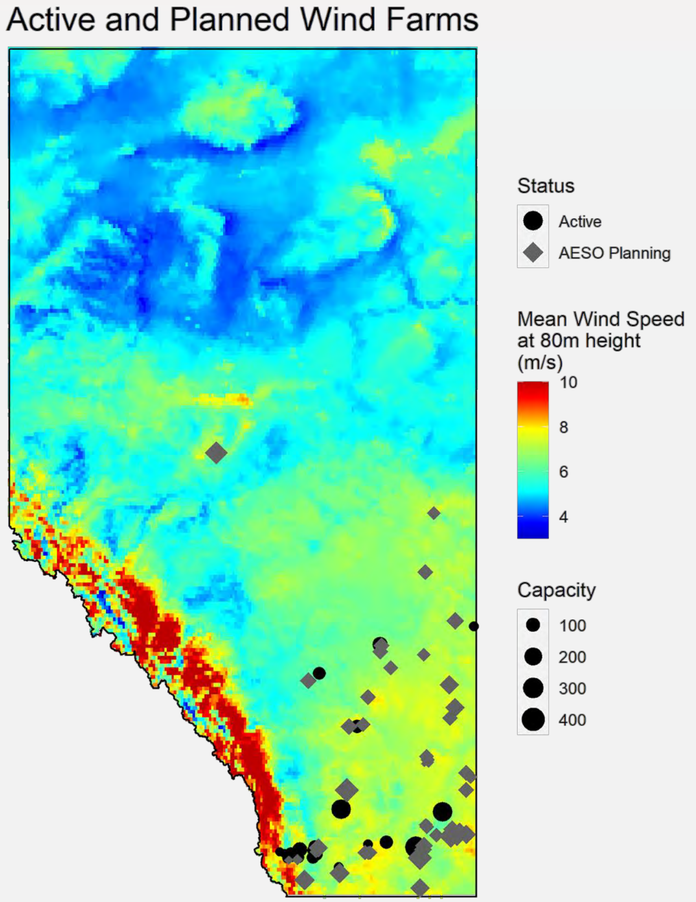
Centre for Applied Business Research in Energy & the Environment (CABREE)

- Independent research centre
- Led by Dr. Andrew Leach and Dr. Tim Weis
- Focused on energy market and climate change analysis in support of public policy development and debate

Examples of Current Research



Graphic: William Noel



Graphic: Taylor Pawlenchuk

Examples of Current Research

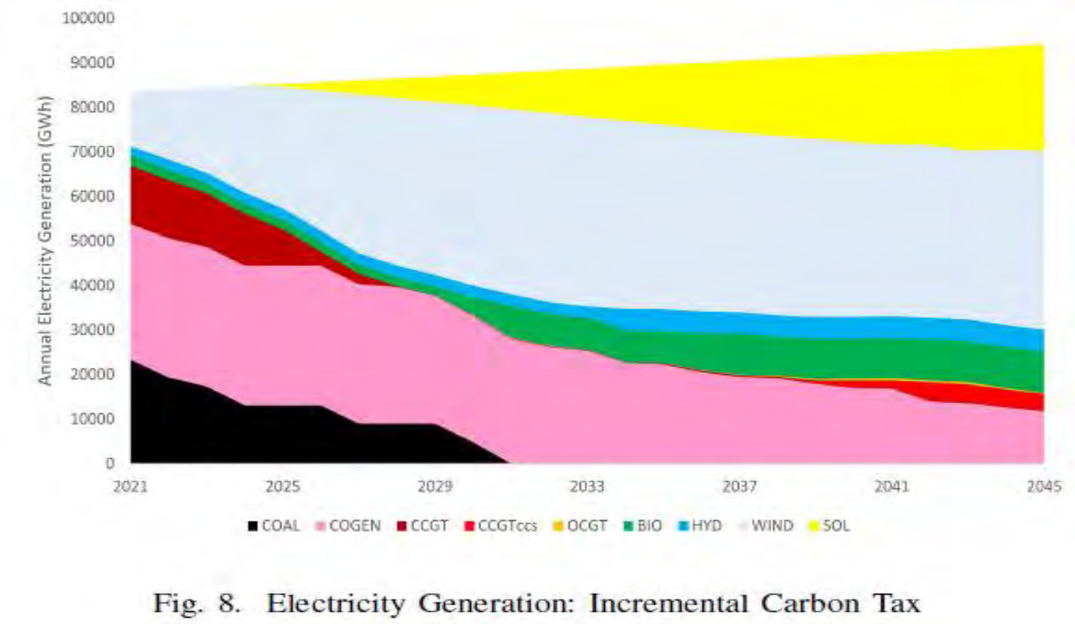
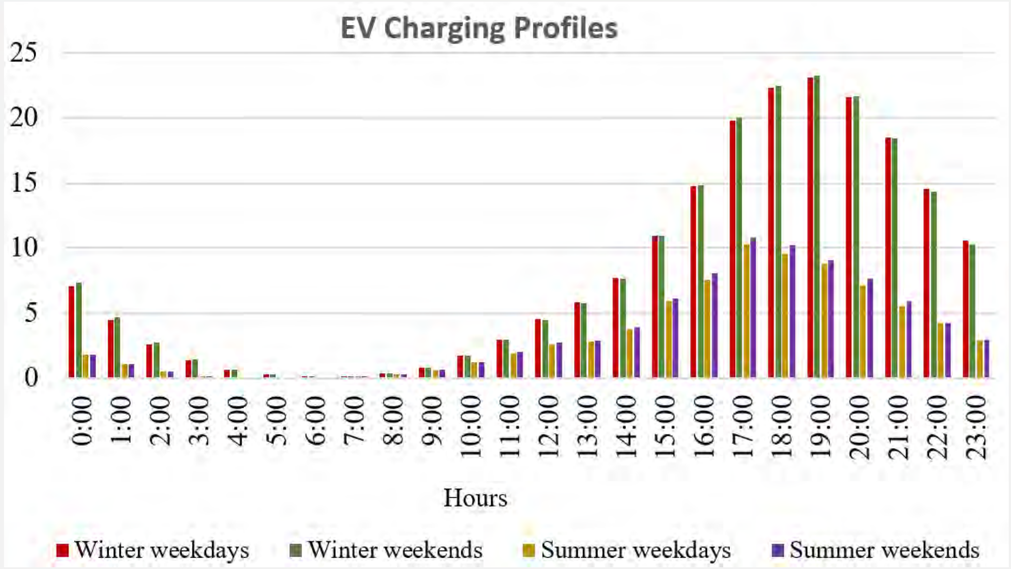
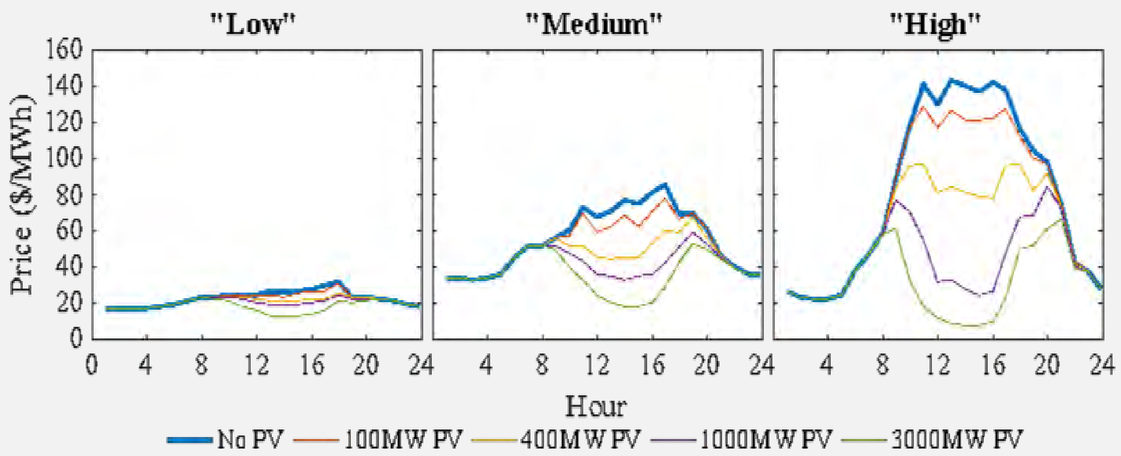


Fig. 8. Electricity Generation: Incremental Carbon Tax

Graphic: Ziad Memon





Graphic: Gloria Duran

Kivalliq Hydro-Fiber Link Background (KHFL)

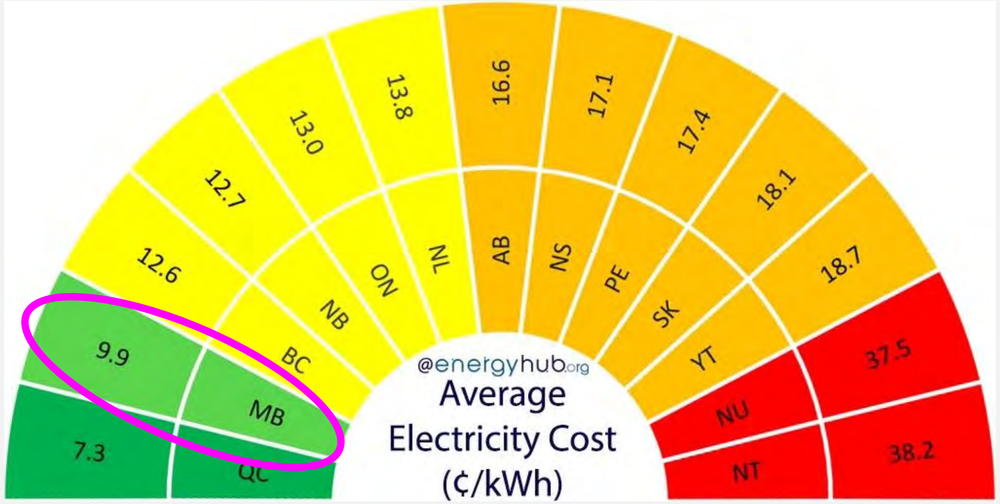
- Led by the Kivalliq Inuit Association (“KIA”)
- 150 MW capacity project over 1200 km
  - Goal of ‘complete’ fossil fuel replacement for both electricity **and** electrification of heat
- Includes fiber-optic Internet
- Estimated ~1.75 billion CAD
- 2020 Canadian Infrastructure Bank MOU
- 2021 CanNor $3 million feasibility study

Source: https://www.kivalliqlink.ca/

Overview

- KHFL ‘uniqueness’
  - Not all (or even many) remote communities have the opportunity for grid extension
- UofA team engaged by conservation society Oceans North (www.oceansnorth.org) to provide independent review of the proposed project and compare with alternatives
- Quantify emissions reductions possibilities and opportunities to achieve close to 100% reductions (not including transportation)

Source: https://www.kivalliqlink.ca/



KHFL Communities

- Location: South-Eastern region of Nunavut, bordering Manitoba and Hudson's Bay. Five (coastal and inland) hamlets able to connect.
- Population: 8,440 (2016, Statistics Canada)
- Energy profile:
  - 25.3 million L/yr (QEC)
  - ~9 t_{CO2e}/yr/person (WWF, 2016)
  - 3.4%/yr energy production growth (BBA, 2015)

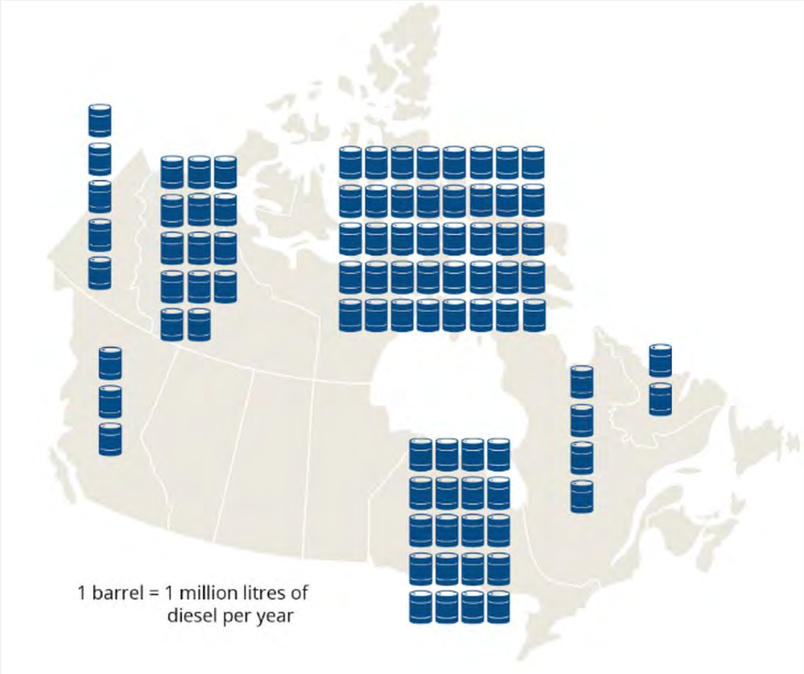
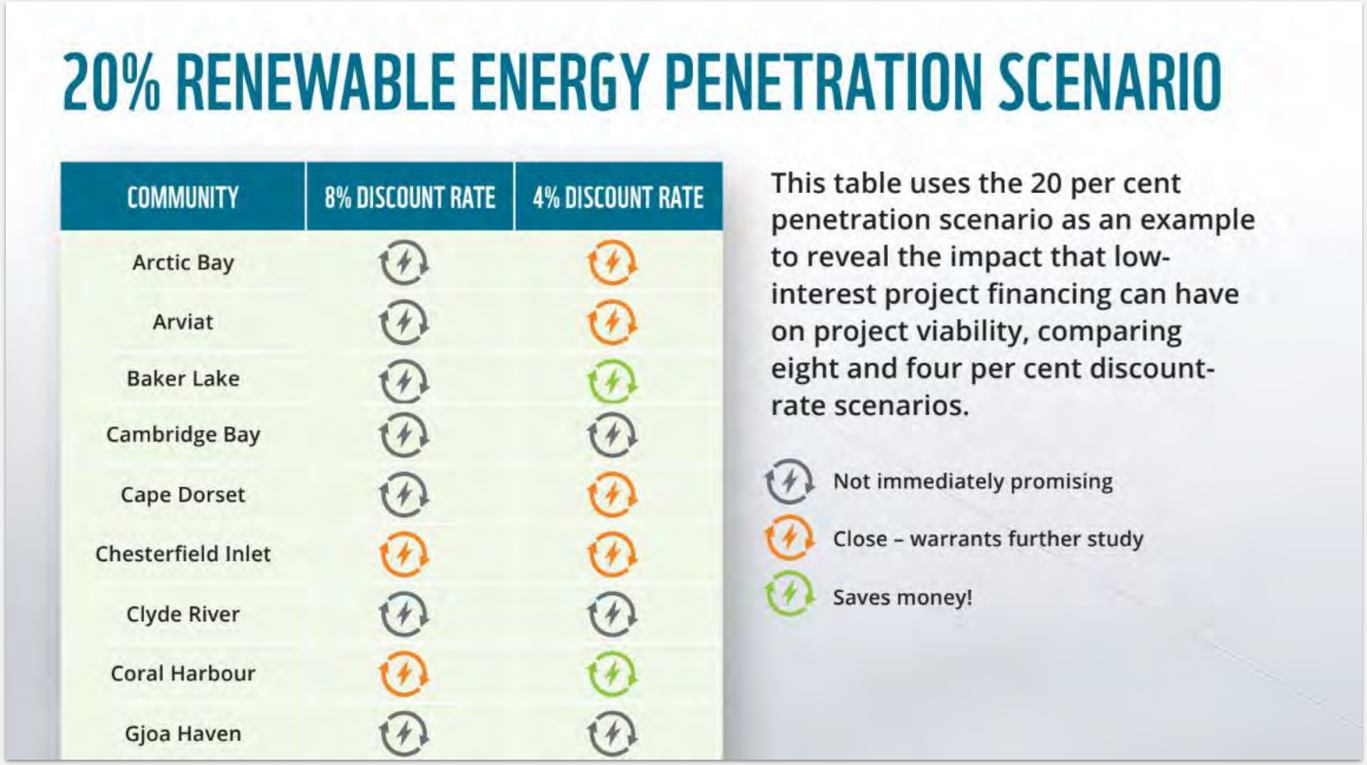


Figure by Pembina Institute

Potential for Renewables in the Kivalliq Region



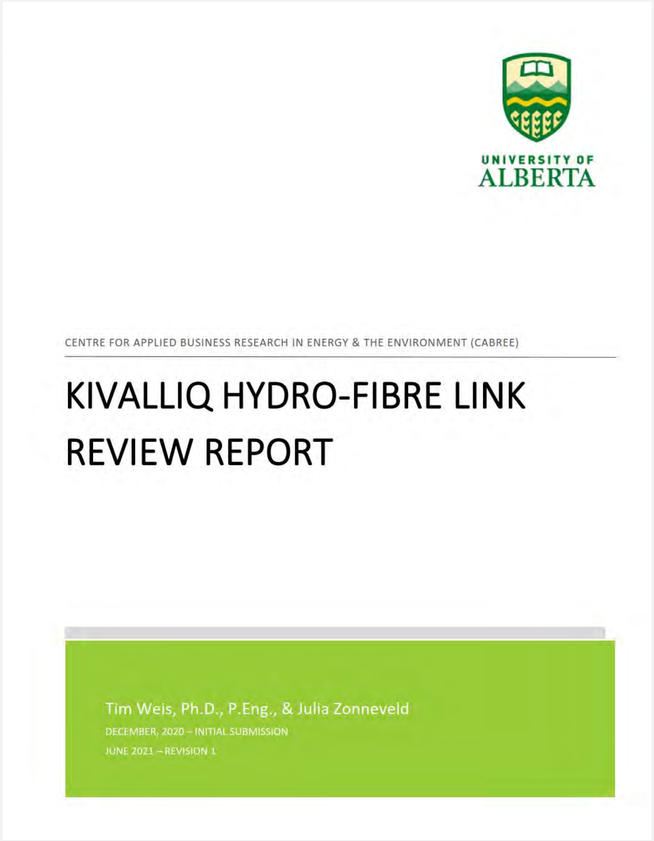
WWF Final Renewable Energy Report 2019

Potential for Renewables in the Kivalliq Region

Potential for Wind Energy in Nunavut Communities by JP Pinard, Ph.D., P.Eng.

HOMER Inputs (UofA)

- BBA scoping study
- Similar assumptions to WWF, hamlets modelled individually
- NASA data for solar resource
- Canadian Wind Atlas data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CENTRE FOR APPLIED BUSINESS RESEARCH IN ENERGY & THE ENVIRONMENT (CABREE)

KIVALLIQ HYDRO-FIBRE LINK REVIEW REPORT

Tim Weis, Ph.D., P.Eng., & Julia Zonneveld

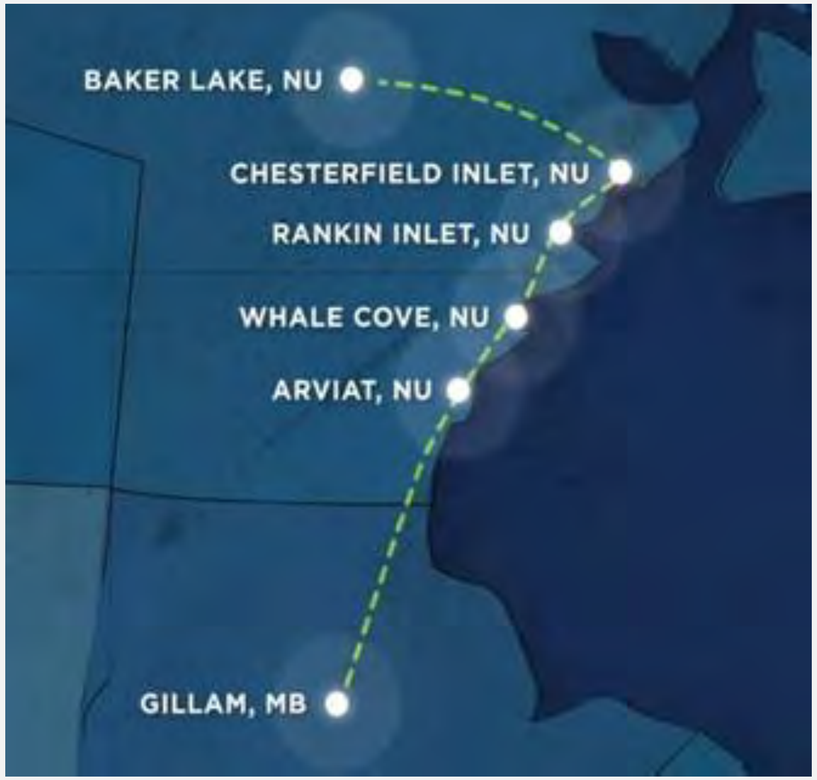
DECEMBER, 2020 – INITIAL SUBMISSION

JUNE 2021 – REVISION 1

HOMER Pro
STANDALONE MICROGRIDS

KHFL Potential Benefits

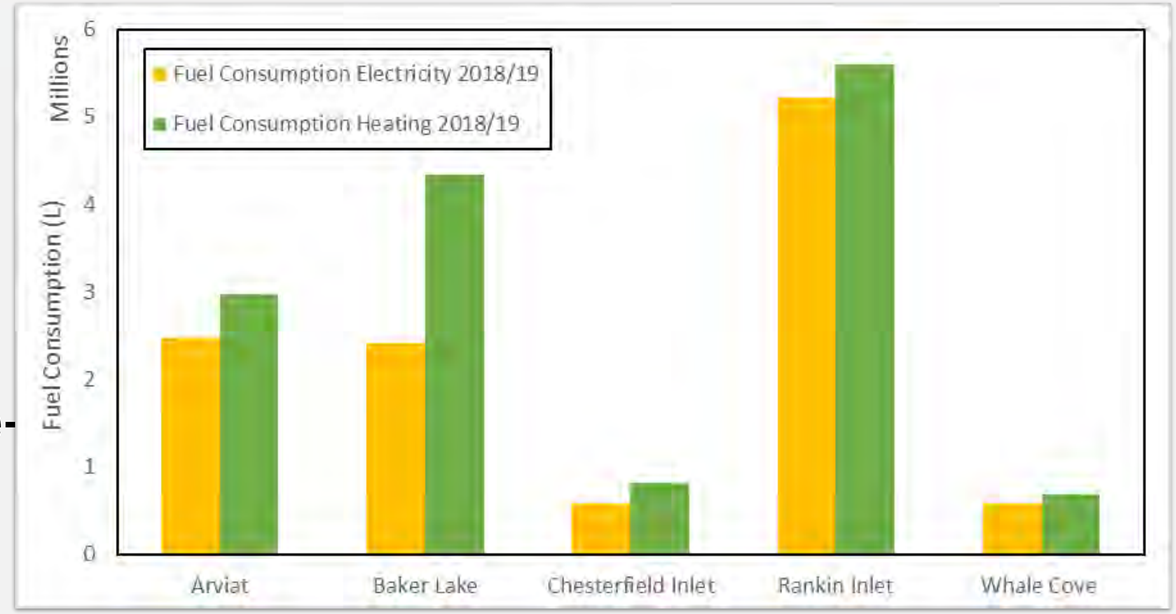
- Very low emissions factor of <1 t_{CO2e}/GWh from Manitoba Hydro (compared to diesel ~750 t_{CO2e}/GWh)
- High potential for GHG reduction, getting very close to 100% renewable electricity and heat
- Community fuel savings 25 million L/yr
- GHG reduction ~70,000 t_{CO2e}/yr
- Over ½ of the benefits by including heat savings



Source: Nunatsiaq News

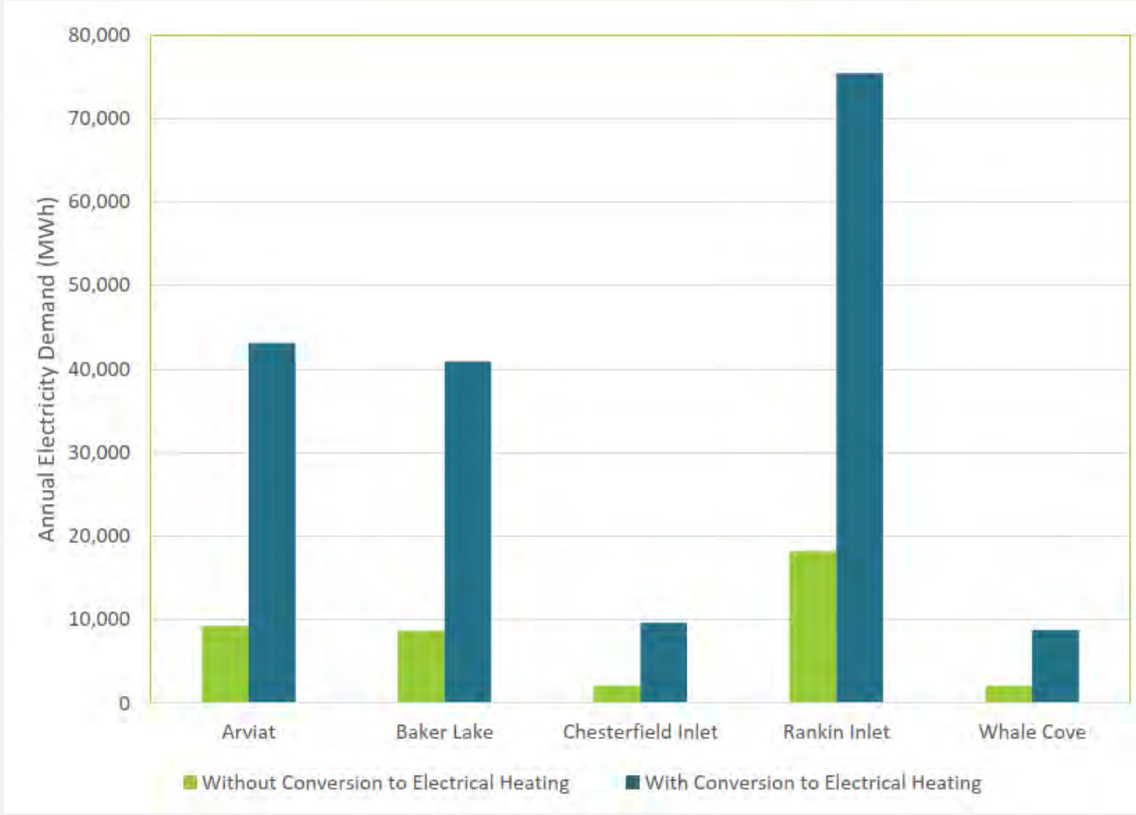
Challenges Identified

- Financing/access to government support
- Risk of cost escalation/overruns
- Electrification of heating (physical change-out/community support)
- Outages – amplified risk with heating
- Increases the of risk associated with outages and importance of reliability
- Diesel generators redundancy

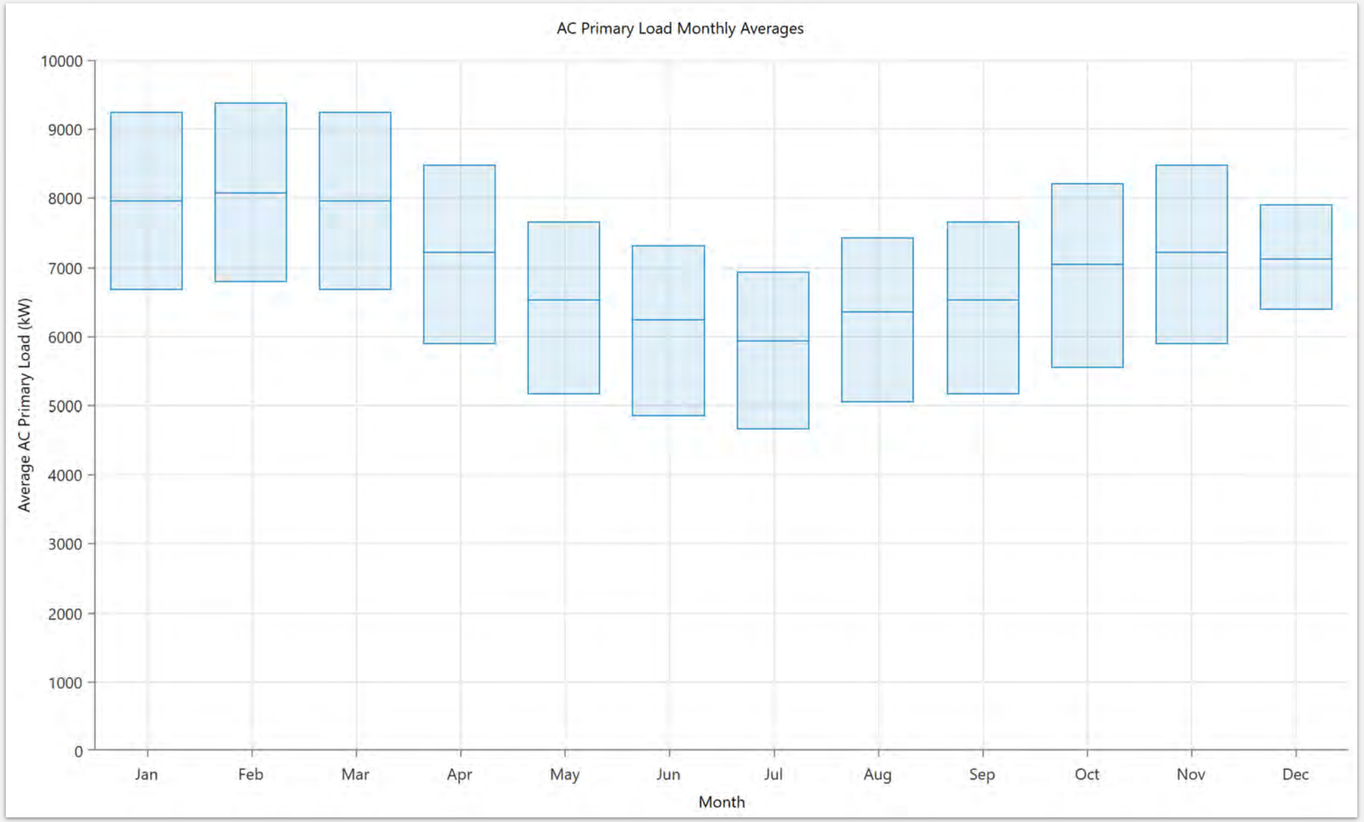


Addressing the Heating Challenge - New Study

- Initially homes likely to retain redundant fossil fuel heating, but become expensive for new buildings and maintenance due to low usage rates
- Electric heating uptake could be limited if dual systems required
- Scale up of diesel generator infrastructure (~4X) to cover electric heating during outages
- District heating model
  - Model community energy systems only (mining analysis not included)

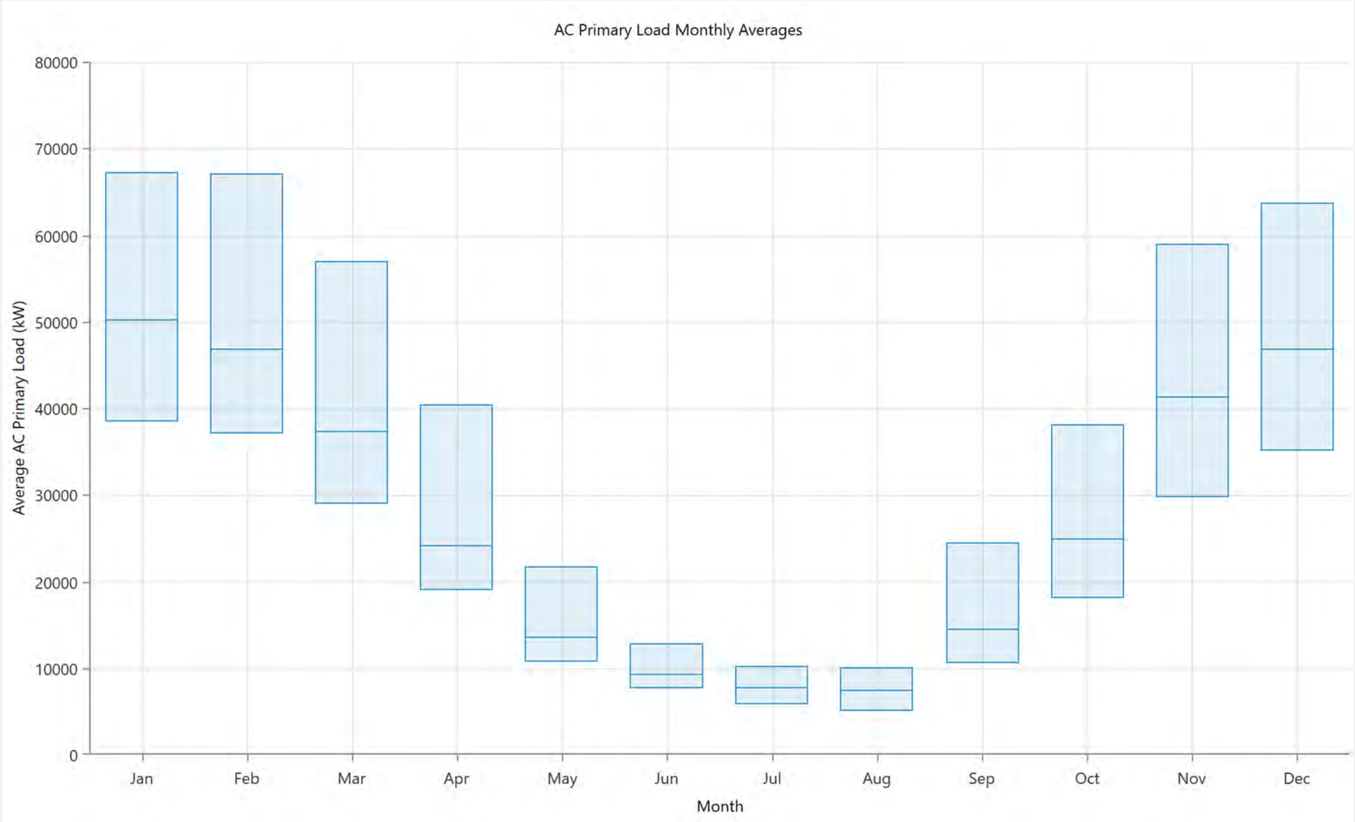


Community Electricity Demand Profiles



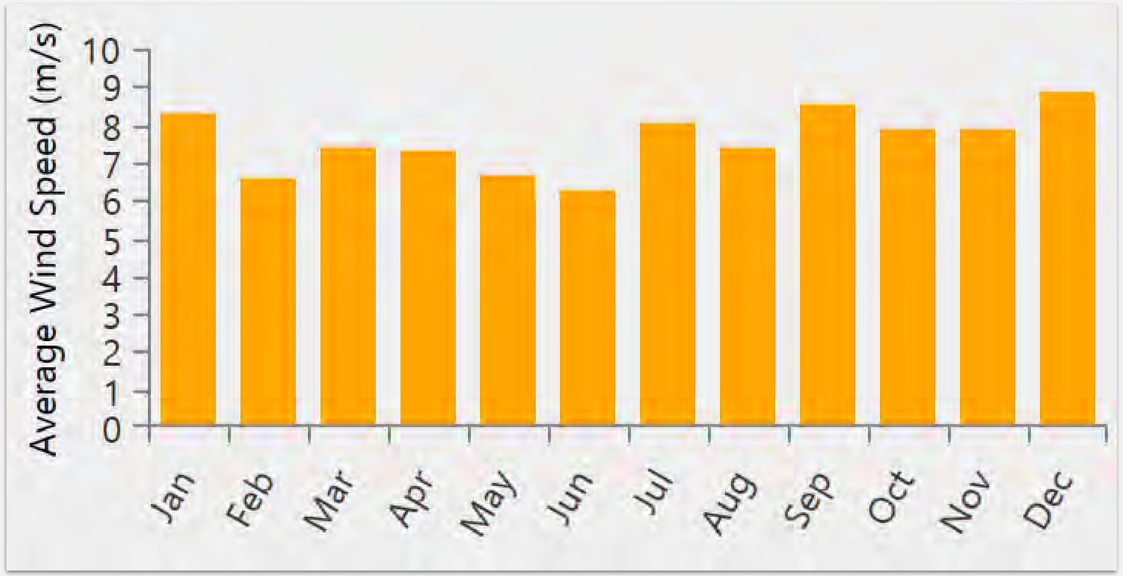
Annual Community Electric Load

Community Demand Profiles with Electric Heating

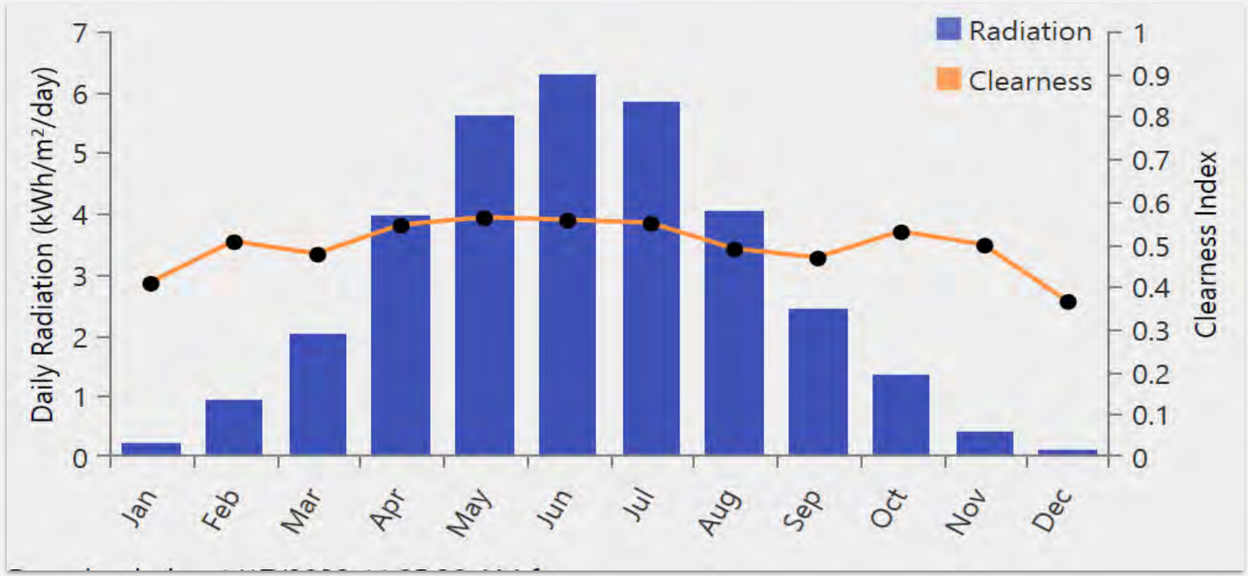


Annual Community Electric and Thermal Load

Wind and Solar Resources



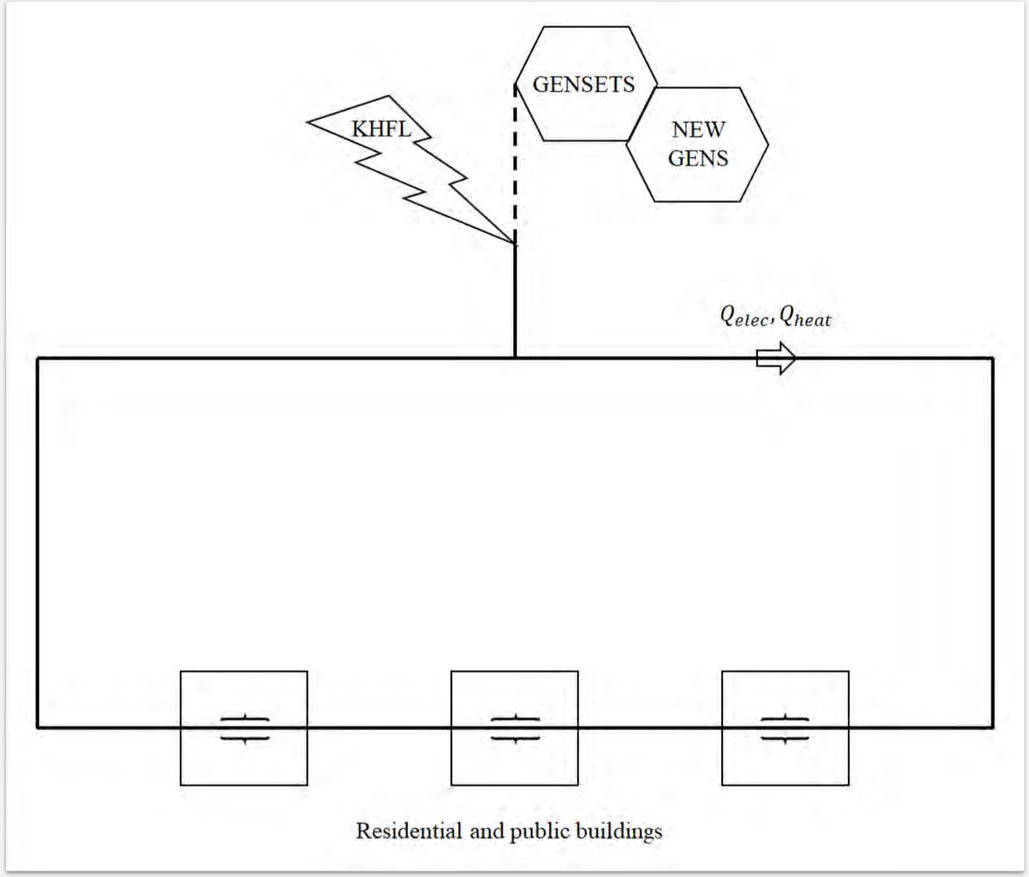
Rankin Inlet Annual Wind Resource



Rankin Inlet Annual Solar Resource

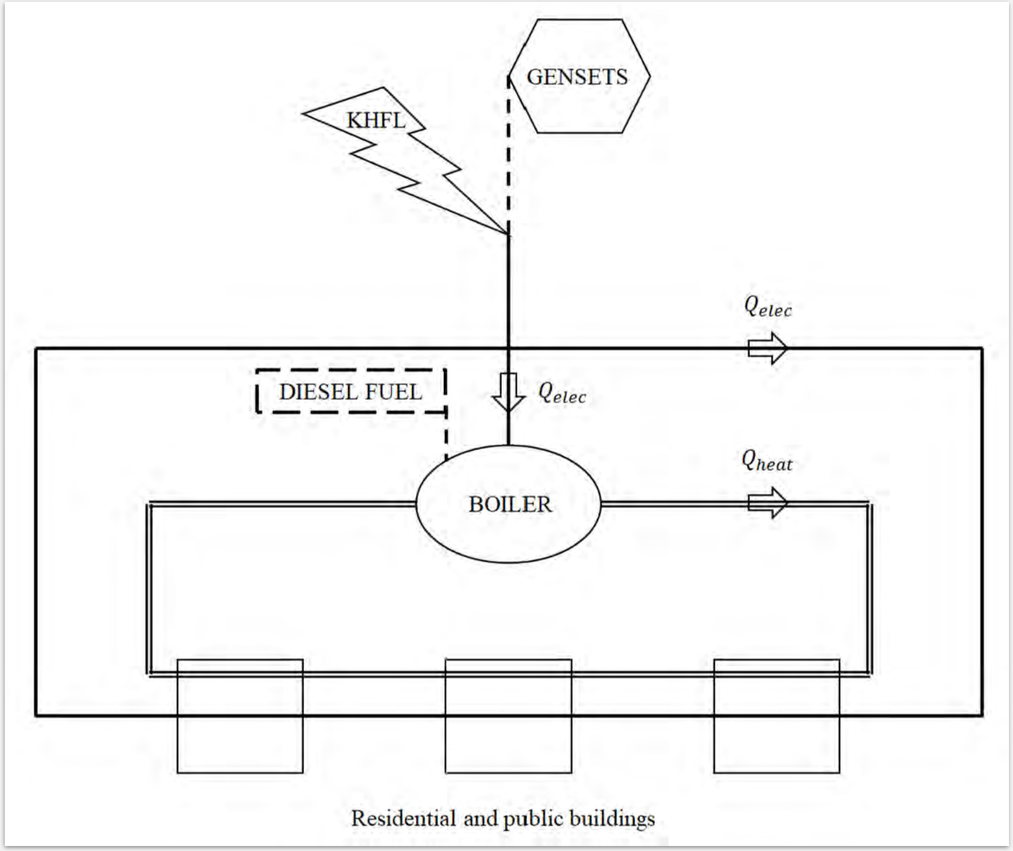
Scenario Analysis: KHFL with Electric Heating

- Distributed electric heating in individual households
- Assumes 100% electric heating conversion
- Assumes diesel gensets need to service combined electricity and heating load



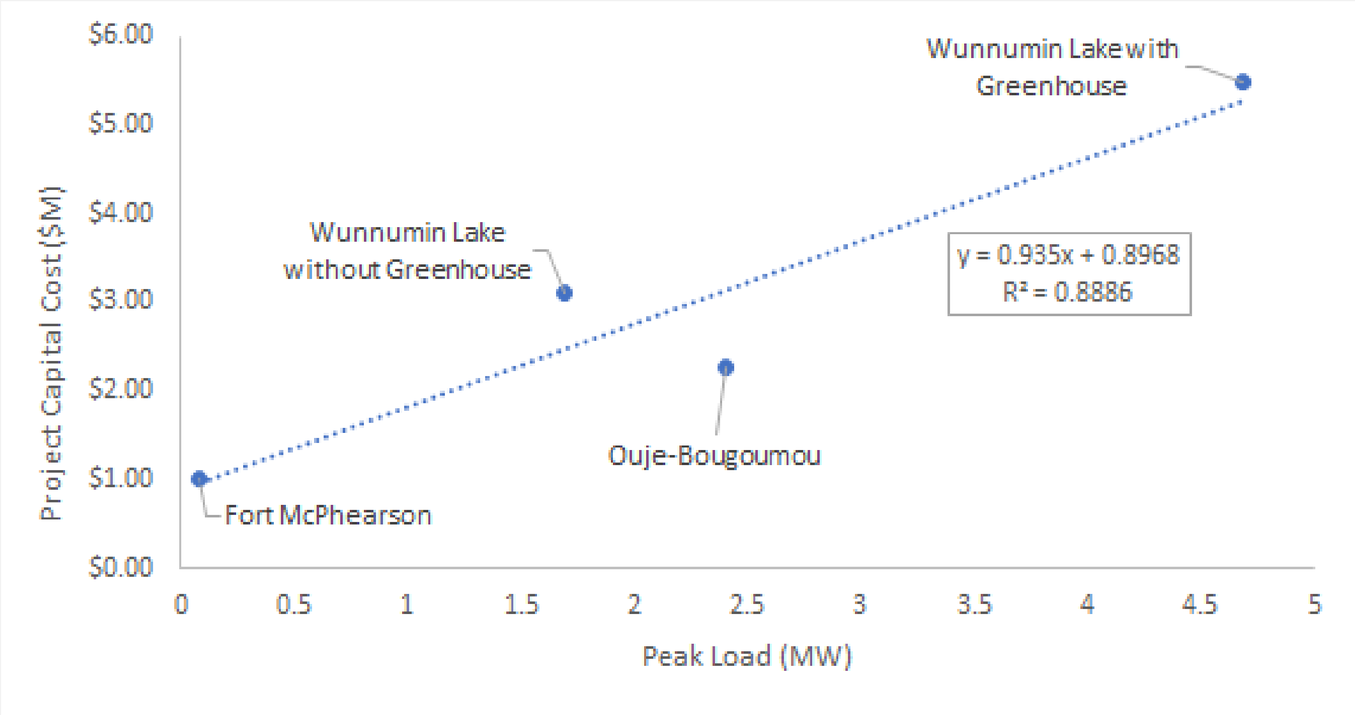
Scenario Analysis: KHFL with District Heating

- Central electric boiler with diesel fuel backup
- Maintain generators in case of outages - serving electric load



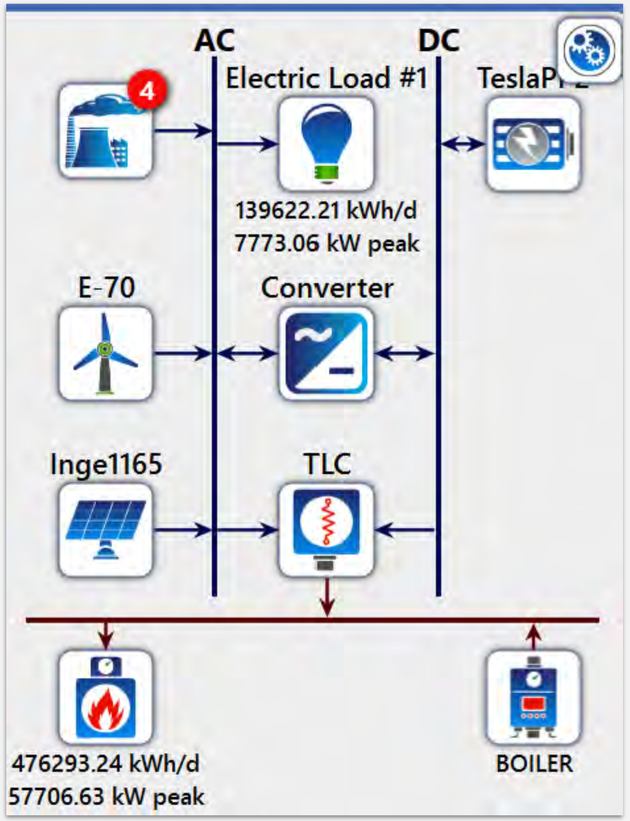
Northern District Heating Projects

- Examples in other northern communities
- Reference to existing remote district heating cost estimates
  - Note: district heating costs can be very site-specific, especially for low density communities



Scenario Analysis: Renewables with District Heating

- Central electric boiler and heating serves as dump load
  - Allows for increased renewable penetration
- Generators integrated into system, often as auxiliary load



Optimized Renewable Fraction

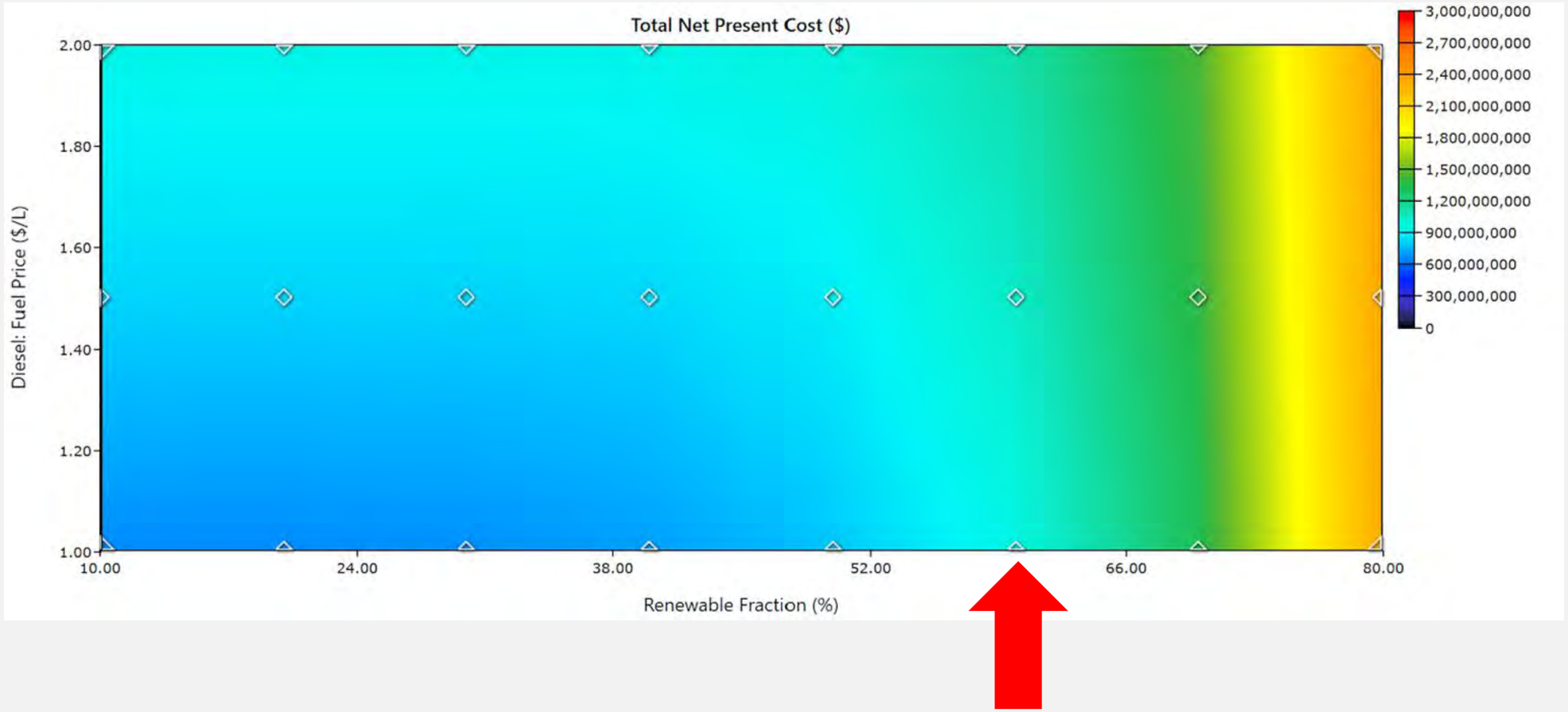
- HOMER building solar, wind, battery storage
  - Validation of previous studies
- Optimal renewable energy penetration with respect to diesel costs
  - $1.00/L; 21.3%
  - $1.50/L; 32.7%
  - $2.00/L; 39.4%

Optimized Renewable Fraction – Household Energy Costs/Yr

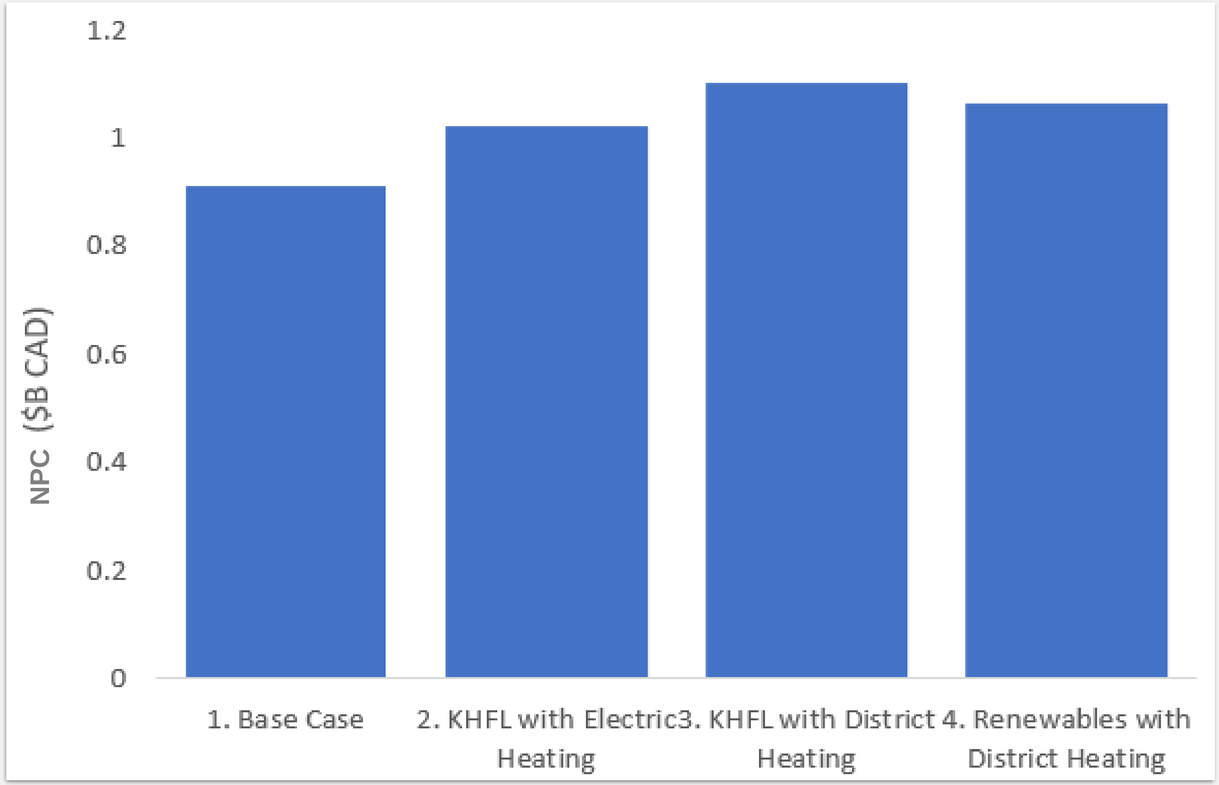
- At $1.00/L, up to 21% renewables reduce emissions without increasing annual household costs
- Above $1.50/L diesel fuel, renewables scenarios lower annual energy costs

Diesel Costs ($/L)	BAU - Diesel	Optimized Renewables + District Heating
1.00	$10,500	$10,600
1.50	$14,200	$13,000
2.00	$18,000	$15,100

Forcing High Local Renewables Without KHFL



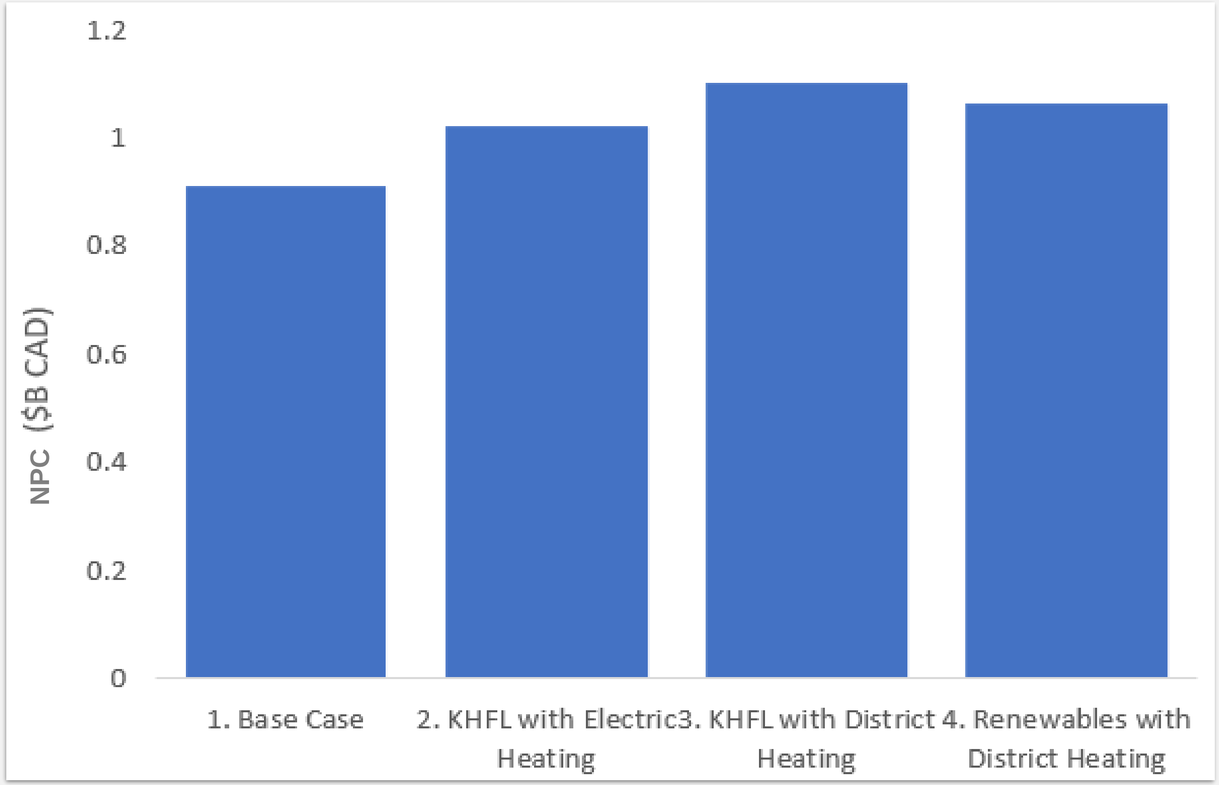
Scenario Analysis

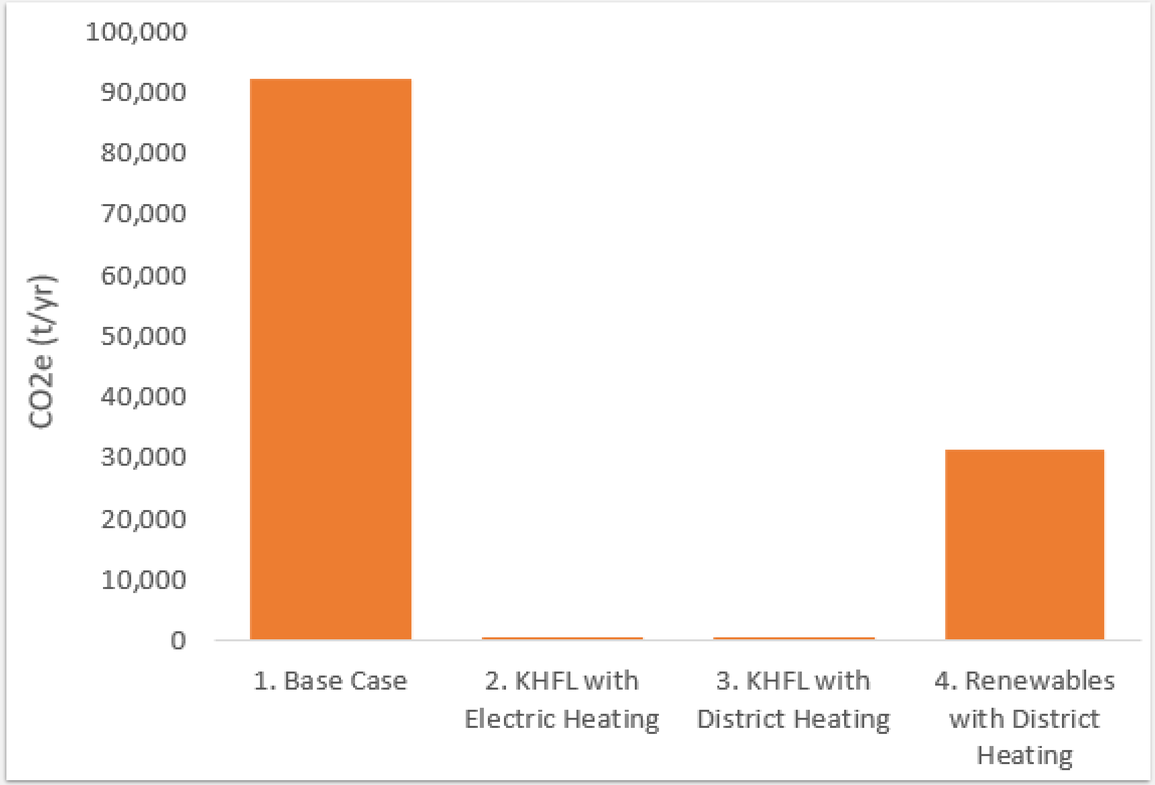


Middle scenario

- $1.50/L
- 20 outage hours
- 60% renewables (not optimized case)
- Lowest cost scenario (not shown) ~20% renewables

Scenario Analysis ($1.50/L and 60% renewables)





Sensitivity Results

- General model results
  - Local renewable energy lowest cost, but not lowest GHGs
  - Key variables: Diesel cost, capital cost, discount rate, KHFL outages
  - For high outage hours, and low diesel costs, base case/RE “wins”
  - Moderate to higher diesel costs, KHFL (with heating) wins
    - District heating outperformed electric heating for high outage hours

- KHFL Outage Hours
  - Bookend cases for the two models with the KHFL
  - 0 hours/yr & 400 hours/yr
  - Top limit based on Kyuquot, BC (Ka:'yu:'k't'h'/Che:k:tles7et'h' First Nations)

Sensitivity Results : Outage hours cont'd

Bookend cases

	KHFL with Electric Heating		KHFL with District Heating	
	0 outage hrs	400 outage hrs	0 outage hrs	400 outage hrs
NPC (CAD)	1.02 B	1.16 B	1.10 B	1.13 B

Limitations of Model

- Thermal Load Controller (TLC) replacing electric boiler
- Modelling KHFL as PPA in HOMER
- District heating model costing
- Aggregated loads
  - Rankin Inlet renewable case resources (best case scenario)
- Focus on communities (assessment of mines not included)

Key Conclusions

- Preliminary assessment of district heating suggests benefits in all scenarios
- The KHFL, if completed on budget, presents the lowest cost option for the communities and mines to move towards 100% renewable energy (including heating), equivalent to 56,000 passenger vehicles' emissions
  - The project is ambitious and will require multiple levels of support to complete, including heating electrification and load growth (including mining)
  - Outages need additional study: frequency and duration

Future considerations

- Hydrogen production
- Thermal mass heating
- Electric vehicles

Thanks - We Love to Hear Your Feedback on Future Work

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