Long-term Renewable Energy Electricity Planning for Remote Communities

Nunavut Mining Symposium

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OUTLINE

- Waterloo Institute for Sustainable Energy.
- Motivation:
  - Energy issues in remote communities (RCs).
  - Renewable energy microgrids in Canada.
- Objectives.
- Electricity in remote communities in Canada:
  - Characteristics of RCs and challenges.
- Long-term renewable energy planning:
  - Customer types in RCs.
  - Mathematical modeling.
- Case study.
- Conclusions.

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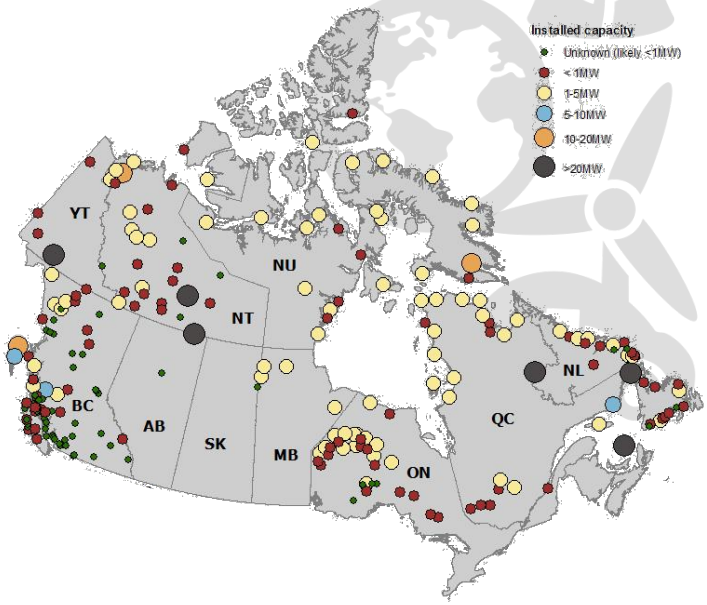
MOTIVATION

- Canada (similar in other parts of the world, e.g., Chile):
  - Approx. 200,000 people live in off-grid communities.
  - 63% of this population relies on diesel-fuel for electricity generation.
  - High electricity price (0.3–2.6 $/kWh).
    - Limited access to some of these communities.
    - Limited fuel storage capacity.
    - Aging diesel generators.
  - Recent remote microgrid efforts:
    - Renewable energy (RE) integration.
    - Demand response projects.
    - Community energy baseline.



MOTIVATION

- Isolated microgrid planning needs:
  - Planning models considering current equipment and control strategies to propose size and location.
  - Identify RE resources and community energy issues.
  - Understand existing operation practices.
  - Identify stakeholders, regulatory and subsidy frameworks, and financing mechanisms.
  - Understand electricity rates and detailed cost breakdown.

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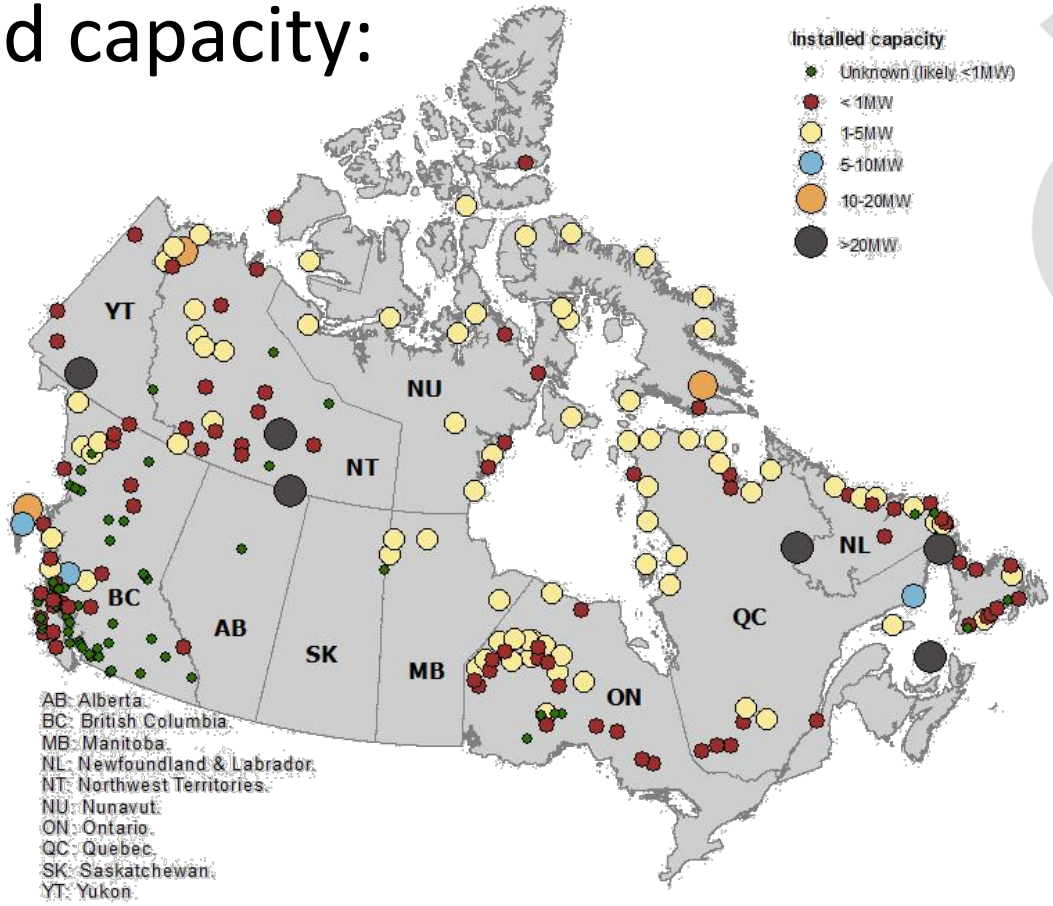
OBJECTIVES

- Create Northern and Remote Communities (N&RCs) microgrid database:
  - Understanding of communities' status and requirements.
  - Obtain up-to-date energy-related technical, economic, environmental, social, and policy information.
- Propose long-term RE planning models that properly consider relevant technical, economic, environmental, social, and policy issues to propose realistic alternatives for N&RCs.

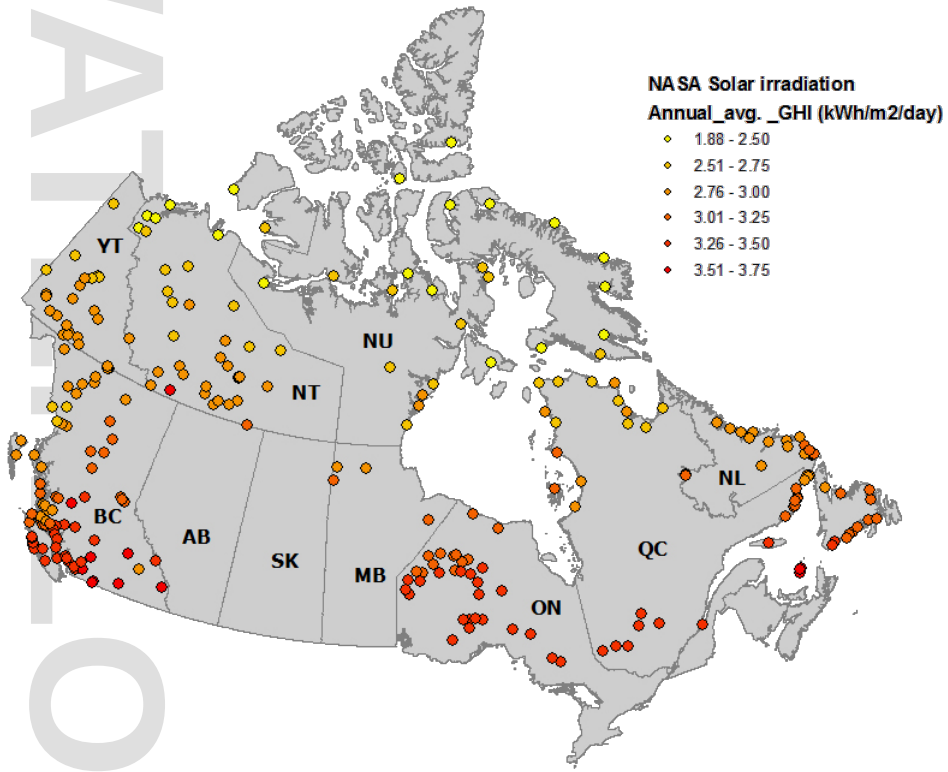
Electricity in Remote Communities

- Installed capacity:

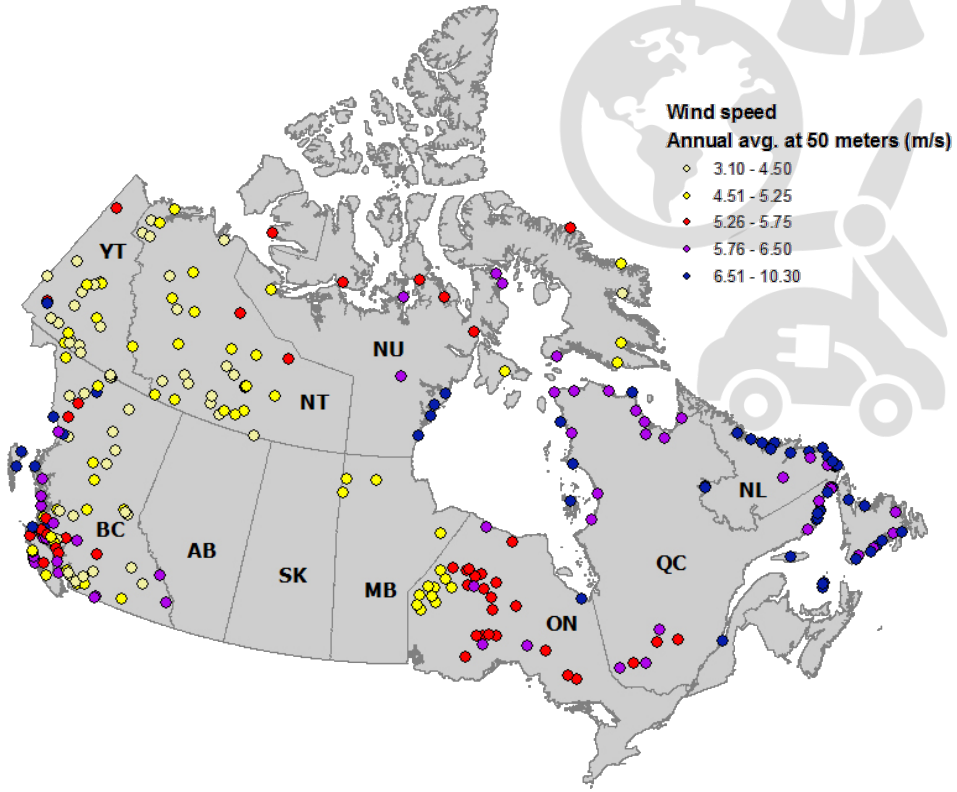


Electricity in Remote Communities

Solar resources



Wind resources



Electricity in Remote Communities

- Diesel generators in N&RCs:
  - 90% engines are between 100kW and 3MW.
  - Plants typically have 3 to 5 engine arrangements.
  - Plant rated capacity is typically 40% to 60% of installed capacity.
  - Fuel efficiency range: 2.4-3.9 kWh/litre.
  - Fuel supply channels vary significantly depending on location.
- Distribution system in N&RCs:
  - Voltage levels: 4.16–25kV.
  - System losses range from 5% to 20% due to technical and non-technical losses.
  - Unbalanced operation.
  - Short feeders.

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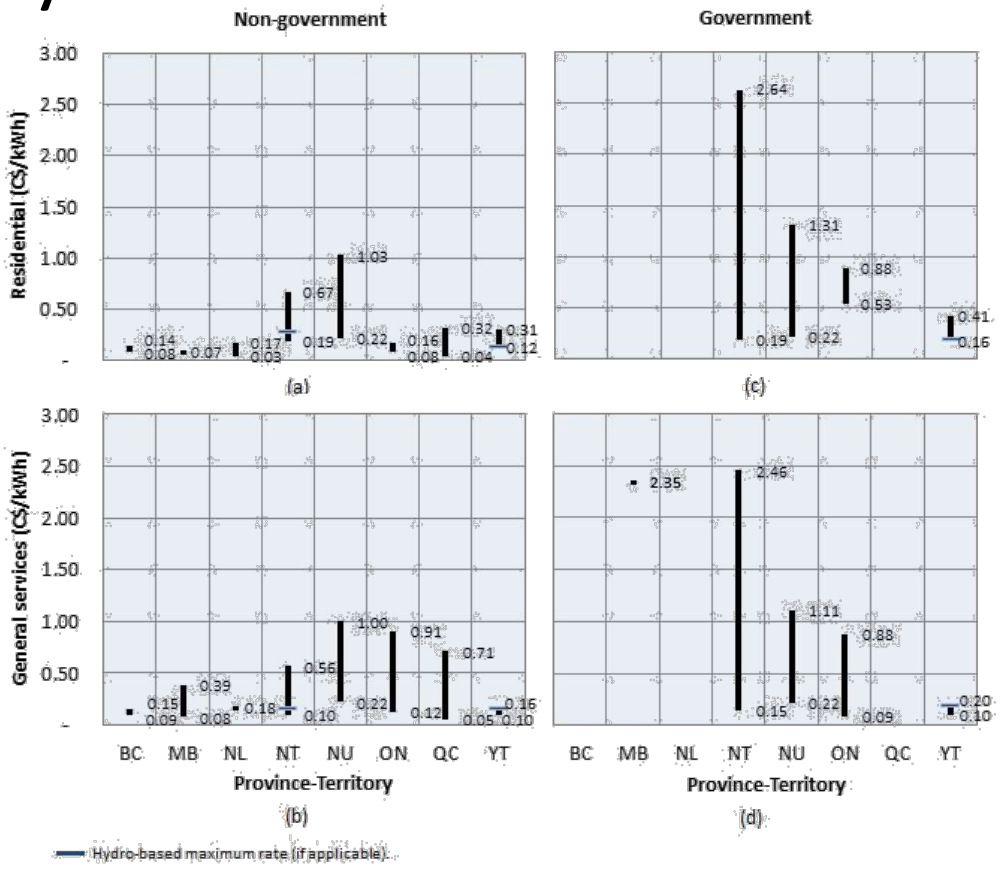
Electricity in Remote Communities

- Electricity challenges in N&RCs:
  - Fossil fuel dependency.
  - Load restrictions.
  - Equipment deployment costs.
  - Operation and avoided fuel costs.
  - Subsidy frameworks.
  - Winter roads.
  - Community operated utilities.
  - Various technical challenges:
    - Unbalanced loads.
    - Controls.
    - RE integration.

Electricity in Remote Communities

- Electricity rates:



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Electricity in Remote Communities

- Type of current/potential electricity rates:
  - Unsubsidized.
  - Subsidized.
  - Avoided fuel cost.
- Current/potential RE ownership:
  - Utility-owned projects.
  - Power purchase agreements (PPA).
  - Self-consumption.
  - Net-metering.

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Long-term Renewable Energy Planning

- Develop a RE planning model for remote communities that maximizes the economic benefit while identify:
  - RE equipment type and capacity to be deployed.
  - Operation schemes under which RE units can operate.
  - Installation time-frame for RE equipment.
  - RE equipment location for customers whose current load demand is known.

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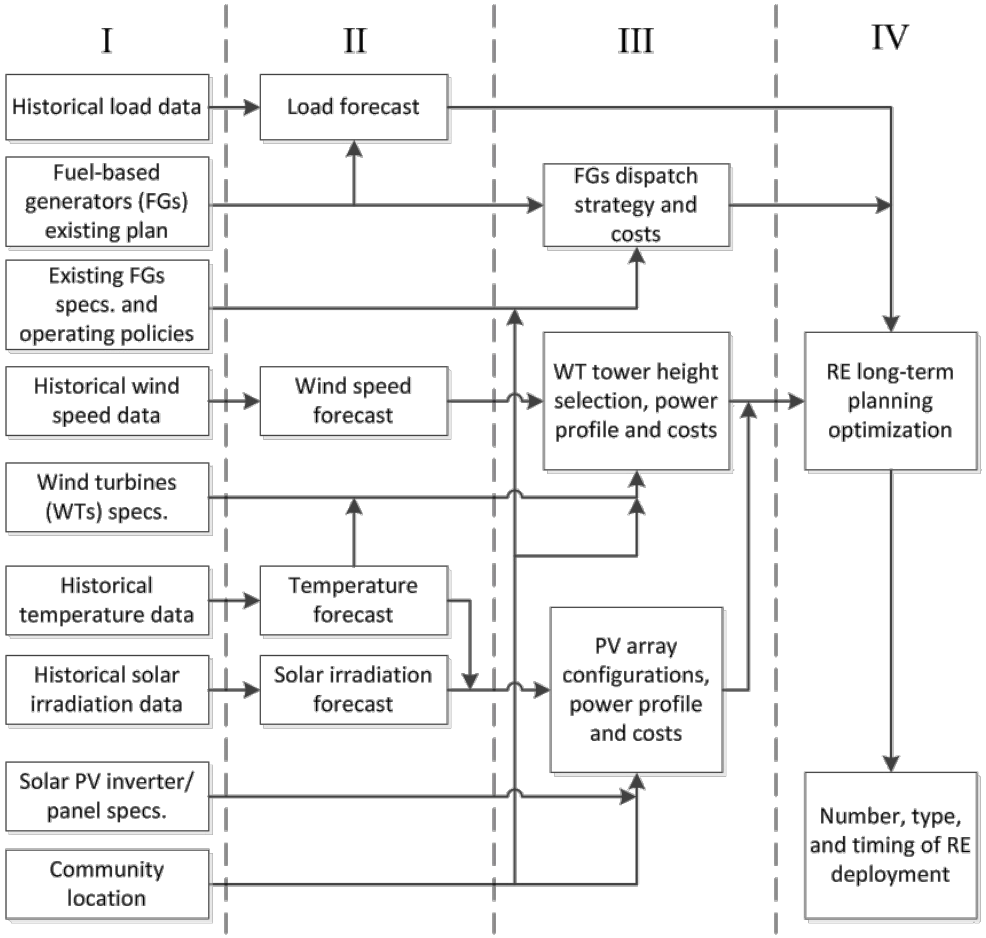
LONG-TERM RENEWABLE ENERGY PLANNING

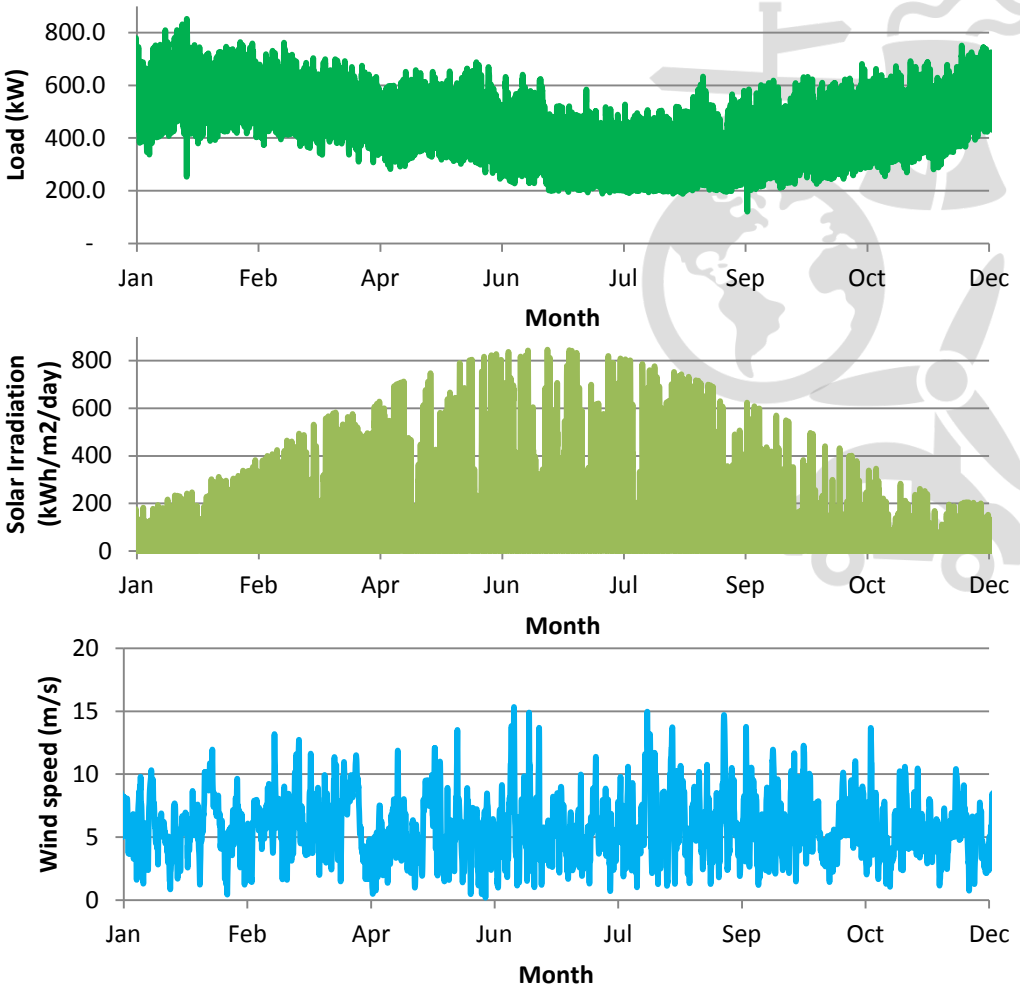


Case Study

- Kasabonika Lake First Nation:
  - Community:
    - Approximately 900 people.
    - 500 km north of Thunder Bay.
    - Winter-road access.
  - Electricity generation:
    - 0.4 MW, 0.6MW, and 1 MW diesel generator in operation.
    - 1.6 MW diesel generator planned.
    - 3x 10 kW Bergey WTs.
    - 1x 30 kW Wenvor WT.
    - 10 kW solar PV array.

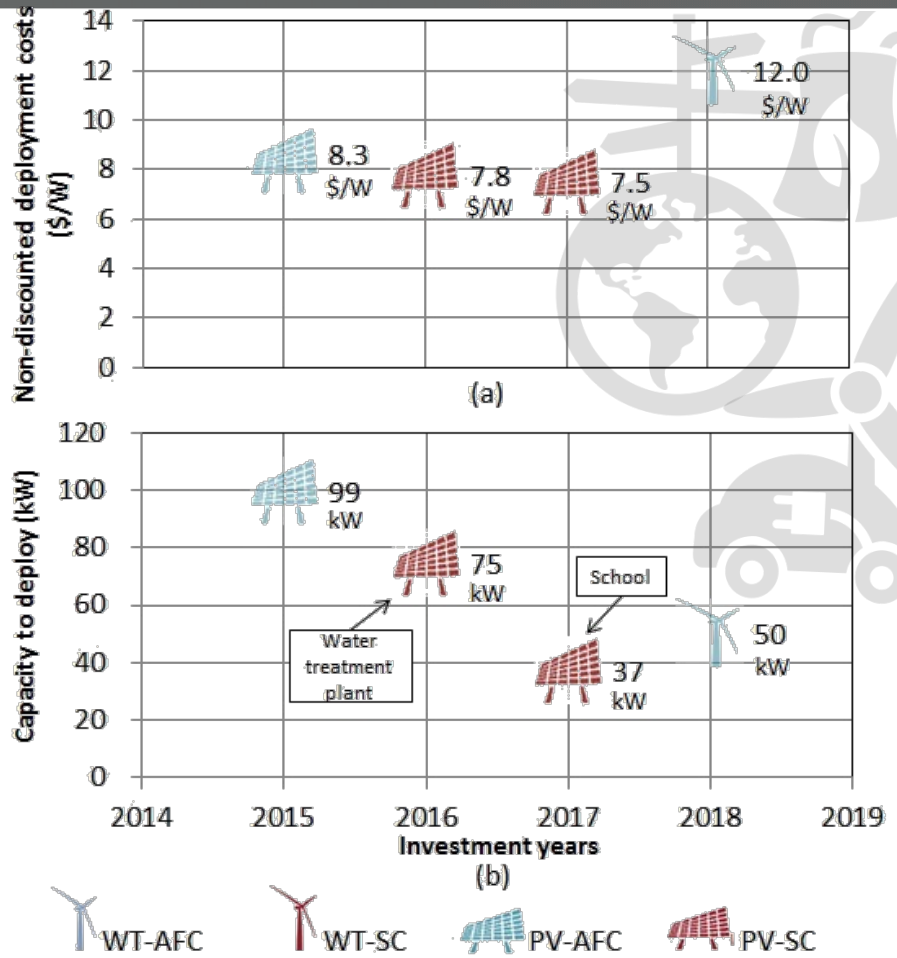
Case Study

- KLFN electric energy demand.
- Solar resource.
- Wind resource.



Case Study

- Model II results:
  - RE equipment type and capacity.
  - RE operation schemes.
  - RE installation time-frame.
  - RE Location for selected customers.

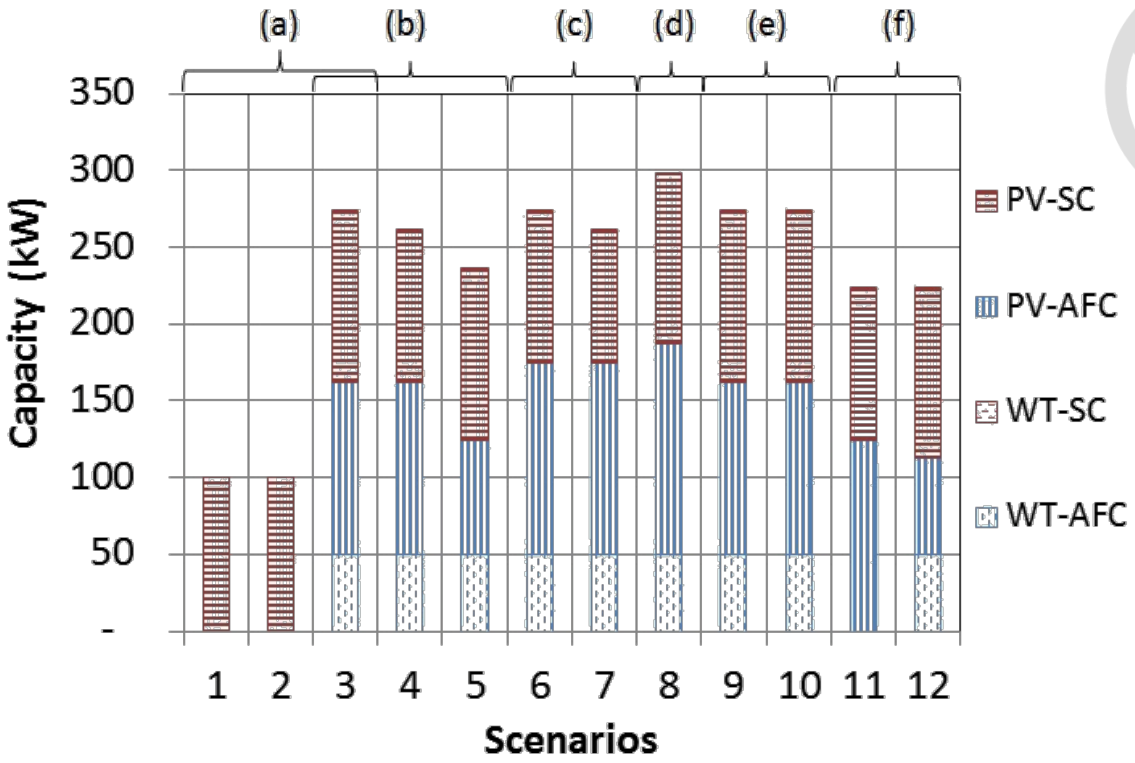


Case Study

- Scenarios:
  - 1 – 3: With/without external funding, and bank loan alternatives.
  - 3 – 5: 4%, 6%, and 8% discount rates.
  - 6 – 7: 5% and 7% fuel cost annual growth.
  - 8: No RE installed capacity limit.
  - 9 – 10: ±6% solar irradiation.
  - 11 – 12: ±10% wind speed variation.

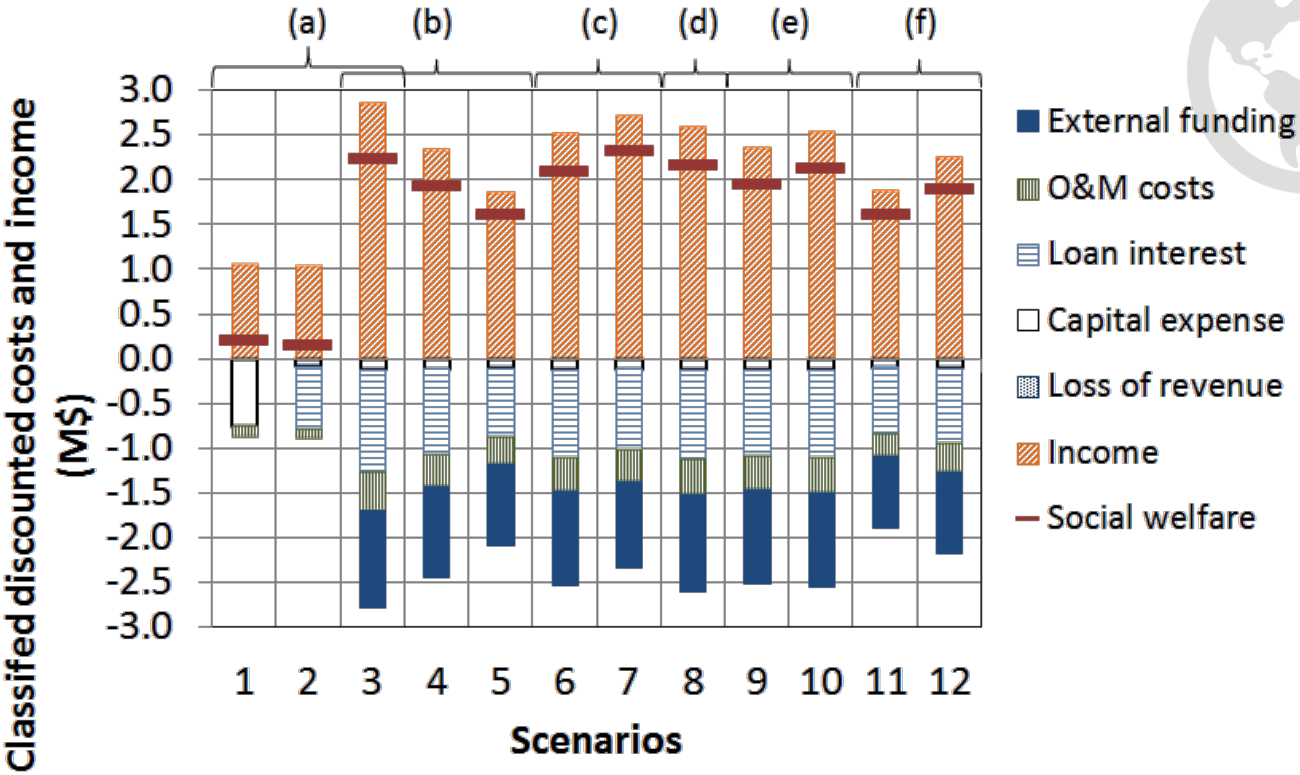
Case Study

- Proposed installed capacity:



Case Study

- Discounted total cash flow:



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CONCLUSIONS

- There is a significant potential for RE integration in remote communities in Canada.
- Their location and accessibility currently limits the type and size of equipment that can be deployed.
- RE projects can be economically and technically feasible when multiple funding alternatives are considered.
- Long-term, Power Purchase Agreements with avoided fuel cost rates can help promote RE integration in remote locations.

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