Status of PV in Canada

Erin M. Tonita
SUNLAB, University of Ottawa, Canada

High Latitude Photovoltaic Workshop, Piteå, Sweden, March 14th, 2024

uOttawa SUNLAB

uOttawa

Acknowledgements

Prof. Karin Hinzer

Prof. Michael Ross

Simon Geoffroy-Gagnon

Dr. Chris Pike

Henry Toal

Dr. Chris Baldus-Jeursen

Dr. Jean-François Lerat

Dr. Silvana Ovaitt

Dr. Chris Deline

Canadian Energy Landscape

- Emissions
- PV capacity
- Policies
- $$

Opportunity Areas

The Prairies

Remote Northern Communities

Canadian Research

Yukon University

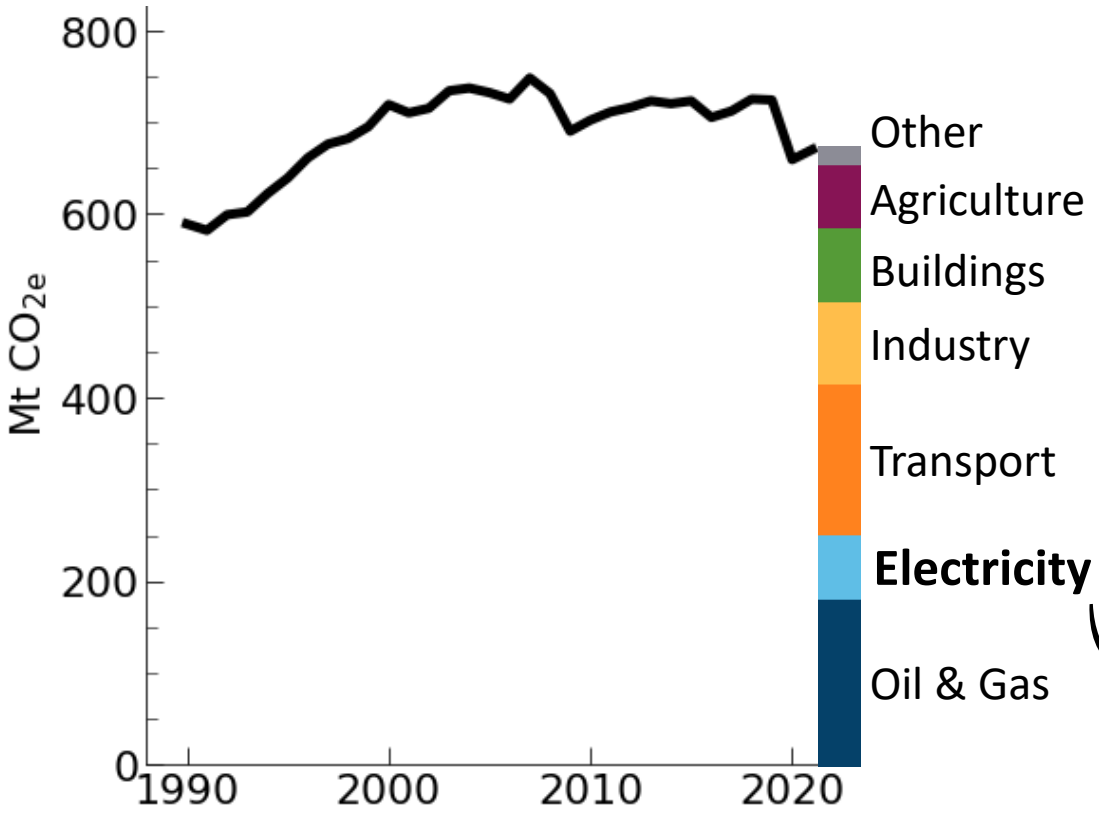
Natural Resources Canada / Ressources naturelles Canada
Canada
CanmetENERGY / CanmetÉNERGIE

UNIVERSITÉ DE SHERBROOKE

Western University · Canada

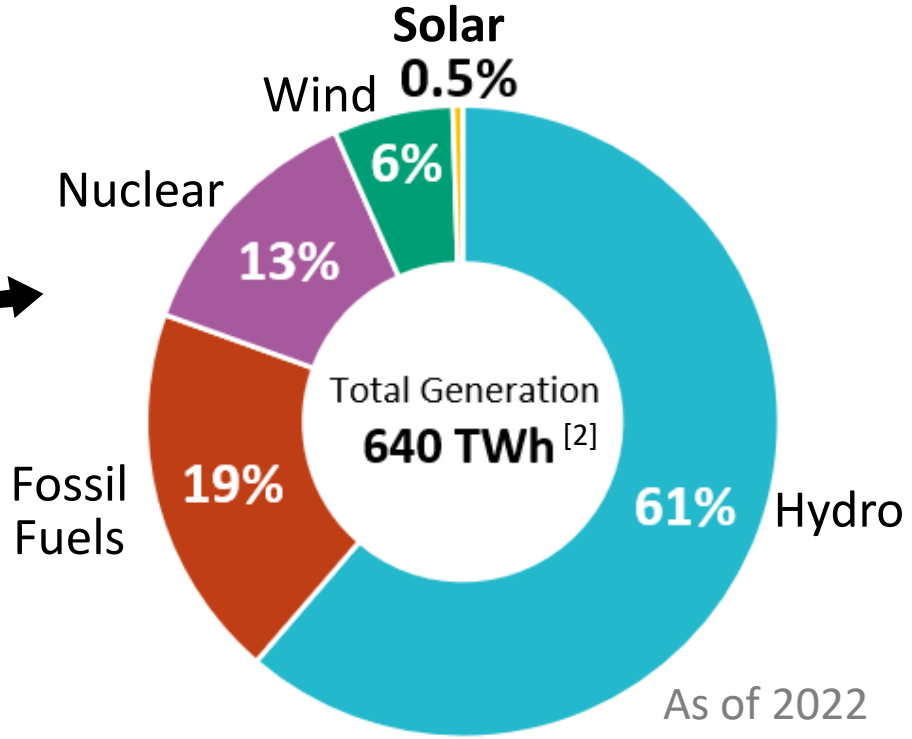
uOttawa

Energy & Emissions in Canada



www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

- 6th global energy use [1]
- **2% global GHG emissions**
- **~80 Mt-CO_{2e} / year** from **fossil-fuel** electricity
- **Electrification** to increase the importance of clean electricity



As of 2022

Growing Solar Capacity

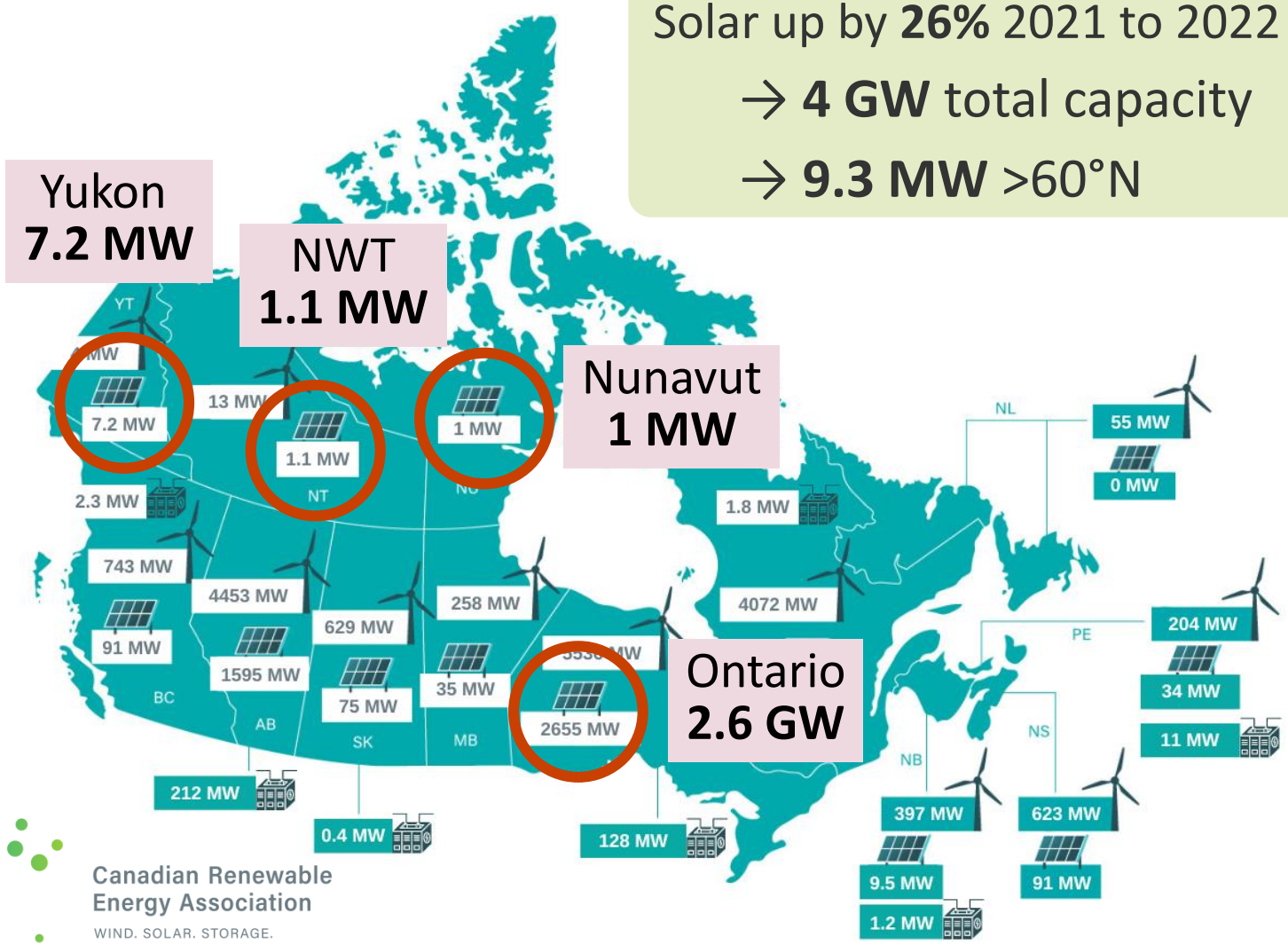
Solar up by **26%** 2021 to 2022

→ **4 GW** total capacity

→ **9.3 MW** >60°N

Most PV: **Ontario**

→ **Feed-in-tariff** started 2009, now phased out



Canadian Renewable Energy Association
WIND. SOLAR. STORAGE.

As of Dec. 2023

New installations 2023

- **360 MW** utility-scale
- **1.2 GW** on-site

Planned & proposed

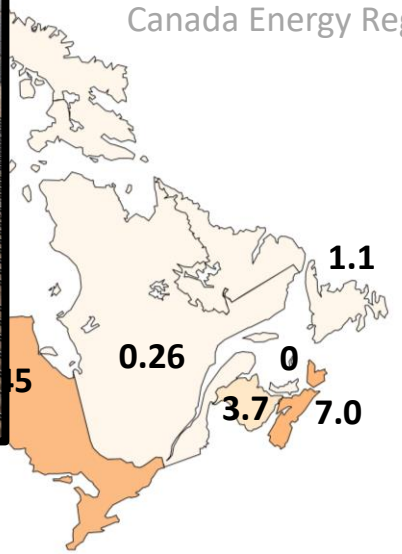
- Yukon: **5.5 MW**
- Alberta: >**10 GW**

→ Includes a mix of solar + storage

Opportunity # 1: The Canadian Prairies

Electricity emissions
Mt-CO_{2eq}

Canada Energy Regulator

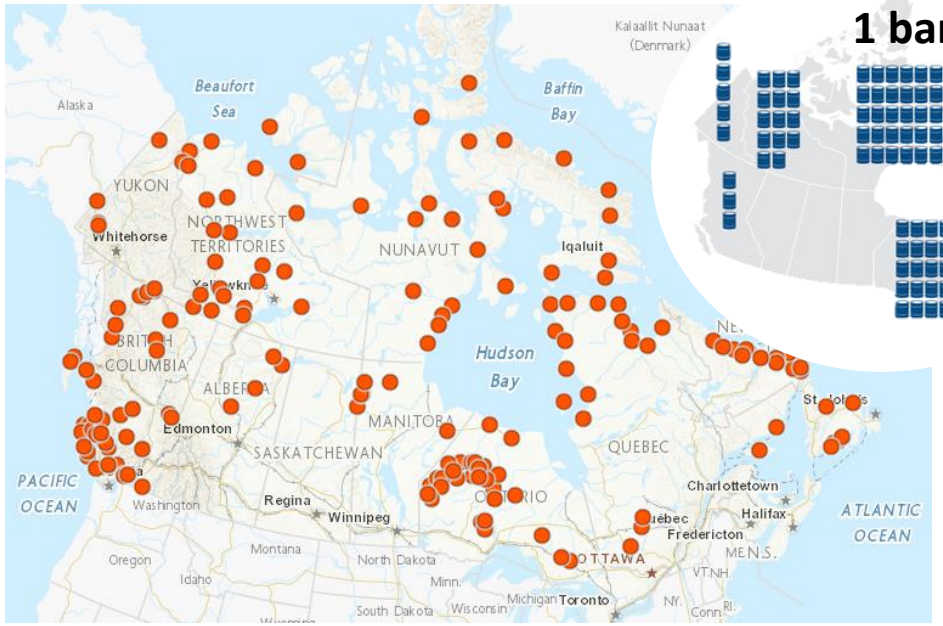


- Fantastic solar energy **resource**
- Greatest potential to **offset CO_2**
- ¾ of new renewable energy projects in 2022 were in Alberta [1]

- Government mandated **moratorium** on renewable projects, Aug. 2023 – Feb. 2024 [1]
- **Concerns**: land-use, grid integration, visual appeal
- Still installing **new gas plants**

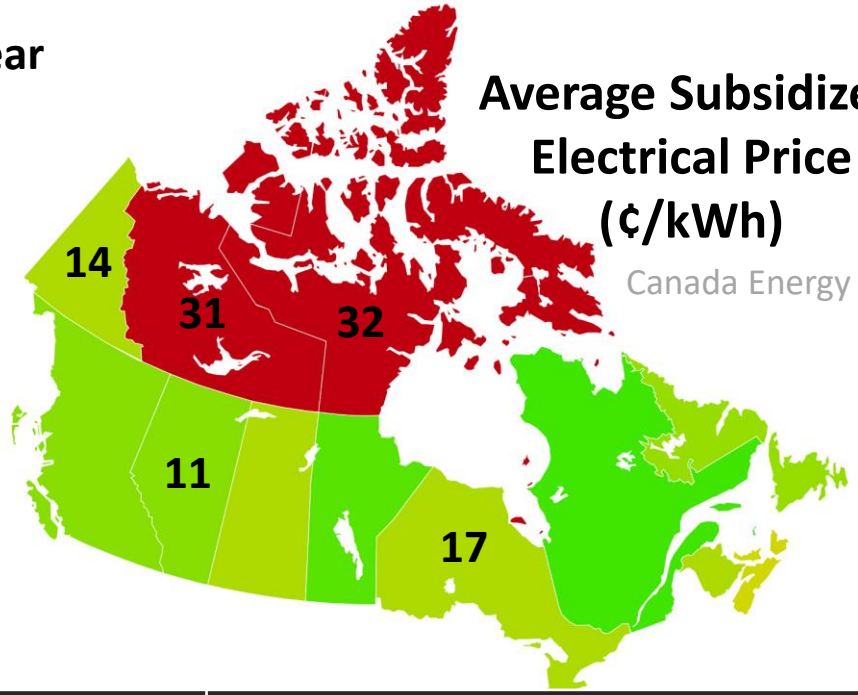
[1]. Pembina Institute, “Investment impact of Alberta’s renewable energy moratorium – factsheet” (2023).

Opportunity #2: Remote Communities



1 barrel = 1 ML diesel / year

NRCan, "Remote communities energy database"



Average Subsidized Electrical Price (¢/kWh)

Canada Energy Regulator

- **200+** remote communities using **diesel**
- Solar to **reduce electricity costs** [1]
  - Canadian average: 13¢/kWh
  - Unsubsidized Nunavut: **52-112¢/kWh**

	Average Installation Cost ($/W) [2]
Ontario	$2.4 – 3.0
Alberta	$2.6 – 3.3
Yukon	$3.0 – 3.8
Nunavut	$3.9 – 4.9

→ Best residential PV economics in the North

[1]. Canada Energy Regulator, "Explaining the high cost of power in northern Canada"
[2]. www.energyhub.org/cost-solar-power-canada/

Programs Supporting High Latitude PV

- Clean Energy for Rural and Remote Communities Program
- Indigenous Off-Diesel Initiative
- Smart Renewables and Electrification Pathways Program
- Northern REACHE Program

INDIGENOUS CLEAN ENERGY

PEMBINA institute

Government of Canada / Gouvernement du Canada

- **70%** of Canada's remote communities are **indigenous**
- Indigenous communities are **leading climate action** and **climate justice** in Canada

Image from Wah-ila-toos clean energy initiatives webpage, canada.ca

Recent Northern PV Installations

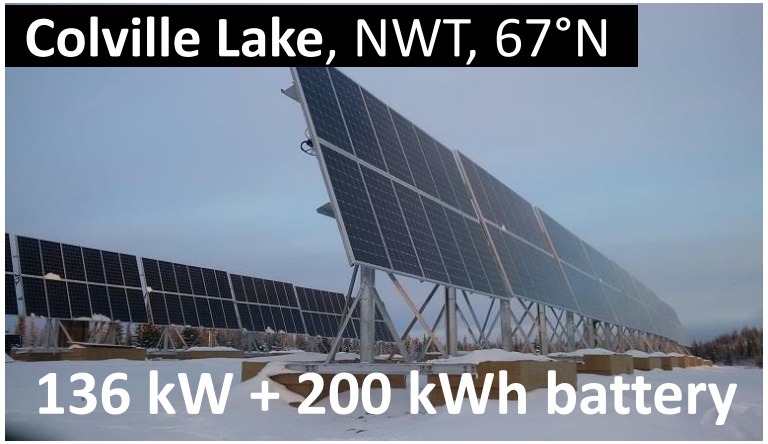
Fort Chipewyan, Alberta, 59°N

- **Largest indigenous solar farm** in Canada
- Reduces diesel consumption by **25%**
- Offsets 2200 t-CO_2 / year

Fort Simpson, NWT, 62°N

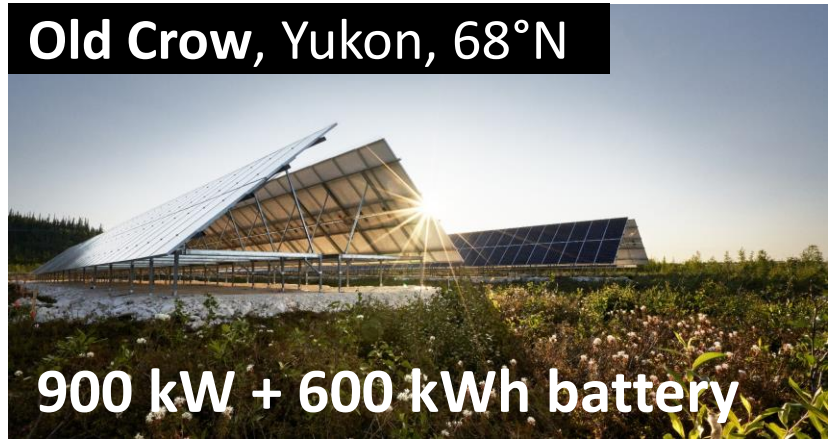
→ **15%** of community load

Colville Lake, NWT, 67°N



→ Reduces generation run time:
25% winter
75% summer

Old Crow, Yukon, 68°N



→ **24%** of community load

Canadian Energy Landscape

- Emissions
- PV capacity
- Policies
- $$

Opportunity Areas

The Prairies

Remote Northern Communities

Canadian Research

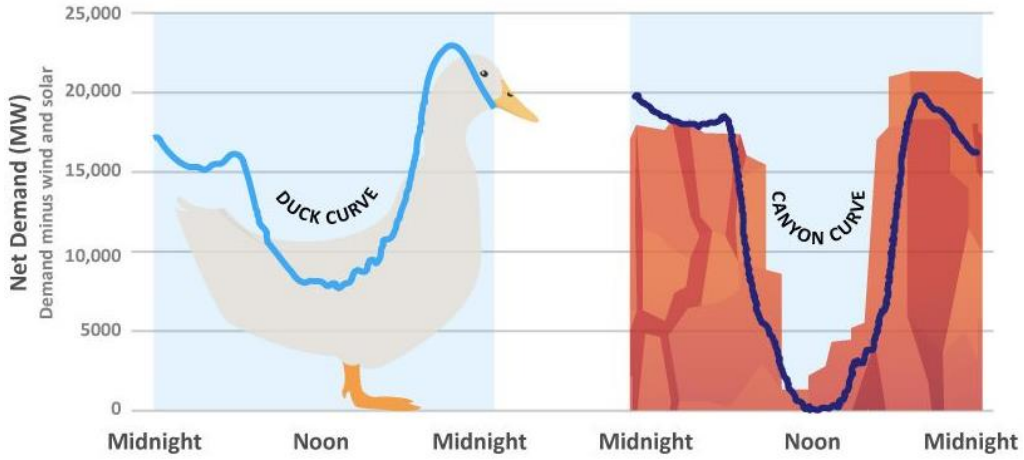
Power Impact Studies

Dr. Michael Ross
Industrial Research Chair in
Northern Energy Innovation

Image from Beaver Creek power impact study

Main research question:

How can we reduce diesel reliance in the North while supporting community microgrids?



→ Priorities: interfacing with communities & northern energy utilities

Ongoing projects:

- EVs and smart heating
- Renewable power systems impact studies
- Residential heat pump studies
- Energy literacy

- For small microgrid, “canyon curve” looks like a ***black start***
- Delayed restart of diesel due to inertia requirements

Snow Studies

Jean-François Lerat
Project OLAF R&D Manager

Partners:
TotalEnergies, Stace, CNRS

→ **Project OLAF**: Photovoltaique fonte de neige

Main research question:

How can we maximize the energy of PV in snowy environments?

Examining the impact of snow on:
- Instrumentation & sensors
- O&M
- PV performance
- Module design

End goal: Decision-making tool for designing PV systems and practices in snowy environments

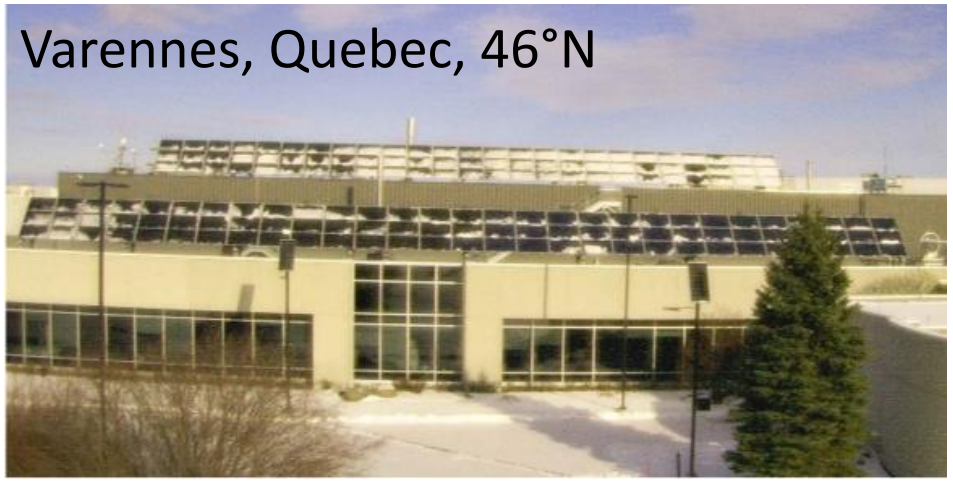
Université de Sherbrooke PV Array Field
- Rooftop PV: 30°/10° tilt
- Ground-mounted: 45°/30° tilt
- Double-axis trackers
- Frame/frameless
- Bifacial/monofacial
- Full/Half-cut

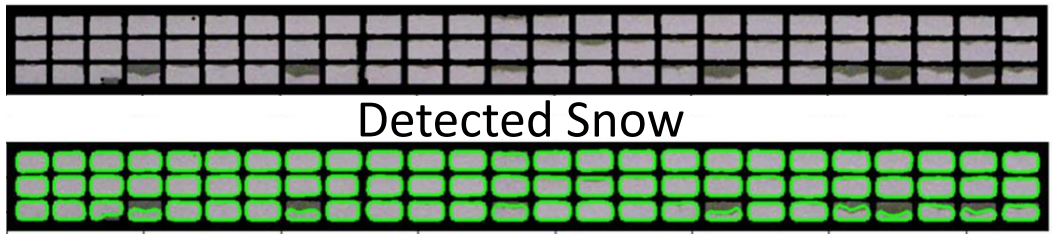
Snow Modelling

Natural Resources Canada / Ressources naturelles Canada
Canada
CanmetENERGY / CanmetÉNERGIE
Western University · Canada

Dr. Chris Baldus-Jeursen
Solar PV Researcher, NRCan

Dr. Joshua Pearce
Professor Western University

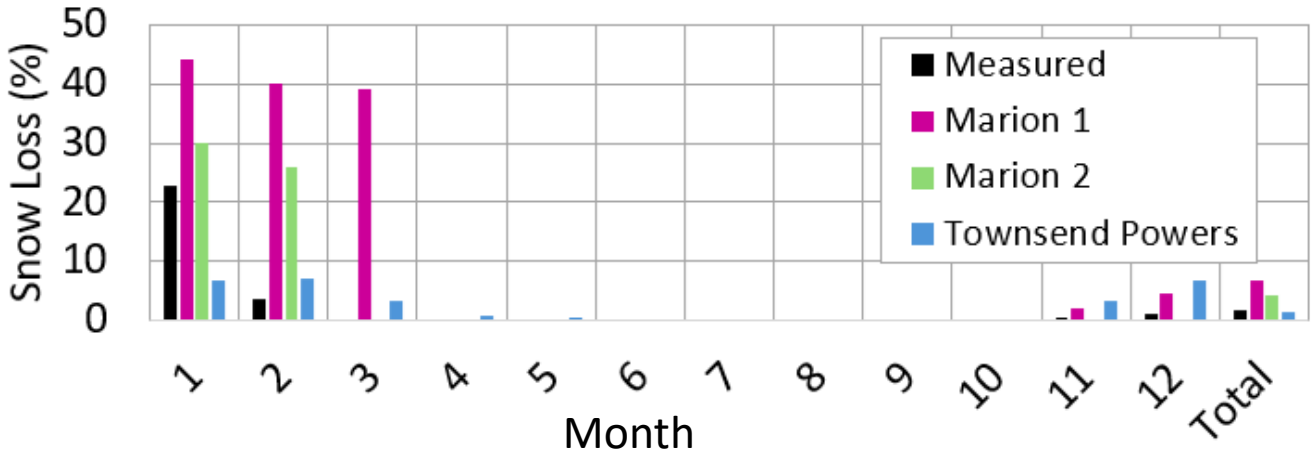




→ Developed algorithm for identifying snow accumulation on panels [1]

Main research question:

How accurate are predictions of snow loss using Marion vs Townsend and Powers models?



- Townsend Powers closer agreement annually [1]
- Marion model sensitive to sliding coefficient

→ Need more research and validation

[1]. C. Baldus-Jeursen *et al.*, "Snow losses for PV systems: validating the Marion and Townsend models," *J. of Photovolt.*, 13(4), 610-620 (2023).

System Design & Instrumentation

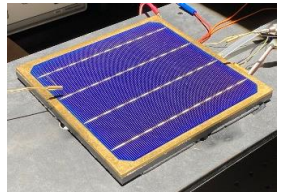
Dr. Karin Hinzer
Founder of the SUNLAB,
University of Ottawa
Dr. Jacob Krich
Dr. Henry Schriemer
Dr. Javad Fattahi

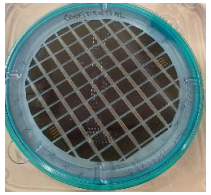
Main research question:

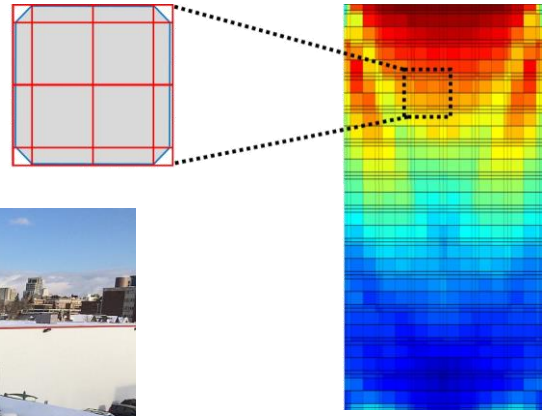
How can we optimize PV devices for integration into the system-level and grid-level considering real-world environmental conditions?

Main research subject areas:

- Photovoltaic device development & characterization
- Photovoltaic systems modelling
- Smart grid design
- Solar resource instrumentation





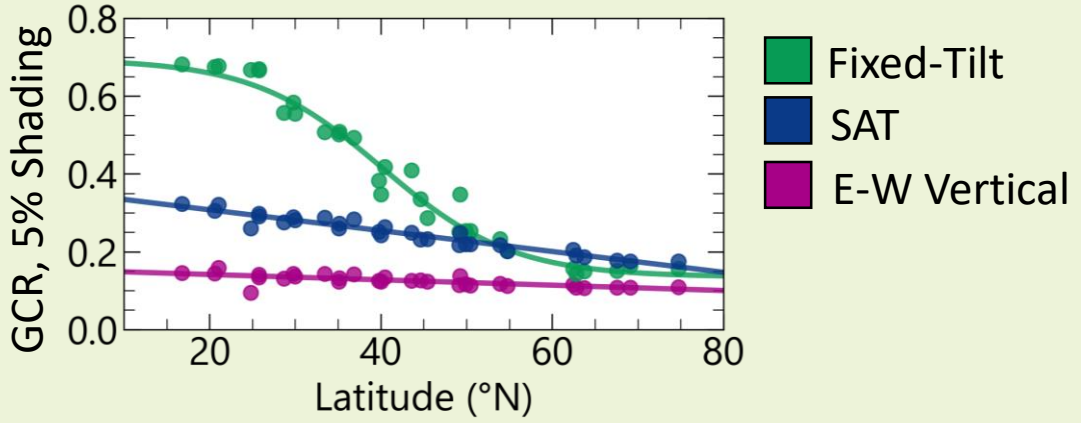


System Modelling

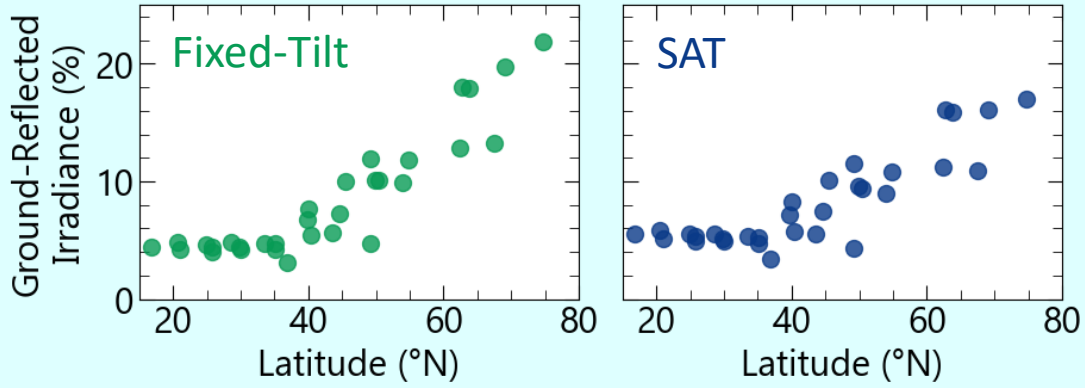
Me! – Erin Tonita
Ph.D Candidate, Physics
University of Ottawa

My main research question:

How do bifacial PV models & systems perform across Canada?



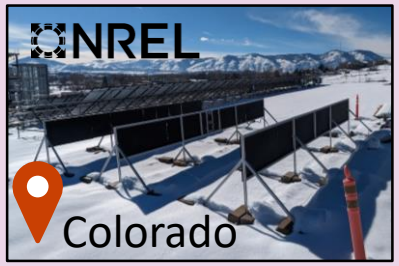
→ **Characterized row-spacing with latitude** [1]



→ **Ground-reflected irradiance ↑ with latitude** [2]

→ **Comparing bifacial irradiance models in 250 locations**

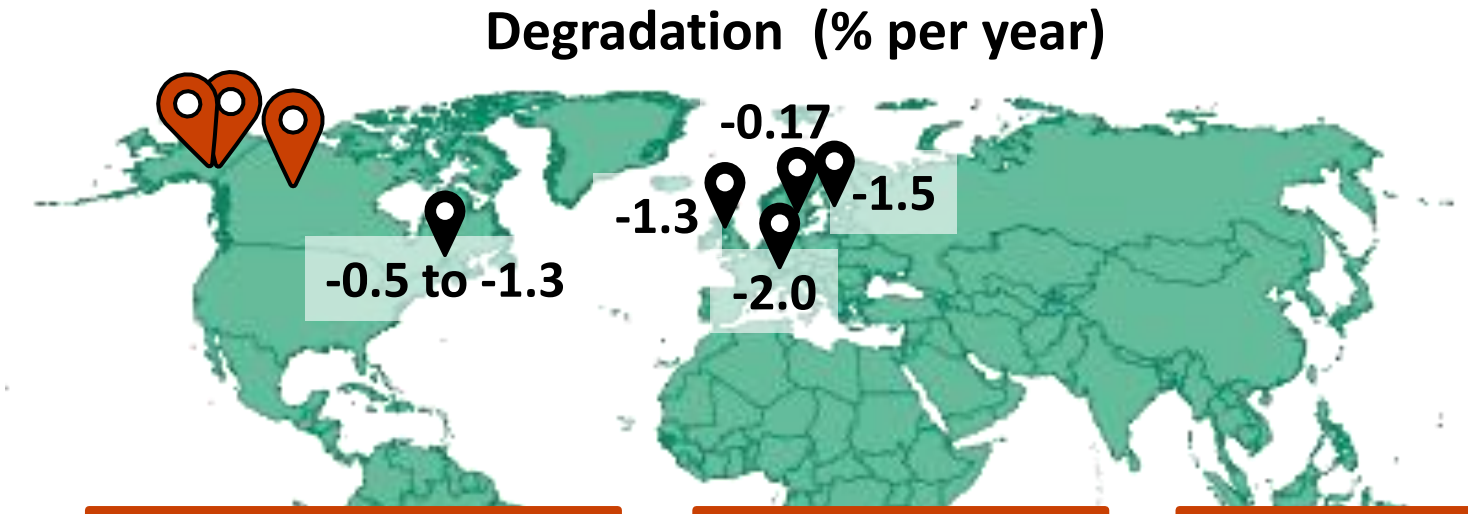
bifacial_radiance bifacialVF System Advisor Model DUET SUNLAB



[1]. E. Tonita *et al.*, "Optimal GCRs for tracked and fixed-tilt photovoltaic systems for latitudes up to 75°N," *Solar Energy*, 258, 8-15 (2023).
[2]. E. Tonita *et al.*, "Quantifying spectral albedo effects on bifacial PV module measurements and system model predictions," *Prog. in Photovolt. Res. Appl.*, 1-13 (2024).

Cold Climate Reliability

- Degradation rates depend on technology, mounting configuration, **climate**
- **Reliability uncertainty** at high latitudes due to conditions like **snowfall**, **freeze-thaw cycles**, **high winds**

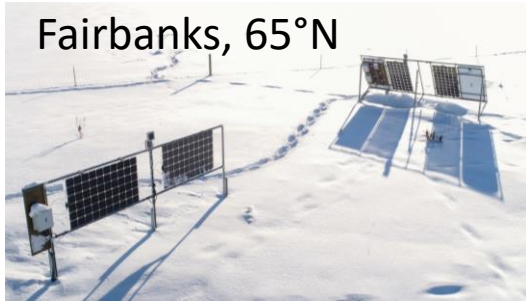


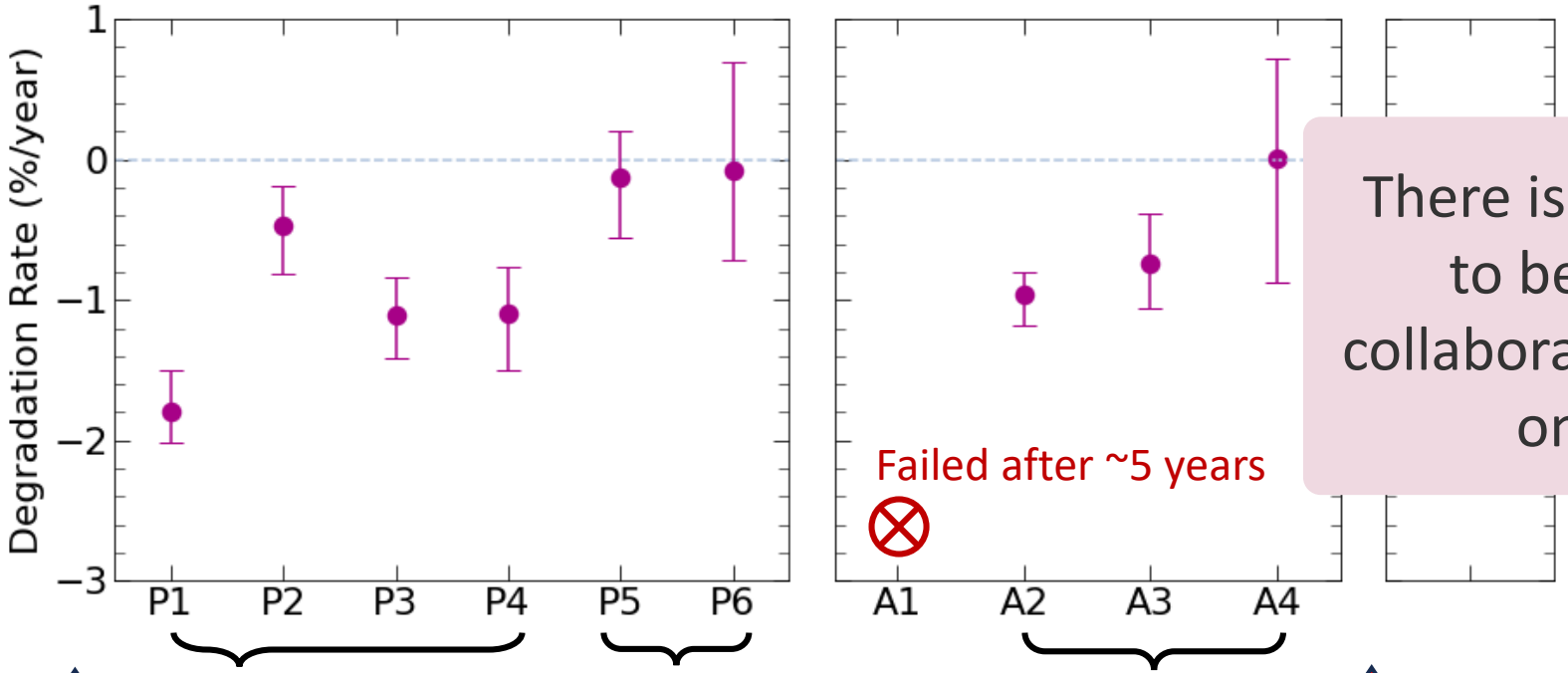
Global average = -0.8% per year
Median module-level = **-0.5%** per year

Cold climate values ranging from **-0.2% to -2.0%** per year [1-5]

1. A. Bradley *et al.*, "Initial analysis of a 22-year old PV system in Quebec, Canada," Natural Resources Canada, poster (2015).
2. M. Dhimish, "Performance ratio and degradation rate analysis of 10-year field exposed residential PV installations in the UK and Ireland," *Clean Technologies*, 2, 170-183 (2020).
3. N. Bogdanski *et al.*, "PV reliability: results of a German four-year joint project – part II," *Proceedings of 25th EUPVSEC*, Spain (2010).
4. L. Karttunen *et al.*, "Comparing methods for the long-term performance assessment of bifacial PV modules in Nordic conditions," *Renewable Energy,* 219, 119473 (2023).
5. J. Hedstrom, L. Palmbald, "Performance of old PV modules: measurement of 25 years old c-Si modules," *Elforsk Rapport* 06:71 (2006).

Yearly Degradation Rates Vary Widely





There is still a lot of work to be done so let's collaborate and learn from one another!

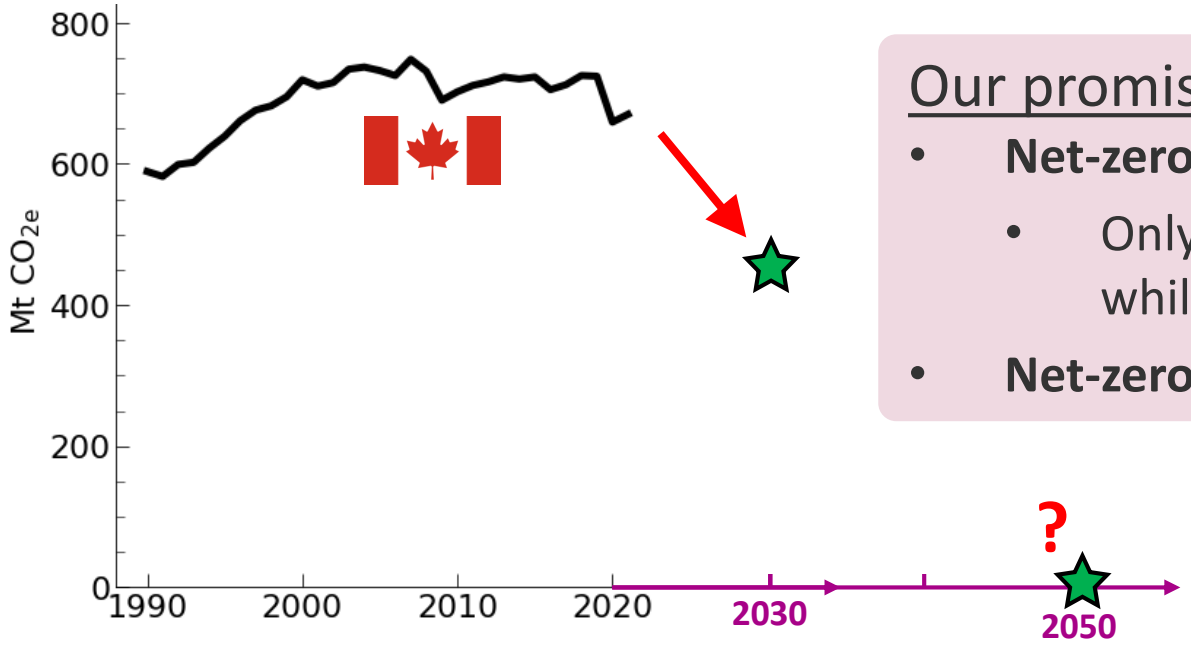
-1.1 ± 0.5 %
Bifacial, SHJ

-0.11 ± 0.03 %
Monofacial PERC

≈ -0.6 ± 0.4 %
Monofacial Al-BSF

-1.5%
Monofacial PERC

To Reach Our Goals We Need to Transition The North



Our promises:

- **Net-zero electricity** grid by **2030**
  - Only possible if we **transition** our **northern communities** while retaining or improving **energy resilience** & **security**
- **Net-zero** emissions by **2050**

Active Canadian PV Research Fields:

- **Snow** impact studies
- Renewable energy integration **power impact studies** for remote communities
- High latitude **systems modelling**
- Cold climate **degradation**

+ a lot more!

Let's collaborate!

Feel free to reach out for Canadian connections & collaboration!
Canada is also recently a member of Horizon Europe

Erin Tonita
etoni044@uottawa.ca