Cold Climate
Climate Change

Cédric Arbez, Manager, Research and Innovation, Nergica

March 31, 2021

Canadian Wind Energy Research Network

Cold Climate

IEA Wind TCP Task 19 : Wind Energy in Cold Climate

IEA Wind TCP Task 19 mission is to improve large scale deployment of cold climate wind power in a safe and economically feasible manner.

The group studies a variety of topics, including: project development; operation and maintenance (O&M); health, safety and environment (HSE), standardization and recent research.

- 11 participating countries, mostly from Europe.
- Current workplan (2019-2021) available here: https://community.ieawind.org/task19/home
- Several public references for the research community and wind industry here.
- Next work plan under construction (2021-2023), please contribute and share your ideas!
- Also, please share the title of your ongoing Cold Climate research projects with me before April 16, 2021, for reporting at the Task 19. Next meeting is planned for the week of April 26, 2021.
- Canada's representative on IEA Wind Task 19 :

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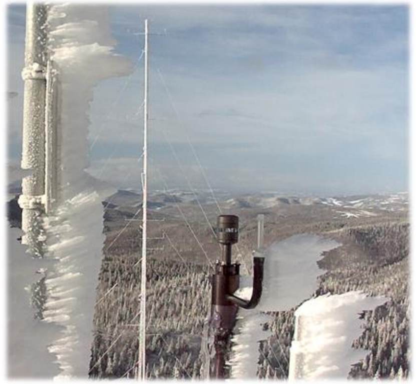
With the support from :

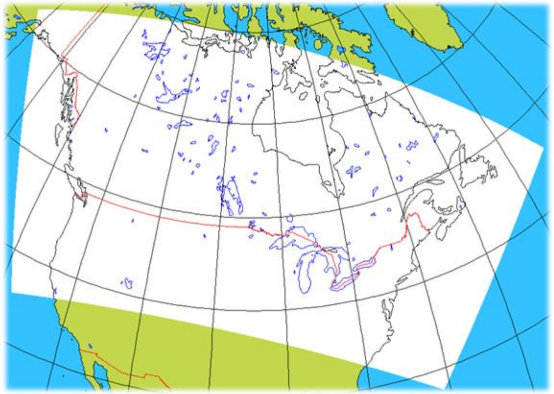
Natural Resources Canada   Ressources naturelles Canada

Canada

Cold Climate Research at Nergica

Nergica owns and operates a 4MW wind farm in Gaspé (Qc) composed of two Senvion MM92 and two 126 meters met-masts. 75% of commercially available icing detectors are running on the site. Nergica has also developed a camera system that can be installed on wind turbines nacelle and hub or met towers to monitor icing for R&D purposes. Nergica operates the GPEO icing model, which can run on the whole GEM-LAM HRDPS domain (Canada and Northern US), in collaboration with ECCC.





Ongoing Cold Climate research projects :

- Climate change impact on wind energy potential in Canada
  (Nergica, Ouranos, 3 utilities: Hydro-Quebec, Ontario Power, Manitoba Hydro)
- Optimization of wind energy potential assessment and its uncertainties in pre-construction (Nergica, RES Canada)
- Optimal control of a wind turbine equipped with an ice protection system using icing forecasts and icing detection (Nergica, Capstone Infrastructure)
- Structural analysis of a wind turbine blade under icing conditions (ULaval, ÉTS, Nergica)
- Testing of retrofit ice protection systems and icephobic coatings by Canadian operators (on other sites)
- Ice detection system performance assessment (Nergica)

Data can be made available for academic or industrial research projects.

Contact: Charles Godreau, cgodreau@nergica.com

With the support from :

Développement économique Canada pour les régions du Québec
Canada Economic Development for Quebec Regions

Natural Resources Canada
Ressources naturelles Canada
Canada

Environment and Climate Change Canada
Environnement et Changement climatique Canada

NSERC
CRSNG

Québec

Fonds de recherche Nature et technologies
Québec

Leidy Tatiana Contreras Montoya
PhD student – UQAR

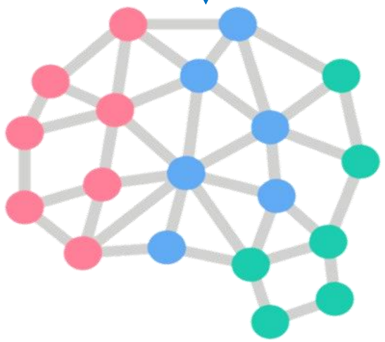
Cold Climates → $$P = \frac{1}{2}\rho A V^3$$

Meteo Conditions

Operating Regimes

Shoja, S. (2016)

= Power Loss -20%



+ π

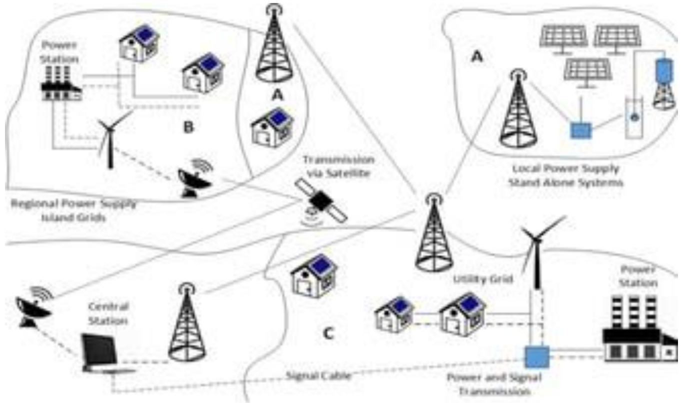
Pi Theorem

= Predict the impact.
Mitigation Scenario.
Timely Intervention

UNIVERSITY OF SASKATCHEWAN
School of Environment and Sustainability
SENS.USASK.CA

Dr. Andrea Kraj, P.Eng

Assistant Professor, SENS, USask



Arctic Energy Security

The prosperity and security, and health of the Arctic depend on sound infrastructure in the built environment. Changes to land, human and marine environments are placing stress on both coastal and inland communities in the Arctic while generating interest for energy and mineral resources, increasing tourism, and opening up new fisheries and transportation routes. The global energy transition is placing greater pressures in Arctic and sub-Arctic regions as sources for renewable energy from wind and hydro, as well as mineral resources. Together, these trends provide new opportunities for sustainable development that have the potential to improve life for Arctic communities.

Smart Microgrids

Distributed generation along with smart grid applications are poised to make important contributions to the clean-tech sector and remote communities. The dependence on one source for energy supply does not prove reliable enough when the renewable resource, such as wind or solar, is variable, creating a dependence on external fuel supply and a vulnerability to foreign control. Developing an energy strategy through intelligent energy system simulation and optimization can help communities make informed decisions about their energy investments. This research is focused on developing sophisticated computer modeling and simulation supporting the design, operation and optimization of advanced power systems with storage for creating intelligent energy networks of any scale.

Icing Mitigation for Wind Turbines in Cold Climates

An immense potential of untapped wind resources exist in cold climates hindered by the uncertainty of the characteristics of the surrounding climatological conditions. One issue facing the optimization of wind power generation in cold climates is ice accumulation on turbine blades. This issue creates concern for efficient energy production, operational safety and grid integration. This research explores mitigation strategies to prevent or delay ice accumulation on wind turbines blades in an effort to enhance the understanding of the icing characteristics and to optimize wind turbine systems in cold climates.

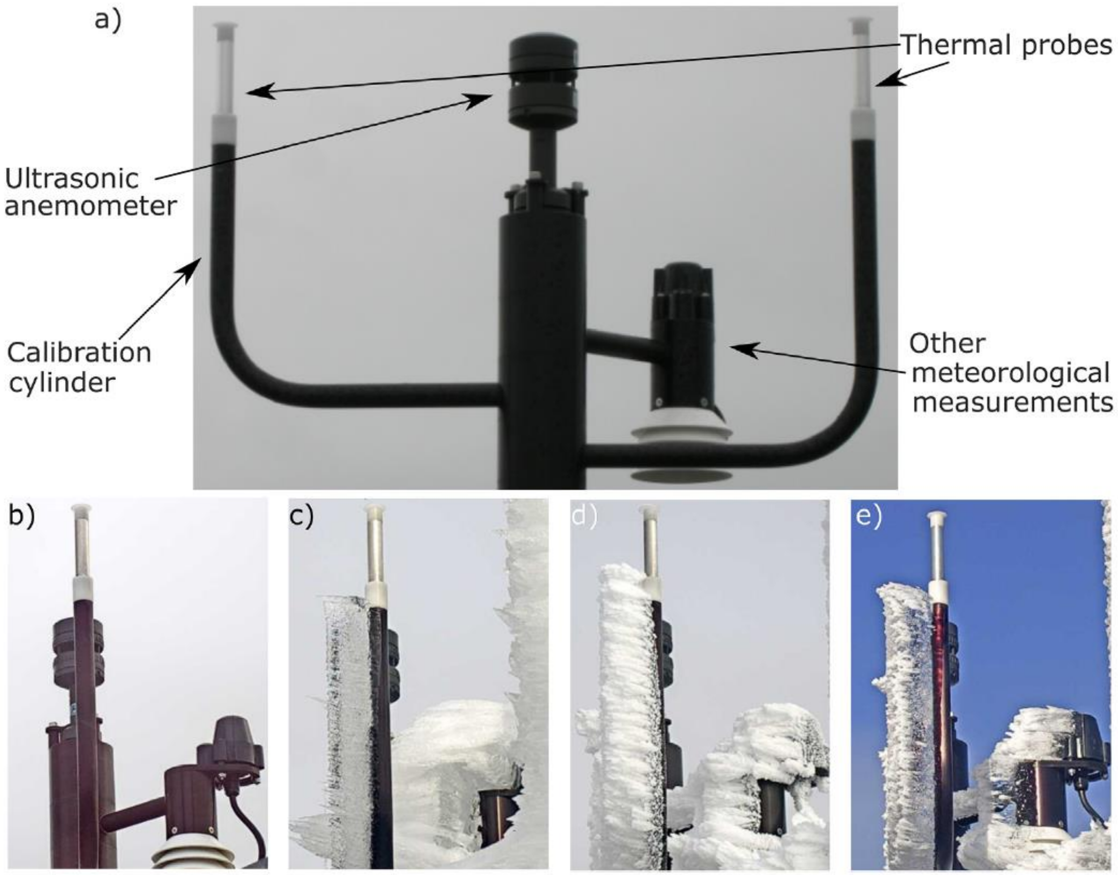
André Bégin-Drolet

Professor, Université Laval

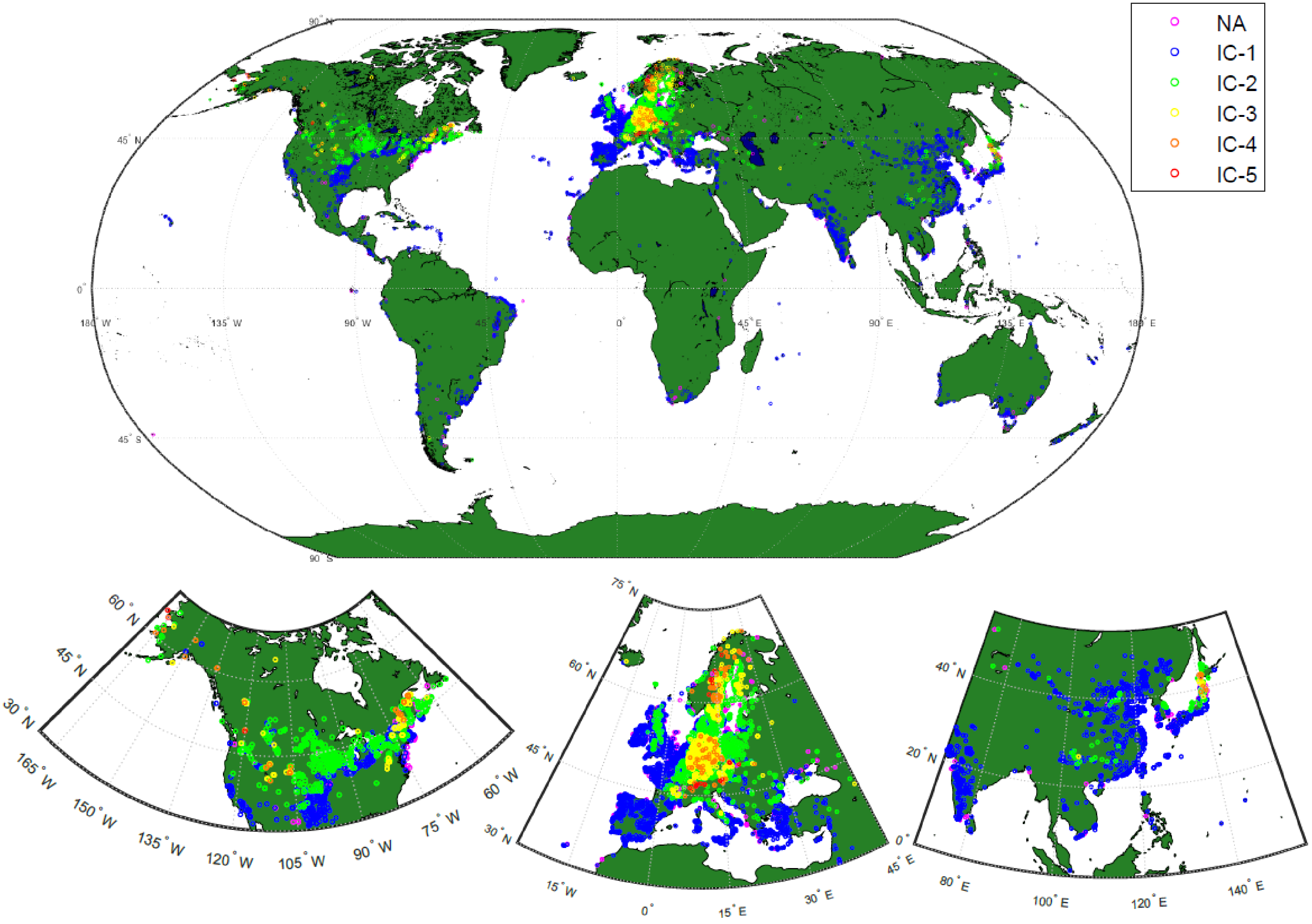
A summary of our research for wind energy in cold climate

Bégin-Drolet *et al.* (2018) *The importance of accurate detection for turbine ice prevention systems*. Winterwind international conference 2018

4 patents
New spin-off company launched in November 2020
www.icetek.ca



Roberge *et al.* (2019) *Field analysis, modeling and characterization of wind turbine hot air ice protection systems*. Cold Regions Science and Technology 163 (2019) 19-26



Roberge *et al.* (2021), under review

<u>IC >= 2</u>

Number of turbines
Canada = 5 065
Europe = 40 385
N USA = 21 498

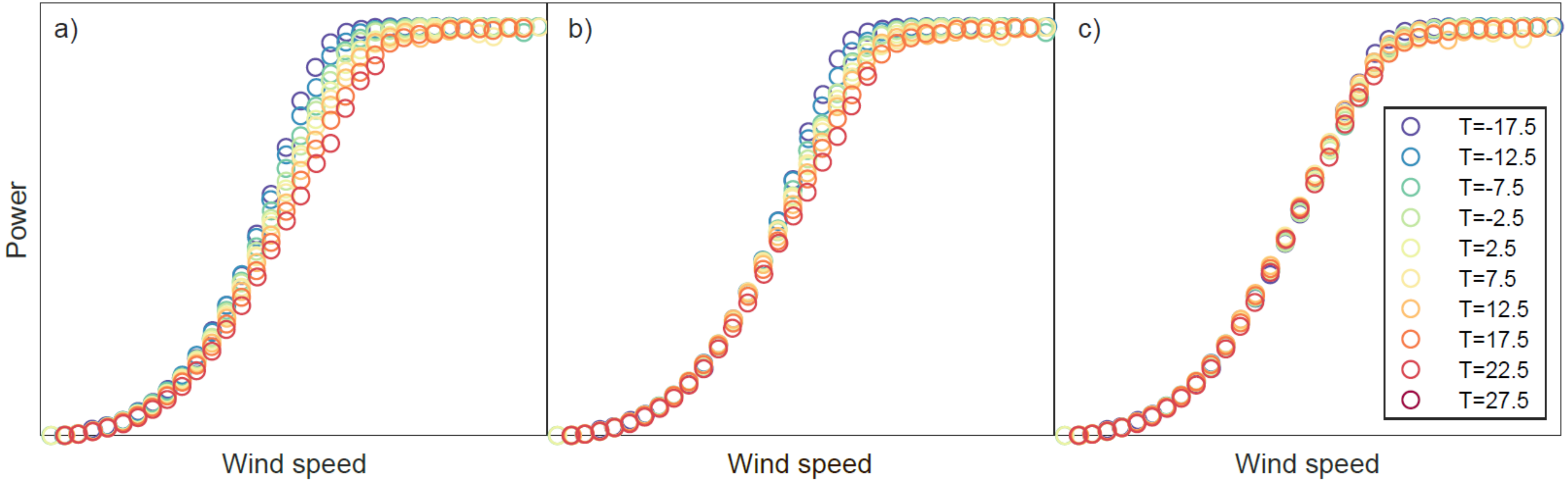
Installed capacity
Canada = 9 850 MW
Europe = 75 044 MW
N USA = 37 573 MW

<u>IC >= 3</u>

Number of turbines
Canada = 1 765
Europe = 4 084
N USA = 1 747

Installed capacity
Canada = 3 677 MW
Europe = 8 728 MW
N USA = 2 883 MW

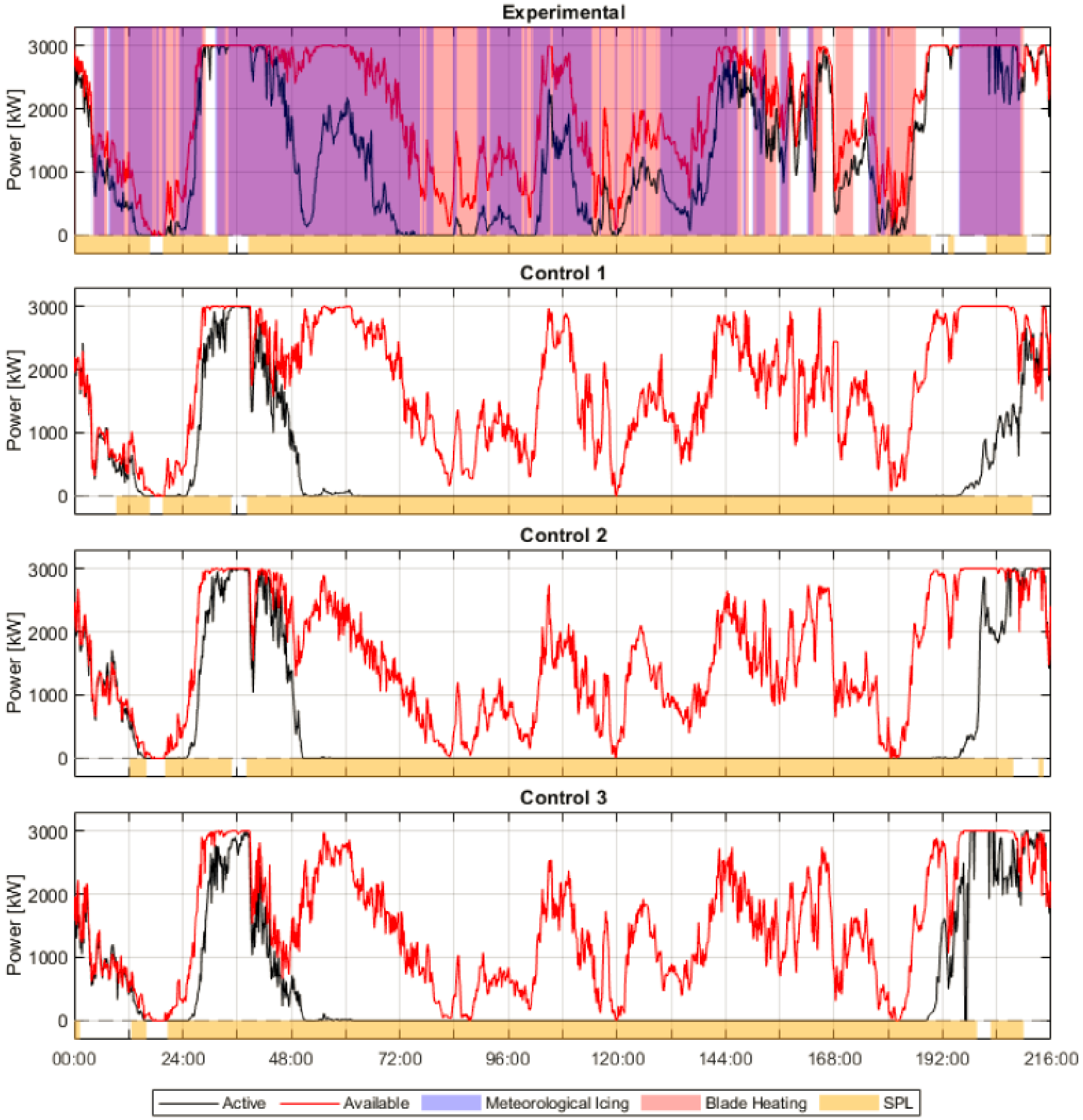
Towards standards in the analysis of wind turbines operating in cold climate



Example data set presenting the binned data divided in wind speed and temperature (in °C) ranges in a situation where the wind speed is :

a) not corrected with temperature
b) Corrected using traditional approach
c) Corrected using new approach

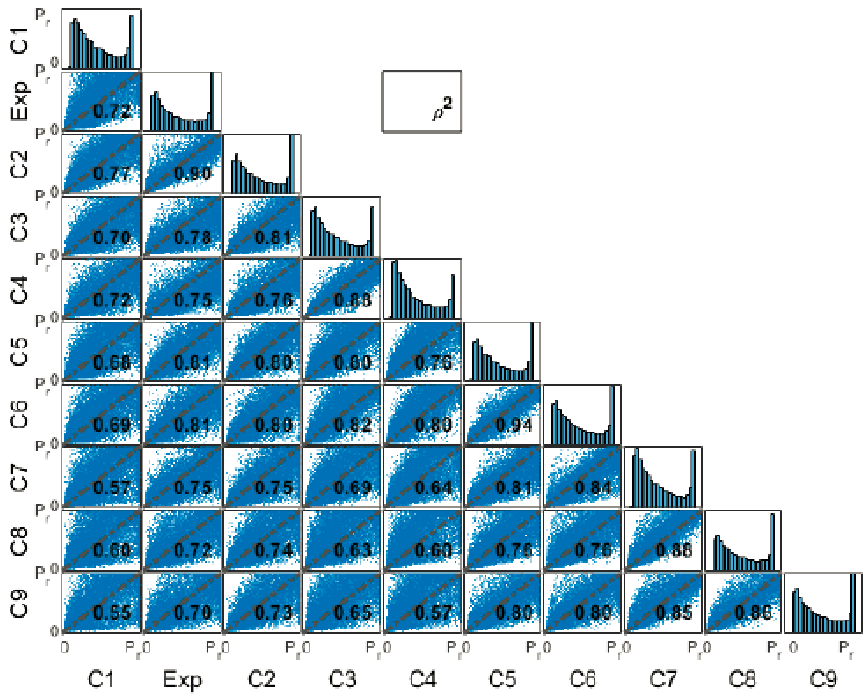
Roberge *et al.* (2021), under review



Roberge *et al.* (2021), under review

How to assess alternative operational strategies?

- Ice Protection Systems (IPS)
- Coatings
- Operation with ice
- …



Vibration control of wind turbine blades using PZT layers

UQAR

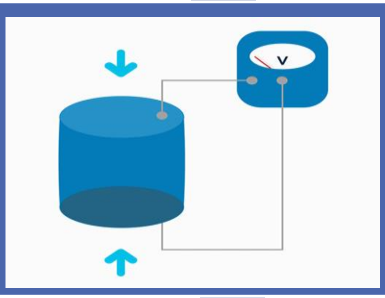
Longer wind turbine blades

= more vibration

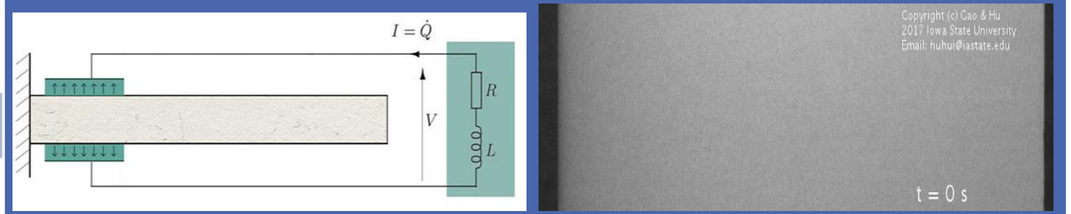
Frozen wind turbines caused blackouts and leave more than 1 million Texans without power as generation capacity reduced to 50% | Tech News | Startups News

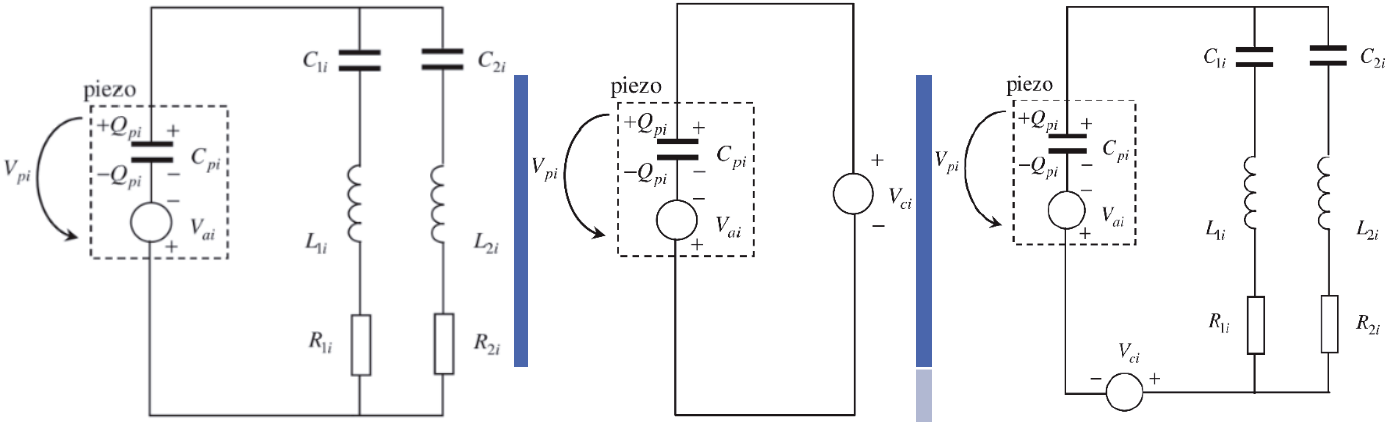
Piezoelectric Layers used as:

1. Sensor 2. Actuator
3. Ice defroster



De-Icing should be considered in cold climates like **Canada** (and sometimes US!)





Passive Active Hybrid

Advantages:

1. Low power consumption 2. Fast response

3. Small saturation strains 4. Lightweight 5.Flexibility

Navid Farazmand

High Peak Pitch Motor Current During Icing

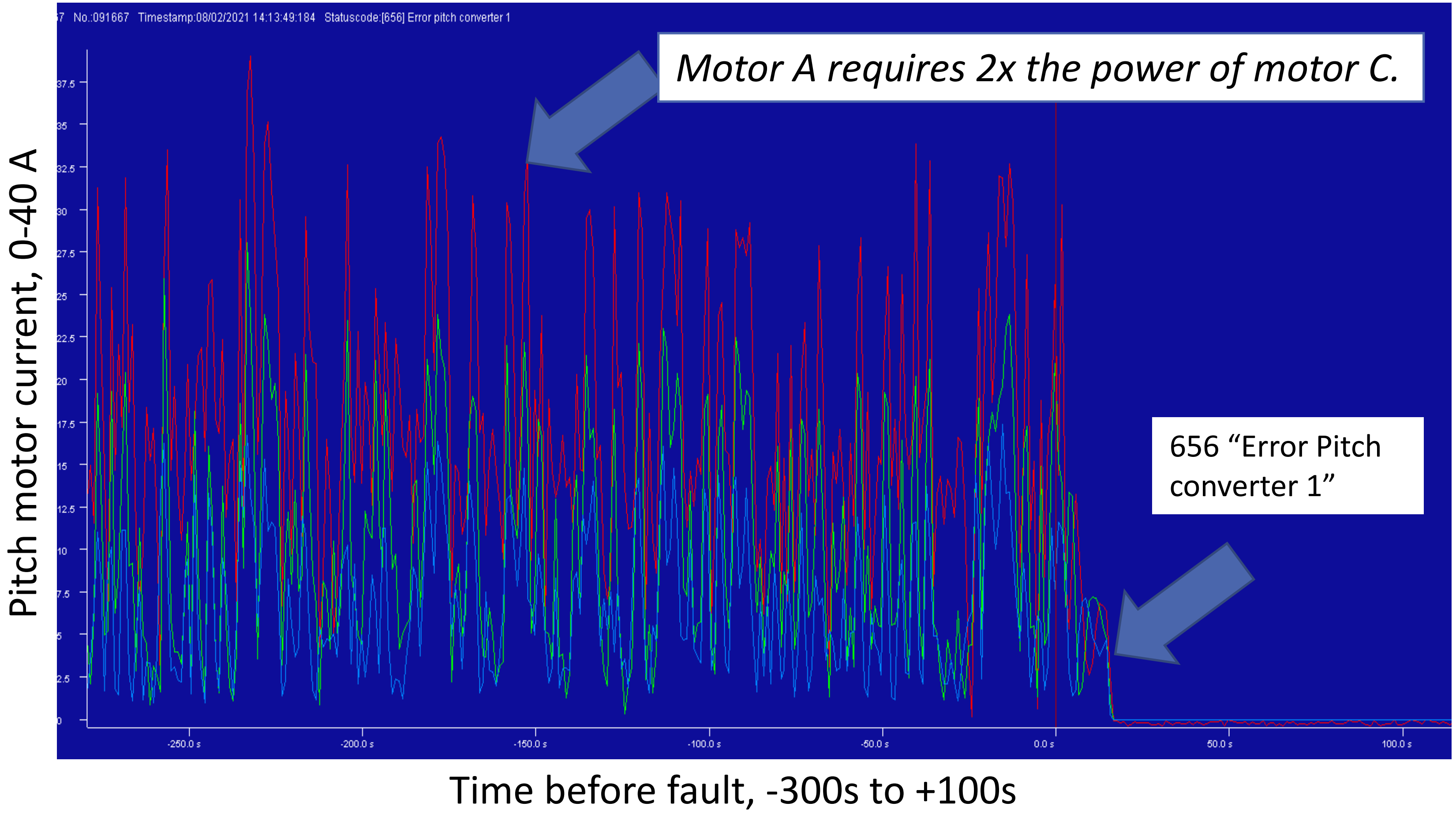
Alexandre Giguere
Operations Coordinator, Enbridge

Background

- Enbridge's Senvion wind turbines in Quebec have multiple pitch motor failures in winter
- We experience many pitch converter events during icing events
- We sometimes see higher current on 1 of the 3 pitch motors during icing periods prior to pitch converter faults

Questions

- Does 1 motor work 2x as hard because of uneven ice load on the 3 blades?
- Could we modify the pitching strategy during IOM (ice operation mode) to improve pitch motor reliability?



SRB WEC18, 2021-02-08 14:13: Currents on 3 pitch motors in the 5 minutes before pitch converter error during icing. Power=2046 kW, wind speed s=14 m/s, blades ~9 deg.

Climate Change

ClimateSense

Term Project – Local Wind Speeds in a Changing Climate

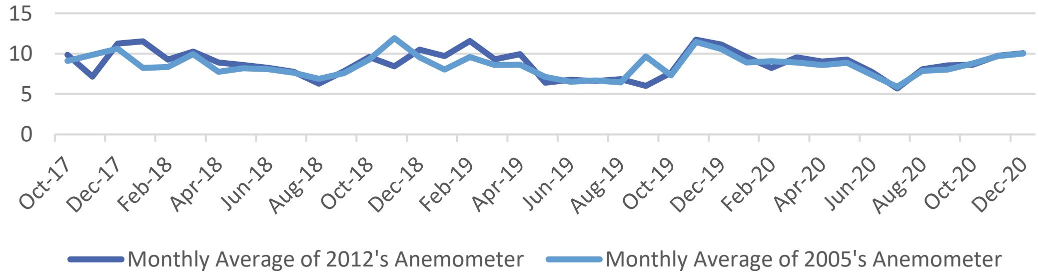
- **Wind speeds, like other climate variables, will change in the future:**
  - Wind speed change predictions are very dependant on methods and models (ie CRCM, HRM3) used
  - Use of local data can aid in verifying model accuracy, and give confidence for use in projections

- **WEICan has historic data stretching back to 1983, however:**
  - Combining raw data sets difficult as variability arises from different towers, anemometer technology, etc, over time
  - Monthly averages seem to agree when comparing our heated (2012) vs. unheated (2005) anemometer

Data set	Altamont	San Gorgonio	Tehachapi
Observed	5.40 (0.37)	4.32 (0.48)	3.02 (0.27)
NARR	2.07 (0.15)	2.58 (0.26)	3.26 (0.27)
CRCM	3.98 (0.13)	6.93 (0.21)	4.50 (0.15)
RegCM3	3.87 (0.11)	3.91 (0.13)	4.49 (0.12)
HRM3	3.41 (0.09)	4.23 (0.11)	3.73 (0.11)

Average Historical Wind Speeds in California Compared as Estimated by Different Sources [1]

Difference between 2005 Met Tower and 2012 Met Tower from Years 2016 - 2020



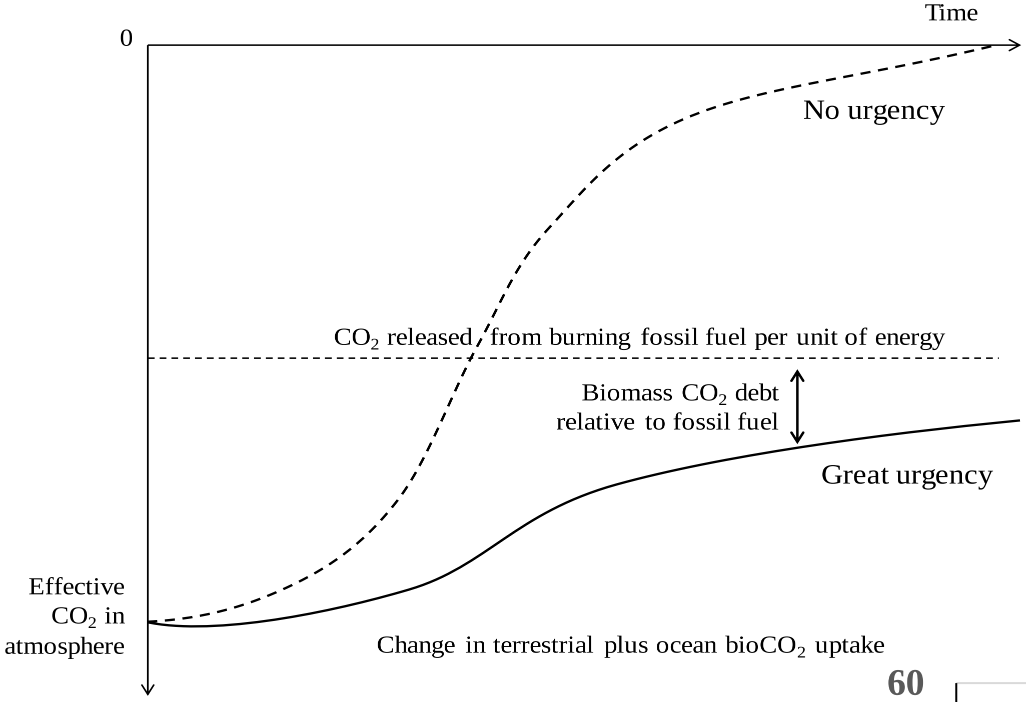
Wind Energy Institute of Canada
Institut de l'énergie éolienne du Canada

Climate Urgency and the Role of Forestry

G Cornelis van Kooten
Department of Economics

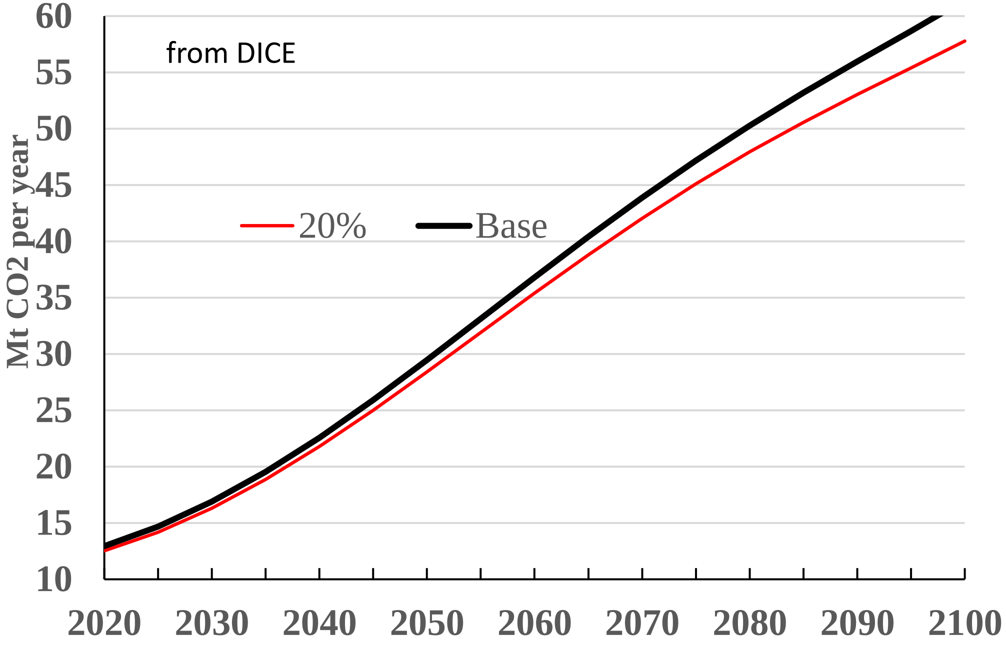
Canadian Wind Energy Research Network

University of Victoria



Carbon flux associated with fossil fuel & biomass power production over time: Lesser vs greater urgency to mitigate climate change. With great urgency, future uptake of carbon by trees is worth much less today, it is possible that the initial debt is never overcome. Then fossil fuels preferred as biomass creates too large an initial impulse to global warming that cannot subsequently be overcome.

Change in industrial emissions from tree planting that annually removes 2.6 Gt CO_2 from atmosphere (note difference between Mt & Gt). Base scenario: no deforestation & no discounting—industrial emissions fall by 62 Mt CO_2 by 2100. If exogenous C fluxes discounted at 20% annually, industrial emissions are slightly lower. Tree planting project sequesters significant carbon but does little to mitigate climate change.



Modelling market impacts of geographic dispersion of wind

Tim Weis, PhD, PEng

Mechanical Engineering / Centre for Applied Business Research in Energy & Environment, University of Alberta

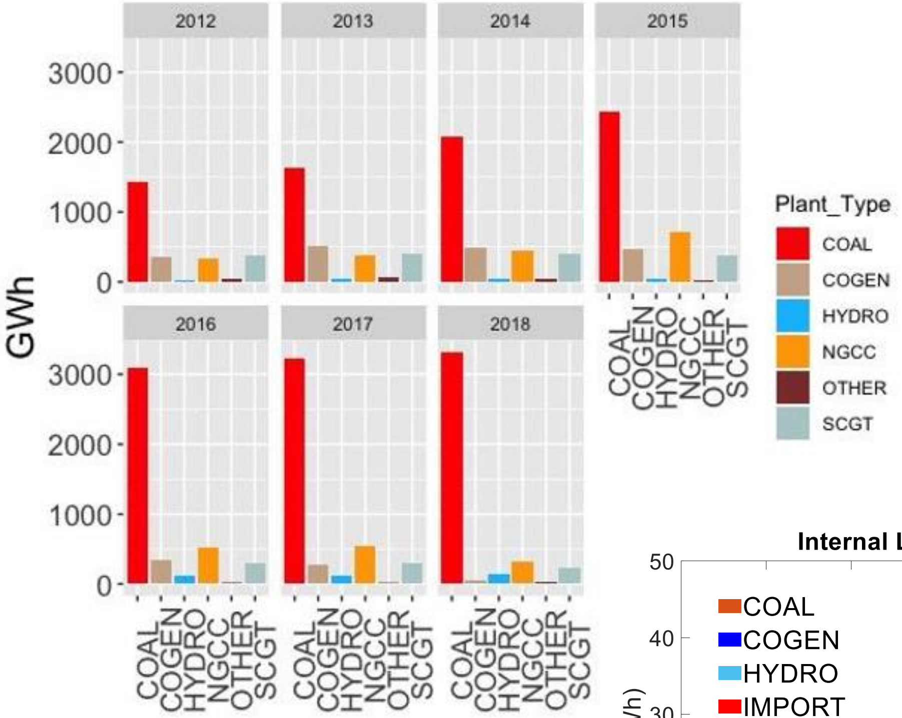
tweis@ualberta.ca

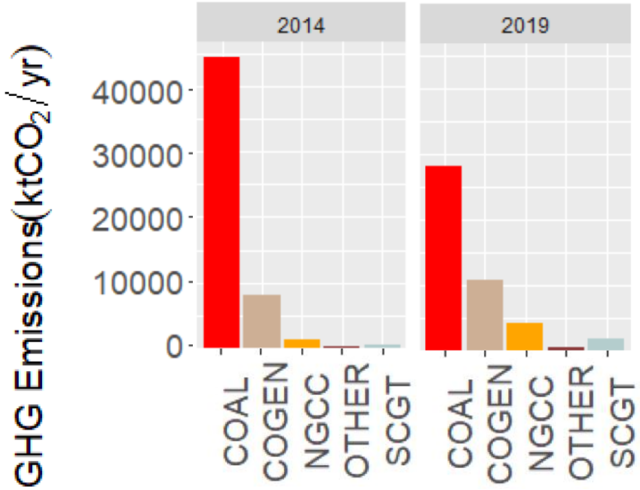
Tim Weis

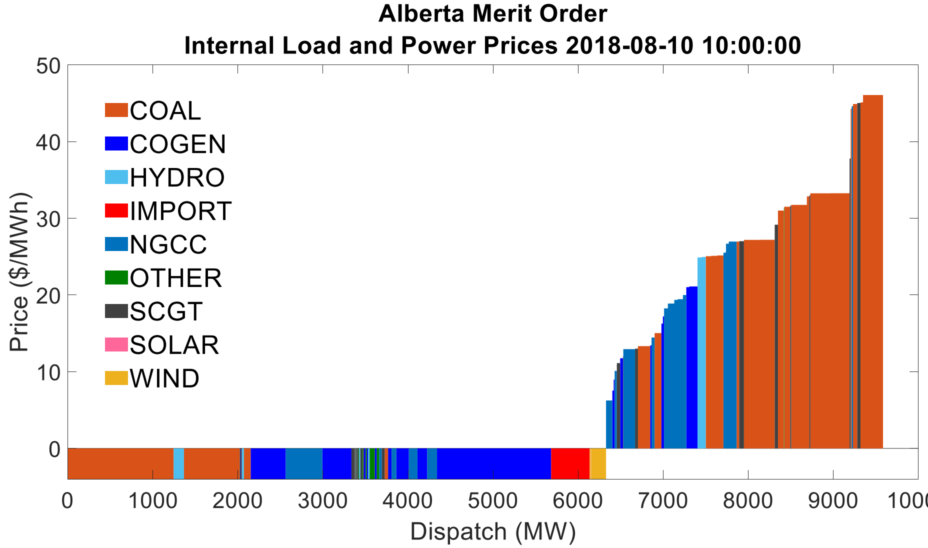
Executive Director, Electricity Research, CABREE

$$\text{EGDF} = (\omega * BM) + \left((1-\omega) * OM\right)$$

EGDF	Electricity Grid Displacement Factor (tCO_2e/MWh)
ω	Weighting factor
BM	Build Margin (tCO_2e/MWh)
OM	Operating Margin (tCO_2e/MWh)







Discussion