SCHULICH School of Engineering

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Introduction to Wind Session

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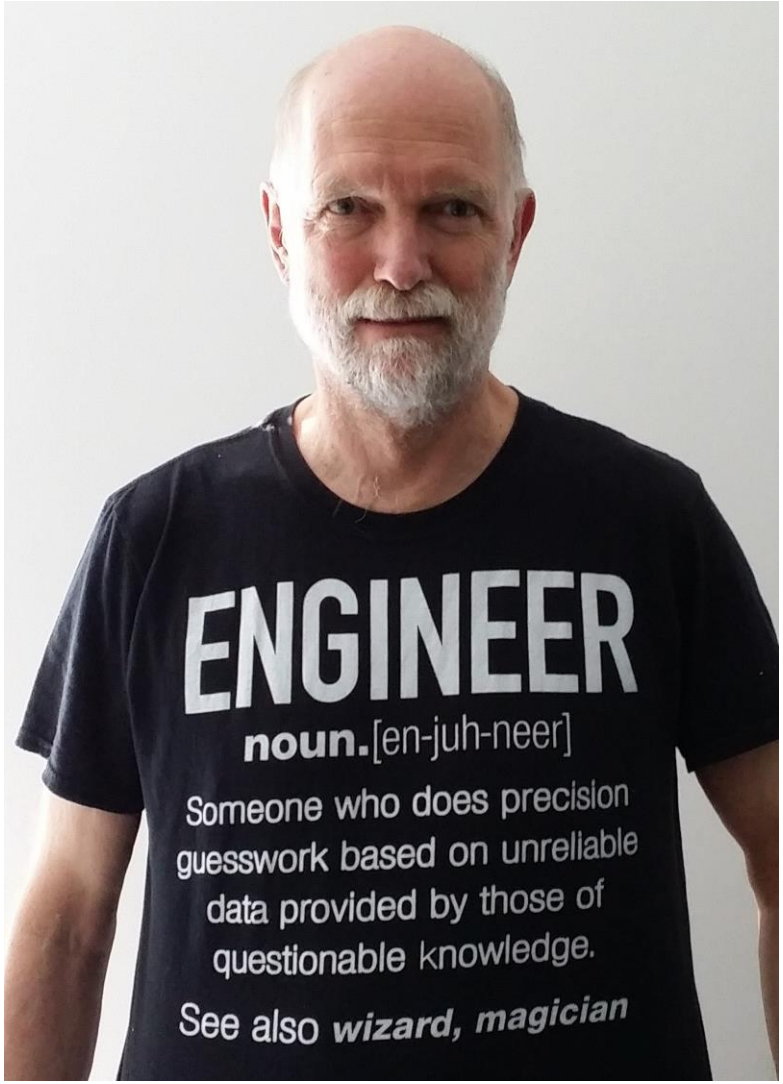
NSERC CRSNG

Modified Schedule

9:00-9:25 + 5 min Q's	Intro to wind energy	David Wood
9:30-9:55 + 5 min Q's	Wind Resource Engineering	Mathew Breaky
10:00-10:25 + 5 min Q's	Fluid-structure interaction	Artem Korobenko
10:30-11:00	Coffee break	
11:00-11:25 + 5 min Q's	Spatial-temporal modeling of wind turbines	Deniz Sezer
11:30-11:55 + 5 min Q's	Vorticity, Impulse and Wind turbine Aerodynamics	David Wood
12:00-12:30	Summary/Discussion	

Why engineers and mathematicians should collaborate



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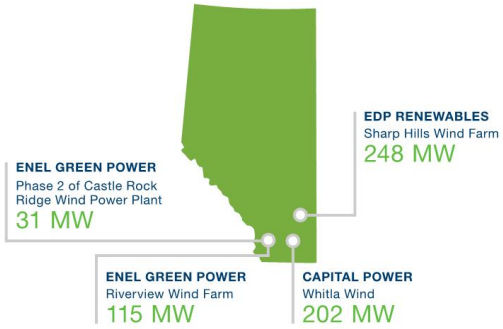
Alberta's Renewable Electricity Program attracts lowest renewable pricing in Canada

Round 1 of the Renewable Electricity Program successfully delivered nearly 600 MW of wind generation at bid prices that are competitive globally and record-setting in Canada. The four successful projects for Round 1 are:



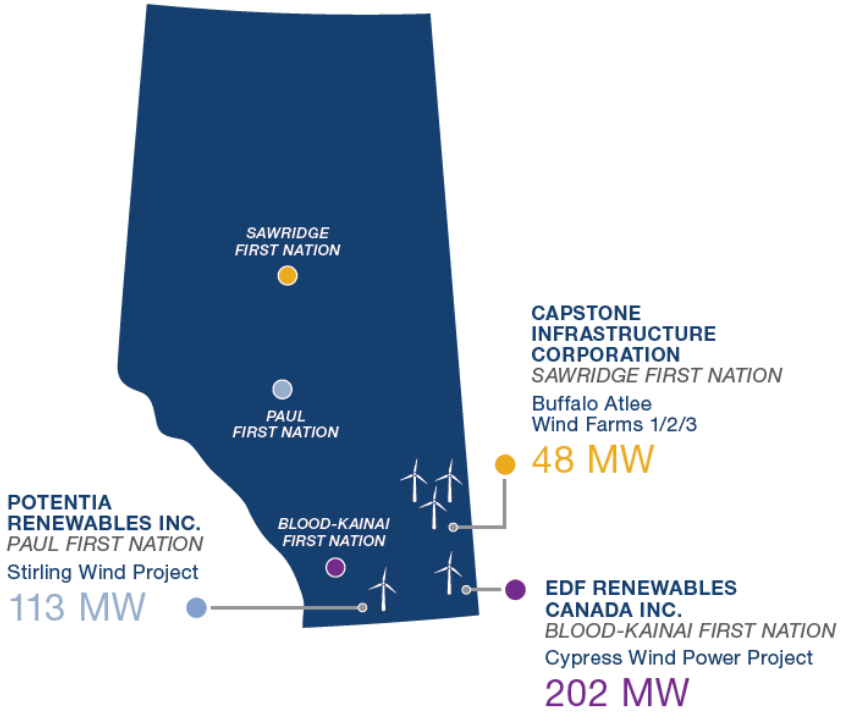
$30.90 — $43.30 = $37/MWh

range of winning bid prices — weighted average price

https://www.aeso.ca/assets/Uploads/REP-Infographic.pdf

Indigenous partnerships fuel the success of REP Round 2

REP Round 2 attracted significant interest from local and international developers eager to invest in Alberta. Successful developers partnered with 3 Indigenous communities to build 5 wind projects totalling 363 MW at a weighted average price of under $39/MWh.



Range of bid prices and weighted average prices

Round 2

$36.99 — $38.97 = $38.69/MWh

range of winning bid prices — weighted average price

https://www.aeso.ca/assets/Uploads/12-18-18-REP-R2-Infographic.pdf

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What are the Main Issues with Wind?

It is often said that wind energy is a “mature” technology. Yes it is, however:

- Wind turbines are getting larger
  - Blades are longer and more flexible
  - Towers are higher
  - Interaction of the aerodynamics/structure/dynamics/control is increasingly important
  - Multi-dimensional optimization and design to limit bending, reduce manufacturing cost, minimize noise etc

- Penetration of wind energy is increasing
  - Siting of wind farms is becoming more important
  - Interaction of wind turbines in wind farms causes fatigue and loss of power
  - How to deal with the intermittency of wind energy
  - Wind farms are experiencing high levels of blade erosion

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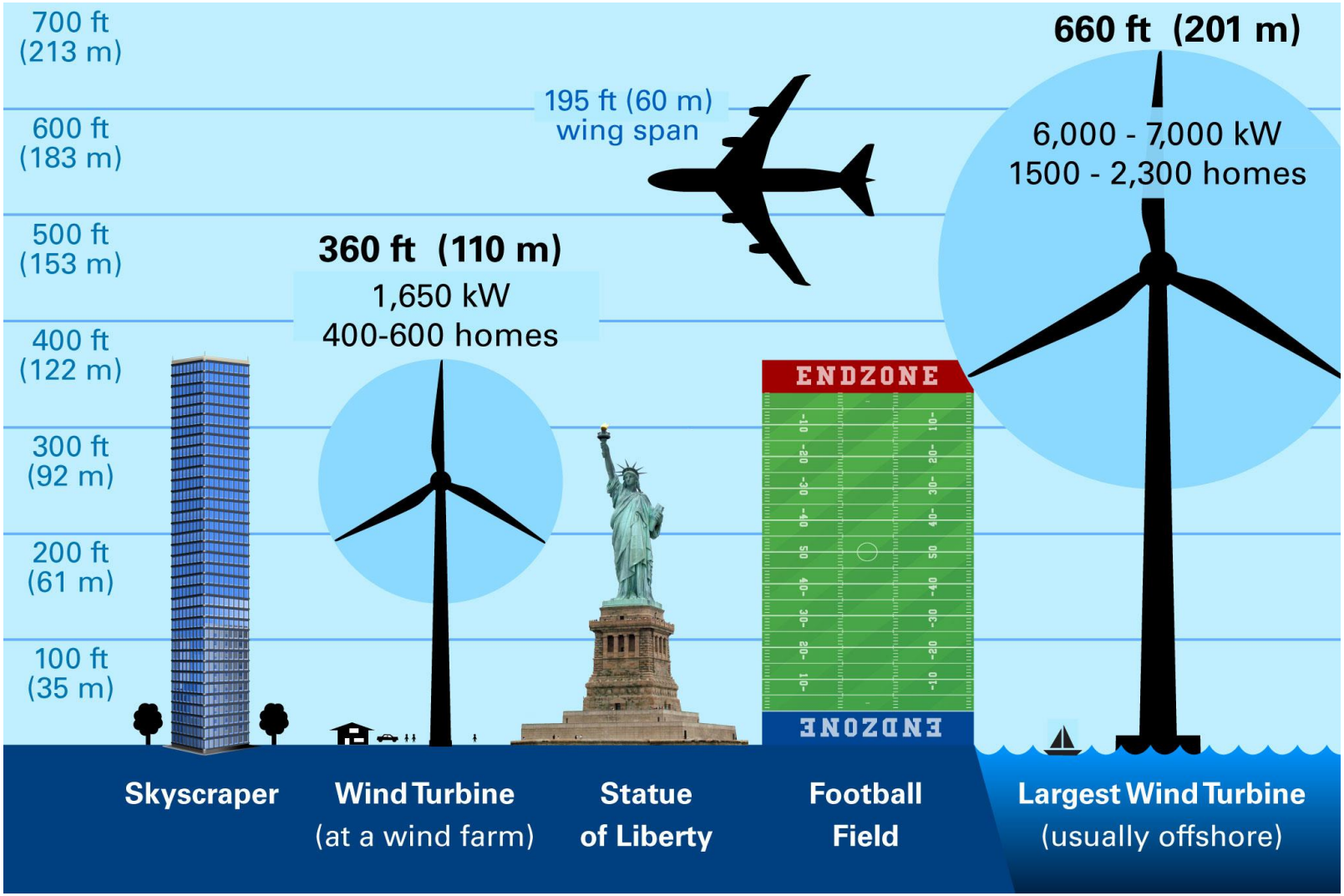
The Longest Blade in the World

https://cleantechnica.com/2019/04/19/absolute-beast-of-a-wooden-wind-turbine-blade-rolls-off-the-assembly-line/

Wind turbines are getting bigger



http://www.city-data.com/forum/green-living/2540299-rationalizations-wind-turbines-beautiful-vs-whats-7.html

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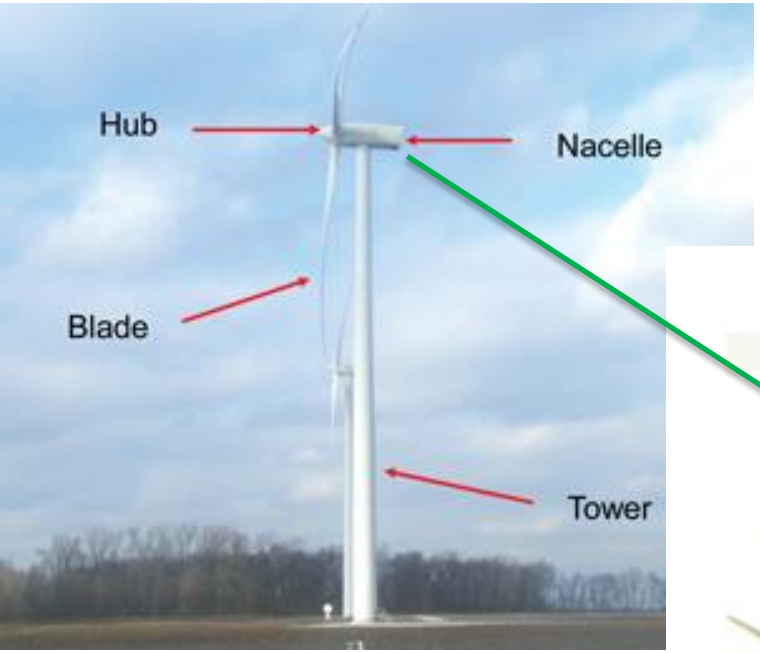
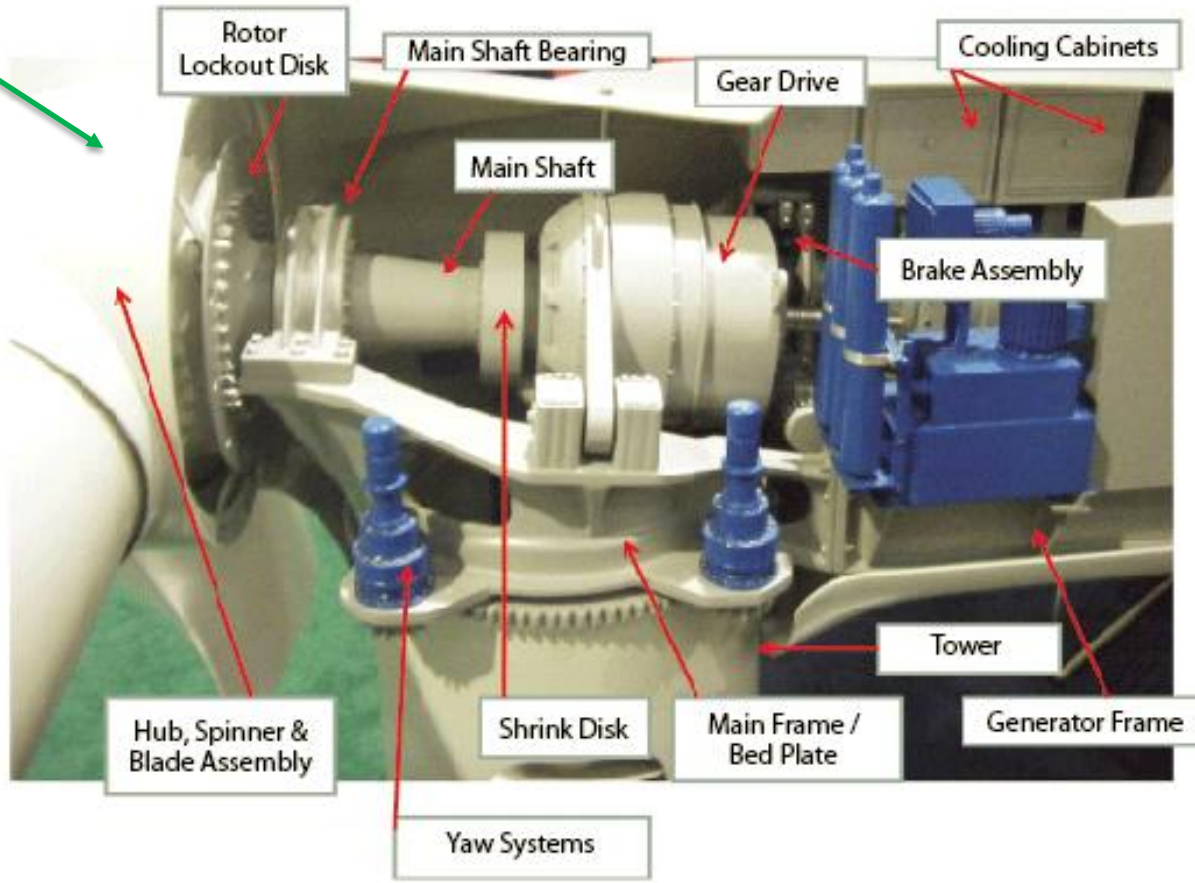
Inside the nacelle





http://sustainablemfr.com/renewable-energy/anatomy-wind-turbine

Wind Turbine Control

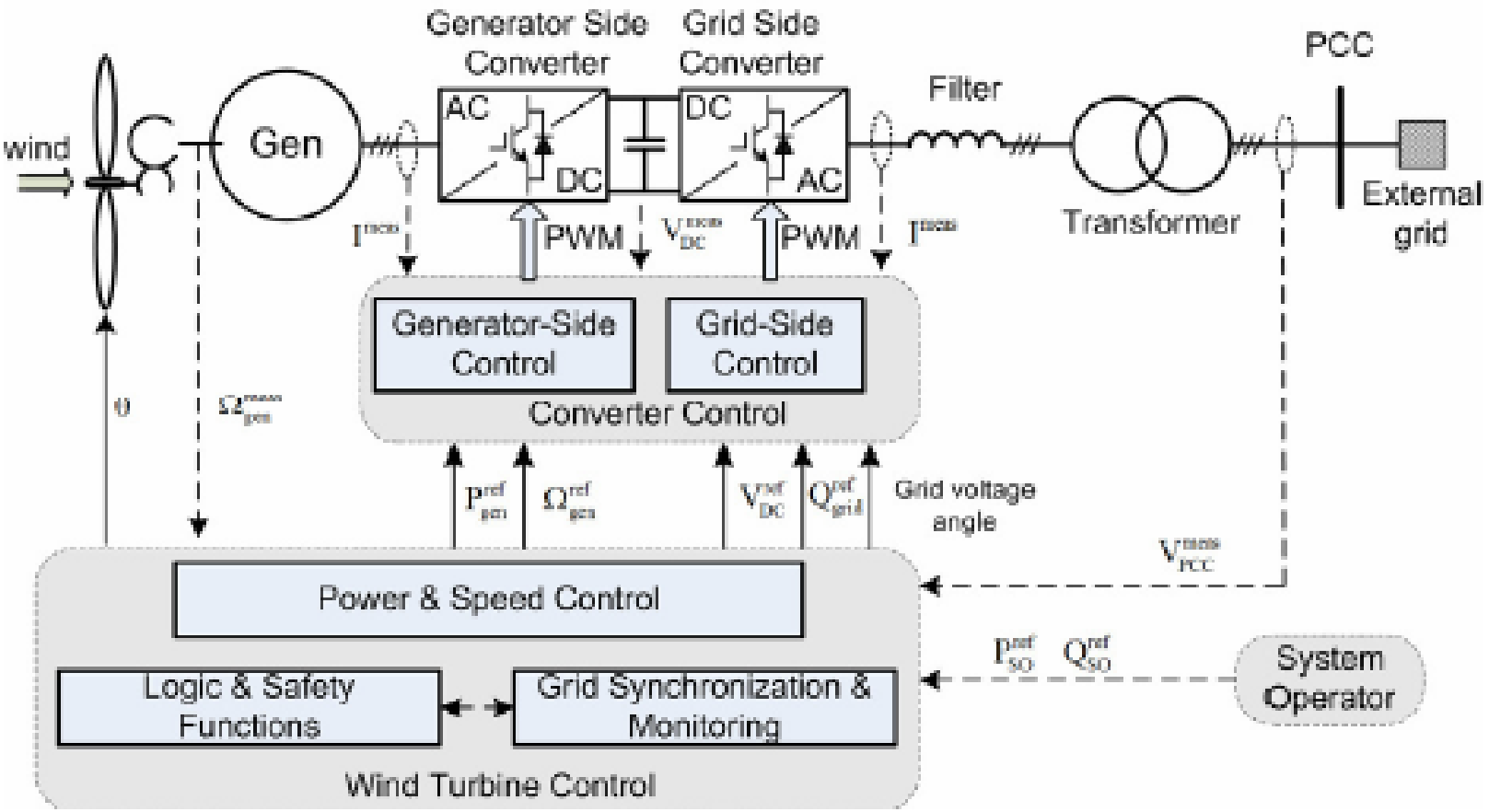


Figure 16. Control levels in a full-rating power converter based wind turbine.

Turbine T5 at the WEICan wind farm

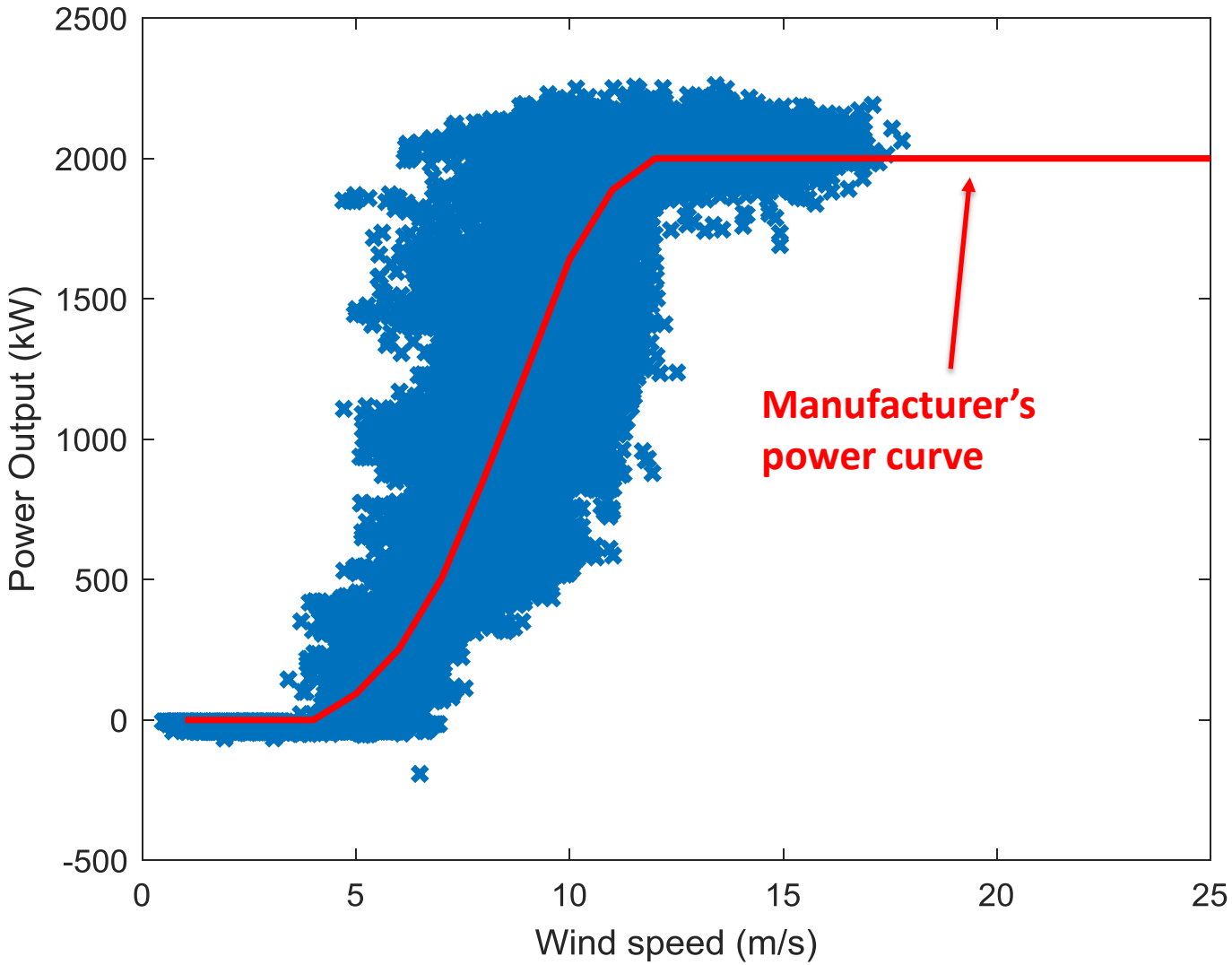
Wind Energy Institute of Canada

Institut de l'énergie éolienne du Canada

One day in the life of T5

Output power versus wind speed

Both averaged over 1 second



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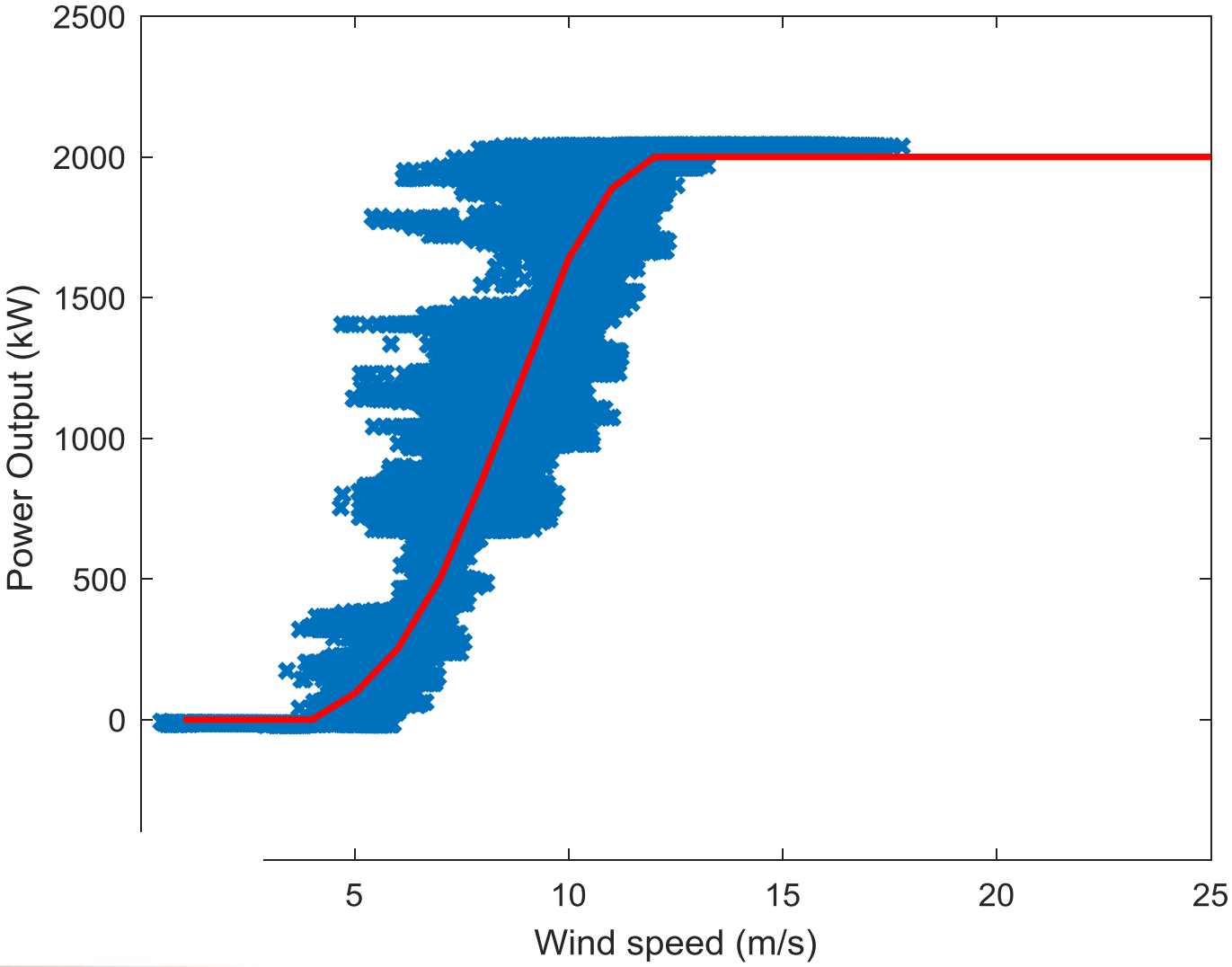
One day in the life of T5

Output power versus wind speed

Both averaged over 10 minutes



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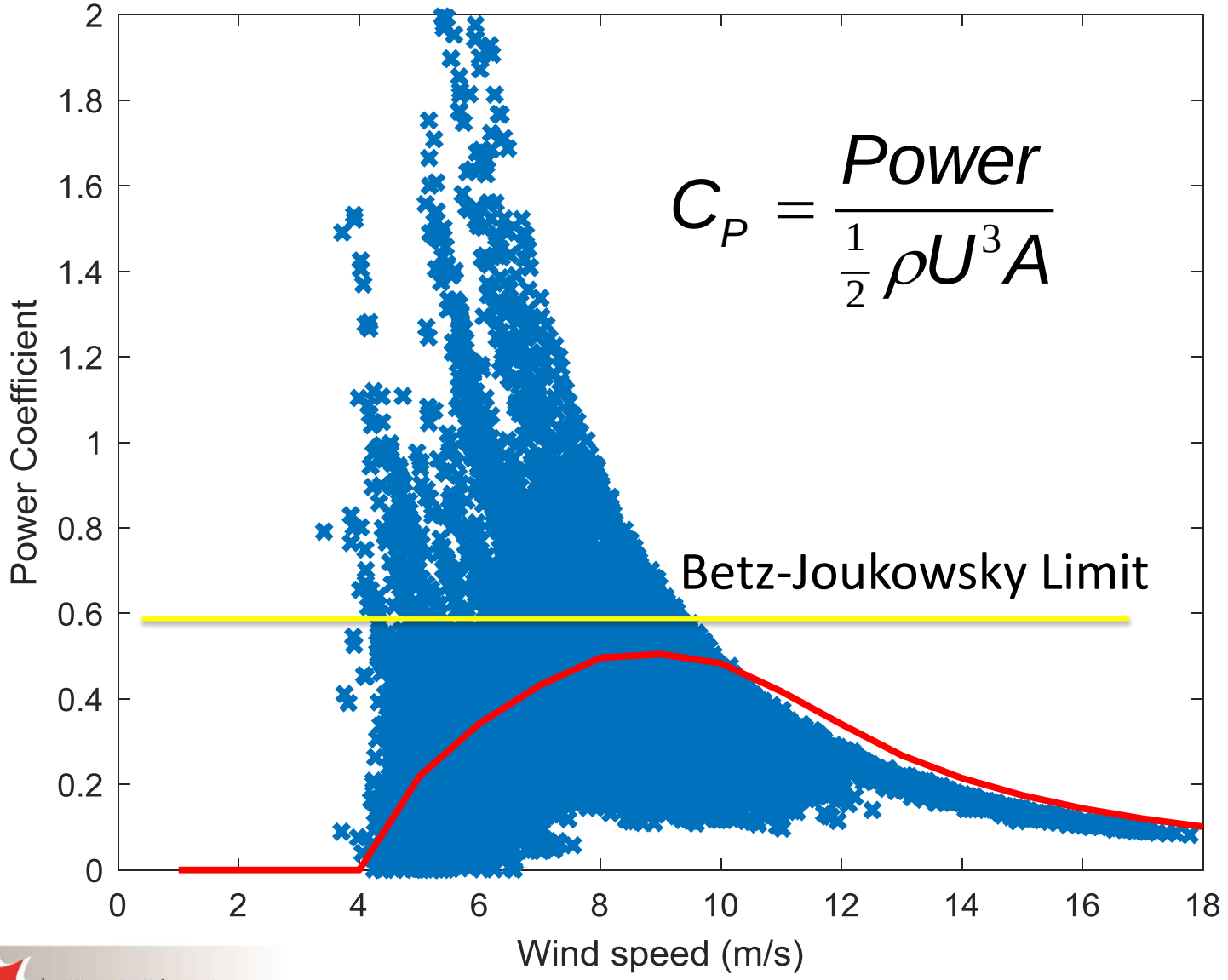
One day in the life of T5

Power coefficient, C_P, versus wind speed

Both averaged over 1 second

ρ – air density
U – wind speed
A – rotor area



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Wind Turbine Interference

Horns Rev offshore wind farm, Denmark

Wind turbine interference – upwind turbines reduce the power available for any downwind turbine

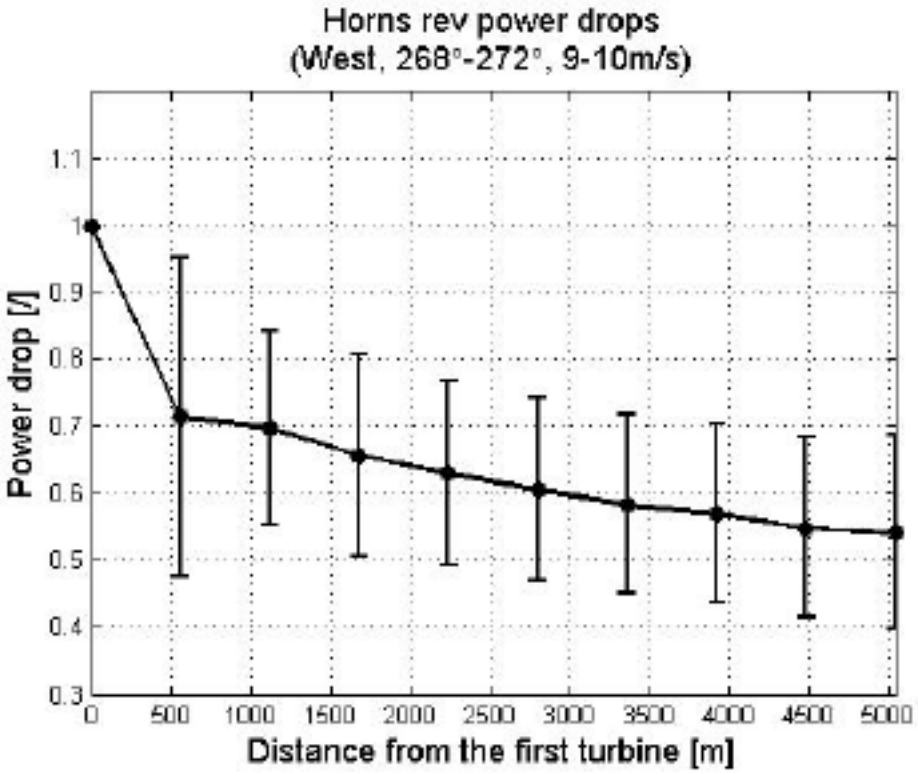


Figure 5.6 Relative power drop 9-10m/s

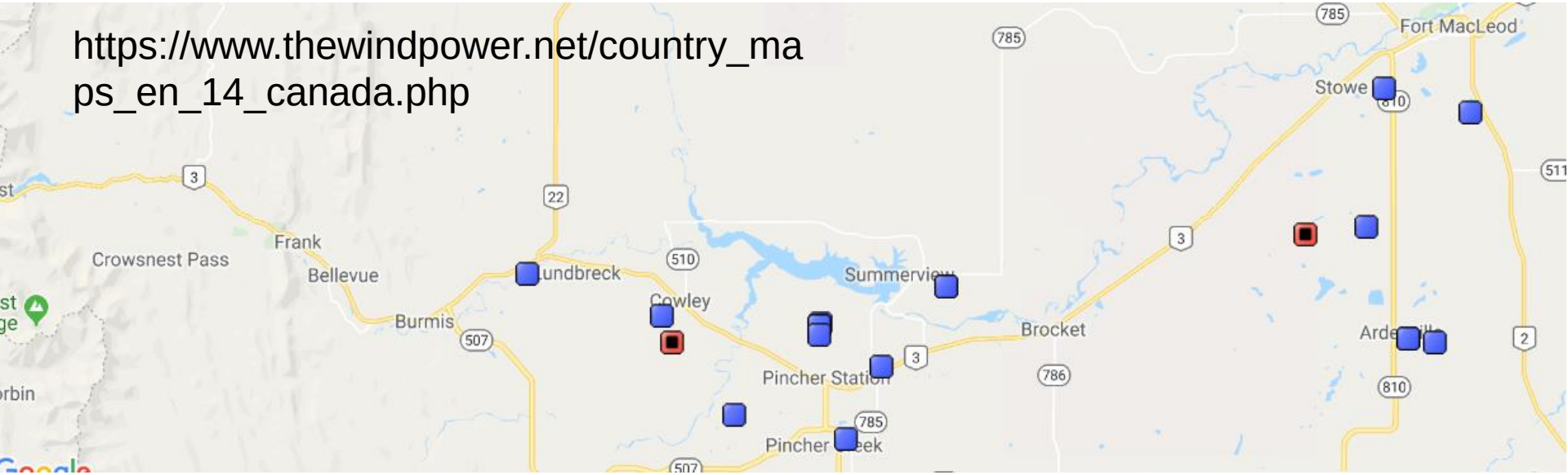
Wind Power in Alberta

Wind Power in Alberta

- Highly concentrated
- 1483 MW, 901 turbines
- 6% of electricity demand

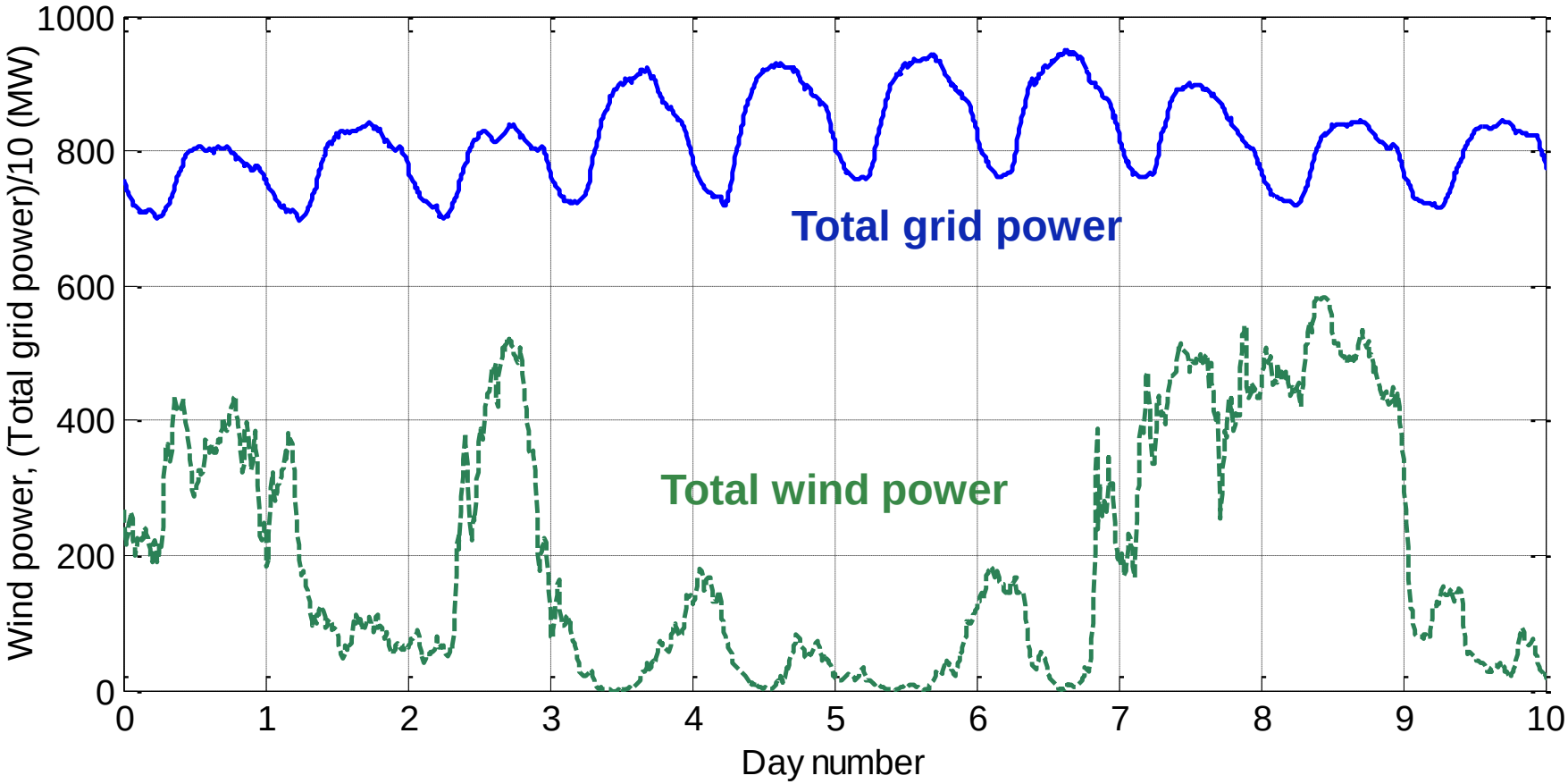
https://canwea.ca/wind-energy/alberta/

https://www.thewindpower.net/country_maps_en_14_canada.php



Total Grid Power and Wind Power for Alberta

10 days in July 2011



Summary

Wind Energy is “mature” but there is still much to learn about:

- Unsteady performance
- Interaction of aerodynamics/structure/dynamics/control
- Optimizing siting
- Dealing with intermittency as wind energy penetration increases