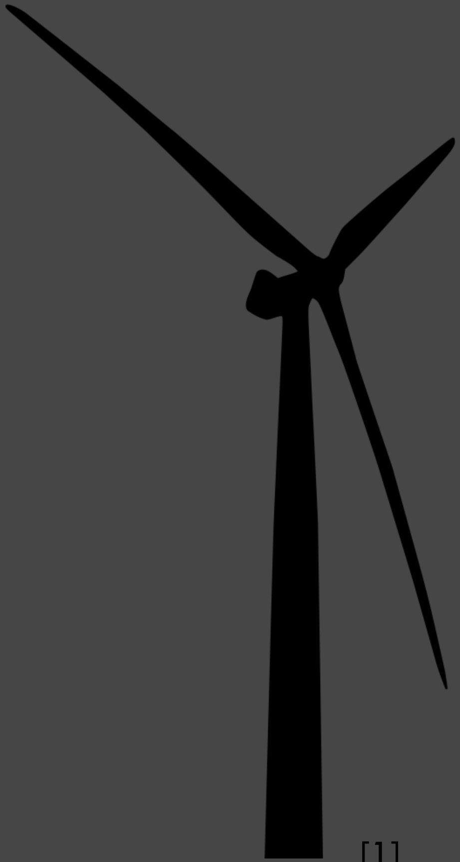


[1]

WIND-DIESEL-STORAGE PROJECT AT KASABONIKA LAKE FIRST NATION

Professor David A. Johnson

Wind Energy Group

Department of Mechanical and Mechatronics Engineering

University of Waterloo

2009 Wind-Diesel Workshop Ottawa

University of Waterloo

- *Large Comprehensive University (30,000 students)*
- *Located in Ontario, Canada*
- *Largest Engineering School in Canada*
- *Known for: Co-Operative Education in Engineering*
  (all Engineering students study (4 months), work in industry (4 months), study, work in industry, etc for the entire program)

  Significant Entrepreneur Culture

  Spin off companies, IP development, Start Up Incubator Centre, Early Stage Investment
  Inventor Owner Policy on IP

Need

- Clean, reliable electricity in remote communities of Canada and the world
- Reduce energy costs and cost uncertainty – fuel and transportation
- Energy costs in remote Canadian communities can be many times greater than grid connected community
- Reduce potential damage to environment from fuel transportation and emissions (gases and particulates)

Solution

- Develop local energy sources (wind, hydro, biomass, geothermal, solar)
- Develop wind turbines specifically for installation and operation in the climatic conditions of remote community
- Develop energy storage media to supply low wind periods – currently using hydrogen generation, storage and fuel cells
  – many other possibilities
- Develop micro grid controller to integrate and control multiple energy sources

Research Goals

- Evaluate technologies for implementation of a wind-diesel-storage system for remote communities of Northern Ontario
  - Scale demonstration site at University of Waterloo ('test drive' components, integration)
  - Strong focus on Community engagement
  - Train 'next generation' of wind-diesel researchers and engineers

Structure

- Project Leaders University of Waterloo (Engineering and Environment)
- Project Researchers (~20 researchers)
  - A team of engineers pursuing advanced degrees led by Professors in Mechanical and Electrical Engineering
  - Graduate researchers in Environment

Structure

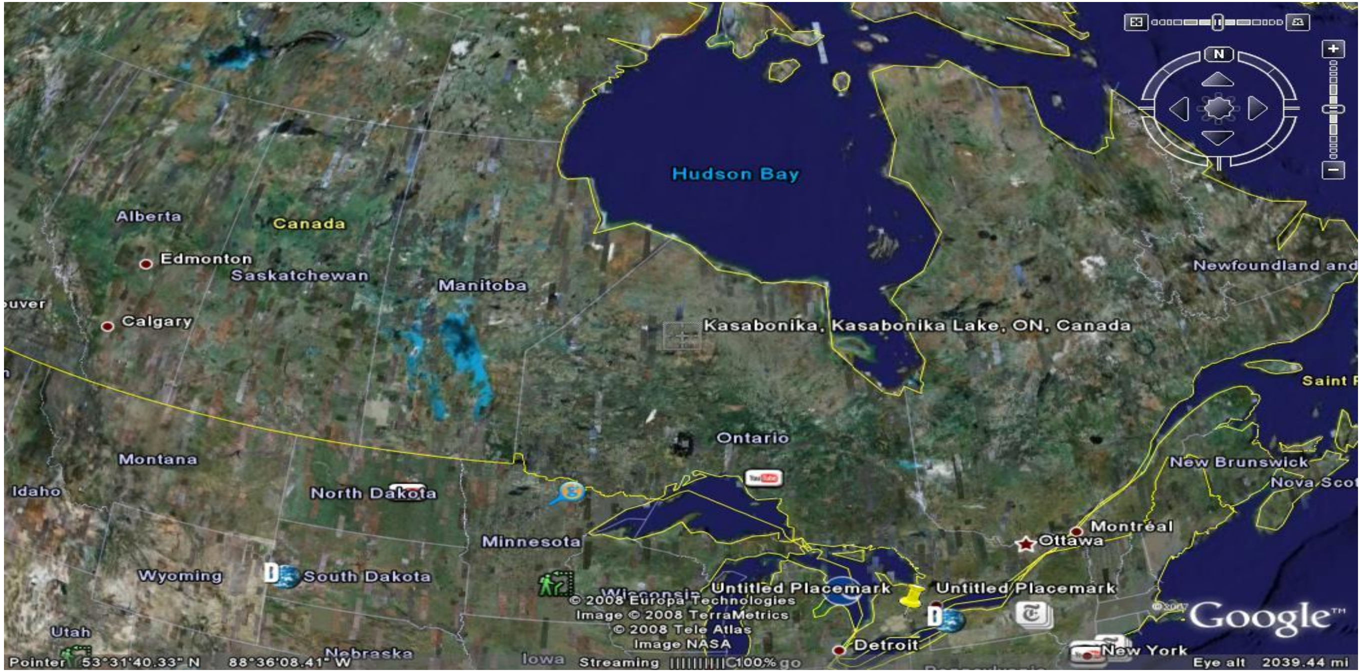
- Phase 1

Demonstration site at the University of Waterloo

- Phase 2

Demonstration site for the North at Kasabonika Lake FN

Location



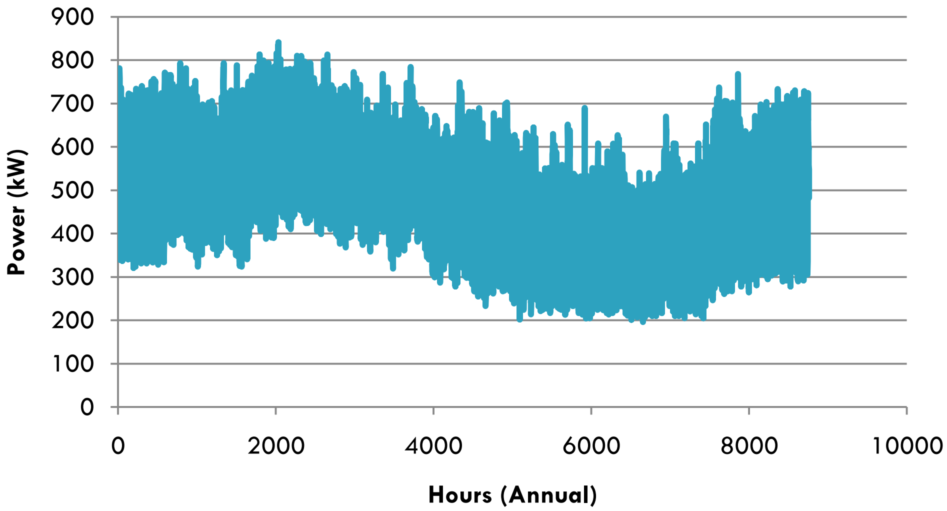
No access roads, fly in community, winter road (Feb-Mar)

Existing System

- **Three Diesel Generators** 1000,600,400 kW

Existing System

- Typical Annual Load
- 200 kW summer min
- 850 kW winter max
- Approaching load limit



Existing System

- Three Pre-Existing Wind Turbines
- 3 x10 kW Bergey
- Date from Ontario Hydro (late 1990’s)
- Community is familiar with turbines (good or bad)
- Noise Issues

Technology activities

- **Three Technology Research Streams**

1. Wind Energy Technologies
2. Energy Storage (hydrogen generation/storage/utilization)
3. Power Integration and Control

Technology activities

Turbine technology

- Wind Resource – better estimate including measurement
- Blades – revised airfoil suitable for anticipated modest wind resource, low noise airfoil, minimize icing
- Local resources for installation/maintenance
- robust, low/no maintenance – also develop community expertise

Technology activities

Energy storage technology

- Investigation of hydrogen-based system
- Electrolysis of water, hydrogen storage, fuel cell
- robust, maximize operation time
- low/no maintenance – also develop community expertise

Technology activities

Micro Grid technology

- Micro grid control
- Power Management and Protection
- maximize operation time
- Multiple input sources
- low/no maintenance – also develop community expertise

Technology activities

- **Year 1:** Connect and Research
  - Select a community
  - Measure wind resource (critical!)
  - Model system (HOMER and in-house code)
  - Research and design technology components
  - Invite local input on design, ease of access
  - Initial discussion of possible sites for turbine, hydrogen system

Community activities

- **Year 1:** Connect and Consult
  - Select a community
  - Listen to community goals – energy map
  - Initial discussion of community members involvement
  - Education project for school
    - Energy: demand, supply, role of renewable energy

Community activities

- **Year 1:** Consultation
  - Presentation to Band Council (October 2008)
  - Presentation to entire community (March 2009)
  - Live presentation, on community radio and with translation
  - Questions from audience and phone in

Community activities

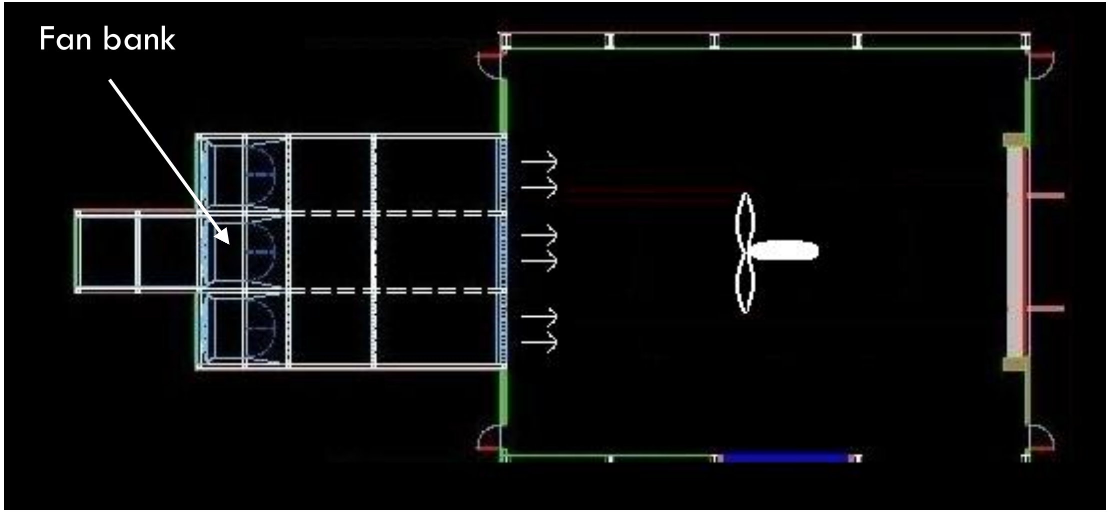
- **Year 2:** System Details
  - Identify site options and sensitivities
  - Listen to community
  - Select site for turbine
  - Share results from Waterloo test system

Community Activities

- **Year 3:** Install system at KLFN
  - Install system and continue research
  - Training for community members
    - Field test verification of operation
  - Share information with community
  - Education project for school
    - Energy – local data on energy produced
    - Measure benefits to community and environment
  - Lessons for other communities
  - Continue to monitor performance

Wind Energy Projects

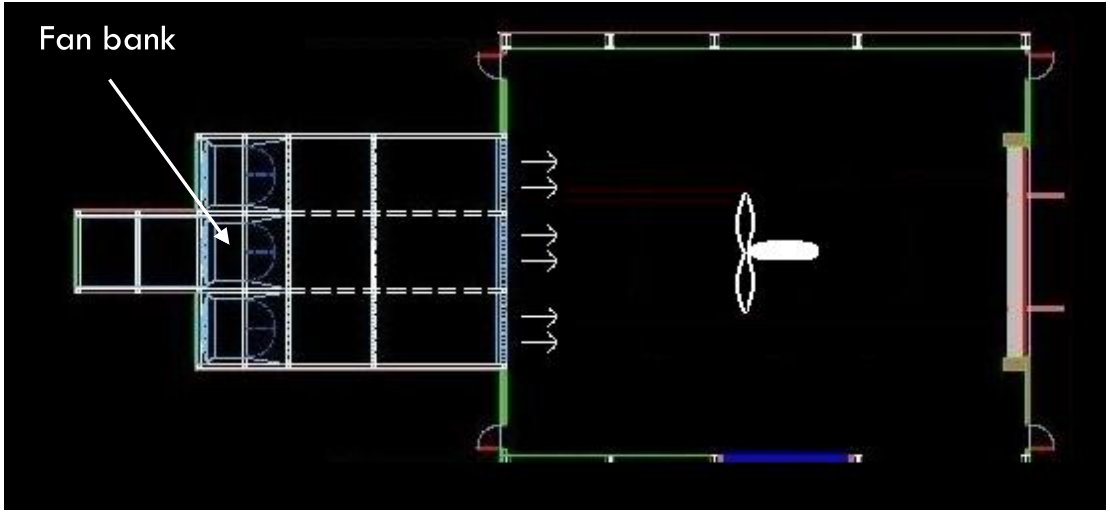
- Waterloo large-scale wind facility
  - 16x20m test section
  - Wind speeds up to 11m/s
  - Horizontal axis wind turbine mounted in test section



UW Large-scale wind facility floor plan.

Experiment - facility

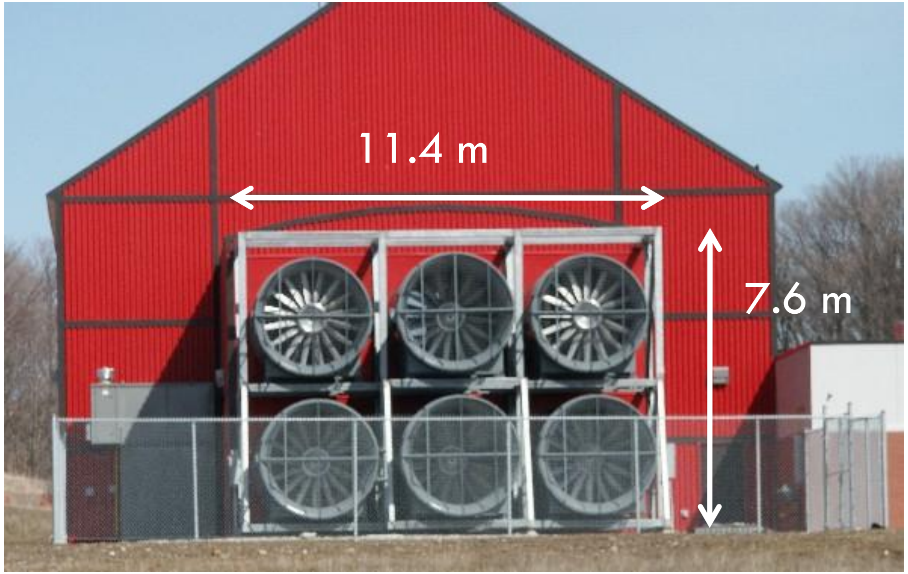
- Waterloo large-scale wind facility
  - 16x20m test section
  - Wind speeds up to 11m/s
  - Horizontal axis wind turbine mounted in test section



UW Large-scale wind facility floor plan.

UW large-scale wind facility

- 6 x 100 hp axial flow fans
- Independent speed control



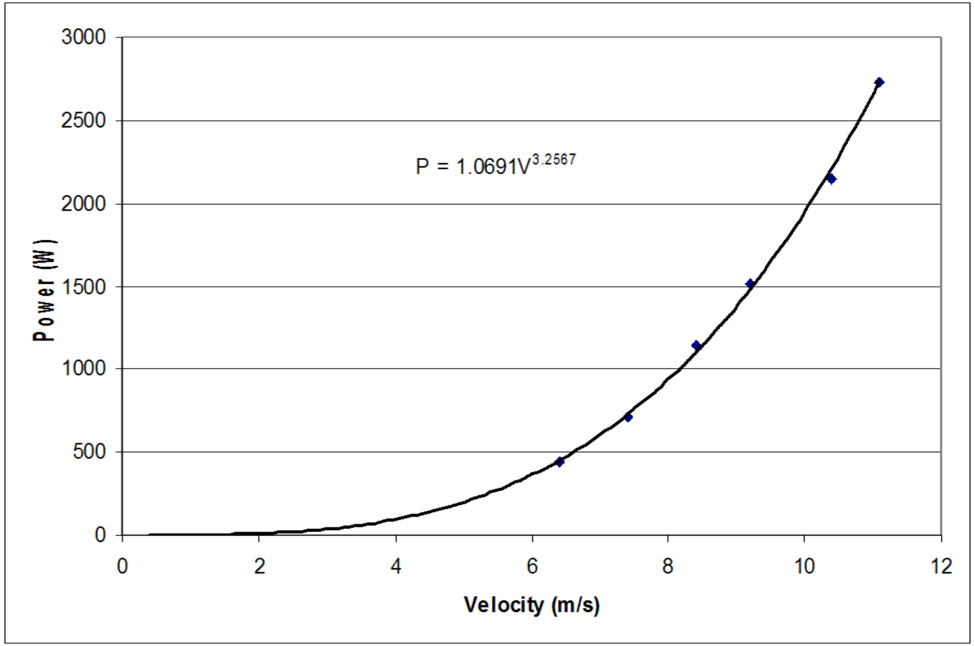
UW Large-scale wind facility

UW WEG wind turbine

- 4.5m diameter
- 3 kW max output
- Variable speed up to 220 rpm
- Output power calculated from voltage and current at load bank
- Designed and manufactured by WEG

UW WEG wind turbine

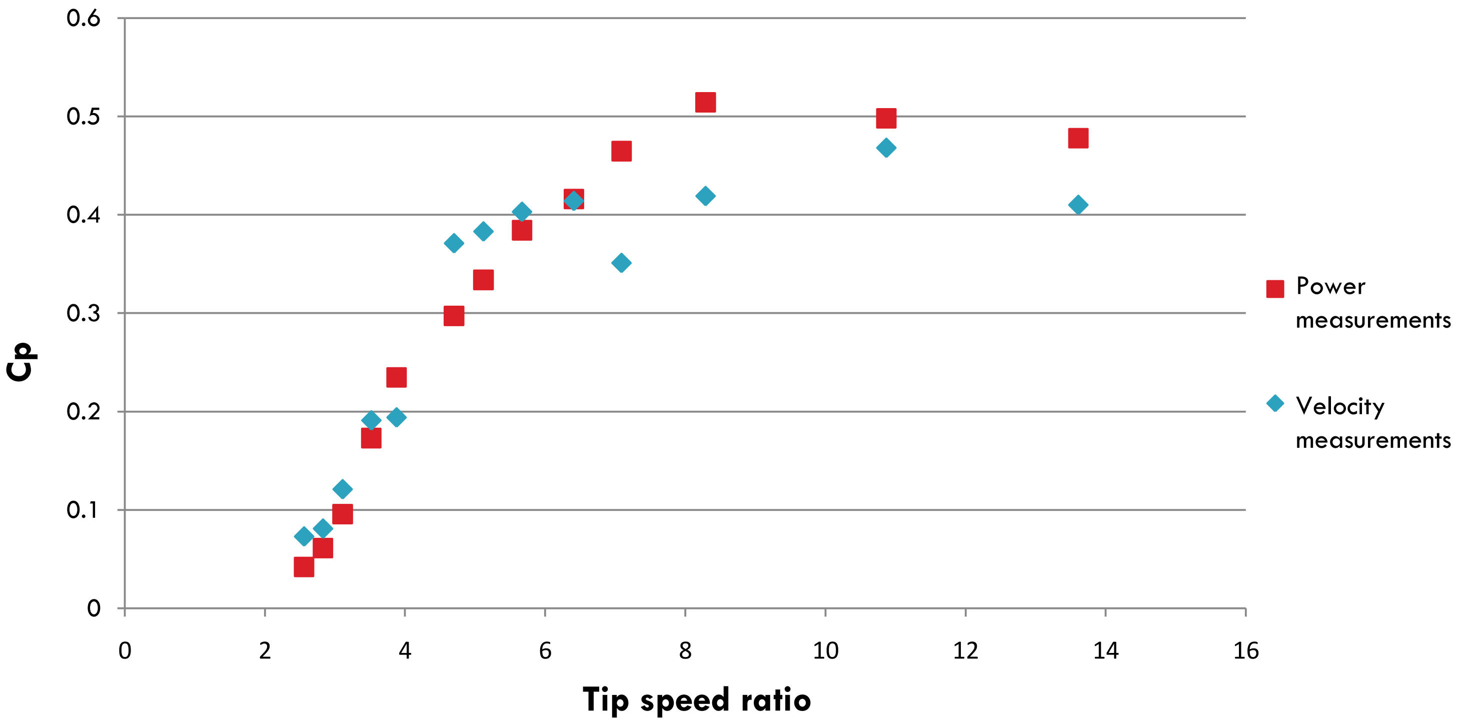
- 4.5m diameter
- 3 kW max output
- Variable speed up to 220 rpm
- Output power calculated from voltage and current at load bank
- Designed and manufactured by WEG



Experiment - setup

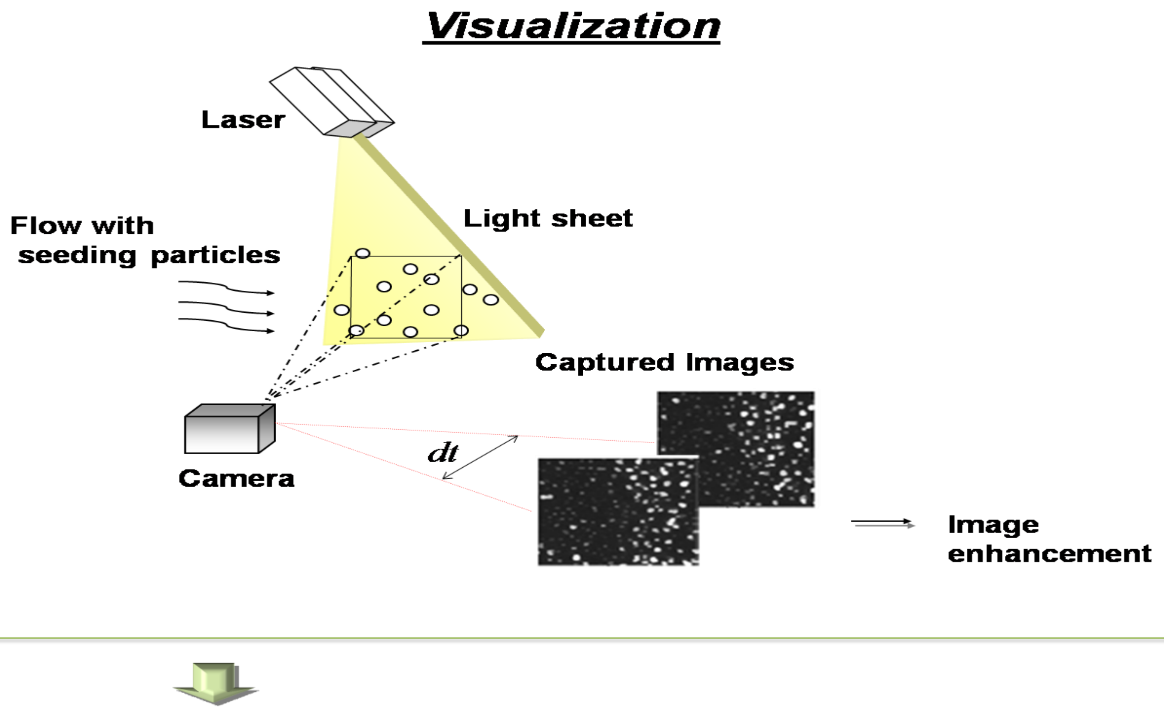
- CSAT 3D sonic anemometer used to measure velocities
  - 3 component simultaneous sampling
  - 60 Hz sampling rate
  - Error +/- 0.001 m/s
  - At least 2700 data points collected at each location
- Supported by horizontal beam mounted behind rotor plane at hub height

Results – C_p vs. tip speed ratio

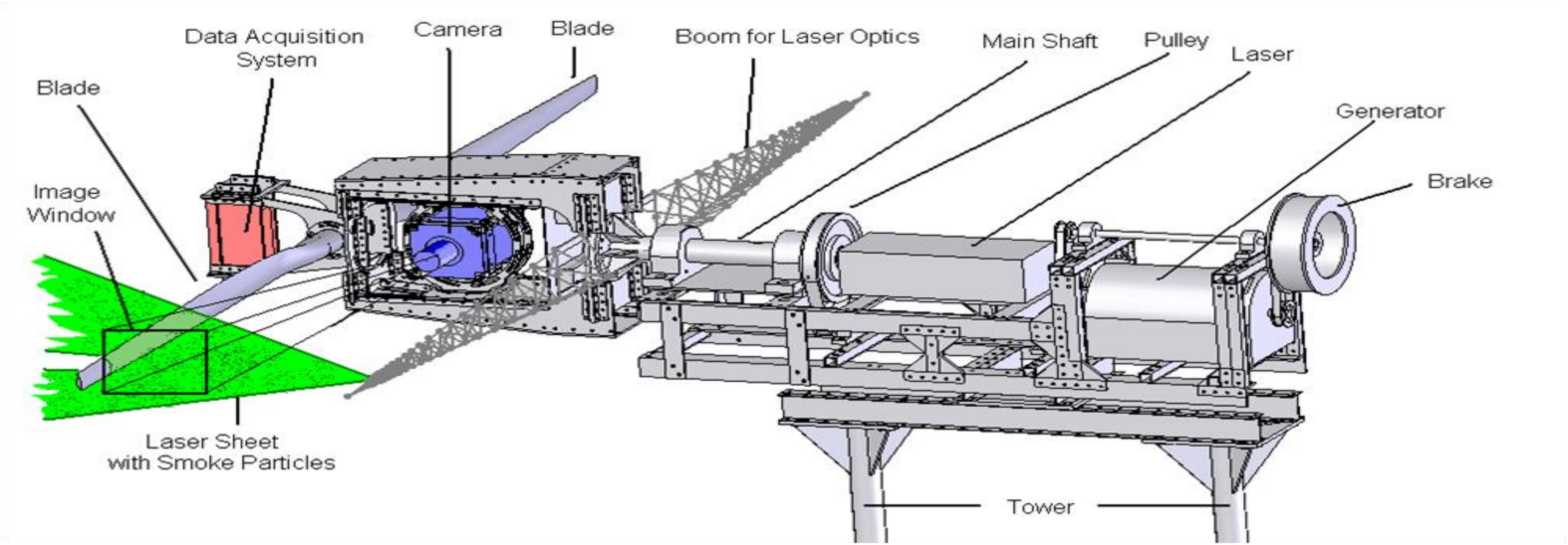


Experiment - equipment

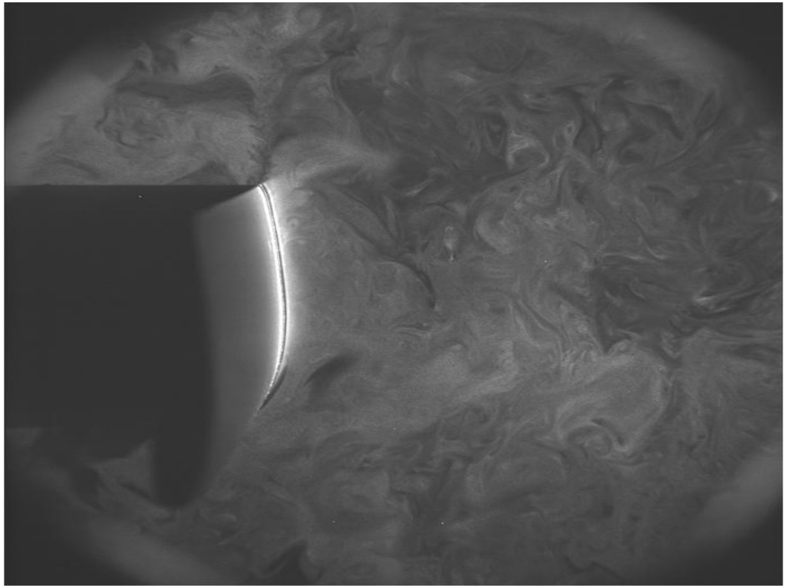
- Laser based particle image velocimetry (PIV) measurements gathered as blade passes through laser sheet

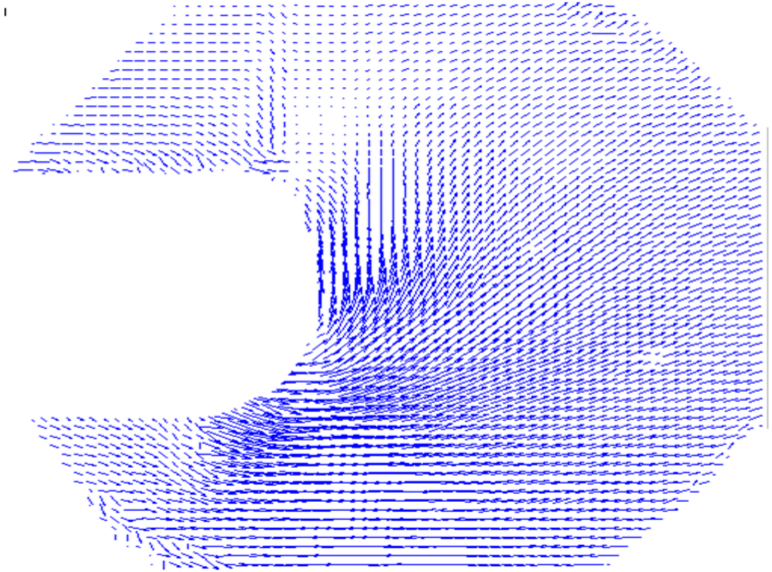


Experiment - equipment



Results - laser





Example PIV results for large turbine rotating velocity measurements

(LEFT) Standard Image – Blade passing through image area
(RIGHT) PIV Velocity Flow Field – high resolution velocity vectors

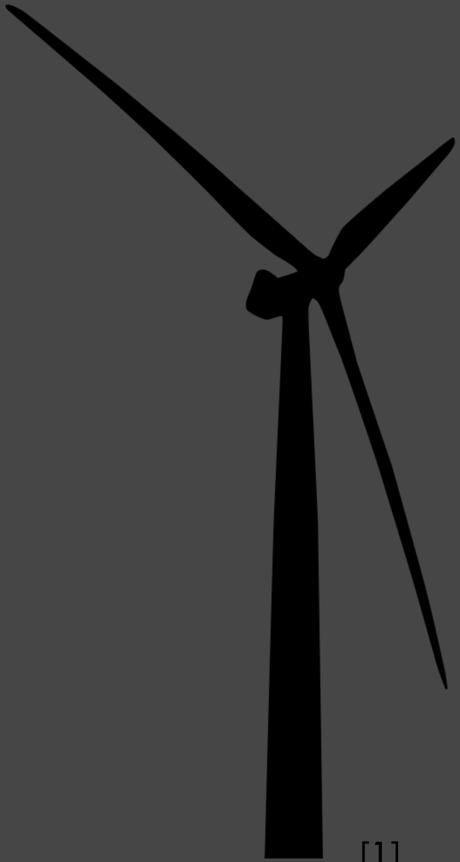
Conclusions

- Two phase project –
  - Phase 1 research on components and integration at demonstration site at Waterloo
  - Phase 2 demonstration site at Kasabonika Lake FN
- Research projects in wind energy, hydrogen generation/storage/utilization, and power electronics/microgrid
- Wind projects will concentrate on wind diesel application in remote northern communities

Partners

- Industry Partners Hydro One Remote Communities
- Kasabonika Lake FN
- Hydrogenics
- Wenvor Technologies
- GE Digital Energy
- Virelec

- **Lead Sponsor Ontario Centres of Excellence - Energy**



[1]

QUESTIONS?