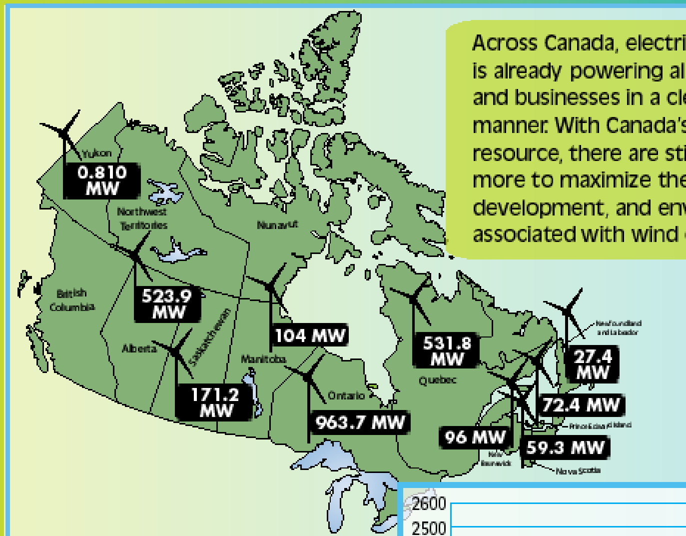
Wind Turbine Blade Design

What is Wind Energy?

- **The term “wind energy” refers to the use of wind as an energy source.**
- **Wind energy systems are developed to transform the kinetic (moving) energy of the wind into mechanical or electrical energy that can then be used in our everyday lives.**
- **Wind turbines generate electricity and are the most widespread use of wind energy today.**

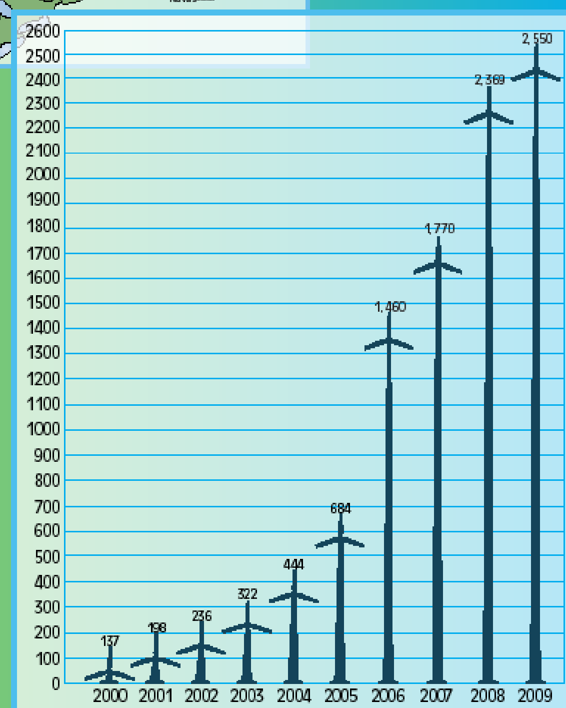
CANADA'S CURRENT INSTALLED CAPACITY : 2, 550 MW



Across Canada, electricity generated from wind is already powering almost 700,000 homes and businesses in a clean, reliable and efficient manner. With Canada's unparalleled wind resource, there are still opportunities to do more to maximize the economic, industrial development, and environmental benefits associated with wind energy for Canada.

- 523 MW of new installed capacity in 2008
- 2008 was Canada's second best year ever in terms of installed capacity
- Growth will be a minimum of 650 MW in 2009
- Canada will pass the 3,000 MW mark in 2009

Installed Capacity (MW)



Wind: Canada's infinite source of clean energy

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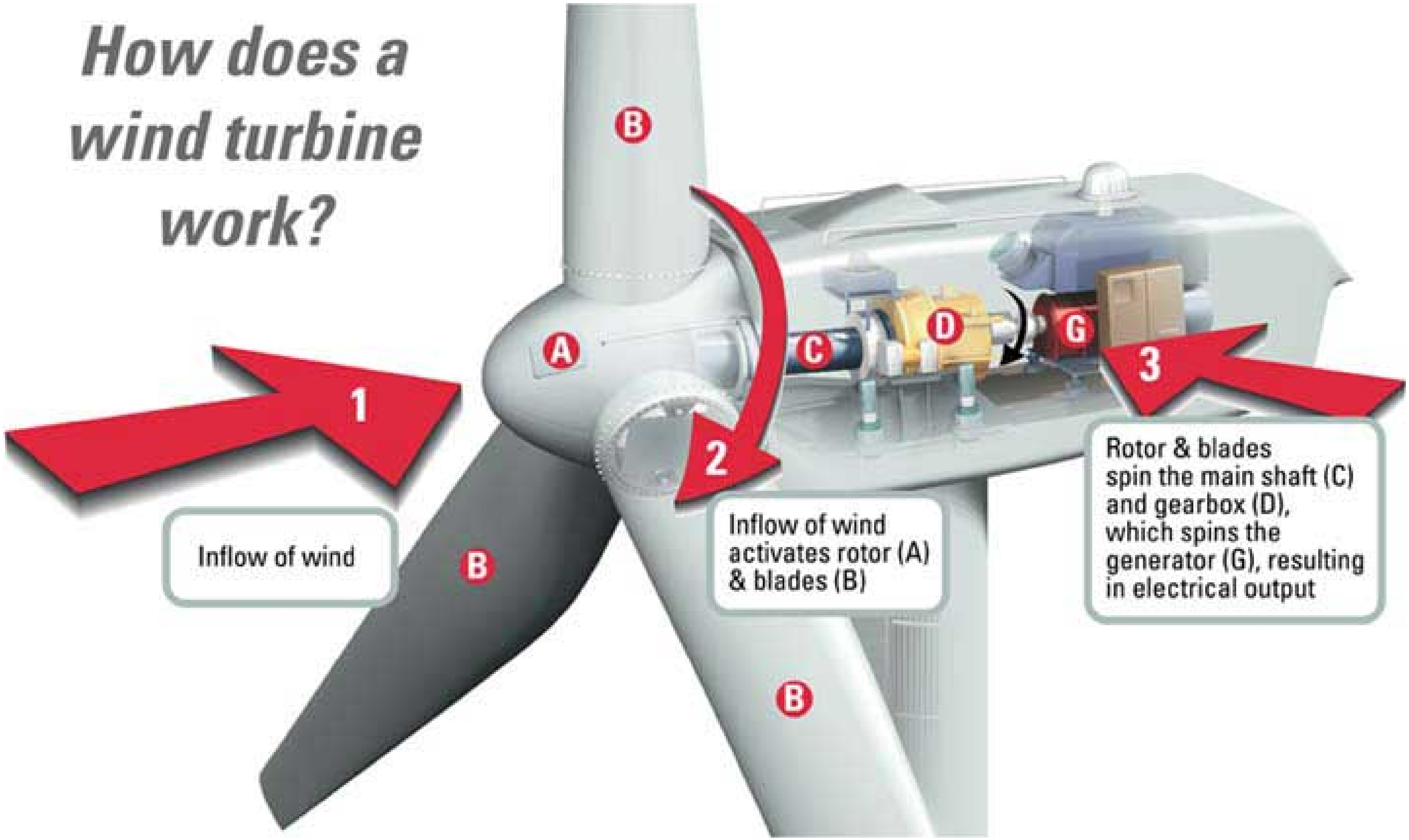
Parts of a Turbine

Rotor

Nacelle (turbine housing)

Tower

Foundation


How does a wind turbine work?
B
A
C
D
G
1
2
3
B
B
Inflow of wind
Inflow of wind activates rotor (A) & blades (B)
Rotor & blades spin the main shaft (C) and gearbox (D), which spins the generator (G), resulting in electrical output

How Wind Turbines Work

- **The wind turns the blades, which spin a shaft, which connects to a generator to make electricity. The electricity is sent through transmission lines to a substation, then onto homes, businesses and schools.**

- **The blades spin because of lift, the same force that allows airplanes to fly.**

How Wind Turbines Work

- **The blades are attached to a hub, which spins as the blades turn.**
- **The blades and hub together are called the rotor.**
- **As the rotor turns, it spins a drive shaft which is connected to a generator inside the housing at the top of the tower. This housing is called the nacelle.**

How Wind Turbines Work

- **The spinning generator produces electricity.**
- **The generator inside of a wind turbine converts the mechanical energy of moving wind into electrical energy that we can use in our homes.**

Lift & Drag Forces

- The ***Lift Force*** is perpendicular to the direction of motion. We want to make this force **BIG.**

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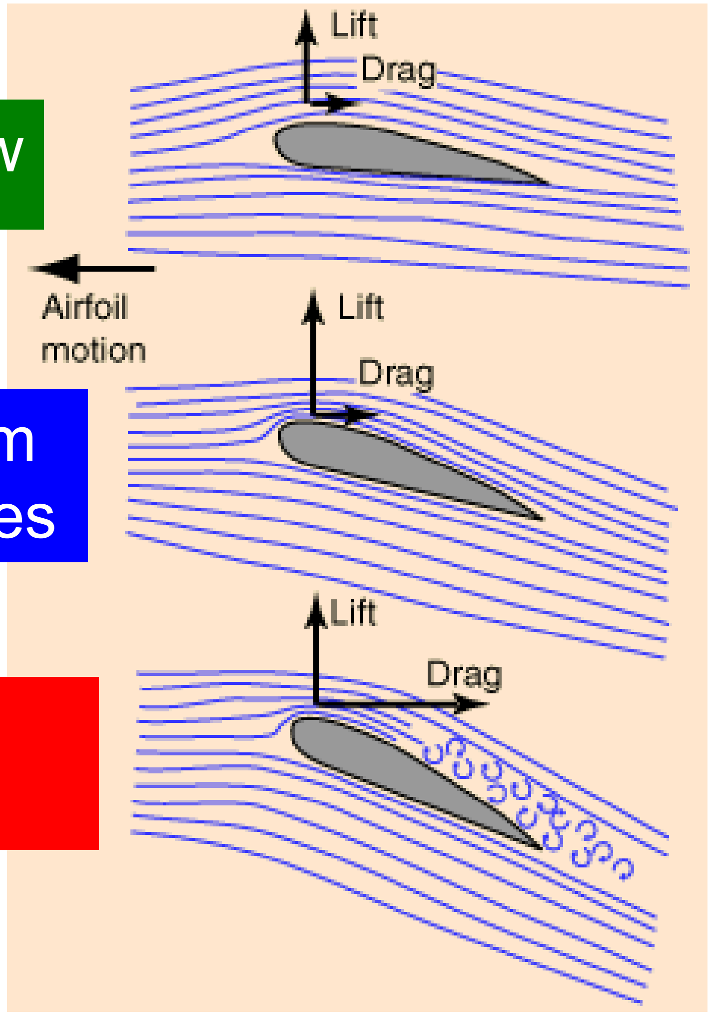
- The ***Drag Force*** is parallel to the direction of motion. We want to make this force **small.**

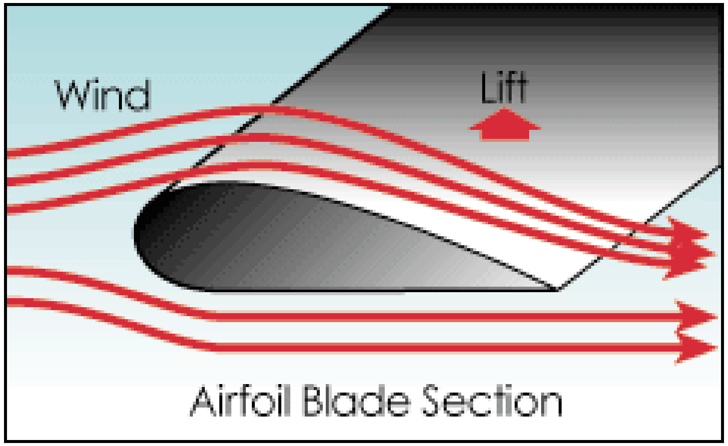
α = low

α = medium
<10 degrees

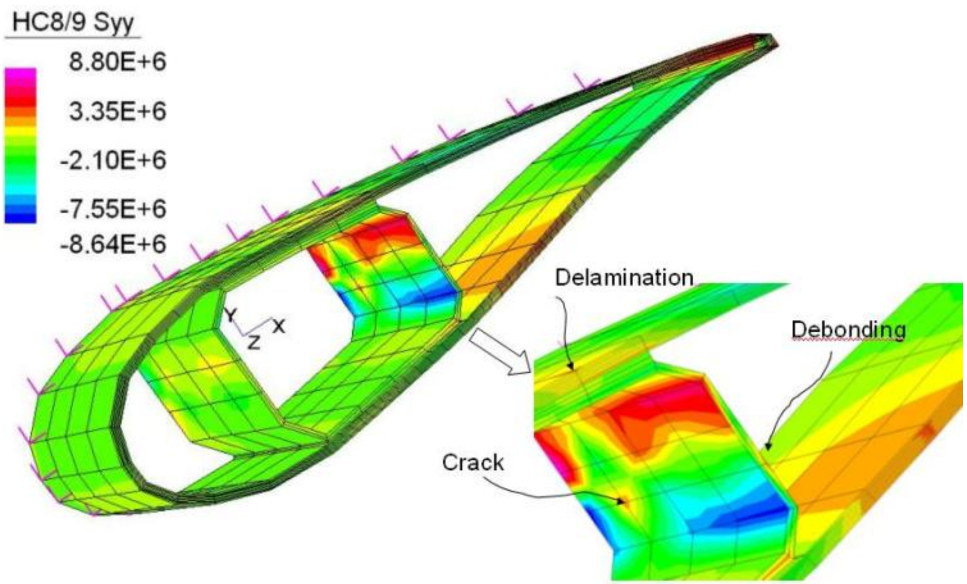
α = High
Stall!!



Airfoil Shape



Just like the wings of an airplane, wind turbine blades use the airfoil shape to create lift and maximize efficiency.



Focus: Blade Design

Student Expectations:

- **Students will research and experiment with different blade shapes, numbers, weight and pitch/angle and complete a work sheet on their findings.**

- **Based on their findings, students will select the method that best captured wind energy and efficiency and design and manufacture a wind turbine blade.**

Wind Turbine Blade Challenge

- **Students perform experiments and design different wind turbine blades**
- **Use simple wind turbine models**
- **Test one variable while holding others constant**
- **Record performance with a multimeter or other load device**
- **Goals: Produce the most voltage, pump the most water, lift the most weight**
  - Minimize Drag
  - Maximize LIFT
  - Harness the POWER of the wind!

Setting Up the Blade Challenge

<u>What You Need:</u>

- Box Fan (2-4 depending on class size)
- Blade Materials
  - Balsa
  - Paper/styrofoam plates/bowls
  - Cardstock, cardboard, corrugated plastic
  - Pie tins, etc.. etc.. etc… (leftover junk!)
- Scissors
- Glue/Tape
- Voltmeters, multimeters, and/or water pumps
- Hubs, motors (generators), towers, dowels

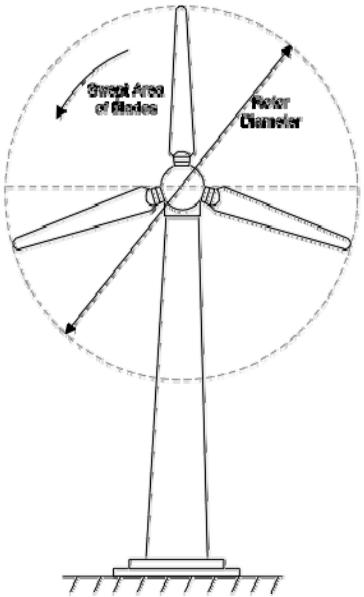
Blade Variables

Keep the following variable in mind when designing your blade:

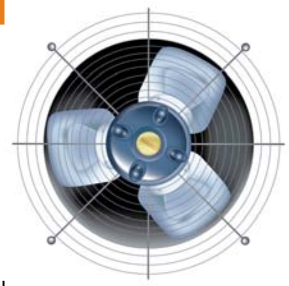
- **Length**
- **Shape**
- **Number of Blades**
- **Material**
- **Weight**
- **Curvature**
- **Pitch/Angle**

Design Constraints

- Cannot use any manufactured blades or propellers.
- Can use only materials approved by instructor.
- Swept area of blades must not exceed 20 inches (50 centimeters).
- Must have no sharp points.
- Must record materials used on your experiment sheet.
- Must test blades at least once before final testing.



Safety Considerations



- **Goggles or safety glasses are to be worn at all times while testing blades.**
- **Do not stand in direct line of rotation of blades while spinning.**
- **Use tools and equipment properly and safely.**
- **Be aware of electrical hazards and the potential for hair/clothing to get caught in rotating fan blades.**

Name: ___________________________

Blade Experiment Sheet

1. How many blades did you place on your hub? ______________

2. What is the “swept area” of your blades? ______________

3. What is the length of your blade? ______________

4. What is the width of your blade? ______________

5. What materials did you use? ________________________________

____

Name: ____________________________

Turbine Work Sheet

Low Wind Speed

Trial #	Variable (length, number, etc.)	Voltage	Amperage	(v x A) = Power
1				
2				
3				

Name: ______________________________

Turbine Work Sheet

High Wind Speed				
Trial #	Variable (length, number, etc.)	Voltage	Amperage	(v x A) = Power
1				
2				
3				

Name: ___________________________

Turbine Work Sheet Final Summary

1. What variable had the greatest impact on your power output?

2. What type of blade worked best at low speed?

3. What type of blade worked best at high speed?

4. What problems did you encounter during the design and manufacture of your blades?

5. How do you think you could improve upon your blade design?

Information courtesy of the Kid Wind Project at www.kidwind.org

and

The American Wind Energy Association at www.awea.org