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People for Energy and Environmental Literacy

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# Wind Energy

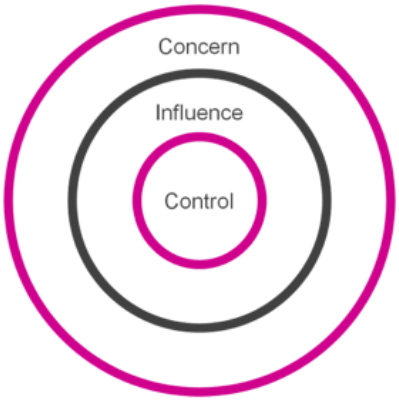
2018

Lesson 6 – Basic Level

Alberta

## Circle of Concern, Control and Influence

- **Circle of concern** - things we may not have direct control over.
- **Circle of influence** - things that I can influence and others can do something.
- **Circle of control** - things I can actually do

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It can be easy for kids to become overwhelmed by the issue of climate change. Using the circle of control, influence and concern helps students to discern what they can affect.

This lesson is focused on the circle of concern.

## Who uses the wind?

- Who?
- What for?
- Plants and animals?

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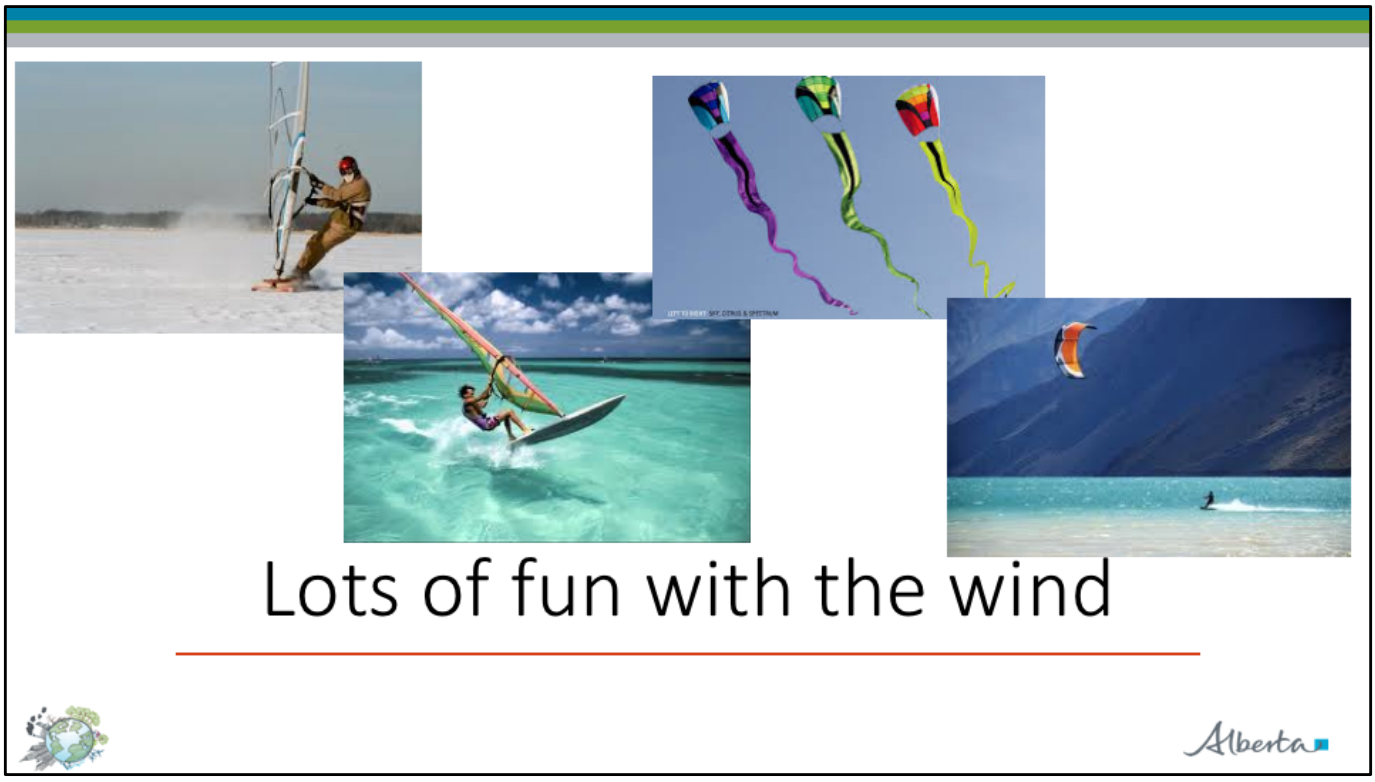
Brainstorm the ways wind is used for each of these questions:
Who uses wind?
What is wind used for?
Do plants and animals use wind?

Write down the student's answer for them to see. Go through the next four slides to see if the students came up with the same ideas, or if there are more ideas they thought of.

# Sail boats use wind!

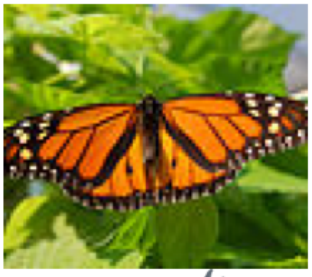
This is one of the earliest uses of wind. The wind is used to push against the sails on the boat, which then causes the boat to move. By changing the direction of the sail, you can change the direction the boat moves.




We can even use the wind for our own fun. Have you ever gone wind surfing or flown a kite? All of these activities shown in the pictures use wind to make objects move.


The wind is even used to dry your clothes. Do you dry your clothes in the wind at home?

# Plants and Animals use the Wind



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Plants and animals even use the wind! Birds and insects use wind to fly in the sky, and many plants use the wind to pollinate.


Now that we understand some of the ways wind is used everyday, lets look at how we can use wind to make electricity!

## Video on Wind Energy

- Wind Power 101 – StudentEnergy
  - Published December 1, 2014
  - This video is 1 min, 46 seconds
- https://www.youtube.com/watch?v=Z5c50-_hcD0

- Wind power is now the cheapest form of electricity

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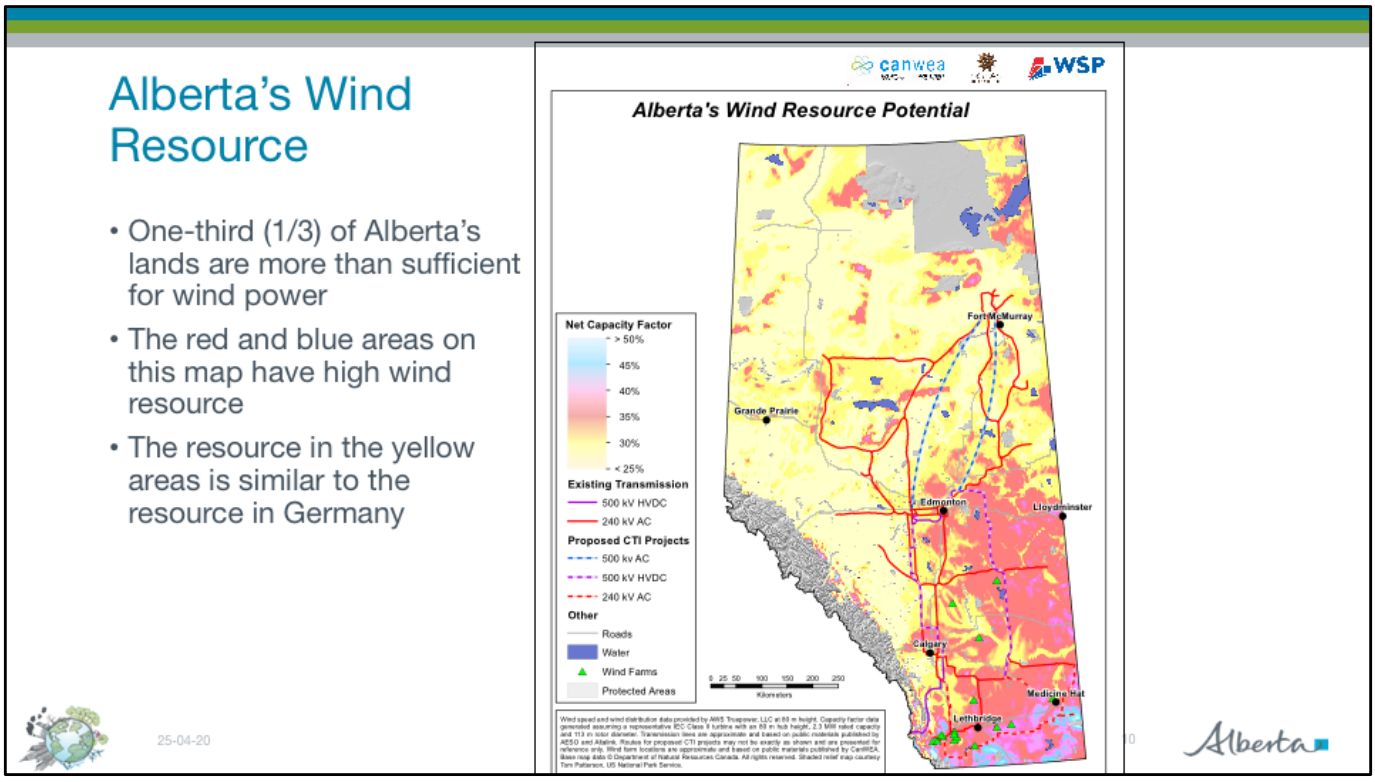
Show the students this video so they gain a basic understanding of what wind is and how it works. Proceed to the following slides when complete.

To watch the videos linked in the presentations, click on the link while in PRESENTATION MODE

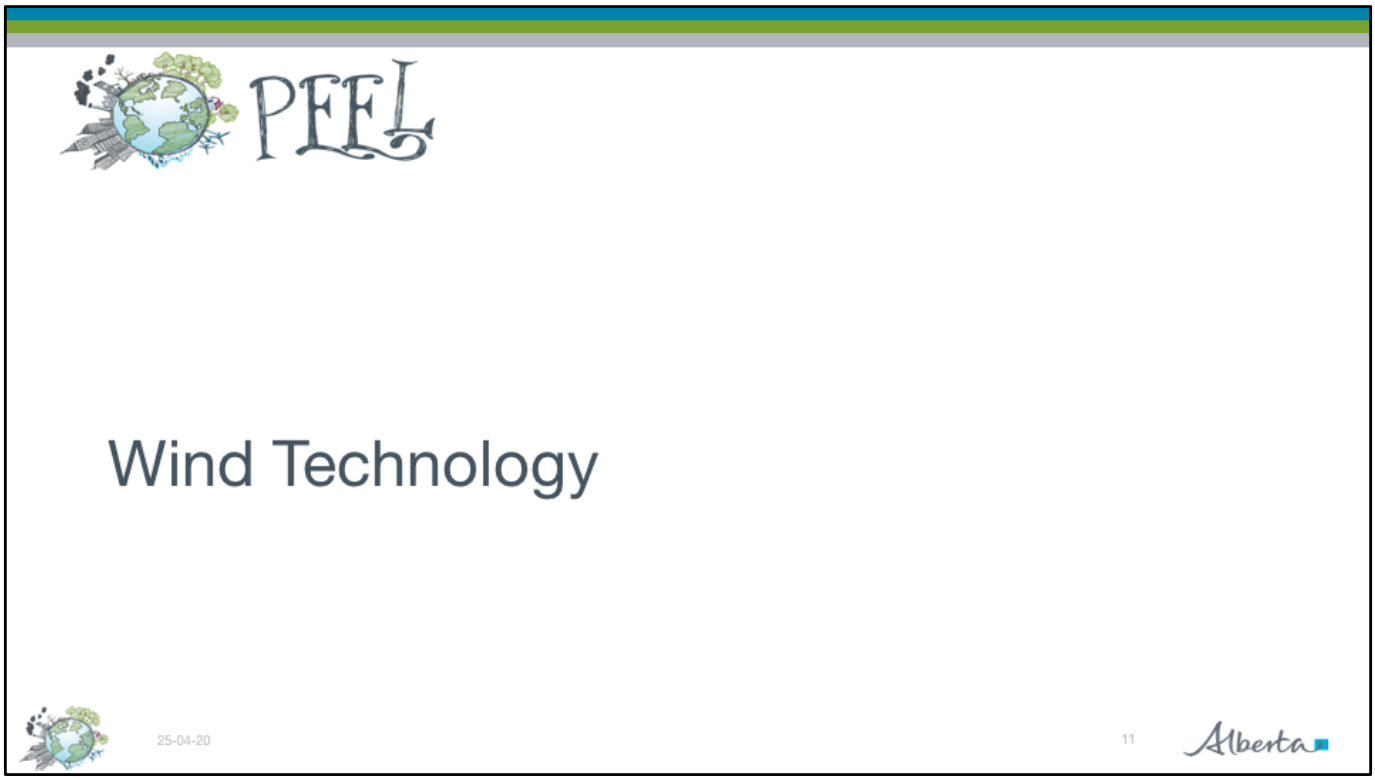



Alberta has lots of wind that can be used to generate electricity. The best wind is located in southern Alberta. One this map, the regions in Alberta with the highest wind speed is marked in blue and red. The rest of Alberta (shown in yellow) has a similar wind resource to Germany! Germany has a lot of wind farms.

In Alberta, most of our wind farms are located in central and southern Alberta. Have you seen any?

As the wind energy continues to grow, we could start to see wind farms in northern Alberta as well!

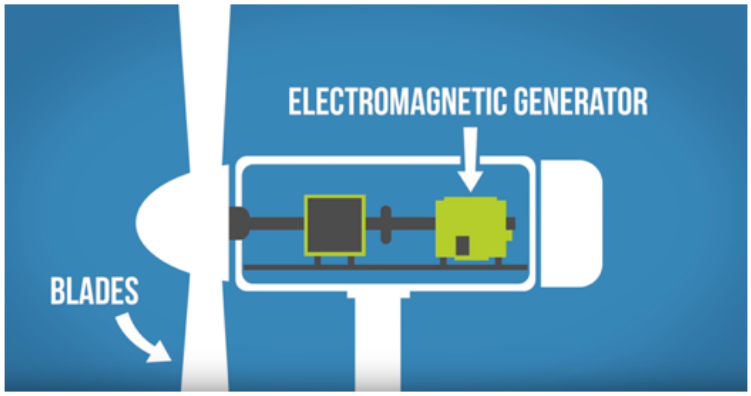
Did you know there is one wind farm in Alberta that has a capacity of 300MW! This wind farm is located north of Lethbridge.




Now we are going to take a close look at some wind technology.

## What is wind energy?

- A wind turbine converts the wind's **kinetic energy** into **mechanical energy**
- A generator then turns this energy into electricity

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Picture from Student Energy - Wind 101 video.

The blades on a wind turbine turn to convert the kinetic energy in with to mechanical energy. The generator, which is found in the nacelle of the turbine, is the component responsible for making electricity.

## Windmills and Wind Turbines

- They may seem the same, but they are very **different**

| WINDMILLS | WIND TURBINES |
| --- | --- |
| • Use the wind's energy to **grind grain** and **pump water**<br>• Has typically multiple blades (4 or more) | • Use the wind's energy to generate **electricity**<br>• Has typically only 3 blades |

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There is a lot of confusion between windmills and wind turbines, and it is a common mistake. Although wind turbines are modeled after windmills, which have been around for centuries, they both service very different purposed. See the comparison above to understand the difference. Wind turbines are also significantly larger in size (as high as 200m!).

For centuries, humans have used the wind to power their activities. Windmills and sailboats have helped us in our lives.

Windmills are used to grind grain and pump water.
Wind turbines produce electricity

# Types of Turbines

## VAWT Turbines

- VAWT = Vertical Axis Wind Turbine

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Does not have to be orientated into the wind<br>• Generator and gearbox located near the ground | • Difficult to erect the towers<br>• Needs external power source to start turning<br>• Turbulent wind near ground creates vibrations, maintenance issues and poor reliability.<br>• Drag created as blades go into wind (50% less efficient than HAWT) |

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HAWT = Horizontal Axis Wind Turbines
The most common turbine you see

There are no VAWT in Alberta. This is not a very common turbine as the production is significantly lower than its alternatives.

## HAWT Turbines

- HAWT = Horizontal Axis Wind Turbine

| ADVANTAGES | DISADVANTAGES |
|---|---|
| • Tall towers to reach higher wind speeds<br>• Variable blade pitch, which gives the turbine blades the optimum angle of attack<br>• High efficiency since blades always move perpendicular to the wind | • Difficult to transport (20% of equipment costs)<br>• Need very tall and expensive crane and skilled operators to install<br>• Massive tower construction is required to support heavy blades, gearbox and generators |

This is now the standard in the industry.


Image courtesy of Verve Energy



HAWT = Horizontal Axis Wind Turbines

The most common turbine you see

# Turbine Components

Tower, nacelle, rotor and blades

## Towers

Lattice

Tubular (Steel)

Tubular (Precast Concrete)



Lattice towers are no longer installed because of issues with birds nesting in the structure. Canada's first wind farm was built with the lattice style tower. This wind farm was called Cowley Ridge, constructed in 1993, and decommissioned in 2016.

There are some towers that have lifts (small elevators) inside to move people up and down.

## Nacelle and Rotor

- **Nacelle**
  - Holds components including gearbox and generator
  - Made of fiberglass and aluminum
- **Rotor**
  - Comprised of hub and blades
  - Hub – made of cast iron and attaches the blades to main shaft
  - Blades – can be up to 55m long

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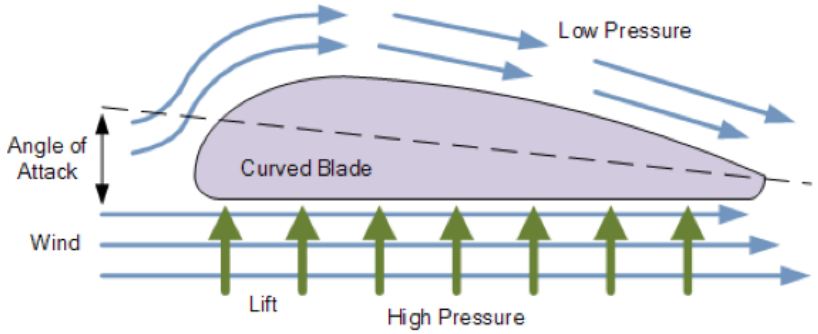
Nacelles are the size of a small bus. Some contain transformers – they hold over 6,000 parts.

The rotor includes the hub and the blades. The blades can be very long. The larger the rotor diameter, the higher the production.

## Blades

- Similar to an airplane wing
- The high and low pressures are on opposite sides of the blade actually push and pull the rotor in a circle






Picture source: http://www.alternative-energy-tutorials.com/energy-articles/wind-turbine-blade-design.html

Blades are a key component of a turbine as they are responsible for making the turbine spin and therefore energy generation.

## Size of a Turbine Blade



This is a picture of a turbine blade that belongs to the Blackspring Ridge Wind Farm in Alberta.

## Types of Wind Power

| | | |
|---|---|---|
| Large | Onshore (utility-scale)<br>> 100 kW<br>Ground  | Offshore<br>>100 kW<br>Water  |
| Small | Distributed wind<br>< 100 kW<br>Ground  | N/A |

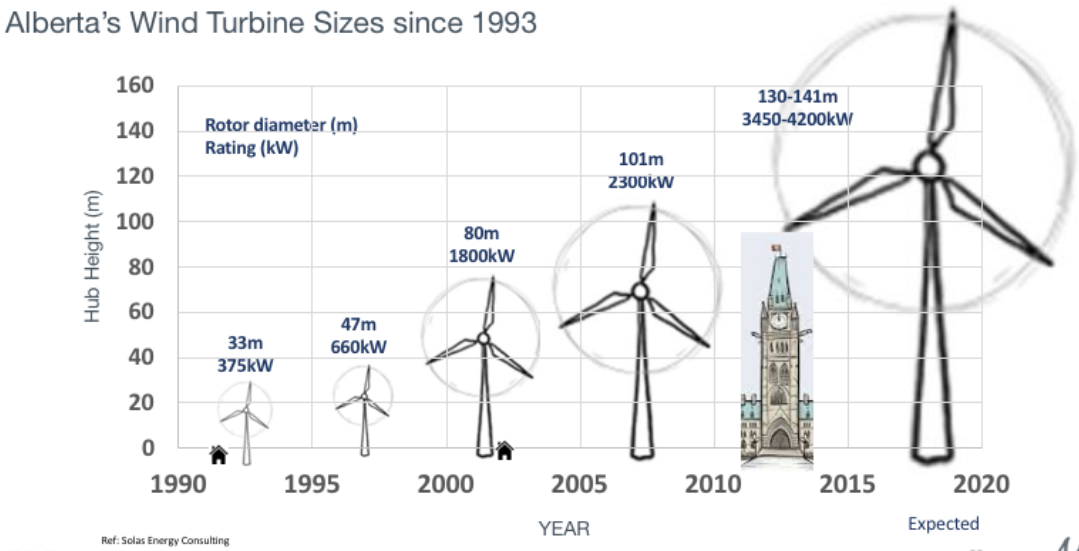


There are three main types of wind power:

1. Utility-scale wind
   - Turbines generate over 100 kilowatts of electricity! These are the large wind farms that supply electricity to our homes. They are located onshore (on the ground).
2. Offshore wind
   - Turbines that are found in large bodies of water (i.e., the ocean). This is very common in European countries!
3. Distributed or “small” wind
   - Turbines that generate under 100 kilowatts of energy. The electricity is directly used to power a home, farm or small business. This is called distributed wind because it can connect directly to the distribution grid, where as large scale connects to the transmission grid.

In Alberta, we have many onshore utility scale wind farms. The largest wind farms currently in operation are Blackspring Ridge, and Halkirk wind farms

## The Evolution of Wind Turbine Sizes




As the picture shows, turbines have increased significantly in height since they first emerged in 1993. As the turbines increase in size, their capacity does as well. This means that more electricity can be generated from fewer turbines.

Technological improvements have allowed turbines to become bigger over time.

- A higher tower means access to higher wind speeds
- A larger rotor means more energy is generated

# Size of a Turbine

# How to Build a Wind Turbine

## Time Lapse of a Wind Turbine Construction

- From the Ground Up: Building our energy future, one turbine at a time – MidAmericanEnergyCo
  - Published April 22, 2015
  - This video is 5 min, 48 seconds
  - All units are in imperial
- https://www.youtube.com/watch?v=84BeVq2Jm88&feature=player_embedded



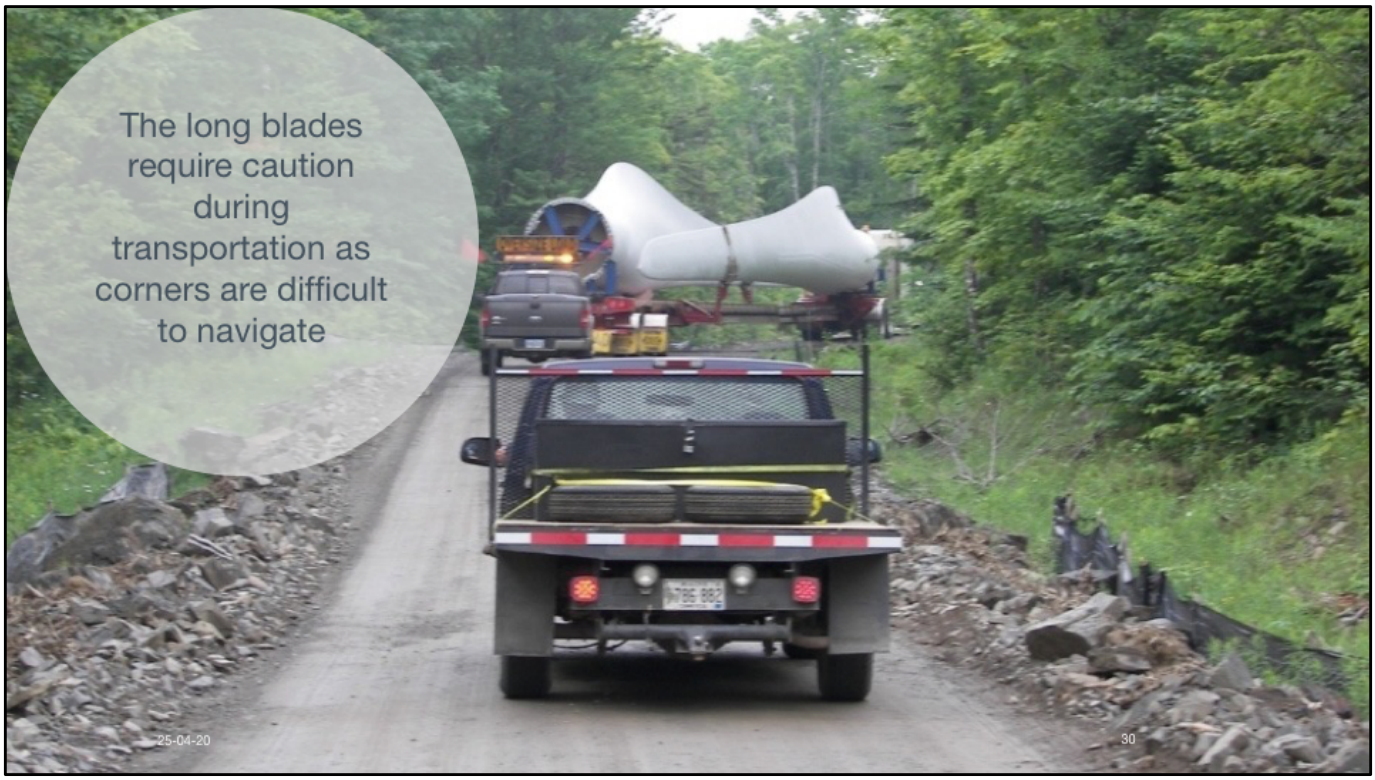
This video is almost 6 minutes long. The video shows a time lapse of a wind turbine being constructed. It also provides information about each step in the installation process.

1. A large hole is dug out for the foundation

2. Foundation is laid


# 3. Blades are transported to the site

A single turbine blade is commonly 40 meters long!


The long blades require caution during transportation as corners are difficult to navigate
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4. Tower sections are transported to the site
This photo shows one tower section being transported
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# 5. Installing the turbine


Vestas


Vestas
Vestas
Vestas


6. Completed Turbine and Wind Farm
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# Important Studies Before Construction

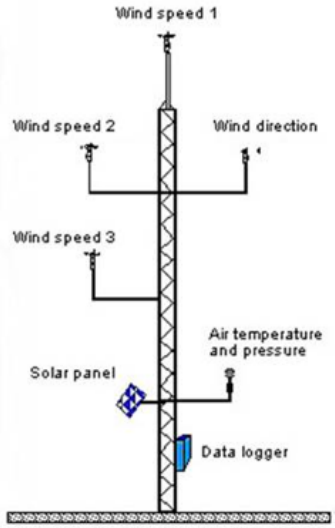
- **Environmental Studies:**
  - Birds and bats
  - Vegetation
  - Wetlands
- **Noise Studies:**
  - How loud will the turbines and substations be at nearby houses
- **Visual and Shadow Flicker Studies:**
  - How will the Wind Power Project look on the landscape
  - Will the rotation of the blades create a strobe like effect and cause irritation to nearby homeowners

# Wind Measurements

Met towers, SODAR, LIDAR

## How is the Wind Resource Determined?

- Meteorological (Met) Towers are used to measure the wind's speed and direction, and air temperature and pressure
- **Anemometers** tell you the wind shear (the force and direction of the wind)
- Met towers are 60 to 100 metres high!






Met towers are used to measure many properties of wind. The wind speed in measured at different heights as the wind speed changes at higher altitudes. Met towers are also equipped with devices to measure the wind direction and the air temperature and pressure. In the picture, a solar panel is present, which is used to power the measurement devices. The data logger collects all the data from the instruments to be analyzed by specialists later on. Met towers are a crucial part of wind power project development. Without sufficient data, the maximum productivity and generation may not be optimal.

## Met Towers Instruments

- Instruments installed on a met tower:

Cup Anemometer

Propeller Anemometer

Measures wind speed

Direction Vane

Measures wind direction

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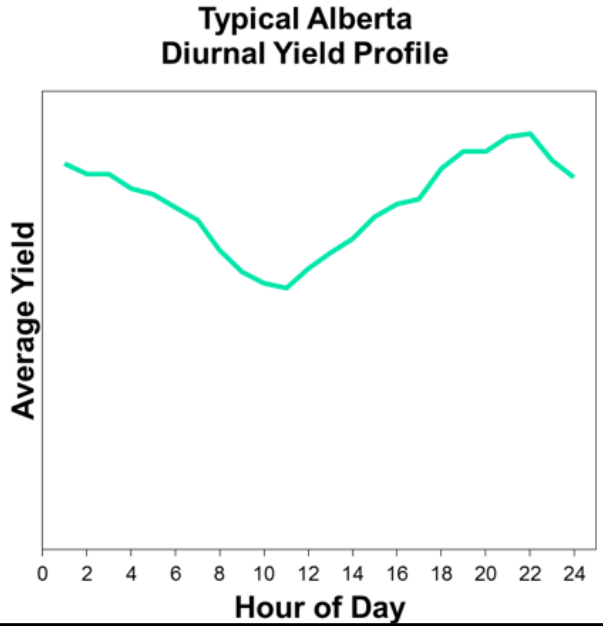
These are some devices that are commonly installed on a met tower to conduct the wind resource studies. The two anemometers are used to measure the wind speeds. These are usually placed at different levels to get an accurate reading of how the wind speed changes with height. This will allow the analysts to determine the optimal turbine height.

A direction vane is used to determine the wind direction. This is important to to measure because it will help determine which direction the turbine should face. For the best generation, turbines should face into the wind.

## Production Profile of Wind






Here is how the electricity production from wind varies throughout the day. Ask the students what they notice about the graph. Hint most of the wind energy production occurs at night!

# ACTIVITY – Wind turbine design challenge

See lesson plan (page 7) for instruction and handout



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# QUIZ!

## Wind is…

A) Moving Clouds
B) Moving Trees
C) Moving Air



Answer: C) Moving Air

## Energy in wind comes from the…

A) Earth
B) Ocean
C) Sun

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Answer: B) Ocean

## A tool that measures the SPEED of the wind is…

A) Anemometer
B) Thermometer
C) Weather Vane



Answer: A) Anemometer

## A tool that measures the DIRECTION of the wind is…

A) Anemometer
B) Weather Vane
C) Thermometer



Answer: B) Weather Vane

## A wind turbine uses energy to make…

A) Electricity
B) Heat
C) Flour



Answer: A) Electricity

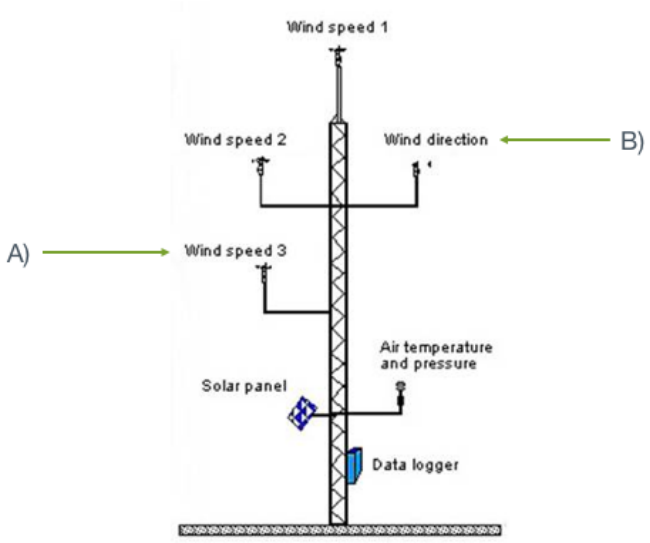
## What part of the wind turbine captures the wind?

A) Tower
B) Nacelle
C) Blades



Answer: C) Blades

## Name the instruments at the indicated locations

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A) Anemometer

Can a student name the two types? Cup and propeller

B) Weather Vane

## Recap!

- Wind turbines are complex systems
- Wind turbines are effective for electricity production
- Wind turbines require studies and consultation prior to development
- There are many careers associated to the development and operation of a wind farm
- Alberta has strong wind potential and many opportunities for expansion

## GreenLearning.ca Additional Resources

- Re-Energy: http://www.greenlearning.ca/programs/re-energy/

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If you would like to learn more about this topic, visit the links above.

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# THANK YOU!

PEEL is supported by the Community Environment Action Program. This project is offered in partnership with GreenLearning Canada Foundation, provider of free online education programs about energy, climate change and green economy.

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# EXTENSIONS

## Build Your Own Wind Turbine

- Read the background information in the handout provided.
- **Task:** Design and create a wind turbine that can lift a weight up 30 centimetres high.
- You must research, plan, create, test, reflect/improve.
- Make sure you meet the criteria listed on the handout




Teachers: show this video by TeacherGeek (7 min, 42 sec) to help them with ideas on how to build their turbine and what their turbine should do.

# Research Questions

- How do windmills and wind turbines work?
- What parts will I need to have in my design? (Base, tower, blades, shaft, etc.)
- What is the best angle (pitch) to have my blades at?
- How will I convert wind energy (kinetic energy) into mechanical energy?
- What simple machines could I use to help with my design? (Pulleys, gears, wheel and axle, lever)