Wind Energy

An exploration of wind energy and wind turbines

By Mike Kelly

Learning Goals: Below are the learning targets for the wind energy unit.

1. I can explain how wind is produced and what makes for a good wind energy site.
2. I can explain why electricity generated from wind is a "good" source of energy.
3. I can identify the major components of a wind turbine.
4. I can list several of the design factors that produce efficient wind turbines
5. I can describe at least one occupation associated with wind turbines and know what education is required for this position.
6. I use sound experimental design practices while performing my investigation.

Assessment Plan:

Name of Assessment	Type of Assessment	Learning Objective	Format of Assessment
Pre-Assessment (see attached "Wind Survey")	Formative	Includes all learning objective for the wind unit	Paper/Pencil test with multiple choice, true/false and short response
Daily exit ticket	Formative	Based on daily sub learning target that support a main learning targets as listed	Clicker based daily assessment to insure students are acquiring the small concepts that support the larger idea
Lab reports (see attached "Wind Generator & Blade Experiment Sheet")	Formative	Labs are focused on experimental designs and factors the effect wind turbine design	Guided open response. Reinforces the concepts of good experimental design by routine practice in a

			guided fashion
Turbine Blade competition	Formative	focused on experimental designs and factors the effect wind turbine design	
Post Assessment (see attached "Wind Survey Final")	Summative	Includes all learning targets for the wind unit	Open response which will give student to explain their overall knowledge on this content

These learning targets and assessments support teaching the following science content standards while integrating literacy into this content area.

Content Standards: As the Colorado Content Standards are currently under revision and lack details; the unit content was mapped to the National Science Education Content Standards. Revision to Colorado State standards will be made when they are finalized. **Bolded standards are emphasized in this unit.**

Secondary Content Standard A: SCIENCE AS INQUIRY

1. **Abilities Necessary to do Scientific Inquiry**
    a. **Identify question and concepts that guide scientific investigation.**
    b. **Design and conduct scientific investigations.**
    c. **Use technology and mathematics to improve investigations and communications.**
    d. **Formulate and revise scientific explanations and models using logic and evidence.**
    e. **Recognize and analyze alternative explanations and models.**
    f. **Communicate and defend a scientific argument**

Secondary Content Standard B: PHYSICAL SCIENCE

1. **Structure of Atoms**
    a. Matter is made of minute particles called atoms, which are composed of even smaller components. These components have measurable properties, such as mass and electrical charge.

b. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electrical force between the nucleus and the electrons hold the atoms together.
c. The Atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that fifer in the number of neutrons, these atoms are called isotopes of an element.

4. Motions and Forces
    c. The electrical force is a universal force that exists between two charge objects.

Secondary Content Standard D: EARTH AND SPACE SCIENCE

1. Energy in Earth System
- **a. Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from the earth's original formation.**
- **c. Heating of earth's surface and atmosphere by the sun drive convection within the atmospheres and oceans, producing winds and ocean currents.**
- **d. Global climate is determined by energy transfer from the sun at and near the earth's surface.**

Secondary Content Standard E: SCIENCE AND TECHNOLOGY

1. Abilities of Technological Design
- **a. Identify a problem or design an opportunity.**
- **b. Propose designs and choose between alternative solutions.**
- **c. Implement a proposed solution**
- **d. Evaluate the solution and its consequence**
- **e. Communicate the problem, process, and solution**

Secondary Content Standard F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

3. Natural Resources
- **a. Human populations use resources in the environment to maintain and improve their existence.**
- **b. The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and depletes those resources that cannot be renewed.**

5. Natural and Human-Induced Hazards
- **d. Natural and Human-Induced Hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by**

humans bring benefits to society, as well as cause risk. Students should understand the costs and trade-offs of various hazards – ranging from those with minor risk to a few people to major catastrophes with major risk to many people.

6. **Science and Technology in Local, National and Global Challenges**
    a. Science and technology can indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge
    b. Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology related challenges. However, understanding science alone will not resolve local, national and global challenges.
    c. Individuals and society must decide on proposals involving new research and the introduction of new technologies into society.

Implementation Design:

Below is my daily plan to cover this content.

Wind Turbine Unit Plan

Lesson Plan Overview: The lesson has student go through the design process and scientific method to test important design aspect of wind turbines and wind turbine blades.

Day 1:

- Have students take the Wind Survey as a pre-test.
- Power Point/video presentation makes connections between wind energy to other energies, generators, weather and wind.
- Building an electrical generator (teacher demonstration). Instruction for building this is included on following pages.
- Generators/Motor demonstration with Genecon (teacher demonstration).
- Time permitting- Gas Convection Apparatus and Touch Paper demonstrates the formation of convection currents in air. WWW.sargentWelch.com item # CP77560-00 ($41.10) & item #WL1728 ($10.80)
- Students will read the 1st half (through electricity section) of the Student Guide on wind energy for homework.

Day 2:

- Class Discussion on homework reading.
- Demonstrate the Kid wind Turbine with the fan and multimeter
    - Explain the components of the turbine and how to use the multimeter using the transparency.
- Have several students explore the turbine output at various distances from the fan and at different fan speeds, as measured by the multimeter.
- Brainstorm on factors/variables that effect wind turbine design.
- Explain the goals of the following lab experiments. Review what practices make for good experimental design and the need to control variables.
- Student will read the remainder of the Student Guide.

Day 3:

- Class will be broken into 8 groups. Two groups will explore one of the following set of variables. Variable groups are 1) number of blades and length of blades; 2) Mass of blade and mass distribution; 3) blade pitch and generator type; 4) gear ratios. Student will use the Wind Turbine Experiment Sheet to record their work.
- Review of safety, reminder about the importance of having the ability to share out meaningful results, and reminder of not wasting material.
- Each group will write up the experimental design prior to conducting any experiment. Teacher authorization is required prior to experimentation.

Day 4:

- Group presentation of results. Each group will have five minutes to explain their test and their results.

Day 5:

- Slideshow of possible blade design ideas
- Groups will now attempt to create an optimal wind generator based on the results of their peers and each group's ideas for optimal blade design. Each design team will document their wind turbine design on the Wind Turbine Competition Form.
- Results of all groups will be collected on the Class Data Sheet.
- Power in the Wind calculation and efficiency calculation assigned as homework.

Day 6: Visit to Ponnequin Wind Farm and Vestas wind turbine blade manufacturing facility in Windsor

Day 7:

- Examination of Air-X wind turbine (teacher lead).
- Last chance revision to make the ultimate wind generator.
- After School project: setting up Air-X turbine system for powering class room laptop PCs.

Day 8:

- Post assessment.
- Wind Expo: groups will display/explain their turbine design to class visitors. (Other classes, other schools, Qwest, administration.)
- Awards

Analysis of Learning Results:

TBD as lessons/assessments are rolled out.

Wind Survey (Pre-Assessment)

Name:_____

1. What causes wind?
   a) Solar flares b) global warming c) solar radiation d)ocean currents

2. What would make an ideal site for a wind farm?
   a) Mountain top b) sea coast c) narrow valley d)all the above

3. What are some of the design consideration for making an efficient wind turbine?

4. What kinds of jobs are associated with the wind energy?

5. Name some key elements for designing/conducting experimentation?

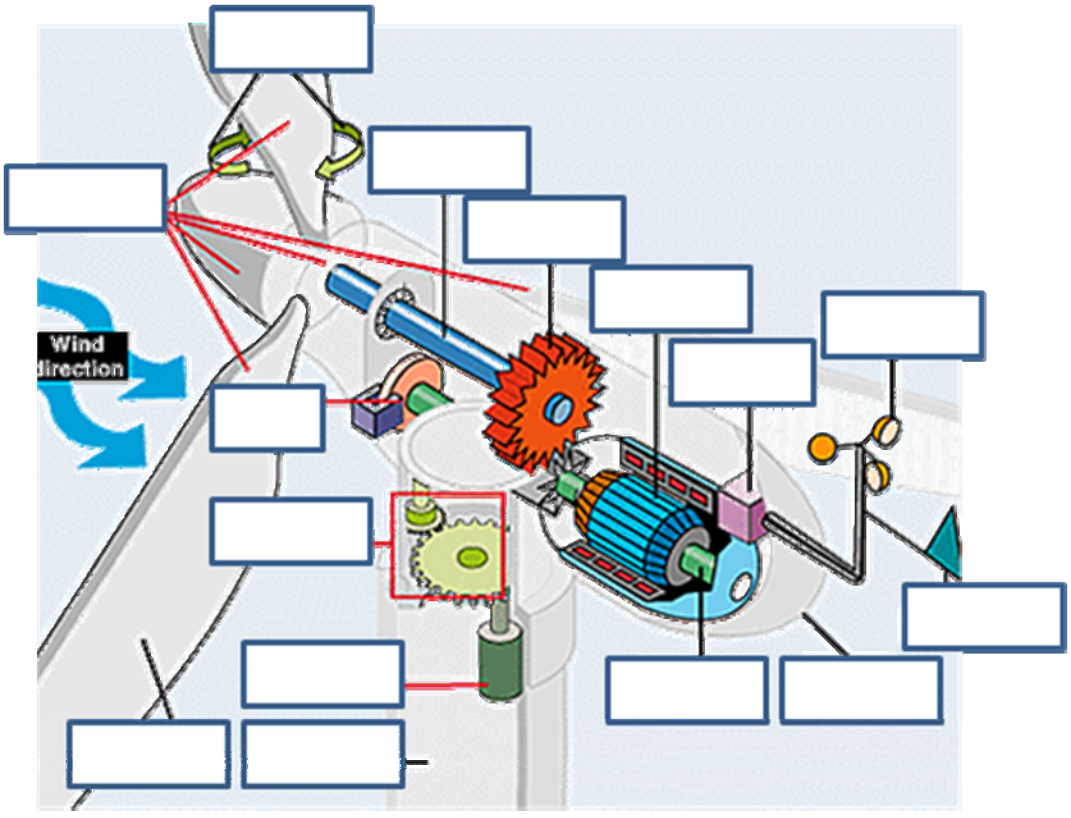
6. Currently, wind energy produces how much of the total electricity generated in the U.S. today
   a) 1% b) 5% c) 10% d) 25%

7. One reason for not using wind turbines is that it kills too many birds.
   a) true b) false

8. Wind turbine technology is fairly new and consequently too expensive to be a cost effective energy solution.
   a) true b) false

9. The U.S. does not have sufficient wind for wind generation as compared to other countries who generate considerable amount of electricity from wind.
   a) True b) false

10. Identify the following components of a wind turbine



Rotor	Brake	Blades	Controller
Pitch	Yaw drive	Gear Box	Wind vane
Low-speed shaft	Yaw motor	Generator	Nacelle
High-speed shaft	Tower	Anemometer	

Wind Generator & Blade Experiment Sheet

Name _____

What variable(s) will you test for your experiment? _____

Describe how you perform this experiment. BE SPECIFIC! What materials will you use, how many times will you test, how will you change your variable, how will you record output.

Important!! What things do you have to keep the same (constant) as you perform this experiment?

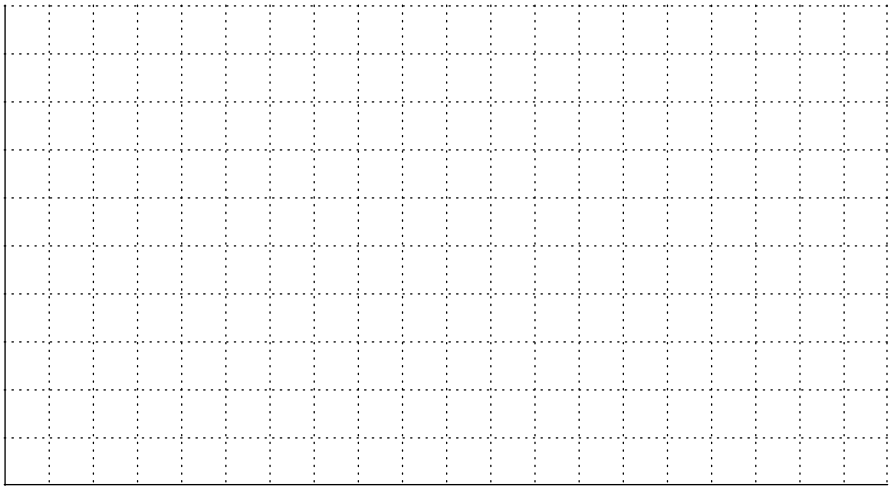
Make a prediction! What do you think will happen as you change your variable?

Teacher Authorization to Begin Experimentation _____

Data Tally Sheet

Trial #	Variable	Voltage (volts)	Current (amps)	Power (watts)

Graph of Your Data:



Experimental Reflections

1. How did the voltage/amperage/wattage change as a result of manipulating your variable?

2. Do you think that your variable has a large or small effect on power production?

3. What was the optimal setting for the variable that you tested?

4. If you were a lead design engineer what would you recommend your company do to their turbine or turbine blades? Why?

5. What problems did you encounter as you performed your experiments? What other variables was hard to hold constant?

Final Wind Survey

Name:_____

1. Explain how wind is produced.

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2. Describe an ideal site for a wind farm.

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3. What are some of the design consideration for making an efficient wind turbine?

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4. Describe what kinds of jobs are associated with the wind energy.

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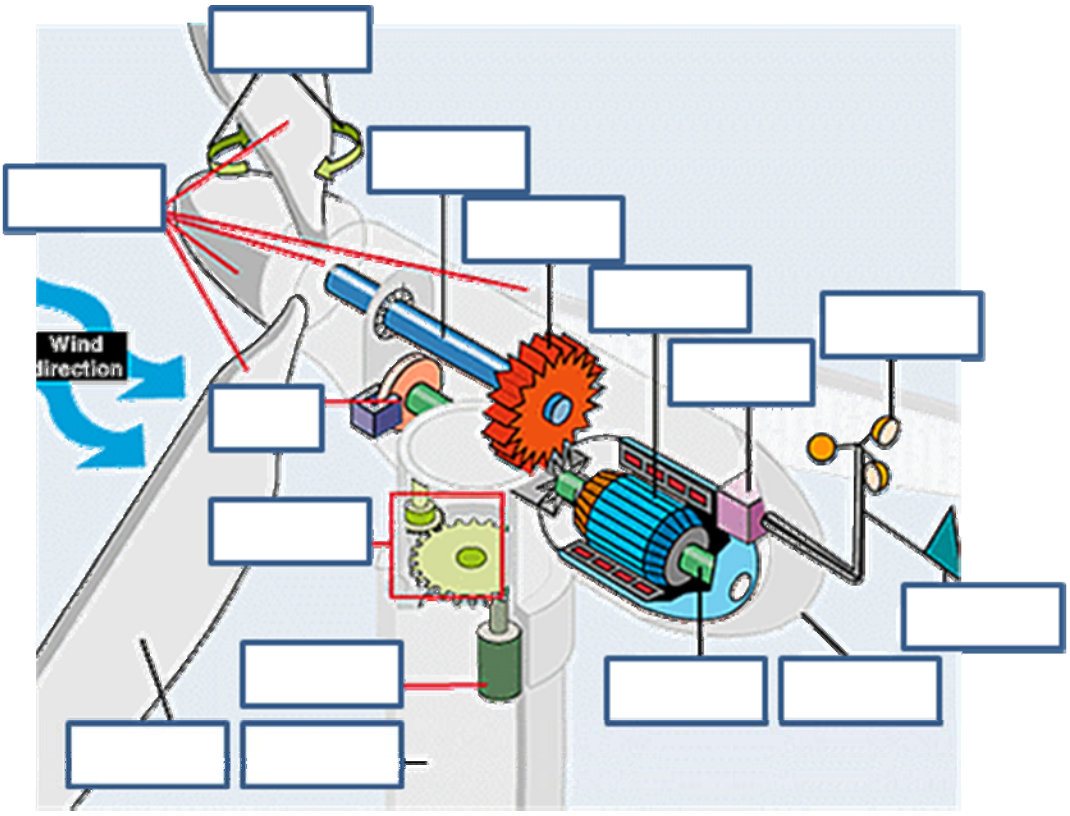
5. Name some key elements for designing/conducting experimentation.

6. Explain why electricity generated from wind is a “good” source of energy for the U.S.

7. Identify the following components of a wind turbine.



Rotor	Brake	Blades	Controller
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