Renewable Energy Projects
for the Classroom

Illinois Valley Community College
Oglesby, IL 61348
www.ivcc.edu/wind
www.ivcc.edu/nsf

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Renewable Energy Projects for the Classroom

By

Jim Gibson, Sue Isermann, Jamie Gahm and Rose Marie Lynch

Illinois Valley Community College
815 North Orlando Smith Road
Oglesby, IL 61348
815-224-2720
www.ivcc.edu/wind
www.ivcc.edu/nsf

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To Anyone Considering a Renewable Energy Project:

This handbook is designed to provide instructions and resources to enable teachers, including those without a technical background, to guide students in renewable energy projects. The projects or modules in this handbook were developed by middle school through community college teachers enrolled in a course entitled Introduction to Renewable Energy Topics for Teachers. Organized through Illinois Valley Community College’s Continuing Education Division and taught by IVCC’s Program Coordinator of Electronics in summer 2013, the course offered two semester hours of graduate-level credit through Quincy University.

We encourage you to give your students first-hand experience with a renewable energy project that you can utilize to introduce or reinforce an unlimited number of concepts, at varying levels of expertise, in a number of subject areas.

Jim Gibson
Jamie Gahm
Sue Isermann
Rose Marie Lynch

Acknowledgements

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NSF Grant Principal Investigator: Jim Gibson, Program Coordinator of Electronics  
jim_gibson@ivcc.edu

NSF Grant Co-PIs:  
Sue Isermann, Associate Vice President for Academic Affairs  
sue_isermann@ivcc.edu  
Jamie Gahm, Director of Continuing Education and Business Services  
jamie_gahm@ivcc.edu  
Rose Marie Lynch, Communications Instructor  
rosemarie_lynch@ivcc.edu

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While the activities in this handbook were developed with specific student groups in mind, many of these activities are adaptable to varying ages of students.
Jim Gibson, Program Coordinator of Illinois Valley Community College’s Electronics Program, demonstrates renewable energy trainers to teachers enrolled in Introduction to Renewable Energy Topics for Teachers, the course in which the activities in this handbook were developed.

FOR MEDIA COVERAGE OF THE COURSE:

“Teachers learn about renewable energy: Going ‘off the grid’”
By Amy Flanery
News Tribune, LaSalle, IL
July 12, 2013
newstrib.com/main.asp?SectionID=2&SubSectionID=126&ArticleID=30117
Introduction to Renewable Energy

Developed for Middle School Level

By Donna Gerrard

Background: This lesson plan will be used to enhance the sixth grade science chapter on the major energy sources and energy efficiency and conservation.

The objective is to provide a hands-on lesson to increase the students’ awareness to energy efficiency. Solar energy will be discussed in this lesson but the other alternative energies will be discussed as well.

LESSON PLAN: ENERGY FROM THE SUN

Time: three-class period of 45 minutes each.

Objective:

- The student will be able to recognize the importance of alternate energy sources.

Activity 1: Introduction

The students will be asked to do the “What a Day!” activity (below), and then share and discuss their decisions.
What a Day

You wake up one morning and find all your sources of energy are gone. There is no TV, sour milk in the refrigerator, no lights. What will you do? Devise a survival plan for you and your family.

Materials:
- Science journals
- Student guides (background information from manual)
- Computer lab
- DMM
- Solar panel
- Red and black clip lead
- Red and black jumper
- Motor
- Sunshine

Activity 2: Research

Procedure: In the science journal the student will write what he thinks he knows, what he wants to know, and after doing some research in the computer lab, what he learned.

Suggested websites for videos:
- www.nationalgeographic.com/video/environment/energy
- www.neok12.com/solar-energy
- www.science.howstuffworks.com
- www.teachertube.com/viewvideo

Suggested websites:
- www.energy.gov/kids
- www.eia.doe.gov/kids
- www.energystar.gov/kids
- www.nrel.gov
- www.eere.energy.gov
- www.energy.sandia.gov
- www.nasa.gov
- www.southwestpv.com
Activity 3: How a solar thermal energy source works. (Ch 7-1)
For these activities the teacher will utilize GREENtech Energy Efficiency & Renewable Energy Training Lab. The students will be arranged into groups and given a student guide to do the given experiments.

Objective: The student will learn to measure the DC voltage output of a solar panel.

Activity 4: Power a motor with a solar cell. (Ch 7-2)

Objective: The student will connect a solar panel to power a motor.

Activity 5: Observe effect of tilt on a solar panel. (7-5)

Objectives:
- The student will demonstrate how a solar panel reacts to direct and indirect rays from the sun in order to produce electricity.
- The student will understand why solar panels must be oriented at the proper angle to the light source for maximum electrical output.
ASSESSMENT

Activity 6: Solar Oven

Objective:
The student will construct a solar oven using a variety of materials. The student should be able to understand the transformation of radiant energy to thermal energy to have a working oven.

Activity 7: Use solar energy to produce electricity assessment.

Objective:
The student will use the vocabulary words to explain how electricity is produced by photovoltaic systems and concentrated solar power systems.

Dish/engine systems
Electricity
Electrons
Parabolic troughs
PV system
Radiant energy
Residential
Solar Cell
Solar power towers
Thermal energy
Utility scale

TEACHER RESOURCES:
- www.NEED.org
- GREENtech Energy Efficiency & Renewable Energy Training Lab by Graymark
Solar Energy Unit

Developed for Middle School Level

By Teresa Sigler

Overview: 4 – 5 days

- Introduction to solar energy
- How solar panels work
- The four different types of solar panels
- Using a Digital Multimeter
- Measuring DC voltage with the DMM
- Building a solar oven

Day 1

Objective: Students will be able to understand how solar panels work.

Introduction:

Have you ever seen solar panels on a house or business?
How do you think they work?
Discussion – assess for prior knowledge.

Instructions:

- Vocabulary sheet with definitions
- Diagram of solar panel – students will label with assistance.
- Video on Promethean Board showing how a solar panel is constructed and how they work.

Evaluation: Teacher will monitor that students are labeling their solar panel diagram.
Check for understanding after the video through discussion.
Day 2

Objective: Students will be measuring and comparing the DC voltage output from the solar panel with different lighting situations.

Introduction: We will be measuring the voltage that the solar panel will be producing. This activity was obtained, but modified, through GREENtech Energy Efficiency & Renewable Energy Training Lab Book by Graymark.

Materials needed: everything will be located in tubs labeled for each lab station.
   3 volt solar cell
   Digital multimeter
   Red Jumper
   Black Jumper
   Black clip lead
   Red clip lead
   Clamp on light
   40, 60 &100 watt light bulb
   Ruler

Instructions
1. Get out the Digital Multimeter (DMM). Set the dial to 20Volt DC range turning it to the right side of the meter.
3. Connect one end of the Black clip lead to the other end of the black jumper.
4. Connect the other end of the Black clip lead to the Black DMM Lead.
6. Connect one end of the Red clip lead to the other end of the Red Jumper.

Procedure
1. Get out the chart that you will be recording voltage on. The reading should be between 0.5 volts and 3.0 volts. The exact reading will depend on the amount of light reaching the Solar Panel.
2. Classroom lights will be off. Read and record on your chart, the voltage on the display screen.
3. One set of classroom lights will be turned on. Read and record on your chart, the voltage on the display screen.
4. Both sets of classroom lights will be turned on. Read and record on your chart, the voltage on the display screen.
5. Place a 40 watt light bulb in your clamp on light. Plug in the light. Hold the light an arms length away from the solar panel. Read and record on your chart, the voltage on the display screen.
6. Using your ruler, hold the light 12 inches away from solar panel. Read and record.
7. Using your ruler, hold the light 6 inches away from solar panel. Read and record.
8. Turn off light and let it cool.
9. Replace 40 watt light bulb with a 60 watt bulb and repeat steps 5, 6, 7 & 8.
10. Replace 60 watt light bulb with a 100 watt bulb and repeat steps 5, 6, 7 & 8.
11. After turning off the clamp on light, students will discuss with their group their finding and record what they have concluded from this activity on their chart.

Evaluation
1. Students will remain on task and will cooperate with their group members.
2. Students will record their readings and then draw a conclusion after the activity.
3. The teacher will circulate throughout the room and assess for understanding of directions and what they have concluded based on their recordings.

**Chart for Recording**

**Day 2**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Voltage</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lights off in classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Half of the lights on in classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All lights on in the classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armes length</td>
<td>12 inches above</td>
<td>6 inches above</td>
</tr>
<tr>
<td>Voltage</td>
<td>Voltage</td>
<td>Voltage</td>
</tr>
<tr>
<td>40 watt bulb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 watt bulb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 watt bulb</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion**
## Chart for Recording
### Day 3

<table>
<thead>
<tr>
<th>Description</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar panel on West side of building facing West</td>
<td></td>
</tr>
<tr>
<td>Solar panel on South side of building facing South</td>
<td></td>
</tr>
<tr>
<td>Solar panel on East side of building facing East</td>
<td></td>
</tr>
<tr>
<td>Solar panel on North side of building facing North</td>
<td></td>
</tr>
<tr>
<td>Solar panel directly facing the sun</td>
<td></td>
</tr>
<tr>
<td>Voltage measured after 30 seconds</td>
<td></td>
</tr>
<tr>
<td>Solar panel directly facing the sun with piece of paper covering half of solar panel</td>
<td></td>
</tr>
<tr>
<td>Solar panel directly facing the sun with piece of paper covering whole solar panel</td>
<td></td>
</tr>
</tbody>
</table>

## Conclusion
Day 3

Objective: Students will use their solar panel and Digital Multimeter outside to gather readings using sunlight on each side of the building. They will then conclude whether sunlight creates more voltage than lamp light.

Introduction: We will discuss whether the students think the sunlight will generate more voltage than the lamp light.

Materials needed will be located in the tub labeled for each lab station.
- 3 volt solar cell
- Digital Multimeter
- Red Jumper
- Black Jumper
- Black clip lead
- Red clip lead
- Piece of paper

Instructions
1. Get out the Digital Multimeter (DMM). Set the dial to 20 volt DC range turning it to the right side of the meter.
3. Connect one end of the Black clip lead to the other end of the black jumper.
4. Connect the other end of the black clip lead to the Black DMM Lead.
6. Connect one end of the Red clip lead to the other end of the Red Jumper.

Procedure
1. Get out the chart for Day 3 that you will be recording voltage.
2. We will exit the building to the West. Our first reading will be on the West side of the building. Your team will set the solar panel and DMM on the grass at the top of the hill, facing West and get your reading. Please handle the solar panel and DMM carefully. Get your reading and record on your chart.
3. We will then move to the South side of the building. We will place the solar panel and DMM on the grass behind the sidewalk facing South. Get your reading and record on your chart.
4. We will then move to the East side of the building and place the solar panel and DMM on the grass facing East. Get your reading and record.
5. We will then move to the North side of the building and place the solar panel and DMM on the grass facing North. Get your reading and record.
6. We will now locate and position our panel directly facing the sun. Get your reading and record.
7. Leaving your solar panel and DMM where they are we are now going to place a sheet of paper to cover half of the solar panel. We will leave it covered for 30 seconds. Get your reading and record.
8. Leaving your solar panel and DMM where they are we are now going to place a
sheet of paper to cover the whole solar panel. We will leave it covered for 30
seconds. Get your reading and record.

Evaluation
1. Students will remain on task and cooperate with their group members.
2. Students will record their readings and then draw a conclusion after the activity.
3. Students will handle their equipment with care throughout our activity.
4. The teacher will circulate throughout the groups and assess for understanding of
Directions and what they have concluded based on their recordings.

Day 4/5

Objective: The students will construct a solar oven.

Introduction:

Students will work in their lab groups to construct a pizza oven. Activity was
obtained through the U.S. Department of Energy-Energy Efficiency and
www1.eere.energy.gov/kids/roofus/printable_version/pizza_box.html

Materials needed:
Everything will be located in tubs labeled for each lab station.
One large pizza box
Newspapers
Tape
Scissors
Black construction paper
Clear plastic wrap
Aluminum foil
A piece of notebook paper
A pencil or pen
A ruler

Instructions
1. Start with pizza box folded into its box shape and closed.
2. Place the piece of notebook paper in the center of the lid of the box and trace
its outline on the lid. Set piece of paper aside.
3. Cut two the two long edges and the short edge closest to the front of the box.
of the rectangle that you just traced on the lid of the box. This should form a
flap in the lid.
4. Gently fold the flap back along the uncut edge to form a crease.
5. Wrap the underside (inside) face of this flap with aluminum foil. Tape it on the outside so that the foil is held firmly. Try to keep the tape from showing on the foil side of the flap. The foil will help to reflect the sunlight into the box.
6. Open the box and place a piece of black construction paper in so it fits the bottom of the box. This will help to absorb the sun’s heat.
7. Close the box, roll up some newspaper, and fit it around the inside edges of the box. This is the insulation that helps hold in the sun’s heat. It should be about 1 to 1 ½ inches thick. Use tape to hold the newspaper in place, but only tape it to the bottom of the box.
8. Cut two pieces of plastic wrap an inch larger than the flap opening on the box top. Open the box again and tape one piece of plastic wrap to the underside of the flap opening. After taping one side, BE SURE TO PULL THE PLASTIC WRAP TIGHT, and tape down all four sides so the plastic is sealed against the cardboard. Then close the box and tape the other piece of plastic wrap to the top of the open flap. Again, be sure the plastic wrap is tight and tape down all four edges to form a seal. This creates a layer of air as insulation that helps keep the sun’s heat in the box.
9. We’re ready to try it out! We’ll take chocolate chip cookies outside to place in the box to warm up. Open the box, put the treat in the center and close the box. Now open the flap and turn the box so the foil is facing the sun. The shadow of the flap should go straight back on to the back of the box. Move the flap up and down and note how it reflects the sunlight. Use your ruler to prop up the flap so that it bounces the sunlight into the box.
10. Wait about a half hour for the box to warm up in the sun. Then enjoy your warmed up treat!
11. It won’t get really hot, so you can’t bake things in it. We can only warm things up.

Evaluation
1. Students will cooperate with peers within their lab group.
2. Students will follow all directions and use tools safely.
3. Teacher will evaluate progress and that all directions are being followed, by circulating around the room during activity.
4. Design should be evaluated to see if students can make any improvements.

Solar Energy Vocabulary
1. Flat plate collector—most common solar collector for solar water-heating systems in homes and solar space heating. A flat-plate collector is an insulated metal box with a glass or plastic cover (called glazing) and a dark-colored absorber plate.
2. **Liquid flat plate collector** – Heats liquid as it flows through tubes in or adjacent to the absorber plate. This is the simplest liquid system using household water, which is heated as it passes directly through the collector and then flows to the house.

3. **Air flat place collector** - These are used basically for solar space heating. The absorber plates can be metal sheets, layers of screen, or non-metallic materials. The air flows past the absorber by using natural convection or a fan. Air is not a good conductor for heat, so less heat is transferred from an air collector’s absorber than a liquid collector’s absorber. This is less efficient than liquid collectors.

4. **Evacuated tube collector** - These can achieve extremely high temperatures (170 degrees F to 350 degrees F). These are more appropriate for commercial and industrial use. More expensive than flap plate collectors.

5. **Alternative energy** – A “non-conventional” energy system that includes solar electric systems, wind generator systems, and small hydro-electric systems.

6. **DC** – Direct Current

7. **AC** – Alternating Current

8. **Photon** – A particle of light that acts as an individual unit of energy.

9. **Renewable energy** – Energy from sources that are not easily depleted such as moving water (hydro), biomass, geothermal energy, solar energy, and wind energy.

10. **Solar Energy** – Electromagnetic energy transmitted from the sun (solar radiation). The amount that reaches the earth is equal to one billionth of total solar energy generated, or the equivalent of about 420 trillion kilowatt hours.

11. **Volt** – A unit of electrical measurement. One volt will cause a current of one ampere (amp) to flow through a resistance of one ohm.
Wind Turbines as an Alternative Energy Source: Lesson One

Developed for Middle School Level

By Darcy Welsh

SKILL OBJECTIVES

After completion of this lesson you will have the skills to:

- Present your opinion on wind technology both verbally and written.

INTRODUCTION

In this lesson you will research wind turbines, test different blades and pitch of wind turbine making comparisons of the output, formulate an opinion on using wind turbines as an alternative energy source, and present your findings and opinion to a group in a debate format.

ITEMS NEEDED

You will need the following items:

- See individual lessons for items needed in each exercise.
- Use the following website to build wind turbines for exercises in this lesson. http://wind.jmu.edu/education/activities/wind_basicpvcwindturbine.pdf

DMM SETUP

See individual exercises.

CIRCUIT SETUP

See individual exercises.

PROCEDURE

1. Complete exercises 1.1 through 1.4.
2. Split the class into 7 groups: farmers for wind farms, farmers against the wind farms, town people for the wind farms, town people against the wind farms, business and industry representatives, the wind farm company representatives, the politicians of that district.
3. Each group will prepare a general statement on their opinion of a wind farm being placed in their township. Strong support is needed for any statements with sources cited. General statements will be read at the start of the debate. They should be 2-3 min in length.
4. Groups will be given two days to research in depth and formulate their point of view.
5. The third day will culminate the activity with a debate and vote. One person will be selected to present for their group. This person can be chosen at random or decided upon ahead of time.

6. The debate starts with each group stating their opening remarks.

7. Once everyone has made their statements, the moderator (teacher) will then recognize speakers who wish to challenge their opponents.

8. Rebuttal time will be limited to 2-3 min.

9. Allow the last ten minutes for a "vote" on the decision with a written paragraph stating how and why the student has selected the opinion.

CONCLUSION  Formulate a conclusion from this exercise.
Review Wind Energy: Exercise 1.1

SKILL OBJECTIVES

After completion of this lesson you will have the skills to:

- Research wind energy.

INTRODUCTION

In this lesson you will research wind power from the information on the approved websites.

ITEMS NEEDED

You will need the following items:

- computer
- Internet access

DMM SETUP

None

CIRCUIT SETUP

None

PROCEDURE

1. With computer on and connected to the Internet, use the browser to navigate to http://www.nrel.gov/wind/
2. Click on the Wind Basics under Resources.
4. Use the browser to navigate to http://www1.eere.energy.gov/wind/wind_basics.html
5. Click on the Energy Basics tab on the left.
7. Use the browser to navigate to www.need.org/needpdf/Energy From The Wind Student Guide.pdf
9. Use the browser to navigate to www.nrel.gov/gis/pdfs/eere_wind/eere_illinois.pdf Note what areas have higher elevations by county in your science journal. In your journal record your thoughts as to why these areas would be desirable locations.
for a wind farm? Note any other factors you think may be important in wind farm site selection.

CONCLUSION  Formulate a conclusion from your research.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Test the Number of Turbine Blades and Compare Results: Exercise 1.2

SKILL OBJECTIVES

After completion of this lesson you will have the skills to:

1. Change blades of the turbine.
2. Adjust the pitch of turbine blades.

INTRODUCTION

In this lesson you will measure the wind turbine output comparing the number of blades from 6, 4, 3, 2, and finally 1.

ITEMS NEEDED You will need the following items:

- 6 turbine blades of the same design
- crimping hub
- protractor tool
- assembled wind turbine
- fan
- DMM
- graph paper

DMM SETUP Select 20 DC Volt range

CIRCUIT SETUP

1. Table fan in off position
2. Connect fan to 110 Volt AC outlet
3. Distance from fan to turbine is about two feet
4. Connect black lead to black DMM lead.
5. Connect red lead to red DMM lead.
PROCEDURE

1. Create a data table in your science journal.
2. Select 6 blades of the same design.
3. Attach the 6 blades to the crimping hub, making sure they are evenly spaced.
4. Set the pitch at 5° for all the blades using a protractor tool.
5. Attach the crimping hub to the drive shaft, check to be sure it is secure.
6. Observe the DMM as the table fan is turned on high.
7. Watch the meter for a minute and take the highest voltage reading.
8. Record the voltage in your science journal.
9. Turn the fan to off.
10. Disconnect the jumper cables.
11. Turn the DMM to off.
12. Repeat steps 2-11 with 4 blades.
13. Repeat steps 2-11 with 3 blades.
14. Repeat steps 2-11 with 2 blades.
15. Repeat steps 2-11 with 1 blade.
16. Graph your results.

CONCLUSION  Formulate a conclusion from this exercise, cite data from your graph.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________
Test the Pitch of Turbine Blades and Compare Results: Exercise 1.3

SKILL OBJECTIVES

After completion of this lesson you will have the skills to:

1. Change blades of the turbine.
2. Adjust the pitch of turbine blades.

INTRODUCTION

In this lesson you will measure the wind turbine output comparing the pitch of 3 blades.

ITEMS NEEDED

You will need the following items:

- 3 turbine blades of the same design
- crimping hub
- protractor tool
- assembled wind turbine
- fan
- DMM
- graph paper

DMM SETUP

Select 20 DC Volt range

CIRCUIT SETUP

1. Table fan in off position.
2. Connect fan to 110 Volt AC outlet.
3. Distance from fan to turbine is about two feet.
4. Connect black lead to black DMM lead.
5. Connect red lead to red DMM lead.

PROCEDURE

1. Create a data table in your science journal.
2. Select 3 blades of the same design.
3. Attach the blades to the crimping hub, making sure they are evenly spaced.
4. Set the pitch at 0° for all the blades using a protractor tool.
5. Attach the crimping hub to the drive shaft, check to be sure it is secure.
6. Observe the DMM as the table fan is turned on high.
7. Watch the meter for a minute and take the highest voltage reading.
8. Record the voltage in your data table.
9. Turn the fan to off.
10. Disconnect the jumper cables.
11. Turn the DMM to off.
12. Repeat steps 4-11 with the pitch at 5°.
13. Repeat steps 4-11 with the pitch at 10°
14. Repeat steps 4-11 with the pitch at 45°.
15. Repeat steps 4-11 with the pitch at 90°.
16. Graph your results.

CONCLUSION  Formulate a conclusion from this exercise, cite data from your graph.

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________
Test the Length of Turbine Blades and Compare Results: Exercise 1.4

SKILL OBJECTIVES

After completion of this lesson you will have the skills to:

1. Change blades of the turbine.
2. Adjust the pitch of turbine blades.

INTRODUCTION

In this lesson you will measure the wind turbine output comparing different lengths of turbine blades.

ITEMS NEEDED

You will need the following items:

- 4 sets of 3 turbine blades in the following lengths: 4", 6", 8", and 10".
- crimping hub
- protractor tool
- assembled wind turbine
- fan
- DMM
- graph paper

DMM SETUP

Select 20 DC Volt range

CIRCUIT SETUP

1. Table fan in off position.
2. Connect fan to 110 Volt AC outlet.
3. Distance from fan to turbine is about two feet.
4. Connect black lead to black DMM lead.
5. Connect red lead to red DMM lead.

PROCEDURE

1. Create a data table in your science journal.
2. Select 3 blades 4” in length.
3. Attach the 3 blades to the crimping hub, making sure they are evenly spaced.
4. Set the pitch at 5° for all the blades using a protractor tool.
5. Attach the crimping hub to the drive shaft, check to be sure it is secure.
6. Observe the DMM as the table fan is turned on high.
7. Watch the meter for a minute and take the highest voltage reading.
8. Record the voltage in your data table.
9. Turn the fan to off.
10. Disconnect the jumper cables.
11. Turn the DMM to off.
12. Repeat steps 2-11 with 6” blades.
13. Repeat steps 2-11 with 8” blades.
14. Repeat steps 2-11 with 10" blades.
15. Graph your results.

**CONCLUSION** Formulate a conclusion from this exercise, cite data from your graph.
# Alternative Fuel Lesson: Driver Education

**Developed for High School Level**

By Kari Hagerty

<table>
<thead>
<tr>
<th>Placement of Lesson</th>
<th>The lesson will be introduced after completion of Unit 4. The topics of Buying a Vehicle, Environmental Concerns, and Planning Travel are all taught within these chapters.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>After completing the activities compiled to create this lesson, students will have the ability to explain the different types of alternative fuels and use the skills acquired to research each of them. Students will be able to compare practicality and benefits as well as pitfalls of owning such a vehicle. At the conclusion, students will be able to apply knowledge to both purchase an alternatively fueled vehicle and plan travel.</td>
</tr>
<tr>
<td>Procedure</td>
<td>Lesson will require 4 (50 minute) class periods.</td>
</tr>
</tbody>
</table>
| Previous Knowledge  | Buying a Vehicle (Chapter 16)  
Environmental Concerns (Chapter 16)  
Maintaining a vehicle (fuel saving strategies) Chapter 17  
Planning Travel (Chapter 18)  
Calculating distance traveled using mpg of a vehicle  
Prior assignments (map project/family car research project) |
| Materials Needed    | Access to Internet/Computer Lab  
Poster Board (1/pair)  
Alternative Fuels Intro Worksheet  
Previously completed Map Project (completed in Chapter 18)  
Family Vehicle Specs (completed in Chapter 16) |
| Cross Curricular    | Writing reflection (WAC)  
Computing miles per gallon (Math)  
Using map (Geography)  
Alternative fuels (Science)  
Computer/internet use (Technology) |
Day 1

Objective

Students will be reintroduced to Alternative Fuels. (previously introduced in Chapter 16) In partners students will research their assigned fuel alternative and complete the coinciding worksheet. (attached) This will be self-guided group work. Students will then be able to construct a poster board outlining important facts for display.

Procedure

Divide students into partners.
Students will find assigned computer and log on.
Students will retrieve Alternative fuel source and worksheet from instructor.
Students will log onto: http://www.afdc.energy.gov/fuels/

After completion of the worksheet students will choose a vehicle and arrange information on poster board.
On the opposite side of the poster board students will arrange the information of their family car. (previous assignment)

Evaluation

Teacher will continuously check for understanding by questioning.
Teacher will monitor progress of the students.
Teacher will grade the worksheet after completion.
Teacher will observe construction of the poster boards.

Day 2 and Day 3

Objective

Students will be able to recall and explain information about the alternative fuel researched the previous day. Students will be able to compare and contrast different vehicles and fuel sources.

Procedure

Students will be given a number within their pairs (1 or 2)
Group 1 will set up their poster board in designated areas of the classroom.
Teacher will determine which fuel/car the student is promoting.
The classroom will be comparative to a car sales lot with each student attempting to “sell” their vehicle.
The remaining students will be given a budget, and instructed to “shop” for a new vehicle.
Students will roam, investigate, and question, students from group 1 about their vehicles. Students will make a decision on what type of car will be purchased. Student will write a reflection supporting their choice of purchase. This will conclude day 2.

On Day 3 the exact same format will take place with Group 2 setting up the poster board and Group 1 “shopping”. Group 2 will use the opposite side of the poster board. (ex. Group 1: Family Car, Group 2: Alternative Fuel Car)

### Evaluation
- Teacher will monitor discussion.
- Teacher will observe the “selling points” of the groups.
- Reflection will be graded based on a rubric.

## Day 4

### Objective
- Students will be able to plan a trip using their Alternative Fueled Vehicle. Students will recall information learned and apply it to get to their destination safely.

### Procedure
- Students will compare map routes of the family vehicle (previous assignment) and possibility of alternatively fueled vehicle following the same route. Students will decide, between both partners which person’s destination is preferred. After deciding, students will evaluate the route, confirming it is a safe/effective way of travel. Students will use the website http://www.afdc.energy.gov/fuels/ to choose locations to refuel. Students will alter route as needed (ex. Stopping points, rest areas, hotel) Students will prepare route comparative to map project. Students will highlight any changes that have taken place.

### Evaluation
- Teacher will visually observe the students.
- Teacher will observe discussions.
- Teacher will collect map routes/changes and grade.
ALTERNATIVE FUEL WORKSHEET

NAME: __________________________________________

Alternative Fuel Type: __________________________________________

Description: ___________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Benefits: ________________________________________________________
________________________________________________________________
________________________________________________________________

Vehicles: ________________________________________________________
________________________________________________________________
________________________________________________________________

How is this fuel produced?
________________________________________________________________
________________________________________________________________
________________________________________________________________

How is this fuel distributed?
________________________________________________________________
________________________________________________________________
________________________________________________________________

Availability in our area?
________________________________________________________________
________________________________________________________________
________________________________________________________________

Emissions: ________________________________________________________
________________________________________________________________
________________________________________________________________

Incentives and Laws:
________________________________________________________________
________________________________________________________________
________________________________________________________________

Station Locations:
________________________________________________________________
________________________________________________________________
________________________________________________________________
MAP PROJECT
You will plan a trip, at least 800 miles from Streator. Once you determine your destination, you will use Map Quest to confirm the mileage. On your trip there are many things you must consider. Use the guidelines below to plan your route, stops, cost of travel etc. You may use any appropriate websites to help you complete this (ex. Hotels.com)

The maximum driving time per day is 8 hours unless you have a traveler that can also drive. If so, you may extend daily driving time to 10 hours. This is not overall time but actual time on the road. You will need to factor this into your stopping points.

Fill out the attached worksheet as you go. This, along with your travel plan, is what you will turn in for a grade after completion.
MAP PROJECT WORKSHEET

Name: ________________________________________________________________

Travelers
Who is traveling with you? ______________________________________________
Are they able to share driving time? ________________________________________
Are there any special concerns (child, elder, handicap, medical issue)? _______
If so, how will this affect your travel?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Destination
Where are you going? _____________________________________________________
How many miles from Streator? _____________________________________________
What is the driving time it will take you to get to your destination? ____________
Are there any specific worries (weather, mountains, etc)? ________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Cost
What type of vehicle will you be using? ____________________________________
What is the average mpg? _________________________________________________
How many gallon tank is in this vehicle? ____________________________________
How many miles will you get with a full tank? ______________________________

Planning Travel
How many times will you need to fill your gas tank? _________________________
Using a fuel cost calculator, approximately how much will this trip cost you in fuel alone? __________________
Compare this cost to flying to this destination. You may use any airport in Illinois.
(Don’t forget to add the fuel cost to get to and from the airport as well as any parking fees) Which is more cost effective?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Remember you are only allowed to drive 8 hours per day. Where will you need to stop for rest? Factor in possible traffic, construction and delays, and choose a place/hotel/bed and breakfast to rest. If your destination requires 2 stays, go ahead and plan both of those.
Overnight Stop #1
City: __________________________________________________
Hotel:_________________________________________________
Cost per night:________________________________________

Overnight Stop #2 (if needed)
City:___________________________________________________
Hotel:_________________________________________________
Cost per night:________________________________________
Now create your travel plan. This will be an agenda with departure times, stop times, eating times, fueling times, sleeping times etc. You may separate or combine any of these.

**TRAVEL PLAN**
Departure Time: _________________________________________________________
I plan to drive _____ miles before stopping.  
I will need to fuel up for the first time around ___________________ (city, state) and it will cost approx.. $____________. It will take somewhere around _________ minutes at a gas station.

Use the example below to create your plan.

**EXAMPLE**

Departing from: Streator IL  
Traveling to: New Orleans, LA  
Total Expected Driving Time: 14 hours and 56 minutes

Total Miles: 910  
Gas Mileage: 15 gallon tank, 22 mpg : I will need to stop before 330 miles traveled for gasoline.

**Day 1**
8:00 am: Depart Streator  
11:30 am: Stop for fuel, lunch, and restroom in Edwardsville IL. Estimated time at stop is 45 minutes.  
12:15 depart Edwardsville IL  
3:50 pm: arrive Sikeston MO restroom break Estimated Stop time 15 min.  
4:05 leave: Sikeston  
5:05 arrive Cape Girardeau MO. Staying for the evening Eating, and fueling up here.

Hotel: ABC Inn  
Cost: $89 a night

Total Driving time: 8 hours 5 minutes  
Total time since departure 9 hrs 5 min

**Day 2**
8 am : leave Cape Girardeau MO  
10: 40 am: using the restroom and grabbing a snack, also topping off gas tank in Memphis TN
Estimated stop time 30 minutes
11:10: departing Memphis
2: 25: arriving in Jackson MS, will sit down and have lunch, get gas, etc.
Estimated stop time 1 hour 30 min.
4:00 pm: leaving Jackson
7:20 pm: Arriving in New Orleans

Total Driving time Day 2: 9 hours 20 minutes
Total Time since Day 2 departure: 11 hours 20 minutes

Total Driving Time: 17 hours 20 min.
Estimated time traveling including hotel stay 35 hours 20 minutes
Estimated time traveling not including hotel stay: 20 hours and 35 minutes
Angular and Linear Speed of Wind Turbines: Geometry

Developed for High School Level

By Theresa Bugelholl

PRE ASSIGNMENT

In the near future we will visit wind turbines. One of the activities we will do is to calculate the angular speed and linear speed of the blades. This assignment will help prepare you for the visit and assigned activities.

1. Estimate the height of the tower (Remember units):

2. Estimate the length of one blade:


4. Search the internet for the tower height and blade length.

   Tower Height:
   Blade length:
   Internet source:

5. What is the circumference of the circle traced out by the outermost part of the blade? (Show the formula and work)

Indirect Measurement

When we are at the wind turbine, we will indirectly measure the height of the tower and the length of one blade.

Read the section in the geometry book about methods of indirect measurement.

6. Do you think any of these methods could be used to measure the height of the tower or the length of a blade? Why or why not.

Right Triangle Trigonometry Review:

7. Find the value of the variables:
Angular Speed and Linear Speed:

Research angular speed and linear speed to answer the following questions:

8. What is angular speed? And its units?

9. What is linear speed? And its units?

For the trip to the wind turbine, please have with you:

- Pencil
- Calculator
- Clipboard
- Good attitude
- This completed pre-assignment sheet
WIND TURBINE VISIT ASSIGNMENT

Objective:

- The students will use an indirect measurement method to measure the length of a wind turbine blade.
- The students will calculate the angular speed and the linear speed of a wind turbine.
- The students will work in teams of two or three and compare their answers with two other groups.

Materials:

- Stopwatch
- Estes Rocket – Altitrak
- Calculators
- Clipboards
- Assignment sheet and pencil
- Map of area including point from which to measure angle of elevations and ground distance to wind turbine.

Previous knowledge:

- Right Triangle Trigonometry
- Discussion of indirect measurements and different methods
- Angular and Linear speed lecture
- Demonstration of Estes Altitrak use

Pre-assignment:

- Wind Turbines Angular and Linear Speed Pre-assignment Sheet.
Procedure:

The following will be performed at a wind turbine site. You will work with one or two other students in a group. Record the names of the students in your group and the date below. Each student must complete their own assignment sheet.

Name: ___________________________ Date: ________________________

Partners: __________________________

Part A: **Determine the angular speed (revolutions per minute) of a blade.**

1. Pick one blade and watch it through several revolutions. Time the blade through one complete revolution. Record the data 4 times.

2. Convert the data from revolutions per second to revolutions per minute.

**Suggestions:**
- Start and stop the stopwatch as the blade passes by the tower base.
- If one revolution is too fast, or your times are not consistent, then allow the blade to go two or three revolutions.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of revolutions</td>
<td>Time (seconds)</td>
<td># revolutions / time (A/B)</td>
<td>conversion</td>
<td>Revolutions / minute (RPM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60 seconds / minute</td>
<td>C X D</td>
</tr>
<tr>
<td></td>
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<td>60 seconds / minute</td>
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<td></td>
<td>60 seconds / minute</td>
<td></td>
</tr>
</tbody>
</table>
**Part B: Determine the height of the tower base (ground level to hub).**

1. Go to the designated location to determine the height of the tower (see map).
   
   Record the distance from the wind turbine from the map: ____________

2. Locate the correct wind turbine.

3. Use the Estes Altitrak to determine the angle of elevation.
   
   Record the angle of elevation: ____________

4. Draw and label a right triangle such that the adjacent side to the angle of elevation is the distance to the tower and the opposite side is the height of the tower

5. Calculate the height of the tower. (show work and units)
Part C: Determine the length of a turbine blade.

1. Record the height of the tower calculated in Part B. 

2. Using the tower as your reference point, locate where the tip of the blade as it passes by the tower.

3. Use the Estes Altitrak to determine the angle of elevation to the tip of the blade at the point in number 2.
   a. Record the angle of elevation: 
   b. Record the distance from the wind turbine from the map: 

4. Draw and label a right triangle such that the adjacent side to the angle of elevation is the distance to the tower and the opposite side is the distance from the ground to the tip of the blade.

5. Calculate the distance from the tip of the blade to the ground.

6. To determine the length of the blade, subtract the distance in number 5 from the distance in number 1.
Compare your results with two other groups:

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Names</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angular Speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height of tower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of turbine blade</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discuss the differences in your answers.

Calculate the linear speed of a bug riding the tip of the blade.

Calculate the linear speed of a bug riding on the blade 10 feet from the hub.
Reflection

Choose one of the following:

_____ I did not enjoy this activity.
_____ I somewhat enjoyed this activity.
_____ This activity was OK.
_____ This was one of the best activities we have done. Make sure you do it next year.

Choose one of the following:

_____ This activity was useless in helping me understand any of the objectives. I still do not understand ____________________.
_____ This activity helped me visualize and understand the objectives.
_____ Just reading the book and a quick lecture would have been good enough for understanding the concepts.

Choose one of the following:

_____ It was good to work in teams for this activity.
_____ I would have preferred to work independently for this project.
_____ It made no difference if I had a partner or worked independently.

Any additional comments:
Residence: Alternative Sustainable Energy System

Developed for High School Level

By Daniel Cornwall

This lesson will look at alternative sustainable energy system the student will use to power their home. At least 25% of the electrical systems in the student design will be powered through the use of alternative sustainable energy systems. In addition, the student will work with a technical drafting student to plan the hardware, circuitry, plumbing and mounting requirements for their system.

Lecture suggestions:

- Solar Energy
- Wind Turbine
- Fuel Cells
- Bio Fuels
- Geothermal Energy
- Hydroelectric Systems

Additional work suggestions (if needed):

- Lab work for Solar Energy
- Lab work for Wind Turbines
- Lab work for Fuel Cell

Knowledge Objectives:

1. Define renewable energy.
2. Define sustainable energy.
3. List renewable energy sources.
4. List non-renewable energy sources.
5. Describe the basic principles of different types of energy sources.
6. Create a list of resources that was used to research the alternative energy used in their design.

Definitions: To have an effective discussion about energy, we must agree on the definition of terms.

RENEWABLE ENERGY
There are several forms of energy that are considered renewable energy:
• Biofuel  
• Biomass  
• Geothermal  
• Hydro power  
• Solar power  
• Tidal power  
• Wave power  
• Wind power

Renewable energy is energy generated from natural resources, such as sunlight, wind, rain, tides and geothermal heat, which are renewable (naturally replenished).

**SUSTAINABLE ENERGY**  
Sustainable energy is the provision of energy such that meets the needs of the present without compromising the ability of future generations to meet their needs.

**BROADER INTERPRETATION**  
A broader interpretation may allow inclusion of fossil fuels and nuclear fission as transitional sources while technology develops, as long as new sources are developed for future generations to use.

**NARROWER INTERPRETATION**  
A narrower interpretation includes only energy sources which are not expected to deplete in a time frame relevant to the human race.

**Resources:**

• U.S. Department of Energy (www.energy.gov)  
• National Renewable Energy Laboratory –NREL (www.nrel.gov)  
• U.S. Department of Energy Energy Information Administration (www.tonto.eia.doe.gov)  
• Energy Efficiency and Renewable Energy-EERE (www.eere.energy.gov)  
• Southwest Photovoltaic (PV) Systems, Inc. (www.southwestpv.com)  
• National Aeronautics and Space Administration-NASA (www.nasa.gov)  
• Siemens (www.powergeneration.siemens.com)  
• Air Products and Chemicals, Inc. (www.airproducts.com)
DAY ½

TIME: 43 minutes per day
FORMAT: Instructor lead lecture
OBJECTIVES: Energy Overview – Chapter 2
- Introduction
- Energy Production & Construction
- National Renewable Energy Laboratory
  - EXERCISE 2.1 - Review Material Available from NREL
- Energy Types
  - Atomic
  - Chemical
  - Electrical
  - Heat
  - Light
  - Magnetic
  - Mechanical
  - Pressure
  - Sound
- Summary

DAY ¾

TIME: 43 Minutes per day
FORMAT: Laboratory work
OBJECTIVES: Renewable Energy Monitor – Chapter 5
- Introduction
- Installing Software
  - EXERCISE 5.1 - Install Renewable Energy Monitor Software
  - EXERCISE 5.2 - Become Familiar with Renewable Energy Monitor Software
- Using Measurement Software
  - EXERCISE 5.3 - Connect Renewable Energy Monitor to Computer
  - EXERCISE 5.4 - Measuring Resistance, Voltage, Current & Watts
  - EXERCISE 5.5 - Measure Solar Panel Output with Computer Interface
  - EXERCISE 5.6 - Capture and View a Plot
- Summary

DAY 5

TIME: 43 Minutes
FORMAT: Laboratory work
OBJECTIVES: Solar Panels
• Introduction
• Labs
  o EXERCISE 7.1 - Measure Solar Panel Output
  o EXERCISE 7.2 - Power Motor with Solar Cell
  o EXERCISE 7.3 - Observe Effect of Various Light Levels on Solar Cell

• Summary

DAY 6

TIME: 43 Minutes
FORMAT: Laboratory work
OBJECTIVES: Wind Turbines
• Introduction
• Labs
  o EXERCISE 9.1 - Assemble Wind Turbine
  o EXERCISE 9.2 - Test Wind Turbine
  o EXERCISE 9.3 - Change Wind Turbine Blades & Measure

• Summary

DAY 7

TIME: 43 Minutes
FORMAT: Laboratory work
OBJECTIVES: Fuel Cells and Zero Emissions Car
• Introduction
• Labs
  o EXERCISE 11.1 - Set Up Fuel Cell Assembly
  o EXERCISE 11.2 - Purging the Fuel Cell
  o EXERCISE 11.3 - Battery Powered Water Electrolysis
  o EXERCISE 11.4 - Zero Emissions Fuel Cell Car Operation

• Summary

DAY 8/9/10

TIME: 43 Minutes per day
FORMAT: Internet Research
OBJECTIVES: Choose Renewable Energy System for Home Design Project

• Introduction
• Portfolio Research
  o Type of Renewable Energy to be Used
  o Size and Model of Design
Pricing and Budget
- Assemble Portfolio for initial meeting with Contractor
- Schedule contractor meeting

**DAY 11/12**

TIME: 39 Minutes (ACCESS) per day
FORMAT: Team Meeting
OBJECTIVES: Contractor Meeting for Home Design Project

- Introduction
- Portfolio
  - Renewable Energy Discussion
  - Size and Model of Design
  - Equipment Design Needs
  - Timeline for Project
- Contractor Requirement for Home Design Project
- Schedule additional contractor meeting

**DAY ??**

TIME: 39 Minutes (ACCESS) per day
FORMAT: Team Meeting
OBJECTIVES: Contractor Meeting for Home Design Project

- Contractor Design Project
- Schedule additional contractor meeting
Sustainable Energy Planning
Developed for Community College Level
By Mike Phillips

**Summary:** Students research, report on, and discuss various sources of energy. Students analyze and evaluate energy sources and develop plans for their home and for the country.

**Context**

**Audience**
Introductory college level/general education course in environmental science.

**Skills and concepts that students must have mastered**
Students must be able to identify and assess energy sources using published resources and personal observation.

Students must be able to analyze energy sources in the context of their home and community and assess the likely costs and benefits of using different energy sources.

Students must be able to analyze energy resources and develop usage plans that are reasonable, effective, and appropriate.

**How the activity is situated in the course**
The assignment is undertaken in mid to late term. The class first covers basic concepts in science and environmental science including scientific methodology, environmental ethics, environmental economics, political decision-making. Students should also be familiar with basic concepts of chemistry, physics, biology, and geology; these concepts will be discussed and may be reviewed if necessary.
Goals

Content/concepts goals for this activity
Students can assess the costs and benefits of a variety of energy sources. They can research and describe the history of the source, its current uses, the positive and negative consequences of its use, and its prospects for inclusion in a sustainable energy plan.

Higher order thinking skills goals for this activity
Students must be able to evaluate data on energy sources to develop an assessment of the consequences of their use. Students must be able to evaluate a variety of energy sources and incorporate their findings into the development of a comprehensive energy plan.

Other skills goals for this activity
Students must be able to use the internet to collect information. Students must be able to share collected information with their peers. Students must be able to assemble information and conclusions into a coherent written paper with properly cited resources.

Description and Teaching Materials

Part 1, Introduction of Energy sources (one or two class sessions):
- Small groups develop lists of energy sources and report out to class. The lists should be as broad as possible and include: human muscle, animal (muscle & oil), plant (eating and burning), wind, moving water, coal, petroleum, natural gas, nuclear fission, solar, nuclear fusion, batteries, hydrogen fuel cell, geothermal
- Class discussion of the classification of energy sources by various characteristics including: when used (historical, modern, developing); renewable vs non-renewable; how used (direct, processed, converted); sources vs storage/transfer methods. For example, wind energy has historical, modern, and potential future applications, it is renewable, it can be used directly (sailing), processed (windmills), and converted (wind turbines), and it is a source. An example of a storage/transfer method would be fuels cells or batteries.
- Homework: Individual students (or groups) are assigned one to three sources to assess in greater detail and report back to the class with their findings. The report should include a description of how the energy source (or transfer technology) works, current use, availability, sustainability, the costs of use (setup, operation & maintenance), limitations/disadvantages (social, physical, technological, energy conversion factor), environmental concerns and benefits, advantages of use, typical time for return of investment cost, future prospects.

Part 2, Discussion of Energy sources (may take two to six (or more) class sessions depending on level of detail/depth of discussion, time constraints):
• Students (individual or groups) present findings to class as a one page executive summary and a short presentation.
• The instructor (or student presenters) may include a demonstration of source using a hands on demonstration, a video tour, or a field visit.
• The instructor will lead a discussion of the source (acting as resource and moderator). The discussion should include how the source works, its costs vs benefits, its current status, and its prospects as a future source of energy.
• This part should conclude with a discussion of energy use projections and energy conservation and efficiency.

Part 3: Capstone Assignments (may assign one or have students pick):

• Capstone Assignment #1: Develop a sustainable/renewable energy plan for your home that is cost effective and realistic and identifies:
  o Sources
    ▪ Which source(s)?
    ▪ Why?
  o Efficiencies
    ▪ Which method(s)?
    ▪ Why?
  o Set-up costs
  o Time for return on initial investment
  o Operation/maintenance/replacement costs
  o Energy storage/transfer
    ▪ self-contained (batteries, fuel cells, other technology)
    ▪ on the grid
  o Practicality: Why will this work?

• Capstone Assignment #2: Develop a sustainable/renewable energy plan for the President that:
  o Recommends two best sources of energy to increase
    ▪ What should we rely on for the long term?
    ▪ Why?
  o Identifies one current energy source that should be reduced/eliminated
    ▪ What should we stop using?
    ▪ Why?
  o Discusses the role of efficiency/use reduction
  o How can these recommendations be implemented?
    ▪ How do you get private industry to move in this direction?
    ▪ How do you get individuals to move in this direction?
  o Practicality: Why will this work?

The materials will be incorporated into a project web site, including guidelines (and outline), resources, and grade sheet.
Teaching Notes and Tips
It is important that the students have a thorough discussion of each resource. The instructor should guide the class discussion in such a way that the primary costs and benefits of each resource are explored to provide students with a basis for focusing their efforts on the capstone project(s).

Assessment
There should be grading rubrics that assesses all areas including data collection and analysis and clarity of presentation.

References and Resources

General Resources
- Federal government
  - Department of Energy (DOE): http://energy.gov/
    - Office of Science: http://science.energy.gov/
    - Smart Grid: http://www.smartgrid.gov/
    - Alternative Fuels Data Center: http://www.afdc.energy.gov/
  - Sandia National Lab: http://energy.sandia.gov/
  - Energy Information Agency: http://www.eia.gov/
    - Illinois state energy profile: http://www.eia.gov/state/?sid=IL
  - Congressional Research Service reports (search for reports energy, renewable energy, etc.)
    - https://opencrs.com/
    - http://www.phibetaiota.net/2013/07/congression-research-service-catalog/ (scroll down to “Energy” section)
    - http://digital.library.unt.edu/explore/collections/CRSR/browse/

- Other
  - California Energy Commission – Renewable Energy:
    http://www.energy.ca.gov/renewables/
  - Illinois Power Agency: http://www2.illinois.gov/ipa/Pages/default.aspx
  - Illinois Renewable Energy Association:
    http://www.illinoisrenew.org/index.html
  - National Council for Science and the Environment:
    http://www.ncseonline.org/
o Database of State Incentives for Renewables & Efficiency: http://www.dsireusa.org/
o Renewable Energy World: http://www.renewableenergyworld.com
o ComEd: https://www.comed.com
  ▪ Smart Grid: https://www.comed.com/technology/smart-grid/
  ▪ Residential Real-Time Pricing Program: https://rrtp.comed.com/
o Excelon: http://www.exeloncorp.com
o Ameren: http://www.ameren.com
  ▪ Sustainability: http://www.ameren.com/Sustainability/Pages/SustainableActivities.aspx
o Power Grid applet: http://tcipg.mste.illinois.edu/applet/pg#

Efficiency & Home-Use &Policy

• Efficiency
  o DOE, Reducing Your Energy Use: http://energy.gov/energysaver/articles/reducing-your-electricity-use
  o DOE, Home Efficiency: http://energy.gov/public-services/homes

• Home
  o DOE, To Generate or Not to Generate: http://energy.gov/energysaver/articles/generate-or-not-generate
  o Homepower Magazine: http://www.homepower.com/
  o Living off the Grid: http://www.todayshomeowner.com/living-off-the-grid-generating-your-own-electricity/

• Policy

Source-specific Resources:

• Solar
  o DOE, Sunshot Initiative: http://www1.eere.energy.gov/solar/sunshot/
- Solar Calculator: http://www.solarenergy.org/solar-calculator
  - Solar Electricity Handbook
    - http://solarelectricityhandbook.com/
    - http://books.google.com/books/about/Solar_Electricity_Handbook.html?id=7OYRgoCFD3cC
  - Home Solar
    - http://solarpyhome.com/
    - DOE, Planning a Home Solar Electric System:
      - http://energy.gov/energysaver/articles/planning-home-solar-electric-system
    - Solar Leasing for Residential Photovoltaic Systems
  - Solar Powered Classroom: http://www.youtube.com/watch?v=8lGjOtIQ1YQ
  - SREC trading
    - http://www.srectrade.com
  - Solar Panel Sources
    - http://www.homesolarpypanels.com/
    - http://www.amerescosolar.com/
- **Wind**
  - Illinois Wind: http://www.illinoiswind.org/
  - NREL, Wind Research: http://www.nrel.gov/wind/
  - http://bergey.com/
  - National Wind Watch: http://www.wind-watch.org/ (this group opposes large scale wind turbine development)
- **Water Power**
  - DOE, Microhydropower Systems:
    - http://energy.gov/energysaver/articles/microhydropower-systems
  - Small Hydro and Low-Head Hydro Power Technologies and Prospects:
- **Fuel Cells**
- Geothermal
  - NREL, Geothermal: http://www.nrel.gov/geothermal/

- Biomass
  - NREL, Biomass: http://www.nrel.gov/biomass/
  - Ethanol Laws and Incentives: http://www.afdc.energy.gov/fuels/laws/3252
Biofuels: Cellulosic Ethanol Lab

Developed for Community College Level

By Keith King and LeeAnn Johnson

Learning Objectives: After successfully completing this lab exercise:

- Students will gain an understanding of how using biofuels are more sustainable than fossil fuels. Students should also gain an understanding that cellulosic biofuels are more sustainable because they are not made from products like corn and sugar cane that could otherwise have been used for food.
- Students will understand the function and structure of cellulose in plants. It will be critical for students to understand that cellulose, although it is composed primarily of the sugar glucose, cannot be digested by humans.
- Students will gain an understanding of how enzymes work and recognize their role as biological catalysts.
- Students will gain an understanding of anaerobic fermentation and recognize that it converts glucose and other simple sugars into ethanol.

Introduction:

In the United States and much of the world, a significant portion of our energy is produced by nonrenewable fossil fuels such as coal, oil and natural gas. Fossil fuels will eventually dwindle and become very expensive to use. They also cause irreversible damage to our environment. Renewable energy resources such as wind, solar, hydroelectric and biofuels are much more sustainable than fossil fuels (Renewable Energy Basics).

Biomass energy, energy derived from plants or plant-derived materials, can be used to create fuel and power that would normally be created from fossil fuels. The benefits of using biomass to produce energy include the reduction of greenhouse gas emissions, reduction of our dependence on foreign countries for oil, and support of our US agriculture and forest industries.

Biomass, unlike some other renewable energy sources, is often changed directly into liquid fuels known as “biofuels”. Two common biofuels include ethanol and biodiesel. Ethanol, a type of alcohol, is commonly produced from fermentation of carbohydrates such as starch or sugar. Today, scientists are working on technology that will allow ethanol to be produced from cellulose, a polysaccharide that is found in the cell walls of
plants. Cellulose, non-digestible by humans, possesses a dense crystalline structure that is held together by rigid chemical bonds (Ragauskas). Some animals, insects and microbes are able to digest cellulose and consequently release plant sugars, which provide energy.

These organisms use enzymes to digest cellulose. Enzymes are proteins that speed up the rate of chemical reactions. Enzymes are catalysts, meaning they speed up the reaction without being used up, therefore an enzyme can be used over and over again. Cellulase is the enzyme that breaks down cellulose, allowing sugars to be released (*Cellulase Production*). The sugars can then be fermented into ethanol, which can be used as an alternative fuel source.

Fermentation is a chemical process in which carbohydrates are broken down into end products such as gas, alcohol and acids. Fermentation is an anaerobic process, meaning it occurs without oxygen. Yeasts are organisms that commonly carry out ethanol fermentation when cutoff from oxygen. Carbon dioxide is a byproduct of fermentation, which can be observed using a fermentation tube which traps the gas in a tube so it can be measured.

### Materials:

Paper Slurry-Shredded paper added to a 5-gallon bucket mixed with warm water. Mix approximately 2 parts water to one part paper. Allow to soak overnight and blend in a kitchen blender until it has the consistency of a thin liquid.

1% Cellulase Solution-Add 10 g of cellulase (available from Carolina Biological Supply) to a liter of distilled water

Yeast Suspension-1 gram dry yeast (available at grocery store) per 100 ml of distilled water.

Benedict’s Solution in dropper bottles

Test Tubes | Fermentation Tubes | Millimeter Rules
---|---|---
250 ml Flasks | Hot Water Baths | Metal Mesh Strainer

### Cellulase Digestion Procedure:

1. Prepare two 250 ml flasks by adding 100 ml of paper slurry to each. Label one "digestion” and the other “control.” Also label them with your name and the date.
2. Test these solutions for sugars by labeling two test tubes D and C. Add 2 ml of the digestion to the tube labeled D, and 2 ml of the control to the tube labeled C.
Add 20 drops of Benedict’s reagent to each tube and place them in a hot water bath. Record any color change you see in the data table. Benedict’s changes green to reddish orange in the presence of reducing sugars like glucose, orange/reddish colors indicate high concentrations of these sugars.

3. Add 10 ml of 1% cellulase solution to the flask labeled digestion (BioFuels: Cellulose Lab Investigation Sheet). Leave the control flask unaltered. Cover the tops of the flasks with plastic wrap and allow the solution to sit overnight.

4. After the solutions sit for at least 24 hours, use the metal strainer to filter both solutions into new flasks. Test both solutions for the presence of sugars as described in step 2 above. Record any color changes you see in the data table.

5. Add 10 ml of your digested paper solution to a fermentation tube labeled D. Fill the rest of the tube with yeast suspension. Repeat this process for your control flask into a fermentation tube labeled C. Make sure you label the fermentation tubes with your initials. Allow the tubes to sit at room temperature for approximately 24 hours. Measure the bubble production in the tubes.

<table>
<thead>
<tr>
<th></th>
<th>Digested Paper</th>
<th>Control Paper</th>
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<tbody>
<tr>
<td>Benedict’s Reaction before digestion.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benedict’s Reaction after digestion.</td>
<td></td>
<td></td>
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<tr>
<td>Amount of CO$_2$ produced in fermentation tube (mm)</td>
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</table>

What can you conclude from this experiment?

Why don’t you have to continually add cellulase throughout the process as it digests?

Why does the paper/yeast solution have to be cut off from air for fermentation to occur?
References


The Effects of Wind Obstructions on the Power Generation of Wind Turbines

By Michael Bates

This activity is meant to be used as a lab component of a unit on renewable energy, specifically Wind Power.

Prior Knowledge required:
- Use of a Digital Millimeter to measure Voltage.
- Familiar with the form and function of Wind turbines.
- Knowledge of Experiment Design and its terms.

Purpose: Determine the minimum distance a wind turbine needs to be from wind obstructions to operate most efficiently.

Materials: A three speed fan, model wind turbine, meter stick, masking tape, pencil or fine point maker, multi-meter with appropriate leads and jumpers, lab packet and scratch paper, box of colored pencils, 4ft by 8ft clear flat area and 6 textbooks.

Part 1: Choosing the best wind turbine location.

Procedures:
1. Place the fan in the middle of one of the 4 ft.table edges.
2. Measure 33 cm from the base of the fan. Place a piece of masking tape on the table to mark this spot.
3. Move the 0cm end of the meter stick on the marked spot with the 100cm end pointing toward the far end of the table. Tape the meterstick to the table with two 12 cm pieces of tape. Place a second meter stick with its 0cm end butted up to the 100cm end of the first meter stick and tape it down.(See figure 1)
4. Set up the model Wind Turbine and attach it to a multi-meter.
5. Starting at 20cm on the first meter stick record number of volts created by the Wind Turbine at each distance in increments of 20 cm.
6. Use data chart #1 to record the results in the appropriate columns. (allow the fan to run for 10 seconds to get up to speed before taking your readings)
7. Calculate the average # of volts produced at each of the distances. Record the average in the Average Volts column for each distance
8. Use your data to create a graph of volts created at the different distances for each of the three speeds and the average. (use green for Low, yellow for Medium, red for High and blue for Average)
QUESTION #1: Examine the line graph and draw and vertical line in blue through the high volt production for each of the speeds. At what distance would you position the Wind turbine from the fan to maximize energy production considering variable wind speeds throughout the year.
Chosen distance ____cm.
Explain why you chose this distance.
____________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Part 2: Examining the negative effects of wind obstructions on Wind turbine production.

Problem: How does the nearness of an obstruction downgrade a wind turbine’s ability to generate power?
Procedures:
1. Place the Wind Turbine and multi-meter at the distance you selected in Part 1 to best maximize energy production. Tape it in place.
2. Measure 20 cm from the base of the Wind Turbine. Place a Stack of 6 textbooks (represent a 3 story building) on the table at this spot.
3. Run the fan and record the power production in volts off the multi-meter. Record your results on to Data Chart #2.
4. Move the stack of books at 20 cm increments away from the turbine and toward the fan.
5. Repeat steps 3 and 4 until the stack of books are at or nearer to the fan than the 0cm end of the first meter stick.
6. Use your data to create a graph of volts created with the obstruction at the different distances in front of the Wind Turbine for each of the three speeds. (use green for Low, yellow for Medium, red for High and blue for Average)

QUESTION #2 Did the obstruction’s distance affect the energy production of the wind turbine?

QUESTION #3 Did the power production increase or decrease? ____________________________

QUESTION #4 Explain why?
________________________________________________________________________
________________________________________________________________________

<table>
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<th>nd meter</th>
<th>Low</th>
<th>Med.</th>
<th>High</th>
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<td>100</td>
<td>233</td>
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Data Chart 1: Wind Turbine Volt Production

Use color pencils to plot the # of Volts generated by winds of the three fan speeds. Assign an appropriate range for Volts for the Y axis. Draw four lines: yellow for low, green for medium, red for high, and blue for average.
Low speed = Yellow
Medium = Green
High = Red
Average = Blue

Graph 1: Power Production in Volts With Distance
Distance to obstruction | Low | Med. | High | Average
--- | --- | --- | --- | ---
20 | | | | |
40 | | | | |
60 | | | | |
80 | | | | |
100 | | | | |
120 | | | | |
140 | | | | |
160 | | | | |
180 | | | | |
200 | | | | |

**Data Chart 2: Wind Turbine Volt Production With a Wind Obstruction at Different Distances**

Use color pencils to plot the # of Volts generated by winds of the three fan speeds in graph 2 below. Assign an appropriate range for Volts for the Y axis. Use four lines: Yellow for low, green for medium, red for high and blue for average.
Analysis and Conclusions:

1. What things about this experiment remained constant?

2. What two variables did you change in this experiment?

3. How could this activity be considered three experiments in one?

4. Why was it important to calculate the average $V$ generated? (Hint: “Mother Nature” can be fickle)

5. What assumptions can be made from the data graphed in this activity?

6. What change(s) could we make to this experiment to answer more specific questions about wind turbine power production?
Appendix: Course Plan

COURSE TITLE: INTRODUCTION TO RENEWABLE ENERGY TOPICS FOR TEACHERS
2 semester hours of graduate credit

Tentative Scheduling: Summer, five days
8 a.m. – 3 p.m. (32.5 contact hours + ½ hour lunch)

1. COURSE DESCRIPTION/CATALOG DESCRIPTION

This course introduces high school and community college teachers to renewable energy impact, sources, and technologies and guides them in developing hands-on modules or projects in renewable energy, which can be utilized in their courses to promote awareness of and interest in renewable energy.

2. COURSE OVERVIEW

Participants will be introduced to basic concepts in renewable energy (wind, solar, bio-fuels, and geothermal/solarthermal) in project-based format. In wind energy, for example, participants will be introduced to basic concepts while working in teams to build a mini wind farm. This project will be utilized to illustrate how renewable energy projects can be completed in a classroom with readily available or inexpensive materials, by students of varying ages/varying levels of expertise, and with a focus on any of a variety of concepts; for example:

- In science: Using hand held test equipment
- In math: The relationship between force, magnetic field strength and induced voltage
- In industrial technology: Building the tower and siting the turbine
- In electricity: Wiring and the importance of color coding
- In business: The costs of wind energy
- In agriculture: The impact wind energy on agriculture
- In history or current affairs: Results of a “brown out” in a region
- In government: The role the state of Illinois is playing in encouraging wind energy
- In communication: Writing instructions for assembling the wind farm or delivering a persuasive pitch for wind energy

Participants will develop a module or project for use in their course(s).
3. **STUDENT LEARNING OBJECTIVES:**

Participants will emerge with
- An understanding of the basics and impact of renewable energy with emphasis on sources and technologies more widely employed in north central Illinois (primarily wind and solar).
- A renewable energy module or project to utilize in their course(s), adapted to their discipline
- Resources for additional renewable energy information and additional modules or projects for their classroom use

4. **TEACHING METHODS / CLASS FORMAT**

The content for this course will be taught largely through small group, hands-on projects, but will also include lecture, large group discussions, and student presentations. The course will culminate with participants applying their knowledge by developing a module or project which they can use to promote awareness of and interest in renewable energy in a course(s) they teach.

**COURSE INSTRUCTOR:** Jim Gibson, IVCC Program Coordinator of Electronics and renewable energy instructor. Email: jim_gibson@ivcc.edu  Phone: 815-224-0453

5. **READINGS/RESOURCES**

Participants will utilize web-based readings and resources for background information on renewable energy and for sample classroom modules in their area of interest.

Readings/resources include:

- Advanced Biofuels USA  http://advancedbiofuelsusa.info/education/forteachers
- Alliance to Save Energy http://ase.org/topics/education
- Boise State University; Lesson Plans using Common Core Standards http://coen.boisestate.edu/windenergy/wfs/teacherresources/
- Clean Energy Resource Teams http://www.cleanenergyresourceteams.org
• Engineering, Go For It
  http://www.egfi-k12.org/
• Wind Power Lesson
  http://teachers.egfi-k12.org/lesson-wind-power/
  For Teachers
  http://teachers.egfi-k12.org/
• Federal Resources for Educational Excellence
  http://free.ed.gov/subjects.cfm?Subjects_id=249&res_feature_request=1
• Greening Schools:  A Project by the Illinois EPA and WMRC
  http://greeningschools.org/resources/view_cat_teacher.cfm?id=134
• GreenLearning Canada:  re-energy.ca  Plans for building models of wind turbines, solar ovens, etc.  http://www.re-energy.ca
• Green Teacher; Education for Planet Earth (commercial magazine site)
  http://greenteacher.com/
• Horizon Wind Energy; For teachers, kids, and consumers
  http://www.horizonwind.com/about/ftkc/
• InfinitePower.org (Texas State Energy Conservation Office)
  http://www.infinitepower.org/lessonplans.htm
• James Madison University; Alternative Energy Educational Resources
  http://aeer.cisat.jmu.edu/activities.html
• KidWind Project
  http://learn.kidwind.org/
  Teacher Resources
  http://learn.kidwind.org/teach
  WindWise Education
  http://learn.kidwind.org/windwise
• Minnesota Energy Careers; Educators Resources in Energy
  http://www.iseek.org/industry/energy/education/curriculum.html
• National Energy Education Development Project,  K-12 Curriculum Guides
  http://www.need.org/Guides-Subject.php
• National Renewable Energy Laboratory
  www.nrel.gov
  Low resolution photos
  http://www.nrel.gov/data/pix/searchpix.html
  Education Programs
  http://www.nrel.gov/education/
• NEED Project:  Putting Energy into Education,  Transportation Fuels:
  Biodiesel Curriculum Projects  http://www.biodiesel.org
• Ohio Energy Project (Solar Curriculum)
  http://www.ohioenergy/org/need.html
• ScienceEducation.gov - Supporting Science, Technology, Engineering, and Mathematics Education for America
  http://www.scienceeducation.gov/
Participants will also utilize laboratory manuals for the renewable energy trainers that will be used in the course.

Additional readings/resources will be provided by the instructor as needed.

6. UNITS OF WORK:

The course will be divided into five units: one unit in each of the types of renewable energy (wind, solar, bio-fuel, and geothermal/solarthermal) and one unit in development, preparation and presentation of a renewable energy project implementation plan.

<table>
<thead>
<tr>
<th>UNIT</th>
<th>CONTENT</th>
<th>LEARNING EXPERIENCES</th>
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</thead>
<tbody>
<tr>
<td>1: Wind Energy Hours 6.5*</td>
<td>Research supporting wind energy: • needs • resources • activities</td>
<td>Reading, web searches, learning activities, small group work and lab reporting Texts/readsings: Lab Volt lab manuals, web sites.</td>
</tr>
<tr>
<td>2: Solar Energy Hours 6.5*</td>
<td>Research supporting solar photovoltaic energy: • needs • resources • activities</td>
<td>Reading, web searches, learning activities, small group work and lab reporting Texts/readsings: Lab Volt lab manuals, web sites.</td>
</tr>
<tr>
<td>3: Bio-Fuels Hours 6.5*</td>
<td>Research supporting bio-fuels energy: • needs</td>
<td>Reading, web searches, learning activities, small group work and lab reporting</td>
</tr>
</tbody>
</table>
4: Geothermal/ Solarthermal
Hours 6.5*
- Research supporting geothermal / solarthermal energy:
  - needs
  - resources
  - activities
- Texts/readings: Marcraft text and lab manuals, web sites
- Reading, web searches, learning activities, small group work and lab reporting
- Texts; readings: Lab manuals, web sites

5: Project Implementation Plan
Hours: 27 – 32.5
- Group work on implementation report and presentation
- Individual work, program inclusion, individual implementation plan and group presentation

*Participants will work in four groups or teams for units 1 – 4 in researching, exploring, and completing laboratory activities in the four categories of renewable energy included. Each group will focus on one of the four units at the beginning, and groups will rotate through the units; for example, during the first 6.5 hours of the course, group 1 would focus on wind energy, group 2 on solar energy, group 3 on bio-fuels, and group 4 on geothermal/solarthermal. During the next 6.5 hours of the course, groups would rotate to a different type of renewable energy.

7. CLASS ASSIGNMENTS

1. Laboratory reports. At the end of each unit, submit a laboratory/unit report.
2. Classroom participation activities. Participate in class, team activities, and lab activities.
3. Prepare/deliver an oral project presentation.
4. Prepare/submit a written project implementation plan.

8. GRADES/EVALUATION

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Labs</td>
<td>40%</td>
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<tr>
<td>Renewable energy project presentation</td>
<td>30%</td>
</tr>
<tr>
<td>Renewable energy project implementation plan</td>
<td>30%</td>
</tr>
</tbody>
</table>

9. BIBLIOGRAPHY

See readings/resources above.

10. ATTENDANCE POLICY
Students are expected to attend all classes, and absences will affect the final course grade. If absence from class is unavoidable, it is the student’s responsibility to explain the absence to the instructor and arrange to complete any work missed.

**11. ACADEMIC HONESTY**

Students are expected to maintain academic honesty by doing their own work. Academic dishonesty (cheating or plagiarism, etc.) will result in the student’s receiving a zero for that assignment and may result in the student being withdrawn from the course.

Development of this course was supported by National Science Foundation grant #1003730, “Preparing a New Workforce for a Sustainable Economy.”
Additional Resources

In addition to the resources listed with the activities and the course syllabus (in the Appendix), see the following:

For an additional classroom activity adaptable to varying ages:


For additional resources related to wind energy:

- Illinois Valley Community College, Wind Energy Program Web Site
  Information on IVCC’s Wind Energy Technician Certificate programs and videos demonstrating the work of wind energy technicians
  http://www.ivcc.edu/wind

- Illinois Valley Community College, National Science Foundation Grant Web Site
  Information on wind energy careers, IVCC’s Wind Energy Technician Certificates, and NSF grant activities for the wind energy programs.
  http://www.ivcc.edu/nsf