Turbines for Lifting Using Kinetic Energy

What is the best turbine blade design to lift the most using kinetic energy?

Prepared By: Kimberly Villani

Overview & Purpose: The more kinetic energy (faster it spins) the more weight a wind turbine will lift. Also, the best designed blades will lead to faster spinning and more KE. The KE will also change as the blades spin faster or slow based on the design.

Objectives: *Students will...*

- Design wind turbine blades to successfully lift a number of weights.
- Make a claim of the best blade design using kinetic energy to lift the weights.
- Be able to gather and organize data & observations to support their claim.
- Be able to construct and present an argument to the class to support their claim.
- Be able to complete all of the above working in small groups.

Background Information: Students need to know some basics on a wind turbine including its structure and its purpose. Students need to be able to work in small groups to build, construct, and test Kidwind turbines. Students must also know that kinetic energy is energy of motion.

NEXT GENERATION SCIENCE STANDARDS

Performance Expectations *Students who demonstrate understanding can:*

MS-PS3 Energy-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Classroom Activities/Procedures & Timeline

1. Lead a class discussion on wind turbines to see what students already know about them: have they seen them, what do they look like, where are they found, what are they for, etc.?
2. Would a faster or slower spinning turbine generate more or less electricity? Discuss that the design of a turbine is important to generate as much electricity as possible. Review kinetic energy as well, if needed.
3. Assemble the students into groups and describe activity. Students need to discuss and/or draw a design that they believe will lift the most weight (claim); why do they think it will be the best?
4. Assist/supervise students in the building & testing of their designs. Set a time limit to fit into 1-2 class periods.
5. Have the students share their results and support/refute their claim including what went well and what didn't.
6. Review connections between kinetic energy and electrical energy in the turbines.

Assessments: (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)

Group that lifts the most washers can be designated the "winner."

Teacher can also grade the student lab write up and participation in activity.

Questions can also be used as a follow-up or review such as: giving examples or diagrams of turbines and asking the students which would lift the most or least and why.

Extensions/Homework:

Allow students to rank and constructively comment on other groups turbine designs and claims, including a scale such as 1-5. Can be done verbally or written on a sheet of paper (can even be anonymous if desired).

More time to revise designs and test;

Watch video and complete video worksheet.

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References:

www.kidwind.org

www.nasa.gov

www.WindWiseEducation.org

Personal Comments/Notes:

This is lesson #1 of the middle school energy unit for MS-PS3-5.

Equipment/Materials/ Technology Needed:

- Kidwind turbine kits or other type : 1 per group with weight holder and a number of washers (approx. 2000 g)
- Box fan(s) for testing designs
- Additional materials for blade design (cardboard, paper, cardstock, construction paper, etc.)
- Scissors, tape and assembly materials.

Teacher Resources:

(e.g., readings, set-up instructions, lecture files, data files, etc.):

Files :

- wind_power_9–12.pdf (background info.)
- AL Turbine Instructions.pdf (background info.)
- BladesLesson–10.pdf (reference for activity)
- windLesson--8.pdf

Student Resources:

(e.g., handouts, worksheets, data, etc.):

- Lab Handout (file for activity 2)
- Video: Wind Turbine Construction Time-Lapse Video http://youtu.be/1AvIhZAqYcE

Accommodations & Safety Concerns:

Electrical safety reminders; caution with fan usage, spinning turbines, and any sharp/pointy objects; safety goggles may be desired

Less variables could also be used in design such as: telling students to all use same number of blades & type of paper

Name: ______________________________ Date: ____________________

Activity 1 — What is the Best Turbine Blade Design to Lift the Most Using Kinetic Energy?

Lesson Objectives:

1 Design wind turbine blades to successfully lift a # of weights.

2 Make a claim of the best blade design using kinetic energy to lift the weights.

3 Gather and organize data & observations to support the claim.

4 Construct and present an argument to the class to support their claim.

Materials: (per group)

- Turbine kit
- Ruler, scissors, tape
- Various type of paper/cardboard for blades
- Box fan
- Set of metric weights (g) and holder

Claim: Construct a claim for what design your group thinks will lift the most weight. Draw & label or explain in detail below: (use additional paper if more space is needed)

Build your design: You must make note of any changes you make from your claim below:

Changes made to original prototype & design:

Test your design & adjust for a second test (time permitted)

Design Variable (What did you do?)	Weights Lifted (g)	Observations (what worked & didn't)

Analysis & Results:

Does your data support or refute your original claim? Explain why using your data and observations. Be prepared to present in detail to the class. (use additional paper if more space is needed)

Lesson 1 Assessment Idea Variation:

Possible writing prompt, discussion, notes, or individual assessment for activity.

1 My claim:

2 My evidence (data & observations):

3 Counter arguments (rebuttals) against my claim:

4 My evidence to refute counter arguments:

5 I could persuade disbelievers:

Electric Turbines Using Kinetic Energy

What is the best turbine blade design to generate the most electricity using kinetic energy?

Prepared By: Kimberly Villani

Overview & Purpose: The more kinetic energy (faster it spins) the more electricity a wind turbine will generate in volts. Also, the best designed blades will lead to faster spinning, more KE, and more volts of electricity. The KE & resulting voltage will also change as the blades spin faster or slower based on the design.

Objectives: *Students will...*

- Design wind turbine blades to successfully generate electricity.
- Make a claim of the best blade design using kinetic energy to generate more volts.
- Be able to gather and organize data & observations to support their claim.
- Be able to construct and present an argument to the class to support their claim.
- Be able to complete all of the above working in small groups.

Background Information: Students should already know some basics on a wind turbine including its structure and its purpose based on the previous activity lifting weights. Students need to be able to work in small groups to build, construct, and test Kidwind turbines. Students must also know that kinetic energy is energy of motion and motion is used to generate electricity.

NEXT GENERATION SCIENCE STANDARDS

Performance Expectations *Students who demonstrate understanding can:*

MS-PS3 Energy-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Classroom Activities/Procedures & Timeline

Activity should take 1-2 class periods in small groups.

Review previous activity of building & designing the turbine blades. What worked & didn't?Begin activity after review, including distribution of materials to groups/students.

Have students sketch, describe, and/or discuss a new design that will generate the most electricity (claim); why will theirs be the best?

Students should build and test design. Teacher should assist in the testing and official recording of group voltages.

Students should then refute/support claims and present/share with classmates.

Optional Research Project (groups): Students should choose to be for or against wind in the future, complete energy assessment from social, economic, and environmental perspectives, tally score, and complete decision grid. Then they can present their argument (pro/con) fully in a large debate/class discussion format and use decision grids for claims/rebuttals.

Assessments: (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)

1. Lab Handout
2. Group or individual sharing of claims and evidence/data
3. Responses/suggestions/reflections by other groups on this group's claims & evidence
4. Presentation rubric (s)

Extensions/Homework:

More time to revise designs and test.

Peer review of the designs.

Follow up questions such as having students describe best design for a particular voltage or giving students multiple designs and having them choose the one that would generate the most electricity and describe why.

Have students research (or provide them with) information on how much electricity turbines generate and more about their actual blade designs and kinetic energy.

Watch video and have students complete wind technician worksheet (career option).

Instead of having students pick for/against wind, have groups research, decide, and display decision grids for comparison.

References:

www.kidwind.org

www.nasa.gov

www.WindWiseEducation.org

Personal Comments/Notes:

This is lesson 2 of the middle school energy unit for MS-PS3-5. It could be done in one or two periods or, using extensions, taught as a part of a larger unit on wind and/or renewable energy.

Equipment/Materials/ Technology Needed:

- Kidwind turbine kits or other type : 1 per group
- Box fan(s) for testing designs
- Volt meter or Multimeter for each group
- Additional materials for blade design (cardboard, paper, cardstock, construction paper, etc.)
- Scissors, tape and assembly materials

Teacher Resources:

(e.g., readings, set-up instructions, lecture files, data files, etc.):

Files :

- wind_power_9–12.pdf (background info.)
- AL Turbine Instructions.pdf (background info.)
- BladesLesson–10.pdf (reference for activity)
- windLesson--8.pdf

Student Resources:

(e.g., handouts, worksheets, data, etc.):

- Lab Handout (file for activity 2)
- L2_WIND_Energy Assessment
- Video: Get Energized: Wind Energy Technician Career http://youtu.be/u-wcOH9nl8g

Accommodations & Safety Concerns:

Electrical safety reminders; caution with fan usage, spinning turbines, meters and wires; safety goggles may be desired Less variables could also be used in design such as: telling students to all use same number of blades & type of paper

Name: ______________________ Date: ______________

Activity 1 — What is the Best Turbine Blade Design to Generate the Most Electricity?

Lesson Objectives:

1 Design wind turbine blades to successfully generate electricity.

2 Make a claim of the best blade design to generate the most volts.

3 Gather and organize data & observations to support the claim.

4 Construct and present an argument to the class to support their claim.

Materials: (per group)

- Turbine kit
- Ruler, scissors, tape
- Various type of paper/cardboard for blades
- Box fan
- Multimeter or Volt meter

Claim: Construct a claim for what design your group thinks will lift the most weight. Draw & label or explain in detail below: (use additional paper if more space is needed)

Build your design: You must make note of any changes you make from your claim below:

Changes made to original prototype & design:

Test your design & adjust for a second test (time permitted)

Design Variable (What did you do?) (New Prototypes)	Electricity Generated (V or mV)	Observations (what worked & didn't)

Analysis & Results:

Does your data support or refute your original claim? Explain why using your data and observations. Be prepared to present in detail to the class. (use additional paper if more space is needed)

GROUP RESULTS

1 Plot your numbers on the decision grid (triangle) below.

2 Use a ruler to connect your points together to make a triangle for your group (within the decision grid.)

3 Shade or color your triangle.

4 Calculate the *area of the original decision grid* (black triangle).

Area of a triangle = ½ base x height

Base (cm) = ________________ Height (cm) = ____________________ Area = ________________________ cm^2

5 Calculate the *area of your colored triangle*.

Base (cm) = ________________ Height (cm) = ____________________ Area = ________________________ cm^2

6 What is the difference between the decision grid and your triangle?

________________________ cm

What does this difference represent?

CLASS RESULTS

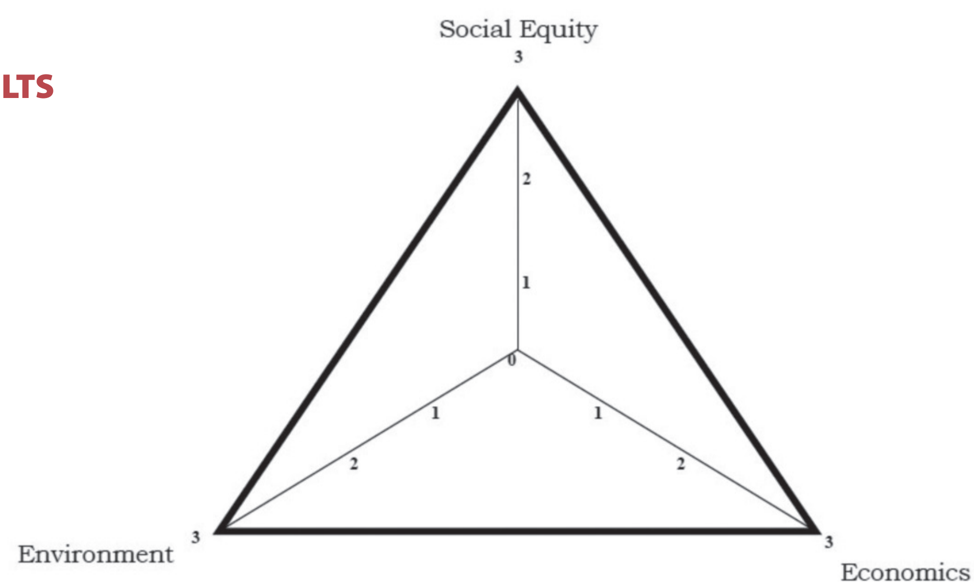

TABLE - CLASS NOTES: Name: ______________________ Date: ______________

GROUP	SOCIAL SCORE	ENVIRONMENT SCORE	ECONOMIC SCORE	AREA OF TRIANGLE

Group Presentation (pros/cons) Grading Idea:

You can evaluate the content of your students on their presentations using the following three-point rubric: (Adjust as needed)

Three points: arguments cover economic, environmental, and physical advantages and/or disadvantages of the power-production method; arguments represent the interests of business owners, families, environmentalists, and power company employees; arguments cover safety concerns of and evaluate efficiency of the energy produced; arguments are logical and well organized.

Two points: only some of the advantages and/or disadvantages of the power-production method are covered; arguments fail to represent one or more of the groups indicated by the assignment; arguments fail to cover safety concerns or efficiency; arguments are logical and well organized

One point: few of the advantages and/or disadvantages of the power-production method are covered; arguments fail to represent most of the groups indicated by the assignment; arguments fail to cover safety concerns and efficiency; arguments poorly organized.

Student Reflection Idea: (writing prompt/discussion/assessment)

Debate topic:

Arguments for (pro):

Arguments against (con):

Rate both sides in terms of evidence (3=strong, 1=weak) and give examples:

After hearing the debates, where do you stand? Explain.

CAREER PROFILE: PAT WALSH, WIND TURBINE TECHNICIAN

A wind turbine technician repairs and maintains wind turbines. That means that every day I get to climb 300-foot towers and fix broken turbines! To be able to repair a wind turbine, I had to become an expert in hydraulics, electricity, wind turbine mechanical systems, and electronics. Technicians must also be physically fit and very safety conscious, as the job can be physically strenuous. Of course, I cannot be afraid of heights, either. While the heights may sound scary, the perks of this job are good. I earn a competitive salary with benefits, not to mention enjoying the spectacular views every day while on the job! In addition, I, like many technicians, got to travel to Europe as part of my training.

Colleges across the United States have begun offering training programs for wind turbine technicians. These 2-year programs teach students everything they need to know to be a certified "wind-smith." I was trained at Iowa Lakes Community College, but my co-workers came from several different schools. These days, demand for wind technicians is high, and some students are hired by the wind industry while they are still finishing their training.

Read the passage above and answer the following questions:

1. What does a wind turbine technician do?
2. What type of training skills does the technician receive?
3. What types of physical requirements are there?
4. What types of training programs are available?
5. Are there jobs available for wind technicians? Explain.
6. **Optional:** Where are wind technician programs available in Illinois? Describe the colleges, types of classes, and amount of time to complete.

ENERGY ASSESSMENT TABLE

Criteria	Rating	Justification and/or Data Used

____________ Overall Average

Overall Summary

Energy & Economics Game

Prepared By: Kimberly Villani

Overview & Purpose: There are many factors that influence the ability of renewable sources to be successful as large-scale electrical energy supplies. Students will be buying and selling electricity from various fossil fuel, renewable and other sources under different economic conditions (rising and falling prices) that will teach students about economic barriers and opportunities for renewable energy.

Objectives: *Students will...*

- Buy or sell energy, keep track of transactions, and make as much money as they can.
- Observe that relative price of energy sources change due to environmental regulations, availability, economic infrastructure, and the prices of competing energy sources.
- Be able to explain how economic conditions and technology can affect the price of renewable energy sources.
- Understand that there are multiple factors involved in determining the cost of electricity.

Background Information: Everyone depends on electricity, but deciding as a utility what source(s) to use/buy, or as an energy source deciding on cost to make sales/profit, is determined by various factors. Students will need a general understanding of the different energy sources of electricity used in this activity (fossil fuels, solar thermal, hydropower, nuclear, biomass, geothermal, photovoltaic, and wind) unless this is intended as an introduction to those types. Students should be able to conduct monetary transactions (add, subtract, or multiply).

NEXT GENERATION SCIENCE STANDARDS

Energy Literacy Essential Principles 5-7:

5 Energy decisions are influenced by economic, political, environmental, and social factors.
6 The amount of energy used by human society depends on many factors.
7 The quality of life of individuals and societies is affected by energy choices.

Classroom Activities/Procedures & Timeline

1. Introduction
2. Divide students into energy sources or utilities and provide appropriate worksheet.
3. Give energy sources paper or materials to make signs for sale.
4. Give utilities envelopes with starting money.
5. Run game (5 minute rounds).
6. Tally student data/lead discussion/allow time to finish worksheets.

Assessments: (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)

- Data Sheet & Questions
- Individual student discussion/feedback on activity

Extensions/Homework:

- Students could research one energy type, career, technology development, and/or location.
- If activity is done at the end of unit: have students link this activity to previous ones/learning outcomes.
- If activity is done at the beginning of unit: have students relate subsequent lessons to what was observed in this activity.

References:

Background information and/or data for discussion:

- http://www.ucsusa.org/clean_energy/smart-energy-solutions/increase-renewables/renewable-energy-electricity-standards-economic-benefits.html
- http://www.okcareertech.org/cac/Pages/resources_products/Career%20Path/CareerPath_interests.pdf

Original unit source:

- http://www.ucsusa.org/assets/documents/clean_energy/renewablesready_fullreport.pdf

Personal Comments/Notes:

This is a lesson of the middle school energy unit for middle school using Energy Literacy Essential Principles. It could be done in one to three periods or, using extensions, taught as a part of a larger unit on fossil fuels and/or renewable energy.

Equipment/Materials/ Technology Needed:

- Handouts
- Approx. $4000 in play money
- Envelopes
- Signs for selling
- Calculators

Teacher Resources:

(e.g., readings, set-up instructions, lecture files, data files, etc.):

- Teacher Background Sheet (2 pages)
- Class Tally Sheet(s)

Student Resources:

(e.g., handouts, worksheets, data, etc.):

- Data Sheet & Questions (utility or energy source), (2 pgs.)
- News Flash Cards (3 pages, 6 total)
- Technology & Supply Advance Cards

Accommodations & Safety Concerns:

Some students may need assistance or more of a breakdown with the math involved in making monetary transactions.

No safety concerns.

Lesson 5–TCH-429.17
Kimberly Villani

Energy & Economics Game

Teacher Background:

Some renewable energy sources can generate electricity at a price competitive with fossil fuels, but most utilities do not choose renewable energy because fossil fuels are cheap and accessible; many utilities are not familiar with renewable technologies; renewable energies are not appropriate in all areas; environmental costs are not reflected in the economic costs of fossil fuels and nuclear power; fossil fuels and nuclear industries are well established, but renewable industries are still small in comparison making them harder to get and often more expensive.

For more information: http://www.ucsusa.org/assets/documents/clean_energy/renewablesready_fullreport.pdf (P. 43-55)

Materials needed: (for 15+ students)

- Game instructions sheets for utilities & energy sources (enough per student or group)
- Energy source description cards (10)
- Technology and supply advance cards (10)
- News flash cards (10)
- Technology and Advance Cards (10)
- Utility play money-each $350 in an envelope ($50, $25, $10, $5, and $1 denominations)
- $500 extra (small denominations) for teacher or "banker" (total =$4000)
- Resources to make signs (energy sources)
- "Energy Marketplace" space/classroom area
- Class Tally Sheets (digital, overheads, etc. for class view)

Procedure:

1. Choose 10 students to be power plants or "energy sources" and give each an energy source selling card (biomass, hydropower, coal, nuclear, etc.) and materials to make a for sale sign (energy type, $$, number of units left).

2. Remaining students will be the utilities–give them a utility buyer card and a $350 envelope.

3. Explain that the teacher is the banker and then pass out instructions to students.

4. Use the following or similar "script" to give a student overview:

   "Today in the United States people are using more and more electricity every year. Those of you that are utilities provide electricity to American industry and the public, 24/7/365, at the cheapest price you can get it. Utilities, however, can choose from a variety of energy sources. Those of you that are energy sources represent power plants that generate electricity. (List sources here and/or have these students read their cards).

   Today's goal for everyone is to make as much money as possible (without cheating)!"

5 Go over instructions and stress the following points: make money, utilities must buy 5 units per round or be fined, energy sources don't need to sell all their units per round, and all students must keep track of the transactions made on their sheets.

6 Each round is 5 minutes. Run round 1 as a practice round. Read the first news flash card (can have copies for energy sources) to the class, and present the energy costs/# units for round 1 to the energy sources (or share with the whole class.) Tell energy sources that they must decide on a cost to sell to the utilities for this round (they can change them during a round, e.g. have a sale) and then to fill out their signs (dry erase boards work best).

7 Begin round by having students make transactions—be prepared for some noise.

8 During the round, have the utilities that have purchased all 5 units take a seat as well as any energy sources that sell out. Give a 1-minute warning and remind utilities that they will be fined if they don't purchase 5 units.

9 End round. Collect (banker) production costs from each energy source. Have students complete data sheets and address and problems or confusion that may have occurred.

10 Run rounds 2-6 the same as round 1 except draw one technology supply/advance card per round.

11 If anyone goes bankrupt, students may sit out or they could negotiate a loan (teacher should decide the protocol).

12 Have students complete questions and/or lead a discussion to get feedback from students as well as tally class results.

Notes:

ROUND 1

Business As Usual | Business is proceeding as usual in the U.S. energy industry.

The United States uses fossil fuels such as coal, natural gas, and oil for most of its electricity. Nuclear power provides 21 percent of U.S. electricity. Renewable energy provides only 10 percent, mostly from hydropower.

The U.S. government subsidizes the fossil fuel and nuclear power industries. Neither the utilities nor these industries have to pay fully for environmental problems caused by these energy sources.

By contrast, the government poorly funds the renewable energy industry. Renewable energy sources are not as well developed as they could be. However, some renewable sources, though not widely used, are already economically competitive with other sources for generating electricity.

Type	Production Cost	Availability	Type	Production Cost	Availability
Coal	6	50	Solar Thermal	9	1
Oil	8	10	Photovoltaics	25	1
Nat. Gas	6	25	Hydropower	6	6
Nuclear	10	25	Biomass	5	2
Geothermal	5	2	Wind	8	1

ROUND 2

NEWS FLASH! | AP – Growing concern over global warming has caused Congress to approve a "carbon tax" that will affect all utilities that burn fossil fuels.

When implemented, this tax will require utilities that burn coal, oil, and natural gas to pay a fee for each ton of carbon dioxide they produce.

This tax will make energy from fossil fuels more expensive and will encourage the development of renewable energy technologies.

Type	Production Cost	Availability	Type	Production Cost	Availability
Coal	10	50	Solar Thermal	9	2
Oil	10	10	Photovoltaics	25	2
Nat. Gas	7	25	Hydropower	6	7
Nuclear	10	25	Biomass	5	3
Geothermal	5	3	Wind	8	2

ROUND 3

NEWS FLASH! | AP – In an unexpected move, Congress removed research and development (R&D) subsidies for the nuclear power industry.

Over the last few decades, the Department of Energy spent a large portion of its R&D budget on nuclear energy. Over the next decade, the nuclear power R&D budget will be reduced by five percent per year, bringing nuclear research in line with research on renewable energy by 2010.

"We felt that federal funding for nuclear power was excessive in light of the nuclear industry's performance over the past 30 years," said Senate leader Neil O'Tip.

Congress also repealed the Price-Anderson Act, which limits a nuclear plant's liability in case of a nuclear accident. Nuclear plant insurance rates will now skyrocket.

Type	Production Cost	Availability	Type	Production Cost	Availability
Coal	10	50	Solar Thermal	9	3
Oil	10	10	Photovoltaics	25	3
Nat. Gas	7	25	Hydropower	6	7
Nuclear	13	15	Biomass	5	4
Geothermal	5	4	Wind	8	2

ROUND 4

NEWS FLASH! | AP – In what is perceived as a victory for the renewable energy industry, Congress today passed big new tax credits for renewable energy development.

Power producers that build new renewable energy plants instead of fossil fuel or nuclear plants will receive a large tax break. Congress enacted the tax credits to spur the development of clean, sustainable, renewable energy.

As a result of the tax credits, electricity from renewable sources is expected to become much more available. It should also be less expensive.

Type	Production Cost	Availability	Type	Production Cost	Availability
Coal	10	50	Solar Thermal	6	15
Oil	10	10	Photovoltaics	15	10
Nat. Gas	7	25	Hydropower	6	8
Nuclear	13	15	Biomass	5	10
Geothermal	5	6	Wind	5	15

ROUND 5

NEWS FLASH! | AP – Cloudy spell in California enters sixth week; confidence in solar energy plummets.

Thirty-six days of clouds, rain, and fog in most of California have caused utilities in that state to reconsider their heavy investments in solar energy. The freak weather has made electricity from California's solar thermal and photovoltaic power plants virtually unavailable, while increasing the demand for electricity as people spend more time indoors.

California utilities took advantage of renewable energy mix credits passed by Congress several years ago and have been buying solar thermal and photovoltaic units as fast as suppliers could provide them. Approximately 10 percent of California's energy is now provided by solar. Unfortunately, this electricity is available only when the sun is shining, as adequate methods of storage have not yet been perfected.

Concern over the reliability of solar energy has caused utilities to cancel orders for new solar thermal and photovoltaic plants. These cancellations are expected to cause bankruptcies and business failures in the relatively young solar industries.

Type	Production Cost	Availability	Type	Production Cost	Availability
Coal	10	50	Solar Thermal	6	7
Oil	15	5	Photovoltaics	11	5
Nat. Gas	13	25	Hydropower	6	9
Nuclear	20	15	Biomass	5	10
Geothermal	5	6	Wind	5	15

ROUND 6

NEWS FLASH! | AP – Iraq invades Kuwait; oil prices soar.

In a sneak attack, Iraqi troops pushed over the border into Kuwait late last night. Tensions between the two countries over oil-production quotas, which led to a similar conflict in 1991, had been mounting over the past year.

Hostilities between the two countries, which could be lengthy, are expected to impede the flow of oil from the Middle East to the United States. In early trading on international markets today, the price of oil was up $10/barrel.

Skyrocketing oil prices are almost certain to mean an increase in the cost of electricity. Although only three percent of the nation's electricity is generated from oil, a rise in oil prices has historically produced a parallel rise in the price of natural gas. Oil and gas together account for 19 percent of the nation's electricity production.

Type	Production Cost	Availability	Type	Production Cost	Availability
Coal	10	50	Solar Thermal	6	15
Oil	15	5	Photovoltaics	11	10
Nat. Gas	13	25	Hydropower	6	9
Nuclear	13	15	Biomass	5	10
Geothermal	5	6	Wind	5	15

ENERGY SOURCE CARDS

(Cut and Pass Out)

Wind

When wind blows on a wind turbine, its blades turn, powering an electricity generator. Electricity from wind is cheap, and it produces no pollutants. Wind turbine farms require large amounts of land, though, and only windy areas can generate electricity economically. Currently, wind generates electricity in large-scale wind farms as well as in small backyard operations.

Coal

Burning coal produces heat, which can then boil water and drive a steam turbine. Coal is a nonrenewable resource, but the United States has large reserves of it. Although it is one of the cheapest ways of generating electricity, burning coal produces more air pollution than other energy sources and contributes to global warming.

Geothermal

Geothermal energy is heat energy stored underground in Earth's crust, in water, rock, or magma. Geothermal energy from water reservoirs is cheap, although there are limited areas where it can be tapped. Other types of geothermal energy are under development.

Photovoltaics

A photovoltaic, or solar, cell converts sunlight directly into electricity, without any polluting by-products. Solar cells are practical for applications that are isolated from major power lines, but they are still expensive for utility-scale use. Technical advances and mass production will help bring their price down in the next decade.

Solar Thermal

In a solar thermal system, mirrors concentrate sunlight on a liquid, heating it into steam. This steam then turns a generator. Solar thermal energy is not yet widespread, and will probably be practical only in sunny regions.

Oil

Burning oil is used to drive a combustion turbine, an engine similar to those used in jet planes. Oil is a nonrenewable resource and is relatively cheap at pres¬ent. Much of our oil is imported from the Middle East, however, so our supply is vulnerable to conflicts in that region. Burning oil produces carbon dioxide, a heat-trapping gas, and other air pollutants.

Hydropower

Hydropower is energy from moving water. In a hydro¬electric dam, falling water turns a turbine, creating electricity. Hydropower generates about seven percent of U.S. electricity. Most feasible hydropower sites have already been developed, however. Building large new dams floods extensive areas, causing social and envi¬ronmental disruption.

Natural Gas

Burning natural gas is used to power a combustion turbine, similar to those used in jet planes. Domestic natural gas supplies are more limited than coal, making them vulnerable to sudden price increases as demand rises. Natural gas produces the least carbon dioxide and other air pollutants of any fossil fuel when it is burned.

Nuclear Fission

When unstable, or radioactive, atoms split, they produce large amounts of heat. Nuclear reactors use this heat to create steam, which then powers electricity generators. Nuclear energy is expensive, though, and can be dangerous. Radioactive leaks can pose problems to public health and safety, and the United States currently has no adequate method of disposing of radioactive waste.

Biomass

Biomass is plant matter that can be burned to produce heat & electricity or converted to liquid & gaseous fuels. Biomass can be organic material from trash and other wastes, or it can be grown for energy use. The price of biomass varies widely depending on its nature. Burning biomass produces carbon dioxide, a heat-trapping gas, but if the land used to grow biomass is replanted, the new plants remove equal amounts of carbon dioxide from the atmosphere, resulting in no net contribution to global warming.

Name: ____

UTILITY SHEET

Instructions:

- You will start the game with an envelope with $350. You must buy 5 units of energy each round. If the round ends before you have bought your units, you will have to pay the bank a fine equal to the highest price offered for a unit of energy during the round times the number of units you need.
- When each round begins, find out what prices different energy sources are offering. Then buy from as many sources as you wish, but keep the amount you spend as low as you can.
- Record on your buyer's card which kinds of energy you bought and how much each cost. At the end of each round, write down how much money you spent below.

Round 1

Energy Type	# Units Bought	Cost per Unit	Total Cost
1			
2			
3			
4			
5			

Round 2

Energy Type	# Units Bought	Cost per Unit	Total Cost
1			
2			
3			
4			
5			

Round 3

Energy Type	# Units Bought	Cost per Unit	Total Cost
1			
2			
3			
4			
5			

Round 4

Energy Type	# Units Bought	Cost per Unit	Total Cost
1			
2			
3			
4			
5			

Round 5

Energy Type	# Units Bought	Cost per Unit	Total Cost
1			
2			
3			
4			
5			

Round 6

Energy Type	# Units Bought	Cost per Unit	Total Cost
1			
2			
3			
4			
5			

Utilities Questions:

1 From which energy source(s) did you buy the most units throughout the game? Why did you choose to buy from the source(s)? Explain.

2 Do you think that cost should be the only factor in determining where utilities buy their electricity? Explain.

3 What 3 or 4 factors seem to influence the price of electricity? Did these factors cause the factors to increase or decrease?

4 Were any sources of energy consistently expensive or cheap? Why do you think it was this way?

5 Were environmental costs a factor in this game? Which energy sources would have the highest costs?

6 What are some ways renewable costs could decrease? Explain.

Conclusion:

7 What did you like or dislike about this game? Explain.

8 Was this game "fair"? Why or why not?

9 How do changes in energy prices affect the American consumer?

Name: ____

UTILITY SHEET

Instructions:

- Make as much money as you can each round, by selling energy units to utilities.
- At the beginning of each round, you will be given a production cost. This is how much it costs you to produce one unit of electricity from your source. A technology and supply advance card drawn at the beginning of each round could reduce this cost and increase the available amount of your energy source. Make sure that you write down any changes in cost caused by a technology or supply advance for your energy source.
- Since your goal is to make as much money as possible, charge utilities the highest price you can for one unit of energy. But remember, you're competing with other energy sources, so if you charge too much, utilities will buy from other sources.
- Before or during each round, you can ask other energy sources how much they plan to charge per energy unit. This will give you a sense of how much you should charge. If you need to, change the price you offer during the round to remain competitive.
- Keep track of the number of energy units you sold during a round, and the price you charged for each unit. Write this information down on your energy source selling table at the end of the round. Since some energy resources are limited, you cannot sell more energy then you have available for each round. Any unsold units remaining at the end of the round are forfeited.
- At the end of each round, you must pay the banker your total production cost. This amount is the production cost per energy unit multiplied by the number of units you sold.
- Record how much money you have left after you pay the banker and be sure table is filled out below.

	Amount to Sell	Production Cost	Total # Sold	Amount to pay banker (Production cost x # sold)	Profit (money left)	Price(s) per units sold
ROUND 1						
ROUND 2						
ROUND 3						
ROUND 4						
ROUND 5						
ROUND 6						

Questions:

1 Were you able to sell all your energy units each round?

2 What change(s) gave you the most units to sell (greater availability)?

3 What factors got more utilities to buy from you and how did you encourage sales?

4 Why did you have to pay production costs each round? What does this cost represent?

5 What factor influenced your production costs?

6 How environmentally “clean” was your energy source? Were the environmental impacts of your energy source included in your cost?

Conclusion:

7 What did you like or dislike about this game? Explain.

8 Was this game “fair”? Why or why not?

9 How do changes in energy prices affect the American consumer?

TECHNOLOGY AND SUPPLY ADVANCE CARDS
(per round)

TECHNOLOGY ADVANCE!

Scientists develop new techniques for producing photo¬voltaic cells, doubling their efficiency and slashing their production cost in half.

- Photovoltaic production costs are $5 less, and 4 additional units are available.

TECHNOLOGY ADVANCE!

Energy engineers perfect the parabolic trough system, a method of solar thermal electricity generation. Now it can produce electricity at lower cost and with increased efficiency.

- Solar thermal production costs are $2 less, and 5 more units are available.

TECHNOLOGY ADVANCE!

Energy engineers develop new techniques for burning coal. Coal-fired power plants will now burn coal more efficiently and produce fewer pollutants. As a result, electricity generation from coal will cost less.

- Coal production costs are $1 less.

SUPPLY ADVANCE!

Extensive new reserves of natural gas have been discov¬ered in the United States.

- Natural gas production costs are $2 less, and 5 more units are available.

TECHNOLOGY ADVANCE!

A new gas-cooled nuclear reactor is developed. This reactor, when standardized and developed across the country, will provide electricity more cheaply and safely than before.

- Nuclear production costs are $2 less, and 5 more units are available.

TECHNOLOGY ADVANCE!

Geological engineers discover how to harness hot dry rock, a form of geothermal energy.

- 10 more units of geothermal energy are available.

TECHNOLOGY ADVANCE!

The ZP5552 model wind turbine, called "the biggest breakthrough in wind technology since the sailboat," has hit the markets. This ultra-efficient, low-cost wind turbine will slash wind-generation prices.

- Wind production costs are $3 less, and 10 more units are available.

SUPPLY ADVANCE!

Opening the Alaska National Wildlife Refuge to oil drill¬ing increases U.S. reserves of oil.

- 1 more unit of oil is available.

TECHNOLOGY ADVANCE!

An efficient technology for converting wood to a com¬bustible gas has been developed. This technology should reduce the cost and increase the availability of biomass energy.

- Biomass production costs are $1 less, and 5 more units are available.

TECHNOLOGY ADVANCE!

New, small-scale hydro technologies are developed, resulting in a decrease in cost and increase in availability.

- Hydropower production costs are $1 less, and 2 more units are available.

ENERGY UNITS PURCHASED BY UTILITIES

	COAL	OIL	NATURAL GAS	NUCLEAR	SOLAR THERMAL	PHOTOVOLTAIC	WIND	GEOTHERMAL	HYDROPOWER	BIOMASS
ROUND 1										
ROUND 2										
ROUND 3										
ROUND 4										
ROUND 5										
ROUND 6										

ENERGY SOURCE PROFITS

ROUND 1										
ROUND 2										
ROUND 3										
ROUND 4										
ROUND 5										
ROUND 6										