Playing It Cool: A Renewable Energy Economics Game

This game simulates some of the economic changes necessary to make renewables succeed as large-scale electricity sources. Students buy and sell electricity from various sources—coal, oil, natural gas, nuclear, and renewables—under a variety of economic conditions. By seeing prices rise and fall, students learn about economic barriers and opportunities for renewables.

In the United States today, some renewable sources can generate electricity at a price competitive with fossil fuels, but most utilities do not opt for renewables. Why is this? For the following reasons:

- Oil, coal, and natural gas are cheap and easily accessible (as of 2001).
- Many utilities are unfamiliar with renewable energy technologies, which are generally very different from conventional fossil fuel technologies.
- At the present time, renewables are not appropriate in all areas.
- Environmental costs are not reflected in the economic costs of fossil fuels and nuclear power.
- The fossil fuel and nuclear industries are well established, whereas the renewable industries are still small in comparison. This makes energy from renewables harder to get and, in some cases, more expensive.

Through the game, students should:

1. Observe that the relative price of renewables changes according to environmental regulations, renewables' availability, economic infrastructure, and the prices of fossil fuel and nuclear power.

2. Be able to explain how these economic conditions affect the price of renewables.

3. Understand the concept of a "level playing field." A level playing field is a state of open economic competition where energy sources are subsidized equally and where an energy source's environmental cost is reflected in its price.

GRADES: 8–12

SUBJECTS: social studies, economics, math

TIME: three to five 45-minute class periods

MATERIALS:
- 20 or fewer copies of the game instructions (student handout, pg. 47)
- 10 energy source description cards (pg. 48)
- 10 technology and supply advance cards (pg. 49)
- 5 News Flash pages (pg. 50; you may want to make these into transparencies)
- 10 or fewer copies of utility buyer cards (pg. 53)

- 10 copies of energy source selling cards (pg. 54)
- index cards
- tape
- $350 worth of play money for each utility, in $1, $5, $10, $20, and $50 denominations
- $500 extra play money, in small denominations, for teacher

PLAYERS NEEDED: at least 15 students

PREPARATION:

1. Photocopy game instructions, energy source description cards, utility buyer cards, and energy source selling cards.

2. Prepare transparencies of News Flash pages.

3. Prepare approximately $4,000 worth of play money.

Note: This is a rewarding but complex game, which will work best when students have some knowledge of renewable energy and/or economics, and when there is plenty of time for play and discussion. During the rounds, the "energy marketplace" will be somewhat chaotic.

PROCEDURE:

1. Tell students they'll be participating in a game about renewable energy called "Playing It Cool."

   a. Clear the center of the room to form a marketplace.
   b. Pick 10 students to be power plants representing different energy sources. Give each a different energy source description card (coal, oil, nuclear, natural gas, solar thermal, photovoltaics, wind, hydropower, biomass, and geothermal), an energy source selling card, and an index card. These students should write the name of their energy source on the index card and tape it to the front of their shirts. This will allow the utilities to identify the energy sources quickly during the game.
   c. Assign the rest of the students to be utilities. If more than 10 students are left, ask some students to team up as one utility. Give each a utility buyer card and $350.
   d. Tell students that you will be the banker for the game.
   e. Distribute copies of the instructions (student handout) to all students.

2. Read the following out loud to the class (or improvise your own material):

   "The year is [current year], the place, the United States. The American economy is sputtering along, using more and more electricity each year.

   [Pointing to students with utility cards] "You people are the utilities, and you provide electricity to American industry and the public. As utilities, you must provide electricity every hour, every day—at the cheapest price you can get it.

   "You can choose to purchase electricity from a variety of energy sources. These people here represent power plants generating electricity using various energy sources [ask them to raise their hands as you read their names]: coal, oil, natural gas, nuclear, solar thermal, photovoltaics, wind, hydropower, biomass, and geothermal. [Ask each energy source to read his or her description card out loud.]

"Your goal—as either a utility or energy source—is to make as much money as you can. As utilities, you buy from the energy sources offering the lowest prices. As energy sources, you offer energy at prices that are high enough for you to make money and low enough that utilities will want to buy energy from you."

3. Go through the specific instructions (student handout) with the students. You may want to read the instructions out loud to the class. You should stress the following points:

   - The goal of the game is to make money.
   - Utilities *must* buy five energy units per round, or be fined. Energy sources do not, however, need to sell all of their units in any given round.
   - Students must keep records of their purchases and sales.

4. Begin the game. Tell students that each round will last five minutes.

   Run through Round 1 as a sample round. Begin by reading News Flash 1, and then read the production costs to the energy sources (or project them on a transparency). Next, pick one technology and supply advance card randomly and read it out loud. Each technology or supply advance changes prices for the duration of the game. Make sure the energy sources write the numbers down. Give the energy sources time to ask each other what prices they plan to set during the round. This will give them a preliminary sense of what price to offer, although they can change it during the round.

   Announce that the marketplace is open. Energy sources may write their selling prices on a piece of paper to hold up for utility buyers.

   When an energy source has sold all of his or her units, he or she should sit down. Similarly, utilities that have purchased their five units of energy for the round should sit down. Announce to the class when one minute is left in the round. Remind utilities that they will be forced to pay a fine if they do not purchase five units of energy.

   When five minutes are up, announce that the energy marketplace is closed. Give students a few minutes to record their sales, purchases, and profits. Collect production costs from the energy sources.

   After the round, review the directions if problems arose. You may want to run this round again, now that students know what to expect.

5. Run Rounds 2, 3, 4, 5, and 6 like Round 1.

   It is possible that some energy sources or utilities may go bankrupt. You may allow them to solicit each other for loans, or simply sit out for the rest of the game.

6. After the final round, discuss the game with the class. Draw a version of the Class Data Sheet (pg. 55) on the blackboard, and get students to fill in the data themselves. After this is done, you may ask students any or all of the following questions:

   General questions:

   a. What did you like or dislike about this game? Was it "fair"?

   b. How do changes in energy prices affect the average American consumer? Ask students to imagine how they would be affected by price changes.

Questions for utilities:

a. From which energy source(s) did you buy the most units throughout the game? What influenced your decision to buy units from these sources?

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

c. List three or four factors that seemed to influence the price of energy. Did these factors cause the prices to increase or decrease?

d. Were any sources of energy consistently expensive or consistently cheap? Why do you think the game was set up that way?

e. Are environmental costs figured into the cost of energy in this game? Which energy sources would have the highest environmental costs?

f. Do you think that energy prices in the United States are determined by a free, open, competitive market? In your opinion, should the government encourage renewable energy use through subsidies?

Questions for energy sources:

a. Were you able to sell all of your units of energy each round?

b. What change(s) gave you more units to sell (greater availability)?

c. What factor(s) seemed to influence the utilities to buy from you? How did you try to encourage them to do so?

d. Why did you have to pay a production cost at the end of each round? What does this cost represent? Be as specific as possible. (Answers could include cost of machinery, land, labor, etc.)

e. What factors influenced your production costs?

f. Environmentally speaking, how "clean" was your energy? Were the environmental effects of producing electricity from your energy source included in its cost?

g. Do you think that energy prices in the United States are determined by a free, open, competitive market? In your opinion, should the government encourage renewable energy use through subsidies?

7. You may want to end by reviewing some of the material covered.

One way to wrap up is to have students discuss how this game differs from real life. The following are some of the important points to stress:

a. Energy conservation is not an option in this game. In general, it is cheaper to use energy more efficiently than it is to purchase or produce additional energy.

b. Economic change usually occurs slowly. Change does not always happen with sudden "news flashes." Energy source availability, for instance, usually changes gradually, but unexpected international events or environmental disasters can lead to sudden changes.

Playing It Cool: Student Instructions

STUDENT HANDOUT

UTILITIES:

You will start the game with $350.

You must buy five 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.*

Write down 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.

ENERGY SOURCES:

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 card 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.

Mark down how much money you have left after you pay the banker.

ENERGY SOURCE DESCRIPTION CARDS

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 windfarms as well as in small backyard operations.

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.

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.

Hydropower

Hydropower is energy from moving water. In a hydroelectric 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 environmental disruption.

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.

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.

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.

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 present. 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.

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.

Biomass

Biomass is plant matter that can be burned to produce heat and electricity or converted to liquid and gaseous fuels. Biomass can be organic material from trash and other wastes, or it can be grown specially 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.

TECHNOLOGY AND SUPPLY ADVANCE CARDS
(Cut these out, mix them up, and pick one at the beginning of each round)

TECHNOLOGY ADVANCE!

Scientists develop new techniques for producing photovoltaic 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 discovered 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 drilling increases U.S. reserves of oil.

- 1 more unit of oil is available.

TECHNOLOGY ADVANCE!

An efficient technology for converting wood to a combustible 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.

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 renewable energy industry is poorly funded by the government. 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.

	Production Cost (dollars per unit)	Availability (units per round)		Production Cost (dollars per unit)	Availability (units per round)
Coal	6	50	Solar Thermal	9	1
Oil	8	10	Photovoltaics	25	1
Natural Gas	6	25	Wind	8	1
Nuclear	10	25	Hydropower	6	6
			Biomass	5	2
			Geothermal	5	2

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.

	Production Cost (dollars per unit)	Availability (units per round)		Production Cost (dollars per unit)	Availability (units per round)
Coal	10	50	Solar Thermal	9	2
Oil	10	10	Photovoltaics	25	2
Natural Gas	7	25	Wind	8	2
Nuclear	10	25	Hydropower	6	7
			Biomass	5	3
			Geothermal	5	3

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.

	Production Cost (dollars per unit)	Availability (units per round)		Production Cost (dollars per unit)	Availability (units per round)
Coal	10	50	Solar Thermal	9	3
Oil	10	10	Photovoltaics	25	3
Natural Gas	7	25	Wind	8	3
Nuclear	13	15	Hydropower	6	7
			Biomass	5	4
			Geothermal	5	4

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.

	Production Cost (dollars per unit)	Availability (units per round)		Production Cost (dollars per unit)	Availability (units per round)
Coal	10	50	Solar Thermal	6	15
Oil	10	10	Photovoltaics	15	10
Natural Gas	7	25	Wind	5	15
Nuclear	13	15	Hydropower	6	8
			Biomass	5	10
			Geothermal	5	6

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.

	Production Cost (dollars per unit)	Availability (units per round)		Production Cost (dollars per unit)	Availability (units per round)
Coal	10	50	Solar Thermal	6	7
Oil	15	5	Photovoltaics	11	5
Natural Gas	13	25	Wind	5	15
Nuclear	20	15	Hydropower	6	9
			Biomass	5	10
			Geothermal	5	6

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.

	Production Cost (dollars per unit)	Availability (units per round)		Production Cost (dollars per unit)	Availability (units per round)
Coal	10	50	Solar Thermal	6	15
Oil	15	5	Photovoltaics	11	10
Natural Gas	13	25	Wind	5	15
Nuclear	13	15	Hydropower	6	9
			Biomass	5	10
			Geothermal	5	6

UTILITY BUYER'S CARD
(Buy 5 units of energy each round)

		KIND OF ENERGY BOUGHT	COST
ROUND 1	1.		
	2.		
	3.		
	4.		
	5.		
		TOTAL:	
ROUND 2	1.		
	2.		
	3.		
	4.		
	5.		
		TOTAL:	
ROUND 3	1.		
	2.		
	3.		
	4.		
	5.		
		TOTAL:	
ROUND 4	1.		
	2.		
	3.		
	4.		
	5.		
		TOTAL:	
ROUND 5	1.		
	2.		
	3.		
	4.		
	5.		
		TOTAL:	
ROUND 6	1.		
	2.		
	3.		
	4.		
	5.		
		TOTAL:	

ENERGY SOURCE SELLING CARD

_____

(name of your energy source here)

	PRODUCTION COST	AMOUNT AVAILABLE TO SELL	AMOUNT SOLD	AMOUNT TO PAY BANKER (production cost x amount sold)	PROFIT (money left)
ROUND 1					
ROUND 2					
ROUND 3					
ROUND 4					
ROUND 5					
ROUND 6					

CLASS DATA SHEET

ENERGY UNITS PURCHASED
(to be filled in by utilities)

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

ENERGY SOURCE PROFITS
(to be filled in by energy sources)

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