Mission Possible: Energy Trade-offs

2011-2012

Students work in groups to develop an energy plan to provide more electricity for a growing country.

ENERGY SOURCES

Grade Level:
- Intermediate
- Secondary

Subject Areas:
- Science
- Social Studies
- Language Arts
- Math
- Technology

NEED
National Energy Education Development Project

Teacher Advisory Board

NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

Teacher Advisory Board Statement

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

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Energy Data Used in NEED Materials

NEED believes in providing the most recently reported energy data available to our teachers and students. Most statistics and data are derived from the U.S. Energy Information Administration's Annual Energy Review that is published in June of each year. Working in partnership with EIA, NEED includes easy to understand data in our curriculum materials. To do further research, visit the EIA web site at www.eia.doe.gov. EIA's Energy Kids site has great lessons and activities for students at www.eia.doe.gov/kids.

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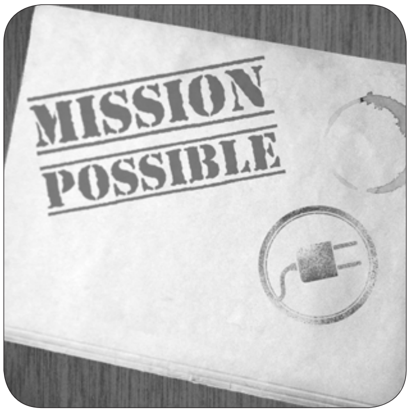

Mission Possible: Energy Trade-offs

Data regarding the cost of electricity is from the Department of Energy's Energy Information Administration, www.eia.doe.gov.

Table of Contents

RECOMMENDED or SAMPLE ENVIRONMENTAL IMPACT UNITS

	FACILITIES	ENVIRONMENTAL IMPACT (EU)
1	Existing Modern Plants	800 EU
2	Modernized Coal Plants	250 EU
3	New Coal Plants	50 EU
4	Wind Farms	0 EU
5	Hydropower Dams	10 EU
6	Nuclear Plants	20 EU
7	Waste-To-Energy Plants	2 EU
8	Natural Gas Plants	30 EU
9	Geothermal Plants	10 EU
10	Solar Plants	0 EU

Correlations to National Science Education Standards: Grades 5-8

This book has been correlated to National Science Education Content Standards.

For correlations to individual state standards, visit **www.NEED.org**.

Content Standard B | *PHYSICAL SCIENCE*

- **Properties and Changes of Properties in Matter**
  - A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.

- **Transfer of Energy**
  - Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
  - In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light mechanical motion, or electricity might all be involved in such transfers.
  - The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

Content Standard C | *LIFE SCIENCE*

- **Populations and Ecosystems**
  - For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.

Content Standard D | *EARTH AND SPACE SCIENCE*

- **Structure of the Earth System**
  - Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues.
  - Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.

Content Standard E | *SCIENCE AND TECHNOLOGY*

- **Understandings about Science and Technology**
  - Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.

Content Standard F | *SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES*

- **Risks and Benefits**
  - Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air, water, soil, and food), with biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking).

- **Science and Technology in Society**
  - Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.

Teacher Guide

Students recognize and evaluate the economic, environmental, and societal trade-offs of the major energy sources used to generate electricity.

Background

Mission Possible: Energy Trade-offs is a cooperative learning activity in which intermediate and secondary students evaluate the advantages and disadvantages of the energy sources used to generate electricity by developing energy plans for a fictitious country and presenting the plans to the class. Several options with different levels of difficulty are provided for the activity. The activity includes a limited number of variables and is not intended to reflect the realities of the global or national economies.

Concepts

- All energy sources have economic, environmental, and societal advantages and disadvantages.
- Economic and environmental impacts are determining factors in the energy sources we use to produce electricity.
- Societal needs, personal beliefs, and changes to the quality of life are important considerations in determining the energy sources we use.
- No one energy source can meet the needs of society today; a variety of energy sources is needed.
- Some energy sources cannot be counted on to produce consistent amounts of electricity 24-hours a day or in all seasons and weather conditions (wind, solar, hydropower).

Time

- Five to seven class periods, plus homework.

Skill Reinforcement

- Critical thinking
- Math––number manipulation––positive and negative integers
- Cooperative learning
- Comparison and contrast
- Negotiation and compromise
- Evaluation of multiple factors
- Presentation and persuasion

Materials and Preparation

- Familiarize yourself with the Teacher and Student Guides. Experiment with several options to decide which option you will use. It is recommended that you complete the activity yourself before assigning it to your students.
- Make one copy of the Student Guide, *Mission Impossible Energy Plan*, and *Facts about Energy Sources and Power Plants* for each student, plus one extra copy of the *Mission Impossible Energy Plan* for each group.
- Make a master of the *Sample Energy Plan* for use with younger students.
- Make available NEED's *Intermediate* or *Secondary Infobooks* as resources on the energy sources.
- Make available computers with spreadsheet capabilities. A sample spreadsheet is available on the NEED web site at www.NEED.org.

Procedure

Option 1 (Simple)

Students use sample environmental impacts and a pre-designed spreadsheet to develop energy plans .

Individual computers with Excel software and spreadsheet from NEED web site pre-loaded.

DAY ONE

- Provide each student with a copy of the Student Guide and *Facts about Energy Sources and Power Plants* and explain the activity to the class. Make sure the students understand that this activity is an exercise to explore trade-offs and the need for multiple energy sources. The activity includes a limited number of variables and is not intended to reflect the realities of the global or national economies. In addition, explain that some energy sources, such as solar and wind, do not produce consistent amounts of electricity all the time, so their total capacity must be increased when choosing these sources. Note also that several energy sources—wind, hydropower, and waste-to-energy—include a limited number of facilities that can be built because of geographical or fuel limitations. Make sure that the students understand that when the old coal plants are modernized, the total environmental impact does not change while total capacity increases, so that the environmental impact per megawatt is reduced with the addition of pollution control devices.
- Review the Student Guide and answer any questions about the activity. Give the students the sample environmental impact figures (from page 3) and have them write them on the blank lines in their Student Guides. Discuss whether students agree or disagree with the sample figures.
- Provide each student with a *Mission Impossible Energy Plan*. Explain that the students will use a pre-designed spreadsheet to formulate their individual energy plans. Use a transparency of the *Sample Energy Plan* to explain the assignment to the class.
- Instruct each student to formulate an individual energy plan, using the *Mission Possible Spreadsheet* that is downloadable from the NEED web site.

DAY TWO

- Divide the class into groups of three–to–five students. Provide a copy of the *Mission Impossible Energy Plan* to each group. Explain that each group will use their individual plans to form a consensus and develop a group energy plan to present to the class.

DAYS THREE AND FOUR

- Have each group present their Energy Plan to the class. The time for this step will depend upon how much discussion you allow with each presentation. You may wish to have the class, acting as a Citizens' Council, vote on each plan after it is presented.

DAY FIVE: EVALUATION AND ASSESSMENT

- Evaluate student performance using class participation, individual plans, group participation, and presentations.
- Design or select two energy plans and have the students evaluate them and write an essay explaining which one they think is the better one.
- Complete the Evaluation Form on page 15 with the class and mail or fax to NEED Headquarters.

Option 2 (Moderate and Technology Intensive)

Students determine environmental impacts and create spreadsheets with formulas provided to develop energy plans.

Individual computers with Excel software required. Instruction necessary in basic spreadsheet development.

- Provide each student with a copy of the Student Guide and *Facts about Energy Sources and Power Plants* and explain the activity to the class. Make sure the students understand that this activity is an exercise to explore trade-offs and the need for multiple energy sources. The activity includes a limited number of variables and is not intended to reflect the realities of the global or national economies. In addition, explain that some energy sources, such as solar and wind, do not produce consistent amounts of electricity all the time, so their total capacity must be increased when choosing these sources.
- Review the Student Guide and answer any questions about the activity.
- Sample environmental impact figures have been provided on page 3. The importance of environmental impact is subjective and difficult to quantify, It is suggested that you take a class period to allow the students, as a class, to determine the environmental impact figures for the activity. Provide the class with the sample figures as a starting point and discuss the advantages and disadvantages of each energy

source. If students have difficulty agreeing upon an impact figure, determine the class average for use in the activity. Be aware that if students place too much emphasis on environmental impact, without consideration of economic impact, they will not be able to develop a plan with the funds available.

- After the class has determined an Environmental Impact figure for each energy source, have the students record the figures on the blank lines in their Student Guides.

NOTE: If you do not give the students the numbers from the sample plan as reference figures, point out that the old coal-fired plants produce 50 EU environmental impact Units) per plant; when the five plants are modernized, each plant's total environmental impact remains the same, but its capacity is increased by 10 MW, resulting in reduced environmental impact per MW.

DAYS TWO AND THREE

- Provide each student with a *Mission Impossible Energy Plan* Form. Explain that the students will create a spreadsheet to formulate their individual energy plans. Use a transparency of the *Sample Energy Plan* to explain the assignment to the class.
- Instruct each student to design a spreadsheet of the *Mission Impossible Energy Plan* using the formulas on the next page. You can provide all or samples of the formulas, depending on the level of competency with Excel.
- When the students have created their spreadsheets, instruct them to formulate individual energy plans.

DAY FOUR

- Divide the class into groups of three–to–five students. Provide a copy of the *Mission Impossible Energy Plan* to each group. Explain that each group will use their individual plans to form a consensus and develop a group energy plan to present to the class.

DAYS FIVE AND SIX

- Have each group present their energy plan to the class. The time for this step will depend upon how much discussion you allow with each presentation. You may wish to have the class, acting as a Citizens' Council, vote on each plan after it is presented.

DAY SEVEN: EVALUATION AND ASSESSMENT

- Evaluate student performance using class participation, individual plans, group participation, and presentations.
- Design or select two energy plans and have the students evaluate them and write an essay explaining which one they think is the better one.
- Complete the *Evaluation Form* on page 15 with the class and mail or fax to NEED Headquarters.

Option 3 (Challenging and Technology-Intensive)

Students determine environmental impacts and create their own spreadsheets. Individual computers with Excel software required. Competency required in basic spreadsheet development.

- Follow the instructions for Option 2, except that students must design their individual spreadsheets without being provided the formulas.

Option 4 (Difficult and Math-Intensive)

Students determine environmental impacts and develop individual energy plans using calculators.

- Follow the instructions for Option 2, except that students develop their energy plans without spreadsheets.

Extensions

- Have students draw maps of Essowess and their individual plans.
- Have students research the area in which they live and write a persuasive paper explaining the type of power plant that should be built to provide added electricity.
- Have students research ways to lower electricity consumption in their community.
- Have students participate in NEED's *Energy Conservation Contract* activity.

Master Spreadsheet with Formulas

ROW	A	B	C	D	E	F	G	REFERENCE FIGURES		
	FACILITIES	# of plants to build	ENVIRO IMPACT (EU) for my plan	ECONOMIC COST ($$) for my plan	CAPACITY MW for my plan	COST OF ELECTRICITY for one kW	TOTAL COST for my plan	Economic Cost to add 1 plant	Capacity in MW of one plant	Enviro Impact for one plant
3	Existing Modern Plants	20	800	800	800	0.05	=E3*F3			
4	Modernize 5 Existing Coal Plants	5	250	250	250	0.05	=E4*F4	40	50	50
5	Build New Coal Plants		=B5*50	=B5*40	=B5*50	0.05	=E5*F5	17	10	3
6	Build up to 2 Biomass Waste-to-Energy Plants		=B6*3	=B6*17	=B6*10	0.06	=E6*F6	25	20	4
7	Build up to 3 Geothermal Plants		=B7*4	=B7*25	=B7*20	0.04	=E7*F7	110	50	10
8	Build up to 2 Hydropower Dams		=B8*10	=B8*110	=B8*50	0.01	=E8*F8	50	50	30
9	Build Natural Gas Plants		=B9*30	=B9*50	=B9*50	0.06	=E9*F9	85	100	20
10	Build Nuclear Plants		=B10*20	=B10*85	=B10*100	0.07	=E10*F10	30	10	0
11	Build Solar Plants		=B12*0	=B11*30	=B12*10	0.02	=E11*F11	9	10	0
12	Build up to 5 Wind Plants		=B12*0	=B12*9	=B12*10	0.04	=E12*F12			
13	**TOTALS**		**=SUM(C3:C12)**	**=SUM(D3:D12)**	**=SUM(E3:E12)**		**=SUM(G3:G12)/E13**			
15	**GOAL**		**1200**	**1700**	**=1500+B11+B12**	**0.05**				

To determine the average cost of electricity per kWh, use the following formula:

Total Cost of all Sources / Total Capacity of all Sources

***Rows are numbered as they are in an Excel spreadsheet.**

Student Guide

Your Mission

Your team has been hired by the governor of Essowess to develop a plan to expand the electricity capacity for the country. The country is growing and has begun to experience brownouts during peak demand times. Your mission is to develop a plan that will meet the electricity demand of Essowess economically, while maintaining the quality of the country's environment.

Essowess has many energy resources that can be used to produce the electricity it will need in the future. You can use any mixture of sources, and as many of each as allowed, as long as you produce the required amount of electricity, while staying within your budget and maintaining the environmental quality of the country. You must convince the governor and the citizens of the country that your plan is the best possible plan for everyone, in terms of jobs, the environment, and the cost of electricity and changes in lifestyle. If your plan costs more than is budgeted, damages the environment more than is acceptable, or raises the cost of electricity, you must win the approval of the Citizens' Council.

Your Goal

	CURRENT STATUS	YOUR GOAL:
Capacity	**1,000 MW**	**1,500 MW**
20 Modern Plants @ 40 MW	*800 MW*	
5 Old Plants @ 40 MW	*200 MW*	
Economic Cost:	**1,000 energy bucks ($$)**	**1,700 energy bucks ($$)**
20 Modern Plants @ 40 $$	*800 $$*	
5 Old Plants @ 40 $$	*200 $$*	
Environmental Cost:	**1,050 enviro-units (EU)**	**1,200 enviro-units (EU)**
20 Modern Plants @ 40 EU	*800 EU*	
5 Old Plants @ 50 EU	*250 EU*	
Cost of Electricity:	**$0.05 kWh**	**$0.05 kWh**

Your Options

Current Facilities

At the present time, 25 coal-fired plants provide Essowess with all of its electricity. Twenty of the plants have modern pollution control devices. Five of the plants are old and must be modernized because they have no pollution control devices. When the old plants are modernized, their total environmental impact remains the same, but their capacity is increased, resulting in lower environmental impact per megawatt.

TO MODERNIZE EACH OLD PLANT:	
Economic Cost (to modernize):	*15 $$*
Economic Cost (job gain):	*–5 $$*
Additional Capacity:	*10 MW*
Additional Environmental Impact:	*0 EU*
Cost of Electricity:	*$0.05 kWh*

COAL-FIRED PLANTS: Coal is an abundant resource in Essowess. The country has a 150–year supply of coal at the current rate of consumption. Half of the reserves, however, are located in wilderness areas.

TO BUILD EACH PLANT (NO MAXIMUM):

Economic Cost (to build):	*50 $$*
Economic Cost (job gain):	*–10 $$*
Capacity:	*50 MW*
Environmental Impact:	*_______________ EU*
Cost of Electricity:	*$0.05 kWh*

WIND FARMS: There are not many places on Essowess that have consistent winds. Along the eastern coastline, however, the wind blows at a rate that would run wind machines most of the year. Some residents along the coast would like to turn the area into a tourist area with resort hotels. Wind farms cannot be counted on to produce electricity 24 hours a day, every day of the year. For every wind farm you build, you must add 1 MW to your capacity goal of 1500 MW.

TO BUILD EACH WIND FARM (MAXIMUM 5–DETERMINED BY SITES WITH ACCEPTABLE WIND SPEED):

Economic Cost (to build):	*10 $$*
Economic Cost (land use loss):	*1 $$*
Economic Cost (job gain):	*–2 $$*
Capacity:	*10 MW*
Environmental Impact:	*_______________ EU*
Cost of electricity:	*$0.04 kWh*

HYDROPOWER PLANTS: The powerful Aichtuwoe River flows from the Osohi Mountains through farmland and a national park to the coast of Essowess. Two hydroelectric dams could be built on the river to produce electricity. There is no other river that can be dammed to produce hydropower.

TO BUILD EACH DAM (MAXIMUM 2–DETERMINED BY ACCEPTABLE SITES ON RIVER):

Economic Cost (to build):	*100 $$*
Economic Cost (land use loss):	*20 $$*
Economic Cost (job/recreation gain):	*–10 $$*
Capacity:	*50 MW*
Environmental Impact:	*_______________ EU*
Cost of electricity:	*$0.01 kWh*

NUCLEAR POWER PLANTS: Essowess has an abundance of uranium that could be mined and processed, providing jobs for many people, if there were a demand. Many people are concerned about nuclear power plants because the country has no place at present to store the spent fuel.

TO BUILD EACH PLANT (NO MAXIMUM):

Economic Cost (to build):	*100 $$*
Economic Cost (job gain):	*–15 $$*
Capacity:	*100 MW*
Environmental Impact:	*_______________ EU*
Cost of electricity:	*$0.07 kWh*

WASTE-TO-ENERGY PLANTS: The non-recyclable trash in Essowess is currently being landfilled. The combustible material in that trash (such as plastics, organic wastes, paper products, etc.) could be burned to produce electricity and reduce the amount of trash sent to landfills. There is enough combustible trash produced to fuel two power plants at the present time.

TO BUILD EACH PLANT (MAXIMUM 2–DETERMINED BY AMOUNT OF ACCEPTABLE TRASH):

Economic Cost (to build):	*20 $$*
Economic Cost (decreased disposal):	*–3 $$*
Capacity:	*10 MW*
Environmental Impact:	_______________ *EU*
Cost of Electricity:	*$0.07 kWh*

NATURAL GAS PLANTS: At present, there is no available natural gas supply on Essowess to fuel natural gas power plants. Geologists believe there are offshore deposits; however, a production and distribution system must be built. This would increase the investment cost, but also provide jobs.

TO BUILD EACH PLANT (NO MAXIMUM):

Economic Cost (to build):	*80 $$*
Economic Cost (job gain):	*–30 $$*
Capacity:	*50 MW*
Environmental Impact:	_______________ *EU*
Cost of Electricity:	*$0.06 kWh*

GEOTHERMAL POWER PLANTS: Several high temperature geothermal reservoirs are located in a wilderness area named for the country's founder, who is buried in a shrine near one of the reservoirs.

TO BUILD EACH PLANT (MAXIMUM 3–DETERMINED BY NUMBER OF RESERVOIRS):

Economic Cost (to build):	*30 $$*
Economic Cost (job gain):	*–5 $$*
Capacity:	*20 MW*
Environmental Impact:	_______________ *EU*
Cost of Electricity:	*$0.04 kWh*

SOLAR POWER PLANTS: The amount of solar radiation in all seasons and in all locations in the country makes it possible to use photovoltaic power plants to produce electricity. Solar systems, however, do not produce electricity 24 hours a day or every day of the year. For every solar plant you build, you must add 1 MW to your capacity goal of 1500 MW.

TO BUILD EACH PLANT (NO MAXIMUM):

Economic Cost (to build):	*30 $$*
Economic Cost (land use loss):	*2 $$*
Economic Cost (job gain):	*–2 $$*
Capacity:	*10 MW*
Environmental Impact:	_______________ *EU*
Cost of Electricity:	*$0.02 kWh*

Facts About Energy Sources and Power Plants

Coal-Fired Plants

- Use an abundant domestic resource—coal.
- Burn coal—the mining of which can damage land and pollute water if not managed well.
- Emit some pollutants into the air when burned, even if advanced anti-pollution measures are installed.
- Produce carbon dioxide (CO_2) when burned.
- Use a nonrenewable resource as fuel.

Wind Farms

- Require a lot of land, but the land can also be used for other purposes.
- Do not produce electricity all of the time.
- Sometimes make noise and may kill birds, but do not pollute the air or water.
- Use an energy source that is free to harvest.
- Use a renewable resource as fuel.

Hydropower Plants

- Require that a lot of land be flooded for the reservoir, which can be used for recreational purposes.
- Can damage ecological habitats.
- Produce no air and minimal water pollution.
- Use a renewable resource as fuel.

Nuclear Power Plants

- Use small amounts of an economical and abundant energy resource.
- Produce no air or water pollution.
- Produce radioactive spent fuel that can be very dangerous and must be stored carefully at secure storage facilities.

Waste-To-Energy Plants

- Burn trash to produce electricity.
- Reduce the need for landfill space.
- Produce CO_2 and limited air pollutants when burned, and can smell bad.

Natural Gas Plants

- Are excellent for peak load plants because they can be brought on-line and shut down quickly.
- Use a clean burning fossil fuel, but still emit CO_2 and some pollutants into the air.
- Use a nonrenewable resource (with undetermined reserves in Essowess).

Geothermal Power Plants

- Are built on the site of the geothermal reservoir.
- Produce few environmental impacts.
- Use a renewable resource.

Solar Power Plants

- Cannot produce electricity all of the time.
- Produce no pollution but require large land areas.
- Use energy from the sun that is free to harvest.
- Use a renewable resource.

Mission Possible Energy Plan

ROW	A	B	C	D	E	F	G	REFERENCE FIGURES		
	FACILITIES	# of plants to build	ENVIRO IMPACT (EU) for my plan	ECONOMIC COST ($$) for my plan	CAPACITY MW for my plan	COST OF ELECTRICITY for one kW	TOTAL COST for my plan	Economic Cost to add 1 plant	Capacity in MW of one plant	Enviro Impact for one plant
3	Existing Modern Plants	20	800	$800	800	0.05	=E3*F3			
4	Modernize 5 Existing Coal Plants	5	250	$250	250	0.05	=E4*F4	40	50	50
5	Build New Coal Plants							17	10	3
6	Build up to 2 Biomass Waste-to-Energy Plants							25	20	4
7	Build up to 3 Geothermal Plants							110	50	10
8	Build up to 2 Hydropower Dams							50	50	30
9	Build Natural Gas Plants							85	100	20
10	Build Nuclear Plants							30	10	0
11	Build Solar Plants							9	10	0
12	Build up to 5 Wind Plants									
13	**TOTALS**									
15	**GOAL**		**1200**	**1700**	**=1500+B11+B12**	**0.05**				

To determine the average cost of electricity per kWh, use the following formula:

Total Cost of all Sources / Total Capacity of all Sources

***Rows are numbered as they are in an Excel spreadsheet.**

Sample Energy Plan

FACILITES	# of plants to build	ENVIRO IMPACT (EU) for my plan	ECONOMIC COST ($$) for my plan	CAPACITY MW for my plan	COST OF ELECTRICITY for one kW	TOTAL COST for my plan	REFERENCE FIGURES		
							Economic Cost to add 1 plant	Capacity in MW of one plant	Enviro Impact for one plant
Existing Modern Plants	20	800	$800	800	$0.05	$40.00			
Modernize 5 Existing Coal Plants	5	250	$250	250	$0.05	$12.50	40	50	$50
Build New Coal Plants	0	0	0	0	$0.05	$0.00	17	10	$3
Build up to 2 Biomass Waste-to-Energy Plants	2	6	$34	20	$0.06	$1.20	25	20	$4
Build up to 3 Geothermal Plants	3	12	$75	60	$0.04	$2.40	110	50	$10
Build up to 2 Hydropower Dams	2	20	$220	100	$0.01	$1.00	50	50	$30
Build Natural Gas Plants	2	60	$100	100	$0.06	$6.00	85	100	$20
Build Nuclear Plants	1	20	$85	100	$0.07	$7.00	30	10	$0
Build Solar Plants	3	0	$90	50	$0.02	$1.00	9	10	$0
Build up to 5 Wind Plants	5	0	$45	50	$0.04	$2.00			
TOTALS		**1168**	**$1,699**	**1,530**		**$0.05**			
GOAL		**1200**	**1700**	**1,508**	**$0.05**				

To determine the average cost of electricity per kWh, use the following formula:

Total Cost of all Sources / Total Capacity of all Sources

***Rows are numbered as they are in an Excel spreadsheet.**

Mission Possible: Energy Trade-offs Evaluation Form

State: ____________ **Grade Level:** ____________ **Number of Students:** ___________

1. **Did you conduct the entire activity?**	❑ Yes	❑ No
2. **Were the instructions clear and easy to follow?**	❑ Yes	❑ No
3. **Did the activity meet your academic objectives?**	❑ Yes	❑ No
4. **Was the activity age appropriate?**	❑ Yes	❑ No
5. **Were the allotted times sufficient to conduct the activity?**	❑ Yes	❑ No
6. **Was the activity easy to use?**	❑ Yes	❑ No
7. **Was the preparation required acceptable for the activity?**	❑ Yes	❑ No
8. **Were the students interested and motivated?**	❑ Yes	❑ No
9. **Was the energy knowledge content age appropriate?**	❑ Yes	❑ No
10. **Would you teach this activity again?**	❑ Yes	❑ No

Please explain any 'no' statement below.

How would you rate the activity overall?	❑ excellent	❑ good	❑ fair	❑ poor
How would your students rate the activity overall?	❑ excellent	❑ good	❑ fair	❑ poor

What would make the unit more useful to you?

Other Comments:

Please fax or mail to: **The NEED Project**
P.O. Box 10101
Manassas, VA 20108
FAX: 1-800-847-1820

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E.M.G. Oil Properties
Encana
Encana Cares Foundation
Energy Education for Michigan
Energy Training Solutions
Energy Solutions Foundation
Entergy
Equitable Resources
First Roswell Company
Foundation for Environmental Education
FPL
The Franklin Institute
GenOn Energy–California
Georgia Environmental Facilities Authority
Government of Thailand–Energy Ministry
Guam Energy Office
Gulf Power
Halliburton Foundation
Hawaii Energy
Gerald Harrington, Geologist
Houston Museum of Natural Science
Hydro Research Foundation
Idaho Department of Education
Idaho National Laboratory
Illinois Clean Energy Community Foundation
Independent Petroleum Association of America
Independent Petroleum Association of New Mexico
Indiana Michigan Power
Interstate Renewable Energy Council
iStem–Idaho STEM Education
Kansas City Power and Light
KBR
Kentucky Clean Fuels Coalition
Kentucky Department of Education
Kentucky Department of Energy Development and Independence
Kentucky Oil and Gas Association
Kentucky Propane Education and Research Council
Kentucky River Properties LLC
Kentucky Utilities Company
Lenfest Foundation
Littler Mendelson
Llano Land and Exploration
Los Alamos National Laboratory
Louisville Gas and Electric Company
Maine Energy Education Project
Maine Public Service Company
Marianas Islands Energy Office
Massachusetts Division of Energy Resources
Lee Matherne Family Foundation
Michigan Oil and Gas Producers Education Foundation
Midwest Energy Cooperative
Mississippi Development Authority–Energy Division
Montana Energy Education Council
The Mosaic Company
NADA Scientific
NASA
National Association of State Energy Officials
National Fuel
National Grid
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
Nebraska Public Power District
New Mexico Oil Corporation
New Mexico Landman's Association
New Orleans Solar Schools Initiative
New York Power Authority
NSTAR
Offshore Energy Center
Offshore Technology Conference
Ohio Energy Project
Pacific Gas and Electric Company
PECO
Petroleum Equipment Suppliers Association
PNM
Puerto Rico Energy Affairs Administration
Puget Sound Energy
Rhode Island Office of Energy Resources
RiverWorks Discovery
Roswell Climate Change Committee
Roswell Geological Society
Sacramento Municipal Utility District
Schneider Electric
Science Museum of Virginia
C.T. Seaver Trust
Shell
Snohomish County Public Utility District–WA
Society of Petroleum Engineers
David Sorenson
Southern Company
Southern LNG
Southwest Gas
Space Sciences Laboratory–University of California Berkeley
Tennessee Department of Economic and Community Development–Energy Division
Tennessee Valley Authority
Toyota
TXU Energy
United States Energy Association
University of Nevada–Las Vegas, NV
U.S. Department of Energy
U.S. Department of Energy–Hydrogen Program
U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy–Office of Fossil Energy
U.S. Department of Energy–Wind for Schools
U.S. Department of Energy–Wind Powering America
U.S. Department of the Interior–Bureau of Land Management
U.S. Department of the Interior–Bureau of Ocean Energy Management, Regulation and Enforcement
U.S. Energy Information Administration
U.S. Environmental Protection Agency
Van Ness Feldman
Virgin Islands Energy Office
Virginia Department of Education
Virginia Department of Mines, Minerals and Energy
Walmart Foundation
Washington and Lee University
Western Kentucky Science Alliance
W. Plack Carr Company
Yates Petroleum Corporation