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The New Activities Handbook for ENERGY EDUCATION

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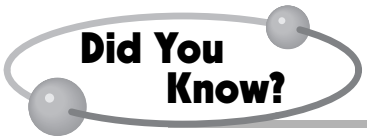
Energy: A Delicate Dilemma



At the beginning of the twenty-first century new cars are expected to emit 70% fewer nitrogen oxides (the main ingredient in smog) and 30% fewer hydrocarbons (one cause of lung disease). The cost is about $60 per car.

NATIONAL SCIENCE EDUCATION STANDARDS

Unifying Concepts and Processes

Evidence, Models, and Explanations

Physical Science

Transfer of Energy

Life Science

Regulation and Behavior

Earth Science

Structure of the Earth System

Science in Personal and Social Perspectives

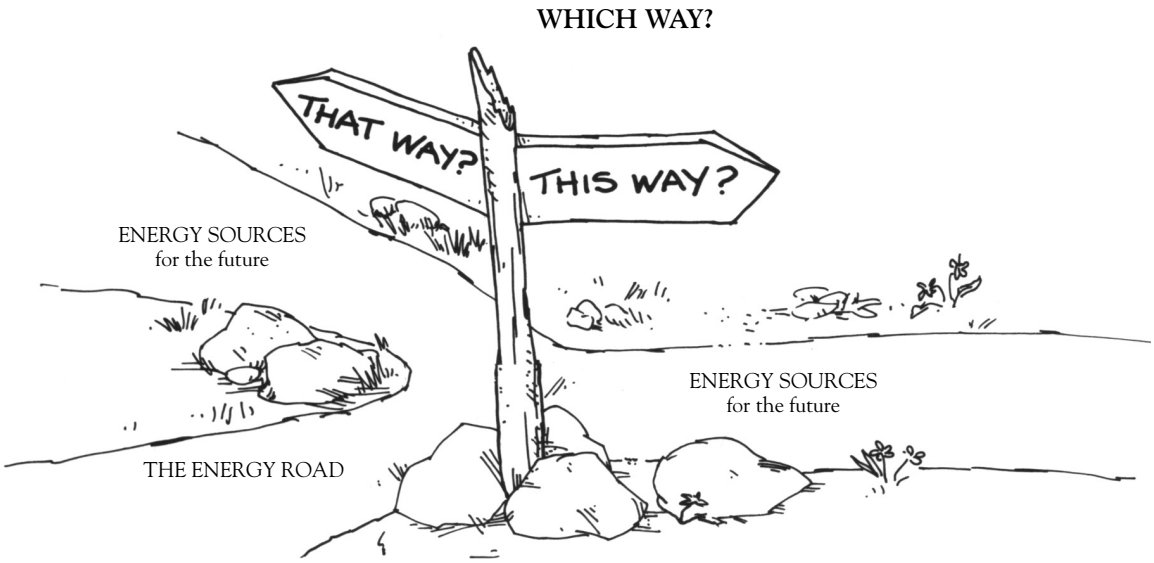
Risks and Benefits

This Way or That Way?

In this activity, you'll consider the pros and cons of different energy sources.

Energy consumption in the United States is about 10,000 watts per person per day. This energy is generated by many different means and is used in transportation; heating and air conditioning our homes, offices, stores, and factories; and in the operation of the industrial processes in the economy. Today the United States spends about $27 billion per year, or $215 per person, for imported oil, as compared to 1970s expenses of about $3 billion, or $15 per person.

The sun has been, and continues to be, the source of all energy since the world began. All living things depend on it for life. Early man got energy from the sun by eating the food that the sun helped to grow. As people looked for ways to accomplish work other than through their own muscle and/or animal power, they discovered and began to use alternative sources of energy—the wind, water, steam, coal, oil, gas, and nuclear. We continue to search for sources of energy to do work, but we are approaching a delicate dilemma. What energy sources will be best for our future? What shall our energy development efforts be directed towards? Which way should we turn?



Who Is Right? Vignettes of Energy Conflicts

Is the Answer Nuclear?

In 1998, there were approximately 110 nuclear power reactors in the United States and a potential of 150 reactors available by the middle of the twenty-first century. In the year 2015, nuclear power could be supplying energy equal to that of 2 billion tons of coal per year. A few of the many advantages of nuclear power as an energy source follow:

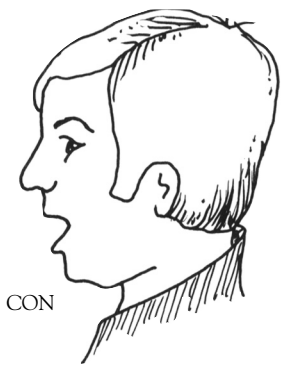
- The United States has domestic uranium resources vast enough to support a huge nuclear power industry for many centuries.
- Uranium mining is environmentally preferable to strip-mining less energy intensive fuels such as coal or oil shale.
- One uranium miner's daily output equals that of 26 coal miners.
- A single truckload of refined uranium holds energy equal to that contained in 4,000 cars full of 100 tons of coal.
- Nuclear power is a proven technology that generates electric power at economic rates.

Day in and day out, the steam flows from the tower that cools the heat of one of the nation's largest nuclear power plants. The plume of steam rises so high that it can be seen for 60 miles in any direction. The cooling tower is over 500 feet (150 meters) high. Now, for the first time since the use of nuclear power as an energy source, we are faced with the issue of disposal of nuclear waste. What do we do with the first load of spent radioactive fuel that's about to be discharged from the plant?

Everyone understands what garbage is, but this garbage is different—it contains the elements strontium and cesium. Both of these elements emit gamma rays (which can penetrate lead) and both stay radioactive for generations, meaning they will still be generating gamma rays over one thousand years from now.

What to do with radioactive waste is the most difficult energy question facing the United States. As of 1998, the United States had already accumulated over 100,000 tons of spent nuclear fuel. This


PRO


CON

- Nuclear fuel can be stockpiled to keep several years' supply in inventory at a plant; thus eliminating the risk of a strike.
- Nuclear power is safe. There have only been minor accidents involving humans and technology.
- The disposal of radioactive wastes is a manageable problem, involving comparatively small volumes of solid wastes.
- The operation of nuclear power plants is environmentally clean; the very small quantities of radioactive releases are carefully monitored and present no danger to community health.

figure doesn't include the 2 million tons of radioactive clothing and medicines discarded and buried underground in the last 25 years. It also doesn't include the 100 million gallons of hot waste generated by the nuclear weapons program.

Thirty-six of the nation's 110 nuclear power plants have run out of room to store their waste. Between 1971 and 1986, 152 accidents were documented in 14 countries.

The states of Oregon, Michigan, and California have already enacted laws banning the "permanent" disposal of radioactive wastes in their states. Where will we put nuclear waste? In your backyard?

Is the Answer Nuclear? What Do You Think?

Is the Answer Coal?

In spite of our growing dependence on other sources of power, fossil fuels will still be our main source of energy through the year 2015. Our immediate need is to derive maximum energy from coal while preserving environmental quality. We have at least a 200 year supply of clean and accessible coal. Power companies and industries must shift to this source of energy, and we must invest in improved mining efficiency, cleaner combustion technology, and a better transportation system for moving coal to its users. The shift from oil and gas usage to coal will reduce the nation's dependence on an insecure foreign energy supply. In the future, coal may be transported directly to the power plant from the mine through pipelines as a slurry.

We must take steps to increase the use of our nation's vast supply of coal. We need to make some reasonable compromises between energy and the environment, we need to relax some of the rigid and utopian environmental standards imposed in an era of wishful thinking, and we need to provide an economic and political atmosphere which will encourage the long-term development of our nation's coal resources.

Coal is not easy to mine, to clean up after, or to transport. Its wastes are unaesthetic and damaging to one's health. Deep mines are costly to companies and to the lungs of miners. Strip mines are costly to the environment and to the mining companies required to rehabilitate the land they have ripped up—putting back the rocks, restoring contours, putting back a blanket of topsoil, seeding, and planting are cost and time intensive activities. Restoration of the landscape is particularly difficult in the semi-arid regions of the West where much of the nation's untapped coal lies buried.

A major part of the capital investment and maintenance costs of coal-fired generating plants is the cost of protecting the quality of air and water in the vicinity of the plant. The effectiveness of the present environmental protection systems is questionable. There is also evidence that the techniques required by the Environmental Protection Agency (EPA) regulations to clean smokestack emissions may actually create pollutants of another type. We must also remember that the "best" fossil fuel plants that we now have can convert only about 40% of the energy stored in these fuels into electricity with about 60% lost as heat.

The disadvantages of coal mining include: stream pollution, floods, landslides, sedimentation, loss of fish and wildlife habitats, sulfuric acid pollution, and thick yellow mining wastes.

Is the Answer Coal? What Do You Think?

Is the Answer Solar?

Using the direct radiant energy of the sun to heat water for household uses and to warm living and working spaces (which constitute more than half our domestic demands) is practical and real *right now*. There is a growing variety of solar collectors of varying complexity and cost available for both commercial and private use. The most significant use of solar energy in the near future will be for home consumption (heating and cooling). Solar thermal plants that produce heat equivalent to that of several thousand suns must be developed and built. This heat can be used to vaporize a liquid which can then be used to run a conventional generating turbine. A major breakthrough in the cost of solar energy generation will come soon.

Remember how large and expensive calculators once were and how rapidly they have become both pocket-size and inexpensive? Solar energy costs will follow the trend of pocket calculators in terms of price, usefulness, and benefits to society.

The sun is not free. Its generous radiation is paid for in advance with the high capital costs of solar installation, backup, and storage systems. Electricity produced by solar thermal plants utilizing space-age technology will cost hundreds of dollars a watt instead of fractions of cents. Reducing the cost will require a major breakthrough comparable to the development of the transistor and miniaturized circuitry. Unfortunately, breakthroughs do not always conform to our schedules.

The sun, for all its power and versatility, has a major flaw; its rays reach us only half the time under the best of circumstances, and there are frequent outages due to passing clouds, smog, and fog. Several days of dense overcast skies could be disastrous. To insure a steady supply of power, electric companies will have to keep conventional plants for backup services. Even the most optimistic experts who foresee that solar energy in its various manifestations will provide nearly all of our energy needs one hundred years from now expect no more than an 8% contribution by the year 2010. The only realistic solar collector available to an individual in the near future will be his south window.

Is the Answer Solar? What Do You Think?

Now that you've read some of our energy conflict vignettes, why don't you, as Pro or Con, try to develop some of your own vignettes in response to the following questions.

Is the answer geothermal?
Is the answer wind?
Is the answer water?
Is the answer thermal?

Next, assume one of the roles assigned to Pro or Con in the following list and address the issues from that point of view.

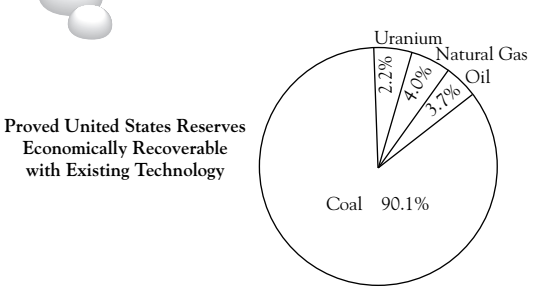
PRO AS THE	CON AS THE
Parent	Child
Oil company person	Conservationist
Oil company person	Stockholder
Scientist	Economist
Economist	Scientist
Consumer	Business person
Business person	Consumer
Electric utility	Consumer
Regulatory agency	Electric utility

Think of other roles that you might like to assume.

We have not yet reached a plateau on the growth curve of energy use; energy consumption should continue to increase during the next 50 to 100 years. Our choice of an energy source for the future will be crucial to those who live on this Earth in the twenty-first century and beyond.

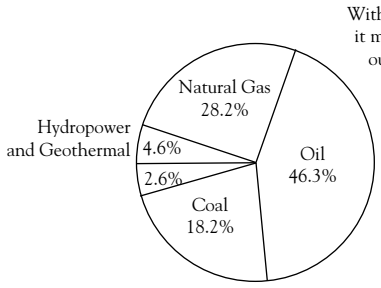
Does It Make Sense?

Reserves vs. Consumption?



Proved United States Reserves Economically Recoverable with Existing Technology

With a 90.1% coal reserve does it make sense to use 18.2% in our current consumption?



United States Consumption Pattern