Lovins on the Soft Path:

An Energy Future with a Future

A Guide to the Film for Students and Teachers

Published by

ROCKY MOUNTAIN INSTITUTE

Table of Contents

Thanks and Credits

Rocky Mountain Institute gratefully acknowledges **Bullfrog Films; Essex County [Mass.] Ecology Center; and Nelson B. Robinson** for their generous support of the study guide.

Lovins on the Soft Path, 1982, by Envision Films, Boston, Massachusetts. Distributed by Bullfrog Films, Oley, Pennsylvania 19547. Copies of the film for sale ($590 16 mm, $295 video) or rental ($80 16 mm) from Bullfrog, 215/779-8226.

Additional copies of this guide available for $5 each, $3.50 in orders of six or more, from Bullfrog and from Rocky Mountain Institute, Drawer 248, Old Snowmass, Colorado 81654.

Written by Seth Zuckerman, Hunter Lovins, and Scrib Fauver
Cartoons by Mark Wilson
Designed and produced by Seth Zuckerman
Printed at The Women's Press, San Francisco, California
Cover photos by Doug Child (the Lovinses in front of their energy-efficient home in Colorado); Pacific Gas and Electric (Altamont Pass windfarm, California); and Sunflower Architects (passive-solar restored farmhouse, Hygiene, Colorado)

Introduction

Dear students and teachers,

Welcome to the study guide to the award-winning film, *Lovins on the Soft Path.*

We have crafted this guide with three purposes in mind: to fit the film more easily into a school curriculum; to update the information in the film, by now four years old; and to provide a more rigorous treatment of some of the points in the film.

The bulk of the booklet is a collection of about a dozen articles on such subtopics as the technologies of sustainable energy, the reasons for the failure of nuclear power, and actions that communities have taken to make their own energy use more sustainable.

Also featured are a transcript of the film (printed in narrow columns), a glossary of energy terms (words in the glossary are marked with a degree mark°), a list of suggested energy activities, and a bibliography of sources for further information. Classes that cannot devote much time to the issue will find the one-page set of discussion questions particularly helpful.

Energy is not always an easy subject to deal with, as it does not fit neatly into any one standard school subject. In fact, you may want to use the film and this guide in social studies, science, and modern history classes alike. Social studies classes may want to focus particularly on such articles as "At the Grassroots," "Changing Energy Paths Without Changing Lifestyles," and "Sustainable Energy and the Third World," which deal with the social and political aspects of energy policy. Science classes may find the series entitled "Can Sustainable Technologies Power America?" of more use, along with the articles on indoor air quality and the comparison of energy obtained from uranium and wood. Classes with an emphasis on economics may benefit most from articles on the financial implications, such as "Utilities: Getting Into the Act," "Can the Free Market Alone Solve the Problem?" and "Nuclear Power, R.I.P." We trust you will find the smorgasbord approach useful; we do not expect that all classes will necessarily use all the articles. By the same token, the suggested activities and the bibliography embrace the natural as well as the social sciences.

Please let us know if you have any comments on the guide, either positive or negative, so that we may improve the next edition.

— Seth Zuckerman
Old Snowmass, Colorado
September 1985

Thanks to John Christensen, Cherry Creek School District, Littleton, Colorado; John Katzenberger, Windstar Foundation, Old Snowmass, Colorado; Mark Munger, Aspen Community School, Woody Creek, Colorado; and Tom Wellnitz, Massachusetts Audubon Society, Lincoln, Massachusetts for their invaluable comments on drafts of this guide.

Transcript

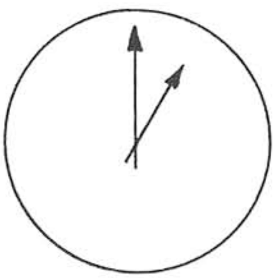
[AMORY LOVINS]
People tend to be intimidated by energy. To say we have to leave this to the experts. It has to do with all these big complicated machines we can't understand. It isn't like this at all. The energy problem is the cracks around my window.

[HUNTER LOVINS]
We are now dependent on a very tenuous energy supply line. We think that our armies and our missiles give us national security, and yet a handful of people can come in virtually any time they like and cut off our energy supply. (Article, p. 19.)

[AMORY]
Arguing about what sort of new power station to build is sort of like debating the best buy in brandy to burn in your car or the best buy in Chippendales to burn in your stove.

[HUNTER]
After five years of firewood development recently with no subsidies, firewood now gives us about twice

Suggested Questions for a One-Hour Discussion of *Lovins on the Soft Path*



[Transcript continues]
as much energy as we get from nuclear power after about 30 years and $40 billion in direct subsidies. (Article, p. 12.)

1970: U.S. domestic oil extraction hit a peak and started to decline. The general public hardly noticed.

1973: The Arab embargo, and the resounding end to the era of cheap energy. *Everybody* noticed.

Yet most people assumed that to stay prosperous, we would have to use more and more energy. And if we couldn't depend on foreign oil, we would have to find more fuel at home. Where would we find it? Hundreds of communities and millions of acres in the West would be affected by uranium, oil shale and coal

Here are a few questions to kick off discussion of the film. Feel free to use this sheet as a master for a class handout and to add other questions you feel would be useful.

What are some of the key points of Amory and Hunter Lovins' arguments?

Do you agree with them? Completely? Partially? Why or why not?

What conclusions do you draw from the way forecasts of energy demand for the year 2000 declined during the '70s?

What are some of the assumptions that Amory and Hunter Lovins make in their approach to energy? Spoken ones? Unspoken ones?

What are some barriers that stand in the way of the sustainable energy path? How easy do you think it may be to surmount them?

Should your county, town, or city neighborhood create something like the Franklin County Energy Project? How would you begin?

Nations and states have energy policies, but so do schools and households (even if just by default). How would you describe the energy policies of your school and family?

What opportunities do you see for using energy more wisely at your school or in your home?

What are some of the problems you see with the hard energy path? With the sustainable energy path? How easy do you think those would be to overcome?

What further information would you like in order to reach a judgment on how to approach energy issues? (Note: if energy will be the subject of just a single class period, the teacher should familiarize him or herself with the resources listed in the Study Guide in order to direct students to the sorts of information they request.)

What has been your own experience with different forms of energy—their ease of use, what they cost, etc.? Do you know anyone who uses renewable energy sources?

In discussing the environmental aspects of various energy sources, there is often uncertainty as to the risks and likely effects. Where do you think the burden of proof should lie? Should the people protesting against a technology demonstrate that it is unsafe, or should the people pushing for the technology show that it is safe? Can you think of similar situations in other industries?

What do you think of the 'end-use' analysis that the Lovinses bring to energy? Can you think of other issues where this type of thinking would be useful? How would you apply end-use analysis to those issues?

Can Sustainable Technologies Power America? Part I: Heat

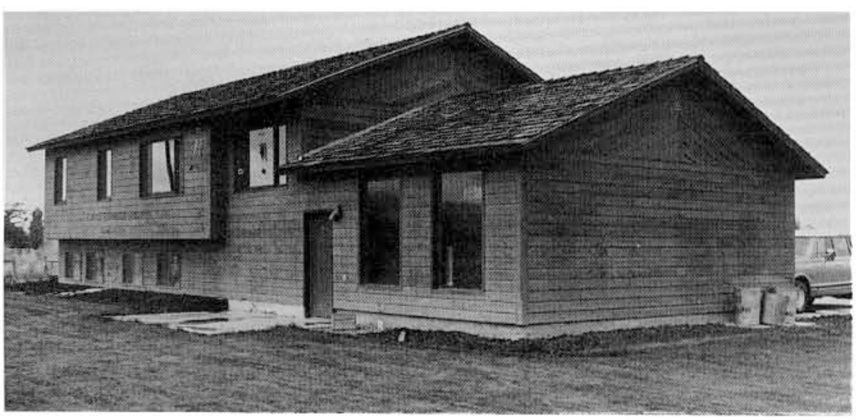
Many people say, "Renewable technologies are very nice, but we could never run the country on them." Is this true? No. There are plenty of renewable technologies available; enough that we could in, say, fifty years, run the United States very comfortably on them. This is also true of all other countries so far studied. Why wait fifty years? It could be done faster, if we put our minds to it, but fifty years is a good guess, based on how long it took to move from wood to coal and from coal to oil. Actually, things are moving quite rapidly. Since 1979, the United States has obtained more new net energy from sun, wind, water, and wood than from oil, gas, coal, uranium, or all of them put together; some 10 percent of U.S. energy is now supplied renewably. In that same period, efficiency gains have provided more than fifty times as much energy as all new net supplies put together.

The following sections will examine the three main uses for which we need energy—heat, liquid fuels and electricity—and show how these end-use needs can be met with renewable sources. They follow the pattern outlined in the film: first, identify the task to be done, then improve the efficiency with which we use energy, and finally, look for the cheapest sources of supply for that energy. This brief treatment can only touch on a few of the vast array of renewable technologies available to meet our needs. It should be sufficient, though, to satisfy you that a sustainable energy future is possible.

Heat

Most energy in almost all economies is used for heat. In the United States, the fraction is about 58 percent, much of which is used for low-temperature (below the boiling point of water) heating and cooling. This energy is used primarily for water and space heating and air conditioning.

The cheapest way to provide the energy we need to keep people comfortable in a building is to design the shell of the building so it keeps heat in during the winter and keeps it out in the summertime. One technique, superinsulation, can reduce a home heating bill to $50 a year or less, even in climates as harsh as the Canadian prairie. In contrast, many badly insulated buildings have monthly energy bills of hundreds of dollars.



This superinsulated house, located in the Colorado Rockies, uses $60 a year in electricity for heating and cooling. (Photo courtesy Dick Bunning)

[Transcript continues]
mines. We would drill for more oil and gas in the Arctic, in wilderness areas, and offshore. We would build over a thousand new power stations and hundreds of synthetic fuel plants.

This trillion-dollar undertaking would be impressive—and so would its risks.

Such a scenario shows continued growth in *overall* energy consumption, fueled by growth in the use of coal and nuclear power as the oil and gas dwindle.

There is an alternative: prospering by using energy more efficiently. In this scenario, nuclear power is unnecessary. Coal, oil and gas are steadily replaced over the next few decades by appropriate renewable sources. By early in the next century, renewables would be our biggest energy source; by 2030, they'd be all we need. (Articles, pp. 3, 5, and 7.)

Superinsulating a building is not hard. It means putting lots of insulation in the walls, roof and floor; using heat-tight windows; and effectively sealing the cracks in the frame and around windows, doors, etc. (See the article on indoor air quality, p. 10.) Often, the extra cost of these measures is even less than the savings from not needing a furnace or heating ducts. Superinsulation can be retrofitted onto existing homes, too. A project in St. Louis and another in rural Kentucky, for instance, found that the extra cost was one or two thousand dollars and raised the mortgage payment less than half as much as it reduced the energy bills.

Passive solar° design is the next cheapest technology. It means using windows to let the sun in, and storing the resulting heat in water or masonry ('thermal mass') until it's needed. For summer cooling, it means window overhangs to keep out the high summer sun but let in the low winter sun; shade trees; and thermal mass to store nighttime coolness for the daytime. Already the United States has more than a million solar buildings. The best buildings, such as the Lovinses' home in Colorado, combine superinsulation and passive solar design to eliminate heating and cooling needs entirely.

Water heating needs can be taken care of by flat-plate solar collectors°, such as you already see on many homes. Well-designed collectors can supply most of the hot water needs of a building. Their performance on cloudy days can also be improved by giving them a 'selective surface' that absorbs heat well but doesn't lose it as easily; a low-technology version of such a coating has already been shown to heat water satisfactorily on a cloudy winter day in Hamburg, Germany.

For higher-temperature industrial heat, efficiency is again the best bargain, using new processes to save heat while producing the same product as before. Once heat needs are minimized, solar energy can be used to provide industrial heat. Various commercially available collectors concentrate sunlight to make steam or give high-temperature heat. Some use trough-like reflectors to focus the sun on a pipe; others focus it to a point. Although these will only work when the sun is shining, the heat can be stored for later use. Backup can also easily be provided with some form of biomass fuel; for example wood use already provides half the heat needs of the pulp and paper industry. Sustainable liquid fuels, discussed next, can also provide backup. Widespread use of solar concentrators in industry will depend on the price of fossil fuel rising a bit above its present level, but when it does, the solar technologies are ready.

Questions:

1. What is the general procedure for applying sustainable energy to an end-use energy need?
2. Why do you think we want to apply efficiency measures first, and only then look for renewable sources of new energy?
3. Can you apply this method to your own house or school?

[Transcript continues]

[NARRATOR]

It's easy to be pessimistic about our energy future. But Amory and Hunter Lovins believe that there's actually reason for optimism—that Americans *can* create a sustainable energy future.

Amory Lovins, physicist turned energy activist, thinks the path we've taken in the past has led us up a blind alley. His 1976 landmark essay in *Foreign Affairs*, "Energy Strategy: The Road Not Taken?" introduced the phrases 'hard path' and 'soft path' to distinguish between conventional and alternative energy strategies. This essay began a vigorous debate on our country's energy policy.

Hunter Lovins, Amory's personal and professional partner, is a lawyer and political scientist. For seven years the assistant director of the California Conservation Project, she designed and implemented environmental and energy education projects and coordinated an extensive program of community participation in urban forestry.

Together, the Lovinses work as a team on energy strategy in more than 15

This rig converts cattle manure into clean, burnable methane gas in less than two weeks. It toured the Southwest demonstrating the energy potential of feedlot wastes. (Photo courtesy Colorado Office of Energy Conservation.)

Can Sustainable Technologies Power America? Part II: Liquid Fuels

The second largest energy need in most countries, including the United States, is for liquid fuels. Liquids have a high heat content per pound; they are portable and convenient. At present, most of our liquid fuels, including gasoline, diesel fuel, and kerosene (jet fuel) come from petroleum, much of that imported from unstable parts of the world.

Because transportation accounts for 62 percent of our oil use, any program to free us from dependence on imports, or, in the longer run, on unsustainable fossil fuels, must provide a convenient, affordable way of moving ourselves around.

The first step is to improve the efficiency with which we use fuel. Passenger automobiles in the United States average about 17 miles per gallon: one-quarter better than they did in 1973, but much lower than the fleet average of new cars (in the mid- to high 20s), and far below the best prototypes, which get more than 70 mpg on the road. One test model, built by Volvo, carries four passengers and features a three-cylinder, heat-insulated, turbocharged engine. Other key factors include better lubricants, more efficient drivetrains, and more streamlined body design.

The next Volvo prototype will include a continuously variable transmission to deliver to the wheels the precise amount of power necessary. It will automatically turn off its engine when idling and coasting, then turn it back on when power is needed. These two modifications are expected to boost the car's efficiency to 85 miles per gallon. Further gains are possible by using a flywheel to capture some of the car's braking energy, or space-age materials to make light but safe car bodies.

What do these innovations mean for total national fuel use? Princeton University's Robert H. Williams projects a fleet of cars and light trucks for 2020 that will use less than a quarter of the energy now consumed. (Half of the fleet he

[Transcript continues]
countries. They have coauthored three books, with several more on the way. They spend much of each year on the move, consulting for governments and corporations and speaking to a wide variety of groups. Their exhausting schedule juggles countless speaking engagements with stretches of writing and thinking time, and even includes several weeks to work with kids at a summer camp in Maine.

At an energy policy workshop in Montana, Amory Lovins delivers the speech which he and Hunter have developed over the years to present their basic ideas.

[AMORY]

But I think it's important to get straight in our heads what the energy problem is. I'd like to do

[Transcript continues]
that by addressing four questions, namely,

- how much energy do we need?
- what kinds of energy do we need?
- where can we get it? and
- how can such a policy actually be implemented?

Let me start with how much energy we need.

There are of course two ways to save energy: one way is to curtail or do without the services the energy gives us. Turn off the lights, leave the house hotter in the summer, colder in the winter, shut down the factories, leave the car at home. . . . I won't be discussing any measures of that kind. I'll be talking only about ways to provide the same services as now or even more of them, using less energy, just by using the energy more productively or more efficiently. (Article, p. 13.)

[HUNTER]

When people invite us to speak, we try to go back to basics. We find that there's large confusion as to what the energy problem really is. People are hung up on which gadget to use, which technology to use, whether we need more oil, whether we need more coal. And before we get to those questions, we should really be asking, what are the tasks that we're trying to accomplish with the energy? And,

assumes is composed of four-passenger cars at 78 miles per gallon, roughly a third are full-size cars and light trucks at 58 mpg, and the rest are a sprinkling of two-seaters at 110 mpg.) Most of the improvements for cars can be applied to trucks as well. A national policy to encourage such efficiency is far more important than programs to develop alternative fuels. It would, for example, save far more oil faster and cheaper to *give* everyone in the country a free 40-mpg car in trade for their old gas-guzzler than to pay what the Federal government proposed to spend to develop the synthetic-fuel program.

Dramatic improvements are likely for aircraft as well. When the current generation of Boeing 757 and 767 jets is fully introduced, fuel efficiency will climb from 17.5 passenger-miles per gallon in 1973 to 45 pmpg, with a further jump to 52 or 54 possible with new propfan designs.

All of this means that total energy use for transportation should drop by half over the next forty years, even if Gross National Product per capita rises by 50 percent. At that level of fuel demand, we can comfortably meet our needs with liquid fuel derived from crop and forestry residues that this country now wastes.

The wastes come in hundreds of forms. Cull potatoes, distressed grain, cannery waste, whey, timber slash—in short, whatever leftovers are plentiful in an area—can be converted into alcohol. Every region has some source: the cotton-gin trash in Texas, for instance, could, if converted to alcohol, run all the cars in the state, once they are as efficient as is cost-effective. The Midwest can contribute spoiled grain, California a variety of agricultural wastes, Pennsylvania apple pomace, etcetera. Cars can be switched without too much difficulty, usually with a simple carburetor modification; ninety percent of Brazil's new 1983 cars ran on alcohol. And while early alcohol stills required a lot of energy to process the fuel, new processes have reduced that fraction to about 20 percent or less—easily provided simply by diverting a fifth of the fuel back into the operation.

These biofuels could meet all of America's liquid fuel needs if we use them very efficiently. But if we choose this route, we must above all remember to respect the fertility of the land. Soils are already being badly depleted with present agricultural practices (see box, p. 28), and it is vital that a biofuels program be designed so as to be truly sustainable. Nutrients from the crop residues must be returned to the land, and the farming practices must not promote erosion or depletion of the water supply.

There are also other renewable fuel options. For example, as the price of photovoltaics° continues to drop, it may soon become possible to make hydrogen with solar electricity and bottle it for use in vehicles. Already Modesto, Calif., runs its municipal vehicle fleet on methane it produces from city sewage. These and other renewable sources guarantee that America need not "run out of gas." As soon as our continuing demand for gasoline uses up the present "glut" caused by increases in efficiency, sustainable technologies stand ready to meet our needs.

Questions:

1. What are the steps toward a sustainably fueled vehicle fleet?
2. What farm, forestry, or municipal wastes can you think of in your area that might be suitable for fuel production?
3. Can you think of any obstacles that might need to be overcome to implement these ideas?

Can Sustainable Technologies Power America? Part III: Electricity

Electricity is the smallest of our end-use needs: roughly 8 percent. But those uses require the very high-quality, expensive energy of electricity. No other energy form will do for such tasks as stereos, home appliances, industrial motors, computers, and lighting. When electricity was cheap, however, we also began using a lot of it for tasks that don't give us our money's worth: heating and cooling. These uneconomic uses are now six percent of our energy demands and growing. Thus, the first step in using electricity sustainably is to use electricity only where cost-effective. The previous section on heat (p. 3), showed how to supply all of our heating energy needs renewably. This means letting superinsulation, passive solar, and other good architecture keep our buildings comfortable, and just using electricity where its real need justifies its high cost. If we then use efficiently the electricity we still need, we will find that it is not hard to meet all our electrical needs with renewables.

New technical fixes are increasing the efficiency of electric use severalfold. For example, SL*18 lightbulbs made by Norelco provide the light of a 75-watt incandescent bulb, yet use only 18 watts. These fluorescents screw into a standard socket, and have an electronic ballast that eliminates the hum and flicker so annoying in regular fluorescents. The SL*18s, now available in many lighting stores, cost $15 each wholesale, about $20 retail. But they last more than ten times as long as a standard bulb, and repay their cost in electricity in a year or two, not even counting the ten replacement bulbs that they make unnecessary. Several other firms are introducing similar lamps, some at even lower prices.

For fixtures that are already use fluorescent tubes, those new electronic ballasts are available separately. These ballasts cut power consumption by more than 40 percent. Combined with their ability to be dimmed manually or automatically in response to the amount of natural light in the room, these ballasts can raise the total energy saving to 70 to 90 percent. If just these bulbs and ballasts were in use throughout the United States, they would save enough electricity to make 75 big power plants unnecessary. Even greater improvement can come from better use of daylighting and improved reflectors in fixtures. And since much of the energy in commercial buildings goes to sucking away the heat that lights give off, more efficient lighting adds up to

[Transcript continues] how much energy do we, in fact, need to accomplish those tasks in the most efficient way and in the cheapest way, the most convenient way.

[AMORY]

Let me try on you a rather mundane story. How many of you remember the pre-war refrigerators which had the motor up on top? Well, those motors were about 90 percent efficient sitting up on top, and nowadays the motors are more like 60 percent efficient, they're underneath and heat goes up where the food is. As a result, a modern refrigerator can easily spend half of its effort taking away the heat of its own motor. Then over the years, the manufacturers have tried to make the inside of a refrigerator bigger without making the outside bigger. Given time, they might, I suppose, have

[Transcript continues] made the inside bigger than the outside. The way they did it, of course, was to skimp on the insulation, so the heat comes straight in through the walls. And then the whole thing is designed so that when you open the door, the cold air falls out so it frosts up inside, so most refrigerators now have electric heaters inside which go on now and then to melt out the frost. Then they also tend to have a strip heater, an electric heater around the door, to keep the gasket from sticking, because it's too simple to use a fry-pan style nonstick coating. Then all this heat is pumped out the back to a kind of radiator which is often pressed right into that thin insulation to help the heat get back inside as fast as possible. And then the resulting refrigerator, if you can call it that, is often installed next to the stove or dishwasher, so when that goes on, it goes on.

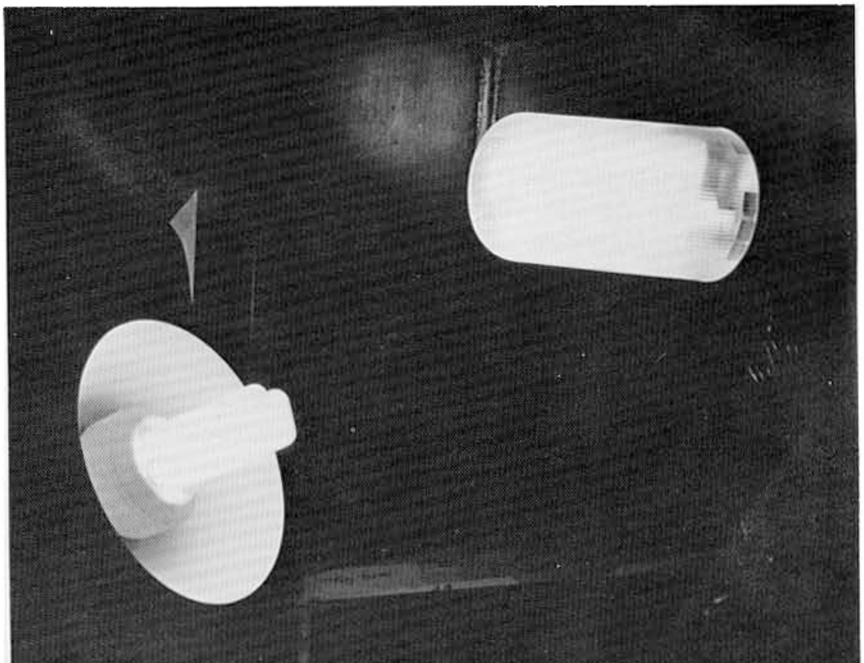
You can try if you like, but I think it's hard to come up with a dumber way to use electricity. And it turns out when you design a refrigerator properly, it will keep the same food just as cold just as conveniently using only a sixth as much electricity as further savings in the cooling and ventilation system.

Refrigerators, some of whose features are discussed in the film, are finally being designed with common sense. The best full-size, frost-free refrigerator-freezer on the American market uses 750 kilowatt-hours° per year, under half of the mid-70s norm. Models already in production in Europe use about 320. And the best prototypes now draw under 100—simply by using thick foam insulation, efficient compressors mounted on top, and good gaskets. Consumption in cold climates can be further reduced with a cooling fin that radiates heat to the outdoors during the winter months.

Motors use three-fifths of all U.S. electricity. Yet most motors now in use are oversized for their work making them function inefficiently at much less than full load. Recently, adjustable speed drives and microprocessor controls have been introduced which can provide just the right amount of electricity to do the job. These measures, along with improvements to drivetrains, can save half of the electricity used by motors, enough to displace 70 large power plants.

Just by using electricity efficiently, we can cost-effectively cut electric demand to a quarter of what it is now. Cheap, existing hydropower would then provide not one-eighth but half of the electricity we need. And we could get the rest from a wide variety of renewable sources. Opportunities abound to get more power from existing dams by installing more turbines in them, rewinding old, inefficient generators, and restoring old dams that have fallen into disuse.

Wind is plentiful in many of the places, such as the Plains and the Intermountain region, which lack hydropower. And cogeneration°, which supplies 15 percent of Europe's power but only 7 percent of our own, is another important source. Cogeneration uses the initial heat of, say, an industrial boiler to make electricity, then applies the remaining heat to run the industrial process, heat water, etc. As one Texas utility man put it, burning fuel just to make electricity is like slaughtering a steer, eating the filet mignon, and throwing the rest away. Burning fuel just for heating is like grinding the whole critter up into hamburger. Cogeneration



These two high-efficiency lightbulbs screw right into ordinary sockets, last ten or more times as long as incandescents, and use a quarter as much energy to put out the same amount of light.

is like cooking each part the way it is tastiest. Thousands of factories, hospitals, universities, and apartment houses are installing cogeneration systems. Although many of these systems use coal or natural gas, an increasing number do use renewable fuel.

What may be the electricity source of the future is catching on fast, too. Photovoltaics°, which convert sunlight directly into electricity with no moving parts, are rapidly becoming economic. They now often outcompete grid electricity if more than a quarter-mile of new power line is needed. Entrepreneurs are even installing PV panels on libraries and fast-food outlets, and making a profit by selling the power to the hosts at a discount from the utility rate.

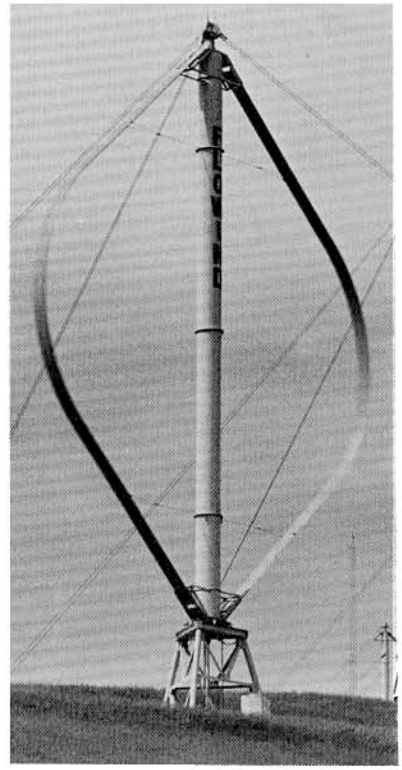
"But," say critics, "what do you do when the sun isn't shining, or there's no breeze to turn the wind machine?" In all of these cases, the fact that most renewable sources don't operate all of the time just needs to be taken into account in designing the system, much as you need to account for the times when a large power plant will fail. However, renewables have an advantage over big power plants. A mixture of solar cells, windmills, and hydro dams gives a power supply made up of many dispersed sources of power of many different sizes that is actually less likely to all fail at once than an average power plant.

But is a collection of small-scale resources enough? In California, the hydro and geothermal power that the utilities already operate, and the renewable power they have contracted for, add up to some 23,000 megawatts° of the 37,000-megawatt state peak demand. Even if no more sustainable power were offered (unlikely), there's already about twice as much as the state would need if it used electricity efficiently.

One advantage to sustainable energy sources is that they can easily work together. One Pennsylvania dairy, for instance, uses manure to make methane, a type of natural gas, which it burns in a cogeneration facility to make $70,000 worth of electricity per year. The waste heat warms the digester, and the digester sludge—with six times as much usable nitrogen as raw manure—is spread on the fields. Meanwhile, the cows' incoming drinking water is used to precool the milk, which both saves energy and warms the water, thus boosting their milk yield. Finally, waste heat from the milk coolers preheats water to wash down the milking parlor. This sort of ingenuity can lead us to sustainable energy abundance—enough energy to provide for us and for generations to come.

Questions:

1. What are two things we must consider before we examine sustainable sources of electricity?
2. What kinds of inefficiency might you want to eliminate in your use of electricity at home? at your school?
3. What are some locally available, renewable resources that might be useful for generating electricity?



Wind machines such as this one are playing a growing role on several states' electric grids. (Photo courtesy Pacific Gas and Electric)

[Transcript continues]
now. That's interesting because refrigerators—if you don't have electric space or water heating—are the biggest contributor to your household electric bill. If you do the same sort of redesign for all household appliances, you'd reduce your electric bill to about a quarter of what it now is. Well, that parable of the refrigerator applies throughout our economy. We're in the position of somebody who can't keep the bathtub full because the water keeps running out, and before we buy a bigger water heater, we

In with the Good Air. . .

[Transcript continues]
ought to get a plug.

[HUNTER]
'Technical fix' is another way to say 'plug', and there are a number of clever technical fixes around.

For example, comfortable cars now on manufacturers' test tracks already get more than 80 miles per gallon. Cost-effective technologies available right now can double the energy efficiency of industrial motors and triple that of lights. And contractors are routinely building houses today that cost about the same to build as old-fashioned houses, but stay warm in the winter and cool in the summer at essentially zero energy cost. (Articles, pp. 3, 5, 7.)

Discovering these 'technical fixes' has dramatically reduced experts' estimates of how much energy the United States will need in the year 2000. In 1972, for example, the *conventional wisdom* of the government was that we were going to need 160 quadrillion BTUs, or 'quads' of energy—more than twice the 76 quads we actually used in 1980. Some government agencies projected even higher needs [190], which we'll call *superstition*, but the Sierra Club's lower estimate [140]

"No air is so unwholesome as that which has been often breathed and seldom changed," said Benjamin Franklin. Even though 200 years have passed since that comment, the problem of indoor air quality is still important. Stories surface periodically of schools, office buildings and even homes where chemicals in the air have made people sick.

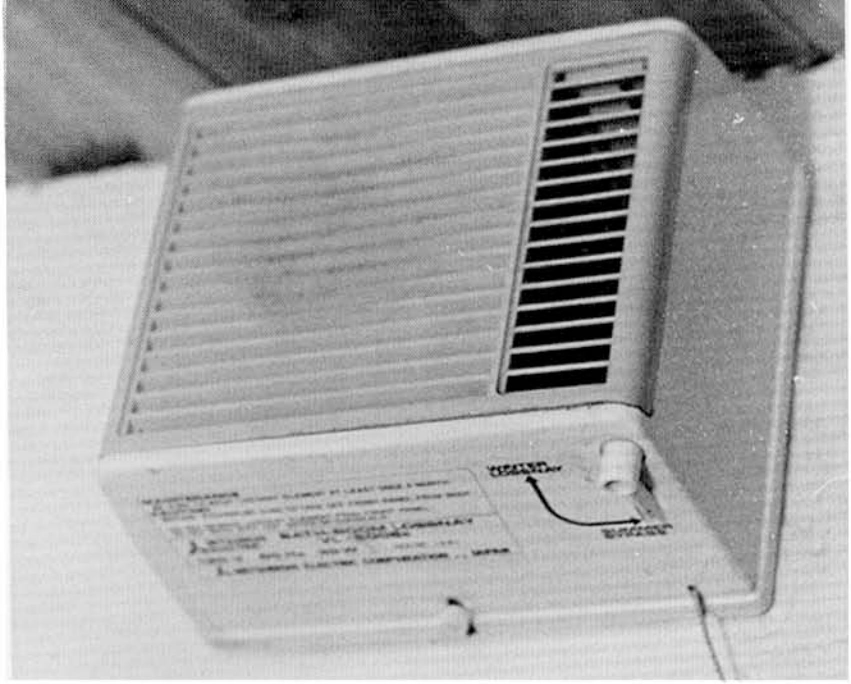
These problems would seem to argue against tightening buildings to keep energy costs down. Some people have claimed that the loss of ventilation through cracks and holes in buildings will mean dangerous indoor air. But in fact, the air in well-designed energy-efficient structures is as clean as their more wasteful predecessors—they just cost less to keep comfortable. The secret to clean air is to keep harmful substances out of the building in the first place, and to control ventilation so you get plenty of fresh air without losing much energy.

What pollutants should we worry about? Cooking and heating can contribute carbon monoxide and nitrogen oxides; smoking contributes those as well as cancer-causing chemicals called benzopyrenes. Certain soils contain low levels of uranium that decay into radioactive radon gas, a cause of lung cancer if inhaled. Many adhesives, plastic products and paints, give off harmful gases, like the formaldehyde contained in some plywood and particle board. Even plastic furniture, carpets and drapes can outgas harmful materials.

The worst case-studies seem ridiculous in hindsight. In Grand Junction, Colo., homes were built with tailings from uranium mines; the air in those homes has proven to have high radon levels. In Washington, D.C., workers in an Environmental Protection Agency office complained of headaches and dizziness; researchers found levels of carbon monoxide three times the outdoor air standard and traced them to an underground parking garage. The door from the garage to the building had been propped open, letting the exhaust fumes in. Clearly, we need to use common sense in occupying and maintaining a building. But how can we avoid generating or admitting the contaminants in the first place?

High-radon soils can be sealed off from the building with paints or plastic sheets; plywood and particle board are available which do not use formaldehyde in the glue that binds them together. Appliances that burn fuel should be vented to the outside; researchers at Lawrence Berkeley Labs estimate that 5 percent of American furnaces have cracks that funnel the exhaust fumes into heating ducts, taking them right to the occupants. And tempting though it may be to move into a new office right away, that is when new materials are giving off the most fumes. Better to wait a few weeks and 'bake out' the worst of the pollutants, as California now does with all new state buildings.

In addition, it is wise to design other aspects of the house—its insulation and passive solar° gain, for instance—well enough that you can bring in enough fresh air directly to keep the air from going stale. Or you can keep the air fresh by controlling the ventilation in the building in such a



An 18-inch-wide air-to-air heat exchanger mounted in the Lovinses' bathroom.

way that the outgoing warm air (in the winter) preheats the incoming fresh air. The devices that perform this service, called 'air-to-air heat exchangers,' cost as little as $200. They can recover 50 to 80 percent of the heat in the outgoing air and can save about ten times as much energy as they consume; they are especially good in such places as bathrooms. Special grease-screened models are available for stove hoods.

Inside the heat exchanger, the two airstreams pass on either side of a thin plastic or metal partition. Thus the heat can be conducted through to the other airstream, but the chemicals in the stale air stay where they belong—on the way out. In the summertime, of course, the process works the other way around: the outgoing air cools off the incoming air, reducing the need for air-conditioning. Some designs even let you keep or get rid of humidity, depending on which you want. (If you do that, however, be careful: some pollutants, notably formaldehyde, will migrate along with the humidity.)

Whatever strategy you adopt, it's important to remember that air quality in *any* building is a very important issue. If you think something is wrong in the air you are breathing, especially if you are smelling chemical fumes, it shouldn't be dismissed as mere troublemaking or hypochondria. A few teachers quit and students transfered out of California's Oakland High School shortly after the school moved into a new building—because their complaints of dizziness, fatigue, nausea and skin rashes weren't taken seriously. Administrators hedged for six months before they even consented to survey the air in the school. But then they found the students had been right: darkroom fumes and formaldehyde from particle-board bookshelves had been in the air.

Questions:

1. What is the most important way of preventing the buildup of unhealthy chemicals in indoor air?
2. What is the concept behind an air-to-air heat exchanger?
3. Do air-quality concerns mean you should not superinsulate a building?

[Transcript continues] was *heresy*, and Amory's still lower figure [125] was *beyond the pale*. By 1974, after the oil embargo, the government's conventional wisdom [140] was still below the utilities' superstition [160], but well above estimates [100,124] by the Ford Foundation's Energy Policy Project. Two years later, the government's forecasters [124] had discovered technical fixes—you really can weatherstrip your house—and the utilities [140] had discovered 'price elasticity of demand,' which means the more they charge you, the less you buy. Amory's estimates in speeches [75] and in *Foreign Affairs* [95] were still lower—as they were also in 1978 [55], but by then the National Academy of Sciences [77] and the government forecasters [95, 123] were also issuing lower figures. By 1980, an Academy panel [54] and a government study [64] were even saying we could be better off while using much less energy than today. Exxon [97] was still in the 'superstition' column. Our latest long-term calculations [15] were still 'beyond the pale'.

But this matrix reveals a dramatic pattern that continues to this day. Every two years, the estimates of future energy needs drop diagonally, becoming one notch more respectable. In

How Do Uranium and Wood Measure Up?

[Transcript continues] less than a decade, the highest forecasts for 2000 have fallen below what the lowest ones had been. And they're still falling.

What Kinds of Energy?

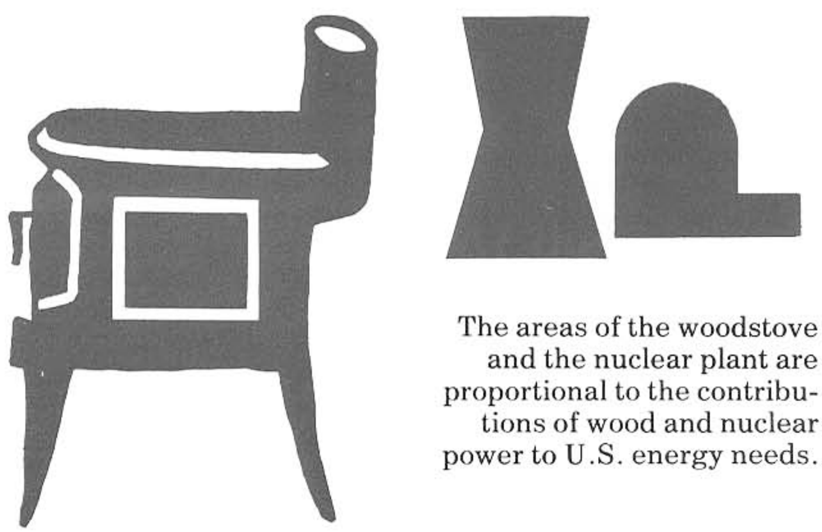
[AMORY]

So how much energy we're going to need is a very important question. It determines whether we need to buy these supply expansions on which we're spending billions of dollars every year. But there's an equally important question which has not been much asked: namely, what kinds of energy do we need, because there are many different forms of energy whose different prices and qualities suit them to different applications. Traditionally, we've ignored those distinctions: in effect, we've said that all kinds of energy are alike. Instead of supposing that the energy problem is simply where to get more energy, of any kind, from any source, at any price, we ought to be starting at the other end of the problem, by asking: What are the many different tasks that we want the energy for? And what is the amount and type and

It might seem hard to believe that firewood provides about twice as much energy as nuclear power. Nuclear plants are very visible and get a lot of publicity. In contrast, wood use tends to be quite decentralized°, hidden within ordinary homes and factories. It's hard to tell it's there—unless we check the statistics.

Nuclear energy comes to us as electricity. In 1984, nuclear plants dispatched 325 billion kilowatt-hours° of electricity. After subtracting the energy lost in transmitting the electricity to users, nuclear power delivered a total of 303 billion kilowatt-hours to U.S. consumers. That electricity had a heat content of 1.03 quads[1] (quadrillion BTU°).

In comparison, the U.S. burned 2.8 quads of wood in 1984, according to the Department of Energy. About one quad of that was used in residential and commercial buildings, and 1.8 quads in industry, mostly in lumber and paper mills. It is fair, however, only to count the fraction of that energy that went to satisfy an end-use° need. The efficiency of home wood-burning is said to be 45 percent (although the more than ten million cast iron stoves now in use generally do better than that), and the efficiency of large industrial boilers is 75 percent, also a conservative estimate. This means that total delivered wood energy in 1984 was 1.8 quads, or a bit less than double the nuclear contribution. The ratios are similar for the preceding four years.



The areas of the woodstove and the nuclear plant are proportional to the contributions of wood and nuclear power to U.S. energy needs.

[1] When we calculate the BTU equivalent of a quantity of electricity, we use its heat equivalent, 3,413 BTU per kilowatt-hour. The reason for this is simple: the only use for new electricity is heat (see the section of the film, "What Kinds of Energy?", this page). The amount of useful energy should not be counted as the amount of heat needed at the powerplant to turn the turbines that generate the electricity, but instead should count the heat it actually provides for people's baseboard heaters. The amount of energy used at the powerplants in 1984 was 3.55 quads—a figure that some authors use to make the nuclear contribution seem three times larger than it really is.

These figures show that woodburning makes up 3.2 percent of U.S. energy consumption, a surprisingly large fraction (compared to 1.8 percent for nuclear). But the actual fraction is probably even higher. Many sources (such as a report from Dartmouth University) believe even more wood is used, because they count not only the wood that people buy, but also that which people cut themselves—which does not all show up in the official statistics. (Indeed, the only wood use counted in most Federal energy compilations is the 0.003 quads burned annually by electric utilities.)

Wood use does have problems, such as toxic and cancer-causing gases in the smoke. Although these can be minimized, of course, by weatherizing houses so that the residents burn less wood and by fitting emission controls onto the stovepipe, woodburning is still not a perfect solution. We mention it, though, because it shows how a large number of small, simple projects can yield more energy faster than a few big projects that cost billions of dollars and take a decade or more to build. Like wood use, the many sources of sustainable energy are just a part of daily life. But until we take stock of how much energy wood and other sustainable sources actually provide, critics will keep trying to make those sources seem less important than they really are.

Questions:

1. Why might some people be surprised at the large share of our energy that comes from wood?
2. How many people that you know heat their homes at least in part with wood?
3. Can you think of other instances where large, visible projects seem to count for more than small but collectively important ones?

[Transcript continues]
source of energy which will do each task the cheapest way?

If we ask that question, then we need to look at what types of energy are physically required at the point of final use. In the United States, for example, our needs are 58 percent for heat, 34 percent for portable liquid fuels for vehicles. Only 8 percent represents all of the special, premium uses which need electricity and which give you your money's worth out of it—because it's a very special, high-quality, and expensive form of energy.

Now, if you were going to use that extra electricity for running electronics, overhead projectors, lights, motors, smelters, appliances, railways, things that really need electricity, then it might be worth paying that sort of premium price.

Changing Energy Paths Without Changing Lifestyles

For some people, the shift to a sustainable° energy path raises images of a radical change in lifestyle, in which people may not drive as much as they want to or keep their houses as comfortable as they would like. Actually, a sustainable energy future will make all of those things easier to obtain than they would be under the so-called hard path°. Here are some of the reasons why.

First, there are many different ways to use less energy.

■ *Curtailment* is what President Reagan meant when he said that conservation means "being colder in the winter and hotter in the summer." It means doing without certain energy services we want.

■ *Lifestyle changes* would include, for example, walking or riding a bicycle instead of driving to school. Lifestyle changes represent different ways of doing the same things, rather than simply doing less. Some people consider them to be curtailment, but those who choose them claim that these changes enhance their lives. For example, if you ride the subway, you avoid sitting in traffic jams and hunting for an affordable parking place.

[Transcript continues]
But those special uses, only 8 percent of our total energy needs, are already filled up because we supply today not 8 percent but 13 percent in the form of electricity, with more on the way. The difference—the other 5 units—is electricity that's already being used as we would have to use still more if we made still more: namely, it's being used inappropriately for low-temperature heating and cooling—space heating, water heating, air conditioning—sort of like cutting butter with a chainsaw, or using a forest fire to fry an egg. It's inelegant, messy, and dangerous, and very expensive.

Well, that implies, in turn, that arguing about what kind of power station to build is completely the wrong question. It's asking where to get more of a very special, expensive kind of energy of which we already have about twice as much as we can get our money's worth out of.

[HUNTER]

Energy planners use what's called a 'spaghetti chart' to show where energy goes in a country. The different *sources of energy*—coal, natural gas, hydro, oil, wood, nuclear—go in on the left-hand side

■ A *technical fix* saves energy in such a way that users typically cannot tell that any change has occurred. *All* of the energy savings in the film are based on technical fixes.

Technical fixes often are more convenient, in addition to saving energy. In a house, proper insulation and weather-stripping eliminate the annoying drafts that plague many houses in the winter. With proper insulation, the furnace in the house (if indeed you still need one) will operate less, producing less dust and soot. Properly insulated pipes save money and are less likely to freeze in winter. You will stay cozy in a superinsulated building, even if your energy is cut off somehow; solar gain and people-heat will keep you warm.

Other sustainable energy strategies can make users' lives more pleasant. In climates where cooling is important, the shade from one large tree and the evaporation of water from its leaves can equal the cooling power of a dozen room air conditioners. Other important methods, such as applying shading film to windows (incidentally cutting down on glare) and installing more efficient air conditioners do not involve a lifestyle change either.

Most of us still remember the gas lines of 1979. That crisis was caused by unsustainable energy use. If another oil crisis occurs, the drivers of 1985-model, 55-mpg cars will spend the least time waiting to buy gasoline. These cars can get from San Francisco to Los Angeles or from Boston to Washington on $9 worth of gas; many of today's 30- to 40-mpg cars have as much usable space as their older cousins that got twelve or fifteen. And when the efficiency revolution has gone a bit farther and alcohol-powered cars go into mass production, people will pull up to the pump and ask for fuel that is made on American farms, just as they now ask for fuel imported from overseas.

Sustainable energy is crucial, too, to the continued health of industry. Rising energy costs have threatened many manufacturers with bankruptcy. More efficient energy use can often enable a company to survive—and that's crucial to the lifestyles of its employees.

So sustainable energy does not have to impose lifestyle hardships on people. In fact, it is the pursuit of the hard energy path that threatens to do so. If we rely on nuclear power for a substantial fraction of our energy needs, even the nuclear advocates admit we will eventually develop a police state to prevent sabotage at nuclear facilities and to monitor the transport of nuclear fuels and wastes—materials that could be hijacked and processed into crude nuclear bombs. If we continue to depend on foreign oil, we will face oil spills, occasional shortages, and cutoffs caused in part by the political instability of many oil exporters. And as we continue to burn fossil fuels, the proven effects, such as acid rain°, and the suspected ones, such as the greenhouse effect°, are likely to grow more severe.

Questions:

1. Which kind of energy-saving category does each of these

measures fall into? A) Gasoline rationing. B) Wrapping an insulation blanket around your water heater. C) Opening windows for ventilation instead of using a fan.

2. How could you change your lifestyle to save energy? Would you like it? What technical fixes can you think of that would give you the same energy services but cost less?

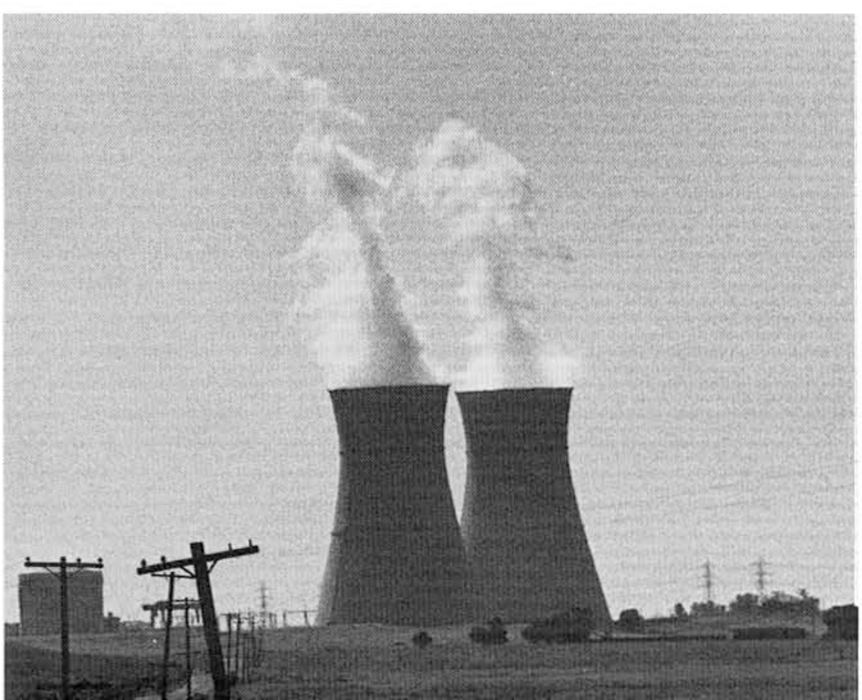
Nuclear Power, R.I.P.

In 1974, official projections said the United States would have a thousand or more nuclear plants operating by the year 2000. At the time, we had only 42 plants. By 1985, only 89 nuclear plants were operating, just 43 were still in planning or construction, and no new plants had been ordered since 1979.

The power source which was going to be the power of the future, "too cheap to meter," has actually cost too much to pay for. Most nuclear plants ran far over budget: California's Diablo Canyon nuclear plant, for instance, was originally projected to cost $350 million; in fact, it cost $5.4 billion. Holes in the ground and half-finished concrete domes across the United States stand as reminders of the collapse of nuclear energy.

Why has the nuclear industry failed? Many problems with the technology remain unsolved: questions of safety, both from catastrophic releases of radiation in an accident and from "normal" radioactive leaks; thermal pollution from the plants' cooling water (which eventually forced the construction of the trademark cooling towers, so the warm water would not be returned to the rivers); and what to do with the nuclear waste, radioactive garbage that will stay dangerous for tens of thousands of years.

But what killed the industry was the rising cost of building the plants, along with the huge increases in utility bills those costs created. Shoreham, the Long Island, N.Y., plant due to come on line in 1985 or 1986, will drive its customers' rates up by a third to a half. But ratepayers aren't



[Transcript continues]
and get processed in power stations, refineries, and other plants. Converting and distributing the energy wastes a lot of it.

Only what's left over can provide us with comfort, light, mobility, ability to make steel, bake bread, watch TV. It's for these *end-uses* that we want energy, not for its own sake. There's no demand for raw kilowatt-hours or for barrels of oil.

For example, French energy planners sought the cheapest way to meet their country's biggest energy need—heating houses. New power stations turned out to be the costliest way, so they were to be discouraged as uneconomic. But meanwhile, more powerful officials started on the left-hand side of the chart.

Nuclear power plants, once expected to play a large role in supplying the nation's energy, have turned out to be too costly a proposition. (Photo by Alec Duncan)

[Transcript continues] They said, foreign oil is unreliable; we need some other energy source; let's build reactors. But the only way to sell the nuclear electricity was for electric heating—which they had agreed not to do.

Which end of the spaghetti chart you start on—what you think the energy problem is—determines what you buy. If you start on the left, trying to replace oil by other fuels without regard to end-use or cost, you might suppose you need more nuclear- or coal-fired power stations. If you start on the right, you'll see that more power stations are the slowest and costliest way to replace oil or to provide the energy services we need.

Where can we get the energy we need?

[AMORY]

All the measures I've described so far only stretch the fossil fuels we've got. They don't replace them in the long run. And having been raised as a normal, healthy technotwit, I always used to assume that the best long-run replacements for the oil and gas were going to be the big, high technologies. Until about five years ago, I started shopping around for the best soft technologies I could find.

I defined soft energy technologies by five properties: first of all, they're *diverse*. There are dozens of different kinds, each one used to do what it does best, not trying to be a panacea. Secondly, they're dumb. When rates go through the roof, they start using electricity more efficiently, making Shoreham even less needed.

One of the most striking nuclear bungles to date was the Washington Public Power Supply System's attempt to build five nuclear plants in the Pacific Northwest, initially priced at $4.1 billion altogether. By 1982, the plants' pricetag had mushroomed to $25 billion, thanks to bad management, low worker productivity, and inflation. Four plants were cancelled or postponed. In July 1983, WPPSS (by now known as Whoops) was unable to meet a $16 million interest payment, and defaulted on $2.25 billion in bonds. Thousands of bondholders were left with near-worthless pieces of paper, and the bond markets reeled in shock. Now, hundreds of lawsuits have been filed against the defaulting utilities, the investment houses that ranked the bonds as virtually risk-free, and the federal agency that encouraged WPPSS to build.

Even though the nuclear promise has soured and the nation is turning its optimism to other energy options, nuclear power has left us with two lasting legacies. The first is nuclear waste: after the nuclear fuel has been used for a few years, its usefulness is over. But where do you throw away spent fuel that contains plutonium, deadly to humans in doses smaller than one-millionth of an ounce, and other radioactive elements? The waste remains extremely dangerous for at least a quarter of a million years. Current plans call for burying it, although no one can say for sure that the trucks won't break open en route to the dump, or that the buried waste won't slowly leach out. The Department of Energy commissioned a study on how to keep people away from the waste; its consultants recommended that the department create a mythology about the "demons" that inhabit the waste site and establish a nuclear priesthood to warn future generations of the dangers. In truth, no one knows how to handle the material responsibly.

The greatest danger of nuclear power, however, is not its health problems, but its contribution to the spread of nuclear bombs to other countries and even to terrorists. All nuclear reactors produce material which can be used to create nuclear bombs. At least a dozen Third World° countries are probably using or planning to use their supposedly peaceful nuclear power programs to make bombs. Nuclear industries in a dozen countries provide an excuse for countries with bomb ambitions to trade in uranium. However, the collapse of nuclear power gives us an opportunity to end this clandestine trade and make the world a safer place to live.

Questions:

1. What has been the principal downfall of nuclear power?
2. How can rising electric rates backfire against a utility?
3. What connections are there between nuclear power and nuclear bombs?
4. Are there any nuclear plants near where you live? What do you hear about them on the news?

Sustainable Energy and the Third World

The energy crisis in this country and other industrialized nations occurred because of the high demand we were placing on commercial fuels: oil, gas, coal, electricity. Yet for most people in the world, the real energy issue is a shortage of fuelwood. This shortage can force women and children to walk miles in search of the wood on which to cook dinner. Rising demand for wood has led to overcutting of forests, and forced people who cannot get wood to burn animal dung, thus keeping the manure from fertilizing the soil. Lush regions have been turned into deserts that can no longer support agriculture. The people wander, causing shortages in other areas or ending up in the slums of the cities.

As wood becomes scarcer, the cost of warmth, cooking and light increases, hitting the common people the hardest. "It costs as much to heat a pot as to fill it," says a proverb from the African country of Mali. Those with a little money try to switch to kerosene, but the poor must just work harder to get wood and charcoal.

Many attempts have been made to solve the problem, but they face great obstacles. Tree-planting is obviously necessary to provide future fuel and hold back the spread of the desert. Species such as the *leucaena*, which is a fast-growing, drought-resistant tree that fertilizes the soil, have been identified as good candidates for reforestation. In some countries, women, who are responsible in most cultures for gathering the fuelwood and for cooking, have begun to take strong stands to preserve the forests. In Northern India, for instance, they have hugged trees that their husbands were about to cut down for lumber. In Kenya, women's groups have spearheaded the Greenbelt Movement which has founded hundreds of public nurseries and tree-lots. Peasants in northern China have had great success in reforestation.

Biogas digesters like this one in Nepal can convert human and animal waste into fuel and safe fertilizer.

Still, many projects fail. Overabundant cattle eat the seedlings, young trees are cut down for firewood, and bureaucratic red tape keeps many efforts from succeeding.

Other technical fixes offer both promise and problems. Solar cookers are inconvenient, require a cash outlay (unlike wood and home-made stoves), and don't cook the same way as wood. In particular, they do not perform the principal function of a hearth: a gathering place and center for the family. With woodstoves, too, the need for a hearth must be respected—and even if people accept a new design, implementation can be slow while each household learns how to build and use it. Even then, enclosed stoves have sometimes been misused so that they were no more efficient than their predecessors. Also, to be truly successful, these programs must improve the indoor air quality in cultures where food is cooked indoors. Many cookstoves put out dangerous pollutants which cause lung disease and blindness. Progress is possible, however. Efforts such as those of Hawaii's East-West Center are demonstrating low-pollution stoves and working with villagers to find designs that fit their needs.

The fuelwood crisis is only one side of the problem. As Third World countries struggled to develop, they began using more oil. Then they tried to maintain their development plans despite the oil shocks. But since the mid-1970s, when the prices of their raw-material exports fell and the price of oil shot up, they have faced a cash squeeze. The average Third World oil-importing nation spends a third of its export earnings on oil. This creates pressure on farmers to grow cash crops for export, such as coffee or cocoa, instead of food crops such as rice and lentils. Consequently, many fertile countries paradoxically have lost the ability to feed their people.

But there is hope: these countries are often blessed with abundant sun, waterflow and wind. Small hydro turbines on streams and irrigation ditches can provide electricity. Such mini-dams are the main source of electricity in more than a quarter of China's provinces. Both China and India have large-scale programs to process manure and human sewage into cooking and heating gas—also resulting in cleaner, safer fertilizer than raw dung. Brazil is converting its auto fleet to run on alcohol, which it produces from sugar cane. Although Brazil's program is not without problems, it cut oil imports 30 percent in 1984, saving the country $1.6 billion.

But the wrong kind of energy development can hinder real economic progress. Many developing nations have begun building big power plants, seeing that as a step toward Western-style industrialization and a way of aiding their citizens. Such schemes, though, drain Third World countries' scarce resources while generating power only for a relatively well-off urban elite. Frequently, the countries build the plants without even having lines to transmit the power to potential users. Worse, countries that have pursued nuclear power usually have done so not because it is a realistic way to meet their people's needs, but in large part to obtain the nuclear-

[Transcript continues] *renewable.* They run on sun, wind, water, farm and forestry wastes, but not on special crops or depletable fuels. Third, they're relatively *simple and understandable* from the user's point of view. They can still of course be technically very sophisticated, maybe like a pocket calculator—I don't know how to build a pocket calculator, I don't quite know what goes on inside, but from my point of view as a user, it's a tool, not a machine. I run it. It doesn't run me. It's something I can make up my own mind about. Fourth and fifth, soft technologies supply energy at the appropriate *scale and quality* for the task they're trying to do, so as to minimize the costs and losses of distributing the energy and of converting the energy, respectively.

Anyhow, I shopped around for the best soft technologies I could find which were already in or entering commercial service, things that are already here and we don't need to wait for them. The best present art in passive and active solar heating, passive solar cooling, high temperature solar heat for industry, which we now know how to collect even on a cloudy winter day in bomb ingredients that reactors produce; Pakistan, Argentina, and India are cases in point. The real need in the Third World is mostly for village-scale projects to help the poorest, not huge concrete monuments to obsolete Western technology.

In fact, in all development projects it is critical to make sure that the technology proposed is appropriate to the need and the culture. Thousands of programs have failed because the technology did not do what the people needed, could not be maintained by local people with local skills, was too fancy to last long where there are no spare parts, or flew in the face of their local traditions. This means, for instance, that in addressing fuelwood problems, most of the attention must go to involving women in the programs, for it is they who have responsibility for cooking and wood-gathering.

But with creativity and sensitivity, solutions can be found. In Nepal, a digester was built to turn human sewage into burnable methane gas. But local taboos made it inconceivable for anyone to take the job of stirring the tank to keep the bacteria digesting. So an enterprising development worker affixed a Buddhist prayer wheel to the stirring rod. Now people spin the wheel as they pass by, sending a prayer to the universe and helping produce the energy they need.

Questions:

1. What is the main energy problem facing most Third World nations? What are some solutions that have been tried? What disadvantages do they have?
2. What problems might Western-style energy development create for Third World countries?
3. What are some considerations you might want to bear in mind if you went to a developing country to provide technical assistance?

[Transcript continues]
Scandinavia, converting farm and forestry wastes to liquid fuels for efficient vehicles (being very careful to protect soil fertility in the process), present hydro, micro-hydro, and a bit of wind power, perhaps for electricity, perhaps for running heat pumps, or water pumps, or compressing air to run machines.

I then reached two conclusions which rather surprised me at the time, but have since become much more widely accepted. The first is that if you add up the best present soft technologies in a particular place, and you use each one to do what it does best, they will be more than enough to meet essentially all of the long-term energy needs of that place. I can't prove this is true for every place, but it's been true of every country so far studied. That's about fifteen of them, including, for exam-

Brittle Power: A Fragile System

When people speak of how vulnerable the U.S. energy system is, they are often referring to the potential for another cutoff of imported oil. But our dependence on centralized systems *within* this country is equally dangerous. From domestic oil and gas pipelines to the cables of the electric grid, the comfort and safety of millions of Americans depends on the proper functioning of many complex systems.

Electricity is a good example. When you flip a switch, you expect electricity to be there. That depends, however, on many large machines, all rotating in perfect time with each other across half a continent. If any fall out of rhythm, if they happen to produce more or less electricity than is being consumed at that instant, or if the electricity can't get where it needs to go, the system begins to destroy itself. This is what happened in the massive Northeast blackouts of 1965 and 1977. Oil refineries, too, depend on a continual flow of raw materials. As the price rose, it became more expensive for refineries to stockpile crude oil, so they stored less of it. But now they can be shut down entirely—in a matter of days—if there is any interruption to the supply of crude.

The potential for sabotage at modern energy facilities is even worse. A small group could shut off three-fourths of the oil and gas to the eastern United States in one evening, without even leaving Louisiana. Using material from poorly guarded nuclear plants, a few people could manufacture a nuclear bomb which, exploded near a nuclear plant, would release enough radioactivity to make a large region uninhabitable for centuries. The Trans-Alaska Pipeline, the Saudi oil loading terminals in the Persian Gulf, and other facilities around the world are easy targets for terrorists. And attacks on energy facilities aren't just the stuff of James Bond films: they have recently happened in 26 states and more than 50 foreign countries. They now occur about once a week (more frequently in Central America).

Is there anything we can do? Of course. First, we must realize that big, modern and fancy may not be best. Our energy planning should instead stress resilience—the ability to withstand unexpected shocks and even bounce back stronger. Perhaps the most important feature of secure energy systems is efficiency. If all the cars in the United States got 65 miles per gallon (less than prototypes already have), they could run for a year on the fuel that was en route from oilfield to gas pump. That would protect us against sudden oil cutoffs, and give us time to improvise other supplies. Similarly, superinsulated houses—because they need little or no energy to stay comfortable—are much more resilient than leaky ones that depend on a continual supply of fuel or electricity.

It is also important that energy systems be decentralized. In 1965, the power engineer in Holyoke, Massachusetts saw the Northeast blackout rolling toward him. He cut the town loose from the regional grid and fired up the city's local gas turbine. Four hours later, that generator had paid for its entire cost simply by sparing the town from what it would have cost to shut down during the region-wide blackout.

Renewable energy can also contribute a lot to our security. It tends to place the energy source much closer to the end-use and to promote decentralization. Its diversity makes up for each kind of source's intermittent supply. A Great Plains farmer whose electricity came from a wind machine on his homestead saw a story on the TV news one night: his area was blacked out. He walked outside, and sure enough, it was. So he went back inside to watch his windpowered TV and find out when his neighbors' lights would come back on. A nation which runs on renewables is much stronger and less vulnerable to attack than one using big power stations and imported oil.

Fortunately, the energy system which a military planner would design to make the country as safe as possible is also the most affordable one. While we can't eliminate the unpleasant surprise of failures, we can certainly move towards a system which minimizes their consequences.

Questions:

1. Think about the energy system that keeps your school or

your house warm in the winter. What could go wrong that might keep it from working?

2. What do we mean by brittleness? Resilience? Give one example of one system of each kind that you depend on.
3. How would your lifestyle change if your supply of affordable energy were cut off?

Skeptics who don't like renewable energy sources point out that solar and other renewables have received big federal tax credits°. These credits, due to expire at the end of 1985, amount to 40 percent of the cost of residential solar systems, 15 percent for business systems. Various states offer further credits to supplement the federal ones. But the critics miss an important point: the entire energy sector is heavily subsidized. H. Richard Heede, a researcher at Rocky Mountain Institute, has spent a year tracing federal energy subsidies through mountains of budget reports. He found that the solar tax credit is tiny ($0.5 billion) compared to benefits given to fossil fuels and nuclear power ($41 billion). The solar subsidies are just an attempt to 'level the playing field' on which energy technologies compete.

What are these subsidies? Some are money that a federal agency spends directly: on research and development, benefits to coal miners who contract black-lung disease, the search for a 'safe' nuclear waste dump, and so on. Some are loans that the federal government backs—enabling investors to obtain credit where they otherwise could not. But energy companies get the greatest value from tax credits and tax deductions°. A few of these tax advantages are available to entrepreneurs who develop renewable energy sources commercially, but none are available to you for insulating your attic or installing a more efficient air conditioner.

The figures in the accompanying graph are taken from Heede's testimony to the House of Representatives in June 1985, before his research was complete. The problem with these uneven subsidies is not just that we should be fair to the various energy sources. Subsidies to fossil fuels and nuclear power make those sources seem cheaper than they really are, thus encouraging people to buy more of them than would be efficient. This uneven subsidization violates one of the conditions for a free market: that consumers see the true cost of the things they buy.

But that's not the only characteristic of a free market absent from the U.S. energy market. According to free market theory, everyone should have fair access to money. This means that the homeowner who wants to install efficient lightbulbs and a solar greenhouse should be able to get the money as readily as a utility that finances a new power plant. Unfortunately, at present that is not the case.

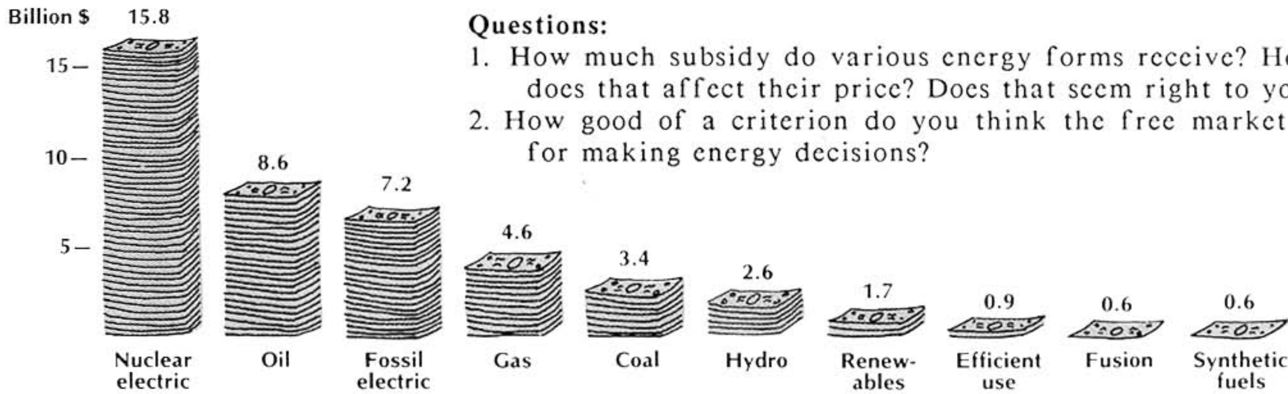
A true free market would also require that all the costs —environmental, social, and medical—of any product be passed on to the prospective buyers. When power plants and automobiles use your lungs to clean up their exhaust, for

Can the Free Market Alone Solve the Problem?

[Transcript continues] ple, the U.S., Canada, Britain, West Germany, France, Sweden, Denmark and Japan, and that's I think a rather suggestive list because it includes countries which are in various combinations cold, cloudy, high latitude, heavily industrialized, and densely populated, or perhaps all of the above. Nonetheless, although the mixture of soft technologies varies a lot between these countries and even between different parts of the same country, there always seems to be enough if you use the energy efficiently.

Secondly, although the soft technologies are not cheap, they're cheaper than not having them. Some cost more and some cost less, but mostly they cost a bit less than today's oil. But they're all cheaper in capital cost, cheaper still in working capital, and several times cheaper in delivered energy price than the hard technologies

This is a graph of federal energy subsidies in Fiscal 1984. Nuclear energy received over a third of the subsidies but delivered under 2 percent of the energy services. Solar, biomass, and wind got 4 percent of the subsidy, paralleling the 4 percent of the energy services they supplied.



instance, that is certainly not true.

Basic economics texts also talk about other conditions of free markets. For a true free market to exist, complete and perfect information should be available to everyone about their energy options; no small groups of buyers or sellers should monopolize a major chunk of the market; people should be able to go into and out of business easily; etc. The energy market has actually done amazingly well, given how imperfect it really is. But in view of the barriers still in the way of the market, it's remarkable how fast energy efficiency and renewables are progressing.

Questions:

1. How much subsidy do various energy forms receive? How does that affect their price? Does that seem right to you?
2. How good of a criterion do you think the free market is for making energy decisions?

Utilities: Getting into the Act

[Transcript continues]
which we would otherwise have to build to do the same tasks. That is not of course the sort of economic comparison which you will normally hear being made.

What our government likes to do is play a little shell game with cost, wherein they compare in cost with each other the things they like to build: coal-fired versus nuclear power plants versus synthetic fuel plants. And then when it comes to the things they haven't historically been quite so excited about, like conservation and solar, they like to compare those

Hardly a week went by in the mid-1980s without an article in *The Wall Street Journal* about a coming cancellation of some electric power plant and the deep financial troubles of the utilities. The construction projects begun in the early to mid-1970s turned out to be unnecessary and unaffordable, but also very costly to get out of. But just when the utilities' situation seemed impossible, a solution took shape. Now, smart utilities are finding it much more profitable to help their customers use less electricity and to buy renewable power from small privately owned generators.

To understand why a program which sounds like a recipe for bankruptcy is really the only way for utilities to stay in business, we must start with how utilities got into their present trouble. From 1950 to 1970, electric demand grew steadily at a 7 percent annual rate, and the more plants the utilities built, the cheaper electricity became. So, understandably, utilities tried to encourage everyone to use more power. Then, around 1970, new power plants began to cost more than old ones. But utilities failed to realize that their product was just like any other: the more it costs, the less of it people will buy. Utilities kept pouring billions of dollars into construction schemes while new demand slackened and prices rose. Demand growth has even stopped in some places. The utilities faced other problems as well. Their new plants required them to borrow most of the billions of dollars they needed at high interest rates. During the plants' long construction times, the utilities were paying interest on money that was earning them nothing. And the cost of all that showed up in the cost of the electricity, too. As demand dropped, the utilities' income dropped, so they had to borrow even more to complete their plants. Most utilities even borrowed to pay their dividends°, and some to pay interest.

But after several years of these financial difficulties and surprises, many utilities, often under pressure from the state regulators, realized that they would be better off buying power from small producers and helping their customers consume less electricity. Many called off expansion schemes: between 1980 and 1984, only 21 large power plants were ordered; 101 were cancelled.

Utilities do some simple arithmetic. First, they take capital costs, the costs of building a plant, and spread it out over the plant's useful life of 20 to 30 years (nuclear) or 30 to 40 years (coal). They add the cost of fuel and of running and maintaining the plant. If there is enough demand for electricity, the utility runs the plant and charges enough for the electricity to pay the capital and operating costs. (Electricity prices are measured in cents per kilowatt-hour. The 1984 national average price was seven cents; power from a new nuclear plant generally costs two to three times as much.)

When demand drops so the utility does not have to run the plant, it saves operating costs. But it still has to pay the capital costs back to the people who put up the money. To make enough money to do this, the utility raises its rates. But then people use even less. Simply put, building new plants to meet people's electricity needs is too costly. A new nuclear plant can cost more than all the rest of a utility's assets. And once the costs of that plant work into electric rates, customers can find themselves paying more each month for electricity than for their mortgage.

But what can a utility and its customers do? Let's do some more math—this time for energy savings and renewables. Suppose the utility lends you $1000 to weatherize your home, about enough to cut your space heating needs by a third. And let's say that it doesn't charge you interest on the loan, so its cost is the interest that it foregoes by not putting the money in the bank; nine percent, for instance, or $90 per year. If you insulated an electrically heated house in an average U.S. climate (like St. Louis or Washington, D.C.), you would need roughly $400 less of electricity per year to stay comfortable. Then the utility can turn around and sell that $400 worth of electricity to someone else, putting it more than $300 ahead.

Meanwhile, you pay the loan back over, say, five years, at $200 per year. So you come out ahead by $200 a year, and when the loan is paid off, you're way ahead, saving electricity—without having invested a cent. This just required that the utility make the economical choice of investing in your insulation before it invests in a very expensive power plant.

Not only is it economically sound for utilities to make no-interest loans to their customers—it is even profitable for them to *give away* energy-efficient devices. Many now offer rebates for buying efficient lightbulbs and appliances; Ore-

[Transcript continues]
costs, not with the competing hard technologies, but instead with the old cheap gas which we're going to run out of or which all these things are meant to replace.

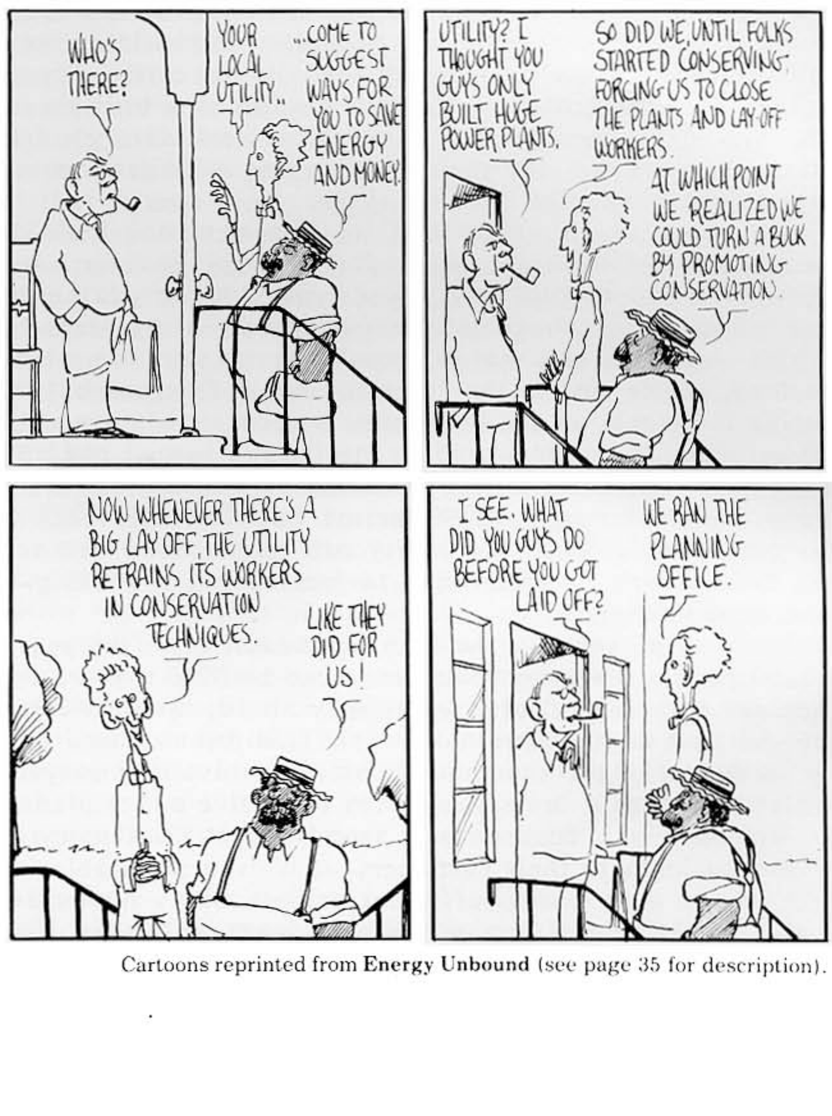
So they're rejecting as uneconomic a lot of renewable sources in the 15-to-25-buck-a-barrel range because they can't compete with 10-buck-a-barrel gas, when the alternative is synfuels at over 40 bucks a barrel and electricity at over a hundred bucks a barrel. That's just nuts. More formally, that leads to a misallocation. (Article, p. 21.)

But what we ought to be doing, of course, is to compare all of these investment opportunities with each other, not some with each other and some with the old cheap gas. And when we do that we find, as the Harvard Business School study found, that in general, the cheapest investments are efficiency improvements, then the soft technologies, then the synthetic fuels, and most expensive by far are the power stations. As a nation, we have been taking those options in reverse order, worst buys first.

Financial Analysts Meeting
[HUNTER]
We're frequently invited to talk to the business community and it's something we're very happy to

gon's Pacific Power and Light is testing a plan in Hood River County whereby it weatherizes your house extensively at its own expense, and pays you a further $1.15 for the first year for every kilowatt-hour of durable heat-saving improvements you make. With these programs, utilities can bring savings on-line several times faster than they could build a new central power plant. They then can sell the saved electricity (made at old, cheap plants) to other customers. What's more, most of the efficiency improvements are cheaper than just the operating costs of most power plants, so it is cheaper for the utilities to install these improvements in people's homes than to continue running their generators.

But buying efficiency is only one side of the issue. There is enough efficiency cost-effective with today's technology to save three-quarters of present electricity use. Still, at some point, as old plants retire and populations grow, some new sources of power will be necessary. After savings, the cheapest sources of new electricity are the appropriate renewables. Some utilities have begun experimenting with renewables, but many, being used to building large power plants, have made their renewables too big and complex to be economical. Meanwhile, however, small-business people have been showing utilities how to do it right. Power compa-



Cartoons reprinted from **Energy Unbound** (see page 35 for description).

[Transcript continues]

do, not only because they control a great deal of the money that goes into the energy sector, but because, increasingly, it's a very worried community. They are beginning to realize that financing these large, centralized projects is not what they thought it was, and they're beginning to get a sense that the energy game is changing on them. And they're not always sure they know what the problem is anymore, and one of the things that we try to do is to help them to reassess what problem it is that they're actually dealing with.

[AMORY]

It doesn't matter what kind of new power station will be able to give you the cheapest electricity because no kind of new power station can come close to competing with the real competitors, the cheapest ways to provide these energy services of heat and mobility. And those cheapest competitors are of course familiar things like weatherstripping, insulation, heat exchangers, greenhouses, planting trees, pyrolizing logging wastes, window overhangs, and shades and shutters. Things which in general cost less than the running costs alone for any sort of new nies have been required since 1982-3 to buy electricity at a fair price from anyone who generated it. So people have set up wind machines, solar cells, and small hydropower turbines and have cogenerated electricity at their factory or building (by using the same fuel to make electricity and useful heat), and are selling the power back to utilities.

That market has taken off spectacularly. In California, for instance, small producers had made firm offers of 20,300 megawatts° of privately owned power to the utilities by March 1985; the state's 1984 peak power demand was only 37,000 megawatts. In addition, state utilities already have 10,000 megawatts of cheap hydro and geothermal° capacity of their own. In fact, the deluge of private offers was so sudden that the utilities called a time-out to keep from being overwhelmed. And it's not just a Californian phenomenon: small power commitments now cover 22 percent of Maine's expected power needs and 14 percent of New Hampshire's.

The utility industry is changing rapidly. As utilities realize that their real business is supplying your energy service needs in the cheapest way, they have shifted away from trying to sell you more electricity so they can build more plants whatever the cost. The smart utility now meets your needs with energy savings and with new electricity, if any, from an entrepreneur's wind machine, a factory's cogeneration rig, or their own small hydro dam, whichever is cheaper. The utilities that adapt gracefully to this new situation will prosper; those that resist won't be around very long.

Questions:

1. What are the different kinds of costs that a utility faces?
2. How is it to a utility's advantage to install efficiency for its customers?
3. What similar programs does your utility operate?

[Transcript continues]
central power station, even a nuclear one. So, if you've just built one, like say Diablo Canyon, you'll save the country money by writing it off and never operating it. Maybe I should run through that one again slowly.

Because we're used to thinking that the competitor is another kind of power plant rather than the cheapest way to do the same end-use task, I think it's a little hard to get used to the idea that what we're competing with isn't an oil- or coal-fired plant. It's weatherstripping. If you were to turn on a newly built, say, reactor, all that you could do with that extra electricity would be low-grade heating and cooling because the premium uses are already filled up. But all that it's worth paying to do low-grade heating and cooling is what it costs to do them in the cheapest way—efficiency improve-

At the Grassroots: Community Energy Achievement

The energy revolution is coming not from the Federal government, but from people's homes and businesses. Local and state governments can be very helpful, and higher levels of government can sometimes be persuaded to help clear some of the market barriers mentioned before, but there is no substitute for people solving their energy problems themselves.

Springfield, Illinois

The Springfield Energy Project began with the realization that $136 million was being drained from this town of 100,000 each year to pay for energy. The organizers of the project contacted 300 people throughout the city, including prominent business and civic leaders and representatives of all segments of the town. At the initial meeting, 200 people showed up and split into task forces. They spent two years taking suggestions from the rest of the townspeople and formulating energy recommendations. The task forces announced their recommendations with great fanfare, and in

[Transcript continues]
ments, passive solar measures, things which come in at about four-tenths of a cent per kilowatt-hour. Whereas the running cost alone for a new reactor is one or two cents a kilowatt-hour, so you're better off not running it. (Article, p. 15.)

[ANALYST]
You give no source material on these statistics that you presented us with. Are they God, U.S. Government, my-handbook-of-fradulent-statistical-manual, or just what is the source material?

[AMORY BEGINS RESPONSE, THEN CONTINUES]
Because our primary argument is the economic one, is that the soft path is the cheapest thing to do, we have to depend on numbers, and some people wonder where our numbers come from. Well, we rely only on cost and performance data that are measured for real devices that you can go out and buy and we're at pains to document where our numbers come from. Some people complain that our books have more footnotes to them than text. But that's the price one pays for letting people go back and see exactly where the numbers

the next elections, the candidates who supported the plan were elected to the city council. Many of the plan's energy-saving recommendations have already been implemented, including:

* Zoning changes to promote urban infilling, thus reducing the need for heavy commuter traffic;

* Credits from the municipal utility for the purchase of high-efficiency air-conditioners and rebates for installing insulation.

* A one-cent-per-gallon gasoline tax to finance transit improvements, such as computerized stoplight synchronization to reduce gas wasted when cars idle at stoplights.

Davis, California

Davis is one of the most famous examples of local energy planning. After the 1973 energy crisis, the city—with input from its citizens—designed a new building code to encourage energy efficiency. Restrictions on clotheslines and shading overhangs were eliminated. Passive solar and earth-sheltered buildings are encouraged, as is tree-planting, to reduce summer cooling needs. The code promotes narrower streets (again, to reduce summer overheating) and cul-de-sacs connected by bike paths—to encourage the use of bicycles instead of automobiles. Not only has the code helped Davis use 30 percent less energy in buildings than it did in 1973 (even though population has grown 7 percent), but the attitudes it fostered even helped Davis win a $100,000 prize from Pacific Gas and Electric in 1981 for cutting its peak summer electricity use an additional 32 percent in one year.

Franklin County, Massachusetts

When the film was made, the Franklin County Energy Project was going strong. More than 90 percent of county residents polled in 1980 said they had reduced their energy use since 1974; energy audits were saving the average participating homeowner more than $500 each year.

But the later story is not purely one of success. The citizens' group disbanded long before it accomplished all of its goals. Its members chose an implementation plan that required state legislation, and many people burned out chasing that elusive goal. At the same time, the group lost its Department of Energy funding in the change of Administrations, and the group's leaders took jobs elsewhere teaching others how to do similar studies.

As people stopped seeing energy as a crisis, the formal effort was much reduced. But the work continues in a quiet way: energy consciousness has become part of good housekeeping. Task forces continue weatherizing and solarizing public buildings, holding occasional workshops, and so on. The Franklin County experience reminds us that while the opportunities are great, all changes of this sort take time.

San Luis Valley, Colorado

The people in the San Luis Valley in southern Colorado

Residents of the San Luis Valley, working together to make and install a hot-air collector. (Photo courtesy the San Luis Valley Energy Office)

faced an instant energy crisis—long before those words had entered most Americans' vocabulary. In 1960, a businessman bought and fenced off land that the residents of the valley had used for grazing and wood-gathering for hundreds of years. But a few people in the valley knew about passive solar design, and taught their neighbors how to build solar greenhouses and hot air and water collectors. They scrounged most of the materials, spending less than $200 per greenhouse for what they couldn't recycle from the dump. Since then, the number of greenhouses in the valley has grown from four to more than two thousand—more than one out of every five structures in the valley has one. The valley now boasts solar trailers, a solar Post Office, and even a solar mortuary. The greenhouse program has cost $4 to $5 million to date, and saves about that much in energy costs every year.

Other projects and benefits have spun off: families grow vegetables in the greenhouses, eating fresh tomatoes in February. Wind machines have sprung up, as have stills to convert cull potatoes and barley washings into fuel alcohol. And the change in people's attitudes hasn't stopped with energy: the community's increasing self-reliance has led to lowered rates of alcoholism, family abuse, and mental problems. Now the people are organizing a local ambulance and emergency medical service in a county that did not have a single physician.

Santa Monica, California

Utilities began offering energy advice to their customers in 1981, but the program hardly met Santa Monica's needs. The 'audits' were aimed only at property owners, but the majority of Santa Monicans are renters who pay their own energy bills, but have no incentive to improve the landlords' property. On the other hand, the landlords have no reason to fix up the property if the tenants pay for heating.

So Santa Monica launched its own "Energy Fitness Program" (a much more inviting name than 'audit'). Instead of just leaving a list of recommendations, the Santa Monica advisers actually install low-cost, high-saving measures for free such as water heater insulation, efficient showerheads, and weatherstripping. This eliminates the bias against renters.

[Transcript continues] come from. And I wish some of our critics were quite as explicit about where their numbers come from.

Because there is disagreement about some of the basic numbers, we are also quite careful to use what are called conservatisms. That is, to weight the argument in a dozen or so ways *unfavorable* to our conclusions, and when we still come out with the same conclusions despite making all these unfavorable assumptions, that's a much more persuasive answer.

[Hunter]

Many utilities are giving low-interest loans to individuals and businesses to finance energy-saving measures. This may sound like a radical idea, but those utilities see it as a better investment than spending billions of dollars to build power plants that may never pay for themselves. (Article, p. 15.) Utilities with over two-fifths of U.S. generating capacity are already offering these loans to their customers because it's the only way they see to stay solvent. Not all financial people agree with such ideas, but economic logic is leading many to views a lot like the soft path.

Having heard of programs which only get a 3 to 5 percent response rate, the Santa Monica advisers give notice of when they will appear, and then go door-to-door through the neighborhood. Within a year, they have reached over a third of the population, especially groups such as the low-income residents that have been hard to reach with ordinary energy messages. Estimated savings total about $500,000 per year, or about $100 annually per dwelling—more than the cost of the program.

Questions:

1. These examples are only a few of the thousands of community programs which have been done in the United States. Has anything similar been done in your area?
2. What do these programs have in common? How do they reach people where other programs do not?
3. Can you think of similar programs that might be useful to your community?
4. If you were going to undertake a community-based energy program, how would you go about it?

Water, Land, and Energy: The Critical Connection

Water is already replacing energy as the most serious resource controversy in the United States. Unfortunately, water policy is repeating all the errors of energy policy in the 1960s. In particular, many people who deal with water policy think that the problem is simply where to get more water, from any source, at any price. But as with energy, it makes more sense to ask what tasks the water is wanted for, and what amount, quality and source of water will perform each task at least cost. This 'end-use' strategy, focusing especially on greater efficiency, has already largely solved the energy crisis. It can also prevent the water crisis we face from getting out of hand.

The water issue, however, is in some ways more complex than energy. Most water in the United States is used to grow food; irrigated farms in seventeen Western states take three-quarters of all the fresh water used in the country. Federal and state water projects provide water to farmers at an average of a sixth the cost of replacing the water. This makes farmers happy, but it encourages overirrigation. Much of that irrigation water comes from "mining" ancient underground water reservoirs, or aquifers. For example, the Ogallala aquifer, stretching under the High Plains from Texas to the Dakotas, is, on the average, already a third gone. In some places, the water table recharges at a quarter of an inch per year, but farmers are annually draining it by a foot or more.

And it isn't just the quantity of water that's affected, it's the quality, too: many agricultural practices pollute the ground- and surface water. In California's Central Valley, decades of irrigation have washed salts into Kesterson wildlife refuge, where a buildup of selenium is killing and deforming fish and waterfowl. Such salt build-ups also reduce the fertility of the land. Irrigation can wash fertilizers, her-

[Transcript continues]
[David Sternlight]
If you don't think about the energy problem in terms of end-use, because that's what people are buying in the market, and in terms of the economic dynamics of it, and if you in fact orient your thinking toward supply sources—oil, coal, gas, and so on—which is traditional, you may wake up one morning to discover a catastrophic change in what you had expected to be happening in those areas without any foresight, warning or explanation. That's a situation that none of us, given

bicides, and pesticides into rivers, lakes, and groundwater.

Just as irrigation is mining the groundwater, so most farms are mining the soil. Soil erosion is worse today than during the Dust Bowl era: topsoil is being lost two to four times as fast as it can be regenerated, with one dumptruck-load of topsoil passing New Orleans in the Mississippi every *second*. But the loss of soil is being temporarily masked by intensive chemotherapy. For example, Illinois corn yields have doubled since 1940. But that gain has required a forty-fold increase in artificial fertilizer and vastly expanded the use of herbicides and insecticides. Not only do these chemicals cost a lot; worse, they are being less effective. Since 1950, pesticide use has multiplied eleven times, yet crop losses to pests have jumped from seven to thirteen percent of crop yields.

All of these forms of chemical farming require huge amounts of energy; naturally, they became popular when energy was cheap. For example, water pumping—85 percent of which is for agriculture—is the biggest user of electricity in California. Around the West, a number of power plants have been justified as necessary for irrigation. Yet plant construction costs passed through to irrigators can make farming uneconomic. Worse, power plants in the West often demand cooling water that is diverted from agriculture. Fertilizers and pesticides are energy-intensive to use, and are even made from natural gas and oil. Energy is important in dis-

A badly eroding field in Idaho, demonstrating the toll row-cropping can take on the soil. (Photo courtesy USDA Soil Conservation Service, Denver)

[Transcript continues]
our various responsibilities, wants to find ourselves in.

What Can We Do?
[HUNTER]

There are so many options for efficiency and for soft technologies that some will be right for you no matter where you live. Millions of people in thousands of communities are weatherizing their houses, and getting more efficient cars, appliances, offices and factories, because these are things individuals and communities can do for themselves. These accessible energy technologies are spreading very quickly. In the past few years, those millions of little energy savings have given us more than fifty times as much new energy as all of the expansions of energy supply put together. We've been solving the energy problem from the bottom

tributing food, too: the average molecule of U.S. food travels thirteen hundred miles before it is consumed. As energy has grown more expensive, the problems of an unsustainable farming system have become front-page news. But the problems reach beyond energy to encompass food prices, the debts that farmers built up to mechanize their operations, and even international trade issues.

How do we solve these problems? First, we should take an end-use approach to water and agriculture. A thorough rethinking of these systems will show the necessity for more efficient irrigation; cheaper, more natural farming practices, less reliance on synthetic fertilizers; and an attitude of stewardship for the land that we depend on. Many groups are working on the problem, including the Land Institute in Salina, Kansas, which is rethinking the basic premises of agriculture and developing sustainable practices; the New Alchemy Institute in East Falmouth, Mass., which integrates housing, renewable energy, fish-farming, and agriculture; the Rodale Research Center in Emmaus, Penn., which investigates techniques of agriculture without chemicals; Ecology Action, in Willits, Calif., which teaches techniques for dense, lush home gardens; the Center for Rural Affairs in Walthill, Neb.; and the Lovinses' Rocky Mountain Institute.

Questions:

1. Where did the food you ate this morning come from? ("The supermarket" doesn't count—where did *they* get it?)
2. What is one way that issues of land and energy are connected? The issues of water and energy?
3. What techniques can you think of that could contribute to sustainable water use and farm practices?

Glossary

Acid rain: Rain (and snow, fog, and sleet) significantly more acidic than normal. Caused by the creation of sulfur and nitrogen oxides when fossil fuels are burned, which then are transformed into acid in the atmosphere.

Active Solar: Collecting solar energy by pumping a fluid—usually water, air, or antifreeze—through collectors.

BTU: British Thermal Unit. The amount of heat that will raise the temperature of a pound of water by one degree Fahrenheit. Roughly the energy in one kitchen match.

Cogeneration: The process of burning fuel to generate electricity and useful heat, e.g., to heat an apartment building or provide heat for an industrial process.

Decentralized: Dispersed, not concentrated in one place.

Dividends: Shares of a corporation's profits paid to its stockholders.

End use: A purpose for which we need energy; the energy service that we seek. Examples: mobility, comfort in extreme weather, hot shower, making cement, watching TV.

Energy: The ability to do work or change the temperature of an object.

Flat-plate collectors: Devices used in active solar systems to collect solar energy. Typically consist of metal tubes bonded to a black metal absorber plate, set in an insulated box behind one or two panes of glass.

Geothermal energy: Energy tapped from the internal heat of the Earth. Natural examples include volcanoes, geysers, and hot springs.

Greenhouse effect: The trapping of heat in the Earth's atmosphere, potentially leading to an increase in world temperature, changes in climate, and rises in level of the oceans. Many scientists suspect that rapid burning of fossil fuels may cause carbon dioxide to accumulate in the atmosphere, bringing about global warming.

Hard path: A style of providing energy services characterized by large energy projects, often with heavy environmental impacts, and by inefficient energy use. Typical fuels include petroleum, natural gas, coal and uranium.

Kilowatt: Unit of power; measures how quickly energy is being used. Most often applied to electricity. One thousand (kilo-) watts. Roughly equal to the consumption of a toaster, 10 bright incandescent lightbulbs, or four older-model television sets.

Kilowatt-hour: Unit of energy; measures how much energy has been used. Equivalent to a kilowatt used for an hour, or a hundred watts used for ten hours.

Megawatt: A measure of power equal to one thousand kilowatts, or a million watts; enough power for a few hundred households. A large power station generates several hundred to a thousand megawatts.

Passive Solar: Using buildings themselves to collect solar heat, without using moving parts or mechanical systems.

Photovoltaics: Devices that convert light directly into electricity, made from material similar to computer chips.

Quad: Standard unit of large quantities of energy, equivalent to one quadrillion (1 followed by 15 zeroes) BTU. The United States used about 77 quads in 1984.

Renewable: Replenished or continually supplied by natural energy flows such as wind, sun, water, and plant growth.

Sustainable path: A style of providing energy services characterized by diverse, renewable sources, matched in scale and quality to the end-use needs they aim to satisfy, used very efficiently and no faster than natural processes supply them. This term refers to the same concept called the **soft path** in the film; many people have found that 'sustainable' is a more descriptive term.

Synergism: The whole's being greater than the sum of its parts.

Therm: Unit by which natural gas is often measured. One hundred thousand BTU, or about a hundred cubic feet of natural gas.

Third World: The less industrialized countries. Most of these countries have high population growth rates; most won their independence from colonial powers since World War Two. Examples: India, Ethiopia, Indonesia, Ecuador.

[Transcript continues]
up, not from the top down. Washington will be the last to know.

The energy problem isn't too complicated or too technical for ordinary people to understand. It's something that each of us can get on with addressing and solving in our own lives. And if we realize that, then we're empowered as individuals and communities to get on with solving the problems. (Article, p. 25.)

Franklin County: A Community That's Solving Its Energy Problems

Franklin County is one of the poorest counties in the state of Massachusetts. It's cold, it's cloudy—some tenuous farms, some old mill towns, a lot of people out of work and very dependent on imported oil. When they looked at this situation and looked at the projections for the future, they realized that now they're sending out of the county each year thirteen hundred dollars per household to pay for energy. Somebody held up a bucket with a hole in it to symbolize the drain of money out of that county. Twenty-three million dollars a year

Suggested Energy Activities

[Transcript continues] going from Franklin County to Venezuela, and they never saw it again. Then somebody added up what that $23 million amounted to. It turned out to be about the same as the payroll of the ten largest employers in town. That got people's attention. They then asked, 'what about the future?' If in the year 2000 they were so lucky as to meet the lowest official forecast of energy needs and prices, things would be four times worse. The average household would send out 5,300 of today's dollars, not counting inflation, to pay for energy. Just to meet the county's energy needs, the single largest employer in town would have to duplicate itself every couple of years for the rest of the century. At that point, things begin to look a little hopeless. The future isn't possible. We can't get there from here.

But then the people talked about what they could do instead. How they could stuff up the little cracks in their houses, which in most houses amount to about a square yard of hole. How they could use passive and active solar heating, how they could provide liquid fuels for their vehicles from

Here are some energy activities that you can try at school and at home.

At School

Discussion:

What energy services does your school need? How is each service being supplied?

Invite a member of the school community who is responsible for buying energy services. Have him or her describe your school's energy system.

What is your school's energy bill? Divide it into its parts —heating, cooling, lighting. (Hint: heating is needed mainly in the winter, lighting year-round, cooling mainly in the summer.) Compare energy costs for fall, winter, and spring. What percentage of your school's budget is spent on energy?

How is your school heated? Is there a better or more suitable way in your climate?

Does your school have insulation? Where? Weatherstripping? Where? Where could either of these be added?

Has your school done anything to use energy more efficiently? Could it do more? Is energy being wasted at your school? Be specific.

Action Projects:

Arrange a tour of your school's boiler room or mechanical systems.

Organize an energy efficiency task force in the school. Try to make a deal with the administration that the money saved will be split between the task force and the school. The same exercise can be done at home: implement an energy-saving measure and compare costs before and after.

Hold a debate on a current energy issue.

At Home

Discussion:

What are the age and efficiency (miles per gallon) of your family car(s)? Make a chart plotting miles per gallon against model year for all the cars owned by the families of students in the class. You may want to break the table out into compact, medium and full-sized cars.

How is your home heated? What steps have you taken to improve the energy efficiency of your home?

Dig up the utility bills for your house or apartment. How big a portion of your bill goes for space heating? For cooling? For general uses?

If your utility gave notice that its generating capacity were overtaxed, and that people needed to turn off appliances for the next three hours to prevent a brownout, what appliances in your home would you turn off? If you and your neighbors had efficient appliances, would brownouts be more or less likely to happen?

Action Project:

Make a list of the appliances and lights in your house. Find out how many watts each one draws. [Usually listed on the machine's nameplate. Approximate wattage is volts (V) times Amps (A). For some, like refrigerators, it may be easier to find an estimate of annual energy use and divide by 12.] Estimate how many hours per week each is used. Then see if the total electricity use you come up with is close to the amount you are billed for. Your table should look like this:

Appliance	Watts	Est. hrs used/mo	Est. kWhr/mo
Toaster	1,000	5	5
Stereo	70	100	7
	⋮		
Total			12

Hands-on activities

Solar Heating
Materials: two boxes, one to fit inside the other; thermometer; plastic film (food wrap); tape; cold water; newspaper or cotton balls; sunny day.
* Set the shoebox on its back. Put the thermometer inside.
* Stretch the film across the top of the box; tape it in place.
* Place the box in the sun. Jiggle the thermometer so that it is in the shade of the edge of the box.
* Note the temperature at the beginning and after 10 or 15 minutes.
* Open the plastic film and let the hot air out. Bring the thermometer back to room temperature by sticking it in cold water.
* When it is back to room temperature, dry it and replace it in the box. Re-cover with plastic film.
* Place the box inside the second box. Pack the space between with crumpled newspaper or cotton balls. Stretch plastic film over the top of the second box and tape it in place.
* Put the assembly back in the sun, and note the temperature as before.
Do you think there will be a difference? If so, what? Why?

Solar water heating
Divide the class into groups of three or four. Each group will design and implement a way to heat one cup or pint of water using only solar energy. See which group can heat the water the most in a given amount of time. You may want to place certain restrictions on size (e.g., must fit in a shoebox), and on the materials that may be used (e.g., tape, plastic film, newspaper, foil, etc.).

Food dryer
Build a food dryer. (Plans in, e.g., *The Mother Earth News*, July/August 1980; much simpler designs work, too.) You can use it to dry fruit (banana chips—mmm!), flowers, or herbs.

A simple food dryer such as this one can dry herbs, fruits and vegetables in a few sunny days.

■ **Page 33**

[Transcript continues] methanol from the sustained yield of some of the unallocated public woodlots, how they could meet their electric needs with wind or six times over with microhydro right within the county. All of these were devices that the machine shops with people out of work could make, right within the county. And they totalled up what this would cost. Twenty-three million dollars. The same amount they're now paying for energy, but the difference is you've just plugged the hole in the bucket. The money stays home, the jobs, the economic multiplier effect stay in Franklin County. As a result, it's no longer a study, it's the Franklin County Energy Project, and they're doing it.

[AMORY]

Some people ask whether the whole American way hasn't been based on producing more, rather than using what we have more thriftily. I think we tend to

Energy in Your Area

Trace your electricity from source (power plant) to light socket. What sources does it come from? Is any of it renewable?

What other fuels do you use? Where do they come from?

If possible, organize a tour of a local utility installation.

Are there buildings in your community that use sustainable technologies? How do they work? Again, try to arrange to see one.

How many nuclear projects are there in your state? How many of them are operating? Where are they? How have they worked?

Give a brief presentation, either about an article you have read in the newspaper or about an energy issue you have followed for a while.

What do you think the prospects are for a community energy project in your area?

Possible oral report topics:

* How do power plants work (hydro, coal, oil, gas, nuclear, wind)?

* How does cogeneration work?

* The 1973 oil embargo: its effects on energy prices and the U.S. in general.

* How have attitudes about energy changed over the past 10 years?

* Washington Public Power Supply System (WPPSS).

* Synthetic Fuels Corporation.

* The current administration's energy policy: what is it? Do you agree?

* Energy projects and activities sponsored in the community: what have they accomplished? How have they worked?

* Your state energy office: what programs does it offer? How has its focus shifted since it was established?

* Sustainable energy companies in your area: what do they produce (or what services do they offer)? How have they done over the past few years?

Digging Deeper: A Bibliography

There are many perspectives on all of this material. Here are a few places to find contradictory views. We hope that readers will satisfy their curiosity and form their own opinions on these topics.

Atomic Industrial Forum, 7101 Wisconsin Ave., Bethesda, MD 20814, 301/654-9260.

Committee for Energy Awareness, 1735 Eye St., N.W., Washington, DC 20006. 202/293-0770.

Edison Electric Institute, 1111 19th St., N.W., Washington, DC 20036, 202/828-7400.

Electric Power Research Institute, P.O. Box 10412, Palo Alto, CA 94303, 415/855-2411.

Your local gas or electric utility

Your state or local energy office or energy extension center

Your state public utilities commission (often called commerce or railroad commission)

For more detail, written for a popular audience:

A good general reference, expanding in plain language on the material in the study guide is *Energy Unbound: A Fable for America's Future*, Sierra Club Books, March 1986. Ca. 400 pp., $14.95, by Hunter Lovins, Amory Lovins, and Seth Zuckerman. The fictional story of a Dubuque, Iowa, housewife who becomes Secretary of Energy by answering a classified ad. Her assistants are confused and incoherent, but she stumbles across a suave analyst who teaches her the basics of energy issues. Witty dialogue with lots of easily understood substance. Illustrated with a dozen cartoons.

A good year-long curriculum is John Christensen's *Global Science*, Kendall/Hunt, 1984. 355 pp., $19.95, from K/H Publishing, 2460 Kerper Blvd., Dubuque, IA 52001; 30-day examination copies available. High school text covering population, food, energy, economics, and the finiteness of resources. Also lab manual ($9.95) and teacher's guide ($19.95).

General references that expand on particular essays in the study guide. Because of space limitations, this lists only a few of the worthy publications. For a more complete listing, try the 11-page annotated bibliography available for $3 from Rocky Mountain Institute, Drawer 248, Snowmass, CO 81654.

Prices (in U.S. $) and availability current as of August 1985 but may change.

Where ordering address given, price includes delivery within the United States.

Prices set off by slashes denote cloth/paperbound prices.

Can Sustainable Technologies Power America?

Leckie, Jim, Masters, Gil, *et al.*, *More Other Homes and Garbage*, Sierra Club Books, 1981. 416 pp., $14.95. Excellent how-to manual. Explains the design of efficient and renewable energy systems—heat, electricity and biogas. Clear enough for the non-technical reader to follow.

Nash, Hugh, ed., *The Energy Controversy*, Brick House, 1979. 450 pp., $7.65, from Friends of the Earth, 1045 Sansome St., San Francisco, CA 94111. Amory Lovins responds to 16 of his critics: his responses are printed side-by-side with their allegations, and readers are invited to decide who is right.

A New Prosperity, Solar Energy Research Institute Solar/Conservation Study, Brick House, 1981. 454 pp., $39.95/19.95. The most comprehensive study of U.S. energy use ever undertaken. Costs of saving and supplying energy sustainably, and policies toward that goal.

Nisson, J.D. Ned, and Dutt, Gautam, *The Superinsulated Home Book*, Wiley, 1985. 316 pp., $19.95. Design and construction of homes that require under $100 worth of heating and cooling per year, in all climates.

Northwest Conservation and Electric Power Plan, Northwest

[Transcript continues]
forget too easily that we don't produce oil or coal, God produces them. All we know how to do is to dig them up and burn them. And if we use them in an inefficient way, we run out. Then it gets very expensive. As energy prices rise, many people see the American dream slipping out of their grasp, and we can't guarantee that a soft energy path would bring energy prices back down to the unrealistically low level where they were in an age when there was a lot of cheap oil. There isn't ever going to be a lot of cheap oil again. What we can guarantee, I think, is that energy prices will be much lower in a soft energy path than if we didn't do it, because then we'd have much worse price rises in the future.

[HUNTER]

We're beginning to feel that the energy problem has been solved conceptually. And while we're now faced with the very tough problems of implementing what we know how to do—bringing the solutions to people in the communities—Amory

[Transcript continues]
and I are hopeful that perhaps we can begin to move on to some of the tougher problems that are also facing us. Problems in water policy, in soil fertility which are now in the state that energy was in in the 1960s: people are not yet aware that these problems are lurking out there. (Article, p. 28.) Particularly as energy and water and soil fertility begin to come together in an integrated resource crisis, we're hopeful that the lessons that we've learned in dealing with the energy problem can serve as a conceptual metaphor that will enable us to come up with some solutions to all of these other problems before they get out of hand.

[AMORY]
If the earth were the size of an egg, then all the water on the earth would be just a little drop, and all the air (if it were the density of water) would be a little droplet about a fortieth as big, and all the arable land would be a not

Power Planning Council (interstate compact), 1985. Two volumes, ca. 150 to 200 pp. each, free from NWPPC, 850 SW Broadway, Suite 1100, Portland, OR 97205. How to meet all needs for additional electric services from efficiency improvements and renewable sources, pushing the need for new power plants far into the future.

Stobaugh, Robert, and Yergin, Daniel, *Energy Future*, Random House, 1982 or latest edition. 368 pp., $6.95. Reviews main energy options, their problems and prospects.

In With the Good Air. . .

Shurcliff, William, *Air to Air Heat Exchangers for Houses*, Brick House, 1982. 224 pp., $17.95/12.95. Principles, cost and performance of air-to-air heat exchangers; directory of manufacturers and suppliers; survey of indoor pollutants. See also Nisson and Dutt, *The Superinsulated Home Book*.

How Do Uranium and Wood Measure Up?

Energy Information Administration, *Estimates of U.S. Wood Energy Consumption from 1980 to 1983*, DOE/EIA-0341(83), November 1984, DOE, Washington, DC 20585. EIA is the standard source of U.S. energy statistics.

Changing Energy Paths Without Changing Lifestyle

Lovins, Amory B. and L. Hunter, *Brittle Power: Energy Strategy for National Security*, Brick House, 1982. 512 pp., $17.95/8.95. Describes some of the beneficial lifestyle implications of a sustainable energy path.

Nuclear Power, R.I.P.

Lovins, Amory B. and L. Hunter, and Ross, Leonard, "Nuclear Power and Nuclear Bombs," in *Foreign Affairs*, Summer 1980, pp. 1137-1177. (Reprint $3 from Council on Foreign Relations, 58 E. 68th St., New York, NY 10021.) Demonstrates the link between nuclear power and the spread of nuclear weapons throughout the world.

O'Heffernan, Patrick, Lovins, Amory B., and L. Hunter, *The First Nuclear World War*, William Morrow, 1983. 444 pp., $17.95. Scenario for a nuclear war and how to prevent one from happening.

Patterson, Walter C., *Nuclear Power*, Penguin, 1983. 256 pp., $4.95. Nuclear technology, how it works and sometimes doesn't, and associated policy issues.

Sustainable Energy and the Third World

Brown, Lester R., *et al.*, *State of the World 1985*, W.W. Norton, 1985. 301 pp., $18.95/8.95. Global perspective on problems of environment, health, energy and population.

TRANET Journal, quarterly, $30/year from P.O. Box 567, Rangeley, ME 04970. Abstracts of and access to developments in appropriate technology worldwide.

Brittle Power: A Fragile System

Lovins, Amory B., and L. Hunter, *Brittle Power*. The vulnerability of centralized energy systems to accident, natural disaster, and sabotage; designing resilience into a system through the use of efficiency and renewables.

Can the Free Market Alone Solve the Problem?

Heede, H. Richard, *Preliminary Assessment of Federal Energy Subsidies in Fiscal Year 1984*, Rocky Mountain Institute, 1985. 29 pp., $20 from RMI, Drawer 248, Old Snowmass, CO 81654. Counts subsidies to energy sources and end-use efficiency. More detailed version set for late 1985.

Utilities: Getting Into the Act

Munson, Richard, *The Power Makers*, Rodale Press, 1985. 320 pp., $16.95. Popular survey of the institutional revolution in the electric utility industry.

At the Grassroots

Nichols, John, *The Milagro Beanfield War*, Ballantine, 1974. 652 pp., $3.50. Fiction based on fact about a poor community in northern New Mexico, which, threatened by low self-esteem and water-grabbing land-speculators, manages to hold onto its livelihood and character and to regain some of its pride. Hilarious as well as educational.

Shining Examples, Center for Renewable Resources, 1980. 210 pp., $5 from CRR, Suite 638, 1001 Connecticut Ave., N.W., Washington, DC 20036. Summary of several dozen community renewable energy projects, including successes and lessons of each.

Water, Land & Energy: The Critical Nexus

Empty Breadbasket, Cornucopia Project of Rodale Press, 1981, 170 pp., $4.95 from Rodale, 33 E. Minor Ct., Emmaus, PA 18049. A review of the problems facing American agriculture and the growing threat of infertility and unsustainable farming.

Jackson, Wes *et al.*, editors, *Meeting the Expectations of the Land*, North Point Press, 1984. 320 pp., $22.50/12.50. Anthology on the gathering crisis in American agriculture, and visions of a sustainable agriculture that could replace the current practices of soil-mining.

Sheaffer, John R., and Stevens, Leonard A., *Future Water*, William Morrow, 1983. 288 pp., $14.95. Halting the waste of water in America can do more to prevent a shortage than all the new supply options under consideration—and be cheaper to boot.

[Transcript continues]

quite visible speck of dust, and that drop and droplet and speck are all that keep the earth different from the moon. If you take that sort of view of the world, then the fossil fuel, the millions of years' accumulation that we're burning up in less than a hundred years, for the most part, is just a little blip. History goes along for a very long time and there's a little spike and then it fades out again. And that, I think, is not an acceptable approach to our future. We hear many people now considering the future as somehow a short-term thing, and we don't like that philosophically. I don't think it's a moral position.

We're trying to come up with an approach to the energy problem and then we hope to many others, which will make it possible not only for our own children, but for children a very long time from now, to live a good life and enjoy the earth as we have done.

[End of Transcript]

This study guide expands on many points made in the award-winning documentary, *Lovins on the Soft Path.* Ranging from policy and economics to energy technology, the guide also includes a transcript of the film, a collection of classroom energy activities, suggested questions for a one-hour discussion of the film, a glossary of energy terms, and a guide to digging deeper into the issues. Articles include:

* Can Sustainable Technologies Power America? (3 parts)
* In With the Good Air: Indoor Air Quality and Energy Efficiency
* How Do Uranium and Wood Measure Up?
* Changing Energy Paths Without Changing Lifestyle
* Nuclear Power, R.I.P.
* Sustainable Energy and the Third World
* Brittle Power: A Fragile System
* Can the Free Market Alone Solve the Problem?
* At the Grassroots: Community Energy Achievement
* Water, Land, and Energy: The Critical Connection
* Utilities Get Into the Act

Lovins on the Soft Path has garnered critical praise and numerous awards, including the following prizes:

- Blue Ribbon, American Film Festival, 1982
- Best Science and Technology Film, San Francisco International Film Festival, 1983
- Best of Festival, National Association for Environmental Education Film Festival, 1982
- Best Energy Film, Audubon International Environmental Film Festival, 1982
- Chris Bronze Plaque, Columbus International Film Festival, 1982

[For information on how to order the film, see the inside front cover.]

Other Bullfrog Films you may find of interest:
Toast (12 min., 1977): A classic, very funny film that demonstrates the interconnected nature of the systems that bring a piece of toast to your table.
Small is Beautiful (28 min., 1981): A warm portrait of E.F. Schumacher, the British economist who was the first to question unbridled growth. National Film Board of Canada production.
Kilowatts from Cowpies (25 min., 1982): How animal wastes from farms and feedlots are being used to produce useful, renewable fuel.
A Portrait of Small Hydro (28 min., 1984): Portrait of three entrepreneurs who are putting old dam sites back into power production, thereby revitalizing small communities.
River Town (28 min., 1984): Inspiring story of Soldier's Grove, Wisc.—the flood-plagued community that refused to die and became the nation's first solar town.
New Alchemy (29 min., 1984): Fascinating portrait of the New Alchemy Institute, where the emphasis is on a whole-systems approach to research in solar energy, aquaculture, bioshelters, wind power, and related fields.

Amory and Hunter Lovins are the principals and founders of Rocky Mountain Institute, a nonprofit education foundation based on the Western Slope of the Colorado Rockies. They work there with a staff of fifteen in a superefficient building that uses no commercial energy for heating or cooling, despite the area's severe climate (lows of minus forty degrees F). Their work has expanded from energy to include extensive consulting on utility issues; efficient, sustainable use of water and agricultural resources; fostering global security from the bottom up; and building sustainable local economics. More information about any of these programs is available from the Institute at Drawer 248, Old Snowmass, CO 81654.