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Energy Alternatives

Curriculum Unit 81.05.09
by Thelma Stepan

This unit is designed to be used with average to lower ability high school juniors and seniors living in an urban New England environment. The majority of these students will end their formal education upon high school graduation. They tend to be interested only in the practical aspects of science, and not in abstract theory. The unit should take from four to six weeks to complete, depending upon the time spent on projects.

The purpose of the unit is to introduce to the students all aspects of energy use in the United States, with the objective of making him an "educated consumer. and an intelligent voter on energy issues. To this end, the subject will be treated in a general manner and will include a "little bit about a lot of things" rather than delve deeply into any one area.

It is not my intention to recommend any one course of action to the students. Rather, I intend to present as much relevant information about our energy situation as is feasible, and to arm the student with sufficient facts to make appropriate decisions in the future. It is also hoped that this information will be shared with the families of the students. Those choices appropriate for New England will be emphasized.

Objectives

1. To familiarize the student with mankind's history of energy use, beginning with the harnessing of the energy in animal muscles, continuing through his discovery of the power in wind and water and concluding with the present research in solar and fusion generated power. The focus will be on New England's historical sources of power. The present situation in New Haven will be investigated in a community survey.
2. To define for the student, in simplified fashion, the physical science aspects of energy, including such terms as work, power, calorie, joule, technology, etc.
3. To briefly describe each alternative source of energy possible now and in the foreseeable future, including the available reserves, monetary and environmental costs, technical aspects, and general advantages and disadvantages of each source. Those sources included will be wood, coal, oil, gas, water (including hydroelectric and tidal), wind, geothermal, solar and nuclear

energy “including fission, fusion and breeded reactors).

4. To determine appropriate methods of conservation of energy in the various aspects of urban New England living .

5. To apply the information learned during this unit in several practical projects including:

a. A role playing activity designed to demonstrate the political processes involved in energy legislation and the difficulties encountered in reaching any acceptable community agreement on solutions to energy and to related environmental problems.

b. To plan a suitable apartment or home for New England, making the most efficient use of available energy sources and including as many conservation measures as is economically reasonable.

c. To develop, as a group project, a long term plan for energy development in New England, based on the knowledge gained from this unit.

If the unit is successful, by its students will have realized that there is no one specific cause to our energy problems, nor is there one magical solution. They led to discover that a combination of conservation measures, new technology, and renewable energy sources will have to be adopted. should also be prepared to effectively participate in the political processes necessary to bring these solutions about.

The History of Energy Use

There has always been work that needs to be done—and work requires energy. Over the centuries, the sources for this energy have changed.

Even the cave man needed to travel in search of game and to bring back water, food and wood to the campsite. At first man used his muscles for every job. This really big jobs would require the cooperation of several people. Eventually, the idea of harnessing the superior muscle power of larger animals occurred and such animals as horses, camels and elephants were put to work.

As time went on, a particularly observant early man, (the prototype scientist, no doubt) noted that logs and other debris were moved along with ease by flowing water, and the raft and dugout canoe were born. Soon some other enterprising and observant fellow noticed the wind howling through the trees and tried adding a sail to his canoe. Man was now set firmly on his continuing quest to get the maximum amount of work accomplished with the minimum expenditure of his own muscle energy.

Soon simple machines were invented. A *machine* is any device which makes it easier or more convenient to do work. The lever was probably first, soon followed by the most important invention of all time , the wheel and axle. Machines, such as the wheel, are not sources of energy, but they do allow us to accomplish much more work with much less energy. This is called *efficiency* .

New England is a mountainous, wooded area streams and rivers. This wood from these forests and the water in the streams provided a convenient source of energy for the mills and factories that our early forebears developed. After Independence, when England no longer required that we send them our raw materials for manufacture, technology began developing new, effective ways to use available energy. *Technology* is a combination of physical skill and scientific knowledge, devoted to developing new and more efficient machines. As we are located on the Atlantic coast, sailboats were conveniently ready to carry off our goods for trade.

In 1769, the steam engine was ready to use and modern industry came into being, leaving simple water wheels and windmills to fall into disrepair and become quaint antiques. One hundred years later the electric motor was designed. These new machines made work easier, but were less efficient in the sense that they required fuel and heat to operate.

The atomic age only came into being in the 1940's, a mere forty years ago. Once again New England, with its high population density and intense industrial development was in the forefront of the new technology. We now get a higher percentage of our electricity from nuclear reactors than any other part of the country.

It should be interesting at this point, to do an survey of New Haven, questioning city officials, the United Illuminating Company and local merchants and residents on the reality of their energy sources and their conceptions of our energy condition. A sample questionnaire can be at the conclusion of the unit.

An excellent film titled "The Great Search" is available, free of charge, from the United Illuminating Company in New Haven. It tells the history of energy use with Walt Disney animation.

If we take a good look at our lifestyle, with each passing year we become more and more energy intense: that is, we require larger and larger amounts of energy. Only one hundred years ago, farmers used animals to till the soil, the automobile was unknown and ladies washed dishes and did laundry by hand.

When the parents of our students were children, we had increased our energy needs, but we were still way below our present energy levels. They walked to school, their mothers did not have self-cleaning ovens, refrigerators were just replacing ice boxes, and milk came in returnable glass bottles, not throw-away plastic which requires energy to make, and which are manufactured from petroleum products. The clothes they wore were mostly cotton and wool, natural fibers. Our students will notice that almost all of the clothing they are wearing are synthetics, manufactured from fossil fuels.

Students could benefit from discussing these changes with an older family member, like a grandparent, or a neighbor and reporting *on* their observations to the class.

What is Energy

In any discussion of energy we will encounter scientific terms which should be understood by the student.

The scientific definition of *energy* is "the ability to do work" or "to transfer heat". *Work* , in the scientific sense, is only accomplished when an object is moved over a distance. The amount of energy required depends upon the mass of the object and the distance it is moved. For example, it would require twice as much energy to move 10 kilograms for a distance of one meter, as to move 5 kilograms the same distance. It would also be true that the same amount of work would be done in moving 5 kilograms over 10 meters, as in moving 10 kilograms over 5 meters. The push or pull required to move the object is called a *force* .

Whenever work is done, energy is from one form to another. If I lift a baseball over my head, I use chemical energy in my body to lift the ball. *Chemical energy* is energy stored in chemical bonds. The energy is transferred from my body to the ball and is stored in the ball as *potential energ* y. Potential energy is stored energy. If I drop the ball, that stored energy is changed to *kinetic energy* (the energy of action) as the ball falls back down. Several examples, such as rolling a rock up a hill, can be used to demonstrate this concept to the students.

When energy is transformed in the form of heat, changes in composition or state will occur. If we transfer the potential energy stored in wood to heat by burning the wood, the wood is transformed into gases and ashes and the temperature of the surrounding air will rise. If we add heat to ice, it becomes a liquid.

Energy is measured in units called *calories* . A calorie is the amount of heat required to raise the temperature of 1 gram of water by 1 degree Celsius. This calorie of heat supplies the energy to do 4 *joules* of work. One joule of work is used to move a 1 kilogram mass for a distance of 1 meter.

The term *watt* refers to doing 1 joule of work *in* each second. A 100 watt light bulb uses the energy required to do 100 joules per second. *When* we buy electric power to do our work, we buy it in units called kilowatt hours. A kilowatt hour is 1000 watts used for a period of one hour. The term horsepower, used to describe motors, is equal to 746 watts. It originated from noting about how much work a horse could accomplish *on a* treadmill.

As in all other aspects of energy follows certain natural laws. The energy laws The first law of thermodynamics states that in any ordinary physical or chemical process, energy is nor destroyed, but merely changed from one form to another—the energy lost by one system must be gained by another. The second law of thermodynamics, known as the "law of energy degradation. states that in any energy transformation, some energy is transformed into low quality heat energy which is lost to the environment. An excellent example is the automobile engine. In its operation, 20% of the energy contained in the gasoline is used to move the car, 80% is lost in heat. This great loss is typical of the efficiency of an energy transformation. 10% efficiency is very common.

The same type of loss occurs as energy moves through biological systems. The energy is transformed by photosynthesis into potential chemical energy stored in food. In the case of corn, for example, if we eat the corn ourselves, we lose some energy, but we make the most efficient use of it. However, it we eat a cow that has eaten the corn, the energy has been transformed twice and each time 80 or 90 percent of the energy content is lost. Transforming the corn into gasohol would not be as efficient a use as eating the corn directly.

It should become obvious to the student that the more directly a source of energy is used the more efficiently it is used, and the smaller the heat loss. This should be remembered when we compare the efficiency of a water wheel to generating electricity with water and then transferring the energy over long distances for the sake of comenience, or of heating our homes with coal as compared to heating with electricity generated *by burning* coal.

Alternate Energy Sources

Petroleum

We presently obtain about 75% of use in Connecticut from petroleum. This is a source of power to fuel our automobiles, trucks and airplanes and no adequate substitute is available for that purpose. However, we also use it to generate much of our It is *convenient* to use as a liquid fuel and it is relatively low in pollutants when compared to coal. Our generating plants were either designed for oil or converted from coal to oil use when oil was cheap and plentiful.

However, there are several reasons why we should not depend so heavily upon oil for heat *and* electricity. Over one third of the oil we use is imported and this leaves us at the mercy of unstable foreign governments for vital fuels. It is also very expensive, having increased from seven a barrel to over thirty dollars a barrel in the past decade.

Since oil is so suitable for automobiles, and as the basic material for many of the synthetic materials we have come to take for granted, it seems inappropriate to use it for heat when other fuels are available.

Oil is a fossil fuel and thus is not unlimited in supply. Many experts predict that the reserves will be essentially exhausted over the next half century. We have used in less than one hundred years, the oil nature took millions of years to transform. We can conserve a great deal by burning other fuels for electricity, by driving smaller fuel efficient cars, by using mass transit when possible and by walking and biking when we can.

Coal

While coal is also a fossil fuel, we have much larger supplies available. Experts predict that the United States has enough coal to last up to 1500 years. As coal is plentiful *in* America, it would greatly decrease our dependence on foreign oil.

Unfortunately, cheap oil lured us away from coal and most electric generating plants converted from coal to oil in the past thirty years. In New England, in 1947, nearly half of our energy came from coal—in 1981 only one fifth was from coal. There are deposits of coal suitable for mining in Rhode Island and Maine, but the size of the deposits and the accessibility of the sites makes coal minting in New England a questionable proposition.

However, coal also has its drawbacks . Mining is a dangerous occupation, causing accidental death, respiratory difficulties such as emphysema and “black lung” disease. Deposits vary *in* quality and much of it has a high sulfur content which is very polluting to the air. The sulfur is converted to sulfuric acid which leads to acid rain which crops and fish in rivers and lakes. Coal mining is destructive to the land on which it is mined and many deposits are in areas difficult

Natural Gas

Natural gas is also a fossil fuel, formed from plants and animals that died and decayed in the absence of oxygen millions of years ago. It is the cleanest and least polluting of our fossil fuels. Presently it accounts for about one third of the heat energy in this country for homes (space heating). Estimates of available reserves vary greatly from one source to another and much research is being done on more ways to use it.

Solar

To many, solar energy seems to be an obvious solution to our energy problems. There is an inexhaustible supply that is readily available to everyone. However, we do not yet have the technology available to efficiently use it, or to store its energy for times when the sun does not shine.

There are two ways of utilizing the sun's energy, passive solar energy, and active solar energy. Passive solar energy involves absorbing and storing the energy from the sun in the most efficient way, without involving such technologies as circulators, or attempting to transform the sun's heat into electrical energy. This is accomplished by taking advantage of the "greenhouse effect". Light rays will enter through the glass in a solar collector, or a window in a house, and be absorbed by the materials behind the glass which will become warmer. Some of this heat is radiated back out into space, but the longer heat rays are trapped and cannot escape back through the glass. The greater the mass you have behind the glass to store the heat, the greater the amount of energy which can be stored.

Active solar energy is a much more complicated process, involving such things as thermostats which valves when appropriate temperatures are reached, employs motors and pumps to circulate heated water or air, and involves a great initial investment.

We now know of many ways to build a house that effectively utilizes heat from the sun, and it is relatively inexpensive to include these so-called "passive solar" features in a new home. However, there are millions of existing buildings and homes that would be exhorbinantly expensive to change to take advantage of the sun's energy, or "retrofit" for solar.

Solar research is not popular with the energy industry because—let us face it—no one owns the sun. They may be able to sell us the materials and equipment to use the sun, but selling sunlight would be more difficult than selling the Brooklyn Bridge. Research is being done on converting sunlight to electric energy, but not enough money and energy are going into the effort to get exciting results as yet. More effort is being spent looking for new sources of oil.

In order to greatly reduce the energy needed in a home, it should have glass facing south, with heat absorbing material such as a brick wall or spanish tile floors behind the glass to absorb the heat when the sun shines, and radiate it when the room is cool. Old oil barrels painted black and filled with water make very effective absorbers. The house should be well insulated, and trees should be planted to give summer shade but access to the sun in winter. The north side should be well protected with evergreen trees and should have no windows.

Our homes and apartments can be altered, however, with relatively little expense, to increase their energy efficiency and solar absorbing power. we can add insulation, install storm windows (cheap plastic film will do), and make inside shutters for winter use. Tightly fitted heavy cardboard will do the trick if wood runs into too much expense. Drapes and curtains do not hold in heat. Heated air rises up behind the curtains and is cooled by the windows, defeating their intended purpose. Experimental greenhouses added to the southern exposure of existing homes has cut fuel by up to 20%.

Wood

New England is 80% wooded. At first glance this would seem to be a magic answer for us, but there are many problems. Heating with wood is inconvenient. Most Americans are not willing to chop, stack and carry wood, tend the fires, and put up with the unevenness of heat that is produced in a wood stove. Most much heat up the chimney.

Seventy-five percent of our woodlands are privately owned, and much of this is not available for fuel. If not carefully monitored, lumbering can be destructive to our forests and woodlands. The chainsaw is a dangerous weapon and many accidents could occur in the hands of amateurs.

Water Power

New England has many rivers and streams and many small hydroelectric plants are in existence but out of service, replaced by larger fossil fuel generators. Reactivating them could economically augment the power supply of many of our small communities and industries. Here too, though, are some disadvantages. The dams and generators can be destructive to fishing and recreation and can interfere with water supplies.

Power generated by the great tidal surges would seem to be suitable for a coastal area such as ours, but it is only practical to harness tides in areas where the incoming tides are funneled into a narrow area and a very high "head" is built up. There are only a couple of places suitable as sites, and they are on our northern borders and most will require Canadian cooperation for development.

There is some research being done on generating power from the heat absorbed by the sea from the sun and exchanging the warmed waters with the colder deep water.

Solid Waste

Many communities are experimenting with converting solid wastes (garbage) to fuel. This not only turns a disposal problem into a power source, but also leads to recycling of metals which can be salvaged in the process. This has been tried in Bridgeport without much success. There were unpleasant odors, residents objected to the constant flow of incoming garbage, and pollution was a problem. The technology involved still needs much developing.

There are in existence several successful solid waste conversion facilities. Nashville heats part of its business district with waste, and Chicago has a project which seems to be working.

Wind Power

While it is certainly practical to use old existing windmills for pumping and thus saving power, wind generated electricity would be unreliable in New England. In most cases the cost of the wind generator cannot be recovered in a reasonable time from the output of electricity. The most popular available type plugs into the home circuit, generating when the wind blows, and cutting off when it is calm. The law states that any excess power generated by an individual mill must be purchased by the electric company. Winds are just not constant and predictable enough in this area to warrant the investment.

To depend completely on wind generated power means that it must be stored for calm periods. I have examined some of these systems in operation and one large outside wall was completely built in with storage batteries to keep a relatively constant supply. The best systems available are not too reliable nor do they generate the amount of power we need to power our appliances.

Geothermal Power

Geothermal power is obtained by heating water with the hot rocks beneath the surface of the earth. This is not suitable in the northeast because the hot interior of the earth is far beneath the surface here. Some areas, however, such as Northern California, Wyoming and Iceland have a very thin crust and thus a cheap source of power is available. Suitable technology is rapidly developing.

Nuclear Powe r

At the present time our nuclear energy is obtained from a process called fission. This occurs when a uranium atom is struck by a sub-atomic particle called a neutron and splits into two lighter nuclei, releasing much energy in the process and sending off more neutrons to split other nuclei in a “chain reaction”.

This process does not pollute the air and saves millions of barrels of oil per year, lessening our dependence on foreign oil. It uses only small amounts of radioactive elements to do its job.

One of the waste products of fission is plutonium, a radioactive substance that remains dangerous for hundreds of years. Shipping this substance through our populated areas is a very unpopular project, and finding a safe place to store it is extremely difficult. This substance can also be manufactured into atomic bombs. Already there is a substantial amount that cannot be accounted for.

There is always the danger that we will not be able to cool the reactor sufficiently and that it will overheat and melt through its container. This is the dreaded “meltdown” which would release radioactive substances into the environment. It should be noted, however, that no serious accident has ever occurred at a nuclear reactor.

Two other types of nuclear generators are now expert mental, One, the breeder reactor, is a fission generator that produces new fuel as it generates energy. This new fuel is created as a product of the splitting of the original atoms and more fuel is produced than was originally placed in the reactor.

The other, fusion generation, involves the same type of reaction that produces energy in the sun. In this process, two hydrogen atoms fuse to form one heavier helium atom, releasing energy in the process. In order for this fusion to take place the hydrogen must be heated to millions of degrees. The problem facing engineers and scientists is containing this extremely hot matter. We are attempting to contain it in electromagnetic fields and laser beams are being experimented with. If we could perfect the technology, this would be an extremely useful fuel source. We have unlimited hydrogen available for fuel in the waters of the oceans. The helium produced would pose no radioactive hazards and the process would stop itself as soon as it cooled. The problems would be to keep it going, not as with fusion, to keep it under control.

Now that we have looked at the various alternatives available to us, we will have to choose that combination of power sources that will best allow us to have a future with the kind of standard of living we desire, without depleting our resources or polluting our environment to the point that it reduces our quality of life. The choices will not be easy. Sacrifices will have to be made. The population of the world is rapidly increasing and we cannot continue to use a disproportionate portion of the world’s resources with impunity.

Activities

Questionnaire about energy use in New Haven

(These are sample questions only. Students should help devise the list)

1. Do you heat with coal, oil, electricity or natural gas?
2. What is the usual temperature setting in winter?
3. Are you air conditioned? What is the temperature setting?
4. Does the building have storm windows? Insulation?
5. What is the source of most of your electricity?
6. Do you approve or disapprove of power generated from atomic energy?
7. Has your energy consumption increased or decreased over the past three years?
8. Do energy costs significantly affect your profit?
9. Do you plan on instituting any energy saving measures in the near future? What are they?
10. Do you feel that conservation measures could significantly affect your energy costs?
11. Do you believe there really is an energy crisis?
12. What is the cause of the so-called energy crisis.

Role Playing

In order to demonstrate the difficulties involved in coming to community agreement on energy and related environmental problems, variations of the following role playing activity can be used successfully, after the information in the unit has been fairly well absorbed. This can then be expanded to "how just how difficult it is to solve these on a statewide or national basis, let alone internationally.

The problem is as follows: The small town of Clearwater is in a beautiful valley on the shores of a winding river. This river used to be excellent for fishing and swimming. The town has an electric generating plant which uses cheap, high sulfur coal from a nearby mine. This cheap power was the main reason for the "Blue Gadget Corporation" locating its factory there. The coal mines employ 23% of the town workers and the factory employs 33% of the work force. However, pollution from this dirty coal has become so bad that the fish can no longer survive in the river, it is no longer to swim in and respiratory illness have shown a sharp increase.

Environmental groups in the town have succeeded in having a town meeting called to try to find a solution to the problem. The teacher plays the role of town clerk and as such moderates the meeting. Students should be given their assigned roles a few days before the meeting in order to prepare their statements and to be armed with pertinent “facts. for the debates which will occur. Since first devising this activity, it has been observed that students become very involved in the project and learn a great deal from it. The teacher can usually learn a surprising amount as well.

Roles

Bill Jones . Mayor. Mr. Jones is married and has two sons. He also owns the local bowling alley which depends mainly on local workers for its income. He is up for re-election in three months time.

Carol Thomson and Tom Smith . They are local high school students who represent the Environmental Club at the school. They both are avid water sports fans and they have led the movement that obtained several thousand signatures on a petition to require the local power plant to convert to oil—a much cleaner but more expensive type of fuel.

George Watson, M.D. Dr. Watson, local physician, has noted a 70% increase in respiratory ailments over the past 6 years. His own 7 year old daughter suffers from asthma.

Leroy McIvor . Leroy is president of the power company. He has a beautiful home 7 miles north of the town, which avoids the pollution. His board of directors has advised him to fight the petition all the way because the price of power would almost double if the conversion were forced by law.

Margaret Donaldson . This lady is president of the Blue Gadget factory. she has a beautiful old home near the river and is also president of the local historical society. She is married and has one daughter who lives in town and three grandchildren. She has been instructed by her board of directors that if the price of power increases by a very wide margin, that it will no longer be economically feasible to operate the factory at that site and it will simply close down throwing many men out of work.

Ben Stephens is president of the coal miners union and a long time resident of the town. His teenage children are very unhappy because they can no longer swim or fish in the river. His members are afraid that they will be out of work if the power company converts to oil and no longer uses the coal. Shipping it out of the area would be a problem.

Similar sketches of the motivations and responsibilities of town citizens can be given until each student has a part to play. Care should be taken to give enough information about the character to guide the student in the attitudes he or she must take, without giving so much guidance that the student has no leeway to be creative.

Model Building

Students should be supplied with simple model building materials such as cardboard, clear plastic, balsa wood, etc. Using the information they have absorbed about landscaping, insulation, passive solar energy, etc. they should be broken up into groups of three or four students and asked to build a model of an energy efficient apartment or home.

Long Range Planning

Students again be broken into small groups and instructed to develop a long range plan for energy conservation and development of suitable energy sources for the New England area.

Resources

Science Activities in Energey . This is probably the most useful source available. It consists Of a series of science activities and simple experiments explicitly planned and described in electrical, solar, wind and chemical energy and in conservation. They are available free of charge from: The American Museum of Atomic Energy; Oak Ridge Associated Universities; P.O. Box 117, Oak Kidge, TN, 37830. The experiments are on cards and may be photocopied for distribution. A set of these activities are available at the Institute office.

Films

The United Illuminating Company has available a number of excellent films on energy, at no charge to the user. It is necessary only to pick up and return the films from their office and to reserve three weeks in advance. To reserve films or to request a complete listing of films, just call U.I. at 787-7245, New Haven.

Those films I would particularly recommend are

A is for Atom . an animated explanation of radioactivity.

The Great Search A Walt Disney production of the history of energy development.

Resource Recovery How solid waste is being used for energy.

Films can also be obtained from The Department of Energy at: The Department of Energy Film Library, Technical Information Center, P.O. Box 62, Oak Ridge, TN, 37830.

Teacher Bibliography

Most of these publications will be available at the Yale New Haven Teachers' Institute. Many were obtained from the United States Department of Energy.

Award Winning Energy Education Activities _for Elementary and High School Teachers. A detailed collection of practical activities.

Energy Education Workshop Handbook . Prepared by the National Science Teachers' Association, this book is a complete guide to available materials for an energy enriched curriculum.

How a Bill Becomes a Law . Includes pre-tests, information, activities, case study of a bill etc.

Ideas and Activities for Teaching Energy Conservation . from the University of Tennessee Environment center, Knoxville, Tennessee, 1977.

Transportation and the City . A study of the interrelationship, of transportation and energy with suggested activities, materials, etc.

Student Bibliography

(Teachers will also find these books of interest)

Commoner, Barry. *The Politics of Energy* . New York, Alfred A Knopf. 1979. A comprehensive discussion of our present national energy plan and how we can act politically to bring about a more self-sufficient energy status.

Mazria, Edward. *The Passive Solar Book* . Emmaus, PA, Rodale Press, l979. A complete guide to passive home, greenhouse and building design.

Oxenhorn, Joseph M. *Energy and Our Future* . New York, Globe Book Co., Inc. 1979. A concise, clearly written paperback text on energy alternatives.

Seney, Nowel, and Clayton, Larry, eds. *Energy Saving Projec* ts You Can Build . *Des* Moines, Iowa, Meredith Corporation, 1979. A Better Homes and Gardens book of simple to build and relatively inexpensive energy saving projects with step by step instructions and illustrations.

Stobaugh, Robert and Yergen, Daniel, eds., *Energy Future* . New York, Ballantine Books, l979. A report of the Energy Project at the Harvard Business School. A comprehensive examination of the energy options facing us today.

Stoner, Carol. *Producing Your Own Power* . New York, Vintage Books of Random House, 1974. A primer on how to make nature’s energy sources work for you.