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ABSTRACT

Curriculum guidelines for the local development of energy conservation programs in public schools reflect an interdisciplinary educational approach--the result of a coordinated effort by industry, commerce, education, and government agencies concerned with the energy crisis. The scope and nature of the problem, with its implications for education and lifestyle, are contained in the opening perspective. Guidelines are suggested for the study of energy conservation, with the goals--broad overarching principles--followed by the objectives--specific types of performances necessary to realize the goals. Brief descriptions of representative activities exemplify districtwide, local school, and nationally developed approaches to energy conservation. A list and description of free or inexpensive instruction materials includes ordering information. Guiding principles for establishing energy conservation programs together with suggested curriculum development procedures at the district, local school, and classroom levels are provided. The appendix contains a summary of the present availability and future prospects of different energy sources. (MLF)

ENERGY CONSERVATION

Guidelines for Action

Suggested Guidelines for Local School District Development of Energy Conservation Programs

Michigan Association of School Administrators
Region 9
Energy Conservation Curriculum Committee
Dr. James H. Doyle, Chairman
April, 1974

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Associated Petroleum Industries of Michigan
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Michigan Consolidated Gas Company
Wayne County Intermediate School District

CONTENTS

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PREFACE

Governor William Milliken in his 1974 State of the State Message, said:

> "No single factor could have a greater bearing on the State of the State this year than the energy crises."

Michigan has a crude oil deficit of 95%, a natural gas deficit of 96%, a coal deficit of 100%, and a deficiency of water power to generate electricity. Few states have such potential for discomfort and disruption due to an energy shortage!

Compounding Michigan's energy dilemma is its heavy emphasis on motor vehicle manufacturing. The gasoline shortage has affected automobile demand and caused large-scale lay-offs in the industry.

As the energy problem grew in Michigan, various groups pondered its implications. One of these groups, Region 9 of the Michigan Association of School Administrators, assembled an energy conservation curriculum committee composed of educators, representatives of Michigan utility companies, and the petroleum industry. This group was charged with the task of providing curriculum guidelines for the local development of energy conservation programs in public schools. The guidelines were to reflect an interdisciplinary educational approach, and should be the result of a coordinated effort of industry, commerce, education, and government agenices concerned with the energy crisis.

The committee members viewed their charge as offering an opportunity for a cooperating group to examine the goals of education (in the context of the energy crisis) as they relate to meeting the challenge of today and building a better world for tomorrow. They further agreed that their task was to stimulate educators to plan creatively for learning and teaching.

I. ENERGY CONSERVATION: A PERSPECTIVE

Scope and Nature of the Problem

An energy shortage descended upon the American scene in the fall of 1973. Whether the change in energy resources is real or an illusion, whether it is a crisis or a crunch, whether it is temporary or permanent are questions that are being debated. Whatever answers are finally reached will not vitiate the need for educational agencies to examine the problem and to formulate guidelines for students, teachers, and administrators. The following pages are aimed at putting the energy crunch-crisis into a practically-oriented guide for learners and teachers.

Among the thousands of words written and uttered about the energy emergency, there are few, if any, that deal with a definition of **energy**. The word is equated with power, force, strength, and most often with fuel. It brings to mind pictures of oil and natural gas wells, coal mines, electric power plants, and possibly atomic fission. The equating of energy with fuel seems to have been accepted to the point that when an announcement is made that the president is to speak on energy, newspapers quote a "spokesman" as saying that the president will "lay out our program dealing with fuel shortages."[1]

For most adults the idea of energy as it relates to fuel (which is transformed into energy) is clear and adequate. However, in an educational context, energy should be defined in such general terms that it is understood as a concept. For this purpose the physics definition of energy as the capacity to perform work or, as a fifth-grader paraphrased it, as "what makes things go" seems useful. The forms in which energy exists - mechanical, thermal, electrical, chemical, radiant, and atomic - are produced by appropriate processes utilizing the transformation of various kinds of fuels. The energy dilemma which is facing Americans is a part of a complex problem related to fuel utilization and the standard of living. The problem might well be considered as a by-product of success - success in reducing hunger and cold, in increasing life span, in lowering infant mortality, in raising farm output, and in easing the burdens of

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[1] **Detroit News**, January 19, 1974, p. 1.

physical labor. The scope of the problem, then, extends from home to industrial complex, from individual to big government, reaching across international boundaries, creating new political, economic, social, and human roles.

There is a direct relationship between energy use per person and standard of living. Therefore, the actual survival of people in a complex, technological society depends upon an adequate, deliverable supply of all forms of energy. Opinions differ about the availability of an adequate, deliverable supply of energy. William G. Meese of Detroit Edison Company states, "There is no real shortage of primary energy in this country"[2], while John W. Duane of Consumer's Power Company says, "To put it simply, our nation's energy appetite has now outstripped our ability to produce adequate energy."[3] A newspaper headlines "U.S. Self-Sufficiency by 1980 is Infeasible."[4]

While full knowledge about stockpiles of fuels for energy production are not available, certain other pertinent information is known. The known data will serve to outline the scope of the energy problem.

The United States has 6% of the world's population. It consumes 35% of the world's energy.

The United States has finite reserves of fossil (coal, oil, natural gas) and nuclear (uranium) fuel. One-third of the total raw energy resources goes into personal use, two-thirds into business and industry. Of the one-third for personal purposes, one-third is used for transportation and two-thirds for the home. One half of the business and industry portion is used for the production of raw materials, chemicals, plastics, process heat and the other half for transportation, agriculture, mining, etc. This total energy pie then can be divided into thirds: one-third for personal use, one-third for the production of raw materials and process heat, and one-third for other business and industrial uses.

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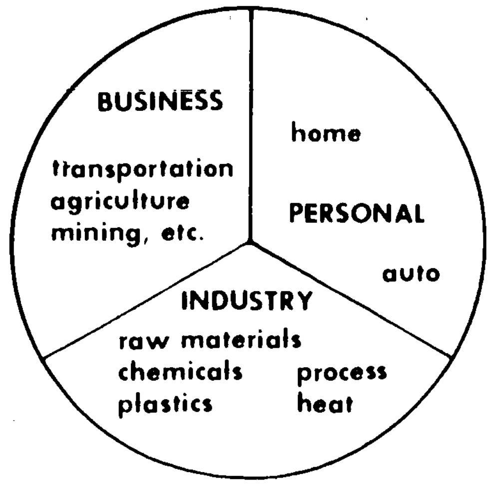
[2]William G. Meese, "The Man-Made Energy Crisis," **NAM Reports,** September 3, 1973, p. 8.

[3]John W. Duane, Interview, February 13, 1974

[4]**The New York Times,** December 2, 1973



Michigan is an energy-poor state, importing more than 90% of its fuel. Its vulnerability would be even greater without its proximity to present direct pipelines.

It took millions of years for the natural creation of the fossil fuels which our industrial, technological society will consume in a matter of a few hundred years. In the perspective of the 5,000 years of recorded history, the use of these fuels will be a brief episode. The availability of abundant energy from them cannot continue to be assumed. The people of the United States have created the highest standard of living in the history of the world, and energy has been the key to this progress. With a projected tripling of energy consumption by the year 2000 based on current or improved standard of living requirements, the scope of the energy emergency becomes two-fold: immediate and long range. The immediate efforts at solutions call for awareness, conservation, and care in terms of societal and individual goals; the long range approaches require action, research and development. The expectations of a better tomorrow are dependent upon sound and timely individual and group decisions on energy policies.

Implications for Education

Educators functioning within the present system are merchandisers of the future. They have the power to transmit to the young the deepest values, highest hopes, and most profound responsibilities of mankind. The future of education is the future of society; at the same time the future of society is inseparable from what is happening to children in schools now.

The educational system must **plan** for changes that appear to be inevitable in an energy mutating future. If planning does not take place, then the changes will happen randomly in response to crises and pressures from special interest groups. Instead of orderly, understood evolution there might well be turbulent, misunderstood disorganization. Daniel Bell has written:

> "Time, said St. Augustine, is a three-fold present: the present as we experience it, the past as a present memory, and the future as a present expectation. By that criterion, the world of the year 2000 has already arrived. . . . The future is not an overarching leap into the distance; it begins in the present."

Studies of the future will surely gain importance in schools as long range planning becomes necessary in many fields of human endeavor. The energy crisis is one such area, having both national and global significance. It may be that the energy crisis will be instrumental in implementing futures research in schools.

Specifically the energy dilemma brings the school face to face with long and short term implications. The more immediate responsibilities involve transmitting facts about fuel shortages - as they relate to energy - as it relates to values - as they relate to life styles. Today's schools hold tomorrow's energy consumers and regulators. The long range implications, then, go beyond definitions of terms and helpful hints on conserving energy now. Educators are faced with reaching many learners of many ages in many situations, helping them to clarify their values, set their goals, and act on the basis of their decisions. Energy must be recognized as a topic for all classes - science and social studies, math and reading, recreation and leadership training - and treated in interdisciplinary sessions with input from industry and community resources.

Daniel Bell, "The Year 2000 - The Trajectory of an Idea," **Daedalus,** Vol. 96, No. 3 (Summer, 1967), Proceedings of the American Academy of Arts & Sciences, p. 639.

Implications for Our Way of Life

In 1972 the average American household **everyday** used the energy equivalent of

46 pounds of coal
9.5 gallons of oil
7 gallons of natural gas
1 gallon of water power
.5 pints of nuclear energy

Until the 1973 energy crisis there were two widely accepted divergent views of the future of this average American household. One held that exotic energy sources, developed before the end of the century, would revolutionize energy supply to such an extent that unlimited virtually free energy would liberate the members of the household to refine social, economic, political, technological and human relationships. The other view, more pervasive since the 1973 focus on energy, pictured a significant reduction in available energy by the end of the century resulting in changing life styles for the members of the household so that they would fit into a lower energy economy.

Expressed national goals of full employment, alleviation of poverty, environmental quality, and national security require energy. The decisions made today about the value of these goals in relation to their energy cost to individuals and society will determine future human life styles as well as present ones.

Energy consumption and the satisfaction of human wants are integrally linked. More and bigger cars, more and longer vacations, more and fancier home apppliances require more and more energy. Will an informed public drive smaller, more efficient automobiles more slowly? Will city workers living in the suburbs use mass transit systems? How long will the novelty of 68 homes, offices and schools in which sweaters are a necessity last? What happens to a leisure-oriented society with no means of travel and no cheap-energy hobbies?

Population change is another important determinant of energy demand. Dr. Milton Russell, an economics professor of Southern Illinois University, states that "we can confidently assert that population will be higher in 2000 than it is now. It seems likely, then, that energy consumption will increase. What changes in life styles are compatible with this increase in numbers of people? Will research to increase life span or reduce infant mortality cease? Will capital punishment be reinstated? Will energy using life saving devices be discarded? What quality of life for how many can be afforded?

The "good life" in the U.S. is not a fact for everyone. Adequate diet, housing, and medical care are not equally available to the citizens of this affluent nation. To bring the disadvantaged people into the economic main stream and to provide productive play time for a leisure-oriented industrial society require higher economic productivity. This productivity can only be achieved by greater use of energy consuming machines to increase the output of individual workers. Economic growth with the accompanying increase in energy consumption is necessary for social change.

Pollution control is a new industry that will create new energy demands. For the greater part of our industrial era pollutants have been poured into the atmosphere and bodies of water at almost no cost to the energy user. Now the social costs of waste disposal appear to have greater value than the dollar costs, and an energy-environment balance is being recommended. On what basis will industrial engineers, housewives, legislators, and environmentalist interact to achieve a balance? The answer to this question strikes at the heart of our industrialized society and ultimately must depend on the basic goals we identify and quantify.

The "American way of life" is dependent upon energy. At the present time there are no energy resources that will permit all of mankind to enjoy the energy consumption of the U.S. and the "American way of life." Hopefully, the citizens of the U.S. will not stumble into new or different ways for themselves and will not let geographical chance dictate the way of life for anyone. The identification of long and short range quantifiable goals based on articulated values will enable each person to justify individual and group energy consumption as it relates to ways of life. Social and physical scientists, economists and politicians, artists and humanitarians will have to work together to build the energy-changed society of the 21st century.

Milton Russell, "Energy, Economic Growth and Human Welfare", **Panhandle Magazine**, Winter 1972-73, p. 8.

II. SUGGESTED GUIDELINES FOR STUDY OF ENERGY CONSERVATION

Principles of Energy Conservation

In a statement to the Joint Hearings on Conservation and Efficient Uses of Energy to the U.S. House of Representatives in July, 1973, William R. Ralls, Commissioner of the Michigan Public Service Commission stated:

> "The major requirement dramatically indicated by current energy shortages. . .is a new philosophy in energy policy at all levels. It should be aimed at providing sufficient energy to meet our present needs through more efficient usage and conservation rather than providing huge quantities of cheap energy regardless of waste and environmental harms."[1]

How can energy be conserved? (1) By maximizing the efficient production, distribution, and use of energy and minimizing the waste of human and fuel resources. (This kind of conservation requires an informed public involved in energy policy decisions.) (2) Establishing a stated energy policy aimed at promoting conservation rather than consumption which can be articulated and put into practice at all levels of government and in energy industries. (3) Energy conservation as it relates to environmental quality can be defined and explained. (For example, conservation measures can improve environmental quality by reducing the amount of waste in energy processes.) (4) Environmental controls can promote energy conservation by increasing the cost of producing and consuming energy. (5) Consumer education programs can be implemented. (6) Minimum efficiency standards can be established for building designs and appliances. (7) Tax incentives can be established for research and implementation of more efficient industrial practices and processes. (8) Another way to conserve energy would be to restrict its use. (This course, however, would limit economic growth, reduce social

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[1] William R. Ralls, "Conservation and Efficient Use of Energy: A State Regulator's View", Statement to the Joint Hearings on Conservation and Efficient Use of Energy, U.S. House of Representatives, July 10, 1973, p. 4.

progress, and curtail environmental improvements. Although it would conserve energy, it is not a recommended means of conservation, the main principle of which is wise use for the benefit of all segments of society.)

Values Related to Energy Conservation

There are no simple solutions to the energy emergency. It is a complex problem subject to pressures and demands from both producers and consumers. It challenges individual and societal goals and values, cost effectiveness, industrialization, and progress, life style and an adequate standard of living for everyone. What may be considered as technologically feasible may be humanistically unwise. Defining such terms as **wise** use for the **benefit** of **all** (energy conservation) requires value judgments and assumptions. One assumption is that changes in energy consumption must be made since the present economic and social structure are designed for abundant fuel supplied at low cost, a situation which no longer exists. The changes could be as simple as individuals' voluntarily keeping their homes warmer in summer, cooler in winter, and observing gasless days. On the other hand, a total revamping of life styles could be mandated if predictions of energy retrenchment and research and development are not accurate.

The conservation of resources so that subsequent generations will have basic creature comforts is assumed as necessary for the continued development of mankind. There can be little argument with the concept that no one generation should exploit its resources to the detriment of the future of mankind. However, definitions of exploitation, present versus future good, adequate prediction and forecasts of possible futures, and direct line consequences of actions make the future life styles of later generations somewhat hazardous in terms of present energy conservation.

The development and utilization of new sources of energy - nuclear, geothermal, solar - is assumed as being necessary and valuable despite the extensive capital investments required.

Finally, an assumption is made that the American people, once they have complete information, can evaluate costs against total benefits and make wise choices which will insure adequate energy, a "good life" for all people, a booming economy, and environmental quality. Policies and attitudes which are perceived as priority for the people of the United States must eventually be examined in terms of all mankind.

Goals and Objectives

Goals are the broad overarching principles which are the bases for educational programs. Objectives are the specific types of performances necessary to realize the goals. Basic goals for educational programs in Michigan are indicated in **The Common Goals of Michigan Education** (Michigan State Department of Education, 1971). Common goals from this document which relate to energy conservation programs are:

Citizenship and Morality

Goal 2 - Citizenship and Social Responsibility

Michigan education must assure the development of mature and responsible citizens, with the full sense of social awareness and moral and ethical values needed in a heterogeneous society. It must encourage critical but constructive thinking and responsible involvement, with consideration for the rights of all, in the resolution of the problems of our society. . .

Goal 6 - Community Participation

Michigan education must develop effective means for utilizing community resources and making these resources available to the community.

Student Learning

Goal 2 - Preparation for a Changing Society

Michigan education must encourage and prepare the individual to become responsive to the needs created and opportunities afforded by an ever-changing social, economic, and political environment both here and throughout the world. . .

Goal 4 - Creative, Constructive, and Critical Thinking

Michigan education must foster the development of the skills of creative, constructive and critical thinking to enable the individual to deal effectively with situations and problems which are new to his experience in ways which encourage him to think and act in an independent, self-fulfilling, and responsible manner.

Goal 5 - Sciences, Arts and Humanities

Michigan education must provide on a continuing basis, to each individual, opportunity and encouragement to gain knowledge and experience in the area of the natural sciences, the social sciences. . so that his personal values and approach to living may be enriched by these experiences.

Goal 6 - Physical and Mental Well-Being

Michigan education must promote the acquisition of good health and safety habits and an understanding of the conditions necessary for physical and mental well-being.

Goal 11 - Environmental Quality

Michigan education must develop within each individual the knowledge and respect necessary for the appreciation, maintenance, protection, and improvement of the physical environment.

Goal 12 - Economic Understanding

Michigan education must provide that every student will gain a critical understanding of his role as a producer and consumer of goods and services, and of the principles involved in the production of goods and services.

Representative Performance Objectives

Objectives are those specific performances which result in the attainment of goals. A performance objective has six elements. They are:

1. A description of the learner(s) who will perform
2. A description of the behavior that they will perform
3. A description of the object of that behavior
4. A description of the time during which the behavior will be performed
5. A description of the measurement methodology that will be used to measure the behavior
6. A description of the criterion of success which would indicate whether or not the objective has been met

Provided herein are examples of performance objectives. Examples are provided rather than an exhaustive list of objectives as the particular objectives sought at the local district, school, and classroom levels will depend upon the locally adopted curricular approach. The grade level of each example objective is given.*

Given sets of statements about energy conservation that are either observations or inferences, the learner will mark those that are inferences (K-3).

Given a set of observations concerning an incident or situation, involving the conservation of energy, the learner will make a valid inference concerning that incident or situation (K-3).

Given a simple experiment in which a physical or chemical change takes place, the learner will be able to orally or in writing describe the objects used, events which happen, and changes which occur (K-3).

Given a set of observations pertaining to an event, and given a set of inferences, the learner can select those inferences which account for the observations (4-6).

Given a hypothesis and a description of an investigation to test the hypothesis, the learner recommends which variables should be controlled to test the hypothesis (4-6)

Given an issue or problem in science that is being solved, the learner will identify new problems resulting from its solution (7-9).

Given one set of statements indicative of scientific evidence and one set of statements indicative of opinion, the learner will identify at least one difference between scientific evidence and opinion (7-9).

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*Based on Michigan Department of Education, **Minimal Performance Objectives for Science Education in Michigan**, Lansing; Michigan Department of Education, January 1974.

Given an energy conservation situation, the learner will rank those scientific activities which are most likely to be beneficial to man (7-9).

Given an energy conservation situation, the learner will list at least two items that explain the situation (7-9).

Given an appropriate problem in energy conservation, a learner will become involved in a team effort directed toward its solution (7-9).

III. REPRESENTATIVE ACTIVITIES AND RESOURCES

Activities

Due to the recent emergence of an emphasis on energy conservation, there is no existing backlog of proven programs and practices. There are, however, excellent examples of effective practices and activities available. Brief descriptions of representative activities are provided here as examples of district-wide, local school, and nationally developed approaches to energy conservation.

Ecology Unit - Livonia Public Schools

The grade 4 social studies program for the Franklin-Churchill Region of the Livonia (Michigan) Public Schools includes a unit on ecology.[1] Among the four main ideas of this unit are two which deal with the propositions that, "Problems arise when the relationship between man and his environment is disrupted" and that "Man is developing many solutions for dealing with the problems of ecological imbalance." The organizing ideas related to these main ideas are that, "In the process of meeting his basic desires and needs through everyday living, man is disturbing his environment, thus causing himself additional problems" and, "When man's wants and needs cause environmental disturbances, he continually seeks solutions to these problems."

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[1]Livonia Public Schools, Franklin-Churchill Region. **Ecology: A Social Studies Program for Grade 4.** Livonia, Michigan; Livonia Schools, September 1973.

The treatment of each main idea in the unit includes a series of learning activities and provides notes to teachers on how to carry out these activities. The unit and its activities were developed by a committee of teachers under the leadership of the regional curriculum coordinator. The Livonia program uses the Taba social studies approach.

In dealing with the main idea concerned with disruption of the relationship between man and his environment the "opener" activity suggests that the teacher indicate:

> "We have been talking about the relationship between man and his environment. What are some of the problems man has created by disturbing his environment?"
>
> 1. "We have mentioned the idea of pollution. What do you think of when you hear the word pollution?" (List these, group, and label.)
>
> 2. "Looking at all your responses, what can you say pollution means?"
>
> ***Suggested Activities***
>
> Bring in pictures of pollution.
>
> Create a two part mural showing a clean environment and a polluted one.
>
> Observe or describe any polluted area of your community.
>
> 3. "Let's take a look at the problems you defined before. Do you have any to add? From this list of problems we have developed, let's choose 5 problems that you would like to learn more about."

The representative chart which is provided in the "notes" part of the unit suggests the problems of water pollution, energy crises, food shortage, land use, waste, and garbage. The students are asked to determine the probable causes and effects related to these problem areas, and to develop solutions to the problems. It is suggested that the students be divided into groups to research the causes and effects related to each problem.

The "opener" activity for the main idea concerning developing many solutions for dealing with problems of ecological imbalance suggests that:

> "We have examined the problems and said that they are caused by our wants. Now what are some of the things that are being done to solve some of these problems?" (The categories listed are: water, energy, food, land, waste.)

A whole series of activities related to these problem areas are suggested including the following dealing with transportation and energy utilization:

> Given the information below, what are some of the things we can do to conserve energy?
>
> **Transportation**
>
> Moving people and freight accounts for about 25% of the energy consumed in the United States. Half of this amount is used by automobiles.
>
> Larger cars with more powerful engines consume more fuel than small ones. For example, a car weighing 5,000 lbs. uses over twice as much fuel as one weighing 2,000 lbs. Other features such as air conditioning and automatic transmissions contribute to fuel consumption.
>
> Some suggested answers:
>
> Buy a car no larger or more powerful than you need, without unnecessary features.
>
> Walk and ride bikes. Half of all automobile trips now cover less than 5 miles.
>
> Ride public transportation where available.
>
> Organize car pools.
>
> Encourage the building of better public transportation systems in your community.
>
> Have your car periodically maintained and keep it tuned up.

The unit includes lists of resources, instructional media, and examples of diagrams and visuals.

Project SEE - Wyandotte Public Schools

Project SEE (Strategies for Environmental Education) of the Wyandotte (Michigan) Public Schools deals with environmental concerns through a student initiated curricular process. It utilizes cross-age student Quest Teams consisting of an elementary, a junior high school, and a senior high school student. Quest in the title of the team refers to both the process of questioning and to questing for knowledge.

The Quest Teams become operative in response to teacher, administrator, or community member questions or concerns relating to the environment. The team meets with the person raising the concern (usually a teacher) and proceeds through an instructional process which includes:

An initial conference to determine the teacher's (or requestor's) goals.

A second conference where the team plans an appropriate approach with the teacher. Other students (users) may join in this conference. A GREEP (Groovy Environmental Education Package) is developed by the team as a result of this conference.

A third conference is held where the finished GREEP is reviewed and necessary equipment and materials for implementation of the GREEP are specified.

A GREEP is an instructional package including:

Title: Energy

Target Population: Secondary to Adult

Statement of Broad Purpose: The purpose of this GREEP is to acquaint students with present and potential sources of energy.

Knowledge: The class should learn:

1. The present sources of energy in the United States.
2. How we use energy.

21

3. The estimated reserve of these energy sources.

4. About the following possible future energy sources:

   a) fossil fuel sources
   b) nuclear fusion
   c) nuclear fission
   d) hydroelectric energy
   e) wind energy
   f) tidal energy
   g) solar energy
   h) geothermal energy

5. How electricity is made by experimenting with a hand-crank generator.

Skills: This GREEP does not attempt to teach any particular skills.

Attitudes: Students should come away from this GREEP:

1. Motivated to try in their own way to conserve energy.
2. Supportive of attempts to develop new energy sources.
3. Refusing to take existing power sources for granted.

The Quest Team teaches the GREEP to other students with the teacher in a facilitating role as discipline monitor.

A GREEP may last from one class period to two weeks of class time.

A list of specific instructional activities; equipment needed; verbal and pictorial description of each item of instructional media with suggested commentary; set of special instructions including a team introduction and background materials, directions for use of special equipment (hand crank generator), and suggestions for using the evaluation instrument provided is included. Follow-up activities are also suggested.

Evaluation is done by the Quest Team and is usually ready within 48 hours.

Project SEE is now in its third year of operation and will transfer completely to local funds next year. The team activity is being decentralized to develop Quest Teams at each school. These teams will operate internally in each school with the cross-age aspect correspondingly constricted.

Energy Crisis Study Units
Utica Community Schools

A series of lesson plans for investigating energy and the energy crisis have been developed by the Utica (Michigan) Public Schools. Following a format suggested by the U.S. Forest Service for lessons dealing with environmental investigations, the lesson plan consists of a series of activities or tasks followed by discussion questions. Each individual task is a self-directed activity that is placed on a card for student use. Task cards have been developed at the upper elementary and junior high school levels. Tasks and other materials are also being developed for the lower elementary grades.

Each investigation is intended to involve the student in the processes of learning to develop an understanding and feeling about his environment and each includes (1) an open question (elicits data and participation), (2) focusing questions (draws attention to specific data), (3) interpretive questions (seeks relationships), and (4) a capstone question (calls for a summarizing or generalizing statement). Summary questions conclude the investigation. Cognitive and affective behavioral outcomes are listed as is a list of materials needed.

Sample tasks are:

Describe in writing the meaning of the statement: "Energy makes the World go Round"

Make and or do a crossword puzzle about energy.

Have an essay contest based on some aspect of the energy crisis.

Take a field trip to a power plant, oil refinery, working windmill, coal mine, etc.

Make a survey of energy resources in your community.

Teacher's Environmental Resource Unit: Energy and Power
Brevard County School Board (Cocao, Florida)

The Broad Spectrum Environmental Education Program, Brevard County School Board (Florida) has produced a teacher's resource unit on 'energy and power.' This resource unit was developed by the Economic/Moral Environteam as part of the Broad

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[1]Brevard County School Board, Economic/Moral Environteam **Teachers Environmental Resource Unit: Energy and Power,** Cocao, Florida; Brevard County School Board, 1972 (ERIC ED 067 303)

Spectrum Program of the Brevard Schools. It includes background information on the energy and power sources of solar energy, fossil fuel, nuclear energy, geothermal energy, superconductivity, magnetohydro-dynamics, and waste recycling. It also deals with man and energy, energy efficiency, energy and the American family, and fossil fuel consumption and pollution. No pupil activities or instructional materials are included as the intent of this unit to provide subject related background information for development of the instructional program.

Energy Conservation Unit - Northrup School River Rouge Public Schools

An example of a classroom developed unit on energy conservation is that of Mr. Larry Bohner, seventh grade teacher at Northrup School, River Rouge (Michigan) Public Schools.

The primary source of materials and information for Mr. Bohner's unit was the newspaper. Two issues of the **Junior Scholastic** magazine (the October 11, 1973 issue dealing with "The Energy Question" and the November 29, 1973 issue discussing "Arab Nations in the '70's") were used for supplemental materials when the unit was taught during December, 1973.

Students were encouraged to develop projects covering all aspects of the energy crisis from the Middle East War to the threat of gas rationing. Points were awarded for each project. Many of the projects were very original, reports Mr. Bohner, and included charts, posters and maps. One display of toy soldiers depicted Egyptian and Israeli soldiers on either side of the Suez Canal. Pictures and articles on political leaders and the people themselves were pasted on the inner sides of the display box for this project.

Mr. Bohner indicates that a project approach was used, ". . because materials are limited in this area. . . .The newspaper provides a plentiful source of material which is easily accessible to most of the students. The response was much better than I expected and I was particularly gratified to note the work and effort done by some of the lower achievers."

Jelly Bean Ecology - Elgin Public Schools

Robert Deem, Science and Outdoor Education Coordinator, School District U-46, Elgin, Illinois, reports in the March, 1973 issue of **Science and Children** on the use of, "making believe" through role-playing as related to the food cycle and more specifically the "energy pyramid" that exists in nature.

The concept of the energy pyramid, and man's dominate role in this process, illustrates another aspect of the total energy picture. The "energy pyramid" begins with the basic units of energy that are found in the soil, air, water, and radiant energy from the sun. These basic units are capable of being used by only those living things equipped with proper facilities for converting basic energy into living matter, namely, the green plants or **producers**. Animals are the **primary consumers** of the energy generated since they alone are able to retrieve energy directly from the producers. Due to incomplete digestion and consumption, however, among other factors, it is estimated that only 10 to 20 percent of the plant (producer) energy is accessible to the plant eater (primary consumer). There are also **secondary consumers** (meat eaters) and **tertiary consumers** (predators) in the natural hierarchy. Man plays a dominate role in this pyramid because he has the capability of controlling all of its levels through a variety of agricultural and environment actions.

To illustrote the concept of the energy pyramid Mr. Deem suggests the use of a bag of jelly beans, some plostic bags, and a class of willing students.

Twenty jelly beans are placed in each of twenty plastic bags. Each jelly bean represents one unit of energy. Twenty volunteers are selected to act as "producers" or green plants. Each "plant" receives one bag of 20 energy units (jelly beans). (The natural process of how green plants make use of soil, water, air, and sunlight can be reviewed at this time.)

Each "plant" has to "store" 15 units of energy by leaving them in the bag. The "plant" eats the 5 units remaining since these would be used by the plant for respiration and its normal activity. (There are now only 300 units available instead of the 400 originally available.)

Four volunteers are selected to act as "primory consumers" or plant eaters. Each "plant eater" collects 60 units from the "plants" and puts them in a plostic bag. This may be done in any combination as long as each "plant" retains three units. The "plant eater" now has 60 units of energy and eoch "plant" has 3. These 3 remaining units represent the roots and part of the stem still in the ground necessary for new growth, and new energy.

Robert Deem "Jelly Bean Ecology," **Science and Children**, March 1973, p. 12-14.

As most plant eaters require large amounts of energy, the "plant eaters" may eat 30 units (jelly beans) leaving 30 units stored. In nature these units would be stored as flesh, bone, fat, and internal organs.

Two students are chosen to act as "secondary consumers" or meat eaters. The "meat eaters" collect 60 units of energy from any of the "plant eaters." In nature this would result from the catch of a "plant eater." Each "meat eater" now has 60 units of energy. Thirty of these can be used up (eaten), but 30 of these must be stored.

Finally a predator (chosen from those left in the class) collects the 60 units remaining of the original 400.

The procedure outlined above dramatically illustrates the concept and operation of the "energy pyramid." Mr. Deem suggests several questions for thought and action in his article.

A Teaching Unit for Energy Education in Elementary Schools The United States Jaycees

The United States Jaycees, as part of their Youth Program for Energy Education, have produced a Teacher's Kit "A Teaching Unit for Energy Education in Elementary Schools."* This unit was prepared by Mrs. Connie Aldrich Qualman of the Farmington (Michigan) Public Schools.

The purpose of the unit is to create an energy thrift ethic among each student. A unit outline is provided which includes (1) a vocabulary list, (2) means by which energy is produced and transmitted for home use, (3) man's past, present, and future needs for and sources of energy, and (4) the causes, implications, and student action related to the energy crisis. A list of activities and teaching suggestions is provided, as well as a list of resource booklets.

Some of the activities suggested include:

> List all the things in your home that use energy. Think about which ones are really necessary. Circle those which you can do without.

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*Available from your local Jaycee Chapter or Mr. Barry P. Walsh, Chairman, Energy Conservation Programs, Michigan Jaycees, 30247 Wicklow Court, Farmington Hills, Michigan 48024.

Think about the way energy is used in your home. Make a list of things in your home that use energy. Classify the items on your list according to the kind of energy they use (electricity, gas, oil, coal). Predict the kind of energy you use the most in your home.

Learn how to read your electric meter to determine how much electricity is used in your home.

Think of ways in which electricity can be conserved in your school. Choose one of your suggestions and test it to determine how much electricity can be saved.

The overall Youth Program for Energy Education utilizes Sammy Saver, Super Energy Aide as a symbolic entity. A Sammy Saver Award of Merit and pledge is provided for those students who pledge to conserve energy.

The Energy-Environment Game -- Edison Electric Institute

The Energy-Environment Game is an educational simulation for classroom use available through the Edison Electric Institute.* It deals with society's demand for increasing amounts of electric energy and the complex questions which result. The game provides problem-solving situations for junior and senior high school students.

Each Environment Game package contains the materials necessary for a class of 32 students. The game may be played by as few as 20 or as many as 40. Thirty-two players' guides, a teacher's guide, a filmstrip and record, a wall poster map, 8 sets of prime source information, and site selection information are included.

During the game students must make decisions regarding the present and future needs for electricity, a proposed site for a new electric generating plant, and a choice between fossil or nuclear fueling. During this process attitudes are analyzed, position statements prepared, discussion takes place, public hearings are held, and research is undertaken.

There are no predetermined answers in the game. Value judgements are made by the students based on researched evidence. There is no time limit on playing the game. It can be played in as few as six class periods or can continue for two weeks or more.

*Orders and inquiries should be addressed to: Dr. Richard B. Scheetz, Coordinator, Education Services, Edisan Electric Institute, 90 Park Avenue, New York, N.Y. 10016.

The Energy Crisis (What You Can Do About It)
Standard Oil of Indiana

The Energy Crisis (What You Can Do About It) is a resource packet with background information on energy and four pre-printed spirit master worksheets dealing with: The Helpers We Have Today, Our Energy Sources, You Can Save Energy, and The Need for Oil.* Each worksheet includes background information for the student and exercises. An explanation of the intent of the packet, discussion of the content of the worksheets, and list of additional instructional activities are included for the teachers.

Instructional Resources

The instructional materials listed below are mainly those which are free or inexpensive. Please contact the companies listed at the end of each items' description for specific ordering procedures. Addresses are provided in the Sources of Help part of this section.

A is for Atom (film) color, 16 minutes

Grades: 7-12

This film tells the story of atomic energy and highlights the significance of the atom's power in peacetime. Professor Atom takes the audience through an animated course in nuclear physics, showing where the power of the atom comes from, how it is released and how it is controlled. The film depicts the future significance of atomic energy in medicine, agriculture, industry and science. (Consumers Power)

The Atom and the Kilowatt (film) color, 12 minutes

Grades: 4-12

The film takes the viewer behind the scenes, using narration and graphic animation to show how a commercial nuclear reactor works and how electricity is produced by nuclear energy using the uranium atom as its heat source. (Teacher's Guide available) (Consumers Power)

*Available from: Director, Youth and Educational Activities, Standard Oil Company (Indiana) Mail Code 3705, 200 East Randolph Drive, Chicago, Illinois 60601.

Boiling Water Reactor (film) color, 10 minutes

Grades: 7-12

Graphic animation and illustrations are used to describe the operation of a boiling water nuclear reactor, how water slows the speed of neutrons and the safeguards employed in nuclear plants. (Consumers Power)

A Consumer's Guide to Efficient Energy Use in the Home (brochure)

Various ideas for energy conservation in the home. (Associated Petroleum Industries)

Do You Know! (brochure)

Discussion of various aspects of natural gas. Includes short quiz. (Associated Petroleum Industries)

EnerCon Checklist (wall chart)

This is a colorful pop-art wall chart for classrooms which contains a variety of helpful ideas on energy conservation. (Consumers Power)

The EnerCon Puzzle (crossword puzzle)

Grades: 7-12

This crossword puzzle on the subject of energy conservation provides an opportunity for students to learn more about today's shortage of energy resources, as well as terms and concepts related to conserving energy. (Consumers Power)

The Energy Challenge (film) color, 25 minutes

A thought provoking energy report brings one of the vital issues of our time into focus, with a study of man's endless search for new sources of energy. (Consumers Power)

The Energy Crisis (slide/tape)

An overview of the energy crisis (available September, 1974) (Michigan Consolidated Gas)

Energy (brochure)

Hints on how to save energy in the home. (Michigan Consolidated Gas)

Energy from the Artic (film) 29 minutes

A fascinating film about Alaska and northwest Canada; the site of a multi-billion-dollar project aimed at easing the nation's energy shortage. Beautiful photography depicts the land, its people and wildlife as viewers watch progress of a 3,000-mile natural gas pipeline. (Michigan Consolidated Gas)

The Energy Gap: What It's All About; Why It May Get Wider; How to Keep the Nation from Falling Into It (brochure)

(Associated Petroleum Industries)

The Energy Problem and You: Student's Guide to Energy Conservation (folder)

This publication opens with a short synopsis of the energy shortage facing America today and provides a list of ways to conserve energy that will furnish a range of topics for discussion periods. Also included are suggested group projects relating to energy resources and their conservation. (Consumers Power)

Energy and Today's Environment (booklet) 20 pages

(Available as a reference booklet for junior high and high school teachers and as student's text.)

This booklet featuring varied scientific techniques, begins with primitive man's need for energy and develops through a projection of future needs. (Consumers Power)

Environment and Technology (filmstrip) 179 frames, color (divided into eight chapters)

(Complete printed narration script with suggested questions to encourage discussion included for teacher reference.)

Grades: high school, adult

Man's need to seek a balance between creature comforts and a healthy environment is discussed in this colorful filmstrip, which is divided into two parts, each including four pauses for discussion. People are demanding an ever higher standard of living, complete with the modern conveniences that advancing technology has produced. At the same time, there is a growing concern about the impact of this technology on the air, water and land essential to man's existence. The filmstrip suggests some answers. (Teacher's guide and Film Supplement Kit available) (Consumers Power)

Environmental Quality Instructional Resource Kits (kit)

Grades: available in elementary, middle school, high school kits.

These complete instructional resource kits on environmental quality include for teachers: a manual, activity guide, tests, wall charts, glossary, bibliography and supplementary resource list; and, for students; a text, environmental career guide and environmental involvement checklist. The kits were developed in consultation with educators and educational editors in response to the growing need for factual comprehensive information on the interrelationships of environment, ecology and energy. (Consumers Power)

Facts About Oil (booklet)

An overview of the petroleum industry from the first well drilled in 1859 to the present - covering exploration, production, refining, transportation, marketing, and the future. (Associated Petroleum Industries)

Fuel for the Future (film) 17 minutes

Developing new reserves of gas and oil for future needs is the subject of this timely film. You'll travel offshore in the Gulf of Mexico, to the Badlands of North Dakota and to the remote Artic as the gas industry searches for supplies to meet the growing energy demands. (Michigan Consolidated Gas)

Gasoline: Questions - Answers (brochure)

(Associated Petroleum Industries)

Geology and Natural Gas (film) color, 15 minutes

Grades: 4-9

This presentation illustrates the geological location of natural gas in sandstone beds and the problems of tapping it for use. Success in harnessing this important natural source of energy is an example of the ability of scientists to control the environment and extract from it mankind's daily needs. (Teacher's Guide available) (Consumers Power)

The Hidden Sea (film) 28 minutes

Centuries ago much of Michigan was covered by an inland sea. As time passed, a geological formation known as the Michigan Basin was formed, containing gas and oil deposits. This documentary shows how the buried rock formations are being converted into reservoires to store natural gas for winter needs. (Michigan Consolidated Gas)

The History of Natural Gas (comic book)

(Michigan Consolidated Gas) &

The History of Natural Gas (booklet) 16 pages, available in classroom quantities

Grades: K-6

This cartoon booklet is designed to help younger students learn through pictures about the discovery, development and uses of natural gas. (Consumers Power)

Impact (film) color, 28 minutes

Grades: 7-10, adult

A story that traces the production, transmission and uses of natural gas, this film includes an introduction to some of the 25,000 by-products manufactured from natural gas components. The story begins with a geologist locating natural gas deposits, illustrates types of equipment used in production, describes how gas-flow is controlled, and finally, shows how gas is used in the home, business, and industry. Emphasis is based on the impact natural gas can have on the growth and prosperity of a community. (Consumers Power)

Instant Power (booklet) 16 pages, available in classroom quantities

Grades: 7-12

This illustrated booklet traces the history of energy from muscle power to electric power, and the history of electricity from Greeks to Edison. It describes the methods of making electricity from coal power to nuclear power, and shows how electricity is used to do work for us. (Teacher's Guide available) (Consumers Power)

It's Your Energy. . . .Use it Wisely! (brochure)

One-hundred hints on how to use electricity more effectively. (Detroit Edison)

Liquid Natural Gas (film) color, 15 minutes

Grades: 8-12

This contemporary scientific film explains changing natural gas to liquid by extreme cold (cryogenics). It shows how natural gas can be handled, transported and stored more easily as a liquid; and points out new uses and possibilities for liquified natural gas. (Teacher's Guide and Film Supplement Kit available) (Consumers Power)

Ludington Pumped Storage Power Plant (booklet) 6 pages, available in classroom quantities

Grades: 7-12

The pumped storage hydroelectric power plant under construction near Ludington will provide Michigan with a huge new source of instant power. The folder outlines capacity, size, and basic operation of the plant and includes a general description of how pumped storage hydroelectric generation works. (Teacher's Guide available) (Consumers Power)

Louisiana Legacy (film) 28 minutes

Visit the beautiful "Cajun Country" of Louisiana, and view offshore exploration in the Gulf of Mexico and historical developments along a pipeline as it carries gas from the south through eight states to northern markets. (Michigan Consolidated Gas)

Man and His Environment (filmstrip) 206 frames, color (divided into eight chapters)

(A complete printed narration script with suggested questions to encourage discussion included for teacher's reference.)

Grades: middle school

Environmental discussion may be prompted by the use of this timely filmstrip, which is divided into two parts, each including four pauses for discussion periods. The film covers historical and modern causes of pollution. Some solutions are suggested, as well as the idea that environmental improvement will take man's total effort. (Teacher's Guide and Filmstrip Supplement Kit available) (Consumers Power)

Michigan Electric Power Pool Control Center (booklet) 8 pages, available in classroom quantities

Grades: 7-12

A look at the operations of the Michigan Electric power pool helps explain how Consumers Power and The Detroit Edison Company insure reliable electric service to their customers, and how the pool is interconnected with the eight-state East Central Area Reliability Coordination Group. (Teacher's Guide available) (Consumers Power)

More Power to You (booklet) 16 pages, available in classroom quantities

Grades: 4-9

This cartoon booklet tells young people the story of electric energy supply and use in Michigan, and provides information about career opportunities. The story takes the reader on a quick tour of the statewide electric network, including emergency power and electronic computer facilities. (Teacher's Guide available) (Consumers Power)

Nation's First Synthetic Natural Gas Plant (folder) 4 pages, available in classroom quantities

Grades: 8-12

To meet the growing demands for natural gas, an important break-through has come with the construction of the nation's first synthetic natural gas plant. This plant at Marysville, Michigan, is designed to make natural gas from the liquid by-products of distant gas wells. (Teacher's Guide available) (Consumers Power)

Natural Gas Operations Folders (three 4-page folders)

Grades: 9-12

Natural Gas for Tomorrow Is Stored Underground, The Computerized Gas System Control System, Compressor Stations Move the Gas, depicts (1) underground storage of quantities of natural gas which would fill an imaginary tank measured one cubic mile; (2) an electronic "brain" at the control center in Jackson watching over 1,300 miles of high-pressure pipelines; (3) giant heart-like compressors speeding natural gas on its way to customers. (Teacher's Guide available) (Consumers Power)

Natural Gas Operations Folders (three 6-page folders)

Grades: 5-8

Storing Energy Underground, This is the Control Center, and Those Powerful Energy Pumps, describe the same natural gas operations as the folders for the high school level but are written for middle school level students. (Teacher's Guide available) (Consumers Power)

Natural Gas Serves Our Community (booklet) 16 pages, available in classroom quantities

Grades: 5-9

This educational booklet on natural gas and energy and service explains how gas is found, drilling procedures, regulation and distribution through pipelines, pumping processes, underground storage, and consumer uses. (Consumers Power)

Natural Gas Serves Our Community (booklet)

Grades: 2-4

This is a new, lower elementary version of an educational booklet on natural gas energy (with the same title) that has been popular with upper elementary teachers for several years. The booklet explains how gas is found, drilling procedures, distribution through pipelines, pumping processes, underground storage and consumer uses. (Consumers Power)

NOTE: At both the 2-4 and 5-9 grade levels, a kit is also available. It combines the booklet with a colorful 27-cutout project which tells the story of natural gas energy in a typical community. The cutouts can be used on a bulletin board with thumb tacks, on blackboards with masking tape, on tables or on felt boards. (Consumers Power)

New for Tomorrow (film) 28 minutes

Produced by the Alaskan Department of Natural Resources, this documentary shows how fuel from the North Slope can be transported through the wilds - without affecting the habitat of the Artic animals. (Michigan Consolidated Gas)

North Coast (film) 20 minutes

Sail on ocean freighters to the industrial heartland of America . . . an area of great natural beauty. See how energy is contributing to a better way of life around the Great Lakes. (Michigan Consolidated Gas)

Nuclear Power and the Environment (film) color, 12 minutes

Grades: 7-12

This film, produced by the U.S. Atomic Energy Commission, shows how electricity is produced with nuclear fuel, and documents the future needs for additional nuclear power plants. The effects of fossil-fueled and nuclear plants on the environment are reviewed, as is the role of nuclear power in helping to improve environmental quality. (Teacher's Guide and Film Supplement Kit available) (Consumers Powers)

Oilman's Fact Finder (brochure)

Provides information on exploration, drilling, and production, transportation, refining, marketing, and several other topics. (Associated Petroleum Industries)

Power for Progress (booklet) 16 pages, available in classroom quantities

Grades: 4-9

This cartoon booklet illustrates the experiences of a high school science class on a field trip to the information center at Consumers Power's Big Rock Point Nuclear Plant. The story includes a brief introduction to the Ludington Plant, and the Palisades Nuclear Power Plant. (Teacher's Guide available) (Consumers Power)

Power When You Need It (folder) 6 pages, available in classroom quantities

Grades: 7-12

Meeting peak demands is one of the key responsibilities of an electric power system. This full-color folder describes "peaking power" and tells how gas turbine electric generating plants utilize jet aircraft engines to help meet daily and emergency surges in demand for power in Michigan. Schematic diagram of a gas turbine generator unit is included. (Teacher's Guide available) (Consumers Power)

A Powerful Friend (Multi-media kit)

Grades: K-3

In a series of three sound filmstrips Franklin, the mule, teaches a young friend about power and energy and shows how electricity, through its many uses, becomes "A

Powerful Friend". The kit includes an activity oriented, fun song for the class, sung (or led) by actor musician Joel Corey. Also included is a Teacher's Guide and three activity sheets printed on duplicating spirit masters. The soundtracks for the filmstrips and the Power Song are on a 33 1/3 rpm disc pulsed for both manual and automatic equipment. "A Powerful Friend" acquaints students with concepts of energy, power, electricity, natural gas, environment, pollution and recycling. (To media centers) (Consumers Power)

Seven Ways to Reduce Fuel Consumption in Household Heating. . . through Energy Conservation (brochure)

(Washington, D.C.: U.S. Government Printing Office, 1973, nd.)

The Story of Natural Gas Energy (booklet) 48 pages, available in classroom quantities

Grade: 7-adult

This comprehensive booklet explains how natural gas was formed and discovered, where it is produced, how it is brought from wells into homes and factories and the many useful jobs it does today and may do tomorrow. (Teacher's Guide available) (Consumers Power)

What Happens When You Turn on the Light (book)

Ever wonder what happens when you turn on the light? Arthur Shay, noted author of books for the young people, traces the route of electricity from the generator through the substation to your home in a series of interesting pictures and informative copy. (Consumers Power)

The World of Energy (filmstrip/tape)

A series of six filmstrip audio tape units dealing with known sources of energy in the earth, and how we tap them for heat, light, manufacturing, transportation, and more. Our fast-disappearing fossil fuels are probed, as is the potential nuclear power. Future energy sources are also explored. (National Geographic Society, Dept. 1037, Washington, D.C. 20036)

Background Materials

Sources of background information include:

American Gas Association *The Natural Gas Supply Problem* Arlington Virginia The Association 1971

American Gas Association "New Sources of Gas — Where and When?" Arlington Va. The Association 1973

American Gas Association "Toward Responsible Energy Policies: A Joint Policy Statement of the American Gas Association, American Petroleum Institute, Atomic Industrial Forum, Inc., Edison Electric Institute, National Coal Association." Washington D.C. The Associations, March 12, 1973

American Nuclear Society *Nuclear Power and the Environment: Questions and Answers* Hinsdale Illinois The Society 1973

American Petroleum Institute *Environmental Research Sponsored by the American Petroleum Institute Annual Report* Washington D.C. The Institute January 1973

American Petroleum Institute *Income Tax Policy for the Petroleum Industry During the 1970's* Washington D.C. The Institute n.d.

American Petroleum Institute *One Answer to the Energy Crisis* Washington D.C. The Institute 1972

American Petroleum Institute "Statement of Policy Energy" Washington D.C. The Institute December 1973

Cambel Ali B "Impact of Energy Demands" *Physics Today* (December 1970) p. 38

Center for Information on America "The Energy Crisis: What Makes it so Complex and Complicated" Washington D.C. The Center 1973

Center for Strategic and International Studies Georgetown University *Understanding the National Energy Dilemma: A Report of the Joint Committee on Atomic Energy* Washington D.C. The Center 1973 (also available in original form from the U.S. Government Printing Office)

Citizens' Advisory Committee on Environmental Quality *Citizen Action Guide to Energy Conservation* Washington D.C. U.S. Government Printing Office 1973

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Freeman S David Toward A Policy of Energy Conservation *Bulletin of the Atomic Scientists* Vol [illegible] no 8 (October 1971) pp 8 12

The Heating Oil Shortage *The New Republic* Vol 168 No 10 March 10 1973 pp 19 21

Hubbert M K Energy Resources in *Resources and Man A Study by* [illegible] *and Man* San Francisco National Academy of Sciences and the National Research Council, 1969

Joint Committee on Atomic Energy, U S Congress Selected Materials on Environmental Effects of Producing Electric Power Washington D C [illegible] Printing Office 1969

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[illegible] Environment Vol 14 No 15 [illegible]

[illegible] An Environmentalist Views the Energy Crisis [illegible] 1971

Michigan [illegible] A *Master Plan for Environmental* [illegible] Governor State of Michigan [illegible]

[illegible] *Environmental Education* [illegible] Department November 1973

Milliken, Hon. William G., *Michigan: State of the State Message*, Lansing, Michigan, State of Michigan, January, 1974

Milliken, Hon. William G., *Special Message to the Legislature on Energy*, Lansing, Michigan, State of Michigan, November 26, 1973

"New Energy Sources", *World Environment Newsletter (included in Saturday Review World)*, (February 2 and 23, 1974), pp. 47-50 and 29-32 respectively

Patterns of Energy Consumption in the United States, Prepared for the President's Office of Science and Technology, Stanford, California: Stanford Research Institute, January, 1972

Subcommittee on the Environment, Committee on Interior and Insular Affairs, U.S. House of Representatives. "America's Energy Potential: A Summary and Explanation". Washington, D.C.: U.S. Government Printing Office, 1973

Ralls, William R., "Conservation and Efficient Use of Energy: A State Regulator's View" (Statement to the Joint Hearings on Conservation and Efficient Use of Energy, U.S. House of Representatives, July 10, 1973), Lansing, Michigan: Michigan Public Service Commission, 1973

Wayne Oakland Federated Library System, *Would You Believe. Energy Crisis*, Wayne, Michigan: The Library, May, 1973

Weinberg, A.M. and Hammond R.P., "Limits to the Use of Energy" *American Scientist*, Vol. 58, 1970, p. 412

"Why We're Running Out of Gasoline", *Popular Science*, Vol. 202, No. 4 (April, 1973) p. 82

Sources of Help

Advice and consultation can be obtained through these resources:

Advisory Council for Environmental Quality, Executive Office of the Governor, State of Michigan, Lansing, Michigan

Associated Petroleum Industries of Michigan, 930 Michigan National Tower, Lansing, Michigan 48933

Center for Environmental Quality, Michigan State University, East Lansing, Michigan

Consumer Alliance of Michigan, Energy Committee, 32517 Avondale, Westland, Michigan 48185

Consumers Power Company, Educational Services Program, 212 W. Michigan Avenue, Jackson, Michigan 49201

Department of Mathematics and Science Education, Detroit Public Schools, 5057 Woodward Avenue, Detroit, Michigan 48202

Detroit Edison Company, Consumer Projects Department, Public Affairs, 2000 Second Avenue, Detroit, Michigan 48226.

ERIC Information Analysis Center for Science, Mathematics, and Environmental Education, 1460 W. Save Avenue, Columbus, Ohio 43210

Department of Commerce, Law Building, Lansing, Michigan 48933

Institute for Environmental Quality, University of Michigan, Ann Arbor, Michigan

Macomb County Intermediate School District, 44001 Garfield, Mt. Clemens, Michigan 48043

Michigan Consolidated Gas Company, One Woodward Avenue, Detroit, Michigan 48226

Michigan Jaycees, Local Jaycee Chapter, or Mr. Barry P. Walsh, Energy Conservation Programs Michigan Jaycees, 30247 Wicklow Court, Farmington Hills, Michigan 48024

Michigan Public Services Commission, Department of Commerce, Law Building, Lansing, Michigan 48913

Oakland County Intermediate School District, 2100 Pontiac Lake Road, Pontiac, Michigan 48054

Dr William Taylor, Advisor, Science and Technology, Office of the Governor, Capital Building, Lansing, Michigan 48933

Wayne County Intermediate School District, 1500 Kales Building, 76 West Adams, Detroit, Michigan 48226

IV. HOW TO GET STARTED

Energy conservation programs should be developed through a variety of approoches. Programs can be initiated simultaniously within the district, ot the locol school level, and in the classroom. They should be interdisciplinory in nature. While each level and type of activity will have its own porticular character, the purpose will be the some - to build knowledge and attitudes focused on the wise and prudent utilization of energy resources.

The need for effective programs leading to the conservation of energy is immediate and compelling. We can not afford to, nor do we need to, wait for a "grond design" to start instructional activity.

Provided below are a set of guiding principles for establishing energy conservation programs together with suggested curriculum development procedures at the district, local school, and classroom levels.

Guiding Principles for Establishing Programs*

1. ***Learning Goals, Objectives, and the Means to Accomplish Them Should be Determined and Specified within Each Individual Classroom, School, and School District in Terms of Their Unique Needs, Interests, Concerns, Capabilities, and Resources.***

   Predetermined programs which are imposed on teachers and students are self-limiting and contrary to wise curriculum development. The unique difference in style of teaching, variations in readiness, range of available resources, and differences in student learning styles which occur should be taken into consideration in program development. Programs should be developed to use the local environment and to meet local needs.

2. ***The Program Should Be Learner Focused.***

   Individual student differences should be accepted and provided for. Student learning must be the end of the educational effort. Only through a change in our collective behavior can energy be conserved.

3. ***The Program Should Provide for Students to be Active Learners.***

   When students are active and use many or all of their senses to learn, learning is more pervasive and lasting. Students who are actively involved in identifying energy conservation problems within their community, investigating the causes of these problems, seeking solutions to these problems, and working with others to implement solutions to these problems will develop the skills necessary to deal with future concerns.

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*Adapted from "Environmental Education Guidelines", Michigan Department of Education, November, 1973.

4. ***The Program Should be Problem-Focused.***

The major goal of energy conservation programs is to develop and implement wise energy utilization practices. We should approach the question of effective energy conservation through problem-solving procedures aimed at root causes. Without developing programs and activities which deal with root problems, we will continue to devise measures which fall short of adequate problem resolution. Students need to develop broad-based skills in decision making, attitude formulation, values clarification, and taking action. Steps involved in the problem-solving process are:

(1) Identifying and Defining the Issue

(2) Collecting Data

(3) Determining Alternative Solutions

(4) Choosing an Effective Solution

(5) Developing a Plan of Action

(6) Carrying out the Plan

5. ***The Program Should Include Opportunities for Learning in all Three Learning Domains - Psychomotor, Affective, and Cognitive.***

The most important impact that students have will be in terms of their actions. Students must be provided with opportunities to examine and clarify their own value systems and the value systems of others. They should have opportunities to acquire knowledge and to increase skills and problem-solving ability.

6. ***The Program Should Recognize the Teacher as a Participant in the Program.***

The teacher should be a part of the learning team, not just a conveyor of facts and information. The teacher should participate in learning experiences based around each student's interest and capabilities. The teacher becomes a resource person, exploring energy conservation issues and approaches with the students.

7. ***The Program Should be Interdisciplinary.***

The success of any energy conservation program lies, in a great measure, upon the success with which it can be integrated into the various aspects of the school program. All subject matter and training areas are related to and should be involved in energy conservation. School programs operate as a discontinuous field of categories in the main. The issues and concerns included in the consideration of energy conservation brush aside artificial and arbitrary boundaries of the school curriculum. No one has a "corner" on education for energy conservation. If it is to be truly representative of the breadth and scope of real life conditions, energy conservation education must include the social, political, cultural and economic influences on those conditions. The program should be integrated into, and correlated with, the existing school curriculum in all grade and subject matter areas, stressing wholeness rather than a fragmented approach.

8. ***The Program Should Span the Curriculum, K-12.***

All grade levels have a direct responsibility to integrate energy conservation concepts into their curricula. The program should be designed to coordinate efforts in each grade, requiring cooperative planning between all levels of education including preschool, elementary, secondary, and adult education. Energy conservation education spans the entire formal education of a student, as well as his informal education (mass communications, community information meetings, conversations, and so forth).

9. ***Teacher In-service Education Must be Emphasized as Part of the Program Prior to, and During its Implementation.***

Teachers play a critical role in energy conservation education. By initiating changes in his own classroom, the teacher affects both the attitudes and knowledge of students. A comprehensive in-service training program for teachers will help increase their understandings, interest, awareness, and instructional skills in the teaching of energy conservation concepts and in all three domains of learning.

10. ***Evaluation Should be a Continuous and Integral Part of the Program.***

In order for the progrom to be successful, there must be a continuous assessment of student needs and learning; teacher interest, skills and effectiveness; administrative concerns and policies; and locol resources, needs and uses. Changes in student attitude should be evaluated by means of attitude inventories administered at selected places throughout the curriculum.

A District-Level Strategy

District-wide energy conservation programs should be developed from a base of community involvement. As effective programs to combat the inefficient use of energy involve a community-wide effort, a range of community members should help specify the objectives to be attained. The student, parent, energy using businessman, general consumer, public utility representative, persons from community organizations, petroleum company manager, and representatives of education should participate.

Specific steps in a district-level strategy may include:

1. Appointment of a representative Program Advisory Committee. The committee could:
   - a. Review background information on energy conservation.
   - b. Review the general goals of the program.
   - c. Develop a written statement of the local school district's philosophy on energy conservation.
2. The services of an Energy Conservation Coordinator should be obtained or assigned. The coordinator can be a part-time or full-time person who is familiar with the technical and philosophical substance of energy conservation. The person may be a part of the school system or could be from some other educational agency.
3. A set of instructional objectives should be developed by a staff committee under the direction of the coordinator. Objectives should be specified in all three domains of learning.

4. The instructional objectives should be reviewed by the Program Advisory Committee as well as other staff members and revised as appropriate.

5. The current status of energy conservation in the school system should be assessed in terms of programs and available resources.

6. A specific strategy for curriculum development and implementation should be identified. (See the suggested approaches for local school and classroom activity which follow.) The guiding principles indicated previously should be followed in development of the curricular approach to be utilized.

7. Resources should be identified and the materials to be used in the program should be evaluated. These materials should:

   a. Provide for active involvement of the student.

   b. Be open-ended in nature and encourage student modification.

   c. Be relevant to the student (i.e., deal with activities and applications with the experience and be of interest to the student).

   d. Show the interdisciplinary nature of energy conservation.

   e. Be significant to and for the solution of energy conservation problems.

   f. Be appropriate to the student's level of cognitive and affective development.

8. In-service education programs for staff should be established.

9. Individual schools should be assisted to develop their own programs.

10. Instruments should be developed to evaluate the effectiveness of the program.

Instructional Activity Development at the Local School

It has been shown that the most effective unit for bringing about instructional change can be the individual school. Program implementation at the local school can involve short lines of interpersonal communications, concentration of resources, direct relationship to the student and community, and a type of cohesiveness which can provide the cement for developing programs which result in improved student learning. Organizational arrangements such as team teaching and sharing of individual areas of expertise can also occur. Community resources can be used.

A general pattern of local school program development includes:

1. Forming a school staff committee to:

   a. Review the current status of energy resources and energy conservation activity in the community, school district, nation, and world.

   b. Obtain information about what guidelines, goals and objectives are available for instructional programs in energy conservation.

   c. Determine what instructional resources are available for use in teaching about energy conservation.

   d. Involve other staff, students, and community members in determining what curricular areas, extra-curricular activities, and community organizations would be the best vehicles for inclusion in a school-wide energy conservation program.

2. Providing an orientation on the nature and status of energy resources as well as the goals and objectives of energy conservation programs to staff. Representative examples of effective programs could be shared (see Section III for examples).

3. Conducting a brainstorming session among staff to develop ideas which might be put into effect at the local school.

4. Determining the nature and pattern of instructional activities related to energy conservation to take place within the school's instructional program and in the school community.

Instructional Activity Within the Classroom

The teacher-student relationship is the most critical one in the development of knowledge, skills, and attitudes by learners. The teacher is the most significant single variable in student learning. Furthermore, a supportive climate enhances motivation and reinforces success experiences which will improve student achievement. Most systematic approaches to instruction include the steps of:

1. Diagnosis of student capabilities and needs.
2. Prescription of appropriate instructional approaches in terms of content to be dealt with and methods to be employed.
3. Instruction by the teacher alone, by the teacher with learning resources, or through media alone. Peer group activities such as cross-age tutoring and interest grouping can also be employed.
4. The effectiveness of the instruction is tested, and. . .
5. Feedback from the evaluation process is used to revise the program.

In an area such as energy conservation other results that should stem from local school activity are:

1. Sharing of effective programs with other schools and district level personnel so that a bank of alternate practices can be built.
2. Evaluation of learning resources in terms of their instructional performance. The resulting information should be shared with others involved in energy conservation programs.
3. Sharing of community resources which are identified.
4. Sharing information about the nature and status of energy resources.

APPENDIX

ENERGY RESOURCES: PRESENT AND FUTURE

In the period from 1950 to 1970 the demand for energy has doubled. By the year 2000, experts tell us that we will be using three times the energy we are now consuming. Where will it come from?

At the present time the sources of energy in the U.S. are: oil, 44%; natural gas, 33%; coal, 18%; hydroelectric power, 4%; nuclear power, 1%. While reserves of these fuels are difficult to estimate, experts assess proven-recoverable fuel reserves as follows:

Coal: 500 years' supply
Oil: 10 years' supply
Natural Gas: 11 years' supply
Shale Oil (in rock): 35-100 years' supply
Nuclear (uranium): 13 years' supply

COAL

The coal industry has a great chance to capitalize on the energy crises. A recent advertisement by American Electric Power Company, Incorporated in **Time Magazine** says, "Coal - good old reliable coal - can help solve the energy crises if America is determined to do so". . despite such problems as "labor stability, price controls, hopper cars, environmental resistance, new mine development, and land reclamation."

Coal is not difficult to find. In fact, the U.S. has 40% of the planet's known coal reserves. Half of this is considered to be economically recoverable with existing know-how.

The trouble with using coal is that under present technological conditions, the solution of one set of problems creates others. There is, as yet, no successful way to burn it cleanly; converting it into a cleaner gas or oil before burning is still neither efficient or commercially feasible; the sulfur emmision standards included in the Federal Clean Air Act of 1970 and in the guidelines of the Environmental Protection Act cannot be met by the October, 1975 deadline. However, most coal-burning utilities believe that they can solve these problems. One approach is the use of low sulphur coal.

Research is underway on four possible solutions to more effective coal utilization: (1) stack-gas scrubbers to remove sulfur dioxide from the effluent gases of burning coal; (2) conversion of coal to low-

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Time Magazine, February 11, 1974, p. 25.

BTU gas; (3) conversion of high sulfur coal to sulfur-free coal or oil; (4) gasification of coal into pipeline quality, high-BTU gas. Any of these solutions would provide some immediate answers to the energy crises. Unfortunately, all are several years away from commercial feasibility, although some scrubbers have been installed by power plants.

Other factors affecting coal utilization include the variety of coal types, strip mining and land reclamation, stringent mine safety regulations, and long transportation distances.

OIL

Oil has served as the nation's main energy source for many years. Oil independence, a part of the U.S. total-energy-self-sufficiency-by-1980 policy, iterated by President Nixon in his January 20, 1974, radio address will have to bring about changed economics and technology to close the energy gap. Imports since the Arab embargo in the Fall of 1973 have been reduced from seven million barrels to roughly four and three-tenths million barrels per day, a loss of about 40% of the total oil imports.

The problems relating to oil shortages in the U.S. today are complex ones dealing with adequate supply, distribution, and refining. Petroleum products are an integral part of everyday life; yet most consumers are unaware of their dependence on them. For example, petroleum powers the transportation network, factories, farms; it heats homes and offices; it furnishes the lubricants to keep myriad wheels turning; it paves streets; it is the raw material from which about 3,000 products are made. These products include drugs (aspirin, for example), detergents, plastic trash bags and food wrap, lipstick, nylon, anti-freeze, film, paint, adhesives, insecticides, perfume, ball point pens, explosives, saccharine, vitamins, matches, fertilizers, soap, radio and TV tubes, telephones, floor tile, phonograph records, urethane padding for furniture, plastics (bottles, dishes, furniture), shoes and shoe soles, synthetic rubber. The industries involved in the manufacturing of these products form a vital part of the economy of the country.The lay-offs attributed to the energy crises, particularly to the lack of petroleum, are creating a major economic crises.

Incentives for finding and developing domestic oil and building domestic refineries seem imperative. Public acceptance of refineries in suitable places where unwarranted environmental destruction can be controlled also seems necessary. Basic research on the compostion and properties of petroleum, its occurrence and recovery, on improving the recoverable energy available from petroleum, on expanding and enhancing technological processes and equipment and on finding new energy sources will most likely raise costs, but will help to meet demands of the foreseeable future.

OIL FROM SHALE AND TAR SANDS

Oil shale is widely available, much [illegible] Federal lands. Tracts of 5000 acres each, recently lea[illegible] Colorado, Utah, and Wyoming, are thought to have 1.8 billion barrels of recoverable oil. Potentially the shale oil available in the United States is considered to be forty times greater than the proved oil reserves, including those in Alaska. The difficulty is separating the oil from the shale.

A promising solution to supplementing oil may be the tar sands of Canada. The Athabasca deposits are thought to contain eighty million barrels of oil recoverable by methods now in use. A subsidiary of Sun Oil Company has been operating there at a loss since 1967. A large United States controlled consortium, Syncrude, expects to be producing oil from these tar sands by 1978.

The problems facing oil extraction from shale or sand are severe. For example, it takes 1.4 tons of high grade shale to produce a barrel (42 gallons) of oil, and 1.2 tons are left as waste. Furthermore, the spent shale has a volume that is one-quarter larger then the shale originally mined. The sheer volume of raw materials dictates extraction and processing where the shale is found. It is evident that obtaining oil from shale will create visual, air, and water pollution problems. The process will require huge amounts of water and extensive environmental damage control measures due to toxic by-products such as mercury, lead, and cadmium, which may be dumped into rivers.

The extracting of oil from tar sands creates these same problems. However, the tar sand land is spongy and sticky, limiting alternative land uses, and in Canada's Athabasca fields adequate water is presently available.

Since the energy emergency, research has been stepped-up both in recovery of oil from shale and tar sands and in making the process economically competitive. Both the risks and the inital capital investment are high in this process.

52

NATURAL GAS

"If imported oil is the problem that has brought the energy situation to the critical stage, it is the government's own natural gas policies that lie at the root of the energy shortage."[2] So says a special report in **Business Week** in the Spring of 1973. It points to the discouraging of exploration for natural gas over the past decade because of taxes and controlled wellhead prices; it cites the Federal Power Commission's controls on gas prices paid by interstate pipelines and its responsibility for keeping gas prices well below those of other fuels; it states that a gas shortage was inevitable and would start a chain reaction throughout the nation's energy supply system.

If natural gas is, indeed, the identifiable root of the energy problem, solutions may still be difficult. The gas industry has three major segments - the producers, the pipeline, and the distribution. Each segment appears to have difficult priorities and approaches to the energy shortage. Among the solutions suggested are: (1) increased prices; (2) further leasing of government-owned offshore tracts on the Gulf and Atlantic coasts; (3) development of potential Alaskan supplies; (4) increased exploration for undiscovered domestic gas estimated by experts to be at 1,100 trillion cubic feet; (5) utilization of liquified natural gas piped from wells to reforming plants like the one in Marysville, Michigan; (6) coal gasification; and (7) underground nuclear fractioning to release gas from tight, impermeable rock formation.

Gas is a clean burning, convenient fuel. It heats half of our homes, produces about one fourth of the nation's electricity, and fuels nearly 49 percent of industrial production. It is an important energy resource and a valuable resource for non-energy uses such as the manufacture of fertilizers and chemicals. To avert further energy problems, it appears necessary that the gas industry be permitted and encouraged to develop the domestic potential of existing natural gas resources.

HYDROELECTRIC POWER

Hydroelectric power is another source of energy. Today, most of the feasible sources of water power, with the possible exceptions of tides and ocean currents, have already been used to their full extent. The amount of water power energy is expected to dwindle in comparison to other energy sources.

[2]"Special Report: Enough Energy - if Resources are Allocated Right," **Business Week**, April 21, 1973, p. 51.

A unique hydroelectric power plant was completed in 1973 in Michigan. The pumped storage hydroelectric plant in Ludington is the largest plant of its kind in operation in the world. It is capable of producing 1,872,000 kilowatts of power to meet peak demands of electricity. It operates by using electricity from other plants during hours of low electrical usage (at night) to pump water from Lake Michigan to a storage pond built above the lake. As demands for energy rise during the day, the water in the storage pond is released to flow back through the plant's generators to produce electric power.

NUCLEAR POWER: BURNER REACTORS

While nuclear power may be one of the best answers to the long range energy crises, there is little chance that it can do much to help the shortage in the next few years. Local blockades, environmental concern, and licensing red tape have stretched the lead time for nuclear plant completion from five to ten years. At the present time there are 39 plants in operation in the United States, 55 being constructed and 114 under contract. By 1984 it is possible for 208 nuclear plants to be producing electricity. The cost of these plants is about $500 million today compared to $375 million for a coal-fired plant with stack scrubbers. Since nuclear fuel (uranium) is much cheaper, the total cost of a nuclear plant will be less expensive than a coal installation.

Although the production of nuclear energy is a rapidly emerging technology which may eventually help meet future energy demands, it is still fraught with environmental and public relations concerns. It may be conceded that some of the current controversy over "nuclear garbage" may be the result of widespread adverse publicity about a new field of technology. However, the problem of waste disposal of radioactive materials produced in nuclear fission continues to be explored and must be resolved for the long term. Present storage methods include placing the radioactive waste solutions in large underground tanks. These tanks are monitored for security and have the advantage of being accessible if their contents are found through future research to have economic potential. Future storage methods will include conversion of these liquid wastes to solids for permanent vault storage.

The Atomic Energy Commission has instituted safety standards for nuclear power plants in terms of the power plant systems, core cooling, siting away from places where earthquakes may occur, and in specifying regulations necessary to meet licensing requirements. Such standards and their constant monitoring and revision should create greater public confidence and perhaps increase the role of nuclear power energy in solving the long-range energy crises.

NUCLEAR POWER: BREEDER REACTOR

A breeder reactor is a nuclear reactor designed both to produce power and to breed new fuel at the same time. When fissionable uranium or plutonium is "burned" or fissioned in such a reactor, the amount of fuel produced from non-fissionable materials in the reactor exceeds the original fuel placed in the reactor. The Enrico Fermi Nuclear Generating Station near Monroe, Michigan, was operated as a breeder reactor in a pilot demonstration during the late 1960's. It has since been closed down. Present predictions are that the Atomic Energy Commission hopes to have a commercial demonstration plant operable by the mid 1980's. The USSR, France, and Great Britian are currently producing electricity in breeder reactors. The same safety and environmental concerns noted for burner reactors exists for breeder reactors.

NUCLEAR POWER: THERMONUCLEAR FUSION

Fusion power is another form of nuclear energy. Thermonuclear fusion is the process which occurs when heavy forms of hydrogen - deuterium and tritium - are heated to such high temperatures that they "fuse" to form new atoms (e.g., helium). In the process a large amount of energy may be used as heat for power productions. The energy available from this source would be inexhaustible if deuterium alone were used, since one out of every 7000 molecules of water (H_2O) is a heavy water molecule (D_2O) containing an atom of deuterium. Thus, the oceans contain sufficient quantities to last for millions of years.

The potential advantages to fusion power are: (1) virtually inexhaustible supply of fuel; (2) less radioactive wastes than those produced by nuclear fission; (3) higher energy efficiency; and (4) greater safety in operation.

The disadvantages of thermonuclear fusion lie in the complex technology surrounding the process. Scientific, engineering, and economic feasibility must be demonstrated before fusion power is possible. The first electricity from fusion probably could not be expected to be provided by utility companies until about the year 2000.

GEOTHERMAL POWER

Geothermal energy is another alternative source of electric power. Power from geothermal energy is generated using the ~~natural~~ steam or hot water trapped in the earth to turn a turbine-generator. Geysers, such as those at Yellowstone National Park and in Northern California, are examples of natural steam and hot water which escape from the earth. In California, utilities are operating, building or planning geothermal steam plants. Those currently operating in the United States account for about 1% of our present electrical capacity.

Although steam geothermal energy is considered by some to be the cleanest source of energy around, it too, has problems. Its efficiency is low (15-25 percent); thermal pollution is as much as six times greater than in fossil fuel plants; the steam contains pollutants such as hydrogen sulfide which should be removed or returned to the earth; drilling and venting is extremely noisy.

Hot water sources of geothermal energy are more abundant than steam. However, there are no geothermal hot water plants in this country. Problems of corrosion, clogging, scaling, and pollutants have not yet been solved.

The largest source of geothermal energy consists of hot dry rock deep in the earth. If this energy could be extracted and used at the earth's surface, it could potentially solve all of our energy needs for centuries. Theoretically this energy could be tapped just by drilling sufficiently deep holes from any point on earth. Present concepts involve fracturing the hot rock either hydraulically or by nuclear devices and passing cold water through the cracks. The resultant hot water or steam would be drawn off at the top to produce electricity. No such processes are currently operating; although hydraulic fracturing is a developed technology in natural gas recovery.

SOLAR ENERGY

Solar energy is electric power generated by using the energy of sunlight falling on the earth. It is a continually renewable source which is now being used in earth satellites and space vehicles to supply electrical power for instruments and communications equipment as well as for heat and water in pilot demonstrations in the United States and overseas.

Solar energy can be converted to electricity by: (1) direct solar heating of water to form steam to drive a turbine-generator; (2) direct conversion using solar cells; (3) thermoelectric generators which produce electricity from the solar heating of the junction of two metals; (4) thermionic generators which produce electricity from solar heated electrodes in a vacuum; (5) burning solar produced hydrogen in an engine or turbine driven generator.

About two dozen experimental solar structures have been built around the country. Four public schools (in Osseo, Minnesota; South Boston, Massachusetts; Warrenton, Virginia; and Timonium, Maryland) will be equipped with solar heating systems in 1974. The orbiting of a solar satellite to collect the sun's rays without disruption by the earth's atmosphere, clouds, or darkness is being investigated by Arthur D. Little Corporation. The University of Arizona has begun a pilot operation of a "solar farm", a series of desert collections connected with pipes to a plant where water is heated to create steam for turbines. IBM, DuPont, Honeywell and many other companies are engaged in solar research.

Even optimistic forecasts concede only small scale commercial operations of solar power installations in the near future. The clean, renewable, and abundant nature of solar energy, together with rising costs of other fuels, will provide strong incentive for extensive utilization of this energy source by the end of the century.

WIND POWER

The winds which are generated by solar heating, contain energy roughly comparable to our present energy consumption. Although wind power is intermittent in most areas, windmill-powered systems to generate electricity could be feasible in special localities, e.g., the Great Plains.

The main effort on harnessing wind energy is the Sandusky windmill, a project of the National Aeronautics and Space Administration, which expects to provide a low-cost model that can be mass produced. Also, several Oregon utility companies are investigating the use of blustering ocean winds to produce electricity.

OCEAN THERMAL GRADIENTS

The ocean can become a solar collector by using the thermal gradients of the sea to power a low pressure turbine. However, the location of the plant would be too distant from consuming centers to transmit the electric power directly. A practical demonstration of this principal has not yet occured.

WASTE

The great attraction for using waste as a source of energy is that it is there. No exploration is required to find it; only means to get rid of it or to utilize it efficiently are needed. Three methods of converting waste materials to energy are possible: combustion, gasification and liquification, and fermentation.

The combustion method is being used in Milan, Italy, to run streetcars and subways; in Philadelphia, Pennsylvania, to produce briquettes for heating; in Pontiac, Michigan, by General Motors to furnish the energy needed by its truck and coach division; and in Nashville, Tennessee, to provide heating and air conditioning. The Coors Brewery, outside of Denver, Colorado, is experimenting with a gasification project fueled entirely by municipal trash and garbage. There are approximately 2500 small bio-gas installations in East Asia where waste products are fermented to produce methane gas as an energy source.

MAGNETOHYDRODYNAMICS (MHD)

Another possible method of producing electric energy is magnetohydrodynamics (MHD). MHD produces electricity by forcing a hot ionized gas past a magnetic field and drawing off electrons to form electric current. MHD is still in the stage of fundamental research.

FLOWER POWER

Growing plants specifically for burning (after sun drying and shredding) has been proposed as a means of storing solar energy (by photosynthesis) and then reclaiming it by combustion. The very low efficiency of photosynthesis makes this an unlikely energy source. However, sunflowers and sugar cane are plants being tested for such use. Growing grain for alcohol production is also inefficient in terms of energy production. In any case, at the present time there is not enough excess crop land to produce a significant amount of such fuel. It would seem more logical to utilize lumbering and agricultural wastes that already exist. It seems improbable that flower power will come into commercial use.