ENERGY: OPTIONS FOR THE FUTURE

Curriculum Development Project For

High School Teachers

FINAL REPORT

April 1978

Submitted to:

Office of University Programs
Department of Energy
Washington, D.C.

Contract #EE77 C 02 4278.A000

Dr. T. Owen Carroll
The Insitute for Energy Research
and
W. Averell Harriman College
State University of New York at Stony Brook
Stony Brook, NY 11794

DISCLAIMER

C O N T E N T S

ACKNOWLEDGMENTS

To carry out this project successfully would not have been possible without the enormous help provided by Mr. Robert Lewis, Associate Project Director, and Mr. Herbert Berger, the Assistant Project Director. Dr. John Truxal, Department of Technology and Society, College of Engineering at Stony Brook, graciously provided graduate students and other financial and administrative support invaluable to the project. Mr. John Fowler of the National Science Teachers Association, provided helpful comments as well as his NSTA energy fact sheets from which we drew material for the curriculum modules prepared here. A review and evaluation team - Mr. King Kryger, Associate Project Director, Project for an Energy-Enriched Curriculum, NSTA, Mr. Douglas Reynolds, Science Coordinator, NYS Department of Education, and Mr. Robert Sigda, Earth Science Teacher, South Hungtington Schools, South Hungtington, New York - gave us many useful suggestions toward concluding this project. Ms. Joan Nash, Bella Mondschein, and Margaret Olk provided a variety of administrative and support services to the project for which we are thankful.

There are, of course, many others at Stony Brook and other institutions who were helpful in providing ideas and thinking through this project. Though not mentioned by name, we mean to thank them also.

Overview

Recent state and regional energy crises demonstrate the delicate balance between the energy systems, the environment, and the economy of both our state and the nation. Indeed, the interaction between these three elements of our society is very complex.

The project was intended to develop curriculum materials which would better provide students with an understanding and awareness of fundamental principles of energy supply, conversion processes, and utilization now and in the future. The project had two specific objectives:

- To transfer knowledge of energy systems, analysis techniques, and advanced technologies from the energy analyst community to the teacher participants.
- To involve teachers in the preparation of modular case studies on energy issues for use within the classroom.

These curriculum modules are intended to enhance the teacher's ability to provide energy related education to students within his or her own academic setting.

The project was organized as a three-week summer program, as noted in the flyer (Appendix A). Mornings were spent in seminars with energy and environmental specialists listed on the following page (their handout lecture notes are included as Appendix B); afternoons were devoted to high school curriculum development based on the seminar discussions.

Since it is not possible to cover all aspects of the energy system, the curriculum development was limited to five areas identified as key issues by the energy experts. They represent important areas from two points of view:

SUMMER ENERGY WORKSHOP - July 11 - July 29, 1977 SUNY

DATE	TITLE	LECTURER
July		
11	INTRODUCTION TO WORKSHOP Introduction to the Energy System	T. Owen Carroll, Professor Institute for Energy Research SUNY at Stony Brook
12	ENERGY CONSUMPTION IN THE RESIDENTIAL SECTOR AND IN TRANSPORTATION	T. Owen Carroll
13	ELECTRICITY GENERATION - NOW	J. Allentuck Energy Policy Analysis Division Brookhaven National Laboratory
14	ELECTRICITY - THE FUTURE	
15	LOAD MANAGEMENT	A.B. Calsetta, Corp. Load Management Adm. Long Island Lighting Company
18	ENERGY DEMAND	Joel Brainard Energy Policy Analysis Division Brookhaven National Laboratory
19	BIOMASS SOURCES	Vinod Mubayi Energy Policy Analysis Division Brookhaven National Laboratory
20	SOLAR AND WIND ENERGY	Harry Davidian Economic Analysis Division Brookhaven National Laboratory
21	ENERGY AND PUBLIC POLICY	Granger Morgan Carnegie-Mellon Institute
22	ENERGY AND THE FOOD SYSTEM	David Pimentel Department of Entomology Cornell University
25	NUCLEAR VERSES COAL	Meyer Steinberg, Head Process Technology Division Department of Applied Science Brookhaven National Laboratory
26	A NORTHEAST ENERGY PERSPECTIVE	Peter Meier Energy Policy Analysis Division Brookhaven National Laboratory
27	ENERGY AND THE ECONOMY	David Behling Economic Analysis Division Brookhaven National Laboratory
28	WORLD ENERGY PERSPECTIVE	Philip Palmedo, Head Energy Policy Analysis Division Department of Applied Science Brookhaven National Laboratory
	WHAT IS ENERGY WORTH?	Ernest Habicht, Director Environmental Defense Fund

(a) energy developments which are now occuring but whose implications are not yet clearly recognized, and/or (b) that broad area of potential new developments which have important implications for the future -

- conservation
- electricity demand scheduling
- energy in the food system
- new technologies (solar, wind, biomass)
- environment

The modules prepared in each of these areas consist of an introductory background statement for the teacher and a series of one-day lesson plans. The set of materials is attached here as Appendix C.

The high school curriculum materials are now circulating widely through notices in the National Science Teachers' Association (NSTA) Newsletter on Energy and Education, and the New York State Teachers' Association. Some lessons have been tried in Delaware with interest and success. At a presentation and workshop at the NSTA Annual Meeting, Washington, D.C., April of 1978, some 50 or more science teachers from the United States and Canadian districts were enthusiastic about trying the curriculum materials in their own teaching situations. And, the National Coordinating Center for Curriculum Development at Stony Brook has undertaken a review of the work.

A Special Note

One of the more intriguing aspects of this particular project deserves special mention. The evaluation team, lecturers, various observers of the program, and the project staff saw the teachers as an exceptionally motivated group of individuals. They were articulate, analytical in their questioning of lecturers, and unusually productive writers. Their contribution to the project went far beyond what was anticipated.

The explanation seems simple, but interesting. The flyer used in recruitment did not contain an application form, but instead asked for a letter "describing your teaching area, your background in curriculum development, and your interest in the project." From such letters, we screened those who appeared poorly suited to the project. However, teacher participants noted that high motivation and interest were somewhat prerequisites even to sitting down to write such a letter, and this provided an excellent selection and evaluation of applicants.

Minority Group Representation

Unfortunately, there was no minority group representation among the twenty-two men and four women participants. Our past extensive experience with minority recruitment suggests the need for early and persistent efforts. The lateness of project contract approval interfered to some extent with out minority recruitment. In addition, though interest in the project was shown by teachers from Maine, Connecticut, New York, and Pennsylvania - though again, because of a late start in initiating the project, most participants were predominantly from Long Island and southern New York areas.

NATIONAL SCIENCE TEACHERS ASSOCIATION

AN AFFILIATE OF
THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

742 CONNECTICUT AVENUE, N.W. WASHINGTON, D.C. 20009 • TELEPHONE: AREA CODE 202 • 265-4150

Robert L. Silber — *Executive Director*

August 23, 1977

Dr. T. Owen Carroll
Associate Professor
Institute for Energy Research
State University of New York at Stony Brook
Stony Brook, New York 11794

Dear Owen:

Enclosed is the evaluation report from Doug Reynolds, Bob Sigda, and myself.

I hope that you will share with the NSTA group the results of your writing workshop. We are anxious to see the materials.

Sincerely,

King C. Kryger
Associate Project Director
Project for an Energy-Enriched
Curriculum

KCK:dlm
enclosure

August 22, 1977

From: Doug Reynolds, Associate
Bureau of Science Education
New York State Department of Education

Robert Sigda
Earth Science Teacher
South Huntington Schools
South Huntington, New York

King Kryger
Associate Project Director
Project for an Energy-Enriched Curriculum
National Science Teachers Association

To: Owen Carrol, Director
Curriculum Development Project for High School Teachers
Institute for Energy Research

Re: Evaluation of Curriculum Development Project

Introduction

The evaluation team met on the morning of July 26th at Stony Brook to plan a strategy for evaluating the project. The team identified several major topic areas for evaluation and divided the responsibility of covering certain of these areas among the team. We then drew up a set of questions under each topic heading. In the afternoon the team interviewed teachers in each of the writing groups using the major topics and the questions designed during our morning planning session.

The evaluation questions were broken down under the following major topic areas: A) Pre-Conference Activities; B) Program Format; C) Effectiveness of Administrative and Instructional Staff; D) Implementation; E) Evaluation of Implemented Material; E) Follow-up Activities.

Overview

The evaluation team concentrated its efforts on determining how effective the program had been from the point of view of the teacher/participants. We did not evaluate the materials that the teachers had written and so cannot comment on its quality or possible effectiveness.

We would like to stress at the outset that our impressions of the project and those of the teachers we interviewed were, on the whole, very positive. The great majority of the teachers interviewed said that they would repeat this project if it were possible to do so. Almost all of the participants felt that they had gained professionally from the experience and all of them said that the staff had been efficient and helpful.

A) Pre-Conference Activities

A number of participants said that notification of the project had come too late and had given them little time to prepare. There seems to have been no mechanism for teachers who had been selected to notify project staff of their continued willingness to participate or their unavailability because of other committments. Several teachers said they would have been better prepared had they known about the possible choice of topics for writing groups.

It is our understanding that the project staff was not given official sanction to begin the program from ERDA until a very late date. It is probable that the delays mentioned above were the result of this fact and fell outside the control of the project staff.

B) Program Format and Workshop Facilities

Teachers reacted very favorably to the way that the program was organized. The morning lectures were a popular feature and almost all of the teachers interviewed said that they had learned a great deal about the national energy situation and that the lecture content very often bore a direct relationship to the materials. The following are some suggestions for improvements made by some of the teachers:

a) A number of teachers said that they would have benefited had there been more time for the separate writing groups to interact.

b) Several teachers suggested that although the lectures were valuable they might have been cut to three or four days a week instead of five to allow more time for writing.

c) Several teachers recommended that all lectures be concentrated in the first 1½ weeks so that the writing teams could build upon this experience during the remaining time for writing and group activities.

d) There was a suggestion that access to laboratory equipment would have been helpful.

C) Effectiveness of Administrative and Instructional Staff

The morning lectures were a popular feature of the program. Participants indicated that the speakers were well prepared and brought useful material with them. One teacher remarked that on a scale of one to ten most of the lecturers would rank from eight to ten.

The administrative staff received very high marks from the teachers. The staff visited groups frequently, assisted the teachers in obtaining materials, and made useful suggestions about the pedagogical content and approach that should be used in preparing materials.

D) Implementation

Nearly all of the teachers said that they were planning to use the materials they developed in their own classrooms and many said that they would pass them on to other teachers in their schools. Teachers felt that the materials could be used in classes of all sizes, that they did not require elaborate equipment or special scheduling of classes because of time allotments.

Teachers were unsure about how effective the materials would be for teachers who had not been involved with their preparation. It was felt that this would depend upon how the materials were re-worked into final form and upon what evaluative procedures are used.

E) Evaluation of Implemented Materials

The writing groups had not considered, in detail, a method of evaluating the effectiveness of these materials or a means of finding out whether the educational objectives had been met. However, all of the teachers questioned saw a need for this procedure and expressed the hope that the project would provide for an evaluation process.

(Note: We understand that the project is searching for mechanisms for evaluating the materials but that the specific methodology has not been decided upon as yet.)

F) Follow-up Activities

The writing groups expressed a desire that the project institute follow-up activities designed to obtain information about how materials can be made more effective in the classroom. It was suggested that one way of doing this would be for the participants to meet again for one day in the late fall after the materials have been trial tested in classrooms.

The evaluation team (and several of the teacher-writers) felt that without some provision for follow-up activities much of the potential of these materials could be lost.

Conclusion

The evaluation team came away from its work with the sense that the project had been very successful. Although we did not get a chance to inspect the materials, it was obvious that in terms of what teachers were discovering about energy and about their own abilities to create energy curriculum materials, the project was a very worthwhile effort. We feel that the program staff should be commended for their fine work in organizing the project and for assisting the writing groups. We recommend that ERDA consider funding more programs of this nature.

C00-4278-1

A P P E N D I X   A

THE FLYER

COO-4278-1

APPENDIX B

Handout Notes from
the Lecturers

(200 pages - included only in copy 1 of Final Report)

COO-4278-1

A P P E N D I X   C

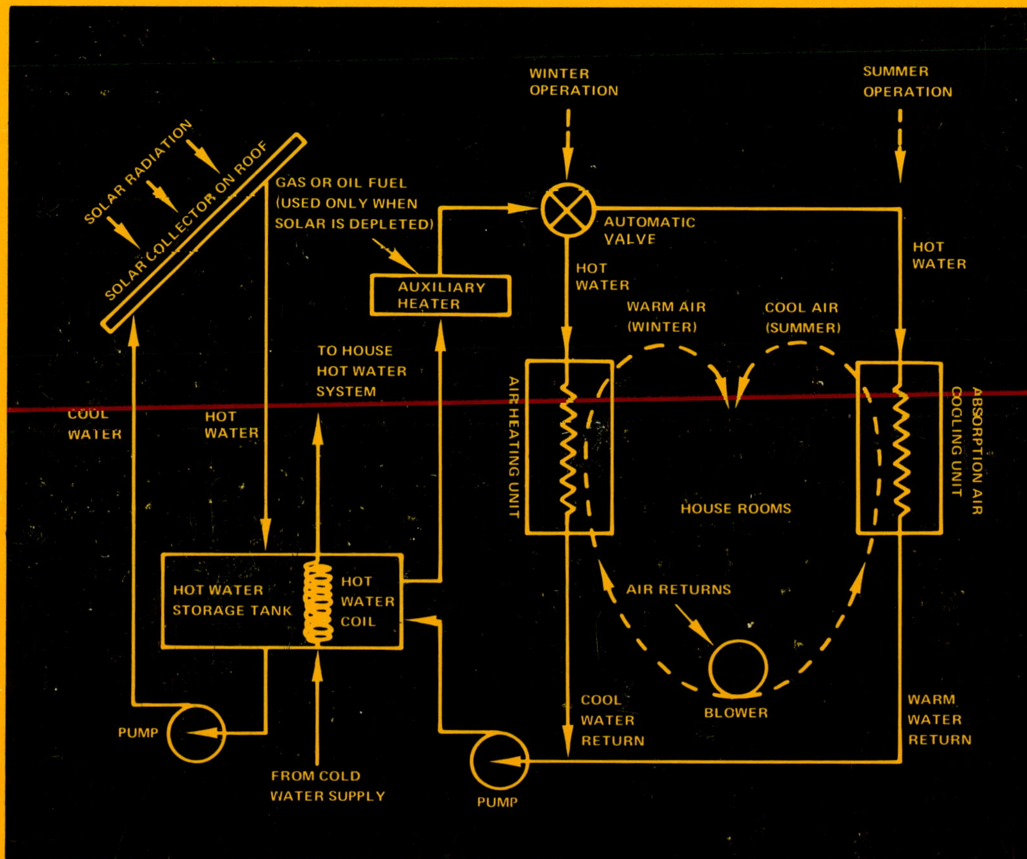
The Curriculum Materials produced in the Project

C00-4228-1

ENERGY: OPTIONS FOR THE FUTURE

CURRICULUM DEVELOPMENT FOR THE HIGH SCHOOL

Conservation



Institute for Energy Research
and
W. Averell Harriman College for Urban & Policy Sciences
State University of New York at Stony Brook
Stony Brook, New York 11794

T. Owen Carroll, *Project Director*
Robert Lewis, *Associate Project Director*
Herbert Berger, *Assistant Project Director*

Funded by
the Office of University Programs
Energy Research and Development Authority
Washington, D. C.

CONSERVATION

Members: Sister Jane Fritz
Raymond Hahn
Alfred Kausch
Edward McGreevy
George Urda

I. Background

II. Student Activities

ACKNOWLEDGEMENTS

To carry out this project successfully would not have been possible without the enormous help provided by Mr. Robert Lewis, Associate Project Director, and Mr. Herbert Berger, the Assistant Project Director. Dr. John Truxal, Department of Technology and Society, College of Engineering at Stony Brook, graciously provided graduate students and other financial and administrative support invaluable to the project. Mr. John Fowler of the National Science Teachers Association, provided helpful comments as well as his NSTA energy fact sheets from which we drew material for the curriculum modules prepared here. A review and evaluation team - Mr. King Kryger, Associate Project Director, Project for an Energy-Enriched Curriculum, NSTA, Mr. Douglas Reynolds, Science Coordinator, NYS Department of Education, and Mr. Robert Sigda, Earth Science Teacher, South Huntington Schools, South Huntington, New York - gave us many useful suggestions toward concluding this project. Ms. Joan Nash, Bella Mondschein, and Margaret Olk provided a variety of administrative and support services to the project for which we are thankful.

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INTRODUCTION

Recent state and regional energy crises demonstrate the delicate balance between the energy system, the environment, and the economy. Indeed, interaction among these three elements in our society is very complex. However, any permanent change in the directions of our energy demand and supply for the future involves the formation of a new "energy ethic". To do so requires a broad base of information and understanding of the energy system, and this needs to be developed, particularly among those still in school. You, the teacher, play a most important role in providing that base of information which will become part of the new generation's thinking about the energy system. These materials are intended to enhance your ability to provide energy-related education to students within your own academic setting and to provide students with a better understanding and awareness of fundamental principles of energy supply, conversion processes and utilization now and in the future.

Since it is not possible to cover all aspects of energy systems, the curriculum materials designed in this project were limited to a number of areas considered important from two points of view: energy developments which are now occurring but whose implications are not yet clearly recognized and/or that broad area of potential new developments which have important implications for the future. The specific areas of curriculum materaials are the following -

CONSERVATION. We are coming to realize, albeit slowly, that the supply of raw materials from which energy is produced is finite and decreasing rapidly. Not only is supply decreasing, but demand continues to grow. The most optimistic forecasts show that the world resources of petroleum and natural gas, the two main sources of energy today, will be gone within the next fifty years. Consequently, we need to explore ways to conserve energy by using fewer energy-intensive devices, reducing our life style to one less dependent on energy, and possibilities for substituting new technologies.

DEMAND SCHEDULING. Electricity, since its first introduction, has provided a cheap, clean, efficient source of energy. We have also come to expect that any required demand for electricity on our part as individual consumers, will be met. We turn on the switch and expect the lights to come on. Large investments in the electricity generating plant are required to satisfy increasing demand, particularly during "peak" periods. Consequently, the overall cost of electricity generation becomes quite expensive - a result we have seen in recent years. The issue is particularly important since utility companies are now testing, and will soon offer to the consumer, electric metering for homes on a demand-scheduled basis.

ENERGY IN THE FOOD SYSTEM. Our agricultural system has become increasingly dependent upon the use of energy-intensive fertilizers for large crop production. In addition, energy requirements for food processing continue to grow. It is estimated that about one half of U.S. freight transportation is involved in the movement of foods of one kind or another. With the decline in the supply of fuels, we must ask whether our current national pattern of energy consumption in the food industries, particularly the trend toward increasing use of energy in food processing and packaging, are desirable trends for the future.

NEW TECHNOLOGIES (Solar, Wind, Biomass). It can be argued that the problem in our energy system today is not that we use too much energy, but rather that we use the wrong kinds of energy. Oil and natural gas form important components for synthetic materials, chemicals, and the like. Wherever possible, they should be conserved for such long-term uses. Consequently, we should shift from a fossil fuel resource base to a renewable energy resource base, particularly the use of solar, wind, and biomass sources.

ENVIRONMENT. The direct use of energy involves various pollutant emissions. In addition, indirect use of energy in the creation of industrial goods has secondary environmental impacts in a number of areas. Of recent concern are long term trends in accumulation of carbon dioxide and other gases and particulate matter in the atmosphere. These seem to produce unfavorable atmospheric conditions involving "the greenhouse effect", thermal inversions, and the like.

The modules prepared in each of these areas consist of an introductory background statement and a series of one-day lesson plans, along with suggested bibliography and references to other materials. The background statements are intended to introduce the topic to you, the teacher, and should reduce your need for reading a number of original papers and other citations to the literature. However, the background statements are sufficiently short that they can not make you an energy expert, and we would hope that you pursue additional reading on your own. Single day lesson plans were designed for easy use within existing courses as well as in the construction of new courses. As a result, it is hoped these curriculum materials will be useful in a variety of courses.

A special note to you, the user of these curriculum materials, is in order. The materials are made available in draft copy because of widespread interest in energy issues. Where you encounter rough spots, loss of proper citations to the literature, or other problems, bear with us. A brief evaluation form is included in this document. We encourage you to give us your reactions and any improvements we might add to make these materials more useful to you and to other teachers. The names and school affiliation of the project participants are noted in the material so you can feel free to contact the individual teachers on specific questions. Finally, these documents reflect a concentrated effort over three weeks by the teachers associated with the curriculum development project, and their efforts to translate energy issues into high school course material for you.

LIST OF PARTICIPANTS

. William Baran, Chrmn/Science Dept.,Niagara Wheatfld Central School District, 2292 Saunders Ave,Settlement Rd.,Sanborn, NY 14132

. Anthony Barchuk, Westbury Public Schools, Westbury, NY 11590

. Barbara Brookmeyer, Francis Lewis High School,58-20 Utopia Prkwy,Flushing,NY 11365

. Malcolm Cooper, 69-07 223 St.,Bayside, NY 11364

. Everett Carr, Herkimer County B.O.C.E.S., Herkimer, NY 11350

. Vincent Corsall, 257 Caldwell Ave., Elmira, NY 14904

. Carole Escobar, Islip Jr. High School, Main St., Islip, NY 11751

. Sr. Jane Fritz, St.Patrick's School, 284 E.Main St., Smithtown, NY 11787

. Edward Greenwood, Forest Hills High School, Forest Hills, NY 11375

. Raymond Hahn, Massepequa High School, 4925 Merrick Rd.,Massepequa, NY 11758

. Henry Harvey, Schroeder Jr. High School, 875 Ridge Rd., Webster, NY 14580

. Louis Bancheri, Chrmn/Science Dept.,Sewanhaka Sr. High School,Floral Park,NY 11001

. Alfred Kausch, Windsor Locks High School, So.Elm St.,Windsor Locks, Conn. 06096

. Efsavia Krasilovsky, Central Islip High School,Wheeler Rd., Central Islip,NY 11722

. Edward McGreevy,Soc.Stud.Dept.,Board of Education,Niagara Falls, NY 14302

. Laura Maitland, Francis Lewis High School,58-20 Utopia Pkwy, Flushing, NY 11365

. Philip Merenda, Science Dept.,Lawrence Sr. High School, Cedarhurst, NY 11516

. Ruth Miner, Science Dept.,Floral Park Memorial High School, Floral Park, NY 11000

. Donald Nelson, Science Dept.,W.L.Boardman Jr. High School, Alice & Beatrice Avenues, Oceanside, NY 11572

. Marvin Ohriner,Science Dept.,Elmont Memorial High School,555 Ridge Rd.,Elmont,NY 1100

. Richard Pav, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776

. Severino Santorelli, Wm.Floyd High School,Mastic Beach Rd.,Mastic Beach,NY 11951

. Gerald Slutsky, Hauppauge Sr. High School, Hauppauge, NY 11787

. James Stark, Chrmn/Science Dept.,Peabody High School,315 S.Bellefld Ave,Pittsburgh, Pa 15213

. George Urda, Chrmn/Science Dept.,Torrington High School,Major Besse Dr.,Torrington, Conn. 06790

. Chris Vigliotta, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776

. Harold Visner,Asst.Prin/Science Dept.,Hillcrest High School,160-05 Highland Avenue, Jamaica, NY 11432

. Henry Whitehead, Chrmn/Science Dept.,Locust Valley High School, Locust Valley,NY 1156

- - - -

Associate Program Director: Robert Lewis, 2611 Silverside Road,Wilmington, Delaware 19810

Assistant Program Director: Herbert D.Berger, #17 Harborview Drive,Northport, NY 11768

ENERGY CONSERVATION

Introduction

"Between now and 2001, [less than] 30 years away, the United States will consume more energy than it has in its entire history. By 2001, the annual world wide demand will probably triple,"[1] yet the natural resources of the earth will still be finite.

The energy problems which we face today and in the future are partially a result of our civilization depending upon non-renewable resources, and also a consequence of total energy consumption which has more than doubled since 1950 while the population has only increased by one-third. Twenty years ago this country was a net exporter of energy; in 1974 it was importing 15% of its energy and 35% of its oil. In 1976 we imported over 40% of our oil and domestic reserves of oil and gas were falling.[2]

Thus the basic energy problem is two-fold:

1) There exists a growing imbalance between the demand for energy and the available supplies, particularly the primary sources such as gas, petroleum, and low polluting or "clean" fuels.
2) The ever increasing exponential growth in the demand and uses of these fuels is producing economic, international and environmental effects that our country can no longer tolerate.*

Since the turn of the century, the people of the United States have been doubling their consumption of electrical energy every 10 years.[3] Coupled to this is fantastic growth in consumption of fossil fuels both by transportation and industry. Only 100 years ago the average person in the United States used about 5 gallons of petroleum per year. Today, the annual per capita consumption has grown to more than 1,000 gallons per year.

*The full impact of this problem can be shown more clearly by the study of the characteristics of any exponential curve and then applying them to the energy situation. In a situation exhibiting exponential growth, the doubling of any quantity at regular intervals results in a number that exceeds the total of all the terms that precede it (for example in the series 1, 2, 4, 8 ... 8 exceeds the sum of 1 + 2 + 4). If this doubling effect is allowed to continue uncontrolled, it will soon become "run-away."

Not only has the amount of energy each person uses grown over the years, but the number of people using energy has also grown. In 1900 there were 75 million people in the United States and each person used 100 million BTU's of energy. Today, there are over 211 million Americans, each using 300 million BTU's of energy. At this rate, all our energy supplies will soon be gone.

The Industrial Revolution ushered in the "New Age of Energy" beginning about 1900 and utilizing such inventions as the automobile and electric light. These and other inventions triggered the shift from coal to oil and the increased need for electrical generating plants.

On November 11, 1965 America received the first hint of what was to become a reality. On that night, there was a power failure. As a result, the entire Eastern Seaboard became dramatically aware of how dependent it had become on electrical energy. Shortly afterward, smaller blackouts and brownouts began to occur frequently. By 1972 the summer power shortages were accompanied by a gasoline shortage and these were accompanied by winter fuel shortages. On October 17, 1973 the oil-rich Middle East nations stopped their oil exports, yet it wasn't until December that the impact of that action was felt. On January 1, 1974 these nations doubled the price of crude oil putting the entire industrialized world in debt to them. Again on July 13, 1977, another blackout in New York City provided a dramatic reminder that we are almost totally dependent on energy provided by our rapidly decreasing natural resources.

America had been drifting toward this crisis for more than a decade with its philosophy of "live better electrically" and "more is better." Now that our demands for energy for transportation, industry, lighting, heating and electrical generation are exceeding our supply of fossil fuels and ability to use them, the United States is faced with more questions: What is it going to do? What are long and short term solutions? What price (both economic and political) is it willing to pay for fuel? What effect will this policy have on the environment? Our industrialized society has already upset the original balance between energy input and output. What long term effect will upsetting this balance have? The answer is yet to be seen.

Today we realize that our present fossil fuel supply is limited and that our use of these fuels is raising the pollution in our environment to new and dangerous levels. But what are our alternatives? Basically we must begin programs of conservation, develop new sources of energy and establish the efficient use and production of energy as a national priority.

Of course, some new oil and natural gas may be discovered which could extend the time before all our fossil fuels are gone. But only by conserving energy - by using less and stretching out our remaining supplies - can we really count on having the time we need to develop new energy sources in the form of solar, geothermal, and nuclear power.*

The development of economically viable fusion, magnetohydrodynamics, breeder reactors, all are long range goals, not present day realities. To expect these concepts to become sources of energy soon, is to ignore completely the difference between scientific hypothesis and commercial fact. If fusion ever is mastered as a "power plant" phenomenon, it will not be until after the year 2000, perhaps 2050. Similar long waiting periods are expected for other "new", and as yet untested, sources of energy. If then, there is no help coming to us in the short term, and the long term holds little promise until close to the year 2000, the question is - "How do we survive between 1977 and 1999?" There can only be one answer - "Reduction in energy consumption, now!"**

Residential Energy Conservation

Three primary uses of energy consume 26% of the total national energy budget. Home heating (w/wo AC) is 70% of home energy use, domestic hot water another 10%, while lighting consumes the bulk of the remainder. Conservation in the home should concentrate on more efficient use of this equipment and where possible less use.

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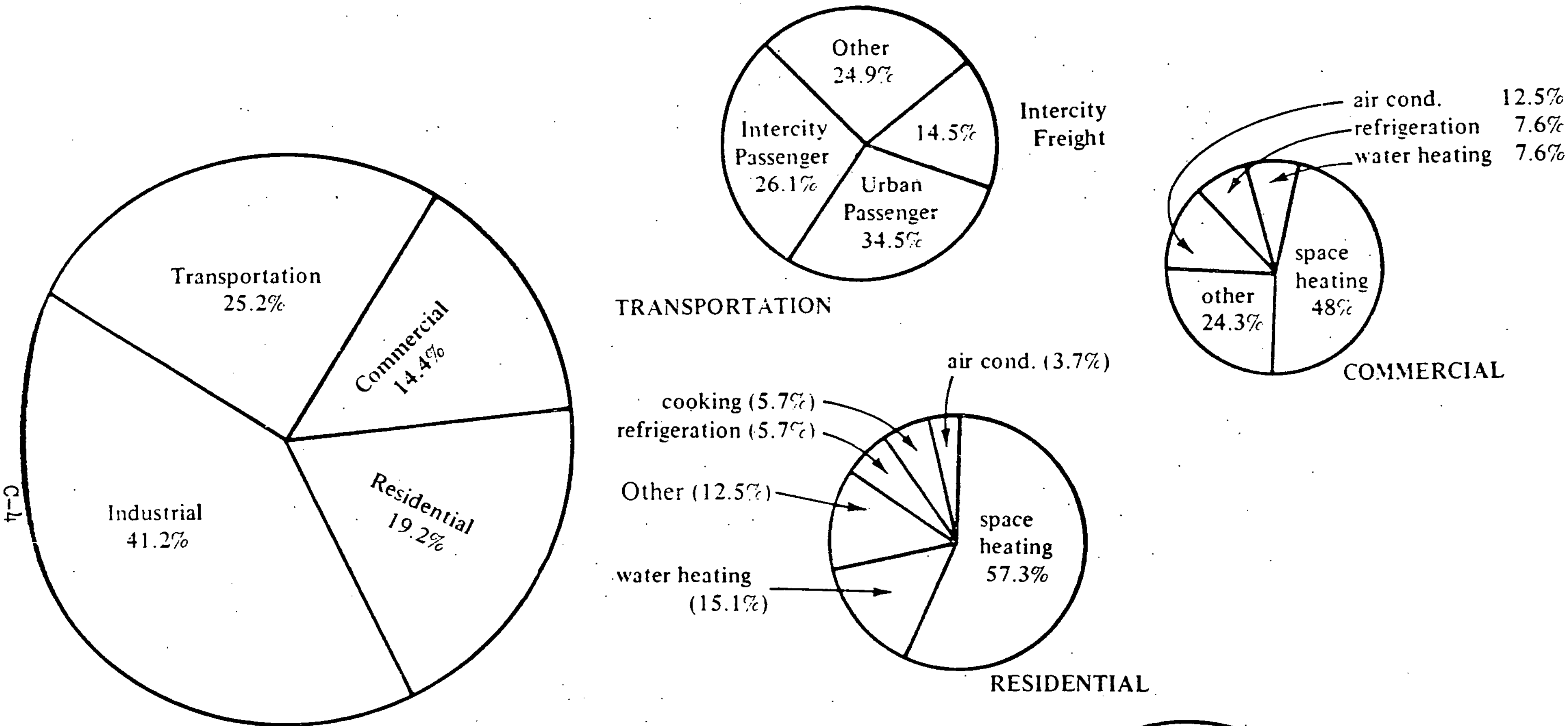
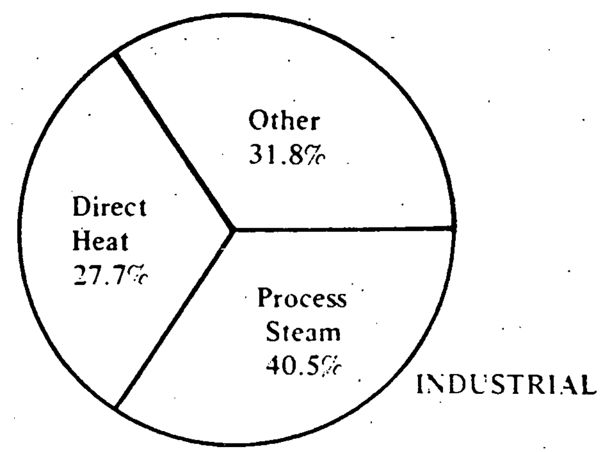
*"Energy Conservation: Understanding and Activities for Young People," Federal Energy Administration.

**Energy Perspectives. Battelle Memorial Institute, 1977

HOW DOES THE U.S. USE ITS ENERGY ?





Source: Participants Handbook - Citizens Workshops of the U.S. Atomic Energy Commission

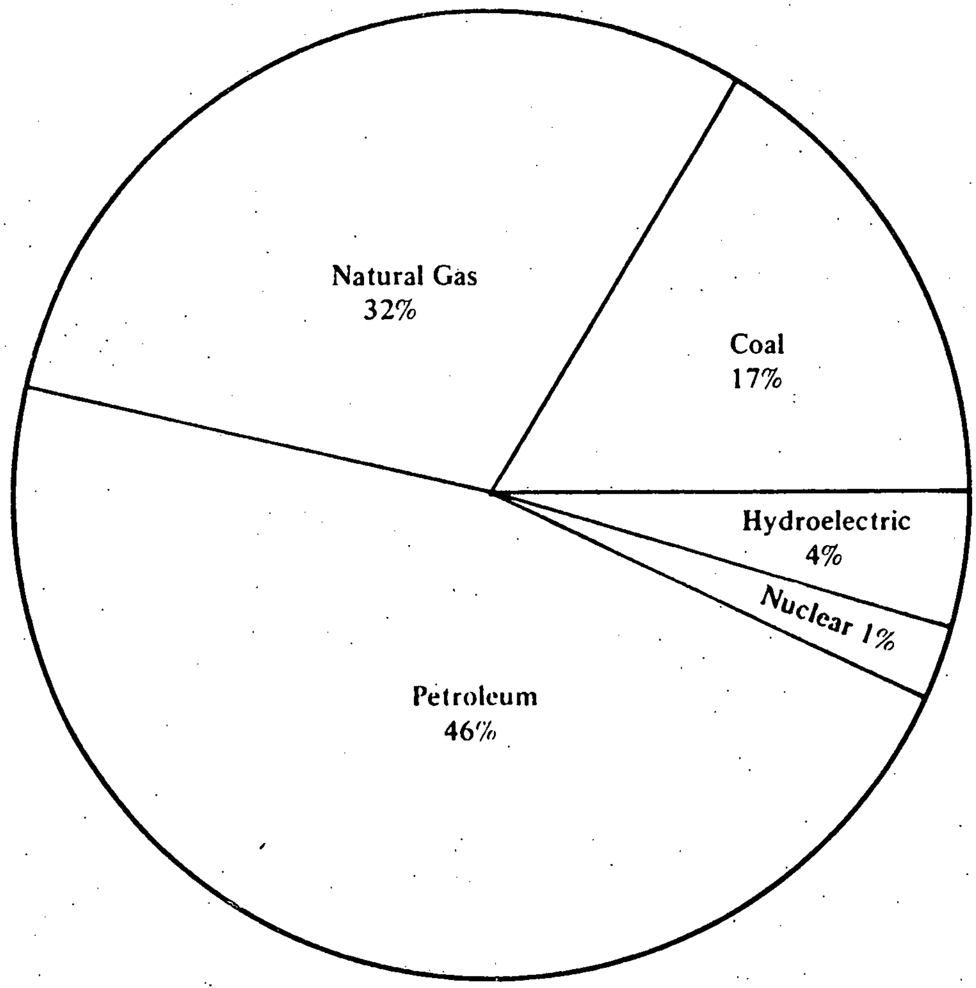
APPENDIX A

PRELIMINARY ESTIMATE:
1974 ANNUAL ENERGY CONSUMPTION IN THE UNITED STATES BY END USE*

SECTOR and END USE		PERCENT OF 1974 TOTAL
RESIDENTIAL		
Space Heating	3,800,000	10.6
Water Heating	1,100,000	3.0
Cooking	320,000	.9
Clothes Drying	160,000	.4
Refrigeration	490,000	1.4
Air Conditioning	420,000	1.2
Lighting and Other	770,000	2.1
Residential TOTAL	7,100,000	20.0%
COMMERCIAL		
Space Heating	2,400,000	6.5
Water Heating	240,000	1.0
Cooking	80,000	.2
Refrigeration	370,000	1.0
Air Conditioning	800,000	2.3
Feedstock	560,000	1.6
Lighting and Other	830,000	2.3
Commercial TOTAL	5,300,000	15.0%
INDUSTRIAL		
Process Steam	5,800,000	16.1
Electric Drive	2,900,000	8.1
Electrolytic Processes	390,000	1.1
Direct Heat	3,800,000	10.6
Feed Stock	1,100,000	4.7
Other	130,000	.4
Industrial TOTAL	14,000,000	41.0%
TRANSPORTATION		
Automobiles	4,300,000	12.1
Trucks	1,700,000	4.6
Aircraft	1,700,000	4.7
Railroads	250,000	.8
Buses	42,000	.1
Waterways	84,000	.2
Pipelines	84,000	.2
Other	640,000	1.8
Transportation TOTAL	8,800,000	24.0%
NATIONAL TOTAL	35,000,000	100.0%

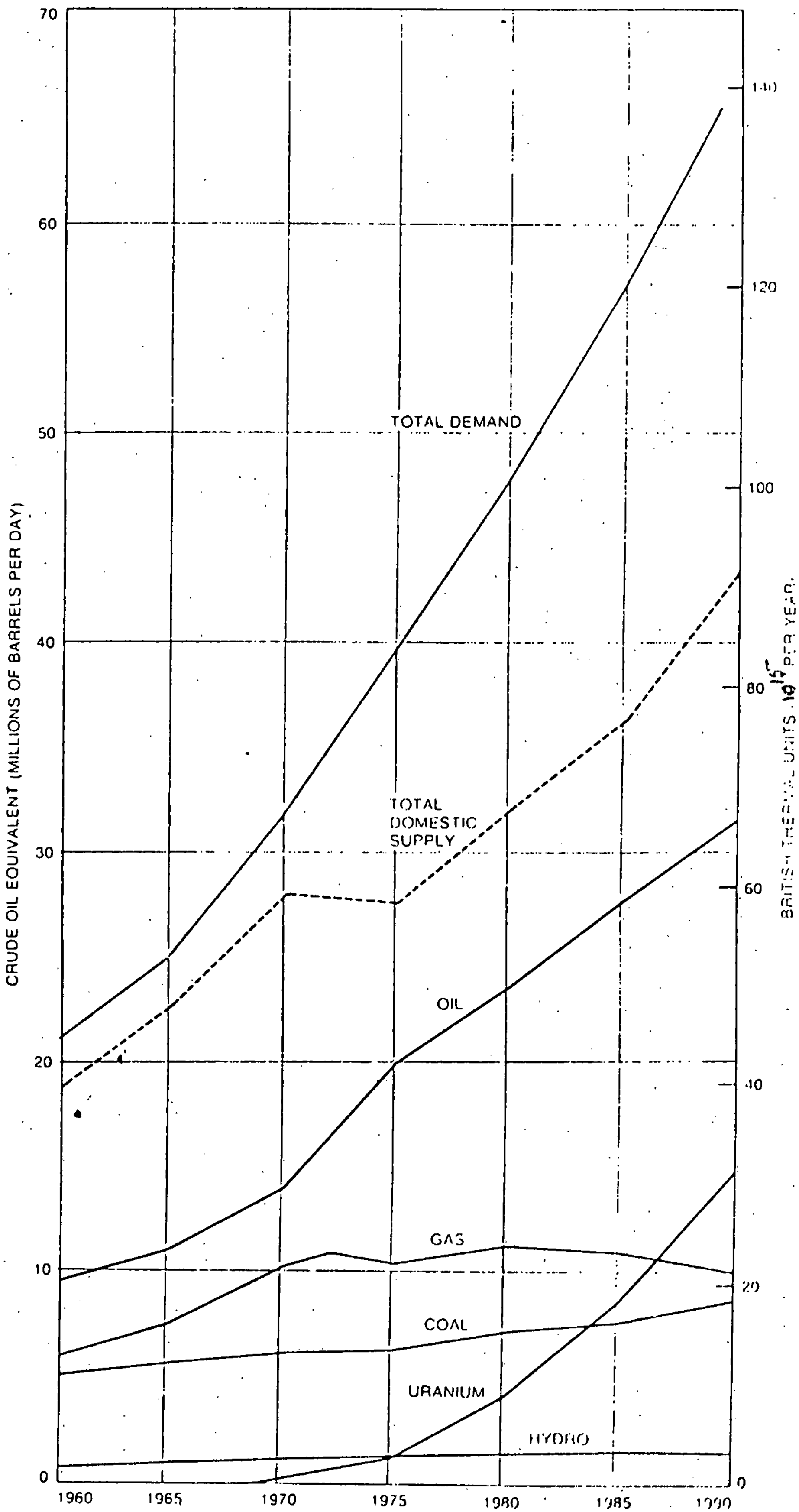
*Totals do not add due to rounding.

Present Sources of Energy*



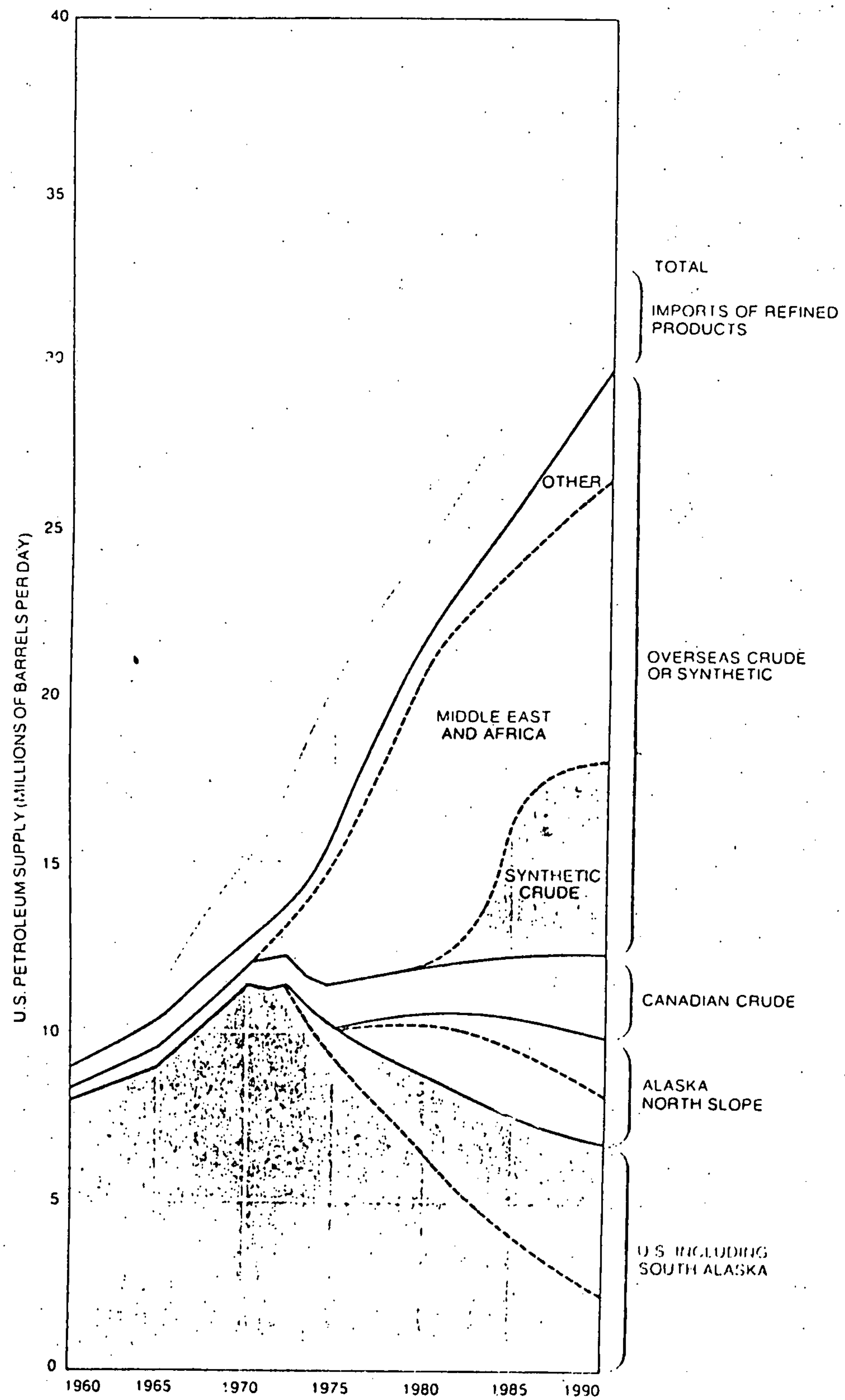
*United States, 1972

Source: Handbook for Citizens Workshop on Energy and Environment (1973-74, USEAC)



TOTAL DEMAND
TOTAL
DOMESTIC
SUPPLY
OIL
GAS
COAL
URANIUM
HYDRO
CRUDE OIL EQUIVALENT (MILLIONS OF BARRELS PER DAY)
70
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
120
100
80
60
40
20
0

US Energy shortage was clearly predictable at least two years ago when the domestic supply of fuels began for the first time to fall sharply behind the rising total demand for energy. Domestic production of natural gas and crude oil reached an all-time high in 1972 and has been falling since. The oil and gas curves plotted here include a rising fraction of imports and, beginning in the late 1970's, limited quantities of synthetic gas and oil from coal and oil shale. The individual curves for hydroelectric power and fuels add up to yield total demand. The widening gap between domestic supply and total demand is accounted for almost entirely by the domestic shortage of oil, as is illustrated on the next page. (The two illustrations closely follow the projections made by the Shell Oil Company.)



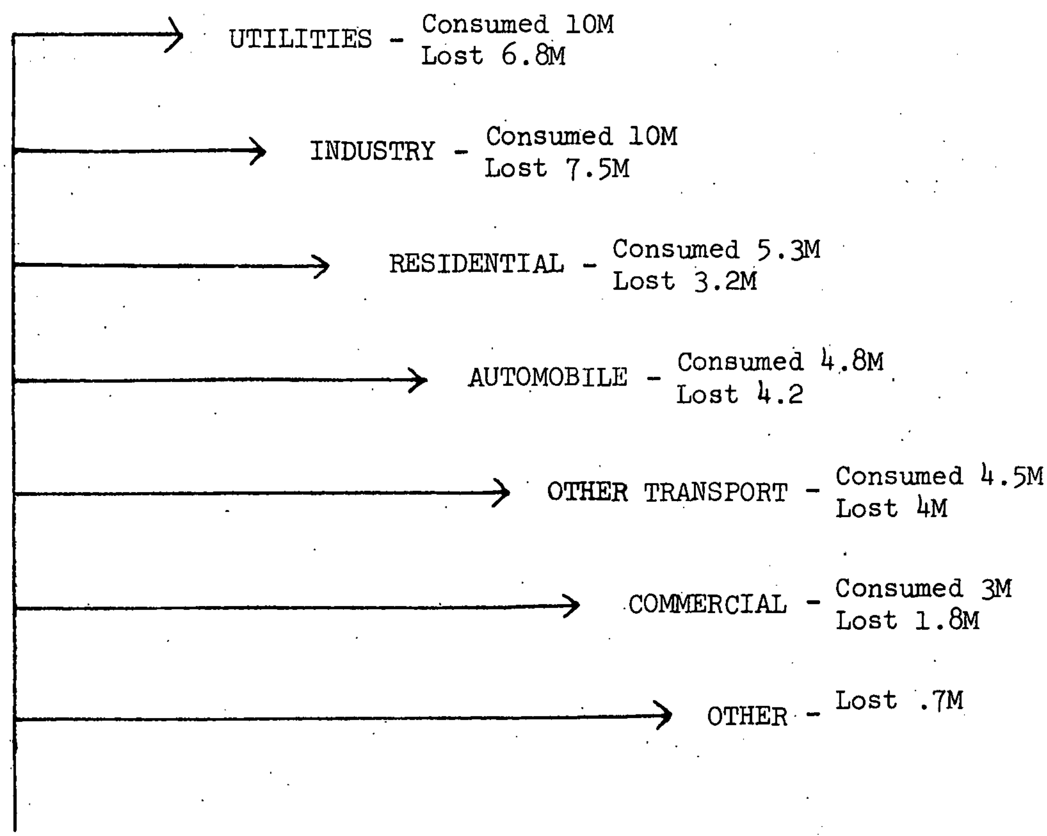
40
35
30
25
20
15
10
5
0
U.S. PETROLEUM SUPPLY (MILLIONS OF BARRELS PER DAY)
1960
1965
1970
1975
1980
1985
1990
OTHER
MIDDLE EAST
AND AFRICA
SYNTHETIC
CRUDE
TOTAL
IMPORTS OF REFINED
PRODUCTS
OVERSEAS CRUDE
OR SYNTHETIC
CANADIAN CRUDE
ALASKA
NORTH SLOPE
SOUTH ALASKA

US dependence on overseas oil cannot be eliminated in the foreseable future except at what would seem to be prohibitive cost. It is estimated that the US will have to import some 16 million barrels per day of oil from overseas in 1990, of which at least 14 million barrels will originate in the Eastern Hemisphere, chiefly the Middle East and Africa. Just to reduce this figure to eight million barrels per day the US would have to build plants capable of producing six million barrels per day of synthetic crude oil from coal or shale, at an estimated cost exceeding $50 billion. This would be virtually as much oil as the US is expected to pump from all its domestic wells in 1990. The broken lines in the projections for the US and the Alaskan North Slope indicate how even their oil output will fall if there are no further discoveries. The curve for total supply is made up of barrels of varying BTU content, depending on source, hence the total corresponds in BTU content, but not exactly in barrels, to the oil curve in the illustration on the preceeding page.

Auto Energy Conservation

The United States loses about two-thirds of the energy it consumes, partly because there are absolute physical limits of efficiency. Half the loss, or the equivalent of 12 million barrels of oil a day, is wasted and much of the waste could be prevented with better conservation measures.

Where the Waste Is

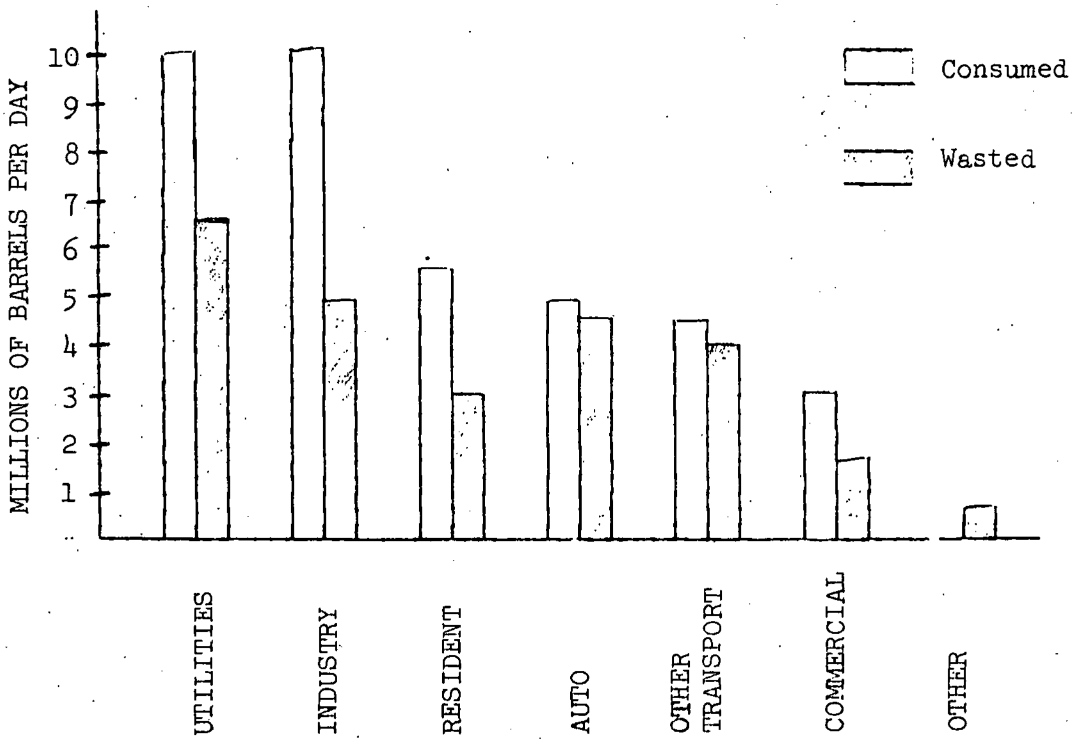


Total Energy Consumption in 1976: 38.3 Million Barrels of Oil Equivalent Per Day

Consumed - 38.3 Million Barrels Equiv.

Lost - 25.7 Million Barrels Equiv.

FIGURE 1



As is seen from Figure 1, it is the auto and other transport modes which show the highest waste to consumption ratio. It is apparent then that the private automobile should be the primary target in any conservation effort which can be undertaken with some ease by every private citizen. Not only is the automobile responsible for much of the energy lost in the area of transportation but for urban travel it is the least efficient mode of transport.

Table I indicates the relative inefficiency of the automobile as a mode of passenger transport.

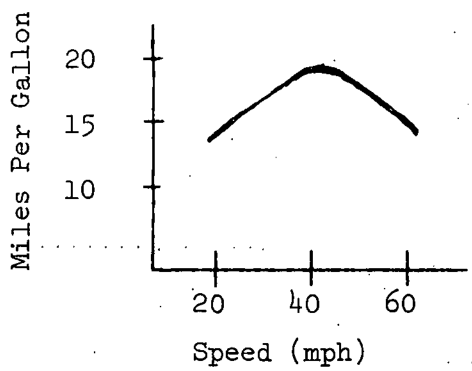
TABLE 7: Passenger Transport (1970)

Transportation Mode	BTU/Passenger-mile
Airplane	8400
Auto (Urban)	8100
Mass Transit (Urban)	3800
Auto (Intercity)	3400
Railroad (Intercity)	2700
Bus (Intercity)	1600
Walking	300
Bicycle	180

The energy requirements of automobiles increased greatly between 1950 and 1970. The reason for this increase is twofold: automobiles were being bult for increased speed and luxury rather than for efficiency; secondly the number of automobiles on the roads have doubled between 1950 and 1970.

From the standpoint of energy efficiency, the automobile is a glutton. While the price of gasoline in previous years was low, the majority of auto owners became wasters, consciously or unconsciously. Thrift and fuel conservation was last on their minds. During the ensuing years, auto manufacturers sold speed, comfort, status and sex appeal. With the price of gasoline declining, relative to other goods, little thought was given to fuel economy. Cars grew heavier, engines grew more powerful. Power brakes, power steering and automatic transmissions became standard equipment. Three-fourths of all GM cars were equipped with air-conditioning. Fuel economy has greatly suffered at the expense of the power requirements of our present day automobiles.

There are a number of single individual measures we might take to conserve on energy use by the automobile. As a driver you can make a major contribution to solving our energy problems by adopting good driving habits which will conserve energy. For example: i) "Speed" is a primary consumer of gasoline. As shown in the figure, most automobiles derive 28% better mileage at 50 mph than at 60 mph. Optimum speed is 35 mph - 40 mph.



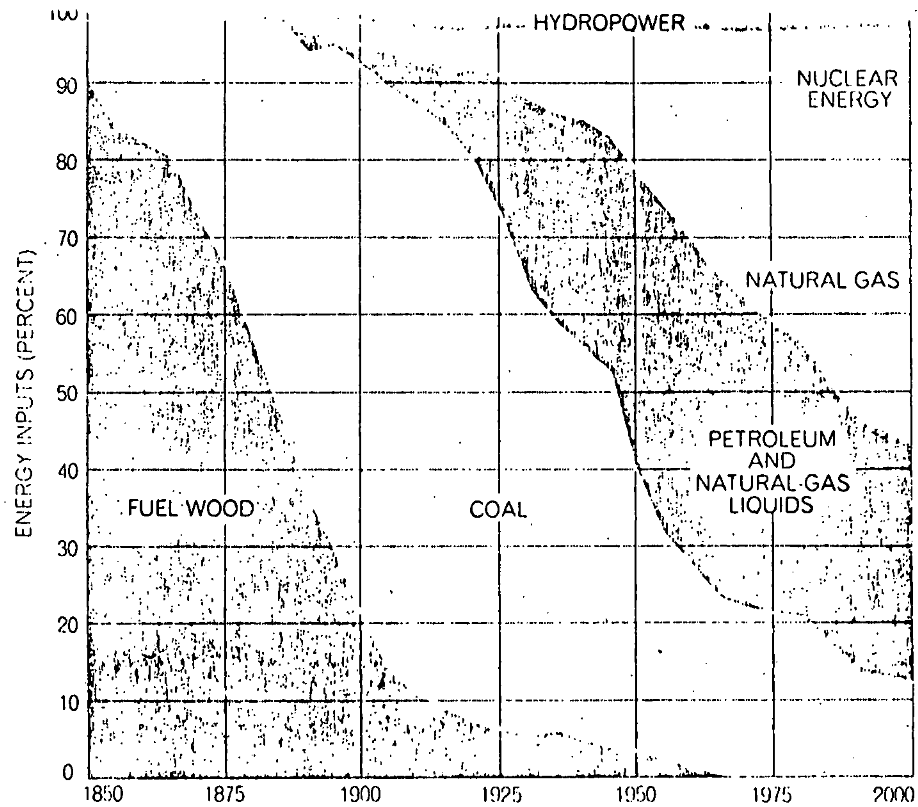
ii) Don't warm up the engine excessively. It is not necessary on cold days to warm the car before driving. The improved viscosity of modern oils has eliminated old-fashioned notions of engine warming. Driving slowly for a quarter of a mile will suffice. iii) Your air conditioner decreases fuel economy by about 10%. Use it only when you're really uncomfortable.
iv) Join a carpool. Out of 58 million workers driving to work, 40 million of them drive alone. This might be the most important action consumers can take to save energy. Using mass transit is another good idea.

Maintenance of the automobile is also essential for conserving energy. A tuned engine is essential to good fuel economy, for example; a) a malfunctioning carburator can waste 3 mpg; b) a misfiring spark plug can waste 2 mpg; and c) a clogged air filter can waste 1 mpg. In general, an "untuned" or neglected engine consumes 6 - 20% more energy than a tuned engine. In addition, it is important to conserve energy by choosing your next car discriminantly. For example, the most significant variable affecting fuel consumption in an automobile is its weight. A car weighing 5000 pounds uses more than twice as much fuel as one weighing 2000 pounds. Buy your next car on the basis of the combination of purchase price and estimated fuel costs for as long as you keep it.

Industrial and Commercial Energy Conservation

Modern industrial society is totally dependent on high rates of consumption of natural gas, petroleum, and coal. These non-renewable fossil-fuel resources currently provide 96% of the gross energy input into the United States economy.[4] (See table below.)

TABLE 8

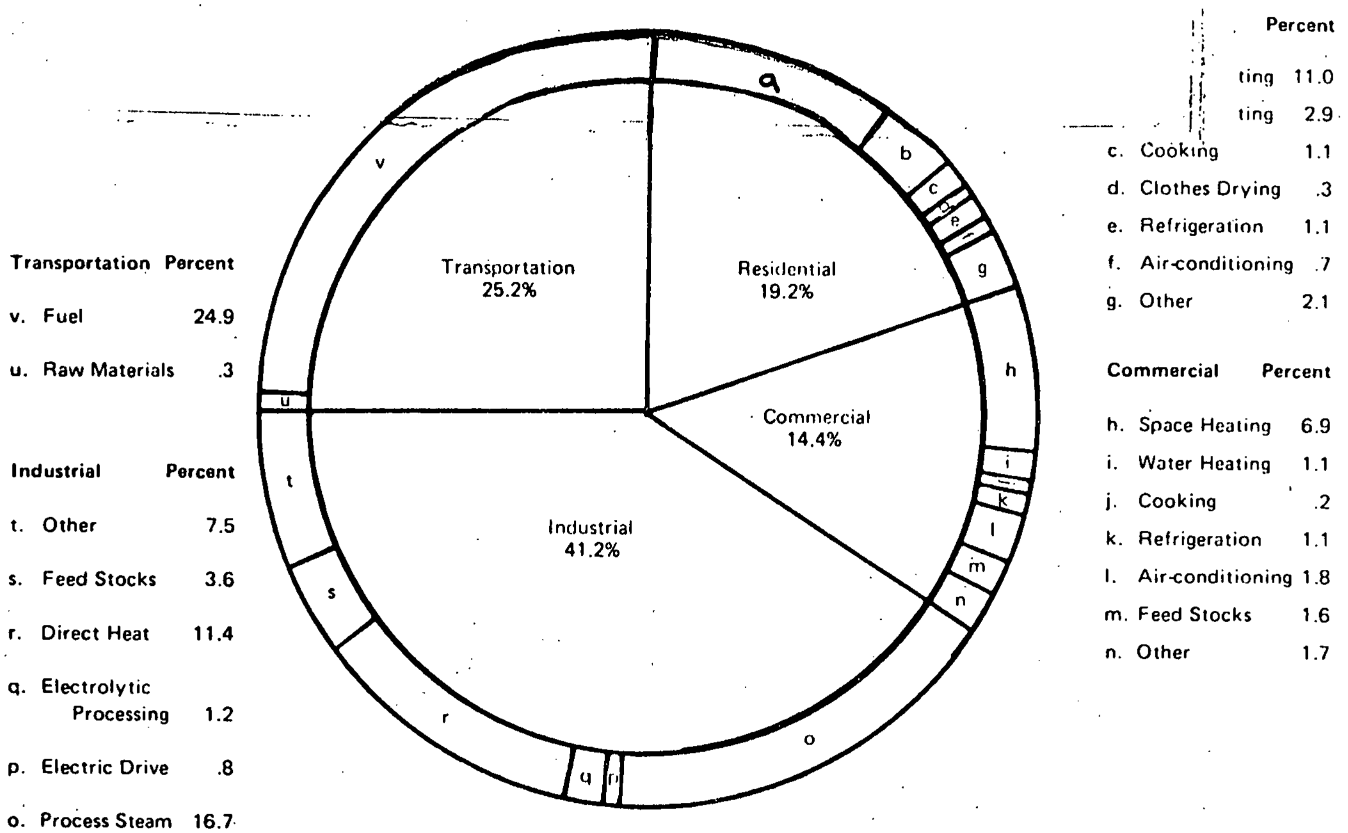


FOSSIL FUELS now account for nearly all the energy input into the U.S. economy. Coal's contribution has decreased since World War II; that of natural gas has increased most in that period. Nuclear energy should contribute a substantial percent within the next 20 years.

Consumption of energy in the industrial society is primarily at the expense of "capital" rather than "income", that is, at the expense of solar energy stored in coal, oil and natural gas rather than solar radiation, water, wind and muscle power.[5] Energy conservation in the industrial and commercial communities is extremely important because of their very large one-way energy demand.

Much of the stress in energy conservation is on private residences which consume approximately only 20%. (See Figure 2 below.)

FIGURE 2



... in the United States, Office of Science and Technology, Executive Office of the President, Wash...

If the residences on the average cut 20% of their energy consumption, it would only mean a total national savings of: 20% x 20% = Total Savings. On the other hand, if the industrial and commercial sectors, which constitute 55% of United States demand could cut energy consumption by an average of 20%, it would mean a total national savings of: 20% x 55% = 11% Total Savings.

Unfortunately, as stated earlier, the modern industrial society thrives on high rates of energy consumption and so has no instinctive incentive to conserve. So while the average homeowner might find higher fuel costs as an incentive to conserve, the industrial and commercial sectors find them an expense which often may be passed on to consumers. So if cutting back on the energy consumed by the industrial and commercial communities is difficult, then how can this segment of society be made to conserve? The answer appears to lie in some of the same methods that are applied to private residences. These methods stress Energy Efficiency rather than simply a drop in energy demand and they include the following:

1. Space Heating - Cooling
2. Insulation
3. Lighting
4. Energy Efficient Industrial Appliances
5. Off-Peak Operation

Modern buildings, with very few exceptions, were not designed to be energy conserving. The World Trade Center in New York is an extreme example. The 100,000 kw or so of power needed by this Center with some 50,000 employees is more power than is required by Schenectady, New York, a city of 100,000 people. Large savings of energy are possible if buildings are deisnged to operate with less energy. For example, a large energy loss in commercial buildings is attributed to "infiltration" which accounts for 25 to 50% of the energy used in heating, cooling, and ventilation. Quite often an entire building is ventilated to the same level as is required in special areas such as bathrooms, kitchens, and conference rooms. It is estimated that reduction of excess ventilation alone could reduce fuel needs by 15% or so.[6]

A major waste of lighting energy occurs in commercial buildings - offices, schools, hospitals, etc. for reasons that seem to have no sound physiological basis. In 1952, for instance, the recommended classroom lighting was 20 foot candles (a measure of brightness). This was raised to 30 in 1957 and to 60 in 1971. Thus "no contest" lighting has resulted in buildings in which all space, not just working space, is brightly lit and this includes walkways and even space near windows for which daylight would suffice.[7]

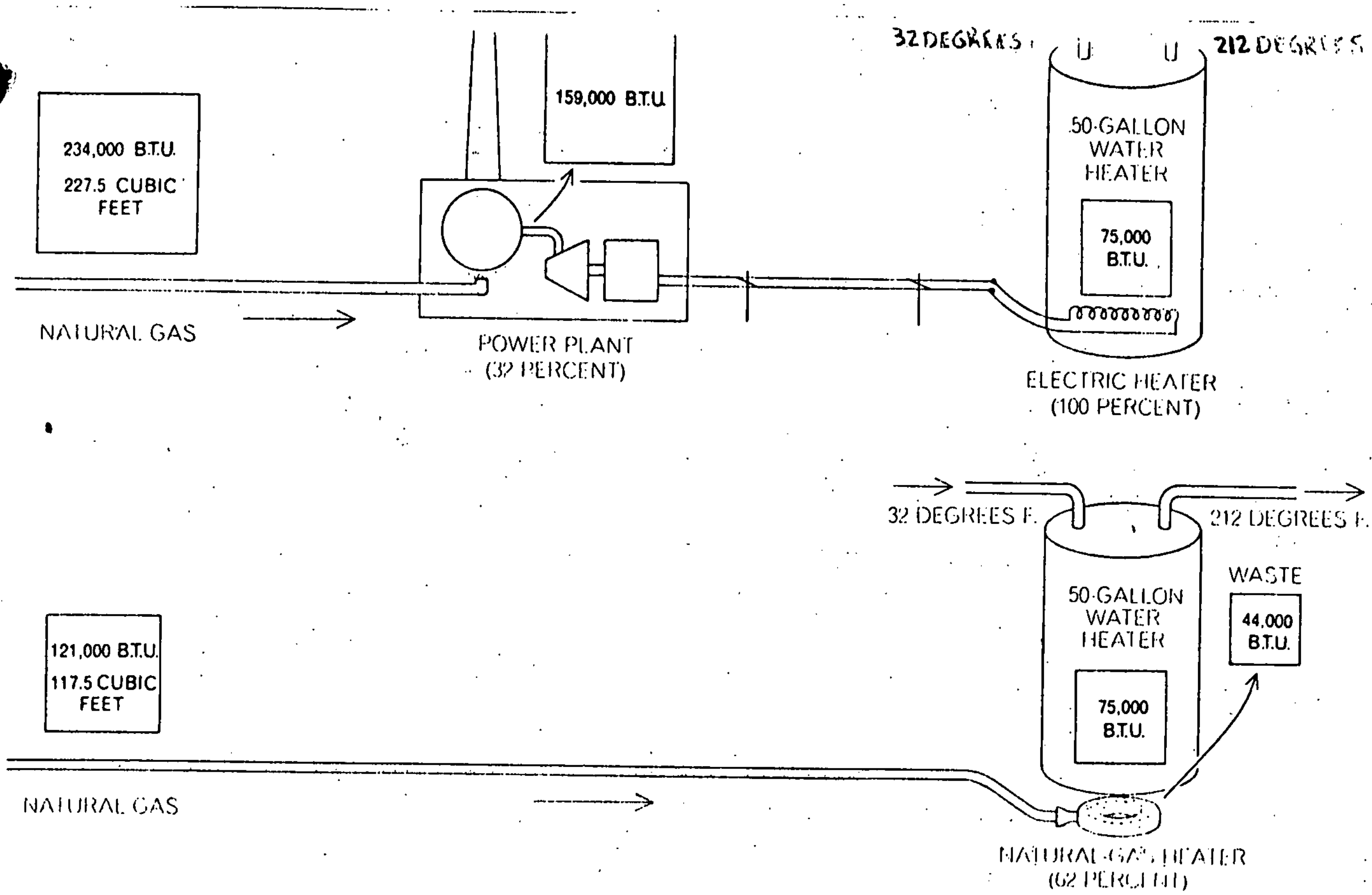
Types of fuel used by industry are also a factor that should be considered with conservation in industry. Table 9 shows the relative percentages of fuel types used by industry. As can be seen in the table, the percent of coal used has decreased since 1960 while oil remained relatively the same and natural gas and electricity has increased. The reasons for the shift to oil and natural gas are not hard to find. The conversion of railroads to diesel engines represents a large substitution of petroleum for coal. Beginning during World War II, the rapid growth of the national network of high-pressure gas-transmission lines greatly extended the availability of natural gas. In recent years, the demand for cleaner air has led to the substitution of natural gas or low-sulfur residual fuel oil for high sulfur coal in many central power plants.[8]

TABLE 9

Industrial Fuels (by percentage)

Energy Source	Percent of Total		
	1960	1968	1974
Coal	26.7	22.6	14.3
Natural Gas	34.3	37.3	37.9
Petroleum Products	19.3	18.0	19.8
Electricity	19.7	22.6	27.9

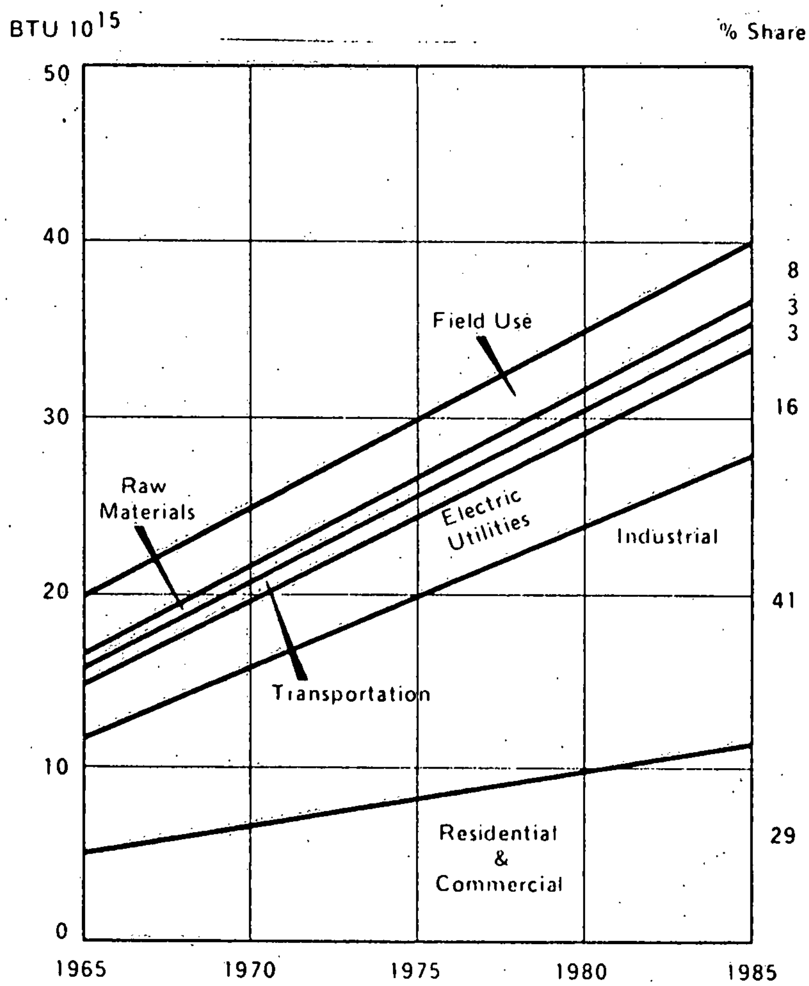
Source: **Patterns of Energy Consumption in the United States, Office of Science and Technology, Executive Office of the President, Washington, D.C., 1972, and Bureau of Mines, U.S. Department of the Interior.**



EFFICIENCIES OF HEATING WATER with natural gas indirectly by generating electricity for use in resistance heating (*top*) and directly (*bottom*) are contrasted. In each case the end result is enough heat to warm 50 gallons of water from 32 degrees Fahrenheit to 212 degrees. Electrical method requires substantially *more* gas even though efficiency at electric heater is nearly 100 percent.

The rise in electricity consumption tends to decrease in efficiency. As can be seen in the diagram above, the use of electrical energy to heat water from a temperature 32°F to 212°F is less efficient than using natural gas directly. However, as noted above, recent years have seen a shift toward natural gas or low sulfur oil, electricity generation, and increasing electric hot water heat. If the electricity portion of energy consumption rises to the predicted levels of 43% to 53% of the country's gross energy consumption by the year 2000, then an amount of energy equal to about half of the useful work done in the United States will be in the form of waste heat from power stations![9]

FIGURE 3: U.S. Demand for Gas
(In Quadrillions of BTU's)



Source: Volume No. 3 Future Requirements Agency, Denver Research Institute; University of Denver; Denver, Colorado; September 1969. Supplemented December 1970.

On the other hand, deposits of natural gas by the year 2000 will have been so depleted as to force the use of this precious resource only for purposes for which no other economically usable raw material is available (See Figure 3 above.).[10] Natural gas consumption should be shifted away from the industrial and commercial sectors specifically in areas where it is used for direct heating, space heating and process steam which are the areas requiring the greatest percent of industrial and commercial energy (See Figure 2 on page C-21) and for which other fuel sources can be substituted having equivalent energy content to natural gas (See Table 10).

TABLE 10: Energy Content of Various Fuels

Fuel	Amount	Energy Equivalent (M Calories)	Energy per Pound (Calories)
Coal			
Soft coal (bituminous)	one ton	6.1	3,100
Hard coal (anthracite)	one ton	6.4	3,200
Oil, distillate (including deisel)	barrel	1.5	4,900
Gasoline	barrel	1.3	4,800
Natural Gas	1,000 ft^3	.26	5,000
Wood	1 cord[b]	5.3	1,250

[a] Million.
[b] One cord is a pile of wood 4 ft. long, 4 ft. high, and 8 ft. long.

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Figures suspected to be inconsistent.

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This guide is the product of the cooperation of the Washington Superintendent of Public Instruction and the Public Power Council in developing educational materials for teachers concerning the concept of energy and its relationship to man and his environment.

Energy Research and Development Administration Film Library. Energy - The American Experience. Film - 28.5 minutes, color, 10mm, loan. P.O. Box 62, Oakridge, Tennessee. Sales Information, Sales Order Department, National Audiovisual Center, Washington, D.C.

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Footnotes

Conservation

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3. Social Studies Introduction .... New York State Power Authority.
4. Page C-20.
5. Page C-20.
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TEST YOUR E.Q.

(Energy Quotient)

Agree or disagree with each of the following statements:

Before		After
________	There really is an energy problem.	________
________	Each one of us must begin to save energy.	________
________	It doesn't really matter if I waste a little energy: it doesn't add up to very much.	________
________	Saving energy can also result in saving money.	________
________	My ideas about the energy problem have not changed this year.	________
________	I would be willing to sacrifice some conveniences in order to save energy.	________
________	I think it is important to consider the energy needs of people in the future.	________
________	I think it is more important to do all the things I want to do right now, even if it means I might not have enough energy in the future.	________
________	There are many things I can do to save energy.	________
________	The sun may be an important source of energy in the future.	________
________	Strip mining and shale are easy solutions to the energy crisis.	________
________	To save energy we can cut down and we can use necessary energy more efficiently.	________
________	Big companies and the government have told us that there is an energy shortage just to scare us.	________

Put a check in front of the statements that you learned something about:

________ Insulation saves energy, by stopping waste.
________ Our supplies of oil and gasoline are running low.
________ Some appliances use a great deal of electricity and energy.
________ There are many practical ways to save energy.
________ Conservation is part of the solution to our energy problem.
________ Carpooling is important.
________ Coal, wood, and water power will not help our home heating problem.
________ Solar energy is a free and unlimited source of energy.
________ For some things, solar is practical for use right now.
________ Nuclear energy still has some problems such as radiation and waste shortage and transportation to overcome.

List 4 ways of conserving energy at home:

1.

2.

3.

4.

List 3 methods used to conserve energy in transportation:

1.

2.

3.

If our oil supplies run out, what are other alternatives?

BURN BABY BURN

Fueling Energy

Objectives

The student should be able to:

a) Describe the relationship between fuel and energy.

b) Calculate energy equivalents for fuels.

c) Analyze why some fuels are more desirable than others for heat production.

d) Demonstrate why heat engines operate most efficiently at peak performance.

e) Discuss need for conservation of nonrenewable sources of fossil fuels.

Overview

Since the Arab oil embargo of 1973, the phrase "energy crisis" has come into wide use throughout the United States. It may be interesting to note that this so called "energy crisis" is not really a crisis in energy but is rather a crisis in fuel. Fuel is the resource from which our industrial society obtains its energy. A student's clear understanding of the energy problem can be reached only if he is first made aware of the relationship between energy and its basic means of production - the burning of fuels.

The student burns a fuel under a beaker filled with a predetermined amount of water. He measures the total temperature change in the water and then calculates the quantity of heat energy produced (in calories) by the burning of that fuel. The heat gained can be calculated by using this equation:

Heat Gained (+Q) = Mass of the water x Temperature change x Specific heat

Specific heat of water = 1.0 cal/g - ^{o}C

Materials

1 fuel source - approximately 1 cm^3 in size (sterno, paraffin, candle, wood splints, paper wad, alcohol*, methanol or iso-propyl)

1 Celsius thermometer (range 0-100 ^{o}C)

*Take extra precautions if alcohol is used since there is a danger of spilling.

1 evaporating dish (or other container suitable for containing combustion)

1 150ml pyrex beaker

1 tripod with wire gauze (or ring stand with ring support)

Room temperature water

Strategy

Ask students what we mean when we use the term "energy crisis". Stimulate class discussion by proposing that there is no energy crisis. Attempt to have students zero in on what the real crisis is - a shortage of non-renewable fossil fuels. When the problem is established, lead into a discussion of how energy is obtained from fuels, and how that energy can be measured. Mention and define such terms as calorie, BTU (British Thermal Unit), and specific heat. Introduce the method to be used in this activity for measuring the number of calories obtained from the burning of a fuel.

Notes to the Teacher

1. Be sure all fuels are approximately the same volume, 1 cm^3 is a good size to work with for sterno since the total burning time will not exceed more than 15 minutes. Other fuels may have to be smaller or larger depending on their burning time.
2. Instruct students not to let the thermometer bulb rest on the bottom of the beaker otherwise they will be measuring the temperature of the flame and not the temperature change within the water.
3. If the temperature change in the water is not very great, the fuel should be moved closer to the beaker.
4. If alcohol is used as the fuel, warn students of its high flammability and the danger a spill could present. (To prevent spillage, it is possible to use a paper towel soaked in alcohol although the results should then be noted as the burning of a paper-alcohol fuel.)
5. Be sure students use room temperature water so that all the heat gained comes from the burning fuel and not from the surrounding room air.
6. Questions may arise about specific heat. It can easily be explained as the ability of a material to absorb heat energy. Water has a high ability to absorb heat: S.H. = 1.0 cal/g - ^{o}C.

Sample Responses

1. Fuel is a material resource and when burned produces energy (fuel represents potential energy).
2. The most important property of a fuel is its energy content.
3. a) Fuel supplies on earth are limited and will eventually run out.
   b) Fuels and material pollutants to the atmosphere when burned incompletely.*
4. Other energy alternatives at this time include the use of nuclear, solar and wind energy, but nuclear "fuel" also has the disadvantage of radiation contamination.
5. a) It possesses the greatest amount of energy at the time the fuel becomes exhausted.
   b) The fuel efficiency tends to increase since most of its heat energy has already been transferred to the water.
6. It is basically the same in a steam engine, most of the fuel that is burned at first goes into converting liquid water to steam. This is why electric power generators remain on even when electric demand is low.
7. a) Natural gas.
   b) Natural gas - it produces the greatest number of calories per pound.
8. a) It is solid and is hard to transport.
   b) It is dirty.
   c) It produces high amounts of sulfur pollutants.
   d) Below ground mining is hazardous. Above ground mining strips the land moisture and ground holding vegetation.
9. a) As a gas, it is hazardous to transport.
   b) It is in small supply worldwide.
   c) It is expensive to liquify (and keep liquified).

Extension Activities

1. Have students burn other fuels and calculate and compare the heat.

*Even complete burning yields CO_2 to the atmosphere which may upset radiative balance of the earth.

2. Have students compare the cost of different fuel types and their relative energy producing efficiencies.
3. Have students list the problems in burning and handling the major types of fossil fuels.
4. Have students compare the economical and environmental efficiency of coal, oil, and gas to produce electricity.

<u>Student Activity Sheet</u>

Name ____________________

Date ____________________

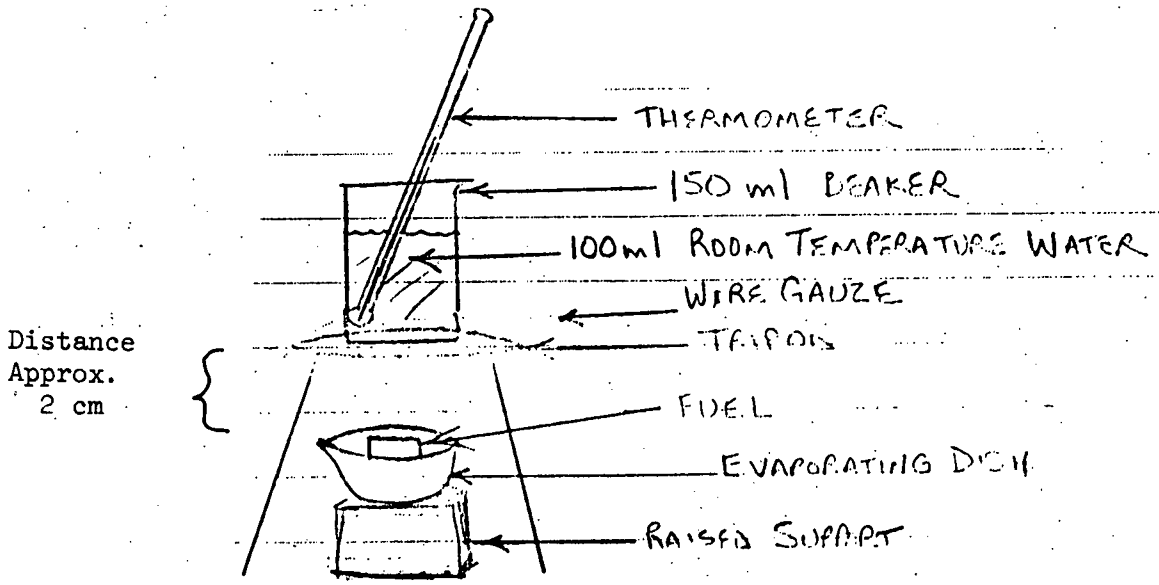


Figure A

<u>Procedure</u>

1. Set up the apparatus as shown in Figure A (Be sure the fuel is no more than 2cm from the beaker.)
2. Place 100ml of room temperature water in the beaker. Record the mass of the water (1ml = 1gm).
3. Record the temperature of the water, at the start, in the chart.
4. Ignite the fuel and record the temperature of the water at 1 minute intervals, until the fuel is completely burned. Record the temperatures in the chart.

5. When the flame is completely burned, subtract the starting temperatures (Ts) from the final temperature (Tf) to get the total temperature change (ΔT). Record in space provided $\Delta T = Tf - Ts$.

6. Calculate the total heat energy gained by the water by using the following equation:

Heat gained = Mass of water x Temperature change (ΔT) x Specific Heat
(Calories) (Grams) (°C) (Cal/gm - °C)

Data

Chart 1

Time (Minutes)	1 Start	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Temperature (°C)																				

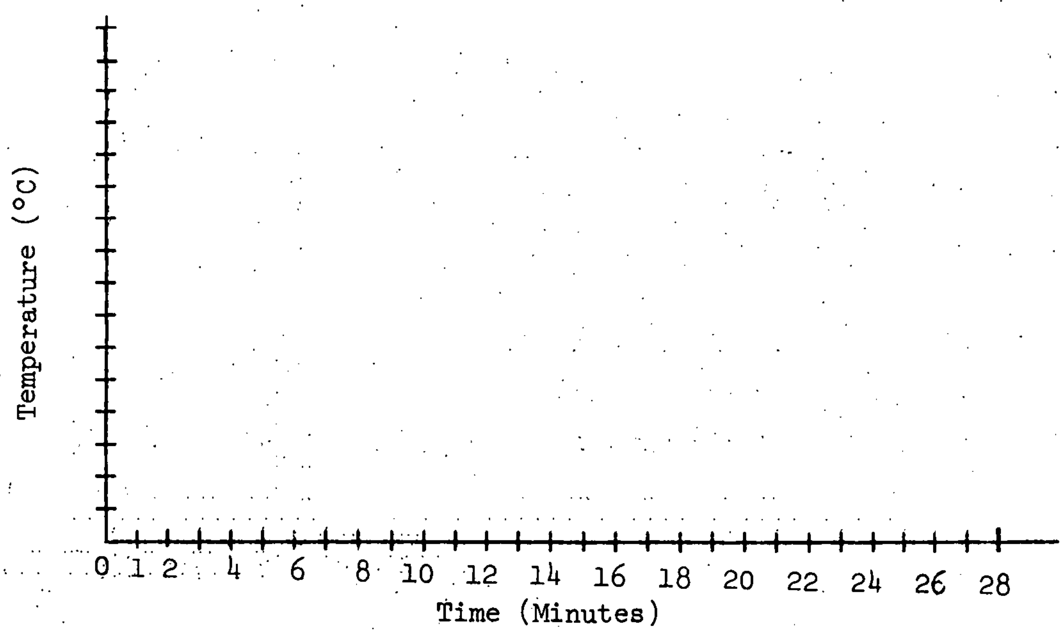
Mass of Water = ____________ Grams

ΔT (Tf - Ts) = ____________ °C

Specific Heat of Water = 1.0 cal/gm - °C

Heat Energy Gained By Water = ____________ Calories

7. Graph temperature (°C) versus time (minutes) on the graph below:



8. Answer the following questions:

   1. What is the difference between energy and fuel?
   2. What is the most important property to look for in choosing a good fuel?
   3. What major disadvantages are there in burning fuel to produce energy?
   4. What other possible alternatives are there to burning fuel to produce energy?
   5. a) According to the graph and your calculations when does the water possess the greatest amount of energy?

      b) If the burning temperature of the fuel remained constant throughout the experiment, and yet the heat energy of the water rose, what can be said about this efficiency of a fuel the longer it burns?
   6. How is question 5b related to the efficiency of a fuel burning in a steam engine (such as one used to power an electric generator)?

Refer to Chart 2 and answer questions 7 - 9.

CHART 2: Energy Content of Various Fuels

Fuel	Amount	Energy Per Pound (Calories)
Coal		
Soft coal (bituminous)	one ton	3,100
Hard coal (anthracite)	one ton	3,200
Oil, distillate (including deisel)	barrel	4,900
Gasoline	barrel	4,800
Natural gas	1,000 ft^3	5,000
Wood	1 cord*	1,250

*One cord is a pile of wood 4 ft. long, 4 ft. high, and 8 ft. long.

7. a) Which fuel would give off the most heat energy per pound when burned?

   b) Which fuel is the most efficient energy source?
8. Coal, as a fuel, produces a relatively high amount of energy per pound. What disadvantages does it possess as an energy source?

9. Natural gas is a good burning fuel, but what limitations does it have as a fuel for automobiles?

Energy - What is the Problem?

Objectives

The students should be able to:

a) Identify some of the problems associated with energy supply.

b) List and discuss some of the consequences of an energy shortage.

c) Name alternate energy sources.

d) Identify some of the consequences and/or problems associated with various energy sources.

e) Find current articles which pertain to problems of energy supply and demand.

Overview

We have an energy problem since our demand for energy is greater than our currently available supply. The consequences of this problem could be serious. There are solutions to this problem, including conservation as well as alternate energy sources (coal, solar, wind, nuclear technologies, etc.). Each of the solutions is only a partial or temporary solution to the energy problem.

Materials

Student activity sheets.

Current newspapers, magazines.

Scissors.

Strategy

This activity is intended to create interest in and promote discussion of the overall problem of energy supply and demand. The questions might be completed and then discussed or they may be answered as a class and discussed one at a time.

After sufficient discussion, the students should look for current information on energy related problems. They might even be encouraged to keep a folder for relevant newspaper and magazine clippings which may be referred to for further information.

Sample Responses

1. The price of oil has risen from $2.70 per barrel in 1973 to $11.51 in 1975 (and recently - 1977 - to about $13 per barrel) and it continues

to rise. The Middle East countries hold a monopoly on supplies of oil. (Answers may vary.)

2. The price will probably continue to rise, especially as it becomes necessary to import more oil.

3. Some of the consequences are: the US will become dependent on the oil producing countries, Americans will lose their jobs, American money will be handed to the countries of the Middle East, and transportation and life styles of Americans will be seriously affected.

4. Our demand.

5. Conservation and alternate energy sources such as solar energy.

6. Drilling and exploration are expensive, time consuming and risky. (Answers will vary.)

7. a) (Answers will vary.) Some areas for consideration are: damage to our economy, international relations, transportation systems, etc.
   b) (Answers will vary.) Petrochemicals, autos, electrical, geothermol, etc. will all benefit.

8. a) Energy problem.
   b) Energy solution.
   c) Energy solution.

10. No. (it was necessary to import about 6 million barrles/day to meet its demands. This amounted to about 37% of its consumption.)

11. The US must import ever increasing amounts of oil to meet its demands. (See graph #2.)

12. The Arab oil embargo of 1973 and the resulting higher prices, caused both the decline in energy consumption (due to conservation) and in oil imports.

13. (Answers will vary.) Discussion of future trends might be an interesting conclusion to this lesson.

Extension Activities

Students might be encouraged to clip articles from current newspapers and magazines and to classify them according to whether they present an energy problem or its solution (or supply and demand).

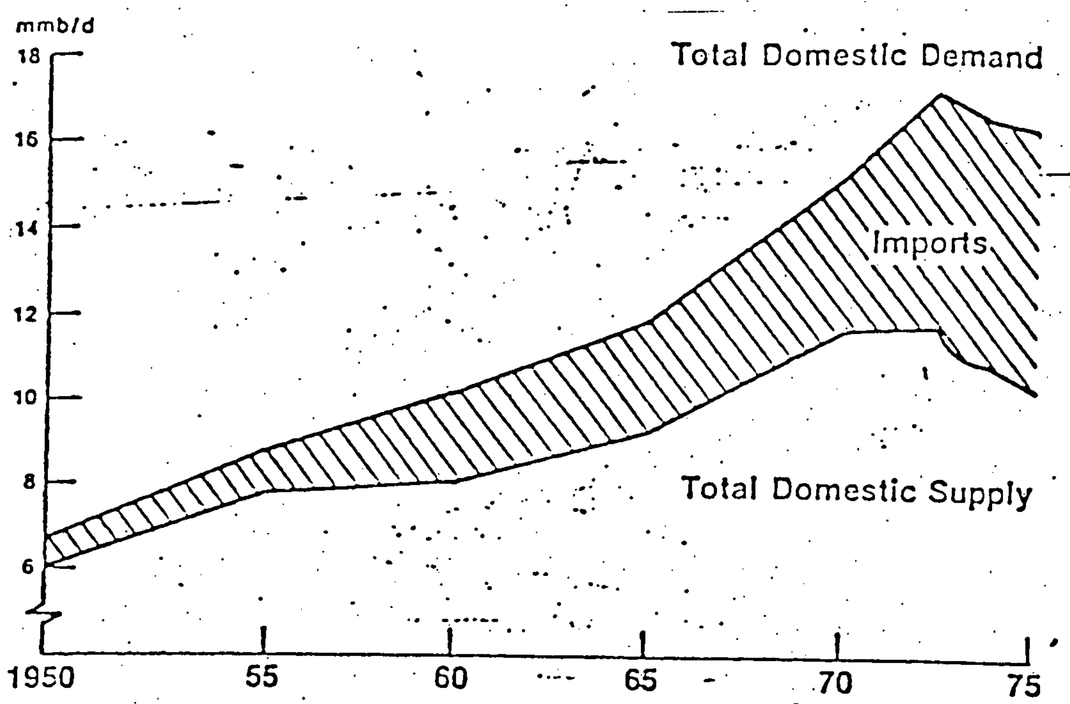
Other resources, such as natural gas, might be investigated.

At present rates of consumption, expected existence of these valuable and non-renewable resources may be calculated. (See Figure 3.)

Example: Using Consumption Rate of 18.5 Q/yr - (1975)

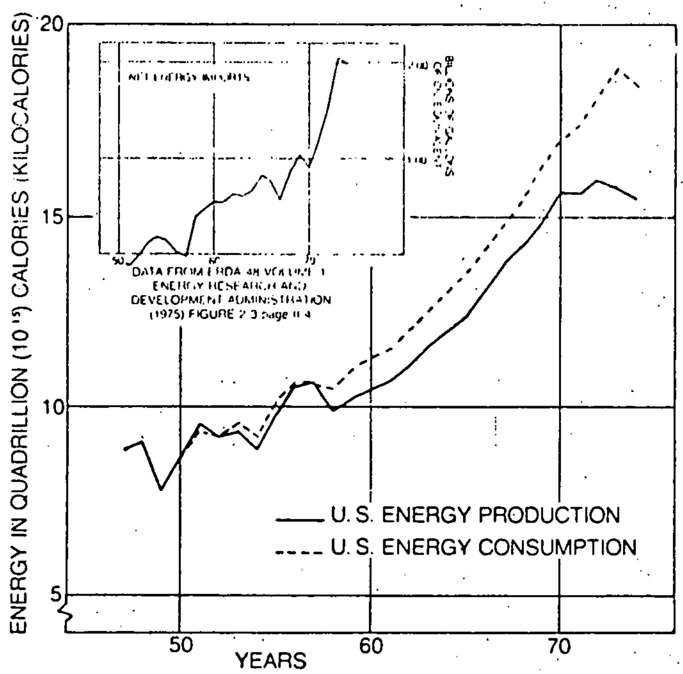
$194Q \div 18.5Q/yr \approx 10.5$ yr (Natural gas)

FIGURE 1: How Did We Become so Vulnerable to Oil Imports?



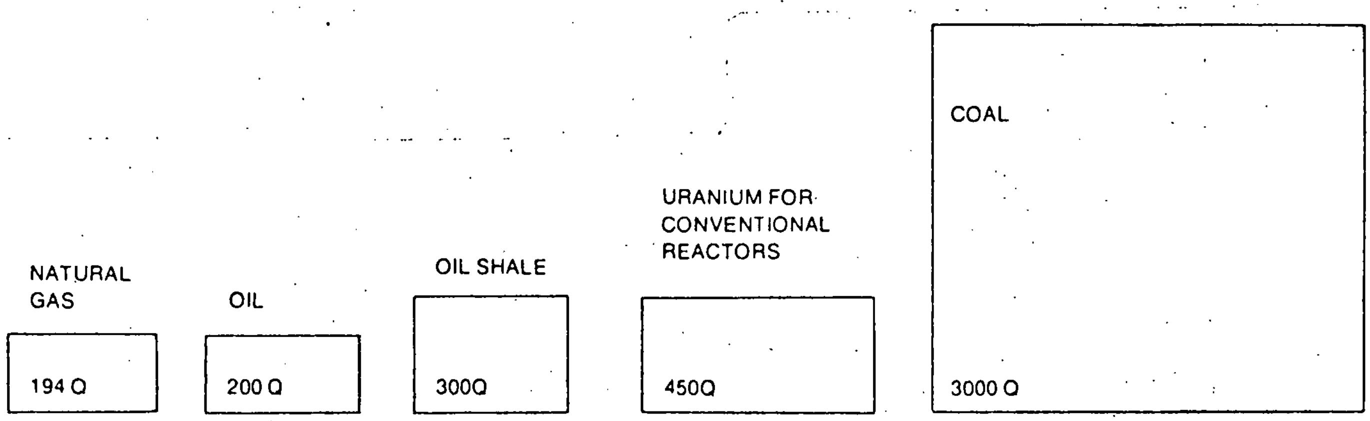
Source: "National Energy Outlook", February, 1976 (p. xxiii).

FIGURE 2: Data From the US Bureau of Mines



Source: The Science Teacher, March, 1976.

FIGURE 3: Energy Resources in Quadrillion (Q) Calories, Shown Graphically by Area. (US Consumption in 1974 Was 18.5 Q Calories.)



Source: The Science Teacher, March, 1976.

References and Resources

National Science Teachers Association, 1975. Energy-Environment Sourcebook, Washington, D.C. (This is an excellent reference book on all aspects of energy technology.)

Federal Energy Administration, 1976. National Energy Outlook, February, Washington, D.C.

ERDA, Pamphlets (available free in classroom quantities.) The Energy Crisis (8 pages), Energy Technology (8 pages), US Energy Options (8 pages), Creating Energy Choices for the Future (16 pages), P.O. Box 62, Oak Ridge, Tennessee 37830.

RHR Filmedia, Inc., "The Hidden Energy Crisis", color, 16mm. Available on free loan, 1212 Avenue of the Americas, New York 10036. (This film presents another consequence of the oil shortage - the loss of petrochemicals.)

Student Activity Sheet

Name ______________________

Date ______________________

The terrible price of inaction:
Lost U.S. dollars.
Lost U.S. jobs.
Lost U.S. independence.

1. What does the cartoon tell you about our energy problem? ______________________

____

2. What doe you think will happen to the price of oil and gasoline in the future? ______________________

____

3. What will happen to the US if the Mid-East countries decide not to sell any oil to us? ______________________

____

4. Which is greater - our supply of oil or the demand for it? ______________________

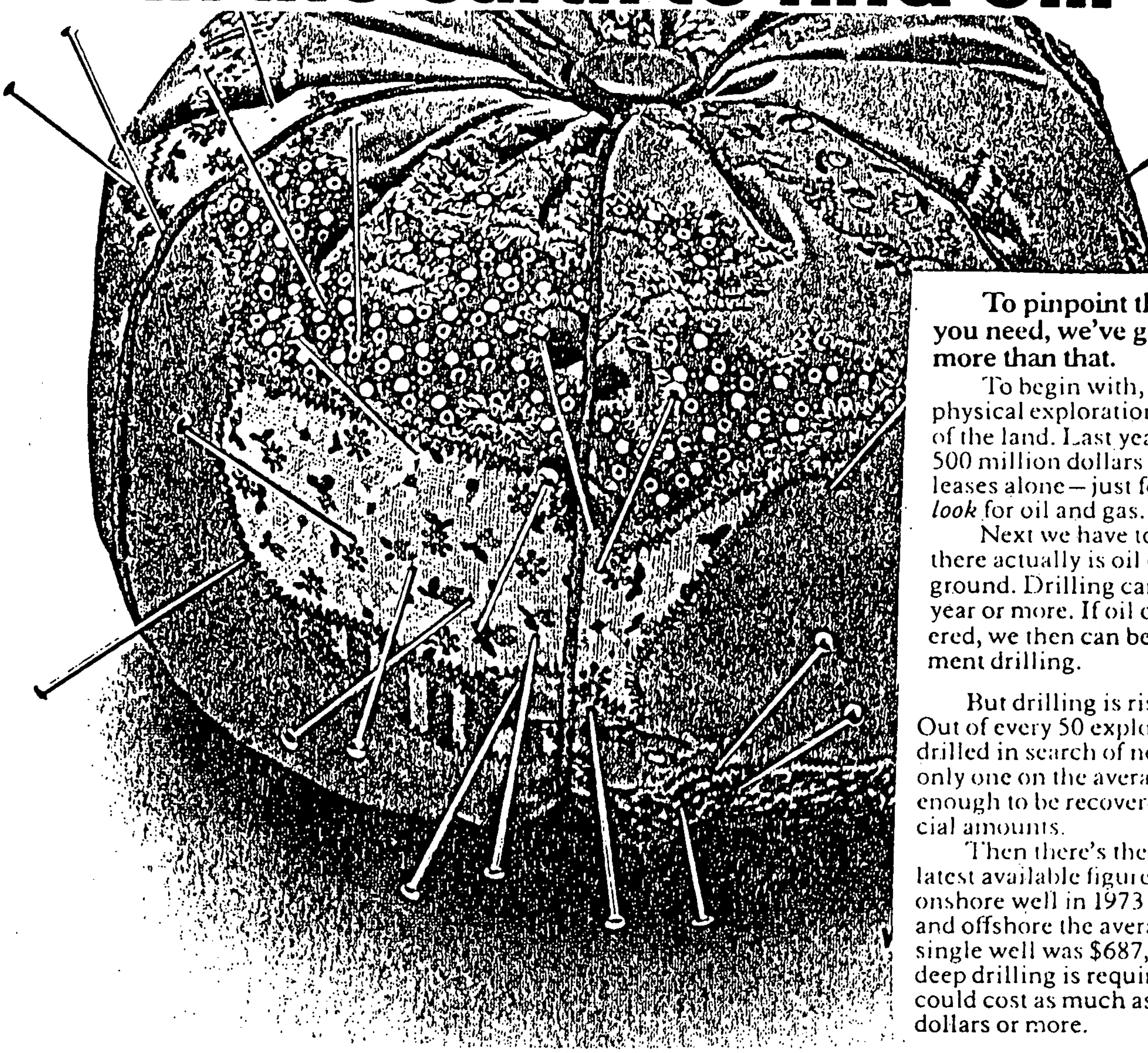
5. What are some alternatives to this problem?______________

____

6. According to this cartoon, how can importing oil affect the US?______

____

Some people think all we have to do is stick holes in the earth to find oil.



To pinpoint the oil and gas you need, we've got to do much more than that.

To begin with, there's the geophysical exploration and the leasing of the land. Last year, we paid over 500 million dollars for offshore leases alone—just for the right to *look* for oil and gas.

Next we have to drill to see if there actually is oil or gas underground. Drilling can take up to a year or more. If oil or gas is discovered, we then can begin development drilling.

But drilling is risky and costly. Out of every 50 exploratory wells drilled in search of new oil or gas... only one on the average finds enough to be recovered in commercial amounts.

Then there's the cost. By the latest available figures, the average onshore well in 1973 cost $107,000, and offshore the average cost of a single well was $687,000. And if deep drilling is required, the well could cost as much as 1 million dollars or more.

7a. What are some of the problems of obtaining new supplies of oil?________

7b. What are some of the possible results of running out of oil?________

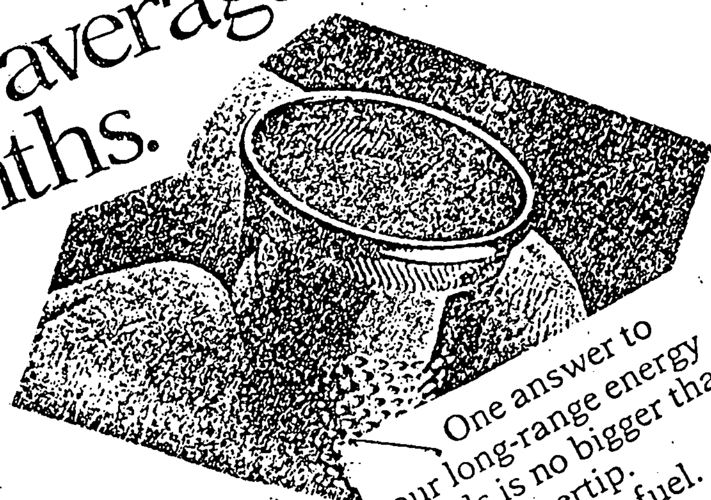
8. If coal must be used instead of oil what are some of the problems which will be caused?________

9. Do these headlines and pictures deal with the energy problem or give a possible solution for the problem? Write the words energy problem or energy solution on the lines after each example.

Could America run out of electricity?

a) ________________

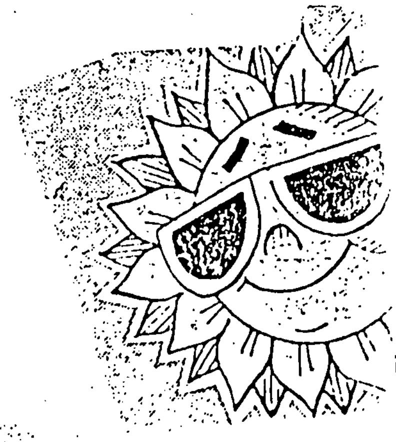
This thimble can hold enough fuel to run the average home for seven months.



b.) ________________

SOLAR ENERGY: A RAY OF HOPE

JEFFREY ANTEVIL of the News Washington Bureau



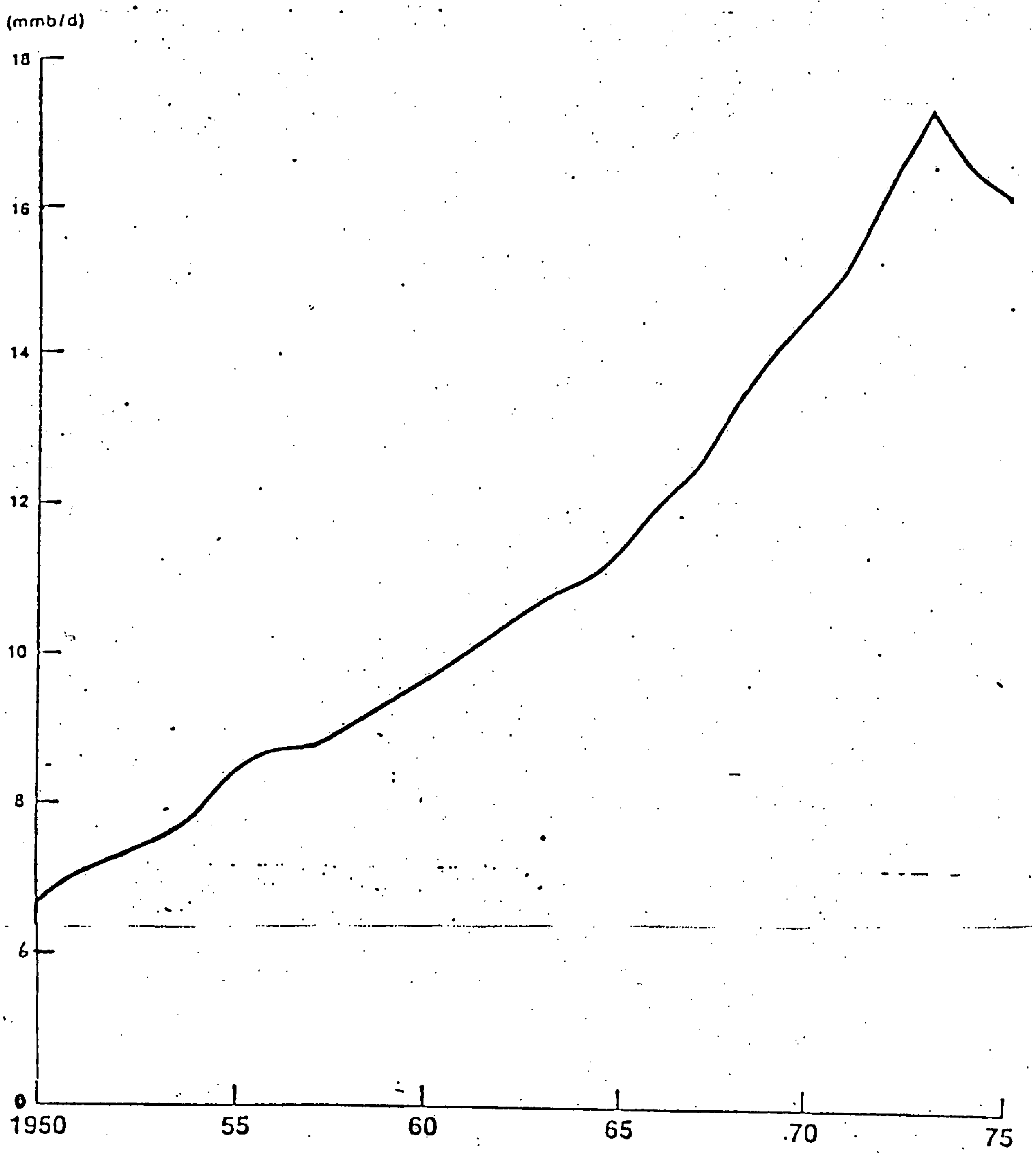
New Horizons of Energy

c)____

Over 46% of our energy demand today is supplied by petroleum or crude oil. Graph #1 shows how much our demand for oil has increased since 1950.

In order to better understand the problem which exists between the amount of oil which we currently use and the amount that the US is capable of producing from domestic oil wells, plot the following information on graph #1. Then compare the amount of oil that can be supplied with the amount that is actually being used.

GRAPH 1: US Petroleum Products Consumption



Source: U.S. Bureau of Mines.

Estimated US Crude Oil Production

Year	Million Barrels Per Day
	5
1950	5
1955	6
1960	7
1965	7.5
1970	11.6
1973	10
1975	9.5

10. According to the graph, was the US able to produce enough oil to satisfy its demands in 1975?_________________________
11. Where must the US get the oil that it needs?_________________________
12. What caused the sudden decline after 1973?_________________________
13. Finish the graph to show what you think will happen to both the supply and the demand for oil by the year 1980. Discuss possible reasons for this trend.

Extension Activity

Look for magazine articles or pictures which tell something about our energy problems. Put them into two groups. Let one group include all those which deal with problems of supplying energy and let the other group include those which explain the demands or users of energy. Briefly list a few ideas about each group. (You may work on this individually or with your classmates.)

Problems of energy supply	Problems of energy demands

GIVE AND TAKE

Energy Demand

Objectives

As a result of this activity, students should be able to:

a) Identify the 4 main users of energy.

b) Realize that the demand for energy is beginning to exceed the rate at which it can be supplied.

c) Understand some of the ways in which our fuel supply is used.

d) Discover that as the demand on our fuel supply increases, the supply will decrease.

e) Make and compare functional (activity) models and descriptive (graph) models with the real world situation.

f) Choose only those energy needs which are most urgent and important.

Overview

We make many demands on our supply of energy. The 4 large consumers use energy at a faster rate than it can be supplied. There is a complex situation of many interactions which affect everyone in supplying and consuming energy. If our demand for energy continues to increase, some energy needs may not be filled. Therefore, we must make choices between "needs" and "wants", and we must learn to use our valuable resources wisely. When the energy demand exceeds the supply, an "Energy Crisis" results.

Materials

For each group:

1 pair of dice

Student activity sheets

120 easily obtainable objects which will stand for energy units (paper clips, straws, pebbles, pieces of paper, etc.)

5 role cards or scorecards

Strategy

Distribute the necessary materials to each group and familiarize the students with the "rules" of this activity.

Emphasize that the students are to assume the roles of the 4 main users of energy. As such they are to decide (by rolling dice) when energy is to be used and for what purpose. One student in each group will be the energy supplier; he will give a unit of energy to the player who rolls the number indicated on the top of his card. Every time the supplier rolls his given number he may add a "newly mined" unit of energy to the energy supply pile.

As players choose the items that the energy is to be "used" for, make sure that they also mark an "X" next to that item on their playing cards. When they have obtained the appropriate number of "X's", or energy units, to fill that need, the item should be circled to indicate that it is completed.

The activity ends when the energy supply is depleted.

The results of each group should be graphed, and when that is completed, the class results should be discussed. Since this activity is based on probability, there may be a variety of results: some similar to the graph given; others very different. However, they should all indicate that the present demand exceeds that rate at which the energy can be produced or supplied.

Students should then be asked to compare their results to real world situations. Does their model show a possible situation? If not, why not? They should be lead to discuss possible situations which could cause the results that they have obtained. For example, if there were a great increase in the amount of energy required for transportation, the students should be able to suggest reasons why this might occur - more private automobiles; shift from cities to suburbs for living, making commuting to jobs necessary, etc.

Sample Responses

1. Will vary with each group.
2. Any new appliances, manufacturing systems, population trend, etc.
3. Will vary.
4. Will vary - for example people conserving, fewer items made, etc.
5. Probably "yes". This might be a good question for further discussion. Were the items not provided for things that were luxuries or were they necessities?
6. The supply decreased.
7. The supply will decrease more rapidly.

8. Yes.

Extention Activities

If the students become interested, you may have a discussion or involve them in further research on why the new energy was being supplied at such a slow rate. Is this realistic? If so, what are some of the problems involved in mining and refining fuels? What are some of the difficulties presented by alternate energy technologies such as solar, wind, biomass, nuclear resources.

To further illustrate the delay in being able to build a power plant to provide for the increased energy demand, you might choose to involve the class in an activity called "The Waiting Game" (available from Con Edison). This gives students some idea of the complexity of the problems of building, licensing and finally getting a power plant "on line" to add to the generating capacity of the utility. (This usually takes about 10 years to complete.)

Another extension activity might involve having students take an electrical appliance survey in their homes (or in school). As they list the appliance they should classify them as to whether they are necessary (such as oil burners, stove, hot water heater, etc.) or whether they are luxuries that they might be willing to do without in order to conserve energy (for example: electric toothbrushes, electric pencilsharpeners, sunlamps, etc.) This type of decision making technique could eventually be an important means to energy conservation.

Resources and Reference Materials

Current periodicals and newspaper articles.

TMMW Bulletin, June, 1974.

Steinhart, C. and J. Energy - Sources, Use and Role in Human Affairs, North Scituate, Massachusetts: Duxbury Press, 1974.

Consolidated Edison. The Waiting Game, 4 Irving Place, New York, 10003. (Available free on request.)

THE WAITING GAME

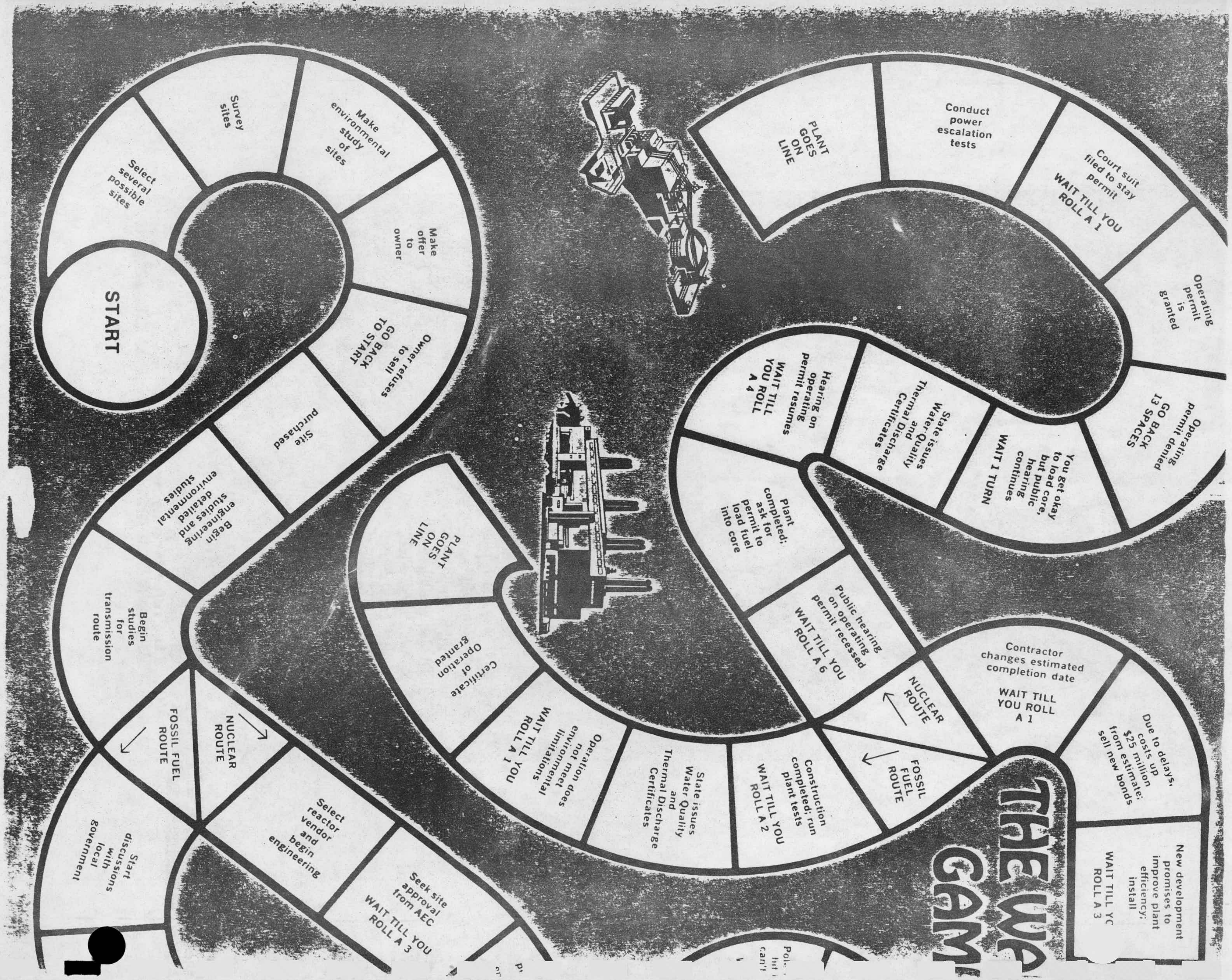
On the next two pages is a game for two or more players. The object is to build a new plant to help meet the power needs of New York City and Westchester County. Using a single dice, each player moves a counter around the board; the first player to reach a "Plant goes on line" square is the winner.

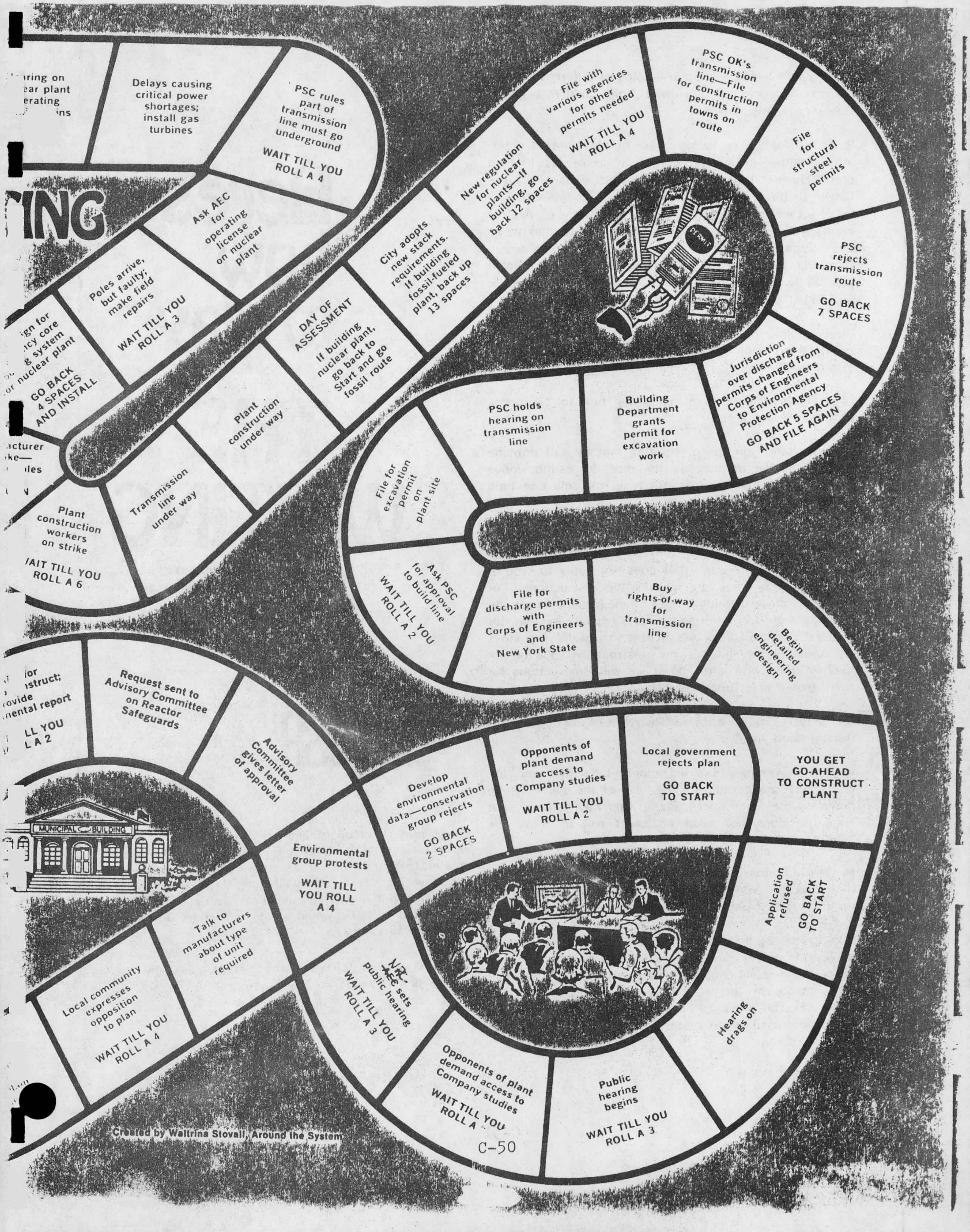
Along the way, each player will pass over squares illustrating the steps—and some of the setbacks—involved in acquiring a site, building and getting authorization to operate a real power plant and the transmission line that usually must be built in conjunction with it. While there isn't room on the game board to show every step, or every possible setback, if you read around the board, you'll get a good idea of some of the problems Con Edison faces in trying to add to its generating capacity.

And if you play the game, you'll understand why we call it "The Waiting Game." Be forewarned: It may seem to be a rather slow and frustrating game—because that's the way building a power plant really is these days.

Reprinted from October 1971 issue of Around the Con Edison System

You'll find the rules for playing the game on the back cover.


START
Select several possible sites
Survey sites
Make environmental study of sites
Make offer to owner
Owner refuses to sell GO BACK TO START
Site purchased
Begin engineering studies and detailed environmental studies
Begin studies for transmission route
FOSSIL FUEL ROUTE
NUCLEAR ROUTE
Start discussions with local government
Select reactor vendor and begin engineering
Seek site approval from AEC WAIT TILL YOU ROLL A 3
PLANT GOES ON LINE
Certificate of Operation granted
Operation does not meet environmental limitations WAIT TILL YOU ROLL A 1
State issues Water Quality and Thermal Discharge Certificates
Construction completed; run plant tests WAIT TILL YOU ROLL A 2
FOSSIL FUEL ROUTE
NUCLEAR ROUTE
Public hearing on operating permit recessed WAIT TILL YOU ROLL A 6
Plant completed: ask for permit to load fuel into core
Hearing on operating permit resumes WAIT TILL YOU ROLL A 4
State issues Water Quality and Thermal Discharge Certificates
You get okay to load core, but public hearing continues WAIT 1 TURN
Operating permit denied GO BACK 13 SPACES
Operating permit is granted
Court suit filed to stay permit WAIT TILL YOU ROLL A 1
Conduct power escalation tests
PLANT GOES ON LINE
Contractor changes estimated completion date WAIT TILL YOU ROLL A 1
Due to delays, costs up $25 million from estimate; sell new bonds
New development promises to improve plant efficiency; install
ROLL A 3
THE


TING
Delays causing critical power shortages; install gas turbines
PSC rules part of transmission line must go underground WAIT TILL YOU ROLL A 4
Ask AEC for operating license on nuclear plant
Poles arrive, but faulty; make field repairs WAIT TILL YOU ROLL A 3
GO BACK 4 SPACES AND INSTALL
Plant construction under way
Transmission line under way
Plant construction workers on strike
ROLL A 6
DAY OF ASSESSMENT If building nuclear plant, go back to Start and go fossil route
City adopts new stack requirements. If building fossil-fueled plant, back up 13 spaces
New regulation for nuclear plants—If building, go back 12 spaces
File with various agencies for other permits needed WAIT TILL YOU ROLL A 4
PSC OK's transmission line—File for construction permits in towns on route
File for structural steel permits
PSC rejects transmission route GO BACK 7 SPACES
Jurisdiction over discharge permits changed from Corps of Engineers to Environmental Protection Agency GO BACK 5 SPACES AND FILE AGAIN
Building Department grants permit for excavation work
PSC holds hearing on transmission line
File for excavation permit on plant site
Ask PSC for approval to build line WAIT TILL YOU ROLL A 2
File for discharge permits with Corps of Engineers and New York State
Buy rights-of-way for transmission line
Begin detailed engineering design
YOU GET GO-AHEAD TO CONSTRUCT PLANT
Local government rejects plan GO BACK TO START
Opponents of plant demand access to Company studies WAIT TILL YOU ROLL A 2
Develop environmental data—conservation group rejects GO BACK 2 SPACES
Request sent to Advisory Committee on Reactor Safeguards
Advisory Committee gives letter of approval
MUNICIPAL BUILDING
Environmental group protests WAIT TILL YOU ROLL A 4
Talk to manufacturers about type of unit required
Local community expresses opposition to plan WAIT TILL YOU ROLL A 4
NRC AEC sets public hearing WAIT TILL YOU ROLL A 3
Opponents of plant demand access to Company studies WAIT TILL YOU ROLL A
Public hearing begins WAIT TILL YOU ROLL A 3
Hearing drags on
Application refused GO BACK TO START
Created by Waltrina Stovall, Around the System

Each player needs a counter—coins of different denominations, or counters borrowed from children's game. One dice is also needed.

Roll the single dice to set order of play and to determine whether player will build nuclear or fossil-fueled plant. Nuclear route is longer because it usually takes longer to build a nuclear plant—5 to 7 years—than a fossil-fueled plant—3 to 5 years. However, nuclear plants are better from an environmental standpoint, so the company tries to go that route rather than fossil, whenever possible. So, player may build a fossil-fueled plant only if he rolls a 1 or 2. Player rolling 3, 4, 5, or 6 must build a nuclear plant.

Player rolling highest number starts play, rolling dice again before moving his counter. Other players follow in clockwise order.

If player lands on space instructing him to "wait one turn," he loses a turn.

If player lands on space requiring him to wait until he rolls a specific number on the dice, he cannot move until he rolls that number. He may roll only one time per turn.

Two or more players may occupy the same space.

If player lands on space that does not apply to type of plant he is building, he ignores the instructions. For example, player building fossil-fueled plant lands on "New design for emergency core cooling system for nuclear plant. Go back 4 spaces and install." He stays on square and ignores the instructions. Player on nuclear route who lands on space with instructions for fossil-fueled plant does likewise.

All players must observe instructions pertaining to transmission line.

Once a player has obtained a permit by an exact roll, he retains the permit for the rest of the game. If he lands on the same space again, after having been sent back, he does not need an exact roll to move his counter.

Nuclear and fossil-fueled routes are the same for most of the game. Where paths divide, player follows path for the type of plant he is building.

About mid-way through game is a "Day of Assessment" square. If player building nuclear plant lands on this space, time is running out—he is not going to be able to complete his plant in time to meet demands for power. So, he must go back to start of game and try the faster fossil-fueled route. Tough—but it's happened to Con Edison.

Here's how to play

THE WAITING GAME

Con Edison clean energy

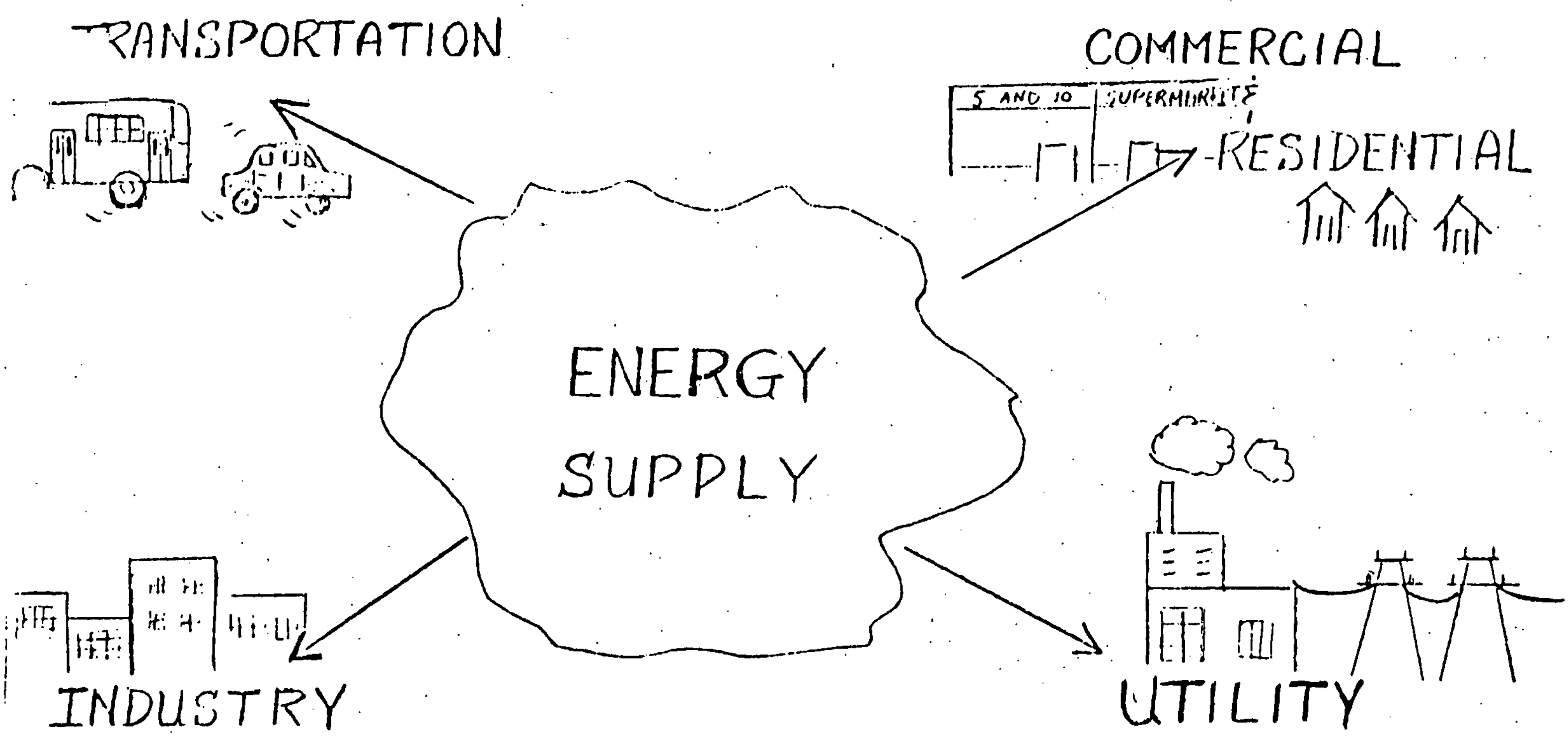
Player must land on "Plant goes on line" space by an exact roll. If he is near the end and rolls a number greater than the number of remaining spaces, he may not move his counter. For example, player 5 steps from end would not move his counter if he rolled a 6. But, if he rolled a 4, he would advance 4 steps and would then have to roll a 1.

The first player to reach the "Plant goes on line" square is the winner of the game.

Student Activity Sheet

Name ____________

Date ____________



Today you will make a model of what our demands for energy are doing to our supply of energy resources.

What are the four main users of energy? ____________, ____________, ____________, and ____________.

1. Form groups of 4 or 5 students. Each student will take the role of one of the four large energy users and will receive a card with the demands he has for energy. One student will be in charge of the "mines" and "oil wells" and will supply additional energy for the group.
2. The person in charge of the energy supply places 100 objects in the center of the group and labels them "Energy Supply". He also gets 20 more objects which stand for the amount of energy that will be added from the mines and oil wells that day. He labels these objects "New Resources" and puts them in front of him.
3. Each person takes a turn rolling the dice; everytime the number in the box on the top of an energy user's card is rolled he may take an object (energy) from the "Energy Supply" pile. When the supplier rolls the number that is shown in the box on his card, he must take an object (energy) from the "New Resources" pile and add it to the "Energy Supply"

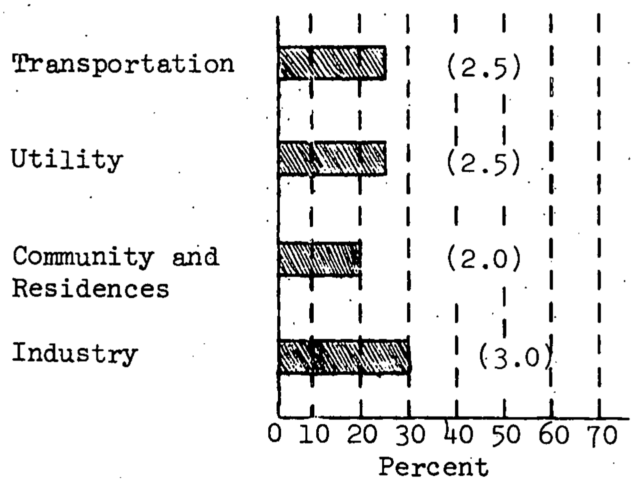
pile in the center of the group.

4. As the users get energy they are able to use it to run their machines, light and heat their homes and factories, run their cars and buses, and so on. To show what the energy is used for, put an "X" next to the right use on your scorecard. If there is a number next to the use, it means that much energy is needed, for example (2) means you must get 2 objects or units of energy in order to fill that need.

5. Try to fill the most important need on your scorecard first. There may not be enough energy to fill all your needs, so choose wisely!

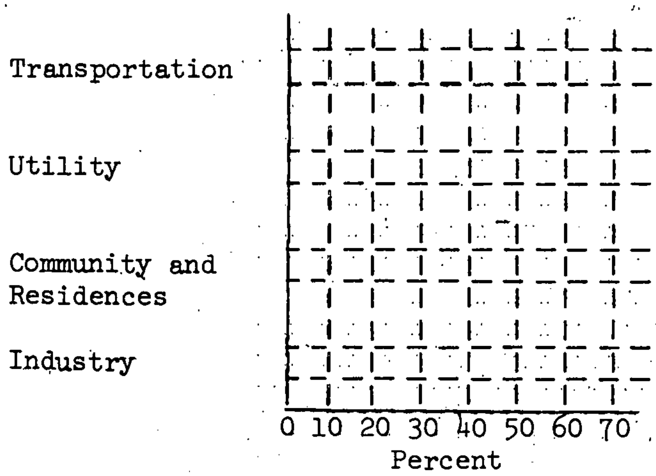
6. Continue to take turns rolling the dice and demanding energy until the objects in the "Energy Supply" pile are gone. Then answer the following questions.

Actual US Energy Use for 1972



Supply? Decreasing

Your Group's Model of Energy Use



Supply? ______________________ (# Left)

How do your results compare with the actual energy used in 1972?

1. Graph your results and the results of the rest of your group in the spaces above. In what area did you "use" more energy than the actual percentages? ______________________
2. Predict what conditions or new inventions you think could lead to this increase in energy use. ______________________ ______________________
3. In what area did you "use" less than the actual values? __________
4. What situations could have caused this? ______________________
5. Were there any important demands on your scorecards that could not be filled? _______. If so, write some of them: ______________
6. What happened to the supply as each player filled his demand? ______ ______________________
7. What will happen to the actual supply of our energy resources if demands in all 4 areas continue to increase? ______________________
8. Is this model similar to the real world situation? ______________
9. Are you beginning to understand what is meant by the words "energy crisis"? Discuss this idea with your classmates.

INDUSTRY (30%)

(You must roll doubles of a total of 7)

Use power for:

lighting (5)_____
heating (5)_____
running large machines (5)_____
manufacturing (5)_____
assembling items (4)_____
packaging items (3)_____
storage (1)_____
safety features (2)_____
waste disposal (2)_____
elevators (2)_____
conveyer belts (2)_____
plastics (5)_____
other ________________________

UTILITY (25%)

(You must roll doubles or a total of 6)

Supply power to:

Heat homes (3)_____
light homes (2)_____
heat stores & offices (2)_____
light stores & offices (2)_____
light factories (2)_____
heat factories (3)_____
run machinery (3)_____
power traffic lights (1)_____
power water pumps, etc (2)_____
telephones (2)_____
run appliances (2)_____
supply computers (2)_____
supply hospitals (3)_____
other ________________________

COMMERCIAL & RESIDENTIAL (20%)

(you must roll doubles or a total of 9 or 11)

Use power for:

heat (3)_____
light (2)_____
hot water (2)_____
refrigerator (2)_____
freezer (2)_____
stove (2)_____
hair dryer (2)_____
clothes washer (1)_____
clothes dryer (2)_____
TV (each) (2)_____
vacuum cleaner (1)_____
dishwasher (2)_____
lawn mower (1)_____
stereo (1)_____
radio (1)_____
clocks (1)_____
electric mixer (1)_____
electric fan (1)_____
toaster (1)_____
electric frying pan (2)_____
electric toothbrush (1)_____
swimming pool pump (2)_____
other ________________________

TRANSPORTATION (25%)

(You must roll doubles or a total of 8)

Use power for:

buses (5)_____
cars (5)_____
trains (4)_____
subways (5)_____
airplanes (5)_____
fire department (2)_____
police department (2)_____
sanitation department (3)_____
freight (3)_____
taxi cabs (2)_____
motorcycles (1)_____
oceanliners (5)_____
motorboats (1)_____
mini-bikes (1)_____
other ________________________

Energy Supplier

You have two jobs:

1. You give the 4 players units of energy (from the pile of 100 units) each time they roll their numbers on the dice.

   When the person in charge of:

   a) transportation rolls doubles or a total of 8 give him 1 object or unit of energy.

   b) industry rolls doubles or a total of 7 give him 1 object or unit of energy.

   c) Utility rolls doubles or a total of 6 give him 1 object or unit of energy.

   d) commercial and residential rolls a total of 9 or 11 or doubles give him 1 object or unit of energy.

2. When you roll a 2 or 12 put 1 object from the "New Resources" pile (pile of 20 objects) into the Energy Supply pile.

WHAT'S WATT

Measuring Energy

Objectives

As a result of this activity the student should be able to:

a) Match forms of energy use or power with a convenient unit for measuring each.

b) Be able to convert from one unit to another.

c) See the relationships between units, and also realize that some units are more convenient to use for a particular energy measurement.

d) Notice that there are common energy units in both the metric and English systems.

Overview

This is intended as a basic lesson for the introduction of students to energy and power units and the differences and/or relationships between them. The following points should be stressed:

Energy may be measured in many different ways and therefore requires the use of many different measuring units.

Energy measurements may be converted from one unit to another.

Power is the rate at which energy is used.

Strategy

Since this unit relys on a "game" format, it will probably be most successful with 7th, 8th, and possibly 9th graders who have had very little or no previous exposure to energy and power units.

The game itself may be used as an introduction to the topic, as a summation of the lesson or even as a reinforcement of what has been previously taught.

The background of your class will determine the amount of introduction needed to play the game. Allow 1 to 2 complete class periods for the completion of this activity.

Materials

Student activity sheets (Playing boards, matching cards, and directions)
Scissors

Sample Responses

FOOTPOUNDS	KILOWATT	WATT-HOUR	MEGA WATT
KILOWATT HOUR	HORSEPOWER	MEGA WATT	(KILO)CALORIE
KILOWATT HOUR	WATT	WATTS	BTU
CALORIE	KILOWATT-HOURS	HORSEPOWER HOUR	KILOWATT

ENERGY UNITS	POWER UNITS
Calorie (kilocalorie)	Watt
Watt-hours	Kilowatt
Kilowatt hours	Megawatt
BTU	Horsepower
Horsepower-hour	

1. Calorie, watt-hours, kilowatt-hours, BTU, horsepower-hours.
2. Watt, kilowatt, megawatt, horsepower.
3. Some units measure heat energy, others electrical energy. There are also different units for measuring very large or very small amounts of energy and power.
4. No. Megawatt is a large unit usually used for measuring the power of something as large as an electric generator. A watt is more convenient.
5. No. The Calorie is a more convenient unit since the energy released by food is often in the form of heat rather than electrical energy.
6. Kilowatt.
7. Calorie.
8. Watt-hour.
9. Foot-pound, BTU.

Energy-Power Tic-Tac-Toe

Energy	Power	Power
	Energy	Power
		Energy

Person to complete row of 3 energy units is the winner.

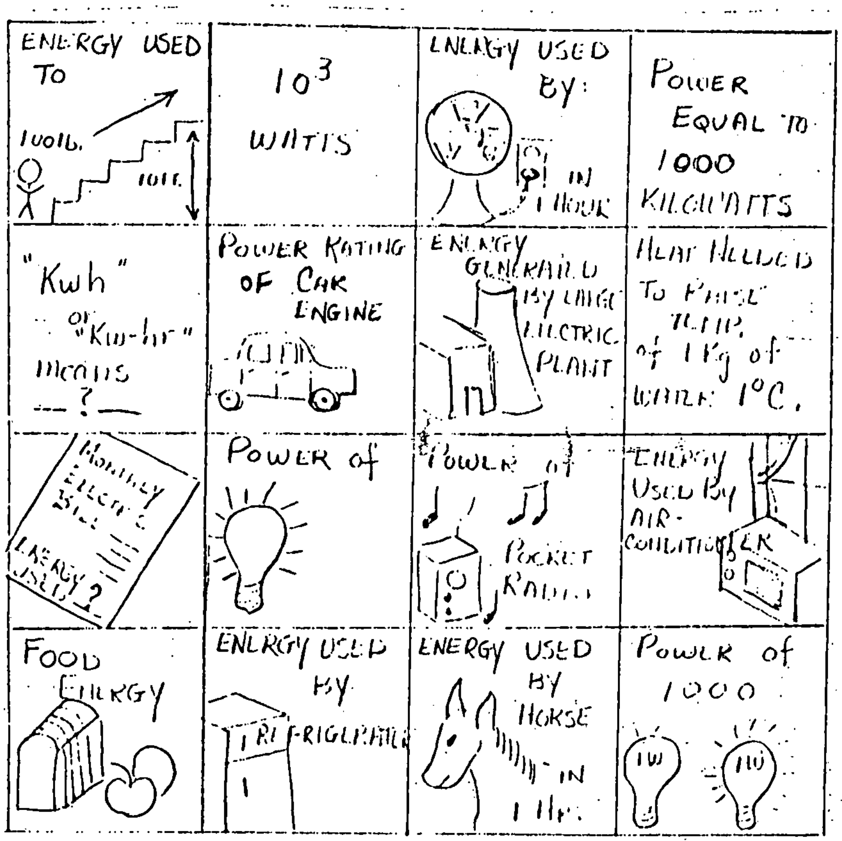
Power	Energy	Energy
Power	Energy	Energy
Power		Power

Person who completed row of 3 power units is the winner.

Student Activity Sheet

Name ____________________

Date ____________________



In this activity you will be asked to match some energy and power users with the most convenient unit commonly used to measure them. Before you begin the game, cut out the "unit cards" from the activity sheet, and place them face down on the table between you and your partner.

Remember: Energy is the ability to do work.

Power is the rate at which energy is used.

To play:

A. Choose a person to begin. Each person in turn may take a "unit" card" and cover a square on his or her playing card. Be sure that the units correctly matches the use. If no match is possible, put the card on the discard pile.

B. The first person to completely cover a row of 4 squares, diagonally, horizontally or vertically is the winner. (Winners should check their "matches" with their teachers.)

Now you should be able to group your "unit cards" into 2 piles - one for power units and the other for energy units. List the units which belong to each group:

Energy Units	Power Units

1. Three energy units are __________, __________, and __________.
2. Two power units (which indicate the rate at which energy is used) are: ____________________ and ____________________.
3. Why do we need more than one unit for measuring energy and power? ________
____
4. Would it be easy to measure the power of a pocket radio in megawatts?
____

5. Would it be easy to measure the energy obtained from food in Kilowatt hours? ____________________ Explain: ____________________

____

Check correct answers:

6. Which unit is larger? watt________ kilowatt________

7. Which unit is commonly used for measuring heat energy? calorie________ watt-sec________

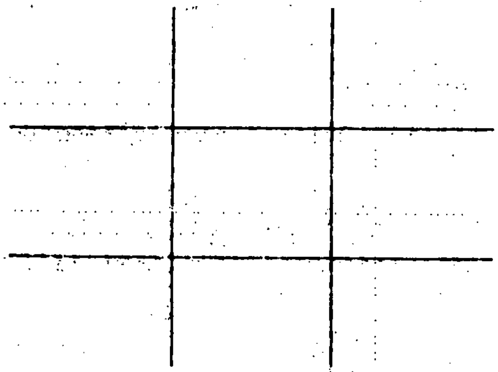
8. Which unit is commonly used to measure electrical energy? watt-hour ________ horsepower-hour________

9. Which units are not metric units? kilowatt________ footpound________ BTU________.

Challenge your partner to a game of Energy-Power Tic-Tac-Toe. Shuffle your "unit cards" and again turn them face down on the table. Each player in turn should take a card and put it carefully on the playing board below in an attempt to form a row of either 3 energy or 3 power cards in a row. Each player may try to block the other player and the player who completes a row; horizontally, vertically or diagonally is the winner.

CALORIE	KILOWATT HOUR	BTU	MEGAWATT	KILOWATT
FOOTPOUND	WATT	KILOWATT HOUR	HORSEPOWER	WATT
WATT HOUR	MEGAWATT	CALORIE	HORSEPOWER HOUR	MEGAWATT
KILOWATT	HORSEPOWER	FOOTPOUND	KILOWATT	CALORIE
HORSEPOWER HOUR	KILOWATT HOUR	KILOWATT HOUR	WATT HOUR	BTU

Energy-Power Tic-Tac-Toe



BETTER InsuLATE THAN NEVER

Insulation

Objectives

The students should be able to:

a) Record and graph temperatures.

b) Observe the effects of insulation on heating and cooking rates.

c) Analyze a mode, investigate places where unwanted heat loss-gain might be eliminated by installing insulation.

Overview

A tin can demonstrates the principle of heat loss by conduction. This principle provides a simple conservation technique for use in the home (or school or any industrial bulding).

It is easily demonstrated how heat loss can be reduced significantly by insulation.

Since space conditioning (both heating and cooling) is the largest residential consumer of energy, a substantial saving in both fuel and dollars can be achieved by the installation of proper insulation.

A small initial capital expenditure for insulation will usually pay for itself in a few years and more importantly will conserve our non-renewable resources.

Materials

Soup can (at least 3 per group)
Thermometers
Scissors
Newspaper
Tape
Source of heat (bunsen burner, immersion heater, etc.)
Graduated Cylinder
Ice cubes (optional)
Other forms of insulation (optional)

Strategy

Depending upon the background this experiment and activity may require very little preparation or might demand an introductory lesson on methods of heat transfer and how to calculate the amount of heat gained or lost by a substance.

Notes to the Teacher

Caution the students to employ previously taught safety techniques when working with hot water. The tin cans (especially those which are not insulated) will become very hot and should be touched only with potholders or asbestos mits. If this presents a problem, the experiment may be modified to work with lower temperatures and longer time intervals.

Sample Responses

1. a) #4. Heat was lost quickly to the air because of no insulation.
   b) #1. Insulation kept heat transfer down to minimum.

2 & 3. Answers will vary based on data. For example: If 200 ml of water cooled from 100°C to 80°C (in 5 minutes) the heat lost would be:

$$Q = \quad tm$$

$$Q = (-20°C)\ (200g)$$

$$Q = 4000 \text{ calories} = -4 \text{ kilocalories (calories) lost}$$

3. Insulation should reduce heat loss considerably.

Extension Activities

Students should be encouraged to check the insulation in their own homes and make necessary changes. They could then calculate savings in dollars and in fuel which result from adding insulation to their own homes.

Other ways of insulating and/or reducing heat loss could also be investigated (storm windows and doors, use of draperies, calking windows and seams, cleaning furnace, insulating hot water tank, etc.)

Resources and References

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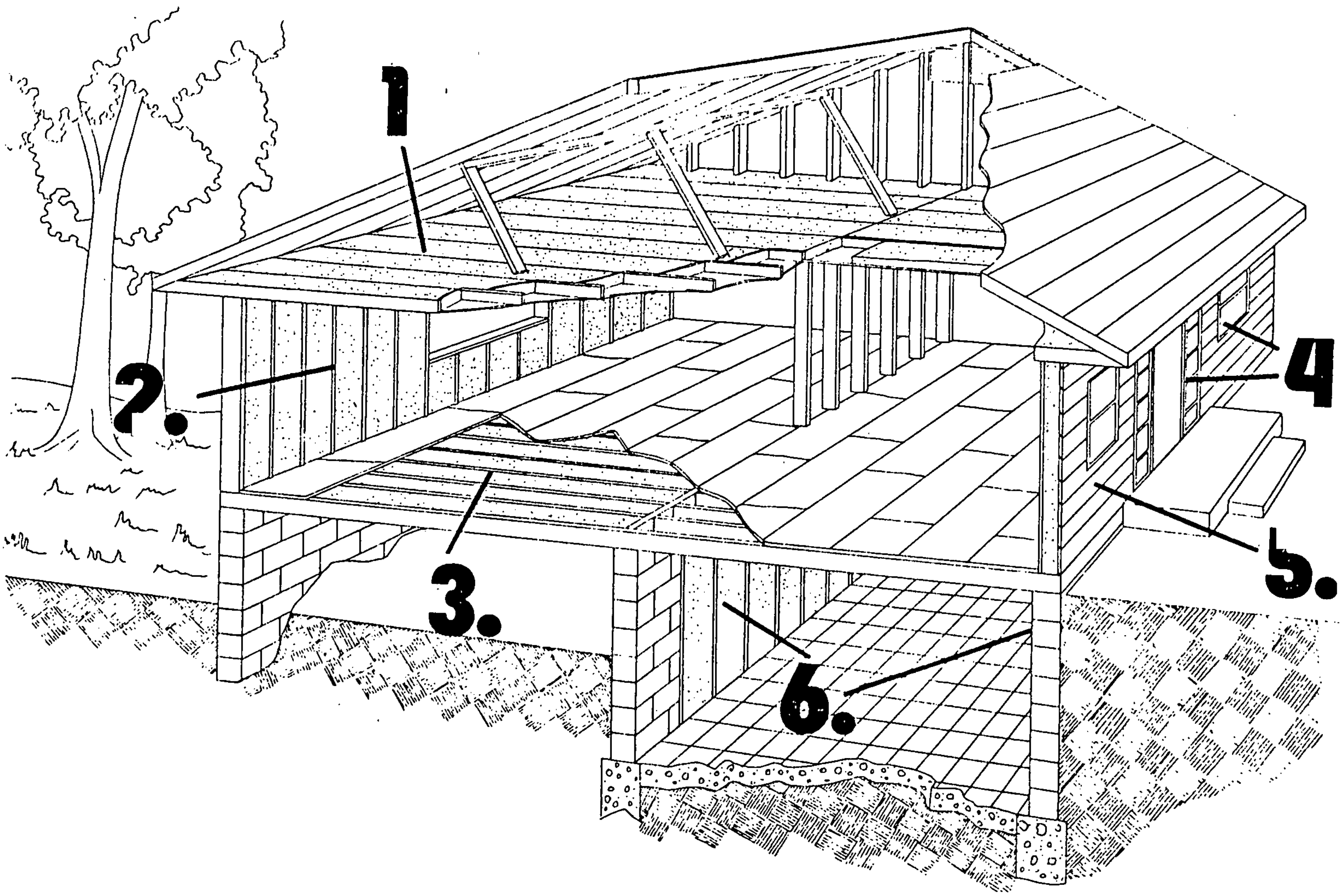


HOW MUCH INSULATION GOES WHERE

The amount of insulation needed epends on the type of insulation used, vailable space, and the amount of xposure of each surface to the ements. For example, because heat ses, more insulation is required in the iling separating the heated area of e house from the unheated attic or of.

One area may need more insulation an another, depending upon design nditions of your home but that never eans that a surface exposed to an heated area should be overlooked. oper insulation is just as important the floor of a room over an unheated rage as it is on the outside walls of a om.

The following are recommended els of insulation for various areas of ur home. It is important, however, to nsider adding insulation beyond se levels for greater protection. The st of added insulation versus the ded savings to be realized should be nsidered, however, in any decision.

1. ATTIC FLOOR: A minimum of 6 inches of fiberglass batt or blanket insulation, loose fiberglass, rock wool or celulose (R-19).

2. OPEN OR UNFINISHED OUT SIDE WALLS: A total of 3 ⅝ inches of fiberglass batt or blanket insulation (R-13).

3. FLOORS OVER UNHEATED BASEMENTS & CRAWL SPACES: A total of 6 inches of fiberglass batt or blanket insulation if vented (R-19). A total or 3-⅝ inches of fiberglass batt or blankets if unvented (R-13).

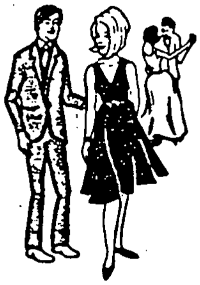
4. WINDOWS, DOORS AND WEATHERSTRIPPING: Storm or double glass on all windows. Storm or insulated doors on all outside doors. Caulking and weather-stripping around all windows, doors and cracks.

5. FINISHED OUTSIDE WALLS: A total of 3⅝ inches of blown or loose-fill fiberglass, rock wool, cellulose (R-13) or 3-¼ inches of urea foam (R-19).

6 HEATED BASEMENT WALL[S]: A total of 3 ½ inches of fibergla[ss] batt or blanket insulation or 2 inches of polystyrene sheets covered with a fire retardant such as sheet rock (R-11).

Energy for Heating and Cooling

6. If possible, during the daytime set bedroom temperatures lower than living areas in the winter and higher in the summer.
7. Assure that your thermostat is properly adjusted.
8. Clean thermostats carefully once a year to remove dust.
9. Locate your thermostat where it will accurately measure the temperature. Be careful it does not pick up heat or cold from other sources such as from hot pipes, sunlight, air ducts, outside doors and heat generating appliances. These external influence can cause the thermostat to respond to artificial calls for different temperatures.

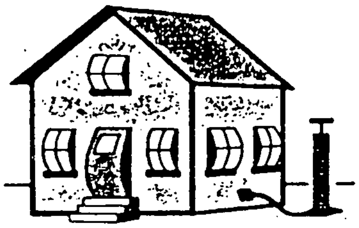


10. Our bodies act as small heaters and humidifiers. When large groups of people are anticipated in a home during the winter, the thermostat can be turned down a couple degrees to avoid becoming too warm and wasting energy.

INSULATION

11. Adequate insulation is the most important consideration in conserving heating and cooling energy in the home. Such insulation will also contribute greatly to our comfort during both summer and winter. Insulation will reduce the leakage of heat into or out of our homes.

ANALOGY - Heating or cooling a house is like pumping air into a porous tire. With a fast leak you must pump continuously and vigorously. Similarly, insufficient insulation will cause your heating and cooling systems to work harder. With a slow leak in the tire, you are not required to pump so hard and can even stop and rest periodically. Sufficient insulation will allow your cooling and heating systems to slow down and rest.



The greatest loss or gain of heat in most homes is through the roof. This is also the easiest area in which to install adequate insulation. Almost every home can hardly afford to have less than 6 inch (15 centimeters) of good insulation in the attic. Insulation in exterior sidewalls and in floors over unheated areas is also highly desirable. The greatest loss through a concrete slab floor is from its edges. Insulation should be placed around the entire perimeter of the slab.

The effectiveness of insulation is indicated by its R-value. The R-value indicates the insulation's resistance to the passage of heat. The higher the R-value, the greater the resistance. R-30 is recommended for attic floors and R-13 is recommended for exterior walls and floors over unheated areas.

Source: Our Energy Problems and Solutions.

Consult a qualified contractor if you are not sure about installation. Care is required since moisture problems can be created if insulation is not properly installed. Remember uninsulated houses leak up to twice as much heat as those properly insulated. Adequate insulation can therefore return substantial savings as shown in the table below.

Insulation	% Fuel Savings
3 inches (7.6 cm) attic floor	26%
2 inches (5 cm) exterior wall	8%
2 inches (5 cm) under lower floor	12%
Additional 1 inch (2.5 cm) attic floor and exterior wall	3%
Additional 3 inches (7.6 cm) in attic	2%
	51%

Even with mild winters where the outside temperature averages 45°F (7.2°C), your insulation investment can be returned within two years and thereafter give you an annual savings.

PUT THE LID ON YOUR HEATING & COOLING COSTS!!!

AIR LEAKAGE

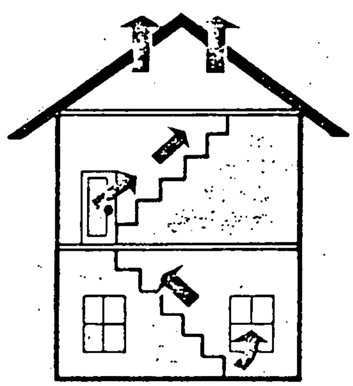
12. A cold draft coming from a window or door can indicate air leakage in and out of the house. To eliminate as much as 30% of your heat losses, install weather stripping at movable joints and caulk around leaking frames. Don't forget the attic door!

Example:

A 1/8 inch (0.3 cm) crack around a standard exterior door loses heat through 29 square inches (187 sq cm) - Believe it or not, this small leak can cost you over 14 dollars each year.

13. Air leakage from heated areas into the attic is especially important:

a) ENERGY LOSS & COST - Since warm air rises, any opening to the attic can cause a significant heat loss. A typical home may easily have 30 square inches (194 sq cm) of leakage to the attic through doors and other penetrations. This leakage can raise your winter heating cost as much as 10%.



b) MOISTURE - Heated air carries moisture to the attic where it can condense and cause wetting of insulation and building materials. In our typical house with 30 square inches (194 sq cm) of leakage, over a gallon (3.8 liters) of moisture can flow into the attic each day, assuming the relative humidity is maintained at 30%.

Look for leakage around loosely fitting attic stair doors, pull-down stairs, electric light penetrations, ceiling fan penetrations, vents, pipes; and air ducts. If your basement is heated, close off upper wall construction that is open to the attic.

PLUG THOSE LEAKS!!!

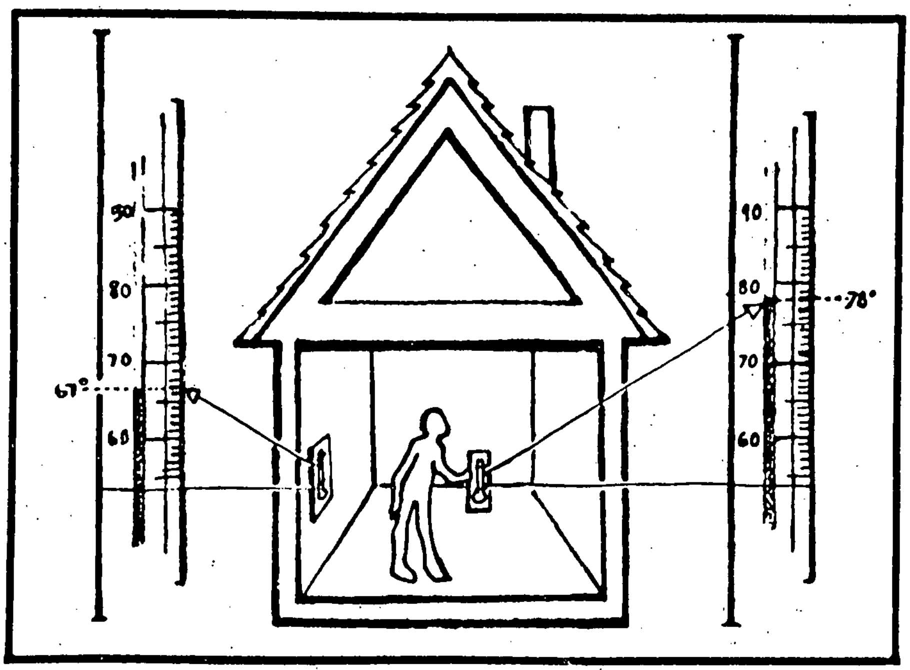
14. If your house uses a combustion type furnace, check to assure adequate direct fresh (outside) air supply direct to the combustion chamber so it won't suck air in through windows.

Extension Activities

Checking Wall Insulation

Objective: To determine the adequacy of wall insulation in a completed structure.

During the heating or cooling season, when the heating or cooling equipment is operating, place a thermometer firmly against the inside surface of an exterior wall and another in the center of the room. It's easiest to hang the thermometer on a picture nail or hook on the wall and place it in a chair in the middle of the room. Allow sufficient time for the temperatures to register and then record the two readings. If the difference between the two readings is greater than 5°F, the wall is probably not adequately insulated. The example illustrated below shows an exterior wall temperature of 67°F and a center of the room temperature of 78°F.



The next step is to determine the difference in the two readings: 78°F-67°F = 11°F. The difference is greater than 5°F, therefore, for this example, we would draw the conclusion that the wall may be inadequately insulated.

Source: Energy Conservation in the Home, University of Tennessee, Knoxville, Tennessee, 1977, p. 203-204.

Now you try this exercise at your house. You may wish to try it in several rooms with exterior walls.

Room ____________________

Outside wall thermometer reading ________________
Center of the room thermometer reading ___________

The difference between the readings:

______________ - ______________ = ______________
(higher reading) (lower reading) (difference)

Is the difference greater than 5°F? __________

Conclusions:

Are there reasons other than inadequate wall insulation which might cause a difference in the temperature readings? _______ What might they be?

Extension Activities (Continued)

1. Investigate home insulation
2. Calculate fuel savings
3. Calculate insulation costs

Sample Improvement Costs

These sample costs were used in estimating the best combination of energy conservation improvements for the various climates and fuel prices covered in this booklet. They include an allowance for commercial installation, except in the case of weather stripping and caulking which is considered to be a do-it-yourself project. While these costs are typical of 1975 prices, there may be considerable variation among specific materials, geographic locations, and suppliers. It usually is worth your time to obtain several estimates for materials and installation before making any purchase. Many of these items can be purchased at substantial discounts if you watch the advertised sales. Considerable savings may be made by installing these yourself, where possible.

ATTIC INSULATION (ALL MATERIALS)

Installed cost per square foot of attic:

R-11 = 15¢	R-44 = 57¢
R-19 = 25¢	R-49 = 64¢
R-22 = 29¢	R-57 = 74¢
R-30 = 39¢	R-60 = 78¢
R-33 = 43¢	R-66 = 86¢

WALL INSULATION (ALL MATERIALS)

Installed cost = 60¢ per square foot of net wall area*

FLOOR INSULATION (MINERAL FIBER BATT)

Installed cost:

R-11 = 20¢
R-19 = 30¢
R-22 = 34¢

DUCT INSULATION (MINERAL FIBER BLANKET)

Installed cost per square foot of material:

R-8 = 30¢	R-32 = 90¢
R-16 = 50¢	R-40 = $1.10
R-24 = 70¢	

STORM WINDOWS (TRIPLE-TRACK, CUSTOM-MADE AND INSTALLED**)

Up to 100 united inches (height + width) = $30.00
Greater than 100 united inches = $30.00 + $.60 per united inch greater than 100"

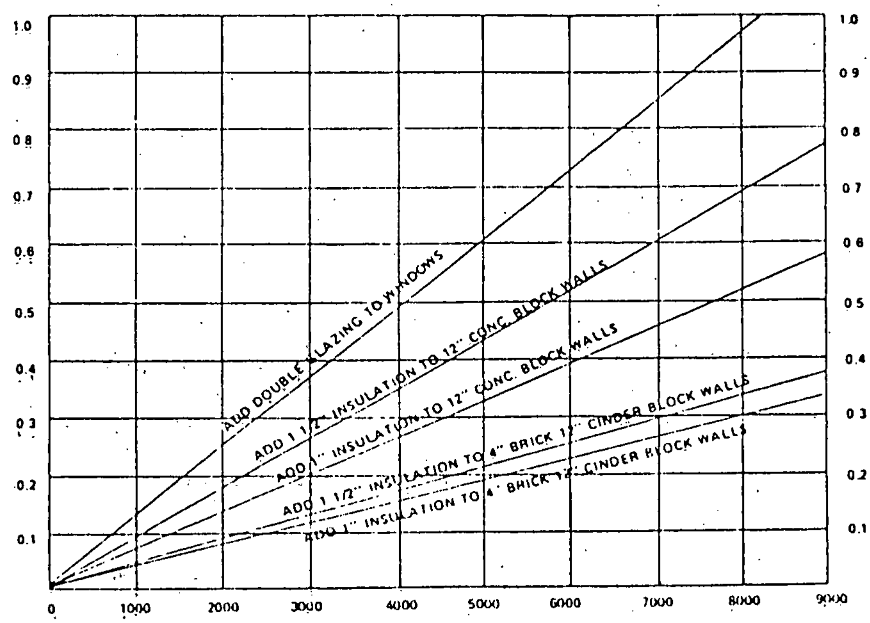
STORM DOORS (CUSTOM-FITTED AND INSTALLED**)

All sizes = $75.00

WEATHER STRIPPING AND CAULKING

Prices vary according to material used. Use the most durable materials available.

Savings From Better Insulation



Gallons of oil-equivalent saved per square foot of building per season vs. degree-days per season by using insulation and double-glazed windows, according to 3M standards. A degree-day is measured from 65°F; one such day is counted for each degree that the temperature drops below that level on each day of the heating season. A cooling season's degree-days above 65°F are counted

Energy Research Reports

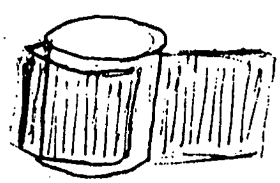
Student Activity Sheet

Name ______________________

Date ____________________

Today you will explore heat conduction and how heat loss can be minimized by the use of insulation.

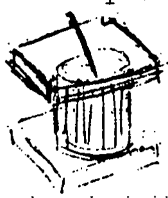
A. Obtain 4 (or 5) soup cans, newspaper, scissors, tape and thermometers as directed. Cut the newspaper in strips equal to the height of the tin can. Wrap 2 cans with 10 layers of newspaper as shown and fasten in place with tape.



B. Make 3 "blankets" of newspaper about 9cm square and 10 layers thick. Put a hole in the center of each of 2 of these through which you can insert a thermometer.

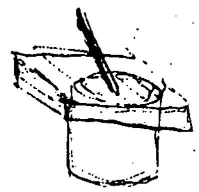
C. Heat water to boiling and carefully add 200ml (approximately 3cm) to each can.

D. Set up and label cans as shown:



#1 Insulate sides, top and bottom

#2 Insulate only sides



#3 Insulate only top

#4 No insulation (control)

See if you can insulate this to give best results.

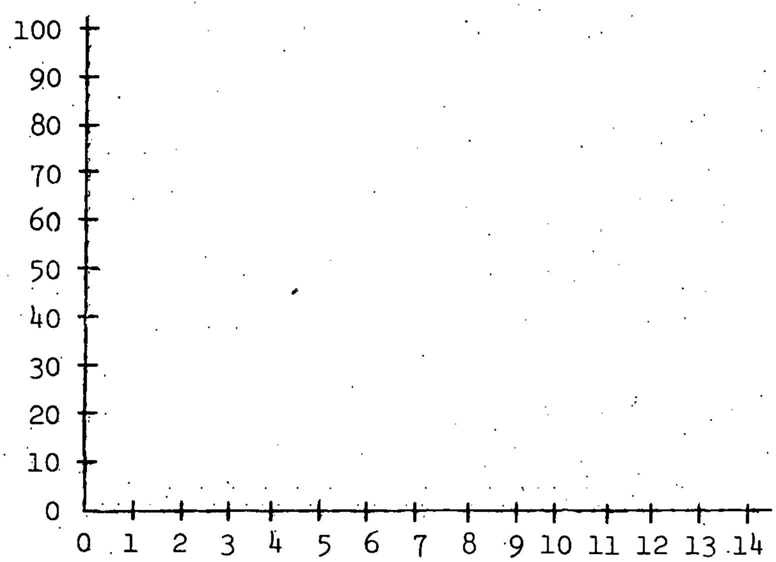
#5

E. Record the temperature of the water in each case at time intervals of 1 minute and plot the values on the graph provided.

F. If time permits, repeat the experiment several times, average your values, then graph your results.

G. If your teacher directs you to consider heat gain, repeat the experiment substituting ice water for boiling water in Step C.

H. Compare the results of this experiment using your graphs, then answer the questions.



Questions

1. a) Which can lost heat the fastest? ______ Why? ____________________

____

   b) Which can lost heat the slowest? ______ Why? ____________________

____

2. How much heat was lost by can #1? ____________________

by can #4? ____________________

by can #5? ____________________ (optional)

To calculate the amount of heat lost (or gained) use the formula:

$$Q = TM$$

Q = heat in calories

T = change in temperature in °C $(T - T_o)$

M = mass in grams (Remember for water 1 ml = 1g)

3. Compare the values for the heat loss of can #1 with that of can #4. Does insulation have a significant effect on heat loss? ____________

Explain: ____

4. Did minimal insulation (cans #2 and #3) have any effect on heat loss?

____

If you observed heat gain using ice water, answer questions 1 - 4 to see if insulation also effected the way the water in the can gained heat.

This model roughly approximates your home:

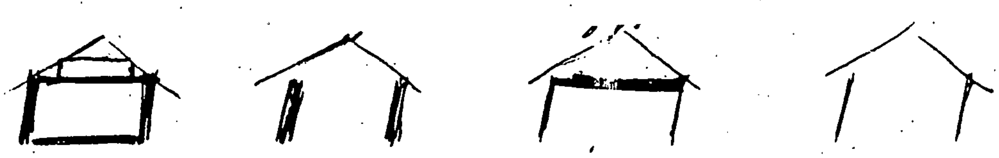
Can #1 would represent a well insulated house;

Can #2 a house with insulation only on walls;

Can #3 a house with ceiling insulation; and

Can #4 a house with insufficient or no insulation.

Which would you choose?



#1 #2 #3 #4

A SWITCH IN TIME SAVES
Solving the Energy Problem

Objectives

The student should be able to:

a) Optimize solutions for energy problems.

b) Describe options the US government may have in dealing with the "energy crisis".

Overview

This activity will have students develop solutions to problems first by themselves, then in small groups and last in a class discussion. Students may role play.

Materials

Student activity sheets

Policy option charts (one per student)

Strategy

Have students, individually, identify in writing the possible options which the US government could consider in dealing with energy problems. At first, give students no guidance or suggestions.

After students have worked independently for a brief period, group students (4-6 students) to develop one list of options.

Bring entire class together. Have each group present the list of options. Have them explain their selection.

Give each student a copy of the handout "policy options".

In original groups, ask students to list 5 options in order in which they would recommend them to the government.

Bring the class together again to hear group reports. Allow time for discussion based on the lists of options.

Consider having the class read a consensus on 5 of the best options. At this point they should be directed to write to the appropriate person in the government, giving their suggestions.

Notes to the Teacher

If students need training in working in groups, teachers might use some of the activities in "Learning Discussion Skills Through Games". Gene and Barbara Stanford, Citation Press, $2.00.

Student Activity Sheet

Name ____________________

Date ____________________

Policy Options

I. Status Quo - Growing dependence on oil imports.

II. Status Quo Plus Oil Stockpiles

III. Expand Domestic Supplies

- A. Fewer environmental constraints
- B. Deregulate domestic prices
- C. Expand sale and leasing of government land
- D. Raise price of imports
- E. Expand research and development activity

IV. Lower Domestic Demand

- A. Raise prices
- B. Raise required efficiency standards
- C. Expand research and development activity to increase efficiency of energy use

Present Dilemma

Degree of uncertainty as to options to be chosen by US government

Degree of uncertainty as to OPEC behavior

Effect of uncertainty on private investment planning

Choosing between trade-offs

A WORD TO THE WISE

Energy Vocabulary

Objectives

The student should be able to:

a) Define technical energy vocabulary needed to study the chart.

b) Practice skills needed to independently acquire necessary technical vocabulary for the study of energy.

Overview

The technical language of a subject generally causes communication problems for students. Given the limitations of time and the extensiveness of the curriculum, it is not possible for a classroom teacher to teach every technical word that his/her students will encounter during the study of a subject.

The solution is to teach a few words in such a way that there is economy of time through transfer of skills. Teach 3 to 5 carefully chosen words so that word analysis, word recognition and word meaning skills are developed. Consistency in this procedure develops students' competence to the point that they can apply skills independently to untaught words.

Materials

Vocabulary list

Pre-post test

Extension activities #1-5

Strategy

Use the following criteria to develop a list of words to be taught: (1) key concepts, (2) relative value and (3) student competence. From the list, select several words to teach carefully emphasizing context, structure or phonetic analysis as appropriate. Choose words because of the skill which can be developed.

What do you do with the remaining words on the list? Pronounce the words for the students, calling attention to letter sequence and configuration. Teacher may give meaning if no aid is provided in the text. Meanings may be drawn from the class as part of inductive development of concepts.

Many times the mere pronunciation of the words will trigger associations with listening and speaking vocabulary.

Notes to the Teacher

Many of the strategies for these instructional activities are taken from Harold Herber's book "Teaching Reading in the Content Areas", Prentice Hall, 1970, Chapter 8.

A vocabulary list is included. Teachers may wish to select words from this list rather than use the entire list. Teachers may wish to add other words appropriate for the energy unit they teach.

Extension Activities

Several activity sheets will be found in the student materials section. These are examples of exercises for the reinforcement of vocabulary. It is possible to develop reinforcement activities at the literal, interpretive and applied level. Some of these (example #1) require students to categorize - an essential ingredient in concept development. This is an interpretive level exercise.

Sample Responses - Extension activity #1

Directions: Listed below are several words from the energy unit. They can be grouped under 3 broad categories. Look for relationships among the words and identify the three categories, listing the appropriate words under each category.

coal, oceans, sun, petroleum, breeder, tides, natural gas, uranium, fission, geothermal, fusion, shale oil, reactor, sun, radiation, wind, waste material

Nuclear	Fossil Fuels	Free Fuels
fission	natural gas	wind
fusion	petroleum	sun
breeder	shale oil	tides
reactor	coal	oceans
radiation		waste material
uranium		geothermal

Sample Responses - Extension activity #2

Directions: In each row of words below, two words are the same. Find the word which is used twice and write it in the space provided.

1. generation   generation generating general generation generic
2. demand   demand remand demean demeanor demand
3. electricity   electricity electrify electrical electrolysis electricity
4. thermal   temporal thermal therm thermometer thermal
5. geothermal   geology geothermal general geography geothermal
6. joule   boule joule goule jewel joule
7. watt   what watt wat watt wait
8. turbine   turbine turbine turbin touring turkey
9. nuclear   nuclear nucleus nuke nuclear nuclei
10. fuel   fool feul feel fuel fuel

Sample Responses - Extension activity #3

Directions: To solve this puzzle, look at the definitions below. Think of a word which fits the definition, has the same number of letter as the number of spaces provided in the corresponding line, and has the given letter in the same position as indicated. Write the word on the line.

1. i n d e p e n d e n c e
2. N u c l e a r
3. d E m a n d
4. s o l a R
5. G e n e r a t i o n
6. s u p p l Y

Definitions:

1. State of being free from outside control.
2. Refers to being within the nucleus of an atom.
3. Rate at which electric energy is delivered to or by a system at a given instant or averaged over any designated period of time, expressed in kilowatts or other suitable units.
4. Radiated directly from the sun.
5. The act or process of producing electric energy from other forms of energy.
6. The amount of energy available for use.

Sample Responses - Extension activity #4

Directions: In each of the sets below, 3 of the words are related. Circle the word that is unrelated. On the line at the top of the set, write the word or phrase that explains the relationship existing among the remaining 3 words.

Fossil Fuels
1. PETROLEUM
COAL
WATER
NATURAL GAS

Energy Measurements
2. KILOWATT
THERM
BTU
ELECTRON

Load
3. PEAK
AVERAGE
BASE
WATT

Energy
4. SOLAR
WIND
NUCLEAR
TURBINE

Power Plants
5. HYDROELECTRIC
THERMAL
CONVECTIONAL
NUCLEAR

Energy
6. KINETIC
NUCLEAR
POWER
POTENTIAL

Sample Responses - Extension activity #5

Directions: Each of the scrambled words below is followed by a definition that states the meaning of the word when put in its correct spelling. Read each of the definitions and then unscramble the word to mean a word corresponding to the given definition. Write the new word in the blank given.

1. RYGENE The capacity to do work — Energy
2. ARELNUC Having to do with energy in an atom's nucleus — Nuclear
3. MADEDN Rate at which energy is delivered — Demand
4. OLSIFS Fuels derived from remains of organic materials — Fossil
5. TLAROGEMH Energy within the earth's crust — Geothermal
6. LAOSR Energy radiated directly from the sun — Solar
7. WROPE Rate at which energy is used — Power
8. TICKENI Energy possessed by objects in motion — Kinetic
9. DERCU Oil units natural state — Crude
10. EROALCI Heat needed to raise temp. of 1g of water 1°C — Calorie

GLOSSARY

Biomass
Calorie
Chemical energy
Conventional hydroelectric plant
Demand
Electricity
Electron
Energy
Energy potential
Fossil fuels
Generation
Generator
Geothermal energy
Hydropower
Load, base
Load, peak
Kinetic energy
Nuclear energy
Peaking plant
Power
Pumped storage plant
Reserve generating capacity
Solar energy
Spinning reserve
System reserve capacity
Thermal plant
Transmission gradient

ENERGY MEASUREMENTS

Barrell
British Thermal Unit (BTU)
Watt
Kilowatt
Kilowatt hour
Megawatt
Therm

GLOSSARY

APPLIANCE SATURATION

Ratio of the number of homes using a specific appliance to the total number of homes.

AVERAGE MEGAWATT

A unit of average energy output over a specified time period (total energy in megawatt-hours divided by the number of hours in the time period).

BASE LOAD

See Load, Base.

BIOMASS

Organic living material from which energy can be extracted.

BLOWDOWN

Water drawn from boiler systems and cold water basins of cooling towers to prevent buildup of solids concentrations. Usually contains chemicals used for pH adjustment and slime control.

BRITISH THERMAL UNIT (BTU)

The standard unit for measurement of the amount of heat energy, such as the heat content of fuel. Equal to the amount of heat energy necessary to raise the temperature of one pound of water one degree Fahrenheit.

CALORIE

The amount of heat needed to raise the temperature of 1 gram of water 1 degree Centigrade. About as much heat as is given off by burning one wooden kitchen match.

CAPABILITY

The maximum load which a generator, turbine, power plant, transmission circuit, or power system can supply under specified conditions for a given time interval without exceeding approved limits of temperature and stress.

Maximum Plant Capability (Hydro)

The maximum load which a hydroelectric plant can supply under optimum head and flow conditions without exceeding approved limits of temperature and stress. This may be less than the overload rating of the generators due to encroachment of tailwater on head at high discharges.

Peaking Capability

The maximum peak load that can be supplied by a generating unit, station, or system in a stated time period. For a hydro project the peaking capability would be equal to the maximum plant capability only under favorable pool and flow conditions, often the peaking capability may be less due to reservoir drawdown or tailwater encroachment.

Ultimate Plant Capability (Hydro)

The maximum plant capability of a hydroelectric plant when all contemplated generating units have been installed.

CAPACITY

The load for which a generator, transmission circuit, power plant, or system is rated. Capacity is also used synonymously with capability.

Dependable Capacity

The load-carrying ability of a station or system under adverse conditions for the time interval and period specified when related to the characteristics.

CAPACITY FACTOR

The ratio of the average load on the generating plant for the period of time considered to the capacity rating of the plant. Unless otherwise identified, capacity factor is computed on an annual basis. In this Appendix, the capacity factor of a hydro plant is based on maximum plant capability and assumed load equal to the average annual energy.

CHEMICAL ENERGY

Energy stored in molecules, as in fossil fuels.

CIRCULATING WATER

See Condenser cooling water. In a closed-cycle cooling system, this refers to the heated water from the condenser which is cooled, usually by evaporative means, and recycled through the condenser.

CONDENSER COOLING WATER

Water required to condense the steam after its discharge from a steam turbine.

CONVENTIONAL HYDROELECTRIC PLANT

A hydroelectric power plant which utilizes streamflow only once as it passes downstream, as opposed to a pumped-storage plant which recirculates all or a portion of the streamflow in the production of power.

COOLING WATER CONSUMPTION

The cooling water withdrawn from the source supplying a generating plant which is lost to the atmosphere. Caused primarily by evaporative cooling of the heated water coming from the condenser. The amount of consumption (loss) is dependent on the type of cooling employed - direct (once-through) cooling pond, or cooling tower. When not returned to the source of supply, blowdown is also included as a consumptive loss.

COOLING WATER LOAD

Waste heat energy dissipated by the cooling water.

COOLING WATER REQUIREMENT

The amount of water needed to pass through the condensing unit in order to condense the steam to water. This amount is dependent on the type of cooling employed and water temperature.

COORDINATED COLUMBIA RIVER SYSTEM

Contractually, the system of hydroelectric projects located on the Columbia River and major tributaries which are operated together on a coordinated basis under the terms of the Pacific Northwest Coordination Agreement.

CRUDE OIL

Petroleum in its natural state.

DEMAND

The rate at which electric energy is delivered to or by a system at a given instant or averaged over any designated period of time, expressed in kilowatts or other suitable units.

DRAWDOWN

The distance that the water surface of a reservoir is lowered from a given elevation as the result of the withdrawal of water. Drawdown may refer to the maximum drawdown for power operation, from normal full pool to minimum power pool. Sometimes drawdown is also expressed in terms of acre-feet of storage withdrawn.

ELECTRICITY

Energy derived from electrons in motion.

ELECTRO-PROCESS INDUSTRY

An industry which required very large amounts of electricity in manufacturing for heat or chemical processes (as distinguished from wheel-turning or mechanical applications). Examples are electric furnace steel, aluminum, and chlorine.

ELECTRON

An elementary particle, with a negative charge, which circles the nucleus of an atom.

ENERGY

That which does or is capable of doing work. It is measured in terms of the work it is capable of doing; electric energy is commonly measured in kilowatt-hours or average megawatts.

Average Annual Energy

Average annual energy generated by a hydroelectric project or system over a specified period. In the Pacific Northwest the average output of most projects is based on the historical flows experienced during the period 1928-58, as modified by appropriate irrigation depletions.

Firm Energy

Electric energy which is considered to have assured availability to the customer to meet all or any agreed upon portion of his load requirements. Firm energy is based on certain specified probability considerations, which, in the Pacific Northwest, are related to the 1928-58 sequence of historical streamflows adopted for making system power regulations. System firm energy capability includes hydro system prime energy, thermal plant energy capabilities, and firm imports.

Kinetic Energy

Energy possessed by objects in motion.

Potential Energy

Energy that is stored in matter because of its position or because of the arrangements of its parts. Examples include the tension of a spring, water stored behind a dam, or chemical energy such as that contained in fuel.

Prime Energy

Hydroelectric energy which is assumed to be available 100% of the time: specifically, the average energy generated during the critical period.

Secondary Energy

All hydroelectric energy other than prime energy: specifically, the difference between average annual energy and prime energy.

Usable Energy

All hydroelectric energy which can be used in meeting system firm and secondary loads. In the early years of this study, it is possible that there may not be a market for all of the secondary energy which could be generated in years of abundant water supply and some of the water may have to be diverted over project spillways and the energy wasted.

ENERGY CONTENT CURVE

A seasonal guide to the use of reservoir storage for at-site and downstream power generation. It is based on the following constraints: (1) During drawdown sufficient storage shall remain in the reservoir to insure meeting its share of the system firm energy requirements in the event of critical period water conditions, (2) Draft of storage for secondary energy production is permitted only to the extent that it will not jeopardize reservoir refill by the end of the coming July. Drafting below the assured refill level is permitted only if required to meet firm energy loads or if such draft is secured by a commitment to return energy equivalent to the drafted water if refill is not otherwise accomplished.

FOSSIL FUELS

Coal, oil, natural gas, and other fuels originating from fossilized geologic deposits and depending on oxidation for release of energy.

GENERATION

The act or process of producing electric energy from other forms of energy; also the amount of electric energy so produced.

GENERATOR

A machine for changing mechanical energy into electrical energy.

GEOTHERMAL ENERGY

Heat energy within the earth's outer crust.

GIGAWATT

One million kilowatts.

HEAD

Gross Head

The difference of elevations between water surfaces of the forebay and tailrace under specified conditions. In this Appendix, gross head generally refers to the difference between normal full pool and average tailwater.

Net Head (Effective Head)

The gross head less all hydraulic losses except those chargeable to the turbine.

HEAT RATE

A measure of generating station thermal efficiency, generally expressed as BTU per (net) kilowatt-hour. It is computed by dividing the total BTU content of the fuel burned (or of heat released from a nuclear reactor) by the resulting net kilowatt-hours generated.

HYDRAULIC CAPACITY

See Capacity, Hydraulic.

HYDROPOWER

Energy in stored or moving water.

INDEPENDENT RESOURCES (HYDROELECTRIC)

The hydroelectric projects of the region which are not included in the Coordinated Columbia River System.

IMPORTS

Power imported from outside the Columbia-North Pacific Region System.

INTERTIE

See Transmission Interconnection.

KINETIC ENERGY

Energy possessed by objects in motion.

LOAD

The amount of power delivered to a given point.

Base Load

The minimum load in a stated period of time.

Firm Load

That part of the system load which must be met with firm power.

Peak Load

Literally, the maximum load in a stated period of time. Sometimes the term is used in a general sense to describe that portion of the load above the base load.

LOAD DIVERSITY

Literally refers to the difference between (1) the sum of the separate peak loads of two or more load areas and (2) the actual coincident peak load of the combined areas. As used in this Appendix, the term applies to the load diversity between two load areas which occurs when their annual peak loads occur in different seasons of the year.

LOAD FACTOR

The ratio of the average load over a designated period to the peak load occurring in that period. In this Appendix the term applies to annual load factor unless otherwise specified.

LOAD SHAPE (LOAD PATTERN)

The characteristic variation in the magnitude of the power load with respect to time. This can be for a daily, weekly, or annual period.

LOSSES (ELECTRIC SYSTEM)

Total electric energy loss in the electric system. It consists of transmission, transformation, and distribution losses and unaccounted-for energy losses between sources of supply and points of delivery.

MOTOR

A machine that converts chemical or electrical energy into mechanical energy.

NORMAL FULL POOL

The maximum forebay water surface elevation within the reservoir's normal operating range.

NUCLEAR ENERGY

Energy within the nucleus of the atom. It can be released by nuclear fission or nuclear fusion.

PEAK LOAD

See Load, Peak.

PEAKING

Power plant operation to meet the variable portion of the daily load. See Load, Peak.

PEAKING PLANT

A power plant which is normally operated to provide all or most of its generation during maximum load periods.

PENSTOCK

A conduit to carry water to the turbines of a hydroelectric plant (usually refers only to conduits which are under pressure).

PLANT FACTOR

Same as Capacity Factor.

PONDAGE

Reservoir power storage capacity of limited magnitude that provides only daily or weekly regulation of streamflow.

POWER

The time rate of transferring energy. Note -- The term is frequently used in a broad sense, as a commodity of capacity and energy, having only general association with classic or scientific meaning.

POWER SUPPLY AREA

Geographic grouping of electric power supplies as established by the Federal Power Commission in accordance with utility service areas.

PUMPED STORAGE PLANT

A hydroelectric power plant which generates electric energy for peak load use by utilizing water pumped into a storage reservoir during off-peak periods.

REREGULATING RESERVOIR

A reservoir located downstream from a hydroelectric peaking plant having sufficient pondage to store the widely fluctuating discharges from the peaking plant and release them in a relatively uniform manner downstream.

RESERVES

Reserve Generating Capacity

See Capacity, Reserve.

Spinning Reserve

Generating capacity connected to the bus and ready to take load. It also includes capacity available in generating units which are operating at less than their capability.

System Reserve Capacity

The difference between the available dependable capacity of the system, including net firm power purchases, and the actual or anticipated peak load for a specified period.

RULE CURVE

A seasonal guide to the use of reservoir storage.

RUN-OF-CANAL PLANT

A hydroelectric plant similar to a run-of-river plant but located on an irrigation canal or waterway instead of a stream.

RUN-OF-RIVER PLANT

A hydroelectric plant which depends chiefly on the flow of a stream as it occurs for generation, as opposed to a storage project, which has sufficient storage capacity to carry water from one season to another. Some run-of-river projects have a limited storage capacity (pondage) which permits them to regulate streamflow on a daily or weekly basis.

STORAGE PROJECT

A project with a reservoir of sufficient size to carry over from the high-flow season to the low-flow season and thus to develop a firm flow substantially more than the minimum natural flow. A storage project may have its own power plant or may be used only for increasing generation at downstream plants.

TAILWATER

The water surface immediately downstream from a dam or hydroelectric powerplant.

THERMAL PLANT

A power generating plant which uses heat to produce energy. Such plants may burn fossil fuels or use nuclear energy to produce the necessary thermal energy.

TRANSMISSION GRID

An interconnected system of electric transmission lines and associated equipment for the movement or transfer of electric energy in bulk between points of supply and points of demand.

TRANSMISSION INTERCONNECTION (INTERTIE)

Transmission circuit used to tie or interconnect two load areas or two utility systems.

ULTIMATE DEVELOPMENT

The maximum contemplated generating installation at a power plant.

Extracted from "Electrical Power", Appendix VX, Columbia-North Pacific Region Comprehensive Framework Study, October, 1977. Bonneville Power Administration

Extension Activity #1

Directions: Listed below are several words from the energy unit. They can be grouped under 3 broad categories. Look for relationships among the words and identify the three categories, listing the appropriate words under each category.

coal, oceans, sun, petroleum, breeder, tides, natural gas, uranium, fission, geothermal, fusion, shale oil, reactor, sun, radiation, wind, waste material

<u>Nuclear</u>	<u>Fossil Fuels</u>	<u>Free Fuels</u>

Extension Activity #2

Directions: In each row of words below, two words are the same. Find the word which is used twice and write it in the space provided.

1. ____________ generation generating general generation generic

2. ____________ demand remand demean demeanor demand

3. ____________ electricity electrify electrical electrolysis electricity

4. ____________ temporal thermal therm thermometer thermal

5. ____________ geology geothermal general geography geothermal

6. ____________ boule joule goule jewel joule

7. ____________ what watt wat watt wait

8. ____________ turbine turbine turbin touring turkey

9. ____________ nuclear nucleus nuke nuclear nuclei

10. ____________ fool feul feel fuel fuel

Extension Activity #3

Directions: To solve this puzzle, look at the definitions below. Think of a word which fits the definition, has the same number of letter as the number of spaces provided in the corresponding line, and has the given letter in the same position as indicated. Write the word on the line.

1. _ _ _ E _ _ _ _ _ _ _ _
2. N _ _ _ _ _ _
3. _ E _ _ _ _
4. _ _ _ _ R
5. G _ _ _ _ _ _ _ _ _
6. _ _ _ _ _ Y

Definitions:

1. State of being free from outside control.
2. Refers to being within the nucleus of an atom.
3. Rate at which electric energy is delivered to or by a system at a given instant or averaged over any designated period of time, expressed in kilowatts or other suitable units.
4. Radiated directly from the sun.
5. The act or process of producing electric energy from other forms of energy.
6. The amount of energy available for use.

Extension Activity #4

Directions: In each of the sets below, 3 of the words are related. Circle the word that is unrelated. On the line at the top of the set, write the word or phrase that explains the relationship existing among the remaining 3 words.

____
1. PETROLEUM
   COAL
   WATER
   NATURAL GAS

____
2. KILOWATT HOUR
   THERM
   BTU
   ELECTRON

____
3. PEAK
   AVERAGE
   BASE
   WATT

____
4. SOLAR
   WIND
   NUCLEAR
   TURBINE

____
5. HYDROELECTRIC
   THERMAL
   CONVECTIONAL
   NUCLEAR

____
6. KINETIC
   NUCLEAR
   POWER
   POTENTIAL

Extension Activity #5

Directions: Each of the scrambled words below is followed by a definition that states the meaning of the word when put in its correct spelling. Read each of the definitions and then unscramble the word to mean a word corresponding to the given definition. Write the new word in the blank given.

1. RYGENE The capacity to do work ____________
2. ARELNUC Having to do with energy in an atom's nucleus ____________
3. MADEDN Rate at which energy is delivered ____________
4. OLSIFS Fuels derived from remains of organic materials ____________
5. TLAROGEMH Energy within the earth's crust ____________
6. LAOSR Energy radiated directly from the sun ____________
7. WROPE Rate at which energy is used ____________
8. TICKENI Energy possessed by objects in motion ____________
9. DERCU Oil units natural state ____________
10. EROALCI Heat needed to raise temp. of 1g of water $1^{o}C$ ____________

FASTER THAN A SPEEDING BULLET

Does the Speed of Any Device Which Uses Energy Affect the Amount of Energy Used?

Objectives

Students should be able to:

a) Experimentally develop a relationship between speed of a D.C. motor (rpm) and number of watts of power required.

b) Graph data and analyze same.

c) Think in terms of energy consumed per performance unit, watts per rpm.

d) On the basis of this experiment and analysis develop a parallel to the automobile as an energy consuming device.

e) Evaluate the relationship between gasoline consumption and speed, mpg/mph.

f) Identify the major factors affecting gasoline consumption at different speeds.

Overview

In this lesson students will, in the laboratory, examine energy consumption as a function of performance. Three activities are slated for this lesson.

Activity I "Hands on" is an activity to determine the relationship between energy consumed and speed. Two to three students per group for this activity.

Activity II involves the same groups of students who are given a data table showing the gas mileage of several cars driven at various speeds. Students are to relate data to the experiment done in Activity I.

Activity III is a teacher initiated discussion: the relationships and curve-data analysis of Activity I and Activity II may not be quite the same. The discrepancy between both activities and their results could utilized as a further discussion of the factors affecting energy consumption at various speeds of the automobile.

Materials

Student Activity Sheets

DC power supply

Small electric motor

Rheostat wire

DC ammeter (0-5 amp)

DC voltmeter (0-1.5)

Stroboscope light

Graph paper (cm.)

Activity II

Ditto sheets of student questions and data of test cars indicating their consumption of gasoline at particular speeds.

Activity III

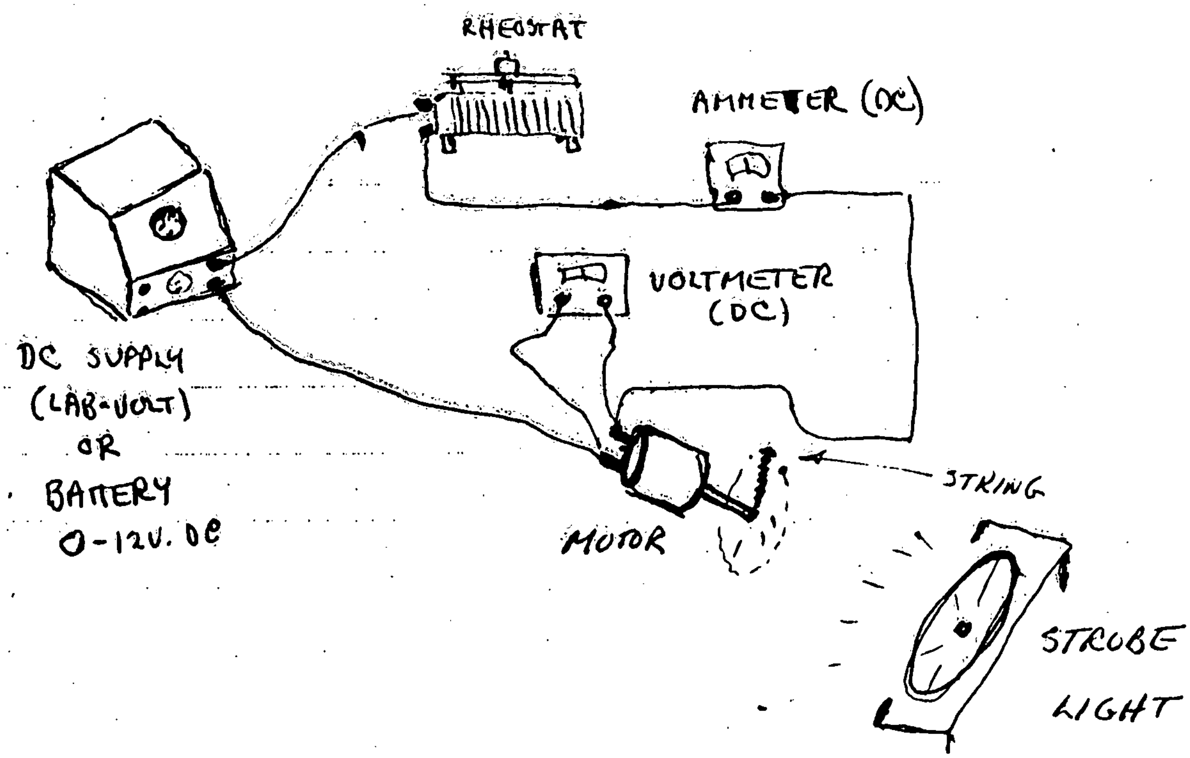
If possible, availability of power mechanics instructor or mechanic to exhibit various test instruments which are used to check automobile performance.

Duration

3 class periods

Strategy

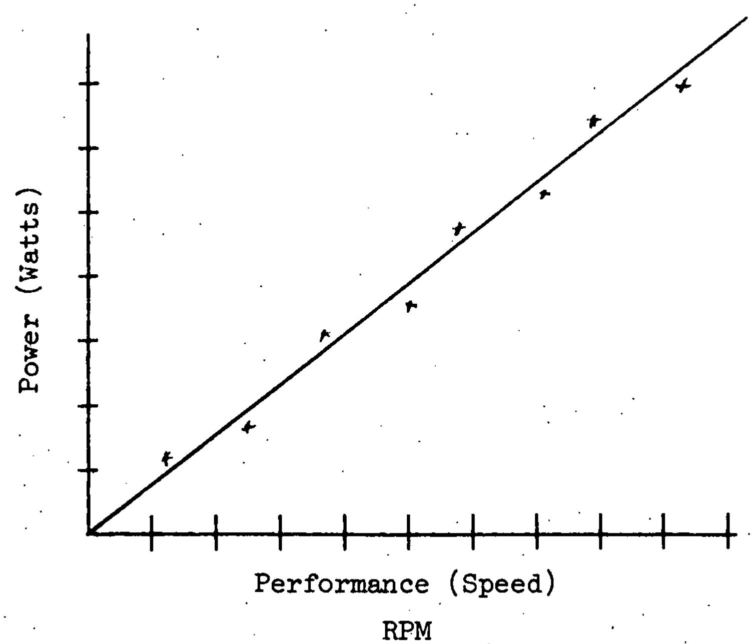
Activity I. Have students set up their own circuits and apparatus. Supply all materials from central location. A one-inch piece of string taped to the shaft of the motor (DC) will suffice as a visual blade to be used in determining the speed (rpm) of the motor when using the stroboscope.



Some preliminary discussion is necessary in the use of the strobe light. Instruct students that when a sensible-stationary picture of the rotating string is achieved, the flash-rate of the strobe light as read from the dial on the strobe is equal to the rotation rate of the motor. The reading on the dial of the strobe light varies with the make of the instrument. (This unit can be borrowed from your physics instructor.)

Activity I - Technique. After students have connected their apparatus properly, instruct them to vary the speed of the motor by varying the current to the motor using the rheostat. Current should be increased in .5 ampere steps, recording from the strobe light the rpm of the motor. Six or eight readings is sufficient for data analysis. A student data chart and graph should resemble the following:

Power	Performance
Watts	RPM
5	30
10	56
15	88
20	124
25	150
30	175



Power in Watts is determined by multiplying the voltage as read from voltmeter times the current (amps) as read from the ammeter for each speed.

Power = Volts x Amps

1 watt = 1 volt x 1 amp

Activity II. Students are given a data table showing the gas mileage of several cars driven at selected speeds. Students should graph this data to see relationships between speed and fuel consumption. After graphs are completed, students answer questions asking them to analyze the data and graphs and consider possible causes for the energy savings at lower highway speeds.

Questions:

1. From your graph, determine the mpg performance at 70 mph.

2. How much fuel is saved by a driver traveling at 50 mph as compared to a driver traveling at 70 mph? Total distance travelled by both is 10,000 miles. Response below.

   At 70 mph, 14.93 miles / gal:

   # of gallons per mile = 1 gal / 14.93 miles = .051 gal / mile

   Total # of gallons consumed in 10,000 miles at 70 mph:
   10,000 miles / 1 (.051 gal / 1 mile) = 510 gallons

   At 50 mph, 19.49 miles / gal:

   # of gallons per mile = 1 gal / 19.49 miles = .067 gal / mile
   Total # of gallons consumed in 10,000 miles at 50 mph:
   10,000 miles / 1 (.067 gal / 1 mile) = 670 gallons

   Amount saved: 670 gallons - 510 gallons = 160 gallons

3. What are the causes of the increase in gasoline consumption as speed increases?

   The two most important causes in gasoline consumption at higher speeds is rolling resistance and air drag.

   Rolling Resistance - Resistance offered by all moving parts such as wheel bearings, drive train (transmission and differential). Rolling resistance also is determined by weight of the car.

   Air Drag - Resistance due to air which engine must overcome. Depends on the shape of the car and its speed. Although most models are somewhat streamlined, much drag is a result of a poorly protected "underbelly" of the car.

4. What might be some other causes of mpg reduction at higher speeds?

   This question might be answered in Activity III. However, let students try to respond to this question by asking them to think about devices in the engine which may cause mpg reduction at high speed.

Example: Engines have shown to lose "spark" at high speed due to conventional "points" in ignition systems. Electronic ignitions are better. Are fuel injection systems better than carburator for fuel economy?

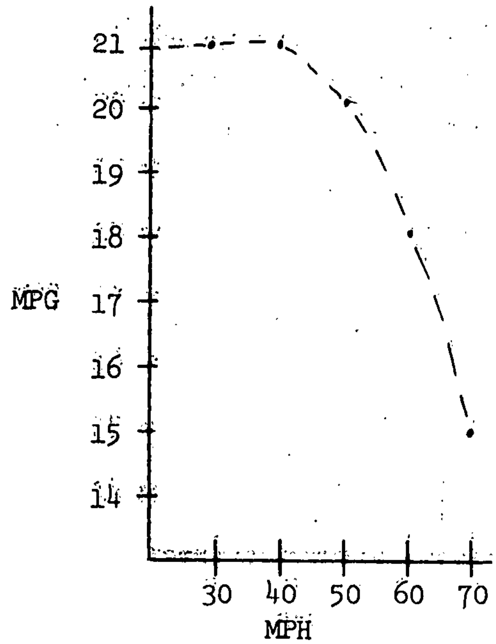
5. If you had the authority- would it be reasonable to, by law, set the speed limit at 40 mph?

The answer to this question is no. There is little savings in driving below 50 mph. A drastic change in the present driving habits would result in a negative reaction by the driving public.

Data

Effect of Speed on Fuel Consumption Rates
Automobiles

Test Car Number and Net Weight (lbs.)	Miles Per Gallon At Selected Speeds				
	30	40	50	60	70
1 (4,880)	17.12	17.20	16.11	14.92	13.13
2 (3,500)	19.30	18.89	17.29	15.67	13.32
2A (3,500)	21.33	21.33	18.94	17.40	15.36
3 (3,540)	23.67	24.59	20.46	14.83	13.42
4 (3,975)	18.25	20.00	16.32	15.77	13.61
5 (2,450)	31.45	35.19	33.05	30.78	22.82
6 (3,820)	22.88	19.41	20.28	17.78	14.88
7 (3,990)	15.61	14.89	16.98	13.67	11.08
8[1] (2,050)	(24.79)	(27.22)	(26.80)	(24.11)	N.A.
9 (2,290)	21.55	20.07	19.11	17.83	16.72
10 (2,400)	22.72	21.94	22.22	21.08	17.21
11 (5,250)	18.33	19.28	15.62	14.22	12.74
12 (4,530)	20.33	20.00	17.50	16.17	14.86
Average (Unweighted)	21.05	21.07	19.49	17.51	14.93



Activity III - Teacher Discussion. Compare and discuss energy consumption versus performance curves done in Activity I and Activity II. In Activity I it appears that the rate at which energy effects the speed of the motor is constant, whereas in Activity II the decrease in mpg as a function of speed is drastic. Point out to the students that in the simple motor experiment all the factors which might hinder performance remained fairly constant. With the automobile, it is apparent that the faster you go, many factors are brought to play which amplify the deterioration of performance. Questions might be raised such as:

Does the fuel-air mixture in the carburator change at high speeds?

How much of a temperature increase of the engine at high speeds?

Do engines operate more efficiently at lower or higher temperatures?

Might there be pre-ignition at high temperatures?

What happens to ignition spark at spark plugs at high speeds?

Invite the power mechanics instructor or an outside mechanic to explain some behaviors of the auto engine.

Student Activity Sheet I

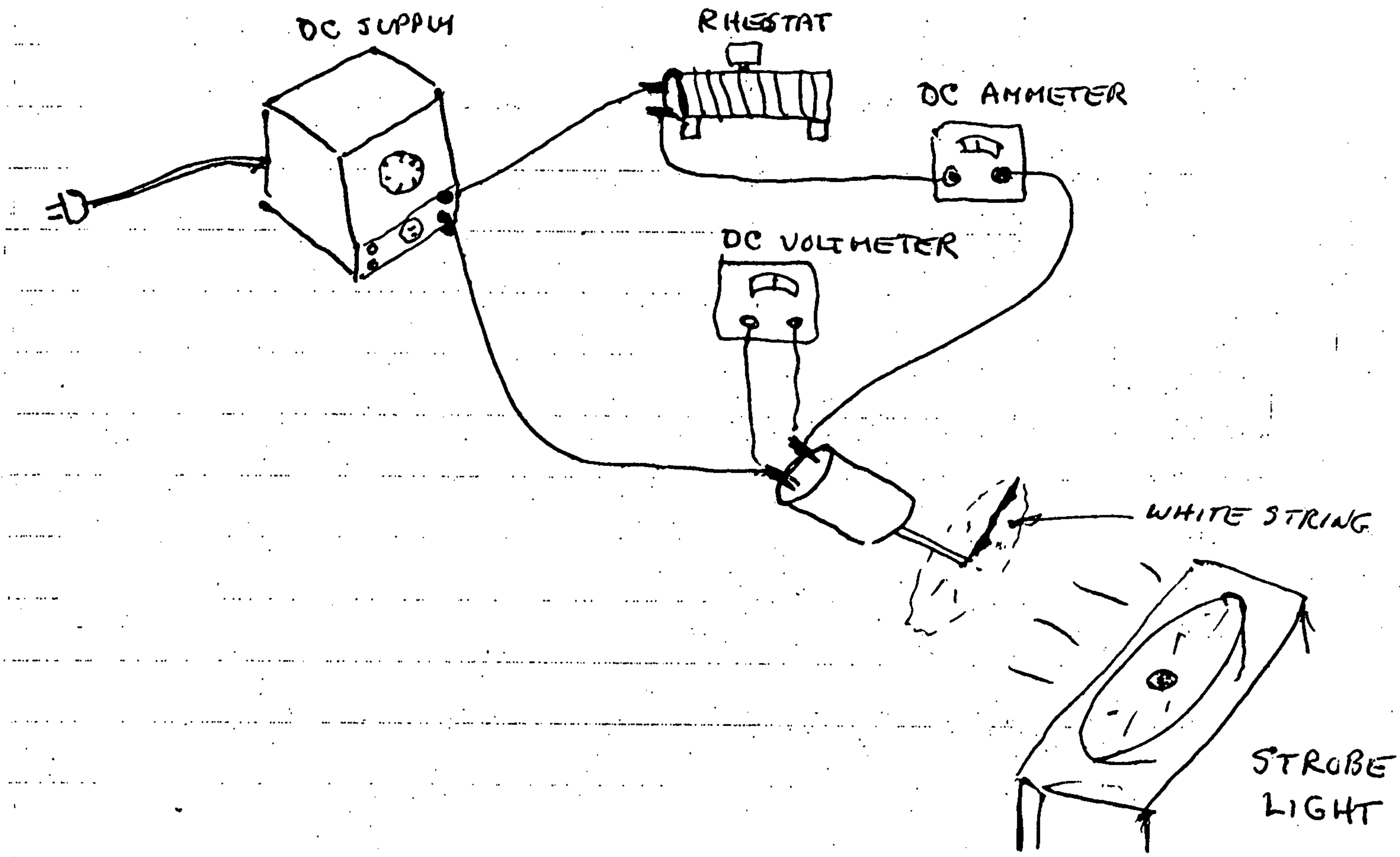
Name ______________________

Date ______________________

Objective: To study the way speed varies with power.

Materials: small DC motor (1.5V), connecting wire, DC supply (0-1.5V), DC voltmeter, (0-5 amp) DC ammeter, rheostat, strobe light, graph paper.

Procedure: Connect apparatus as indicated in the diagram.



Set the rheostat at full resistance position. Adjust the power supply so that voltage across the battery is 1.5 volts. Record the number of amperes flowing through the circuit. If the motor is turning, determine the rpm using the strobe light.

Your teacher will explain how to find the rpm from the strobe light. Record the voltage and amperes in the data table. Record the rpm of the motor in the data table. Adjust rheostat so that current increases in

	Volts	Amps	Power (Watts) Volts x Amps	RPM
Speed 1				
2				
3				
4				
5				
6				

.5 amp steps. Record volts, amps, and rpm for every .5 amp increase. Do this procedure for at least six different speeds. Multiply volts x amps to tell how much power was supplied at each speed. Plot the points on graph paper supplied to you.

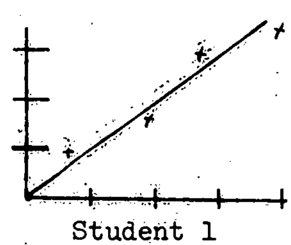
Questions:

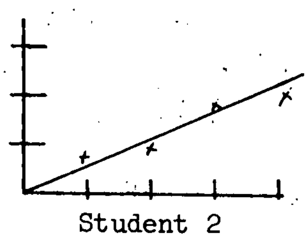
1. How does speed of motor behave when energy is increased?

2. Compare your graph with other groups of students doing this experiment. Are there any differences?

3. What factors might be involved if your graph has a different slope* than someone else?

*Slope of Line





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Student Activity Sheet II

Name ____________________

Date ____________________

The data table which you have been given is the miles per gallon (mpg) at various speeds for different weighted automobiles. The average miles per gallon at these speeds is given in the bottom horizontal row. On the vertical axis of the graph paper plot the mpg. Remember that the range of values for mpg is 14 to 22. Make the origin 14; and divide your graph paper vertically so that the uppermost value is 22. Let the horizontal axis denote speed in mph (miles per hour). Plot the five values of mpg versus mph.

Data

Effect of Speed on Fuel Consumption Rates
Automobiles

Test Car Number and Net Weight (lbs.)	Miles Per Gallon At Selected Speeds 30	40	50	60	70
1 (4,880)	17.12	17.20	16.11	14.92	13.13
2 (3,500)	19.30	18.89	17.29	15.67	13.32
2A (3,500)	21.33	21.33	18.94	17.40	15.36
3 (3,540)	23.67	24.59	20.46	14.83	13.42
4 (3,975)	18.25	20.00	16.32	15.77	13.61
5 (2,450)	31.45	35.19	33.05	30.78	22.82
6 (3,820)	22.88	19.41	20.28	17.78	14.88
7 (3,990)	15.61	14.89	16.98	13.67	11.08
8[1] (2,050)	(24.79)	(27.22)	(26.80)	(24.11)	N.A.
9 (2,290)	21.55	20.07	19.11	17.83	16.72
10 (2,400)	22.72	21.94	22.22	21.08	17.21
11 (5,250)	18.33	19.28	15.62	14.22	12.74
12 (4,530)	20.33	20.00	17.50	16.17	14.86
Average (Unweighted)	21.05	21.07	19.49	17.51	14.93

Using the average values of mpg at selected speeds make a graph of mpg versus mph. Choose the "X" axis as mph.

Questions:

1. From your graph, determine the mpg performance at 65 mph.

2. How much fuel is saved by a driver traveling at 50 mph as compared to a driver traveling at 70 mph? Total distance travelled by both is 10,000 miles.

3. What are the major causes of the increase in gasoline consumption at higher speeds?

4. Can you think of other causes which might be attributed to the engine or automobile itself?

5. If you had the authority, would it be reasonable by law to set the speed limit at 40 mph?

BETTER InfraRED THAN DEAD

Identification of Infiltration Heat Losses and Their Control

Objectives

The student should be able to:

a) Recognize that heat loss through cracks, caulking, breaks, foundation, window and door openings are significant and must be dealt with if fuel and money are to be saved in house heating.

b) Make informed judgments concerning whether and where to insulate the home.

c) Recognize that entrance and exits from the house produce considerable infiltration heat loss and plan to reduce door use appropriately.

Overview

Each cubic foot of cold air that enters the house requires .2 BTU to raise its temperature 1°F. A typical house has an air exchange equal to the full volume of the house every 1.5 hours. The recommended air exchange for good house ventilation is 1 volume/10 hours. Most of the excessive air exchange is due to infiltration of air through open doors, open windows, open fireplace dampers, electrical outlet air leaks on outside walls, poor fitting windows and doors, foundation to structure leaks, caulking deficiencies and the like and can be controlled. Heat loss due to infiltration represents 55.2% of the heating budget and must be examined carefully if a significant reduction in fuel consumption is to be achieved.

Materials

Roll of infra-red film ($3.50/20 exposures roll, color)

35mm camera

Strategy

Define infiltration, demonstrate the use of the 35mm camera. Take a picture of the exterior of the home from each view. Take an additional picture with a door and window open. Process the film and review the pictures in order to identify heat loss areas. Modify the house as the pictures indicate, retake pictures and compare them. If money and time are available, students can take their own picture in their homes.

Notes to the Teacher

Be sure to do the photography on a day when the house is warmer than the outside air. (The greater the temperature difference, the easier it will be to identify problem areas.) On color film green indicates heat loss areas. Film cost is $3.50 for 20 exposures. The processing of black and white prints is $3.00 and color slides are $3.50.

Extension Activities

1. Examination of the school heat loss or the individual classroom loss should be considered.
2. Examination of various insulating materials and their role on specific jobs can be explored.

Student Activity Sheet

Name ______________________

Date ______________________

1. What is infiltration? BTU?

2. How much does it cost per month for the lost heat due to infiltration of cold air?

3. What does the photographic set tell about the use of a door in the winter?

4. How can infiltration be reduced?

PEOPLE IN GLASS HOUSES SHOULDN'T . . .

Radiation Heat Loss Through Windows

Objectives

The student should be able to:

a) State the need to reduce radiation heat loss from the home.

b) Recognize the insulating qualities of various common window insulators such as drapes, shades, etc.

c) Evaluate the radiation loss existing at home and attempt to reduce this loss.

Overview

By constructing a simulation of the condition that exists during the heating season, analysis of radiation heat loss through glazing is possible. The model produces a realistic opportunity to study full heat loss that occurs through glazing. The glazed surface can be varied and data collected to determine the maximum desirable window area and the configuration of these windows. The effect of additional insulation in the window area can also be explored. Since almost .5% of the home heat is lost through glass, an obvious incentive exists to consider the messages of the lesson.

Materials

Styrofoam sheet 1" thick cut to the dimension of the opening at the freezer compartment on the standard 2 door refrigerator-freezer.

Thermometer

3 glass panes cut to model window size

Cloth and other insulating material to shield the room from radiation loss.

Graph paper model of a typical room to the scale of the wall

Freezer compartment (Home Economics or cafeteria)

Strategy

Determine the area of the styrofoam block. Cut a hole in this block equal to the area of window space in a typical wall as described below.

$$\frac{\text{Styrofoam block (sq. ft.)}}{\text{Wall (sq. ft.)}} = \frac{\text{Opening to be cut in block (X)}}{\text{Window area in wall (sq. ft.)}}$$

Insert this block into the opening of the freezer compartment. Secure the glass in front of the opening in the styrofoam with tape. Observe the temperature changes at various locations in the model room floor plan placed $\perp$ to the styrofoam at its base.

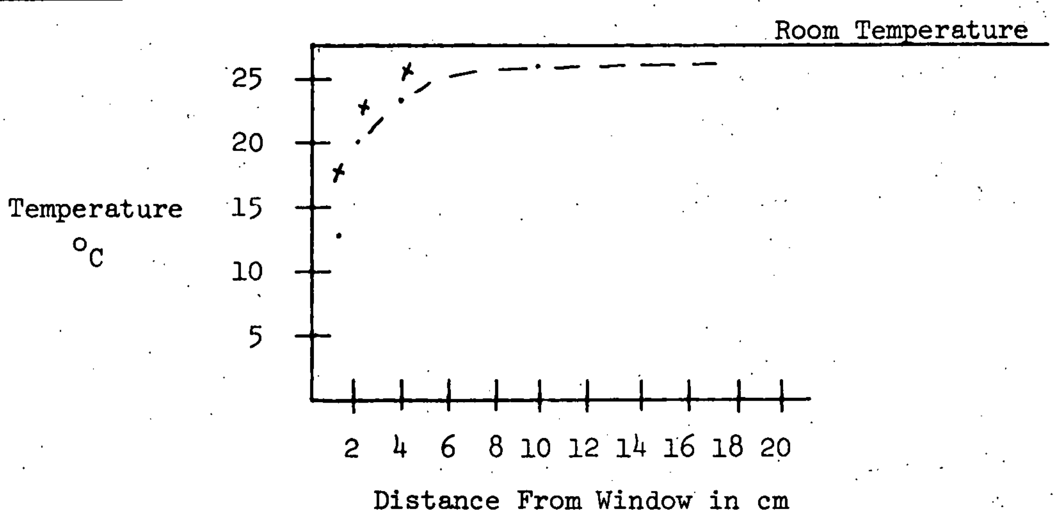
$$\frac{\text{Wall area (sq. ft.)}}{\text{Floor area (sq. ft.)}} = \frac{\text{Styrofoam area (sq. ft.)}}{\text{Graph paper size (X)}}$$

Vary the activity by adding storm sash, drapes, etc. to the model and again determine the changes in temperature.

Notes to the Teacher

Secure the styrofoam to eliminate all air exchanges except that being studied. This activity should be done on a day with low relative humidity to reduce condensation on the glass. Remember to allow the thermometer to stabilize before recording the temperature.

Sample Responses



Freezer temp. ($4^{\circ}F$) = $-14.4^{\circ}C$ · = Third dish towel

Room temp. ($79^{\circ}F$) = $+26.1^{\circ}C$ x = Thick dish towel

Allow 10 minutes to stabilize the system. Time elapsed for measurements and start time 45 minutes.

Extension Activites

1. Graph the relationship between distance from the window and temperature (or temperature change from the normal).
   a) What is the cause of the variation in the temperature readings?
   b) What would you expect to happen if a wind was associated with the low

outside temperature?

c) Were air leaks observed where the styrofoam made contact with the freezer?

d) Suggest a relationship between windows, wall, air leaks, and heating costs. Is there a method by which these losses can be reduced?

2. Graph the relationship between distance from the window and temperature (or temperature change from normal) when the window is insulated with additional glass.

   a) How are graphs 1 and 2 different?

   b) Repeat the second graph activity using additional and varied insulating materials and compare the curves.

3. What is radiation heat loss?

4. Does radiation loss occur through the window?

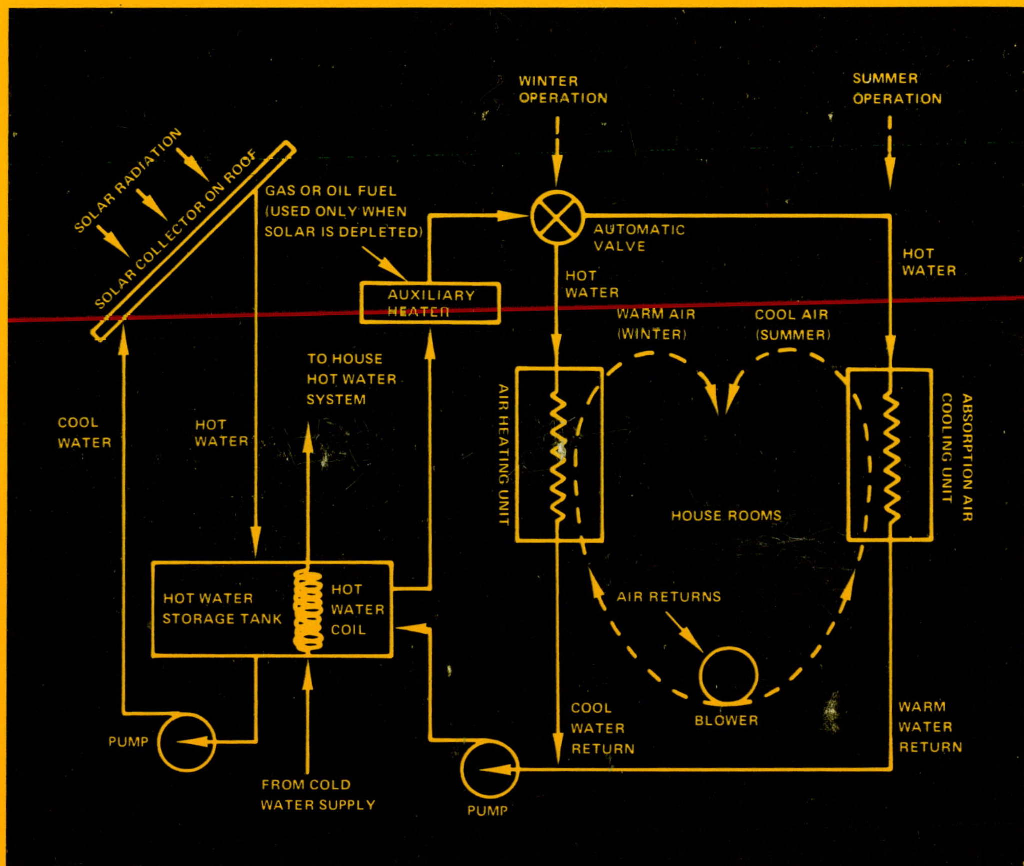
5. Can you distinguish between losses due to conduction, convection and radiation in this experiment?

6. Which of the methods of heat transfer is the most significant in this activity and how do you control it?

ENERGY: OPTIONS FOR THE FUTURE

CURRICULUM DEVELOPMENT FOR THE HIGH SCHOOL

Food & Energy



Institute for Energy Research
and
W. Averell Harriman College for Urban & Policy Sciences
State University of New York at Stony Brook
Stony Brook, New York 11794

T. Owen Carroll, *Project Director*
Robert Lewis, *Associate Project Director*
Herbert Berger, *Assistant Project Director*

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the Office of University Programs
Energy Research and Development Authority
Washington, D. C.

FOOD AND ENERGY

Members: Effie Krasilovsky
Laura Maitland
Severino (Sam) Santorelli
Gerald Slutsky

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INTRODUCTION

Recent state and regional energy crises demonstrate the delicate balance between the energy system, the environment, and the economy. Indeed, interaction among these three elements in our society is very complex. However, any permanent change in the directions of our energy demand and supply for the future involves the formation of a new "energy ethic". To do so requires a broad base of information and understanding of the energy system, and this needs to be developed, particularly among those still in school. You, the teacher, play a most important role in providing that base of information which will become part of the new generation's thinking about the energy system. These materials are intended to enhance your ability to provide energy-related education to students within your own academic setting and to provide students with a better understanding and awareness of fundamental principles of energy supply, conversion processes and utilization now and in the future.

Since it is not possible to cover all aspects of energy systems, the curriculum materials designed in this project were limited to a number of areas considered important from two points of view: energy developments which are now occurring but whose implications are not yet clearly recognized and/or that broad area of potential new developments which have important implications for the future. The specific areas of curriculum materaials are the following -

CONSERVATION. We are coming to realize, albeit slowly, that the supply of raw materials from which energy is produced is finite and decreasing rapidly. Not only is supply decreasing, but demand continues to grow. The most optimistic forecasts show that the world resources of petroleum and natural gas, the two main sources of energy today, will be gone within the next fifty years. Consequently, we need to explore ways to conserve energy by using fewer energy-intensive devices, reducing our life style to one less dependent on energy, and possibilities for substituting new technologies.

DEMAND SCHEDULING. Electricity, since its first introduction, has provided a cheap, clean, efficient source of energy. We have also come to expect that any required demand for electricity on our part as individual consumers, will be met. We turn on the switch and expect the lights to come on. Large investments in the electricity generating plant are required to satisfy increasing demand, particularly during "peak" periods. Consequently, the overall cost of electricity generation becomes quite expensive - a result we have seen in recent years. The issue is particularly important since utility companies are now testing, and will soon offer to the consumer, electric metering for homes on a demand-scheduled basis.

ENERGY IN THE FOOD SYSTEM. Our agricultural system has become increasingly dependent upon the use of energy-intensive fertilizers for large crop production. In addition, energy requirements for food processing continue to grow. It is estimated that about one half of U.S. freight transportation is involved in the movement of foods of one kind or another. With the decline in the supply of fuels, we must ask whether our current national pattern of energy consumption in the food industries, particularly the trend toward increasing use of energy in food processing and packaging, are desirable trends for the future.

NEW TECHNOLOGIES (Solar, Wind, Biomass). It can be argued that the problem in our energy system today is not that we use too much energy, but rather that we use the wrong kinds of energy. Oil and natural gas form important components for synthetic materials, chemicals, and the like. Wherever possible, they should be conserved for such long-term uses. Consequently, we should shift from a fossil fuel resource base to a renewable energy resource base, particularly the use of solar, wind, and biomass sources.

ENVIRONMENT. The direct use of energy involves various pollutant emissions. In addition, indirect use of energy in the creation of industrial goods has secondary environmental impacts in a number of areas. Of recent concern are long term trends in accumulation of carbon dioxide and other gases and particulate matter in the atmosphere. These seem to produce unfavorable atmospheric conditions involving "the greenhouse effect", thermal inversions, and the like.

The modules prepared in each of these areas consist of an introductory background statement and a series of one-day lesson plans, along with suggested bibliography and references to other materials. The background statements are intended to introduce the topic to you, the teacher, and should reduce your need for reading a number of original papers and other citations to the literature. However, the background statements are sufficiently short that they can not make you an energy expert, and we would hope that you pursue additional reading on your own. Single day lesson plans were designed for easy use within existing courses as well as in the construction of new courses. As a result, it is hoped these curriculum materials will be useful in a variety of courses.

A special note to you, the user of these curriculum materials, is in order. The materials are made available in draft copy because of widespread interest in energy issues. Where you encounter rough spots, loss of proper citations to the literature, or other problems, bear with us. A brief evaluation form is included in this document. We encourage you to give us your reactions and any improvements we might add to make these materials more useful to you and to other teachers. The names and school affiliation of the project participants are noted in the material so you can feel free to contact the individual teachers on specific questions. Finally, these documents reflect a concentrated effort over three weeks by the teachers associated with the curriculum development project, and their efforts to translate energy issues into high school course material for you.

LIST OF PARTICIPANTS

- William Baran, Chrmn/Science Dept.,Niagara Wheatfld Central School District, 2292 Saunders Ave,Settlement Rd.,Sanborn, NY 14132
- Anthony Barchuk, Westbury Public Schools, Westbury, NY 11590
- Barbara Brookmeyer, Francis Lewis High School,58-20 Utopia Prkwy,Flushing,NY 11365
- Malcolm Cooper, 69-07 223 St.,Bayside, NY 11364
- Everett Carr, Herkimer County B.O.C.E.S., Herkimer, NY 11350
- Vincent Corsall, 257 Caldwell Ave., Elmira, NY 14904
- Carole Escobar, Islip Jr. High School, Main St., Islip, NY 11751
- Sr. Jane Fritz, St.Patrick's School, 284 E.Main St., Smithtown, NY 11787
- Edward Greenwood, Forest Hills High School, Forest Hills, NY 11375
- Raymond Hahn, Massepequa High School, 4925 Merrick Rd.,Massepequa, NY 11758
- Henry Harvey, Schroeder Jr. High School, 875 Ridge Rd., Webster, NY 14580
- Louis Bancheri, Chrmn/Science Dept.,Sewanhaka Sr. High School,Floral Park,NY 11001
- Alfred Kausch, Windsor Locks High School, So.Elm St.,Windsor Locks, Conn. 06096
- Efsavia Krasilovsky, Central Islip High School,Wheeler Rd., Central Islip,NY 11722
- Edward McGreevy,Soc.Stud.Dept.,Board of Education,Niagara Falls, NY 14302
- Laura Maitland, Francis Lewis High School,58-20 Utopia Pkwy, Flushing, NY 11365
- Philip Merenda, Science Dept.,Lawrence Sr. High School, Cedarhurst, NY 11516
- Ruth Miner, Science Dept.,Floral Park Memorial High School, Floral Park, NY 11000
- Donald Nelson, Science Dept.,W.L.Boardman Jr. High School, Alice & Beatrice Avenues, Oceanside, NY 11572
- Marvin Ohriner,Science Dept.,Elmont Memorial High School,555 Ridge Rd.,Elmont,NY 1100
- Richard Pav, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776
- Severino Santorelli, Wm.Floyd High School,Mastic Beach Rd.,Mastic Beach,NY 11951
- Gerald Slutsky, Hauppauge Sr. High School, Hauppauge, NY 11787
- James Stark, Chrmn/Science Dept.,Peabody High School,315 S.Bellefld Ave,Pittsburgh, Pa 15213
- George Urda, Chrmn/Science Dept.,Torrington High School,Major Besse Dr.,Torrington, Conn. 06790
- Chris Vigliotta, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776
- Harold Visner,Asst.Prin/Science Dept.,Hillcrest High School,160-05 Highland Avenue, Jamaica, NY 11432
- Henry Whitehead, Chrmn/Science Dept.,Locust Valley High School, Locust Valley,NY 11

- - - -

Associate Program Director: Robert Lewis, 2611 Silverside Road,Wilmington, Delaware 19810

Assistant Program Director: Herbert D.Berger, #17 Harborview Drive,Northport, NY 11768

FOOD AND ENERGY

Introduction

ENERGY CRISIS! Long lines at gas stations, cold winter nights with lowered thermostats, shorter factory and store hours, and great numbers of unemployed people are all images these two words evoke. But do you associate a food shortage with an energy crisis?

About "15% of the energy utilized in our economy is used in the food system. Compared with the energy costs of other sectors of our economy, 15% may not appear high, but in gasoline equivalents this is about 330 gallons per capita per year, or a total of 70 billion gallons annually." ,(Pimentel, 1977). According to Pimentel (1977), roughly 25% of the world's energy resources is used in the food production system. Moreover, "to feed the entire world with a U.S. type food system, almost 80% of the world's annual energy expenditure would be required just for the food system" (Steinhart and Steinhart, 1974).

Currently it requires about eight calories of fossil fuel energy to get one food calorie on our plate. We are eating fossil fuels (Fowler,, 1975). Fuel is used both directly and indirectly on the farm, in the food processing industry, in the commercial retailing industry, and in the home (see Table 1). The table shows that energy consumption has increased in all phases of the food system since 1940, but growth has been greatest on the farm. There has been over a four-fold increase on the farm mainly in fuel use, electricity, fertilizer, and energy for farm machinery. Both the food processing industry and commercial/home use each about tripled their energy use between 1940 and 1970.

The Food Chain and Energy Efficiency

Food is energy. Energy from the sun enters living systems through green plants which carry on photosynthesis. Energy transfer to other living things is accomplished by a series of eating and being eaten called the food chain. Obviously solar energy input is necessary in this

Table 1. Energy use in the United States food system. All values are multiplied by 10^{12} calories.

Component	1940	1947	1950	1954	1958	1960	1964	1968	1970
				On farm					
Fuel (direct use)	70.0	136.0	158.0	172.8	179.0	188.0	213.9	226.0	232.0
Electricity	0.7	32.0	32.9	40.0	44.0	46.1	50.0	57.3	63.8
Fertilizer	12.4	19.5	24.0	30.6	32.2	41.0	60.0	87.0	94.0
Agricultural steel	1.6	2.0	2.7	2.5	2.0	1.7	2.5	2.4	2.0
Farm machinery	9.0	34.7	30.0	29.5	50.2	52.0	60.0	75.0	80.0
Tractors	12.8	25.0	30.8	23.6	16.4	11.8	20.0	20.5	19.3
Irrigation	18.0	22.8	25.0	29.6	32.5	33.3	34.1	34.8	35.0
Subtotal	124.5	272.0	303.4	328.6	356.3	373.9	440.5	503.0	526.1
				Processing industry					
Food processing industry	147.0	177.5	192.0	211.5	212.6	224.0	249.0	295.0	308.0
Food processing machinery	0.7	5.7	5.0	4.9	4.9	5.0	6.0	6.0	6.0
Paper packaging	8.5	14.8	17.0	20.0	26.0	28.0	31.0	35.7	38.0
Glass containers	14.0	25.7	26.0	27.0	30.2	31.0	34.0	41.9	47.0
Steel cans and aluminum	38.0	55.8	62.0	73.7	85.4	86.0	91.0	112.2	122.0
Transport (fuel)	49.6	86.1	102.0	122.3	140.2	153.3	184.0	226.6	246.9
Trucks and trailors (manufacture)	28.0	42.0	49.5	47.0	43.0	44.2	61.0	70.2	74.0
Subtotal	285.8	407.6	453.5	506.4	542.3	571.5	656.0	787.6	841.9
				Commercial and home					
Commercial refrigeration and cooking	121.0	141.0	150.0	161.0	176.0	186.2	209.0	241.0	263.0
Refrigeration machinery (home and commercial)	10.0	24.0	25.0	27.5	29.4	32.0	40.0	56.0	61.0
Home refrigeration and cooking	144.2	184.0	202.3	228.0	257.0	276.6	345.0	433.9	480.0
Subtotal	275.2	349.0	377.3	416.5	462.4	494.8	594.0	730.9	804.0
Grand total	685.5	1028.6	1134.2	1251.5	1361.0	1440.2	1690.5	2021.5	2172.0

Source: Steinhart and Steinhart

---

process, as in Figure 1. To solar energy, the farmer adds other significant energy inputs: petroleum products to operate farm machinery and fertizer, which is almost pure energy. Just as in the transformation of other forms of energy, the "law of conservation of energy" applies. When the energy inputs are compared with food energy outputs in the United States, we find that grain crops such as freshly harvested corn require approximately 1.2 calories of energy input for each calorie of food energy output.

The food chain transfers energy from one organism to another. However, each transfer results in some lost energy. Each organism involved in a transfer uses energy to carry on its own life processes and loses some energy in the form of heat. Because energy is lost at each link, the shorter the food chain, the greater the amount of energy that will be available for harvesting. For example, a typical food chain is: corn → cow → human being (Figure I). It takes approximately ten times as much energy to produce a unit of aminal protein as it does to produce a unit of plant protein (Pimentel, 1977). That is, U.S. food production relies particularly on vast fossil energy inputs. These fossil inputs are used to produce large amounts of animal protein, lengthening the food chain. The overall result is relatively energy-inefficient food production in this country.

Let us take a closer look at our farm practices. Farming uses more petroleum than any other single industry in the country. Energy is used in mechanized agricultural production for machinery, transport, irrigation, fertilizers, pesticides, and other management tools. During the last two decades the consumption of fossil energy supplies has been increasing faster than population numbers. While the U.S. population doubled during the past sixty years, its energy consumption now doubles every twenty years (Pimentel, 1977). Also, the energy used in food production has been increasing faster than energy use in other sectors of the economy. For example, energy inputs in U.S. corn production more than tripled since 1945 (see Table 2). In 1975, the energy input for nitrogen fertilizer alone about equalled the total energy inputs for corn production in 1945.

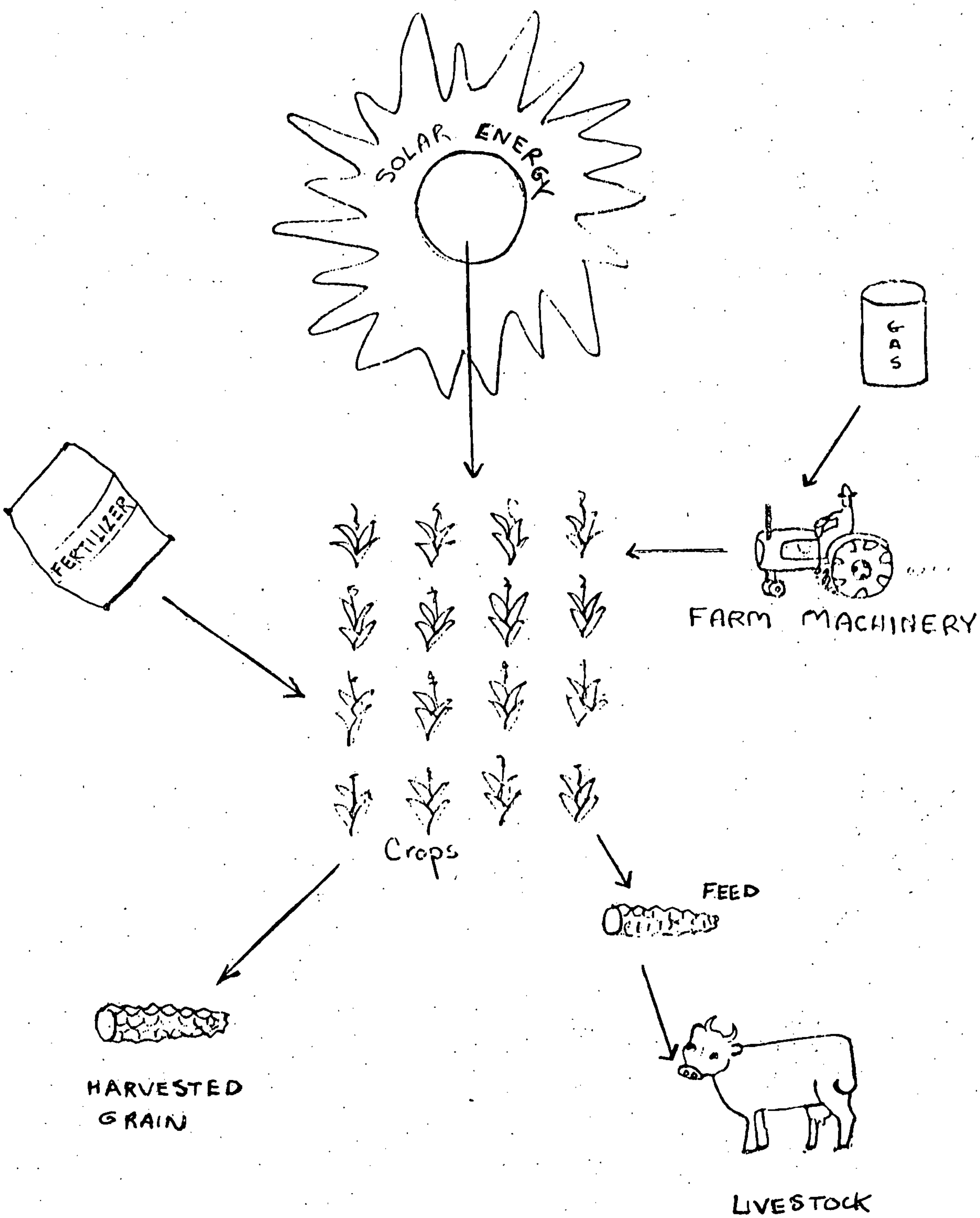
Energy Efficiency in the U.S. Food System

To place the energy inputs for production into perspective with processing, distribution, and preparation, Pimental uses a one pound can of sweet corn as an example. The one pound (455 grams) can contains about 375 calories of food energy. This 375 calories of food energy requires about 450 calories of fossil energy for production. Figure II shows that additional energy is expended for processing the corn and getting that canned product to the consumer who then cooks it. Hence, about 11 calories of fossil energy input results in one calorie of sweet corn food energy at the dinner table.

Table 2. Energy inputs in U.S. corn production.

Input	1945	1975
Labor	22 hrs	7 hrs
Machinery	218,000 kcal	460,000 kcal
Fuel	570,000	850,000
Nitrogen	49,000	900,000
Phosphorus	10,000	93,000
Potassium	5,000	71,000
Limestone	5,000	30,000
Seeds	30,000	50,000
Irrigation	42,000	316,000
Insecticides	0	33,000
Herbicides	0	60,000
Drying	17,000	152,000
Electricity	16,000	154,000
Transportation	20,000	70,000
Totals	982,000 Calories	3,248,000 Calories
Corn Yields	34 bu	86 bu
Output/Input Ratio	3.0	2.4

Source: Pimentel, 1977



Energy Inputs and Food Energy Outputs in U. S. Farming

Figure I

ENERGY INPUTS FOR CANNED CORN

(455 g. = 375 Calories)

HOME	500
SHOPPING	800
DISTRIBUTION	340
TRANSPORT	250
PROCESSING	1760
PRODUCTION	450
TOTAL	4100

ENERGY INPUTS FOR BEEF

(140 g. = 375 Calories)

HOME	155
SHOPPING	250
DISTRIBUTION	105
TRANSPORT	80
PROCESSING	400
PRODUCTION	29,000
TOTAL	29,990

Source: Pimentel
et al, 1975)

Figure II

Some of the energy in production is utilized by farm machinery. While the number of workers engaged in farming is less than one eighth the number involved in 1920 and the number of work animals is small, the number of tractors and their rated horsepower has increased tremendously (Steinhart and Steinhart, 1974).

Although the amount of energy used in corn production is high, for beef the numbers are even more staggering (remember, this is a longer food chain). To equal the same 375 calories of food energy provided in a one pound can of corn, about one-quarter pound of beef must be produced at a cost of 29,000 calories of fossil energy input (see Figure II). The reason is primarily that cattle are fed large quantities of grain. A cow is fed over twenty-one pounds of plant protein in order to produce one pound of protein for human consumption (Lappe, 1972).

The way to improve any efficiency is to reduce the input or increase the output for the same product. This applies as well to farming as to simple machines. Let's look at reducing the input first. Since solar energy is abundant and free, there is no need to reduce this form of energy input. Fertilizer on the other hand, is not abundant and is expensive. Here the farmer can improve his energy efficiency by reducing his use of fertilizer as much as possible. Substituting manure from animals for chemical fertilizer would result in a substantial energy savings of 1,100,000 calories per acre, and effectively recycle these animal wastes. (Pimentel et al., 1973). A second alternative to chemical fertilizers is the planting of legumes (e.g. clover, peas, beans) in rotation with grain crops. Nitrates produced in the roots of these plants fertilize the soil. Energy savings of 1,500,000 calories per acre would be realized from this procedure (Pimentel et al.,1973). Indirectly, because the planting of legumes reduces weed problems, less energy would be needed for weed control. Some experimental farms are feeding plants hydroponically, giving them exactly the nutrients they require in water solution without the use of soil. Since this method requires greatly reduced amounts of fertilizer, significant energy savings are realized.

Input for livestock could be decreased more significantly. "In 1968, U.S. livestock (minus dairy cows) were fed twenty million tons of protein primarily from sources that could have been eaten directly by man. Cattle and hogs alone accounted for one-half of the total protein consumed" (Lappe, 1972). Since livestock can convert inedible substances (e.g. cellulose) into high-quality protein, our protein harvest could be greatly increased if stock were grazed on grasslands unsuitable for farming, making the grains they currently eat available for human consumption.

On the output side of the energy efficiency ratio, important improvements can be made. Corn transforms only about 1-2% of the solar energy that strikes it into edible food. Production of more efficient plant varieties could result in energy outputs of 8-10%. Already, the "green revolution" has produced varieties that transform 4-5% of the available solar energy, and research to find more and better varieties continues. More return on solar energy input can also be produced by intercropping (more than one crop in the same field), multiple cropping (several crops in succession), and relay planting (sowing a second crop between the rows of an earlier, maturing crop). Not only do these techniques make greater use of available solar energy, they also make more efficient use of fertilizer.

Not only do land farms transfer energy, aquatic biomes also transfer energy. "Behind every ounce and a half of tuna that we eat, there is one pound of mackerel, ten pounds of herring, one hundred pounds of zoo plankton, and five hundred pounds of phytoplankton" (Wagner, 1974). If people were to eat more herring and less tuna, much more food energy could be harvested from the sea with the same amount of energy input. But currently, fully one half of the fish being caught are discarded (Wagner, 1974) because Americans are very particular about what they consider edible. In addition, research into plankton harvesting is being conducted as the first step in seafood farming under controlled conditions.

Processing, Packaging, Distribution, and Preparation

After crops are grown and livestock reach maturity, much energy is expended in food processing, packaging, distributing, selling, and preparing before the food is served on your dinner plate. In the past fifty years canned, frozen, and other processed foods have become the principal items of our diet. At present, the food processing industry is the fourth largest energy consuming industry in the country. Hardly any food is eaten as it comes from the fields. Even farmers purchase most of their food from markets in town.

The processing of crops to make nutritious food more attractive to the consumer requires substantial unnecessary energy consumption. For example, raw potatoes are more energy efficient than processed instant potatoes and frozen french fries. Yet nearly 20% of our potato crop is consumed annually in the form of these fries. Similarly, more energy efficient fresh vegetables are transformed into canned and frozen vegetables with high energy inputs.

The energy problem is heightened by the use of energy-intensive materials in the food packaging industry. Aluminum is one of the highest energy consuming materials produced for containers (see Table 3) and between 1971 and 1972 the use of aluminum cans increased 31% (Clark,1974). Although aluminum can be recycled, the process requires considerable amounts of energy. Glass containers that are returned, cleaned and refilled several times are far more energy efficient. If people used returnable bottles for soft drinks and beer, the equivalent of 1,700,000,000 gallons of gasoline would be saved (Pringle, 1975)

Overpacking is another energy "guzzler". Have you ever eaten in a fast food restaurant where your hamburger was wrapped in paper that was put in a box which was placed in a bag on a paper-covered tray? Or have you opened up a package of frankfurters from the supermarket to find each covered with its own wrapper? Energy savings could be realized by the use of less and energy-cheaper packaging.

After packaging in a factory, most products are transported to markets by truck. Some energy could be saved if rail transportation were used more frequently. However, by far the most inefficient delivery system is in transporting food home from the retailer using a four or five thou-

Table 3. Energy Consumption in Basic Materials Processing Per Ton of Product

Material	Energy used for production, manufacturing equipment use, and transportation of finished goods (*in thermal kilowatt-hours*)*
Steel	12,600
Aluminum	67,200
Copper	21,000
High-grade steel (silicone and metal) alloys	59,200
Zinc	14,700
Lead	12,900
Electrically processed metals	51,200
Titanium	141,200
Cement	2,300
Sand and gravel	21
Inorganic chemicals	2,700
Finished plate glass	7,200
Plastics	2,900
Paper	6,400
Coal	42
Lumber	1.51 per board foot

* A thermal kilowatt-hour is an energy measure in electrical terms that takes into account the efficiency of the electrical production and distribution system.

Source: Clark, 1974

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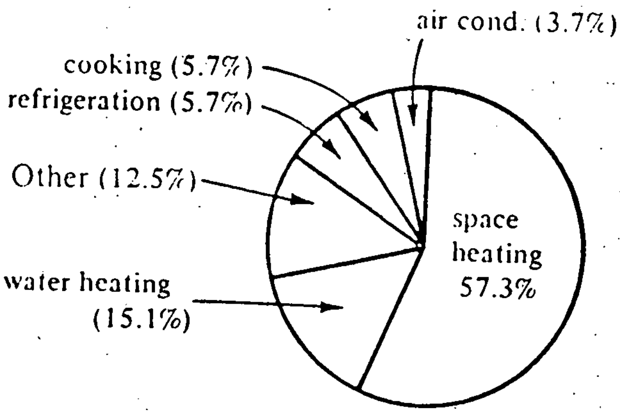
sand pound auto to carry perhaps twenty pounds of groceries. In some cases the energy expended by burning gasoline may be equal to the energy in the foods purchased (Steinhart and Steinhart, 1974). Store delivery routes, shopping car pools, bicycling, and even mass transit would increase energy efficiency.

Energy use for food does not end at our doorsteps. Storage and food preparation require additional energy (see Figure IV) expenditures. Both the number of electric appliances in the house and the electricity consumption resulting from the use of appliances have risen dramatically in recent years (Clark, 1974)(see Table 4).



Source:
Environmental Syllabus, 1977

Energy Use in U. S. Homes

Figure IV

Table 4. Energy Consumption in U.S. Homes

	1960 Saturation	ANNUAL Per Capita KWHE Consumption	1970 Saturation	ANNUAL Per Capita KWHE Consumption
electrical resistance heating	1.5%	41	6.1%	190
Electric water heating	18.6%	232	29.6%	416
Electric ranges	35.6%	118	52.7%	197

	1960 Saturation	ANNUAL Per Capita KWHE Consumption	1970 Saturation	ANNUAL Per Capita KWHE Consumption
Air conditioning total	14.8%	59	42.6%	191
Air conditioning (central)	2.0%	11	5.9%	37
Air conditioning (room)	12.8%	48	36.7%	154
Freezers	22.1%	59	29.6%	92
Dishwashers	6.3%	7	23.7%	27
Portable appliances	—	104	—	223
Refrigerators	98.0%	163	100.0% +	310

Source: Clark, 1974

Technology is already available for constructing better insulated and high efficiency appliances at little additional construction cost (Fisher 1974). For example, in a study conducted by the Department of Housing and Urban Development, Hittman Associates researchers found that redesigning the components of ovens and using different insulation materials could cut energy use in half. They also found that waste heat from freezer and refrigerator condensers can be used in the hot water system of the house (Clark, 1974). In the near future perhaps the price of this system will become competitive. Labeling of equipment and all appliances to indicate their energy efficiency, such as the EER that is currently reported for airconditioners, could then encourage individuals to purchase more efficient machines. Better cooking management would also result in some energy savings. Spies (1974) suggests:

i. cook several items that can be baked at the same temperature for the same meal or for future use;

ii. preheating the oven wastes a great deal of energy;

iii. turn off the oven about ten minutes before food is done. The remaining heat will finish the cooking;

iv. use flat-bottomed pans of the proper size to cover the portion of the burner used; and

An additional suggestion is to use various single-purpose cooking appliances; e.g. coffee makers, waffle irons, toasters, etc., because they are usually more efficient than the range in performing their specific function (Barab, 1976).

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WHAT'S ON YOUR MIND?

(Food System)

Objectives

The student should be able to:

(a) Crystallize his feelings about the U.S. food and energy situation

(b) Gain awareness of the energy needs of our present food system.

Overview

The purpose of this activity is to help you assess your students' awareness of the enormous amounts of energy used by our modern methods of food production and processing.

Strategy

Begin with a short discussion of the present energy crisis by simply asking a student what kinds of energy use have the greatest impact on our energy problem. (Students will probably state that big cars, electric appliances, etc., are to blame. Few, if any, will relate the energy crisis with our present food system.) With the discussion completed have students complete the inventory. A discussion of each item of the inventory should be done by the class. Without having many facts to help them, students will find it hard to decide who is right or wrong. Tell them that they will be confronting many of the topics presented in the questionnaire over the next few days.

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NSTA, 1976. "Agriculture Inventory," Agriculture, Energy and Society. ERDA Technical Information Center, Oak Ridge.

Extension Activities

Have students read background information. A good source is Fowler, pp. 56-57 (see References cited in background). After they have completed reading articles and participating in the unit, have them do the inventory again. Ask them to compare their "before" and "after" responses.

Name ______________________

Date ______________________

What's On Your Mind Actvity Sheet

Directions: Read carefully each statement. For each statement place a check (✓) in the column which most nearly indicates your opinion. The symbols represent the degree of your opinion.

SA = Strongly Agree A = Agree N = Neutral or don't know
D = Disagree SD = Strongly Disagree

	SA	A	N	D	SD
1. To help conserve fossil fuels, Americans should eat less meat.					
2. It is possible to reduce the rate of energy used & still provide every American with a nourishing diet.					
3. Rising food prices in the past 5 yrs have resulted from higher oil prices.					
4. The U.S. should encourage people in developing nations to use our farming & food processing methods.					
5. The amount of petroleum used on American farms is greater than that used in private automobiles.					
6. We get energy from food we eat; however, today we use more energy in growing and preparing food than we get in energy out of it.					
7. A farmer's expenses can affect my life.					
8. Processing food uses more energy than growing food.					
9. Each acre of crop land becomes ever more productive as more fertilizer is applied.					
10. Farm workers & farm animals are more energy-efficient than tractors & other machinery.					
11. The energy farmers use is comparatively cheap when you consider what they produce with it.					
12. Our farmers rely on domestic supplies of oil & natural gas to run their farms.					
13. When we eat food, we're "eating up our oil supplies for the future."					

(continued on next page)

Statement	SA	A	N	D	SD
14. The fact that we all have household helpers like electric appliances has less to do with the rate of energy use than the fact that we simply have more people.					
15. Sometimes less can be more. We have fewer farms today, but each farmer produces more. This situation can go on forever.					

I DIDN'T KNOW IT WAS LOADED

Heat Energy

Objectives

The student should be able to:

(a) Convert food energy to heat energy, or describe food energy converted to heat energy.

(b) Define calorie and Calorie.

(c) Calculate the approximate food energy value of mini-marshmallows and peanuts in Calories.

Overview

This lesson can be used as either a student laboratory activity of a teacher demonstration. In either case, a crude calorimeter (made from a soda can) is used to convert food energy into heat energy and provide data that will allow students to calculate the approximate amount of food energy contained in mini-marshmallows and peanuts.

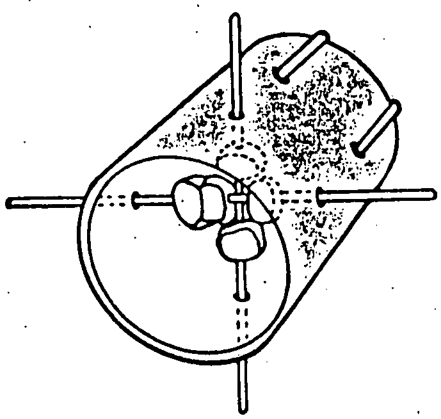
Materials

(Per demonstration or student laboratory group)

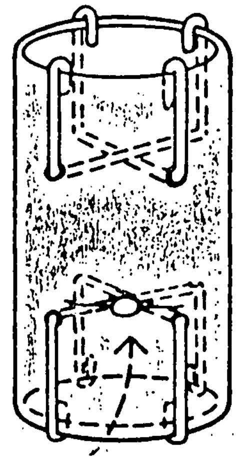
- 1 alcohol burner and stand
- 1 50ml beaker (or larger)
- 1 wired calorimeter (see instructions under Strategy)
- 1 thermometer
- 1 potholder or tongs
- 1 paper towel
- 8 straight pins
- 15 mini-marshmallows
- 3 peanuts

Strategy

Construct ahead of time (or have student aides construct) one wired calorimeter per demonstration or laboratory group. Use 12 oz. soft drink cans. First punch eight holes in each can with a nail or ice pick. The holes should be on opposite sides of the can about 4 cm from each end. Then remove both the top and bottom of the can. Cut four pieces of wire about 18 cm long. Uncoated heavy guage copper wire is excellent. Coat-hanger wire will work too, if you have shears and the strength to bend it.



Calorimeter with marshmallows



Calorimeter with peanut

Introduce the activity by asking, "What is food?" or "Why do we eat food?" Discuss the facts that humans need food energy to provide energy for movement, blood circulation, respiration, and to maintain body temperature, etc.

Define a calorie as a <u>unit of energy</u>, specifically, the amount of energy needed to raise the temperature of 1 gram of water 1°C. Define a Calorie as 1000 calories and equate it to a "diet" calorie.

Pass out the activity sheets and instruct students to collect the data called for and then to calculate the food energy values of mini-marshmallows and peanuts.

After students have completed the laboratory activity and their calculations, discuss and reinforce the results. Some good discussion questions are: "Did you measure all of the food energy released?" "Why is the energy value of peanuts and marshmallows so different?" "How did the energy get into the food?" "Compare and contrast food and petroleum."

You might want to conclude this activity by stressing the idea that food is energy and that it must come from some other source of energy.

Notes to the Teacher

The value of a calorie is really only correct for certain temperatures, but the exact value is never far from 1 between freezing and boiling.

Stale or hard marshmallows work better than fresh ones; they will burn longer and more steadily, and stay on the wire better, and are less apt to be eaten. They must be pushed tightly together to burn completely.

After the foods are ignited,   quickly place on the burner stand and the beaker quickly put in place.

Marshmallows require careful handling or you will end up with a gooey mess on desks, floors, clothing, and equipment.

Pushing the pins into the peanuts without splitting them is difficult. Care must be taken doing this and balancing the nut on the wires.

This kind of calorimeter is very inefficient and the marshmallows would provide about 16,250 calories of heat. Since peanuts vary considerably in size, students will get a wide range of temperature changes. An average size peanut (1 to 1.5 CM in length) should produce a temperature change of about $10^{\circ}C$. This indicates 1200 calories or 1.2 Calories.

Extension

Ask students to convert various amounts of calories into Calories and vice versa. Have them keep track of the number of Calories they consume in a day or a week.

Student Activity Sheet

Name ____________

Date ____________

Heat is a form of energy. A calorie is defined as the amount of heat it takes to raise the temperature of one gram of water one degree Celsius. Therefore, calories are used to measure amounts of energy.

The amount of energy contained in food can easily be calculated by burning it and measuring how much it increases the temperature of a known amount of water. Simply stated:

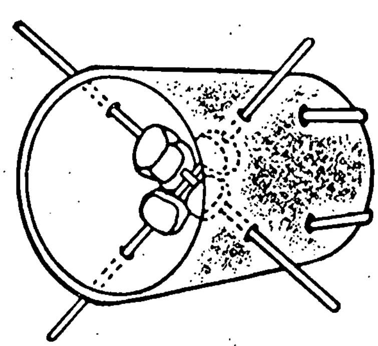
calories = grams of water x change in temperatures (^{o}C)

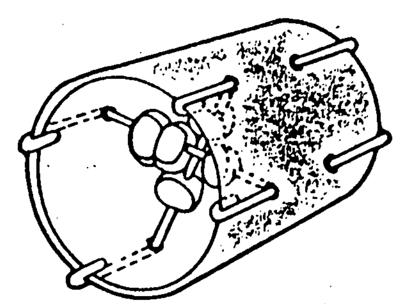
In this activity you will calculate the energy content of marshmallows and peanuts in calories.

1. Select a partner(s) and get the following materials:

   1 alcohol burner and stand
   1 50 ml beaker
   40 ml of tap water (this is equivalent to 40 grams)
   1 wired can
   1 thermometer
   1 potholder or tongs
   1 paper towel
   8 straight pins
   15 mini marshmallows
   3 peanuts

2. Remove the bottom wires from the can. Then thread 3 marshmallows on one wire and 2 on the other. Push all the marshmallows as close together as you can. Put the wires back on the cans as shown.





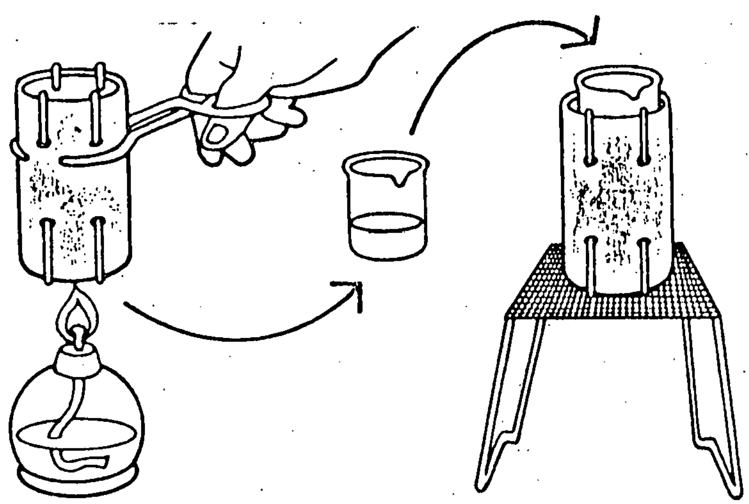
3. Pour 40 ml (this is 40 grams) of water into a beaker. Record the temperature in Table 1.

Table 1

	MARSHMALLOWS				
Trial No.	No of Mini Marshmallows	Mass of H_2O	Start. Temp.	Final Temp.	Change in Temp
1	5	40			
2	5	40			
3	5	40			

__________ Average Temperature Change

4. Read carefully before doing this. Be sure to use a potholder or tongs. Do not pick it up with your hands. Hold the can over the alcohold burner flame until all marshmallows are burning. Using tongs, quickly set the can on the heating stand away from the burner. Instantly place the beaker of water onto the wire basket on the top of the can. Leave it there until the marshmallows burn out.



5. After the marshmallows stop burning, measure the new temperature of the water (°C) and record it under Final Temperature.

6. Repeat this procedure two more times. Use 40 ml of fresh tap water each time. Then calculate the average gain in water temperature.

7. Use the average gain in water temperature to calculate the food energy value of the mini-marshmallows.

8. Push two straight pins into each nut as shown. Balance one nut across the bottom wires. Repeat steps 3 - 6, with the peanut. When you are done, clean the wires, can and stand. Record the data in Table 2.

Table 2

Trial No.	PEANUTS No. of Peanuts	Mass of Water (grams)	Start. Temp. (°C)	Final Temp. (°C)	Change in Temp. (°C)
1	1	40			
2	1	40			
3	1	40			
			Average Change	Temp.	

9. Use the average gain in water temperature to calculate the food energy value of the peanuts.

SUMMING UP

(Energy Cost of Food Production)

Objectives

The student should be able to:

(a) List at least three major forms of food production energy inputs.

(b) Calculate and interpret a food energy input/output ratio.

(c) Describe several ways the U.S. food energy input/output ratio could be improved.

(d) Compare food energy input/output ratios for corn production and beef production.

(e) Compare the U.S. food energy input/output ratio for corn with that of a developing country.

Overview

This lesson can be used as the basis of a class discussion or as a pencil and paper student activity. It is intended to show students that it takes substantial amounts of fossil energy to produce lesser amounts of food energy. Students will learn how to compare energy inputs to energy outputs and how food production can be made more energy efficient. They will also get a chance to discuss food production in Mexico, which is representative of production in developing countries.

Strategy

Start by asking the students where the energy in food comes from. When you have established that it comes from other forms of energy, see how many specific forms of energy input your students can contribute to a chalkboard or transparency list.

Pass out Activity Sheet 1 (or project a transparancy copy of it) and ask students to estimate the energy input from each source identified, and have them record their estimates on the appropriate lines.

Pass out Activity Sheet 2 (or project a copy of it) and ask your students to answer the questions on it.

Discuss the results.

Notes to The Teacher

Corn has been selected as a representative crop because it is an important grain in the U.S., because much data is available, and because its input/output ratio is about average for most crops.

Canning and processing the corn after it has been produced requires about 10 times more energy than growing it does.

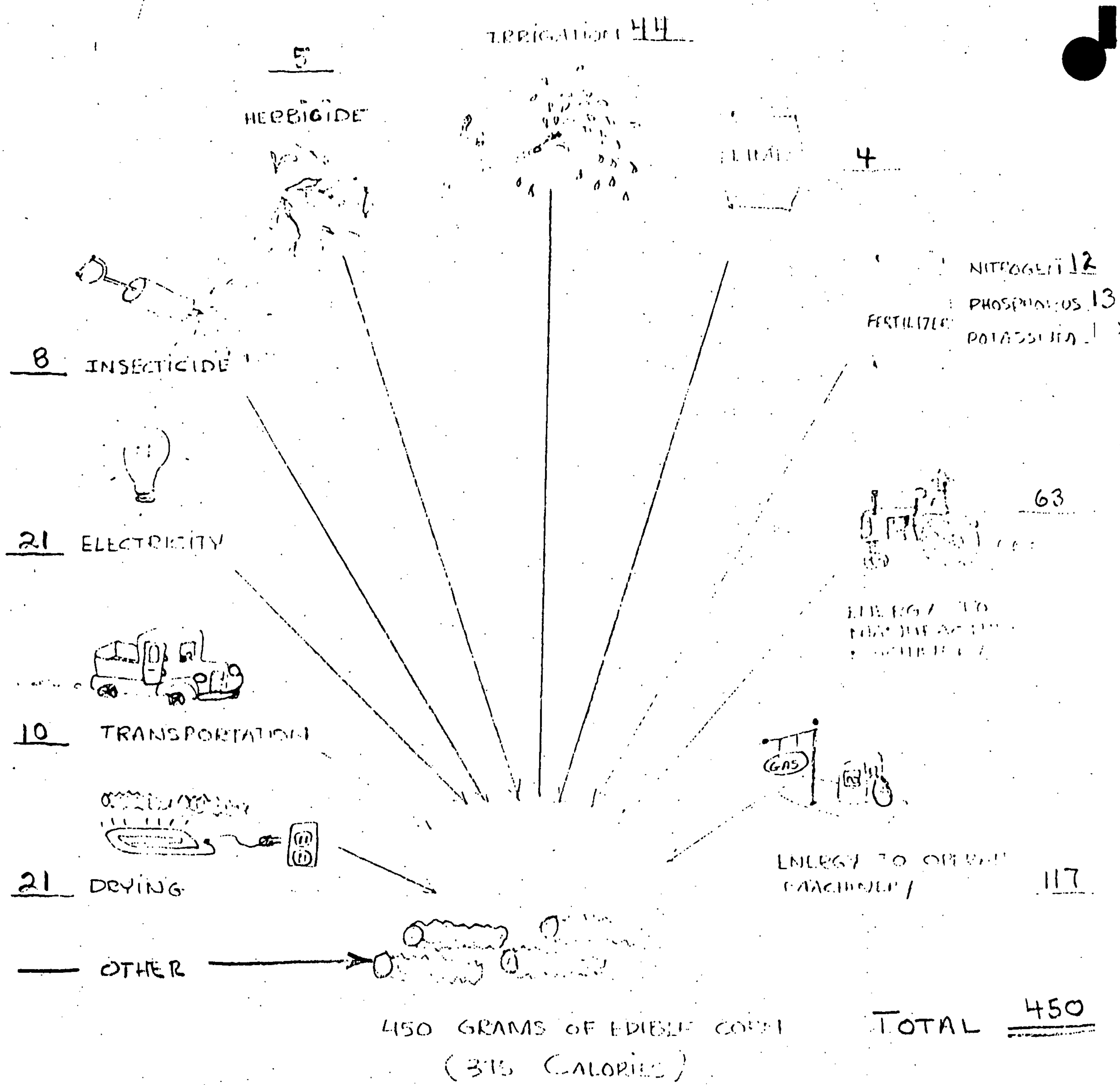
Sample Responses

1. The energy input/output ratio is 1.2 $\left(\frac{450 \text{ Calories}}{375 \text{ Calories}}\right)$.
2. The energy input/output ratio tells how many times greater the energy invested than the energy returned in food production.
3. In general terms the ratio can be improved by decreasing the amount of energy put in, or increasing the amount of energy gotten out.
4. Specific improvements on the input side are: using manure rather than fertilizer, or compost rather than fertilizer, using natural enemies (e.g. lady bugs) or natural deterents (e.g. marigolds) to control pests rather than insecticides, air drying corn in cribs rather than using heaters, buying more efficient farm machinery, using bio mass conversion to produce methane to reduce the need for electricity on the farm, etc. On the output side, more nutritious and energy intense plants can be genetically developed.
5. The input/output ratio for beef production is much higher than the ratio for corn; it is 7 to 8/1. This is because corn is fed to beef cattle and energy is lost by the cattle in life sustaining processes, and also stored in inedible parts of the cow. (This ratio is much lower for grass fed beef.)
6. The input/output ratio for beef could be improved by grazing them on nonarable grasslands or by feeding the more energy efficient crops such as soybeans. (The taste of such beef is usually different.)

7. The energy input/output ratio for corn production in Mexico is about five times higher than the U.S. ratio. This is because they use much greater amounts of human and animal labor than the U.S. does. They also use practically no fertilizer, insecticides, herbicides, or irrigation. (Their yield per acre is a little less than half as much as ours.)

<u>Extension Activities</u>

Calculate the energy input/output ratio including processing, shopping, and home preparation. Calculate the energy input/output ratio for other crops such as soybeans and other meats, such as chicken and pork.

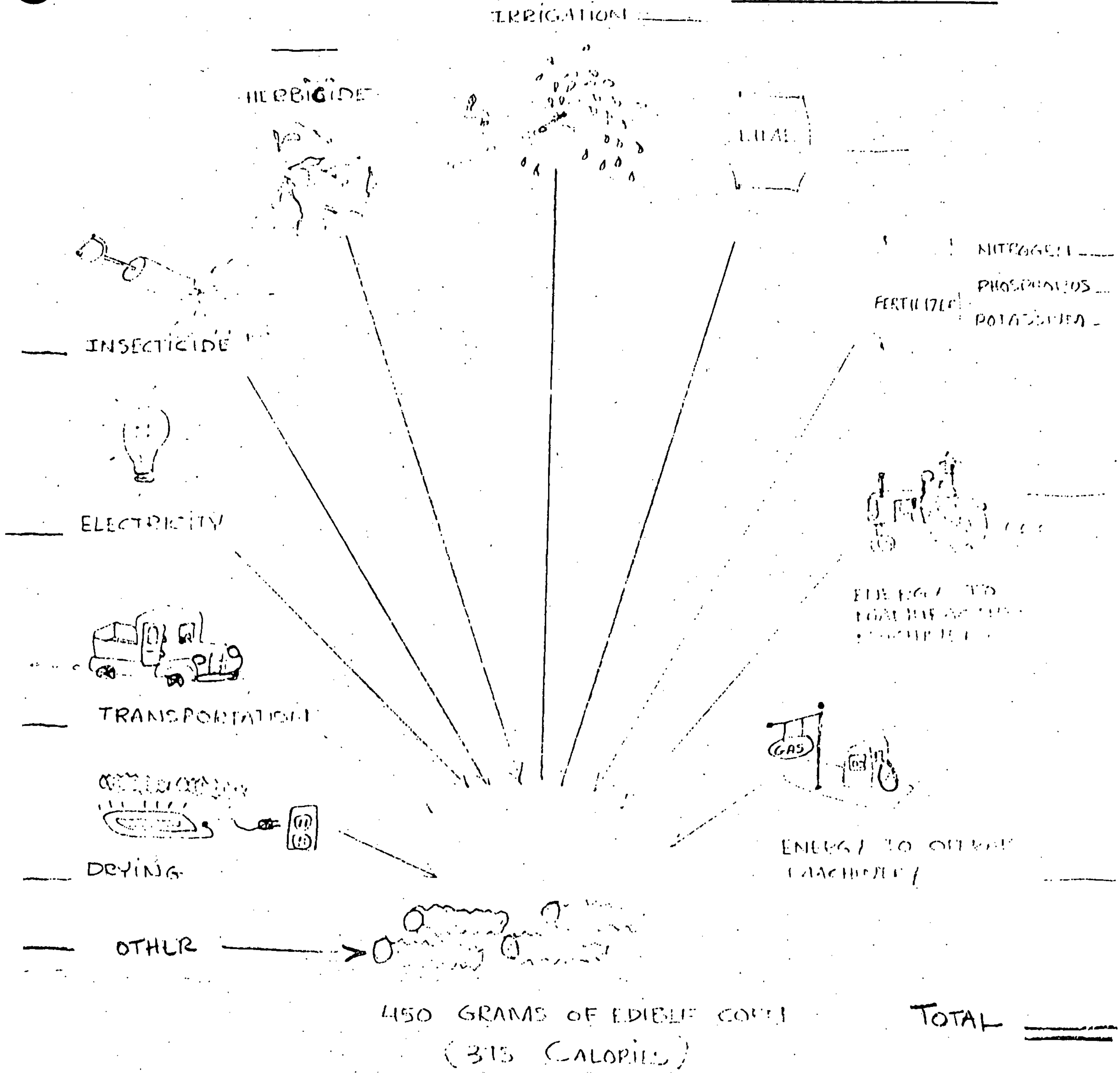


(See attached)

Student Activity Sheet

Name ____________________

Date ____________________



STUDENT ACTIVITY SHEET 2 (Continued)

1. Refer to Activity Sheet 2. Calculate the energy input/output ratio for freshing harvested corn in the United States.

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2. What does the energy input/output ratio mean?

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3. In general terms, what would have to be done to make the ratio "better"?

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4. What specific and practical things might a farmer do to reduce the energy input/output ratio for corn?

____

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5. How do you think the energy input/output ratio for beef production compares to the ratio for corn? Why?

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6. What specific things might a beef rancher do to improve the energy input/output ratio for beef production?

____

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____

____

7. How do you think the energy input/output ratio for corn production in Mexico compares to the ratio in the United States? Explain your answer.

____

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PRAY FOR PREDATORS

The Food-Chain-Action Game

Objectives

Students should be able to:

(a) Identify the energy relationships among organisms of a food chain.

(b) Explain that more energy is contained in green plants of a food chain than in each succeeding level of consumer.

Overview

The body of the lesson is an action game. It is designed to show that not all of the energy contained in one link of the food chain is available to the next link. It is intended to show that more plants than plant eaters and more plant eaters than meat eaters can be successfully supported in a food chain.

Students play different organisms in a food chain. The goal of each organism is to survive through the "day" (5 minutes) by eating enough to live without being eaten. (For details see the Student Activity Sheet).

Materials

For a class of about thirty students -

1 large bag of roasted peanuts in shells (about 2 lbs)
20 sashes or large identification tags of one color
10 sashes or large identification tags of another color
10 sashes or large identification tags of a third color
20 sandwich size plastic bags
1 kitchen timer with a bell (or any timing device & a whistle or loud voice)
Set of Student Activity Sheets

Strategy

Site selection - In advance choose a site. The best site is a grassy field of about 250-300 sq. meters. Any safe indoor or outdoor area with few obstructions is adequate. You can even move all of the desks and chairs against the walls of your classroom and play there.

Seat all students together at the game site.

In introducing this activity discuss that animals eat in order to get energy for the activities characteristic of life and that energy enters the food chain by the conversion of light energy to chemical energy by green plants. You might ask: "Why do cows eat? What do cows eat? How do plants get energy? What organism might eat a cow?"

Explain that the term food chain refers to transfer of energy from one organism to another through a series of eating and being eaten.

Have one student distribute about 100 peanuts over the game area while another hands out activity sheets. You can choose 1/3 of the participants to be mice, 1/3 to be snakes, and 1/3 to be hawks. Give each of the mice one color identification sash and a plastic bag, give each of the snakes another color sash and each of the hawks the third color sash.

Ask students what food chain they are representing in this game. Explain that peanuts on the ground represent plants.

Have students read the instructions for their group. Ask for questions.

Set the timer for 5 minutes, tell students the game is over when the bell rings (or you blow your whistle).

If, after five minutes or less, all of the members of one or more links have perished, stop the game. Call all students back to the staging area. Record the number of survivors. Ask: "What adjustments can we make so that we will have members of each link in the food chain after five minutes?"

Make the adjustments and play the game again. Repeat this until at least one member of each link survives through the "day".

Have all students return to the staging area. Determine the number of participants in each link of the successful community. While students complete the questions on the activity sheet, collect the other materials.

Notes to the Teacher

You may want to introduce the lesson the day before you play the game. You can go to the site and start more quickly this way.

If you choose an outdoor area frequented by animals, you will not have to clean up the peanuts after the game.

The first game is usually over in less than a minute! Either the mice or snakes are all captured.

Don't worry about students who don't want to play. Most get caught up in the game after the first replay or are enticed by the peanuts.

Change only one rule at a time. Successful changes could include adding more mice, having fewer hawks, staggering release of mice first, then snakes, then hawks, and providing areas where mice or snakes can not be captured.

Sample Responses

1. Transfer of energy from one organism to another through a series of eating and being eaten.

2. Plants - mice - snakes - hawks

3. Varies with each series of games ... possibly 80 plants, 11 mice, 5 snakes, 2 hawks.

4. Plants, animal eaters. Plants are the most efficient in getting energy. Animal eaters get energy from other animals who use some of their own body processes and lose some energy as heat.

5. Yes. They depend on organisms that depend on plant eaters which depend on plants. A food chain collapses if a link is missing.

Extension Activities

Play the game with a shorter food chain. Compare the number of plants required to support that community and the longer one in this game.

Discuss what would happen if each link of the food chain had more or fewer members.

Have students list the shortest continuing food chain they can think of, the longest food chain they can think of, and various good chains that include people.

Have students find organisms involved in food chains in your area. Examples are insect larvae on leaves, rabbits eating leaves, etc.

Other Readings

OBIS Trial Edition Set II. 1976. The Food Chain Game. Lawrence Hall of Science, University of California/Berkely, California.

Student Activity Sheet

Name ______________________

Date ______________________

The Game Plan

You are going to play a game of tag in which you collect peanuts. The goal is for at least some plants, one mouse, one snake, and one hawk to survive through the game. The game is over when your teacher gives the signal. Read the directions for your group.

If you are a MOUSE:

You must get enough to eat without being "eaten". During the game you pick up peanuts from the ground and put them in your plastic bag "stomach". When you have at least 10 peanuts in your bag, you may eat half of them. You must avoid getting tagged (eaten) by a snake. If you are tagged by a snake, give him/her your "stomach" and go back to the staging area. (A hawk can not tag you) If you are not captured, return to the staging area when your teacher gives the signal. Record the number of survivors.

If you are a SNAKE:

You must get enough to eat without being "eaten." During the game you tag (eat) mice and take their plastic bag ("stomach"). You must obtain 15 intact peanut shells to be adequately nourished. If you have a few extra, you may eat them, but do not capture additional mice. You must avoid getting tagged (eaten) by a hawk. If you are tagged by a hawk, give him/her your "stomach(s)" and go back to the staging area. (You can not pick up peanuts from the ground) If you are not captured, return to the staging area when your teacher gives the signal. Record the number of survivors.

If you are a HAWK:

You must get enough to eat in order to survive. During the game you tag (eat) snakes and take their plastic bag ("stomach"). You must have 20 intact peanut shells to be adequately nourished. If you have a few extra you may eat them, but do not capture additional snakes. (You may not tag mice, or pick up peanuts from the ground.) When you have 20 intact peanut shells, return to the staging area. Even if you do not have 20 peanuts, return to the staging area when your teacher gives the signal. Record the number of survivors.

RECORD OF SURVIVORS

	At Start of Game				End of Game				
	Approximate # Plant	# Mice	# Snakes	# Hawks	Approxmiate # Plants	# Mice	# Snakes	# Hawks	Other Changes Made In The Game
GAME 1									
GAME 2									
GAME 3									
GAME 4									

NOTE: Mice Survivors Must have 10 nuts
Snake Survivors Must have 15 nuts
Hawk Survivors Must have 20 nuts

Summary Questions

1. What is a food chain? ______________________________

____

____

____

____

2. What food chain was represented in this game? ____________

____

____

____

____

3. In the successful, balanced community how many plants did you start with? How many mice did you start with? How many snakes did you start with? How many hawks did you start with?

Plants________ Mice ________ Snakes ________ Hawks ________

4. A natural community often contains plants, plant eaters, and animal eaters. Which would you expect to find in the greatest quantity? ______________________ Which would you expect to find in the smallest quantity? ______________________ Why? ______________________

____

____

5. Do hawks need plants to survive? Explain ________________

____

____

____

BREAK THE CHAIN HABIT

Examining the Food Chain

Objectives

The student should be able to:

(a) Identify the most and least energy efficient sources of livestock protein.

(b) Explain what the protein conversion efficiency of plants would be if included on a graph.

(c) Explain that more protein and energy are available from plants than from animals in a food chain.

(d) Make decisions about choosing a diet in a world where there will be food shortages.

Overview

Eating several links along the food chain (meat) requires the expenditure of much more energy than eating the first link (vegetables, nuts, and seeds). In this lesson students examine a graph that shows livestock protein conversion efficiency and use this information to help decide how people can best survive in an unusual situation and in an overpopulated world.

Materials

Set of Student Activity Sheets

Strategy

Ask students what cows eat and what organisms frequently eat cows. Ask students for examples of other food chains involving man. Put them on the chalkboard.

Reestablish that more energy is contained in green plants of a food chain than in each succeeding level of consumer.

Hand out student activity sheets and let students work either independently or in groups.

Discuss the answers.

Notes To The Teacher

Discussions resulting from questions 8 and 9 can become passionate and long. If this happens, consider having a separate lesson on this topic.

Sample Responses

1. Various answers. They may include beef, poultry, fish, milk, eggs, peas, beans, lentils, etc.
2. Varied responses.
3. (a) eggs, (b) beef or veal.
4. They are plants.
5. 1.0. 100% of the plant protein could be consumed by humans.
6. Have people eat the corn directly eliminating a link in the chain.
7. Yes. Cattle can eat grass. Marginal farming lands can be used for grazing.
8. Various responses.
9. Various responses.
10. Eat the hens making them last as long as possible. Then eat the cereal. This is good utilization of the food chain. Feeding the cereal to the hens is inefficient.

Extension Activities

Have students do research regarding meat consumption in this country, pet food consumption, farming practices.

Student Activity Sheet

Name ______________________

Date ______________________

1. Try to remember what you ate yesterday. Which of those foods were sources of protein?

____

____

____

____

2. What are your favorite "protein" foods? ______________

____

____

3. A typical food chain in our country is corn plants - cattle - people. How could food be made available to more people from this food chain?

____

____

____

____

____

4. Is there any way that cattle can be raised without using corn or other grains that <u>we</u> can eat directly? Explain.

____

____

____

____

____

The graph on the right shows how many pounds of corn or other protein must be fed to each animal to produce one pound of that animal protein for us to eat.

5. Which animal protein requires the least amount of plant protein to produce?

(a) ______________________________

Which requires the most?

(b) ______________________________

6. Soybeans and nuts have considerable amounts of protein. Why aren't they included in this graph?

____

____

____

7. If the graph were expanded to include soybeans and nuts which conversion efficiency value would they have?

(a) ______________________________

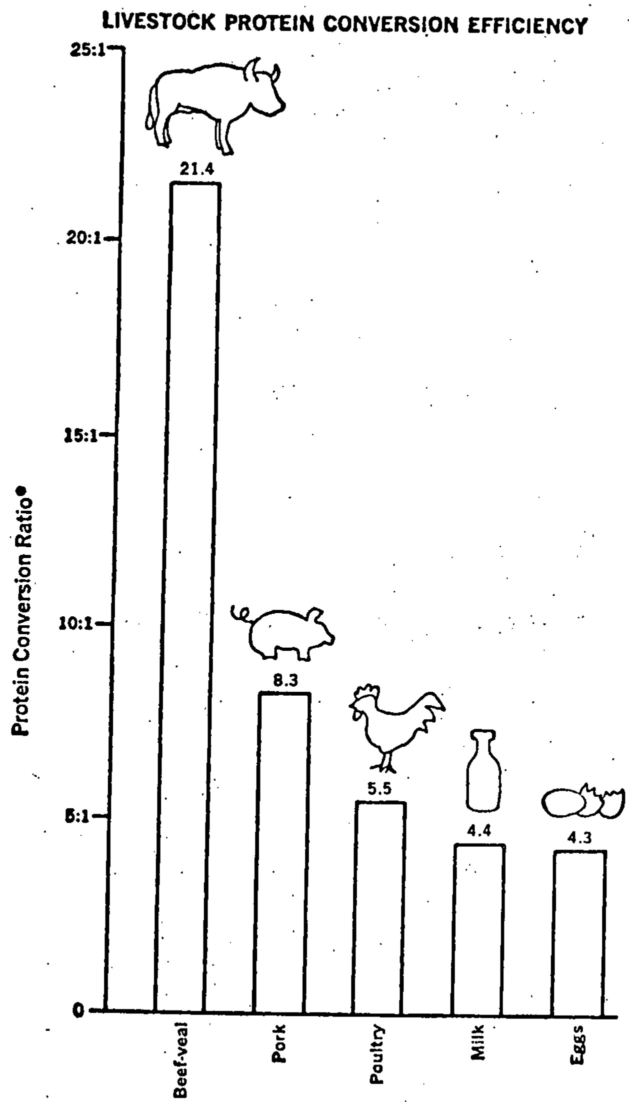
____

What does that mean?

(b) ______________________________

____

____



*No. of lbs. protein fed livestock to produce 1 lb. protein for human consumption.

Source: Lappe 1972

8. The world population is increasing very rapidly. Use of energy is increasing too. Much energy is used in farming and raising animals. The result is that there may be a food shortage during your lifetime. Are you willing to alter your diet to make food available to more people? in the world?

(a)____

____

Why or why not?

(b)____

____

____

If you answered "Yes", how would you alter your diet? ______________

____

____

9. Do you think most Americans can be convinced to alter their diets? Why?

____

____

____

Do you think they should alter their diets? Why? ______________

____

____

10. Consider an imaginary situation. You and another sailor are stranded on a barren island during a cold winter. You were able to save only a crate of cereal and two hens. How can you two survive as long as possible?

____

____

____

TAKE IT OFF

Food Packaging Costs Energy

Objectives

The student should be able to:

(a) Identify over-processed and over-packaged foods.

(b) Choose foods that require limited amounts of energy, processing and packaging.

Overview

The processing of crops to make nutritious foods more desirable requires large amounts of unnecessary energy. The purpose of this lesson is to demonstrate the inefficiency of energy use in food production by close analysis of several processed foods and strong emphasis on over-packaging.

Materials

A can of Pringles potato chips or similar product (optional).

Strategy

1. Prior to starting this lesson give the students the Activity Sheet. Ask them to visit the local grocery store so that they may list as many varieties of each item as they can find. (Example: frozen, canned, fresh, paper package, etc.)

a) cheese	e) cake
b) corn	f) potatoes
c) milk	g) ham
d) juice (orange)	h) coffee

2. Demonstrate some type of procedure which can be used to analyze packaging. Use a can of Pringles potato chips as an extreme example. Besides the fact that these chips are synthetic, the packaging is quite involved. First, the chips are canned in aluminum and capped in plastic, then the can itself is surrounded with paperboard.

3. The day of the lesson have the students rank each individual variety of food on their lists in order from highest energy input to lowest energy input.

4. Ask some students to reproduce their lists on the chalkboard. It may be best to ask them to explain their criteria for arranging each item in that order. Because of the variety of answers, discussion should follow.

Notes to The Teacher

It may be best to review the material in the introduction. Explain that different variety does not mean Del Monte or Libby - does not mean french string beans, yellow snap beans, and green string beans.

Sample Responses

1. The chart - a) Packaging ,b) Precooked, c) frozen
2. Answer will vary. TV dinners is a good example.
3. Hopefully they will select low energy input products.
4. Answers will vary. Less preparation at meal time and advertising are examples.

Extension

Study recycling of containers.

Student Activity Sheet

Name ______________________

Date ______________________

You will be given a list of eight foods. Your assignment is to go to the nearest grocery store and find as many varieties of each item as you can. (Example: frozen, canned, fresh, paper-packaged, etc.)

#1 CHEESE	# 2 CORN	#3 MILK	#4 ORANGE JUICE
#5 CAKE	#6 POTATOES	#7 HAM	#8 COFFEE

From your completed lists select the product which you think has the most energy input and place a star next to it.

1. Why did you choose the items that you starred? ________________

____

____

____

2. In the supermarket you may have noticed energy wasteful products that were not on your list. Name five (5).

____

____

____

____

3. What types of foods would you or other members of your family purchase in order to save energy? (There are no right or wrong answers)

____

____

____

____

4. Why do people buy high energy input products? ________________

____

____

____

Table of Energy required to produce various food packages (After Berry and Makino, 1974)

Package	K cal.
Small paper set-up box	722
Polyethylene pouch (16 oz)	200
Wooden berry basket	69
Steel can (16 oz, steel top)	1,006
Glass jar (16 oz)	1,023
Steel can (12 oz, aluminum top)	568
Aluminum can (12 oz, pop-top)	1,643
Aluminum TV dinner container	1,496
Styrofoam Tray (size 6)	215
Molded pulp tray (size 6)	384
Polyethylene bottle (1 qt)	2,494
Polypropylene bottle (1 qt)	2,752
Plastic milk container (1/2 gal; disposable)	2,159
Glass milk container (1/2 gal; returnable)	4,455
Coca Cola bottle, non-returnable (16 oz)	1,471
Coca Cola bottle, returnable (16 oz)	2,451

*Calculated from data of Berry & Makino

(Tentative by Pimentel unpublished, 1977)

HOME ON THE RANGE

Cost of Home Food Preparation

Objectives

The student should be able to:

(a) Recognize and identify the energy waste in home food preparation.

(b) Become familiar with ways to improve energy efficiency in the home related to food preparation.

(c) Design simple procedures to help improve bad energy habits.

(d) Formulate a sound energy efficient philosophy.

Overview

As a nation our fuel resources are decreasing and our consumption is increasing at rapid rates. We must face the fact that the energy crisis will eventually affect our domestic lives more drastically. The necessity to change and control energy consumption at home is inevitable. In this lesson students will examine the extent of energy use at home and ways to saving energy rated to food preparation.

Materials

Transparency of energy consumed by home appliances

Two sets of Student Activity Sheets

Strategy

Begin this lesson by asking the students about the energy waste in food preparation at home. Some students will probably suggest that refrigerators are great energy users because they are continually in use. Some will conclude that ovens and stoves use the most energy. You might want to explain that smaller specialized appliances are far more efficient. For example, egg cookers shut off, like many other small appliances, as soon as the egg is cooked, reducing the time and amount of energy used. Project and discuss the transparency.

Give each student a copy of the appliance energy requirement and Investigation 2. Encourage students to do the best they can.

Point out that a large amount of energy is wasted traveling by car to the grocery store. A trip to local stores averages 2 miles and the number of items purchased can be four or less - an energy waste. This is one area many students will probably not think about. Hand out Investigation 1. This is to be done over a period of one month and one vacation week. Students are to thoroughly examine the number of trips to the grocery store, the number of items purchased, miles traveled, and the reason for the run. Once this information is gathered, discussion should take place. Students should recommend ways to help change poor habits if they exist.

Notes to The Teacher

You may want to write a form letter to the parents explaining the aim of this project.

Suggest that students keep their investigation charts on the refrigerator in case parents want to add to them.

Sample Responses

1. Answers will vary. (a) make a complete grocery list to make sure nothing is forgotten. (b) pick up small items on the way or returning from another destination.
2. Answers will vary. Savings in money and time are often listed.
3. Answers will vary. Usually holidays mean more travel.
4. More thought should be given to grocery shopping. More organization should be applied when possible. Running to several stores for all different sales is a waste of energy.
5. Some appliances are preferable.
6. Answers will vary.
7. Plan several items that can be baked at the same temperature (possibly for future meals). Do not preheat. Turn off oven 10 minutes before food is done. Plan combination dishes that can be cooked in one pan on one burner. Many others.
8. We can try to conserve in our own lives by being less wasteful.

9. Yes

10. Yes.

Extension Activities

Introduce students to the difference between power and energy.

Measure electric energy of a small battery.

Examine the increase in the consumption of electrical energy over the past 40 years.

Study the electric rate structure.

Calculate the amount of electricity used in their homes.

Electrical Energy Use Chart

Estimated Energy Consumed by Home Appliances in a Month

Food Preparation	Average wattage	Estimated kilowatt hours monthly
Blender	390	1
Broiler	1,440	8
Carving Knife	92	1
Coffee Maker	890	9
Deep Fryer	1,450	7
Dishwasher	1,200	30
Egg Cooker	520	1
Frying Pan	1,200	15
Hot Plate	1,260	8
Mixer	130	1
Oven, Microwave	1,500	25
Oven, Self-cleaning	4,800	95
Range	8,200	97
Roaster	1,340	17
Sandwich Grill	1,160	3
Toaster	1,150	3
Trash Compactor	400	4
Waffle Iron	1,120	2
Waste Disposer	450	3
Food Preservation		
Freezer (15 cu ft)	340	99
Freezer (Frostless 15 cu ft)	440	147
Refrigerator (10 cu ft)	240	60
Refrigerator (Frostless 12 cu ft)	320	110
Refrigerator/Freezer (14 cu ft)	330	94
(Frostless 14 cu ft)	620	152
Laundry		
Clothes Dryer	4,860	83
Iron	1,010	12
Washing Machine (automatic)	510	9
Washing Machine (non-automatic)	290	6
Water Heater (standard)	2,480	352
Water Heater (quick recovery)	4,470	401

Student Activity Sheet

Name ______________________

Date ______________________

Investigation 1

Have you ever given any though to the amount of energy used to place a meal on the table? Just consider how many trips are taken in the automobile to the local food stores for a container of milk or a loaf of bread. Energy conservation and short trips are not truly compatible, but there are ways to make short runs and save energy.

Your assignment is to carefully examine for one month and a vacation week the number of trips to the grocery store, miles traveled, number of items bought and the reasons for making the trip. Use the chart below to help organize this idea. As soon as you have completed this information your teacher and the class will try to help you arrive at some sound suggestions which will help you and your family conserve energy.

# Trips to Grocery Store, Deli. etc.	Miles Traveled	Vehicle Used	# Items Purchased	Reason(s) For Going

Questions

1. After looking over this information what suggestions can you recommend to help reduce the number of trips to the local food stores?

____

____

____

____

____

2. Is it possible to change your parents' habits on food trips? How?

____

____

____

____

3. How did the holiday week compare to the average month chart?

____

If there was a considerable difference, suggest why ____________________

____

____

____

4. What conclusions have you arrived at? ____________________

____

____

____

____

5. List some appliances which are most desirable in the area of energy conservation

6. List some appliances which are least desirable in the area of energy conservation.

7. List suggestions to help improve cooking management in your home.

8. How can you affect the total picture of energy conservation?

9. Suggest how adults can make a contribution to energy conservation in the home.

10. Suggest how teen-agers can make a real contribution to energy conservation in the home?

Investigation 2

Are you aware of the fact that we are probably more dependent on various home appliances for food preparation than people of any other nation in the world? As a consequence, our appliances are major users of energy. It is clear that in the future our choice of energy source in the home may be severely restricted by social cost of making that energy available.

For one week you will compile data needed to complete this chart below. Your teacher will supply you with a table which lists common kitchen appliances and the amount of energy used to run them. At the end of this assignment, your information along with the rest of the class will be examined and hopefully we can recommend some suggestions to help reduce energy waste in our kitchens.

Appliance Used	Amt of Energy Used	Time In Use	Alter- natives	Reason for Use	# of Meals Prepared	# of People Eating	Comments

SMALL TECHNOLOGIES

Introduction

Americans are an energy-hungry people who depend on electricity. Though we are only 6% of the earth's people we use 35% of the total energy produced world-wide each year. In 1973 the sources of that energy were primarily petroleum, natural gas and coal. The problem we face is that these fossil fuels are rapidly being used up.

It is a commonplace of energy discussions to say that the sun is the source of all of the planet's energy. We use its heat and light directly. Plant matter, or biomass, converts sunlight into fossil fuels and other organic materials which can be burned. Winds are another form of energy created by the sun. Uneven heating of the atmosphere sets up currents whose power can be harnessed for our benefit.

Since all depend ultimately on the sun, these are sources of energy which will not run off for about 5 billion years. Each is non-polluting, a "free" fuel and available to the individual homeowner. The technology associated with solar heat collectors, windmills and biomass converters is uncomplicated. All are relatively undeveloped but presently in use on a limited scale.

By substituting for fossil fuels, we release them to be used as chemical raw materials for the myriad synthetic products on which modern life depends. The so-called "small technologies" are attractive also because they are gentle on people, on resources, and on the environment.

Solar, wind and biomass sources of energy are easily understood in a science class, as are the technologies they use. Solar thermal collectors can be used in the context of heat and light units. Wind energy lends itself to discussions of mechanics and electrical generation. Biomass utilizes many biological principles, so traditional subjects can be taught or reinforced while dealing with an issue of central importance.

Solar Energy

The amount of solar energy which actually arrives at ground level, or rooftop, depends on the latitude, the season of the year, local weather, time of day and several other factors. There are charts, based on years of data, collected by the Weather Bureau, which give the mean daily solar radiation by month for all parts of the US. The average in the US is about 177 watts/m^2 or 58 BTU/ft^2/hr. (One BTU or British Thermal Unit is the amount of heat needed to raise the temperature of one kilogram of water one degree Fahrenheit.)

Using the January data, a typical three bedroom house in Connecticut, with 1,000 ft^2 of roof area would receive 5.6 million Calories in that month. Even at 50% efficiency, a roof full of collectors could provide more than half of the 4.8 million Calories such a house would typically require in the winter. We have deliberately chosen a pessimistic case, a Northern state and a winter month, to make the point that solar energy can provide important amounts of heat even in the North.

Hot water needs for a family of four are estimated at 60 gallons a day. A roof top collector of 70 to 90 ft^2 would supply from 60% to 80% depending on the unit and location, so solar thermal collectors can make a substantial impact on a home owner's need for heat and hot water.

Typical space and hot water systems providing upwards of 50% of needs for a family of 4 are estimated by the Federal Energy Administration to have paid for themselves in fuel savings in as little as 4 years or as long as 20 years. The greatest savings are in converting from electric heat to solar and the pay back period (the time it takes to have saved as much as the installation cost) will decrease rapidly as fuels become more scarce and more costly.

To provide all of the heat and hot water needed for a home of 1500 ft^2 in mid-US locations on a 40°F day would require somewhat more than half of the roof area if a single story or slightly more than the roof area of a two story house. A more practical approach for existing homes is to provide from 50% to 80% of the family's needs, even in colder climates, by using the south facing slope. By planning to provide about half of the heat needed in the coldest month the heating needs would be met for most months, and the year round average comes close to 80%.

On a national scale space heating in homes and businesses uses 18% of the energy consumed. By the year 2000 the US Energy Research and

Development Administration expects about 4% of the nation's energy needs to be filled by solar heating and cooling. By the 2020, an impressive 11% of the total is predicted. These are figures for a method of home heating which admirably fulfills the California State Criteria for an Appropriate Technology, as listed below.

CRITERIA FOR AN APPROPRIATE TECHNOLOGY

	APPROPRIATE	INAPPROPRIATE
	ECOLOGICAL	
1.	Does not release pollutants/poisons to environment	Pollutes/poisons environment
2.	Protects existing natural habitat	Destroys natural habitat
3.	Restores viability of ecosystems	Destroys viability of ecosystems
4.	Recycles organic nutrients/creates topsoil	Wastes nutrients and destroys topsoil
5.	Produces food	Destroys food production (potential or actual)
6.	Conserves renewable resources	Overuses renewable resources
	ENERGETIC	
7.	Conserves nonrenewable resources	Uses and wastes nonrenewable resources
8.	Promotes use of renewable energy sources	Uses nonrenewable energy sources
9.	Promotes use of recycled materials	Doesn't use recycled materials
10.	Reduces transportation dependence	Increases dependence on transportation

ECONOMIC

11.	Long life	Short life
12.	Low cost (initial and/ or lifetime)	High cost
13.	Promotes small-scale production, local ownership, bioregional economy	Promotes large-scale centralized enterprises
14.	Promotes "right livelihood" (meaningful work, income)	Dehumanizing/impoverishing work or lack of work
15.	Labor/skill-intensive	Capital-intensive

SOCIAL/POLITICAL/CULTURAL

16.	Provides human habitat	Destroys human habitat
17.	Promotes social flexibility/adaptability	Reduces social flexibility
18.	Promotes self-reliance and community cooperation	Promotes centralized control
19.	Understandable/usable at community level	Understandable to and run by specialists
20.	Creates/maintains natural beauty	Destroys natural beauty

Source: Office of Appropriate Technology, State of California.

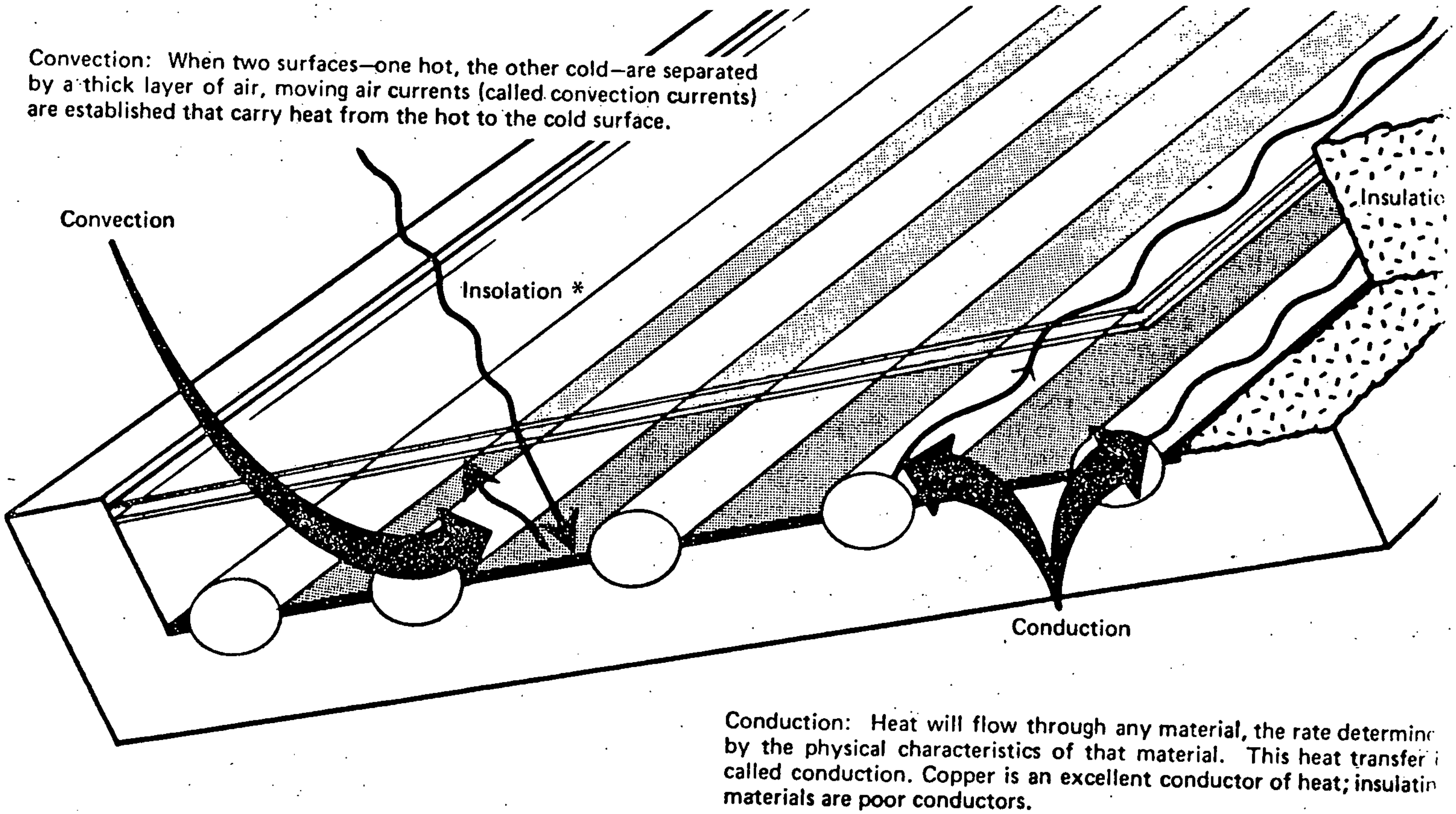
Technology of a Flat Plate Collector

To understand how the heat gets from rooftop to the living space below, look at the diagram of a flat plate collector on the following page. This is the design which has been used successfully for residential and commercial space heating.

The transparent cover serves many purposes. It keeps outside air from carrying away the heat that has been trapped. It also keeps out the wind and the elements, protecting the inside components and reducing energy loss by convection. In warm areas, one cover is usually all that is necessary, but in colder climates, two transparent covers or insulated glass are generally considered necessary.

Here is how the typical flat plate collector works. Solar radiation passes through the transparent cover (a small portion is absorbed or reflected off the cover's surface) and hits the absorber plate. Most of the

How a Flat Plate Collector Works



* Insolation is the rate of solar radiation received per unit area.

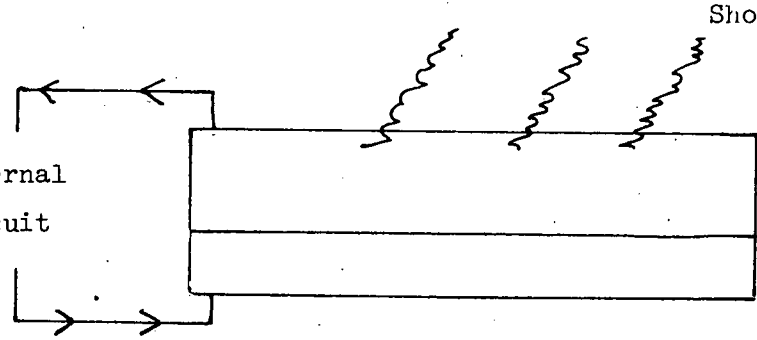
radiation is absorbed by the plate and picked up by the fluid (air, water, or other liquids) passing through the channels in or against the plate. Some of the radiation is reflected off the plate back to the cover -- how much depends upon the absorbing and reflecting characteristics of the coating on the collector plate. The better the absorbing quality, the more radiation captured; the less reflected back to the cover. Special coatings have been developed which are highly absorptive with low reradiation. Don't be turned off by a collector plate because it is black or a dark color; dark colors absorb radiation much better than light colors. Conversely, you can't always tell by the color whether the coating has the desired selectivity characteristics.

Within the house the heated fluid passes through a storage unit in which heat is stored for night time and cloudy days. Storage units are a large tank for water (convenient, inexpensive, low maintenance), rocks (more space needed, no maintenance) or special salts (must be replaced periodically, least amount of space, expensive). Despite its limitations, water is at present the most practical method for storing heat from liquid type collectors. During the day solar heated liquid warms the storage material. Once charged, the storage can provide 3 or 4 days of heat without additional input. Note in the diagrams on the following page that the collector fluid warms only the storage unit. Household heat and hot water are provided by heat exchangers in contact with the storage material. Note also that both systems provide for conventional sources of heat when necessary.

Electrical Generation

Conversion of solar energy to electricity is an attractive idea. We have a lot of one and need a lot of the other. It has been estimated that the present electric demand could be supplied by solar energy plants having a total area of about 2,000 km^2 or about 2% of the land area now devoted to roads.

Direct conversion of sunlight to electricity is possible with photovoltaic cells. These are the light meters commonly used in photography. A typical cell consists of a thin layer of Silicon doped with Phosphorus in contact with a layer of Silicon into which Boron has been introduced. The Phosphorus doped layer has electrons which can be more easily induced to move around than those of pure Silicon and is called an n-type (negative) crystal. The Boron doping leaves an excess of spots for electrons to fill and is called a p-type (positive) crystal.



Sunlight falling on the n-type layer is absorbed by electrons which thus are given energy to travel. Since there are an excess of holes in the other layer, a net flow of electrons between the layers is created by connecting them through an external circuit. Photovoltaic cells are thus self contained sources of electricity.

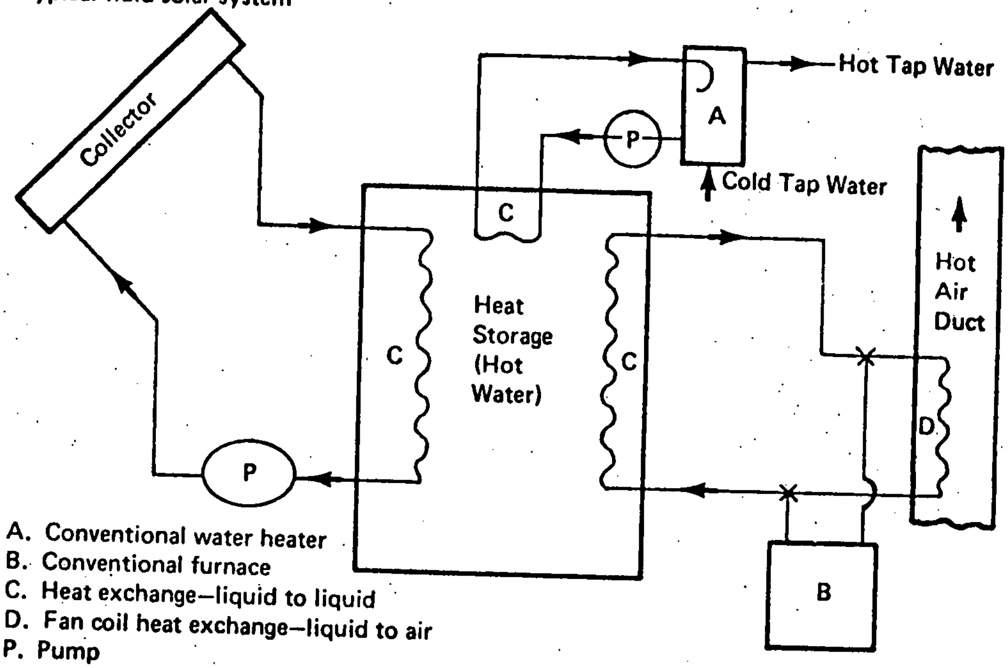
It is, however, electricity at a very low voltage, so that a large surface area is required for practical power output. A need for extreme purity in the Silicon and for a pure crystalline structure when combined with the need for great precision in the addition of doping materials results in a high price. There is a great deal of research going on into both reducing the costs and increasing the efficiency of these cells.

Photovoltaic cells are projected as a reasonable way for homeowners to supply their own electricity one day. In fact, since the peak demand for power is on hot sunny days in mid-summer, when solar energy is also at a peak, such units could feed into the utility when most needed. A physicist, Dr. Karl Boer, of the Institute of Energy Conservation at the University of Delaware, estimates that electricity costs for home units would be 2 to 3 cents per KWH. Utility rates are currently in the 3 to 5 cents per KWH range.

Silicon is the second most abundant material on earth, the major ingredient is sand. Supply is no problem. Solar cells do not create any environmental problems to speak of, especially if roof-mounted. They give every hope of being practical, benign generators and soon.

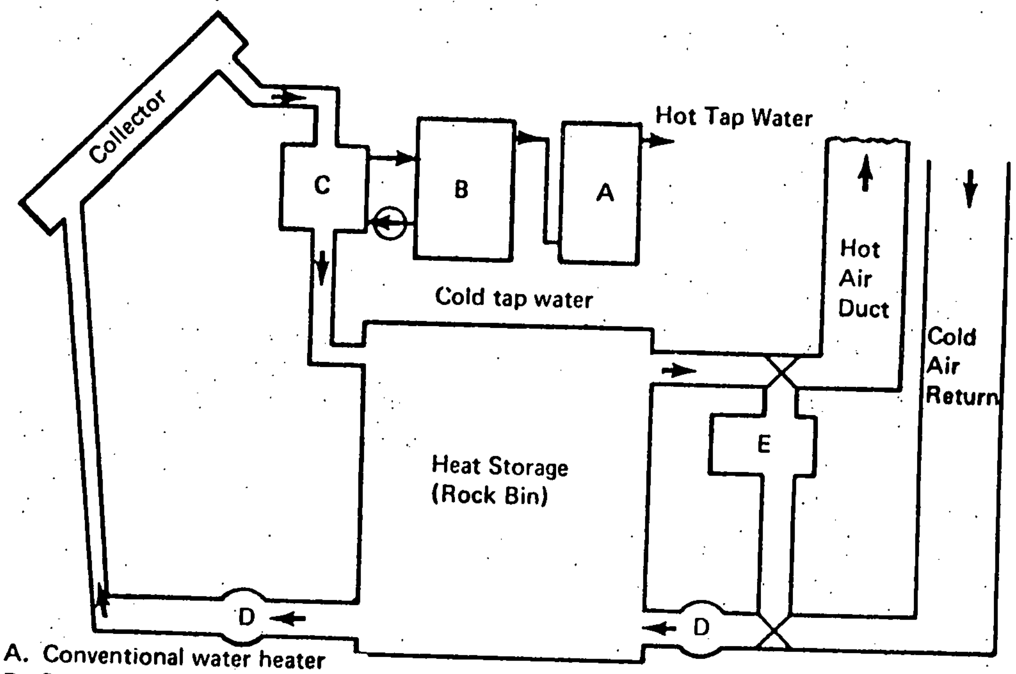
Solar Space Heating and Domestic Hot Water

Typical fluid solar system



A. Conventional water heater
B. Conventional furnace
C. Heat exchange—liquid to liquid
D. Fan coil heat exchange—liquid to air
P. Pump

Typical air solar system



A. Conventional water heater
B. Solar hot water storage
C. Air to liquid heat exchange
D. Blower
E. Conventional furnace

Large scale production of electricity from sunlight depends on the Solar Thermal Conversion schemes, which turn light to heat and use the heat to produce electricity conventionally. One type will consist of a receiver - a boiler mounted on a tower - and a collecting field of mirrors which focus the radiant energy on the tower. Focusing requires that the mirrors track the sun, a complex and expensive business. But an enormous concentration of energy, as much as 1000 times the normal insolation, can be achieved. In the French Pyrennes a solar furnace of this design, used for high temperature research, can produce temperatures as high as 6000°F. This heat could be used to produce supersaturated steam to run turbine generators, as in conventional plants. A major disadvantage of this central receiver plan is that it requires full sunlight and a huge amount of land.

A different system uses sophisticated flat plate collectors feeding their heated fluid to a central storage unit. Parabolic trough concentrators have a parabolic cross section which focuses the sunlight on a pipe carrying the heat collecting fluid through the trough. These do not require tracking, can use diffused light and are thus less troublesome than central receivers. The distributed collector systems collect less energy than the central, leading to a lowered efficiency at the generator end. They too need large areas and share the important difficulty of energy storage. The sun doesn't always shine. Solar Thermal Conversion plants are designed for eventual utility size generation of power and will need substantial breakthroughs in energy storage before they can be put into use on any reasonable scale.

Between roof top flat plate collectors, photovoltaic cells, and STC plants, solar energy has both immediate applicability and future possibilities. If you include the concept of a Solar Satellite Power Station beaming captured sunlight as microwave energy you can envision very long term schemes for utilizing this very attractive energy source for our expanding needs.

<u>Wind Energy</u>

Wind is caused by the uneven heating of the atmosphere (the air around the earth) by the sun. Like the air over a hot stove, air heated by the sun expands and rises. Cooler surface air then flows in to take the heated air's place. This process is called circulation. Two kinds of circulation produce wind: 1) widespread general circulation extending around the earth, and 2) smaller secondary circulation. Winds that occur only in one place are called local winds.

General circulation occurs over large sections of the earth's surface. It produces prevailing winds. Near the equator, heated air rises to about 60,000 feet. Surface air moving in to replace the rising air produces two belts of prevailing winds. These belts lie between the equator and about 30° north and south latitude. The winds there are called trade winds because sailors once relied on them in sailing trading ships.

Secondary circulation is the motion of air around relatively small regions of high and low pressure in the atmosphere. These regions form within the larger general circulation. Air flows toward low-pressure regions called lows or cyclones. Air flows away from high-pressure regions called highs or anticyclones. As in the general circulation, air moving toward the equator moves in a generally westerly direction and air moving away from the equator moves in an easterly direction. As a result, secondary circulation in the Northern Hemisphere is clockwise around a high and counterclockwise around a low. These directions are reversed in the Southern Hemisphere.

Secondary circulations move with the prevailing winds. As they pass a given spot on the earth, the wind direction changes. For example, a low moving eastward across Chicago produces winds that shift from southwest to northwest.

Local winds arise only in specific areas on the earth. Local winds that result from the heating of land during summer and the cooling of land during winter are called monsoons. They blow from the ocean during summer and toward the ocean during winter. Monsoons control the climate in Asia, producing wet summers and dry winters. A warm, dry, local wind that blows down the side of a mountain is called a chinook in the western United States and a foehn in Europe.

Wind Driven Generators

Modern wind driven generators extract energy from the wind and convert it into electricity. A complete wind driven system consists of a:

1) tower to support the wind generator, 2) the propeller and hub system, 3) the tail vane, 4) devices regulating generator voltage, 5) a storage system to store power for use during windless days and, 6) an inverter which converts the stored direct current (D.C.) into regulated alternating current (A.C.) if it is required.

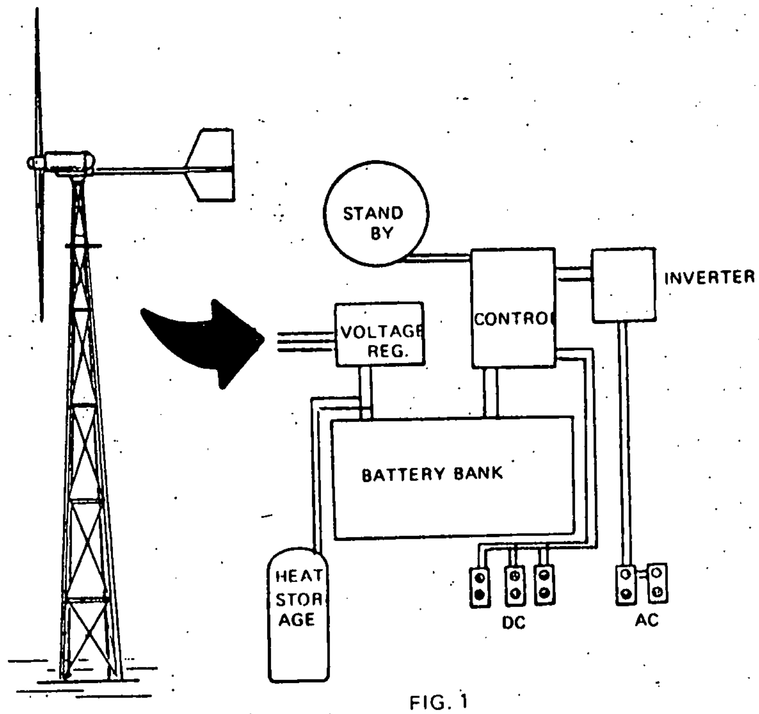


FIG. 1

IN THIS SYSTEM, THE WIND DRIVEN GENERATOR CHARGES A BATTERY BANK, from which DC power is taken directly for use or inverted, making AC for appliances like T.V., and radios. Excess power runs a heating storage system.

Wind pressure turns vanes or propellers attached to a shaft. The revolving shaft, through connections to various gears and mechanical or hydraulic couplings, spins the rotor of a generator. The generator creates an electric current which could be used directly or stored in battery banks.

The power output of a wind machine depends both on wind velocity (or speed) and on the diameter of the blades. For maximum power, a wind machine should have the longest blades possible (about 100 ft. is the maximum now) and should be located in the strongest winds. The height of the wind machine is another important factor because there is greater wind speed and constancy at higher altitudes than at the earth's surface. The expense of building a tower also increases with its height, however, in that most present designs call for a tower between 100 and 150 feet high.

There are a number of US sites where large amounts of wind energy are available: the Great Plains, the eastern foothills of the Rocky Mountains, the Texas Gulf Coast, the Green and White Mountains of New England, the continental shelf of the northeastern United States, and the Aleutian Islands off the coast of California. Among the schemes for using wind power are construction of a grid of wind machines at half mile or mile intervals throughout the Great Plains area. Such a system could produce 190,000 Mw of installed electrical capacity, roughly half of the US total in 1971. Also proposed is an offshore scheme in which the winds would be used to electrolyze water into hydrogen and oxygen. The hydrogen could then be piped to shore or brought in by refrigerated tankers.

Small-scale schemes may also continue to prove promising. A ten foot rotor could provide enough energy for an all-electric single family home in many parts of the US. Another option, too, would be to tie into, or remain tied into the existing utility line, switching to central-station power when the local generator is down or inadequate. Modern "homesteaders" are still finding wind power an economical alternative to having the nearest power company run lines out to their remote areas, and a number of companies are now producing wind electric generators designed for home use.

For all its antiquity, wind machine design is a new challenge to American engineers and several exotic designs have already appeared. Among these are the "Sailwing" (developed at Princeton and scheduled for production by Grumman Corp.) whose blade deforms in the wind and is therefore self-orienting. A prototype is already in operation in India. Also under development are several vertical axis designs which are not dependent on wind direction.

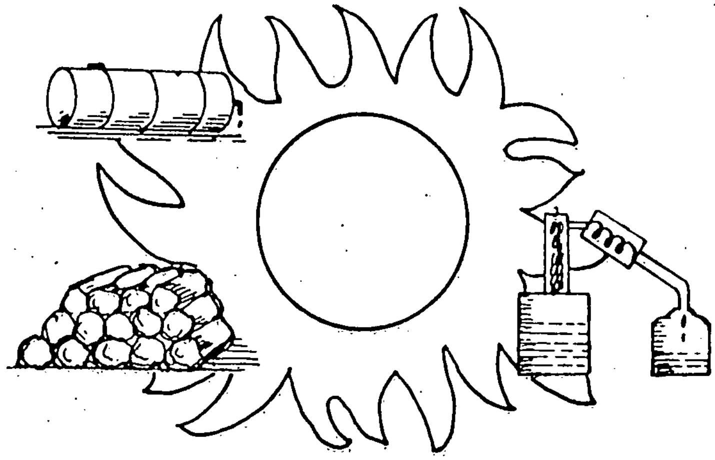
There are a number of advantages of wind power. There is no fuel cost. In addition, wind power is continuously regenerated in the atmosphere under the influence of radiant energy from the sun, and thus is a selfrenewing source of power, does not release pollutants/poisons to the environment, and conserves nonrenewable resources. However, there are a number of factors which limit its immediate use. The initial cost of building the machine is high. A storage system for days of no wind can be expensive. Depending on location of the windmill, care must be taken for high winds, low temperature (ice forming on the blades), and structural dynamics between the tower and the revolving blades. Wind variability also effects the output frequency of the generation. Since standard US power networks require constant frequencey (60 cycles per second) and Alternating Current (AC), some means for regulating the frequency is needed. While constant-speed drives or converters are available, they add to the expense. Finally, a major drawback is land use. Although a single machine does not occupy much space, a giant grid of them complete with power lines would have aesthetic drawbacks, but wind harvesting should be compatible with other uses of the land such as pasturage and farming.

Biomass

Biomass is the term for organic material other than fossil fuels. Plant or animal matter has stored chemical energy by virtue of the process of photo (or chemical) synthesis of protoplasm. Only 0.1% of the incident solar energy is converted to biomass and only 2% of the biomass produced is ever used. Half, or 1%, becomes food and feed, the other 1% is used for fuel and fiber. It is hoped that through improved processing and new technology as much as 40 times as much solar energy (4%) can be utilized.

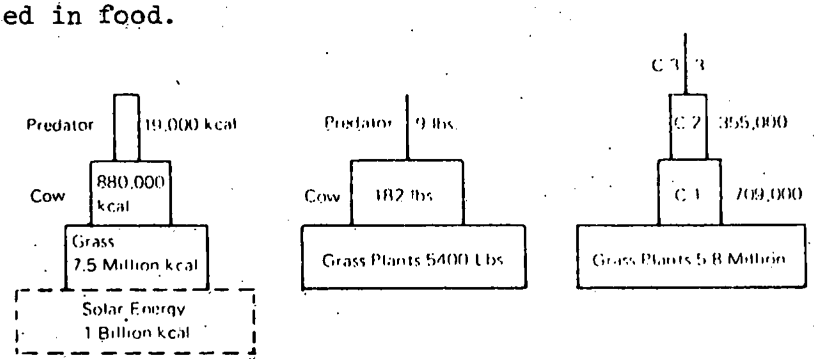
Though it is a tiny fraction of the sun's energy, biomass has in the past provided humanity with 98% of the energy used. About 100 years ago, 90% of the energy in the US came from biomass (including wood and that biomass which became our fossil fuels). Today it still supplies 75%. In developing nations 2/3 of their energy comes from wood, agricultural residue and dry animal wastes. Often, improved combustion methods make more efficient use of these renewable, inexpensive and readily available fuels.

To appreciate the energy supplied by biomass one needs to look at the efficiencies of biomass systems. First, 99% of the incident solar energy is lost to the green plants by reflection and evaporation. Of the 1% absorbed energy about 75% is converted to biomass and is availble as food for herbivors.



BIOMASS PRODUCTION AND CONVERSION

About half is actually consumed. The result is that only 0.5% of the solar energy falling on a field is eaten and passed down the chain. Once eaten, 10% of the energy is utilized to form meat protein. The following schematic shows the efficiency of plants in capturing radiant energy and the losses as it is used in food.



PYRAMID OF ENERGY PYRAMID OF BIOMASS PYRAMID OF NUMBERS

THREE KINDS OF ECOLOGICAL PYRAMIDS BASED ON THE FOOD CHAIN OF A 1 ACRE FIELD OF GRASS OVER 1 YEAR. PYRAMIDS OF ENERGY AND BIOMASS ARE FROM GRASS/COW ECOSYSTEM DESCRIBED IN TEXT. PYRAMID OF NUMBERS IS FROM DATA PRESENTED BY ODUM 1971 (REF. 8), WHERE: C-1=PRIMARY CONSUMERS (HERBIVOROUS INVERTEBRATES); C-2=SECONDARY CONSUMERS(CARNIVOROUS SPIDERS AND INSECTS); C-3= TERTIARY CONSUMERS (MOLES AND BIRDS).

Even at these low efficiencies enormous amounts of energy are available. To convert biomass into units of energy so as to compare it with other fuel sources; it is estimated that one gram dry weight of organic matter is equivalent to 4-5 Kcalories or 1400-1750 Kcalories/per pound, which is 5500-6900 BTU per pound. When larger masses are converted, one metric ton is the equivalent of 1.25 barrels of oil, 1200 cubic feet of gas, or 750 pounds of coal. The table on the following page provides the energy available in a wide range of materials in the biomass - both the readily replaceable and the long range replaceable.

We need to know how much of this energy is actually extracted by various conversion processes. What would be the sense of selecting a less efficient process, assuming all other factors are the same? To give information on the efficiencies of certain biological and mechanical systems, the table below is included.

Efficiences of Solar Energy Conversion Systems: Comparing The Biological With The Mechanical.

* Not including process heat.

	% Efficiency		
	Of Process	To Heat	To Electricity
I. BASIC PHYSICAL CONVERSIONS			
A. STEAM → MECHANICAL ENERGY	10-30		
B. MECHANICAL → ELECTRICAL			80
C. STEAM → ELECTRICAL			A.xB = 8-25
II. SOLAR - MECHANICAL CONVERSIONS			
A. LOW TEMPERATURE SOLAR			
1. Solar energy → hot water		20	
B. HIGH TEMPERATURE SOLAR			
1. Solar heaters, cookers, reflectors		50-80	
2. Solar reflector → steam		40-60	
3. "I-C" above			8-25
4. Solar → steam → electricity			3-15
C. SOLAR → ELECTRICITY (PHOTOCELLS)			
1. Cadmium sulfide			5
2. Silicon			12
D. WIND			
1. Wind → mechanical	44		
2. "I-B" above			80
3. Wind → mechanical → electrical			35
III. SOLAR - BIOLOGICAL CONVERSIONS			
A. FOOD CHAINS			
1. Solar energy → plant chemical energy	0.3-3.0		
2. Plant energy → herbivore energy	5-10		
3. Herbivore → carnivore energy	5-15		
B. WOOD			
1. Solar energy → forest wood	0.5-3.0		
2. Wood → heat (steam)		60-80	
3. "I-C" above			8-25
4. Solar → steam → electrical			.04-.8
C. BIOGAS (DIGESTION)			
1. Solar → plant	.3-3.0		
2. Biomass → biogas*	40-70		
3. Biogas → heat		75	
4. Biogas → heat → mechanical	25-40		
5. "I-B" above			80
6. Organic waste → electricity (via biogas)			.02-.5
D. ALCOHOL (DISTILLATION)			
1. Fruits, grains → ethanol	75		
2. Wood → ethanol	65		
3. Biomass waste → methanol	55		

TABLE IV EFFICIENCIES OF SOLAR ENERGY CONVERSION SYSTEMS: COMPARING THE BIOLOGICAL WITH THE MECHANICAL

*Not including process heat

Energy Values of Various Fossil Fuels and Biofuels

		SOLID	LIQUID	GAS
	kcal/g	BTU/lb	BTU/gal	BTU/ft³
FOSSIL FUEL				
COAL				
bituminous	9.2	13,100		
anthracite	8.9	12,700		
lignite	4.7	6,700		
COAL COKE	9.1	13,000		
CRUDE OIL		18,600	138,000	
FUEL OIL		18,800	148,600	
KEROSENE		19,810	135,100	
GASOLINE		20,250	124,000	
LP-GAS		21,700	95,000	
COAL GAS				450-500
NATURAL GAS (Methane)		21,500	75,250	1050
PROPANE		21,650	92,000	2200-2600
BUTANE		21,250	102,000	2900-3400
BIOFUELS				
CARBOHYDRATES				
sugar	3.7-4.0	5300		
starch/cellulose	4.2	5800		
lignin	6.0	8300		
PROTEIN				
grain/legume	5.7-6.0	8050		
vegetable/fruit	5.0-5.2	7025		
animal/dairy	5.6-5.9	7850		
FATS				
animal	9.5	13,100		
vegetable oil	9.3	12,800		
MICRO-ALGAE	5.0-6.5	9500		
WOOD				
oak, beech	4.1	5650		
pine	4.5	6200		
all woods	4.2	5790		
BRIQUETS	8.1	11,500		
ALCOHOL				
methanol		8600	67,000	
ethanol		12,000	95,000	
BIOGAS (60% CH_4)				600-650
METHANE		21,500	75,250	1050
MISC. "WASTES"				
municipal organic refuse	2.8-3.5	4000-5000		
raw sludge	2.7-5.3	3700-7300		
digested sludge	2.7-5.0	3800-6900		
paper	5.5	7600		
glass	5.6	7700		
leaves	5.2	7100		
dry plant biomass	5.6	8000		
MISC. ANIMALS				
insect	5.4			
earthworm	4.6			
mammal	5.2			

In the US, the Biomass Program has two separate approaches. One aims at increasing the recovery of resources from urban, municipal and industrial wastes. The other concentrates on the development of sources of biomass energy as yet relatively untapped. These areas include land and fresh water "Energy Farms" along with a promising source called Ocean Energy Farming or Aquaculture. In both, plants are grown for their use as biomass sources of more useful forms of energy.

Each year the US produces over 880×10^6 dry tons of organic wastes which is equivalent to 10×10^6 BTU per metric ton or 9Q (a Q is 10^{15} BTU) of energy total. Most of this waste is in the forms of manure and paper. With today's collection and processing methods about 16% can be reclaimed. The processes used to convert the biomass and/or organic wastes are: 1) direct combustion, 2) pyrolysis, and 3) anaerobic digestion.

Direct Combusion in utility boilers can yield 4000 to 5000 BTU per pound as an additive to coal. It can replace as much as 10% of the coal presently used. This is now practiced in the Merrimac Plant near St. Louis, Missouri. At a rate of 27% mix of waste with 77% coal a combustion efficiency of 98% results. In this way waste is turned into cheap electricity.

Pyrolysis is the burning of organic wastes in the absence of air at $200^{\circ}C - 900^{\circ}C$ and STP*. The results are oil and gas which can then be burned as fuel. For each metric ton processed the oil produced yields 4.8×10^6 BTU, an efficiency of 16%. The gas produced yields 5.5×10^6 BTU per metric ton processed, for an efficiency of 55%.

Anaerobic digestion is a biological process which converts the carbon fraction of the biomass to other compounds, releasing the trapped energy. This is the "Small Technology" process used in developing nations and on some small farms in the US.

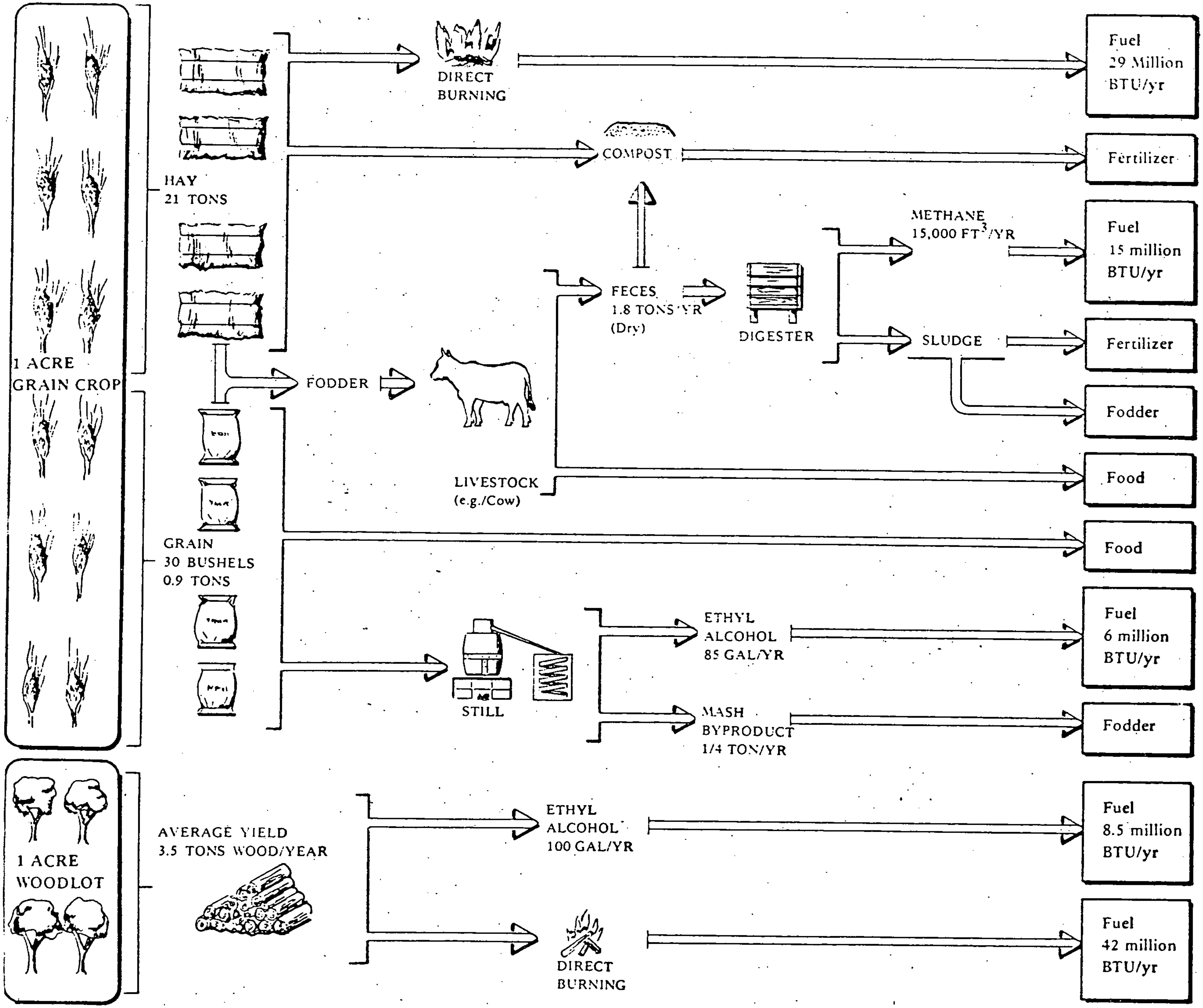
There are two stages to this digestion. First stage-complex organic materials are acted upon by acidogenic (acid forming) bacteria to form fatty acids, glycerol, sugar compounds which are in turn acted on by enzymes to form lower alcohols, acetic acid and carbon dioxide. The second stage is the one in which methanogenic bacteria act on the waste to form methane (CH_4)

* STP = Standard Temperature and Pressure.

and CO_2. This second stage can be accomplished by means of a "Lower Technology Conversion" or mesophylic phase which occurs in a digester or air free pot at 30^{o} - $40^{o}C$ and yields methane gas after about 30 days. It can also occur under "High Technology Conversion" at $60^{o}C$ and produce methane after 2 or 3 days. The heating value of methane is about 500 - 800 BTU/ft^3. This type of small digester operation could supply the cooking fuel for a family of 6 - 8 people.

Ocean Energy Farming is being studied off the coast of San Diego, California under the sponsorship of ERDA and the US Navy. They are growing kelp as the biomass and have had very favorable yields. An idea of the energy available from an acre of grain or woodlot can be obtained from the following figure.

The use of biomass to supply some of our energy needs not only takes into account the vast plant resources of the earth but also aids us in reducing the problems associated with disposal of waste. Digested organic wastes provide combustible gas and valuable fertilizer. Urban wastes help fuel electric generating plants and cut down on the need for land fill. Pollution of ground and ocean water by organic wastes is eased and small farms can be made less dependent on imported fuel. Recycling is an automatic part of the use of urban wastes as fuel and the drain on resources can be alleviated. None of these processes is terribly difficult to engineer and the end result of none is harsh on the environment. Biomass is a practical way to recover some of the incident solar energy.



END PRODUCTS AND ROUGH ENERGY EQUIVALENTS OF VARIOUS BIOMASS CONVERSIONS FROM A 1 ACRE GRAIN FIELD AND WOODLOT.

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A LOT OF HOT AIR

Heat Energy

Objectives

The student should be able to:

a) Demonstrate the conversion of light energy to heat energy.

b) Investigate the effect of color on absorbtion of light.

c) Describe the effect of insulation on convection losses.

Overview

Sunlight passes through the transparent walls of a greenhouse because it has a relatively short wavelength. When the absorbing background radiates the energy back it is in the form of much longer heat waves. Glass reflects these long wavelengths, trapping the energy and raising the temperature of the air inside.

Heat can be lost by conduction through the walls, etc., or by convection if the warm air, rising, can escape. Insulation reduces both of these sources of heat loss.

Materials

Student activity sheets
Ring stands with clamps
paper cups, 6 oz.
Thermometers
Plastic wrap
8 oz. styrofoam cups
rubber bands
Scissors
Heat lamps
Black construction paper
Scotch tape
Aluminum foil
Cotton batting

Strategy

Set up 2 ring stands and affix the thermometer up right with the clamp. Leave enough room to be able to put a cup under the thermometer without moving it. It should be low enough that it will be registering the temperature inside the cup.

Place a heat lamp so that it is equally distant from each thermometer. Do not move the heat lamp or the ring stands after this !!!

Part A - Covering

Place a paper cup so that the thermometer is well down in each cup. Cover one cup with plastic wrap. Hold it on with a rubber band. Record the temperature in each cup next to time 0 on the data table. Now turn on the heat lamp.

Record the temperature on each thermometer every 60 seconds for 10 readings. Graph your data.

Questions:

1. What form of energy is the lamp providing? Light energy
2. What form of energy does the thermometer measure? Heat energy
3. Why should the lamp be equally spaced from the two cups? To provide the same amount of energy to each cup.
4. What difference does the plastic cover make in the air temperature inside the cup? Answers will vary. The covered cup will be warmer.
5. This is called the Greenhouse Effect. How is a greenhouse useful to farmers in the North? They can grow things when the weather is cold, giving them a longer growing season.
6. How do windows on the south side of a house help heat it in the winter? Sunlight enters the house and is converted to heat, while the cold air is kept out. You should also point out that windows do a poorer job of insulating than walls and so should be covered when there is little or no sunlight in the winter.

Part B - Background Absorber

Remove both cups and line one cup with black construction paper. Replace the cups around the thermometers and cover both with plastic wrap. Record the temperature in both cups and then turn on the heat lamp. Record the temperature in each cup every 60 seconds for 10 readings. Graph your data.

Questions:

7. What difference does the black background make in the air temperature? The air is hotter with a black background.
8. Which color is a better absorber of light? Black
9. What color would you expect the background of a solar hot water collector system to be? Black

Notes to the Teacher

If you have small thermometers which do not tip over the cups you can dispense with the ring stands. Paper cups are recommended in order to isolate the factor of insulation. Cotton batting is available in a roll from drug stores.

In each section of the activity just one factor is different between the cups. Students may or may not recognize that the best arrangement is used in the next section.

Extension Activities

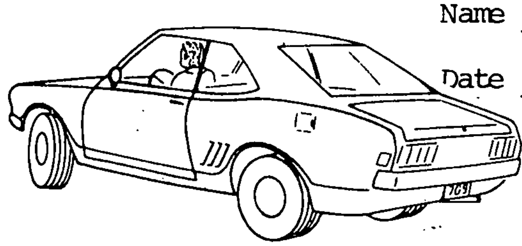
Use sunlight instead of heat lamp. It's slower but less artificial if your aim is to lead into the use of solar energy.

Use silver metal cups instead of paper. There will be a more dramatic change in temperature when you insulate.

Use glass plate instead of plastic wrap to simulate the glass greenhouse and show that it is more efficient than the plastic wrap. In this case the thermometer is pushed through the side of the cup and sealed with clay.

Build a solar collector by using any relatively flat box, lined with black paper or painted black, and covered securely with a transparent lid. Simply put a thermometer inside and compare the inner with outside temperature. You can then run experiments comparing the angle of the incident light with the increase in temperature. This last is an important factor in the placement of actual solar collectors.

Student Activity Sheet



Name ______________________

Date ______________________

Sunlight passes through the transparent walls of a greenhouse because it has a relatively short wavelength. When the absorbing background radiates the energy back it is in the form of much longer heat waves. Glass reflects these long wavelengths, trapping the energy and raising the temperature of the air inside. The same thing happens when your car sits in the sun with the windows closed. This phenomena is known as the greenhouse effect.

Part A

1. What form of energy is the lamp providing? ______________________
2. What form of energy does the thermometer measure? ______________________
3. Why should the cups be equally spaced from the lamp? ______________________
____
4. What difference does the plastic cover make in the air temperature inside the cup? ______________________
5. How is a "greenhouse" useful to farmers in the North? ______________________
____
____
6. How do windows on the south side of a house help heat it in the winter?
____
____

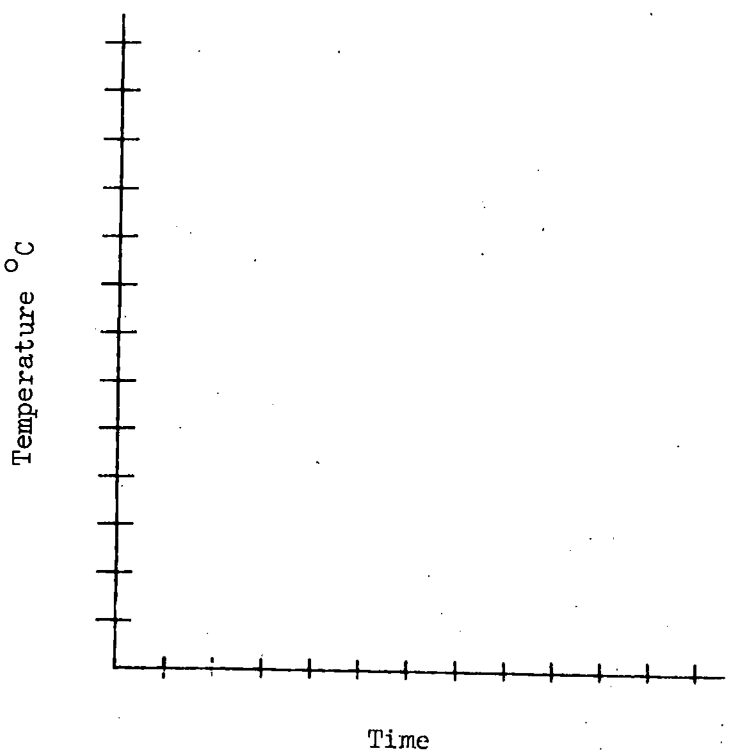
Part B

7. What differences does the black background make in the air temperature?
____
____
8. Which color is a better absorber of light?
9. What color would you expect the background of a solar hot water collector to be? ______________________

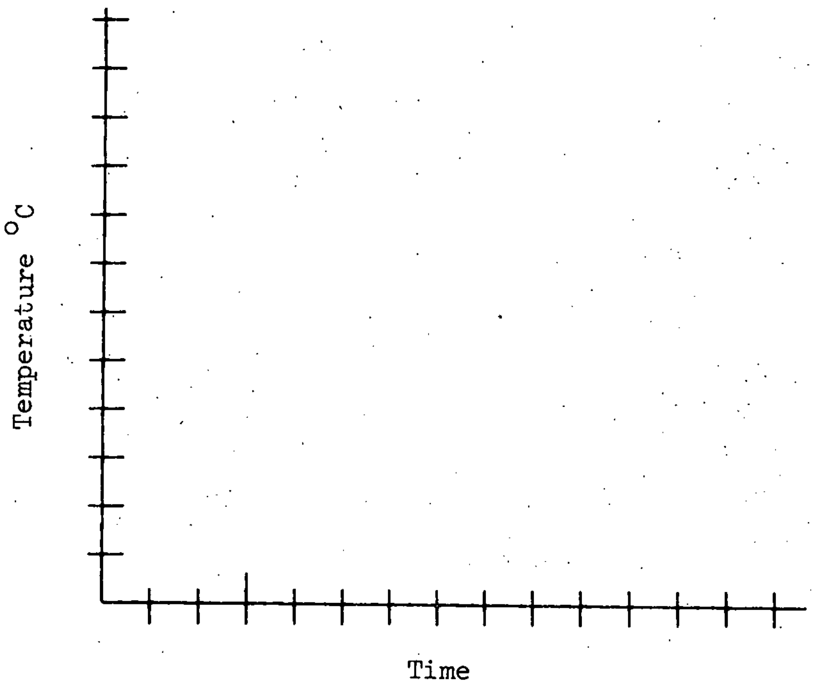
A. Covering

Time	Temperature Covered	Temperature Uncovered
0		
1 minute		
2 minutes		
3 minutes		
4 minutes		
5 minutes		
6 minutes		
7 minutes		
8 minutes		
9 minutes		
10 minutes		

Graph - Uncovered



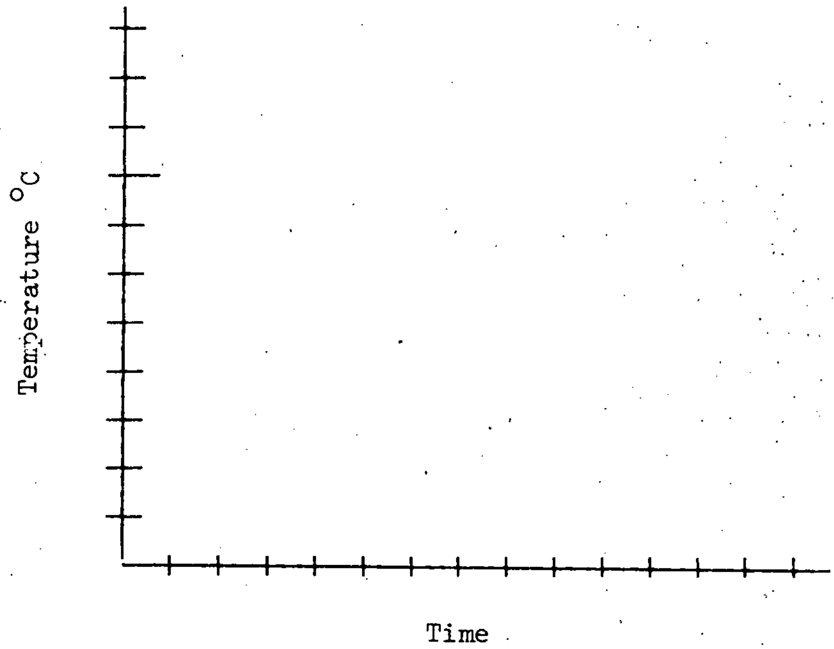
Graph - Covered



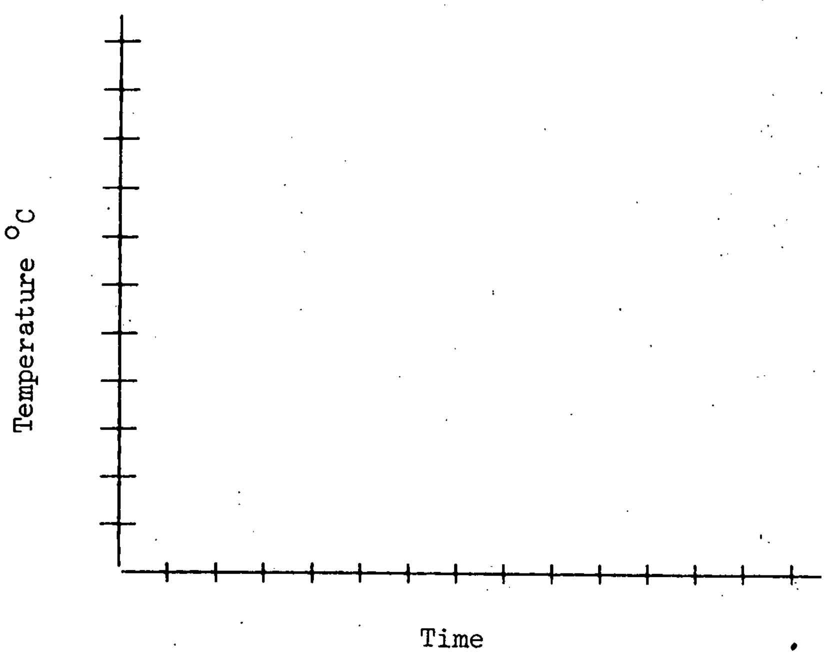
B. Absorbing Background

Time	Temperature Black	White
0		
1 minute		
2 minutes		
3 minutes		
4 minutes		
5 minutes		
6 minutes		
7 minutes		
8 minutes		
9 minutes		
10 minutes		

Graph - White



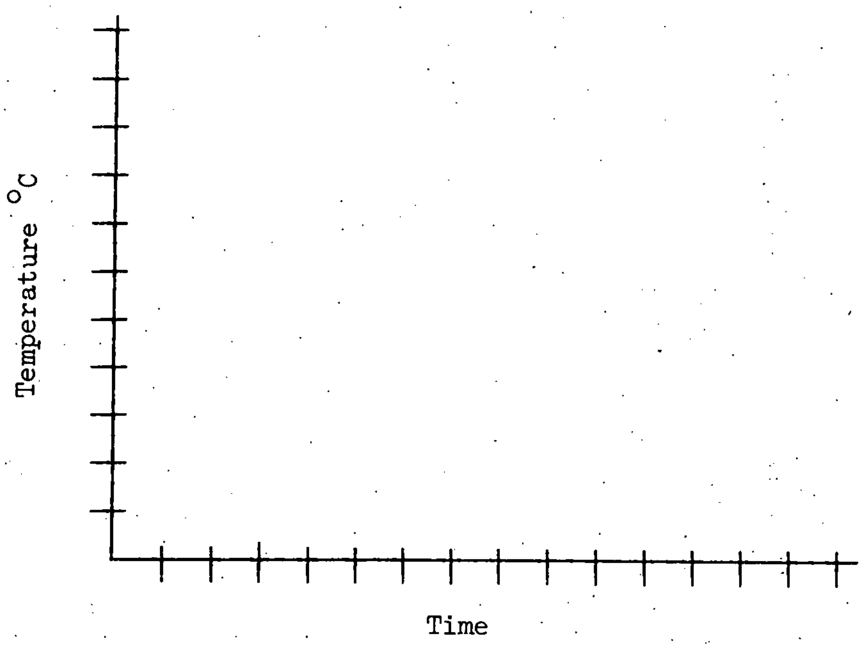
Graph - Black



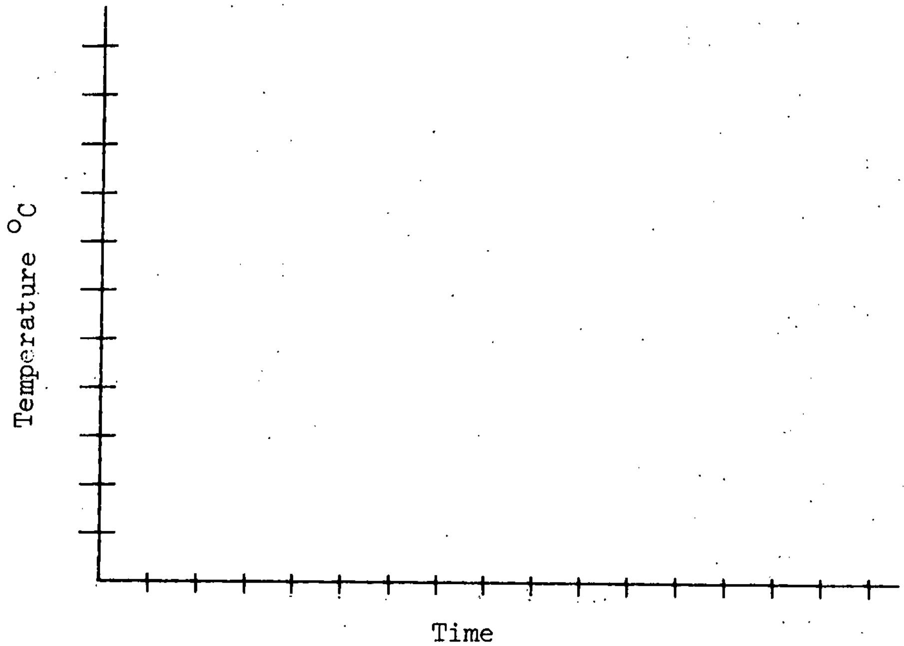
C. Insulation

	Temperature			
Time	Uninsulated	Cotton Batting	Styrofoam	Name of Other
0				
1 minute				
2 minutes				
3 minutes				
4 minutes				
5 minutes				
6 minutes				
7 minutes				
8 minutes				
9 minutes				
10 minutes				

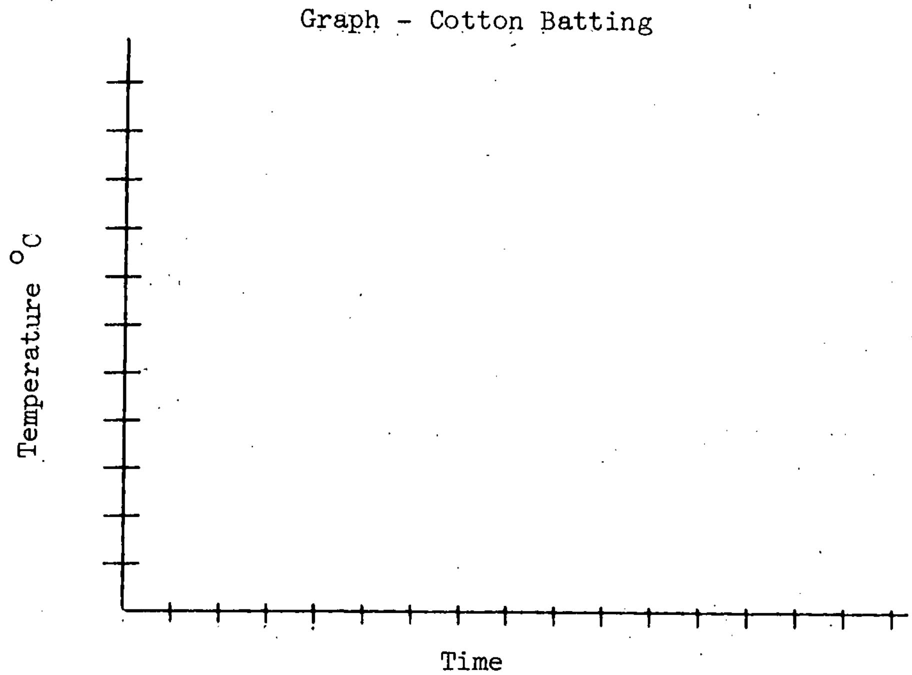
Graph - Noninsulated



Graph - Styrofoam



Graph - Cotton Batting



Conclusion:

In order to best connect sunlight to heat, a solar collector should have certain features. List at least 3 features you would expect to find in a good collector.

IT'S TOO DARN HOT

A Shoebox Solar Collector

Objectives

The student should be able to:

a) Identify solar collector components.

b) Observe the operation of a typical flat plate solar collector.

c) Collect data from a solar collector.

d) Investigate heat losses from the collector enclosure and absorber plate.

e) Attempt to scale up experimental results.

Overview

A flat plate solar collector consists of three basic parts. The collector enclosure, the glazing material and the absorber plate with enclosed thermal fluid. In this experiment no attempt has been made to investigate the function of the glazing material.

The collector enclosure is nothing more than a rectangular casing and insulating material which houses the transparent cover (glazing material) and absorber plate. The function of the insulating material is to reduce heat losses due to conduction.

The solar radiation passes through the transparent cover and hits the absorber plate. Most of the radiation is absorbed by the plate and is picked up by the fluid. The better the absorbing quality, the more radiation captured and the less reflected back to the cover. The less the loss due to radiation and conduction the more efficient the collector.

The efficiency decreases as the temperature difference between the environment and the absorber plate increases. The differences in temperatures causes an increase in energy loss through conduction and reradiation. Heat always flows from a hot surface to a cold one. When an object is warmer than its surroundings, it indicates invisible heat waves to the colder areas.

Materials

Student activity sheets

Shoebox (1/team)

Clear plastic wrap

Construction paper - black and white (1/team)

Masking tape - 1 roll

Graph paper - 4 sheets/team

Heat lamp and support - 1/team

Scissors - 1/team

Tubing clamps - 2/team

Insulation - fiberglass, newspaper

Thermometer - 3/team

Bucket - 1 gal - 2/team

Strategy

The experiment will take 2 to 3 periods. One period to construct the collector and 1 to 2 periods to collect all the data.

At the outset the teacher should determine whether the teams should collect data from all parts of the experiment or collect data only from one part and share with the remainder of the class. The first alternative will require the greatest amount of time. The second involves the problem of distributing data to all teams.

A pre-lab period is not essential since the students will not use all of one period constructing the collector. If no instruction has been given previously on mechanisms of heat loss and graphing techniques, then at least one period will be required.

Fiberglass insulation works quite well in the collector. Try to get 3" bats and have the students cut to fit their box. Thicker bats are hard to cut. The insulation should not be compressed when taped to the collector.

Water spillage is a certainty. Provide toweling and mops.

Use cold tap water to enhance dramatic effects of heating.

Too slow or too rapid a flow rate will effect the data. Adjust to about 1 gallon/5 minutes by changing the height of the bucket above the collector, or adjusting the upper tubing clamp.

The teacher should determine beforehand whether his class can handle qestions 6 through 9. These may not be suitable for all students.

Sample Responses

1. Probably the collector with black paper and insulation would give best data. It has best absorber and least heat loss.
2. Probably 20°C.
3. Depends upon the flow rate.
4. Water has a higher specific heat.
5. Yes.
6. Answers will vary.

Student Activity Sheet

Name ____________________

Date ____________________

A solar collector is designed to transfer the radiant energy of the sun to a thermal fluid. The radiant energy is absorbed by an absorber plate and the heat energy is then collected by the fluid. To insure that the heat energy passes into the fluid the back of the collector is insulated thereby reducing conduction heat losses.

You can determine the value of insulation by comparing the performance of the collector with and without insulation material.

You can also determine the value of absorber plates by comparing the performance of differently colored plates.

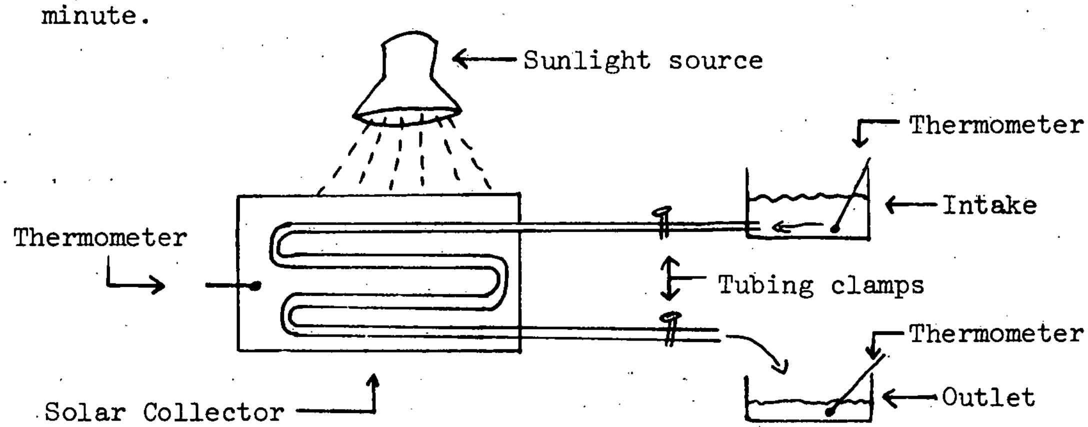
Materials

Shoe box
4 ft tubing (plastic or rubber)
Clear plastic wrap
Construction paper - black and white
Masking tape
Graph paper (4 sheets)
Heat lamp and support
Scissors
Tubing clamps (2)
Thermometer (2)
Insulation - fiberglass, newspaper
Bucket (2)

Procedure

1. Make two holes in one end of the box.
2. Thread tubing through the holes and coil tubing in a zig-zag pattern on the bottom of the box. Tape in place. Tubing should extend from box in two equal lengths.
3. Make a small hole in the opposite end of the box with a pencil for the thermometer.
4. Cut white and black construction paper to fit over the coils. Leave the white in place.
5. Cover the top of the box with clear plastic wrap. Tape if needed.
6. Connect one tube to a bucket held above the collector (about 1 foot). Place the other tube into the second bucket. Water flowing from the upper bucket will be collected in the second

7. Place the lamp approximately 8 - 12" from the collector.
8. Fill the upper bucket with water (be sure clamps are in place).
9. Record the initial temperature of the water on the data sheet.
10. Allow the water to run through the collector fairly slowly so that the bucket empties in 4 to 5 minutes.
11. Measure the air temperature outside the collector.
12. Measure the temperature inside the collector every minute.
13. Measure the temperature of the outlet water (in the lower bucket) every minute.



Data Sheet

Initial Temperature of water (Te) ________________

Ambient Temperature of air (Tair) ________________

Time (Minutes)	0	1	2	3	4	5	6	7	8	9
Intake Temperature										
Collector Temperature										
Outlet Temperature										

Plot on a graph the (a) intake temperature/time, (b) collector temperature/time, and (c) outlet temperature/time.

B. Using the same setup, cover the bottom and all sides of the collector with insulation. Tape firmly in place. If newspaper is used as insulation, use at least 15 sheets.

Repeat steps A-9 through A-13.

Data Sheet

Initial Temperature of water (Te) ____________________

Ambient Temperature of air (Tair) ____________________

Time (Minutes)	0	1	2	3	4	5	6	7	8	9
Intake Temperature										
Collector Temperature										
Outlet Temperature										

Plot graphs for (a) Tcollection/time and (b) Toutlet/time and (c)Tintake/time.

C. Replace white construction paper with the black paper. Remove all the insulation. Repeat steps A-9 through A-13. Make data sheet as above.

D. Cover the bottom and sides with insulation. Leave the black construction paper in place. Repeat steps A-9 through A-13. Make data sheet as above. Plot graphs for (a) Tcollection/time and (b)Toutlet/time.

E. Questions

1. Which collector design was most effective in raising the temperature of the water? Explain why. ____________________

2. What was the greatest rise in air temperature? __________

3. What was the greatest rise in water temperature? __________

4. Why didn't the water temperature rise as much as the air temperature?

5. Does insulation material add significantly to the performance of the collector? ____________________

6. Calculate the heat transfer rate using the flow rate:

   heat transfer rate = (flow rate) x $(T_o - T_1)$

   T_o = outlet temperature

   T_1 = inlet temperature

   flow rate = weight of water / time. (100ml = 100 grams)

7. Compare the heat transfer rates for the four parts of the experiment.

8. Calculate the area of your shoe box. Scale up your calculations to show the heating rate with a collector having 32 sq. ft. of absorber area; i.e., one that might be used on your home.
9. Calculate the amount of solar energy collected during one hour of operation by multiplying the heat transfer rate by 3600 seconds/hour.

Extension Activities

From the wattage rating of the lamp and the length of time it is used, calculate the energy provided by the lamp. Next determine the total energy absorbed by the water. From this data, determine the efficiency of conversion.

COOL, MAN, COOL

Law of Cooling

Objective

The student should be able to:

a) Graphically represent cooling rates.

b) Calculate cooling rates.

c) Demonstrate the effectiveness of insulating materials in reducing heat loss.

d) Understand sources of heat loss from his home.

e) Understand the three mechanisms of heat loss.

Overview

Heat loss occurs by conduction, convection and radiation. In the special case of a house, heat loss is due to the environment, whose temperature is called the ambient temperature.

The heat loss due to radiation occurs because heated objects give off a very low energy, long wavelength electromagnetic energy, that depends upon the temperature of the object. As the object's temperature increases the total energy radiated increases in proportion to the fourth power of the temperature (^{o}K). The main way to reduce radiation is to reflect it back to the source.

The loss of heat energy by conduction is characterized as the flow of heat through molecular collisions of heated molecules with cooler ones. It is supported by matter in contact with a source of heat. To reduce this loss the molecular collisions must be reduced. The lower the density of the insulating material the greater the space between molecules and therefore the less heat loss due to conduction.

The convection of heated air away from the heated object is the third mechanism of heat loss. This loss is supported by freely moving air in contact with the heated object and can be reduced by restricting the movement of air molecules or by eliminating or reducing the molecules between the heat source and the environment.

The loss of heat of a heated object to its environment can be plotted on a temperature-time curve, its cooling curve. The average rate at which heat is being lost for any temperature or time can be calculated as follows:

$$\text{Average rate of heat loss} = \frac{T_o - T_f}{\text{Time}}$$

Materials

Student activity sheets
Immersion heater or hot plate - 1/team
Container 250 ml or 150ml, glass - 1/team
Styrofoam cover for container - 1/team
Thermometer - 1/team
Timer - stopwatch - 1/team
Graph paper - 1/student
Aluminum foil - roll/class
Scissors - 1/team
Masking tape - roll/class
Insulation - styrofoam, newspaper, fiberglass, etc.

Strategy

Carefully go over the procedure with the class (1 period) before they begin the experiment. Discuss heat loss mechanisms. Discuss the law of conservation of energy and matter.

If the teacher wishes he/she may supply large quantities of hot water for the class to speed up the lab. A large coffee urn might be used, water temperatures should be approximately 75°C - 80°C.

During the pre-lab session the teacher should instruct the class as to the team structure of the lab. Should each team attempt to perform all four parts of the experiment? Should a team perform only one part and share results with the other teams? The teacher's decision will determine whether one or two periods are needed to complete the experiment.

Allow one period for a post-lab session for comparison of data, answering questions, and summarizing findings.

Sample Responses

1. A.
2. A cooled fastest.
3. a) A b) D
4. Lack of insulation causes greatest heat losses due to conduction, convection, and radiation.
5. Cooling rate would decrease but would not halve.
6. Insulate attic, walls, floors. Attic most important since heat rises.
7. Answers will vary. Look for 75% reduction for top and less than 70% for sides.
8. (a) More important than (b) Generally (c) Gives best results.

Student Activity Sheet

Name ______________________

Date ______________________

Law of Cooling

The relationship of the amount of heat a hot object loses to its environment and the elapsed time is called the Law of Cooling. Insulation is a material that prevents heat loss again. The flow of heat is always in the direction away from a hot object to a cooler object. A heated house always loses heat to the cooler outside environment in the winter. The heat flow is reversed in the summer.

In this experiment you will find the general form of the cooling curve for a heated fluid and explore several ways in which the rate of cooling can be reduced. The container will represent a house and the heated water will represent the home heat source in the winter.

Materials

Immersion heater or hot plate
Container - 250 or 150ml, glass
Styrofoam cover
Thermometer
Scissors
Timer - stopwatch
Graph paper
Insulation
Aluminum foil
Masking tape

Procedure

A. Set up equipment according to your teacher's instructions. Obtain 100ml hot water. Record the initial temperature of the water in the uninsulated container on the data chart as time 0. (See data chart.) Measure the temperature of the water for each 30 second interval. Record on the data sheet, starting at time 1 and ending after 5 minutes have elapsed (total of 11 readings). Plot the results of your measurements on graph paper, using temperature on the vertical axis and time on the horizontal axis (See Figure #1). Connect the points with a smooth, free hand pencil line. The curve you obtain is called a cooling curve.

B. Wrap the container in a layer of insulation. Tape it securely. Be certain that you also cover the bottom of the container. Obtain 100ml hot water and after recording the initial temperature (T_o) on the data chart repeat steps A-4 and A-5.

C. Wrap the container first with aluminum foil and then with a layer of insulation. Obtain 100ml of hot water and follow steps A-3, A-4 and A-5.

D. Using the same setup as in Part C place a cover on the container and repeat steps A-3, A-4 and A-5 with 100ml hot water. Note: with a pencil, puncture the cover for the thermometer.

Data Chart

Time Time	Part A Insulated	Part B Insulated	Part C Foil and Insulation	Part D With Cover
T_0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

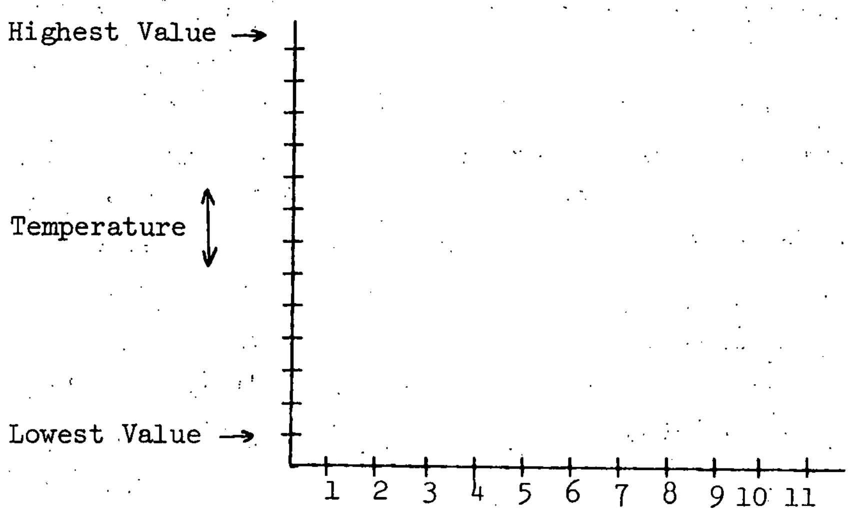


Figure #1

Note: Plot data from all four parts on one graph. Label each curve clearly.

E. Discussion

1. In which direction will heat flow during the winter? (Circle one)

   a. From the house to the environment.

   b. From the environment to the house.

2. Calculate and list the average cooling rates for each part of the experiment.

   a. Uninsulated container ______________ °C/minute

   b. Insulated container ______________ °C/minute

   c. Foil plus insulated container ______________ °C/minute

   d. Foil, insulated container with top ______________ °C/minute

3. In which part of the experiment did you find the:

   a. Largest rate of cooling ______________

   b. Smallest rate of cooling ______________

4. What do your answers to question 3 mean to you? ______________

____

____

5. What do you think would happen if the amount of insulation in Part D was doubled? ______________

   Why not try to find out if your answer was right!!

6. Compare your container to your home. How could you prevent heat losses from your home? ______________

____

7. Heat loss in BTU/hour from a home or your experimental set up may be roughly compared by multiplying the total area by a heat loss multiplier. The H.L.M. varies with the amount of insulation.

   To determine the reduction of heat loss in your set up (Part A and Part D), a) calculate the surface area of the top of the container (πr^2) and multiply it by 16 (uninsulated) or 4 (uninsulated); and b) for the sides, calculate the surface area ($2\pi rh$) and multiply by 13 (uninsulated) or 4 (insulated).

   a) s.a. of top x 16 = __________ b) s.a. of sides x 16 = __________

   c) s.a. of top x 4 = __________ d) s.a. of si-es x 4 = __________

   e) reduction of heat loss; top (a-c) ______________ BTU/hour

   f) reduction of heat loss; sides (b-d) ______________ BTU/hour

g) Percent reduction of heat loss; top (e/a x 100) ___________ BTU/hour

h) Percent reduction of heat loss; sides (f/b x 100) ___________ BTU/hour

8. Discuss the relative value of insulating; a) just the ceiling of your house; b) just the walls of your house; c) or both ceiling and walls of your house.

MAD DOGS AND ENGLISHMEN

Distilling Water Through Solar Energy

Objectives

The student should be able to:

a) Define calorie, kilocalorie and distillation.

b) Set up simple apparatus to distill water.

c) Discuss the process of distilling water using solar energy.

Overview

The rate at which solar energy falls on earth in an average 24 hour period is 3770 kilocalories per square meter. This varies everywhere in the United States.

A calorie is defined as the amount of heat necessary to raise one gram of water one degree Celsius. The Calorie or kilocalorie is 1000 calories and will raise 1000 grams of water one degree Celsius.

The purpose of this experiment is to evaporate (boil) water which will require raising the temperature to 100°C and supplying the heat of vaporization which is 540 calories or .54 kilocalories. This heat of vaporization is released when the water (steam) condenses. A simple pail or bucket could supply between one to two liters of distilled water daily depending on conditions.

Solar Stills and Solar Dryers

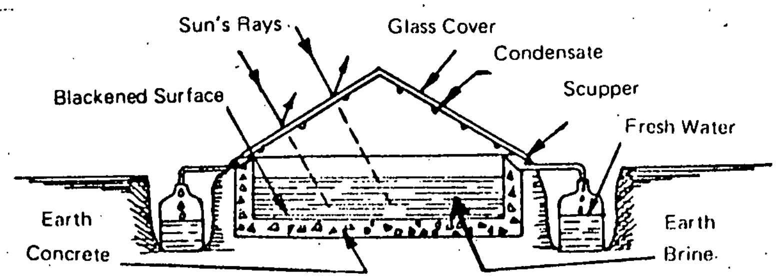
Probably the oldest intentional use of the sun's ability to produce heat came when primitive man allowed pools of salt water to evaporate to produce salt essential to the human diet. This process is still in use, as is demonstrated by the great salt works near San Francisco.

Solar Distillation

Controlled evaporation to produce fresh potable water from salt or brackish sources is a much more recent development. The basic ideas can be traced back for at least a century. The first large solar still was built at Las Salinas in the Andes Mountains of Chile by J. Harding in 1872, to provide drinking water for the men and animals working in a copper mine. It was nearly an acre in extent, made of wood and glass, and it could deliver some 6000 gallons per day of pure water from a very brackish source.

Its principle of operation is exactly the same as that of the many stills which have been built in the past few years in Australia and on the arid Greek islands in the eastern Mediterranean Ocean. The figure below shows the general idea of these simple devices. A water-tight compartment, made of wood or concrete, is painted black to absorb the solar radiation which enters through the glass roof of the still. Salt or brackish water, or even sewage effluent, is allowed to flow into the channel or box to a depth of four to six inches. The incoming solar radiation heats the water, causing some of it to evaporate and this condenses on the inner surface of the glass roof.

Operating Principles of a Glass-covered Solar Still

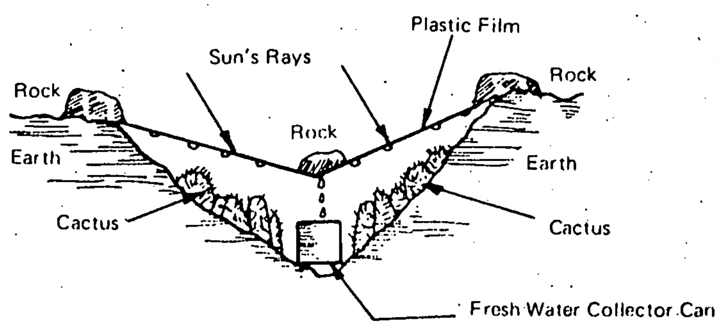


Since water will "wet" clean glass, the condensation takes place in the form of a very thin film which flows down by gravity into the scupper which leads the condensate off to a suitable container. The water channel is insulated by the earth. After some of the water has been distilled off, the brine which is left is flushed out at intervals. This prevents the concentration of salt from building up to the point when it will cover the bottom of the still with reflective white crystals.

The product of such a still is distilled water which can be used for drinking, for filling storage batteries or for any other purpose for which pure water is needed. Attempts have been made to use plastic films as still covers, to eliminate the weight and cost of the glass roofs, but the plastic films have not proved to be as reliable as glass. Most films are not "wet" by water and so the condensation takes place in droplets which tend to reflect the sunlight instead of transmitting it into the basin. Also, few films are completely resistant to deterioration from the ultraviolet component of the solar radiation. They are really only useful in stills which are expected to be used for a short period of time.

The figure below shows the desert survival still devised by R. D. Jackson and C. H. Von Bavel of the Water Resources Laboratory in Phoenix. The kit includes only a sheet of transparent plastic and a tin can, since the other needed materials can be found in the desert. Even in the dryest earth there is always some moisture and it can be distilled out by creating a heat trap, as shown below, by using a transparent plastic cover, a rock to weight the cover down in its center and a can to catch the droplets of moisture as they trickle down the inner surface of the plastic. This is the desert version of the ocean rescue still, developed in 1940 by Dr. Maria Telkes, using inflatable plastic bags which, in an emergency, can be used to make drinking water from ocean water.

Desert Survival Solar Still



The article "Solar Stills and Solar Dryers" is taken from Energy Primer, Portola Institute, 1974.

Materials

Plastic container, or bucket, about 1 liter volume

Plastic to cover and overlap container

String to bind the plastic as a cover on the container

A weight or stone

A tumbler or small tin can that will fit inside the container

Strategy

Put about 3 cm of water in the container and a tumbler in the center of the container.

Place the overlapping plastic on the container and bind it to the sides of the container, making it airtight.

Place a weight or stone on top of the plastic causing it to sag so that the plastic is barely above the tumbler.

Place the container in the sun for a considerable time.

Observe that water evaporates and condenses on the plastic as droplets which run into the glass, in a continuous process.

Repeat the experiment using chopped leaves, plants, or chopped cactus in place of the water.

Repeat using salt water or brine.

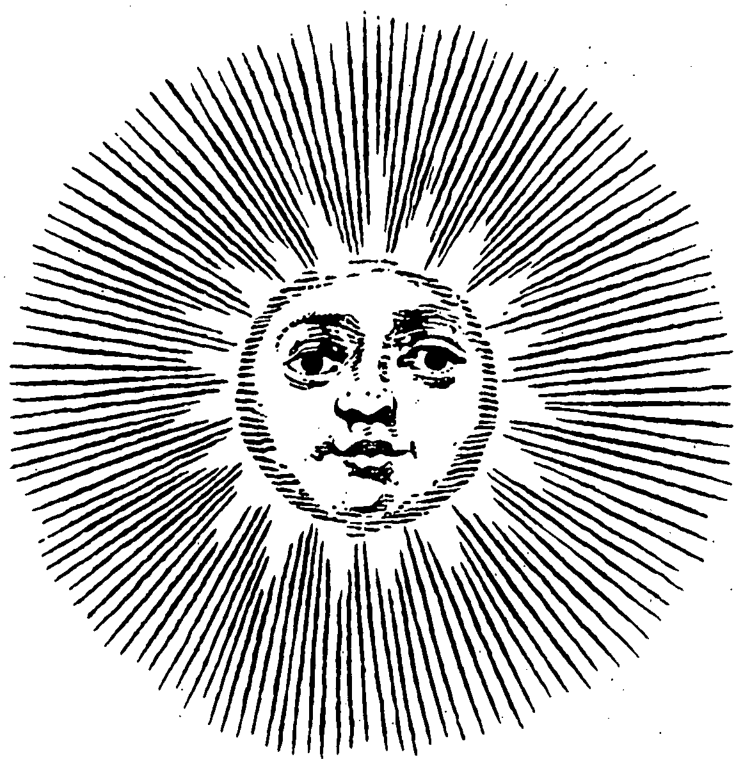
Sample Responses

1. Emergency water supply - camping, etc. Large scale fresh water supply for towns. Desalting water.
2. Sun
3. Use black background. Tilt the apparatus toward the sun. Rotate the apparatus following the sun.

Student Activity Sheet

Name ______________________

Date ______________________



Solar energy falls on the earth at an average rate of 3770 kilocalories per square meter. A calorie is the amount of heat required to raise one gram of water one degree Celsius. A kilocalorie will raise one 1000 grams of water one degree Celsius.

In this activity we will use solar energy to distill water. Distillation is the process of first heating a liquid, and then cooling and condensing the resulting vapor.

Put about 3cm of water in the container and a tumbler in the center of the container.

Place the overlapping plastic on the container and bind it to the sides of the container, making it airtight.

Place a weight or stone on top of the plastic, causing it to sag so that the plastic is barely above the tumbler.

Place the container in the sun for a considerable time.

Observe that the water evaporates and condenses on the plastic as droplets which run into the glass in a continuous process.

Repeat the experiment using chopped leaves, plants or chopped cactus in place of the water. Repeat using salt water or brine.

Questions

1. List practical uses for using solar distillation. ____________________

____

____

2. Where does the heat come from that distilled the water? ____________

____

3. How could you make your solar distillation apparatus work more efficiently. ____

____

____

HOT STUFF

The Principle of a Solar Furnace

Objectives

The student should be able to:

a) Use solar energy to produce high temperatures.

b) Set up a simple high temperature solar apparatus.

Overview

When concentrated on a small area, usually by the use of a lens or a similar converging device, sunlight releases a tremendous amount of energy and is capable of producing very high temperatures.

This principle is utilized in France where a large solar furnace is being built to produce temperatures of 6000°F.

This lesson is an examination of the heating power of solar energy to see the possibilities of a solar furnace.

Materials

Student activity sheets

3 inch magnifying glass

Fresnel lens (This is a 12" square plastic sheet obtainable from Edmunds Scientific Company)

Watch glass

Some strands of solder.

Strategy

Have the students place a drop of water in a watch glass and focus the sun's rays on it with a 3 inch magnifying glass. After a short time the water will boil.

Focus the rays of the sun on a sheet of paper with the 3 inch lens. In a few seconds the paper will scorch, smoke and burn.

Notes to the Teacher

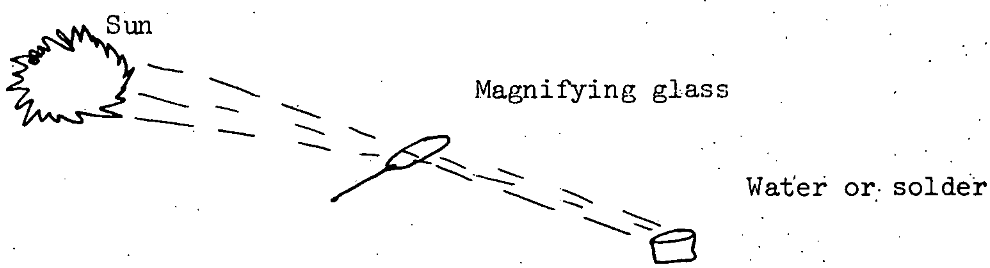
Keep close control. Students like to burn things with magnifiers, including each other.

Sample Responses

1. Water - boils, solder - melts

2. It concentrates the heat energy in a small area.

3.



Extension Activities

For students who have studied chemistry and/or physics:

From data taken from the above experiement including the mass of the solder, calculate the amount of energy, in calories, required to melt the solder. $\Delta H = m \times s \times \Delta T$

Student Activity Sheet

Name ____________________

Date ____________________

In this activity you will use solar energy to reach very high temperatures.

Place a drop of water in a watch glass and focus the sun's rays on it with a 3 inch magnifying glass. After a short time the water will boil.

Focus the rays of the sun on a sheet of paper with the 3 inch lens. In a few seconds the paper will scorch, smoke and burn

Place a thin strand of solder in a watch glass. Focus the sun's rays on the solder with a Fresnel lens. After a minute the solder will melt. (The heat of fusion of solder is about 5 calories per gram. Solder melts at 225°C or 437°F.)

Questions

1. What effect does the magnifying glass have on the water? solder?

____

____

____

2. Why does the magnifying glass cause the temperature to rise? ________

____

____

3. Diagram the apparatus you used. Label your diagram.

THE ANSWER MY FRIEND IS BLOWIN' IN THE WIND

Principles of Wind Power

Objectives

The student should be able to:

a) Read a simple line graph.

b) Compare two graphs with wind speed data and propeller size.

c) Calculate the value of K in the formula $P = KV^3D^2$.

Overview

Principles of Wind Power

The power available from the wind is a measure of how much and how fast the wind energy is being made available to the windmill propeller. The amount of energy is proportional to the kinetic energy of the wind ($KE = \frac{1}{2}mv^2$), and to the area swept out by the moving propeller normal to the wind ($A = \pi d^2/4$, where d = diameter). The speed at which the wind energy is being made available to the propeller is proportional to the wind speed. The power available from the wind is then proportional to the product of these three terms:

$$P \propto (\tfrac{1}{2}mv^2) \cdot \left(\frac{\pi d^2}{4}\right) \cdot v$$

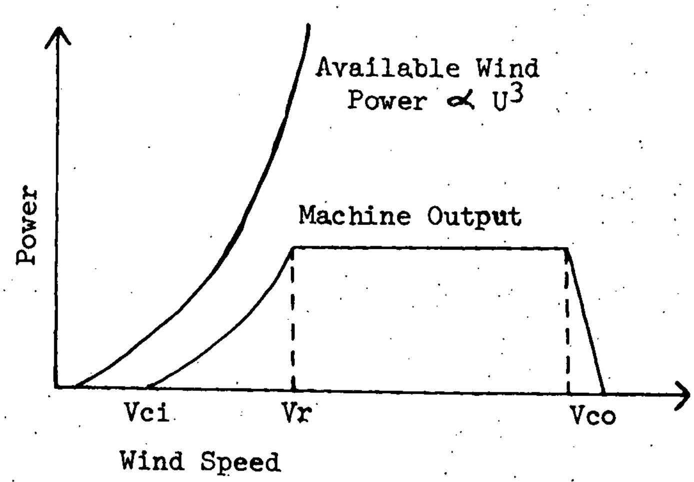
From which: $P \propto v^3d^2$.

The mass of the wind is usually considered constant because the density of the air does not vary appreciably over the operating ranges of temperature, pressures, and humidity.

The relationship given above, written in equation form ($P=kv^3d^2$) is investigated in the accompanying worksheet. Note that this equation gives the power available from the wind and not really the power output of the wind machine as suggested in the worksheet. How the actual power output of a wind machine follows the power available from the wind is a complicated function of the total system design and operation. The discussion that follows attempts to hit upon the main ideas involved.

A windmill propeller is designed differently than an airplane propeller. An airplane propeller is designed with a pitched surface so that it screws itself into the air as a result of its rotation. A windmill propeller is designed like the wings of an airplane so that wind blowing past it causes a differential in pressure on its two surfaces and results in a turning force. Aerodynamic analysis has shown that the theoretical maximum efficiency of an open air wind machine is 59.26%. This value is only for the conversion of the wind power to rotational mechanical power exclusive of frictional losses in bearings and assuming 100% propeller efficiency. For the purpose of electrical power production, a well designed windplant can capture about 35% of the wind power available to it. These additional losses are due to gearbox and mechanical drive inefficiencies, electrical generator inefficiencies, control and storage device inefficiences, and its operating characteristics.

The operating characteristics of a large electricity producing windmachine is depicted in the graph at the right. Note that the available wind power is proportional to the wind speed cubed. Because of friction, a windmill propeller will not begin to turn until the wind speed reaches a cut-in speed Vci. This is typically of the order of 6 - 8 mph. From the cut-in speed up to the machine's rated speed Vr, the machine output follows the power available curve. The difference is due to overall system inefficiencies. A machine's rated speed is typically 10-18 mph. From the machine's rated speed up to a cut out speed Vco (typically 50 mph). The machine output is kept constant. This constraint is due to the necessity for constant generator speed (to maintain constant voltage and frequency output). The spilling of the surplus power may seem very wastefull, but it is not as bad as it may seem at first glance. While it is true that the greater the wind speed, the greater the surplus power to be spilled, it is also true that the percent of the time a particular high speed occurs is a type of inverse function of the speed. In other



words, high wind gusts being of short time duration, require a large power spilling but only for a short time, hence not much energy is lost. The operating range of an electricity producing wind machine is considered to be from Vr to Vco. The numerical values of Vr and Vco are determined by a complex analysis of weather and wind speed distribution data for the proposed site and the specifications of all of the components of the wind machine system.

A Few Comments on the Worksheet

The data supplied in the worksheet came from Energy Primer, Solar, Water, Wind and Biofuels, 1974, Fricke-Parks Press Inc., Fremont, California. No attempt was made by this author to verify the accuracy of the data. The fact that the data very closely follows the S-cubed and d-squared laws makes this author somewhat suspicious that the data was actually contrived and not collected. In this respect, the teacher is left to make his own decision as to its validity.

A more advanced analysis of the data can be made by plotting the logarithm of the power (either ln or log) as a function of the logarithm of the wind speed and then as a function of the logarithm of the propeller diameter. With these log-log plots, the results are straight lines with slopes equal to the exponents of the original variable (3 for wind speed and 2 for propeller diameter). The anti-log of the y-intercept (lnP or log P) gives the value of the constant of proportionality of the original equation. If you have access to a computer, a least squares analysis can also be incorporated.

Materials

Student activity sheets
Overhead projector (optional)

Strategy

Hand out work sheets. Discuss the background materials. Students can do the work sheets, as you do the work on the chalk board or overhead projector.

Sample Responses

1. They are the same.
2. Obviously the larger the propeller, the power output. Power increases as

the square of propeller diameter.

3. $P = (const) \cdot d^2$, const 1.2.

4. One with 20 ft. propellers. Doubling the prop diameter gives four times the power output, not twice.

5. They are the same.

6. Obviously the greater the windspeed, the greater the power output. Power increases as the cube of wind speed.

7. $P = (const) \cdot v^3$, const 0.12

8. They should be nearly equal in value.

9. Gearbox and generator efficiences may not be constant over the operating range of the windmill. The use of variable pitch propeller blades will effect k. The size of the external load which is trying to make use of the power output could affect k.

10.

Pros

a. Power increases as the square of prop diameter.
b. Uses less total land area.
c. Centralized maintenance may be cheaper.
d. Higher towers will put more of the blade into prevailing wind.
e. Cost may be less due to elimination of some duplicate equipment.

Cons

a. Concentrated power requires a more elaborate distribution system.
b. One large windmill is likely to be more susceptible to power loss due to wind variation.
c. Mass production of many units may be more cost effective.
d. Larger windmills require more sophisticated knowledge of material stresses and strains and techniques for proper fabrication.

11. Answers will vary. Up to a point this may be true but obviously excessive winds could result in structural damage to the wind machine. In fact, many wind machine designs call for braking the propeller so that it will not turn when the prevailing winds reach about 50 mph or more for a period of time.

In addition it is usually required that electrical generators run at constant speed over a wide range of wind speeds so that higher wind speeds much of the wind power is not utilized.

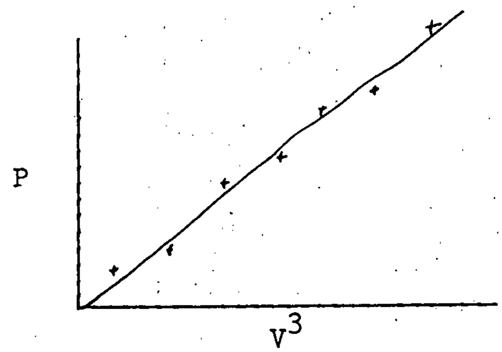
Extension Activities

Activity 3 can be extended to verify the relationship $P = kv^3d^2$.

From the data table, select one diameter and set up another data table as follows:

P	v	v^3

Then plot P, v, and v^3 as follows:

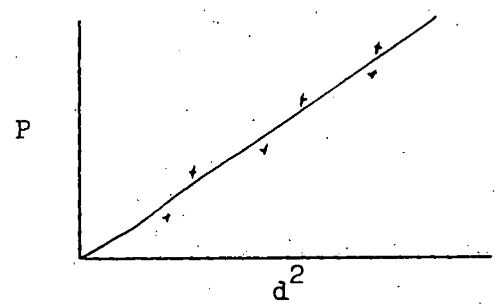


The chart should show a straight line relationship.

From the data table, select one wind velocity and set up a data table as follows:

P	d	d^2

Then plot P, d,,and d^2 as follows:



And again a straight line relationship should appear.

Student Activity Sheet

Name ______________________

Date ______________________

In this activity you will investigate how the power output of a typical small wind powered electric generator depends on both wind speed and propeller diameter.

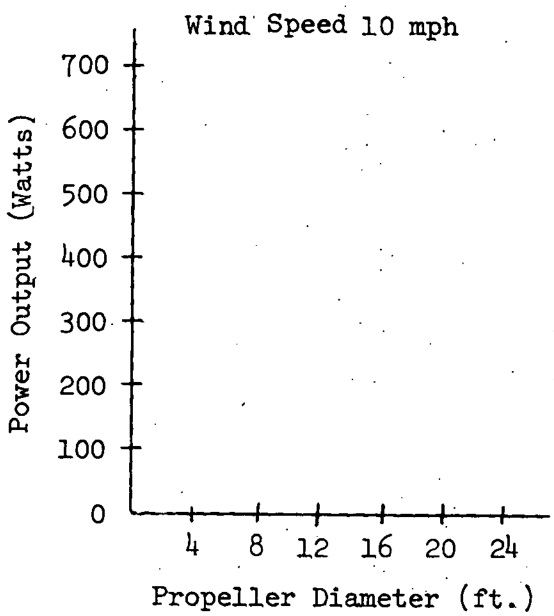
Here is the table of data you will be working with.

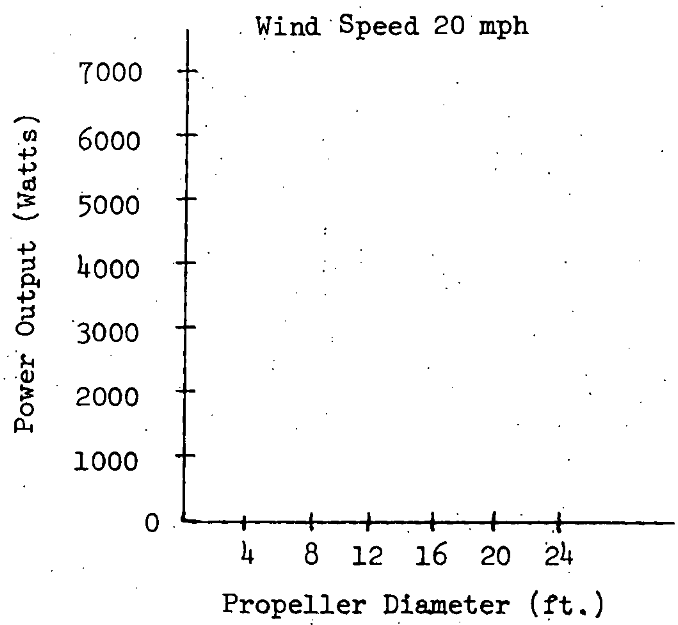
Windmill Power Output in Watts

Propeller Diameter in Feet	Wind Velocity in mph: 5	10	15	20	25	30
2	0.6	5	16	38	73	130
4	2	19	64	150	300	520
6	5	42	140	340	660	1150
8	10	75	260	610	1180	2020
10	15	120	400	950	1840	3180
12	21	170	540	1360	2660	4600
14	29	230	735	1850	3620	6250
16	40	300	1040	2440	4740	8150
18	51	375	1320	3060	6000	10350
20	60	475	1600	3600	7360	12760
22	73	580	1940	4350	8900	15420
24	86	685	2300	5180	10650	18380

Activity 1

On the grids provided below plot the power output as a function of propeller diameter for wind speeds of 10 mph and 20 mph.





Questions

1. How do the general shapes of the two graphs compare? ____________________

____

2. For a given wind speed, how is the power output related to the propeller diameter? ____________________

____

____

3. Try to write a formula which can be used to calculate the power output for various propeller diameters at a wind speed of 10 mph. ____________

____

____

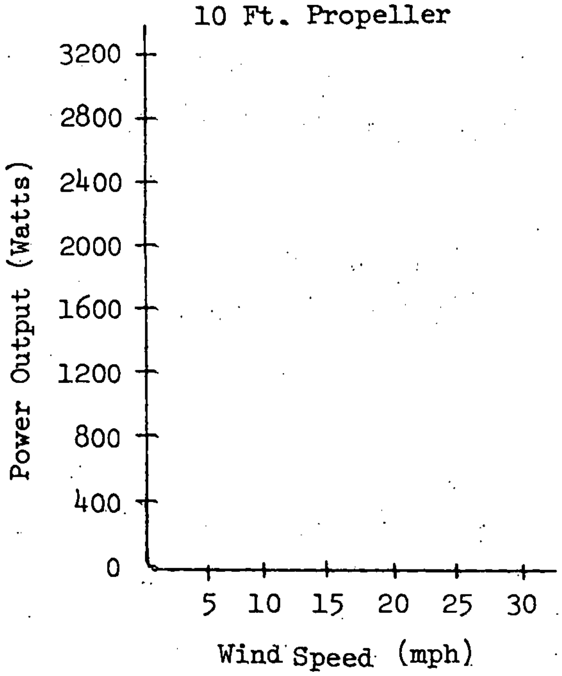
4. Ignoring other considerations, which would produce more power (or would they be the same): two windmills with 10 ft propellers or one windmill with a 20 ft propeller. ____________________

____

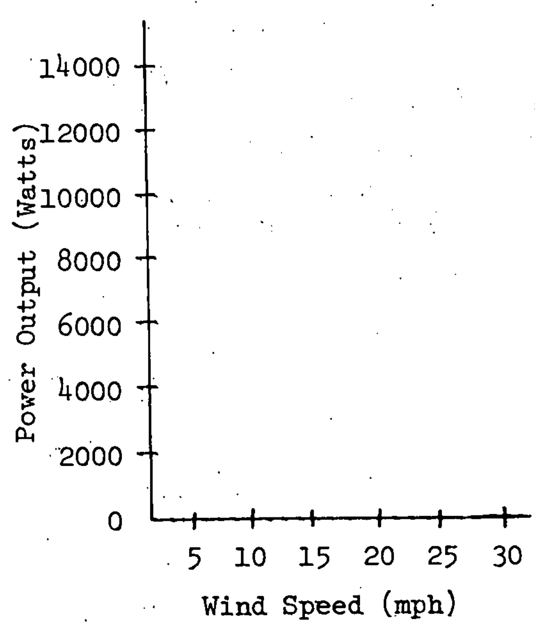
Activity 2

On the grids provided below plot the power output as a function of windspeed for propeller diameters of 10ft and 20 ft.

10 Ft. Propeller



20 Ft. Propeller



Questions

5. How do the general shapes of the two graphs compare? ____________________

____

6. For a given propeller diameter, how is the power output related to the windspeed? ____

____

____

7. Try to write a formula to calculate the power output for various windspeeds with a propeller diameter of 10 ft. ______________________________

____

Activity 3

For the table of data given, the power output of the windmill can be related to windspeed and propeller diameter according to the following equation:

$P = kv^3d^2$ where

P = power output (watts)
v = wind speed (mph)
d = propeller diameter (ft.)
k = constant of proportionality

Using the data in the table, calculate the value of k for the following conditions:

V = 10 mph	v = 20 mph
d = 10 ft.	d = 20 ft.
k = 0.0012	k = 0.001125

Questions

8. The table of data gives 60 different wind speed and propeller diameter combinations from which 60 values of k could be calculated. How would you expect these 60 values of k to compare with each other? ______________

____

____

9. What design and operating features (other than propeller diameter and wind speed) do you think determines the value of k? ____________________

____

____

The following activity is designed for class discussion.

10. List some pros and cons for the following statement:
For a given power requirement, a single large windmill is "better" than several small ones.

Pros	Cons

11. How valid would you say the following statement is: For wind powered generators, "the more wind, the better it is."

LAST BUT YEAST

Fermentation

Objective

The students should be able to:

a) Measure a change in temperature through time in the fermenting process.

b) Observe the production of CO_2 from the fermenting system.

c) Detect, through identifying an odor, the formation of alcohol from the fermenting slurry.

d) List the raw materials necessary for fermentation and the products.

e) Construct a time vs. temperature curve to demonstrate the exothermic nature of the system.

f) Apply the information gleaned from this exercise to the process of generating heat energy directly for fuel and gas needed for photosynthesis.

g) Devise exercises for the anaerobic digestion of organic wastes.

Overview

Aerobic respiration is much more efficient than anaerobic. It has been estimated that about 60% of the total energy in the glucose molecule is released from the process of aerobic respiration as opposed to about 3.2% from the aerobic process. The purpose of this exercise is to demonstrate the release of photochemical energy from organic molecules. The source of molasses, the sugar cane plant, should be recognized as one of the more efficient solar users of the green plants in the US as can be determined in the following narrative and table.

Plants are simply unable to use most of the sunlight available to them. On land, from 70 - 80% of the incident light is reflected or absorbed by physical things other than plants. We can get an idea of what happens to the remaining light energy from an elegant study done on an acre of corn during a 100 day growing season. The study showed that 44.4% of the light received by plants was used to evaporate the 15 inches of rainfall received during the season: 54% was converted directly to heat and lost by convection and radiation, and the minute quantity remaining (1.6%) was actually converted into the tissues of the corn plants. About 33% of this gross productivity was used in respiration leaving 1.2% of the available light energy as corn biomast.

Energy Budget of an Acre of Corn During One Growing Season (100 days). 76.6% of the Solar Energy Assimilated is Put into Biomass.

	Glucose (lbs)	kcal. (million)	Solar Efficiency
INCIDENT SOLAR ENERGY		2.043	
PRODUCTIVITY			
Net (N)	3040	25.3	1.2%
Respiration	930	7.7	0.4%
Gross (G)	3970	33	1.6%
Production efficiency = N/G			76.6%

Photosynthetic Efficiency of Various Plants, Crops, and Ecosystems

	% of Gross Productivity	% of Net Productivity
EXPERIMENTAL		
LABORATORY		
Algae (Chlorella)	20-35	
Dim light experiments	15-20	
FIELD		
Chlorella silt ponds	3.0	
Sewage ponds	2.8	
CULTIVATED CROPS		
PEAK OF SEASON		
Sugar beets, Europe	7.7	5.4
Sugar cane, Hawaii	7.6	4.8
Irrigated corn, Israel	6.8	3.2
DURING SEASON		
Sugar beets, Europe	2.2	
Rice, Japan		2.2
Sugar cane, Java		1.9
Corn, U.S.	1.6	1.3
Water hyacinth	1.5	
Tropical forest plantation	0.7	
ECOSYSTEMS		
Annual desert plants (peak)	6-7	
Tropical rain forest	3.5	
Freshwater springs, Florida	2.7	
Polluted bay, Texas	2.5	
Coral reef	2.4	
Beech forest, Europe	2.2	1.5
Scots pine, Europe		2.4
Oak forest, U.S.	2.0	.91
Perennial herb, grass		1.0
Cattail marsh	0.6	
Lake, Wisconsin	0.4	
Broomsedge community	0.3	
BIOMES		
Open ocean	0.09	
Arctic tundra	0.08	
Desert	0.05	
BIOSPHERE		
Land		0.4
Sea		0.2

Sources: Energy Primer, Portola Institute, 1974.

Materials

Student activity sheets

2 thermos vacuum bottles, approximately 0.5 liter

2 two-holed rubber stoppers or corks to fit the opening of the vacuum bottles

2 glass tubing, 6 mm diameter x 8 cm long

2 thermometer, 20°C to 120°C (1°C graduation)

2 rubber or plastic tubing, 25 - 30cm long (to fit on glass tubing)

3 250ml beakers

500ml 25% molasses solution (75% water)

Glass-marking wax pencil

1/4 package of dry yeast

2 drinking straws

Glycerine or soap solution

Stirring rod, about 20cm long

2 500ml beakers

Strategy

This activity should follow the introduction of the production of energy from anaerobic digesters.

The students' discussion of this area should include the materials which are fed to the digester; the design of the apparatus, the delivery system to the digester; the availability of the raw materials; the time, temperature and mixture materials used in the digester; the systems for evacuating the gasses, liquids and solids from the digester; the products expected and the amount/unit of input materials; the usefullness of the various products; the desirability of the products; the safety precautions needed for the system; the delivery system for the products; the space required for the system and its location on the property; the number of people/size of unit served by the system; economics of the system; need for the system. There should be many more including the social acceptance of the system in various locales.

The conversion factors of 3413 BTU = 1 Kwh = 3600 Joules and 1HP = 0.7455 KW should be supplied to the students to compute the energy input/output/efficiency of the system. Remember that a digester system of the low-tech conversion requires about 30 days to effectively produce methane with 3 pairs. and a high-technology system requires 2 to 3 days. Methane has a heating value of 500 - 800 BTU/ft^3.

This activity will produce CO_2 and alcohol. The change in the lime-water will demonstrate the CO_2 production ($Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$). The distinctive odor of fermenting yeast has been used to deduce the formation of alcohol (ethanol).

$$C_6H_{12}O_6 \xrightarrow{\text{Yeast}} 2C_2H_5OH + 2CO_2$$

It is possible that someone in the class may have experienced this odor eminating from a bakery.

It may serve to demonstrate a fact, that alcohol is combustible, that you ignite a small quantity of alcohol either prior to or following the exercise. This should further enforce the concept of energy from the anaerobic (respiration) digestion of sugars.

Notes to the Teacher

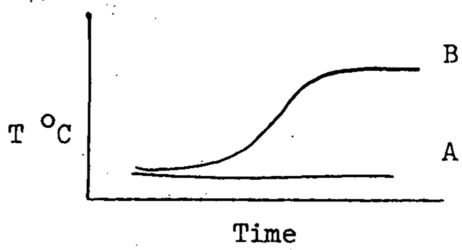
The fermentation process will proceed at a slow rate after the apparatus has been set up, increase and then level off. In order to collect data on temperature change and any change in the limewater solution, students should return to the lab room or wherever the set up is kept to make observations as often as possible for forty-eight hours. The first set of data will be collected in lab at five minute intervals to give the students a feeling for the direction in which the processes will go.

CAUTION: Be sure to instruct the students to lubricate the thermometers and glass tubing with glycerine or soap solution before they insert them into the openings in the stoppers or corks. Also, they should be very careful not to force them either in or out of the stoppers or corks because they break very easily. They should also take precautions when inserting or removing them that the possibility of pushing them into their person, if broken, does not exist.

Sample Responses

1. The limewater becomes cloudy.
2. Bottle A = no temperature change.
   Bottle B = slight increase in temperature after about 45 minutes, then a more marked increase to a point of plateau after about 48 hours -

depending on the amount of molasses and yeast used.

3. 

4. Bottle B.
5. Change in temperature, change in limewater appearance and change in odor of the solution.
6. The reaction eventually takes place in the absence of oxygen.
7. Bottle B.
8. CO_2. The limewater became cloudy, which is one teast for the presence of CO_2.
9. The same gas, CO_2 is released, heat is produced in both reactions; they are chemical reactions which occur at about 37°C.

Extension Activities

Burn grass, nuts, oil, alcohol to determine the change in temperature of water and BTU/gm weight.

Substitute a beaker of an algae mixture for the limewater to note the probable "bloom" effect.

Construct other tests or apparatus set ups for culturing anaerobes.

Report on various types of anaerobic digesters.

Conduct a feasability study on the appropriateness of this technology for the small unit (6 person family), the intermediate sized unit (large kennel or small livestock house) and the large scale unit (municipality or village) using the following information and tables: 1 lb of volatile solids (VS = 5 - 7 ft^3 methane.

		Wet Raw Manure *			Total Solids		Volatile Solids	Livestock Unit
		lb/day	ton/yr	gal/day	lb/day	ton/yr	lb/day	
Bovine								
Dairy Cow	1600	132	24	18	16.6	3.1	13.8	300-350
	1300	107	19.5	15	13.5	2.5	11.2	250-300
Dairy Heifer	1000	85	15.5	11.2	9.2	1.7	7.5	150-200
Beef Feeder	1000	60	11	7.5	6.9	1.3	5.9	150
Beef Stocker	500	45	8.2	5.2	5.8	1.0	4.8	120
Horse								
Large	1000	45	8.2	6.7	9.4	1.7	7.5	180-200
Medium	850	36	6.6	5.4	7.0		5.5	120-150
Pony		15.4			3.0		2.4	50-70
Swine								
Hog Breeder	500	25	4.6	3	2.2	0.4	1.6	40
Hog Feeder	200	13	2.4	2.2	1.2	0.22	1.0	25
	100	6.5	1.2	1.1	0.6	0.11	0.5	13
Wiener	15	1.0	0.2		0.1			
Sheep								
Feeder	100	4	0.7	0.8	1.0	0.18	0.8	20
Lamb	30	1.5	0.3		0.4		0.2	5
Fowl								
Geese, Turkey	15	.6	220 lb	.2 qt	.15	55 lb	.10	2.5
Ducks	6	.4	250 lb	.15 qt	.10	37 lb	.07	1.8
Broiler Chicken	4	.3	110 lb	.1 qt	.07	26 lb	.05	1.3
Laying Hen	4	.2	75 lb	.1 qt	.05	18 lb	.04	1.0

	Portion	Amount	% TS	TS/day	%VS	VS/day	Livestock Unit
Humans (150 lbs)	Urine	2 pt., 2.2 lb	6%	.13	75%	.10	6
	Feces	0.5 lb	27%	.14	92%	.13	
	Total	2.7 lb	11%	.27	84%	.25	

TABLE I MANURE PRODUCTION OF VARIOUS LIVESTOCK AND HUMANS. "Livestock Unit" = VS production relative to laying hens.

*Bulk density of raw manure = 34 ft^3/ton or 60 lb/ft^3, or 8 lb/gal with no flushing water.

USE	FT³	RATE
Lighting	2.5	per mantle per hour
Cooking	8 - 16	per hour per 2 - 4" burner
	12 - 15	per person per day
Incubator	.5 - .7	ft^3 per hour per ft^3 incubator
Gas Refrigerator	1.2	ft^3 per hour per ft^3 refrigerator
Gasoline Engine*		
CH_4	11	per brake horsepower per hour
Bio-Gas	16	per brake horsepower per hour
For Gasoline		
CH_4	135 - 160	per gallon
Bio-Gas	180 - 250	per gallon
For Diesel Oil		
CH_4	150 - 188	per gallon
Bio-Gas	200 - 278	per gallon

*25% efficiency

TABLE II USES FOR METHANE. Consumption of methane and bio-gas for different uses.

Other Readings

Solid Waste as an Energy Source for the Northeast by P.M. Meier and T.H. McCoy, Brookhaven National Laboratory, Upton, N.Y., #50559, June, 1976.

Seminar Report on Microbial Energy Conversion, sponsored jointly by the United Nations Institute for Training and Research (UNITAR) and the Ministry for Research and Technology of the Federal Republic of Germany (BMFT), April - May, 1977.

Energy Primer - Solar, Water, Wind and Biofuels, Portola Institute, 558 Santa Cruz Avenue, Menlo Portz, California, 1974.

Biomass Energy Institute, 310-870 Cambridge Street, Winnepeg, Manitoba, Canada, R3M3H5.

Methane Registers for Full Gas and Fertilizer, L. John Fry and Richard Merrill, New Alchemy Institute West, P.O. Box 376, Pescadero, California, 1973.

Proceedings: Bioconversion Energy Research Conference, Institute for Man and His Environment. University of Massachusetts, Amherst, Mass., June 25-26, 1973.

Concepts in Modern Biology, Kraus, Cambridge Book Co., N.Y., N.Y.

Investigations in Modern Biology, Stock and Banclier, Cambridge Book Co., N.Y., M.Y., 1977.

Student Activity Sheet

Name ____________________

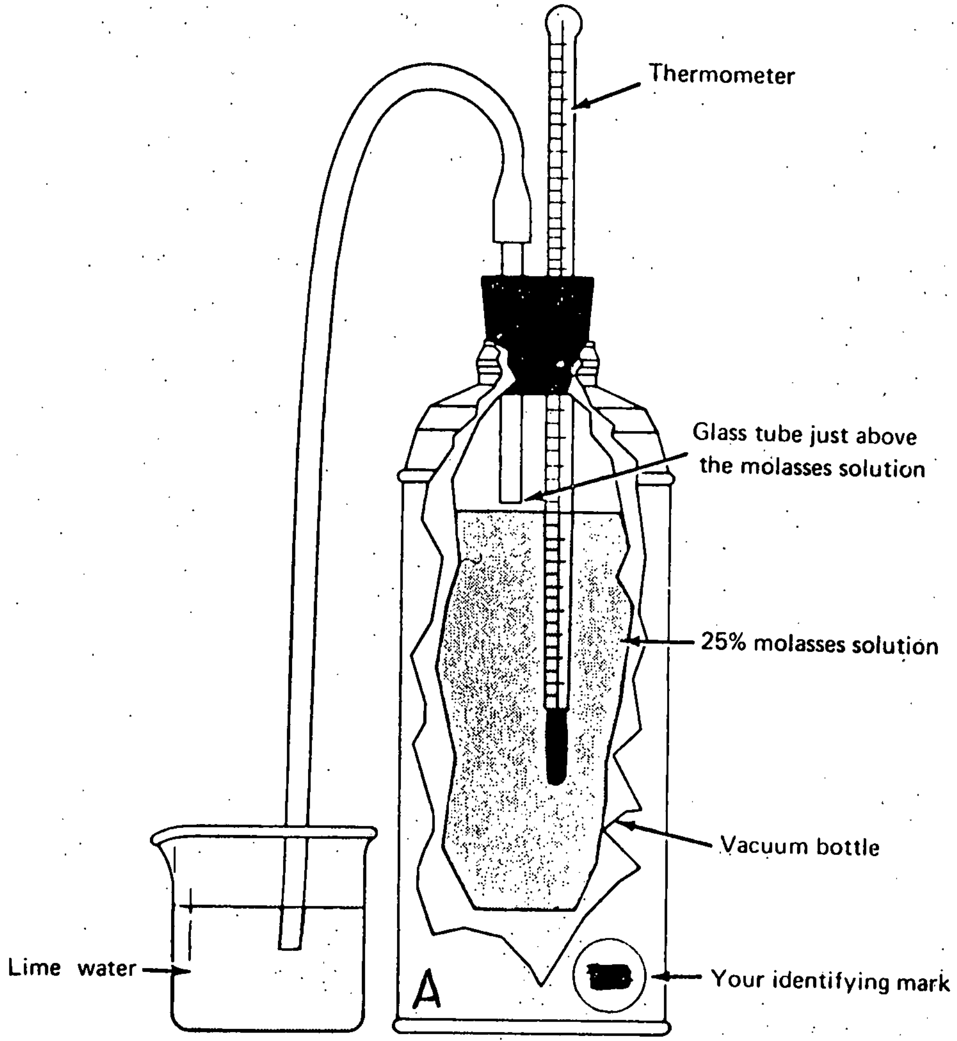
Date ____________________

Purpose: To observe the effects of anaerobic (respiration) fermentation using yeast.

Procedure:

A. Assemble the two sets of apparatus as depicted in the drawing following:

CAUTION: Be sure to lubricate the thermometers and the glass tubing with the glycerin or soap solution before inserting them into the stoppers or corks. Point the thermometers away from your hands and body as you insert them. Be sure not to force the thermometers or glass tubes into the stoppers or corks, they break easily and cause injury.



Procedure for measuring anaerobic respiration in yeast

B. Label the vacuum bottles A and B. Fill them with the molasses solution to a level which is very close to the open end of the glass tube which leads to the tubing to the beaker of limewater. Add the ¼ package of dry yeast to bottle B and gently stir the mixture to suspend the yeast throughout the solution. Place the stoppers securely into the openings of both vacuum bottles. Place the rubber tubing which is attached to the glass tubing in each bottle into each of the two beakers which contain about 200 ml of limewater. Be sure the open end of the rubber tubing is below the surface of the limewater.

C. Pour the remaining limewater (about 100ml) into the third beaker.

Gently exhale through the drinking straw so that the exhaled gases will bubble through the limewater solution. Record any changes which take place in the limewater solution.

D. Observe the change in the appearance of the limewater and the temperature of the molasses solutions in each vacuum bottle at the beginning of this activity and at five minute intervals for the first hour. Observe the appearance of the limewater and the temperature readings as often as possible for the next 24 to 48 hours.

Record the temperatures and appearance of the limewater observed for each bottle and the time elapsed between each reading onto the data chart provided below. (Extend the data chart if necessary to enter all readings.)

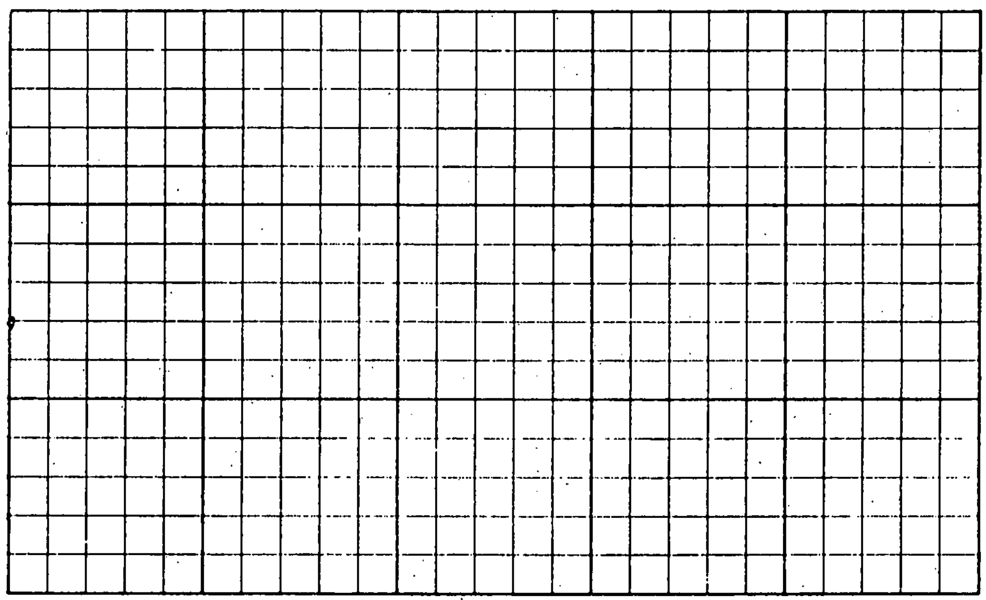
	BOTTLE A		BOTTLE B	
Time started:	°C	Limewater Appearance	°C	Limewater Appearance
Elapsed time:				
"				
"				
"				
"				
"				
"				
"				
"				
"				
"				
"				
"				
"				
"				

2. In which bottle did a chemical change occur, if any?

E. After collecting all the data remove the stoppers from both bottles. Note the distinctly different odors which come from each bottle.

3. Using the data from both bottles, plot the temperature changes as a function of time on the graph grid provided. Plot the data for both bottles on the same grid to provide a comparison at a glance. Label the line plot for each bottle.

Temperature



Time

4. In which bottle did a chemical change occur, if any?

5. On what evidence do you base your reply to question #4?

6. Why is this section of yeast considered anaerobic, even though oxygen was present?

7. From which bottle was a gas produced - if at all? Was it produced in both?

8. If a gas was produced, can you give a tentative identification of it and what do you base this tentative identification on?

9. In what ways does anaerobic digestion or fermentation resemble respiration?

FACT OR FICTION

Is Solar Heating Fact or Science Fiction?

Objectives

Students should be able to:

a) Understand the variations in insolation by month across the country.

b) Compute the conversion from fuel to heat and from insolation to heat.

c) Come away with the recognition that solar energy is a practical alternative to fossil fuels in some parts of the country but is not a panacea.

Overview

Solar heating in this activity refers to flat plate collectors. Typically the collectors are mounted on the roof and slanted so as to have the surface of the collector normal to the sun's rays when you need maximum insolation. That works out in the northern hemisphere to be the latitude plus about 10 degrees as the best angle between the collector and the horizon.

At present the cost of fuel is what drives most homeowners to consider the alternative energy sources. If solar collectors are inexpensive enough then individuals will consider using them to ease the fuel bill. Not many think in terms of dwindling supplies and environmental damage. Students can be reached through the pocketbook. This exercise should convince them that solar collectors of 50% efficiency (a conservative figure - 60% is considered attainable presently) and a reasonable size can in fact be an economical thing to do. As fuel prices continue to rise the economy will be more marked, and the pay back period will shorten.

It is important to point out that only about 50% of the energy entering the atmosphere reaches roof tops, and then that only about 50% of this can be converted by this particular collector. And that is on a sunny day! Students are asked to consider building for the worst possible month or compromising for year round lowering of fuel costs.

You should point out the problems with solar heating are two-fold. First, not all parts of the country get enough over the course of a year to supply them with a significant savings - it is not a solution for all of the United States - and even where it is significantly useful the supply of sunlight is variable. All of the solar systems must have good storage facilities. The cost quoted in the exercises are for installation of a full system - collector, pipes, storage, etc. The costs are from the same source as the charts of insolation - the FEA booklet Buying Solar.

Materials

A fuel bill for one month from the student's home. If students can't get fuel bills have samples ready for them.

An estimate of yearly fuel bills.

Maps showing mean daily solar radiation from Buying Solar.

Strategy

Ask if students would be willing to try a new fuel if it was: a) nonpolluting, b) quiet, efficient, and did not require delivery, c) available to everyone, impossible to embargo, and d) FREE.

Explain that whatever the fuel bill they have in hand, it is sure to increase. Conventional fuels are all being depleted and becoming more expensive.

Solar, wind and biomass energy sources are attractive because they are renewable, and if not free, like the sun, they are cheap.

The question is how much solar collector do you need in order for it to supply a significant amount of heat at a reasonable installation cost. (Only the fuel, sunlight, is FREE.)

The parts of the activity are arranged sequentially so that the steps are small and interconnected.

The kicker is in the last question. Do you build to supply all of the heat for the worst month, as you must with conventional fuels, or do you rely on a back-up system of storage and/or fossil fuels. The answer is not obvious and worth the additional computation. If students do not have a bill for the coldest month, use the example in the sample responses. It pays to use calculators for the math.

Sample Responses

These are figures for January on Long Island, for gas at about 38¢ per 100 cubic foot.

1. 304 hundred cubic feet x 773 BTU/cubic foot = 23.49×10^6 BTU this month.
2. Approximate annual fuel bill is $631. Amount saved in one full year at

80% savings is \$505.

3. Installation cost is \$8,000.

4. Pay back period is: \$8,000 / \$505 = 15.8 years.

5. Mean daily solar radiation = 153 Langleys.

6. 153 Langleys x 3.7 = 566 BTU/ft^2/day.

7. 566 BTU/ft^2/day x 800 ft^2 x 80% = .36 x 10^6 BTU/day.
   .36 x 10^6 BTU/day x 31 days = 11 x 10^6 BTU/month available from the collector.

8. No. It is 47% of the family's need.

9. To supply all of my family's need for heat that month look at question 7. The insolation was 566 BTU/ft^2 but at 80% efficiency only 453 BTU/ft^2 is converted/day, 14000 BTU/ft^2/month.

   $$\frac{\text{23,490,000 BTU's needed}}{\text{14,000 BTU's/square foot}} = \text{1,677 sqare foot collector needed}$$

10. At \$10 per square foot the collector would cost \$16,770 to install and if fuel costs stayed the same it would take 33 years to save that same amount by not having a fuel bill all year.

Notes to the Teacher

On the bill I have, the gas column dow not indicate that the "Units of Use" are hundreds of cubic feet.

Extension Activities

Build a demonstration model of a solar collector. See other activities activities in this set.

Hot water heating uses about 2,000 BTU per month. Calculate how many square feet of a collector at 80% efficiency would be needed just to supply hot water.

Student Activity Sheet

Name ____________________

Date ____________________

A. How much heat does your family use? Your bill tells how many ft^3 (cubic feet) of gas or how many gallons of oil your family used to heat your home and maybe your hot water as well. Use the table below to determine how many BTU's (British Thermal Units) of heat your fuel provided.

1 gallon of home heating oil	provides	8400 BTU	@ 60% efficiency
1 cubic foot of natural gas	provides	773 BTU	@ 75% efficiency

1. Your family used ________ BTU's this month.

B. How much could you save in one year with solar heating? A solar hot water heating system which provides for half of the heat needed in the coldest month of winter could be expected to provide 80% of the heat needed over the whole year.

What would your family save in dollars and cents if they did not have to pay for 80% of the fuel used this year?

2. Amount saved in one full year could be ________________.

C. How long before the savings would cover the cost of installation? The pay back period is the is the length of time it takes for the savings in fuel costs to equal the cost of installation.

If you could save the amount listed on line 2 how long would it take to pay back the cost of an 800 ft^2 collector if it cost \$10 per ft^2 to install?

3. Installation cost at $\$10/ft^2$ = ________________.

4. Pay back period at current fuel cost = ________________ years.

D. Can the sun do it? You know that the amount of wolar energy reaching rooftops depends on the time of day, season of the year, weather and latitude. By gathering information over many years, the Weather Bureau has put together maps which give the average amount of solar energy received in different sections of the country each month. The solar radiation received is called insolation.

From the charts (p.29-34 of the FEA booklet Buying Solar) find the mean daily solar radiation for the month covered by your bill.

5. Mean daily solar radiation = ____________________ Langleys

6. Multiply the Langleys by 3.7 to get BTU/ft^2 = __________ $BTU/ft^2/day$
This is the amount of solar radiation provided (on an average day).

E. How much insolation could we convert to heat? We can never convert all of the available energy to another form of energy. Assume your rooftop collector can convert 80% of the insolation to heat. Assume also that you have a collector of 800 ft^2. (These are reasonable figures for current collectors.)

Put Put your answer from line 6 into the formula below, do the multiplications to find out how much such a collector could be.

E. How much is enough? If the month of your bill is not the coldest part of the year it is important to realize that even if your collector delivers enough heat for some months it may not be enough for the coldest part of the winter. There are two ways to look at this problem. You could buy enough collector to provide all of the heat even for the worst month, or you could buy enough collector to provide all of the heat for part of the year and up to half of what is needed in the deep of winter.

UsingUsing a fuel bill from the coldest month of the year figure out how many ft^2 of collector you would need to supply all of your family's need for hot water and heat. Remember that a two story house has roughly 500 ft^2 to 800 ft^2 of south facing roof.

9. How many ft^2 of collector is needed to supply all of the mid-winter need? ______________________________

10. Considering an installation cost of about $10/ft^2$ would it be practical to install that much collector? ____________________

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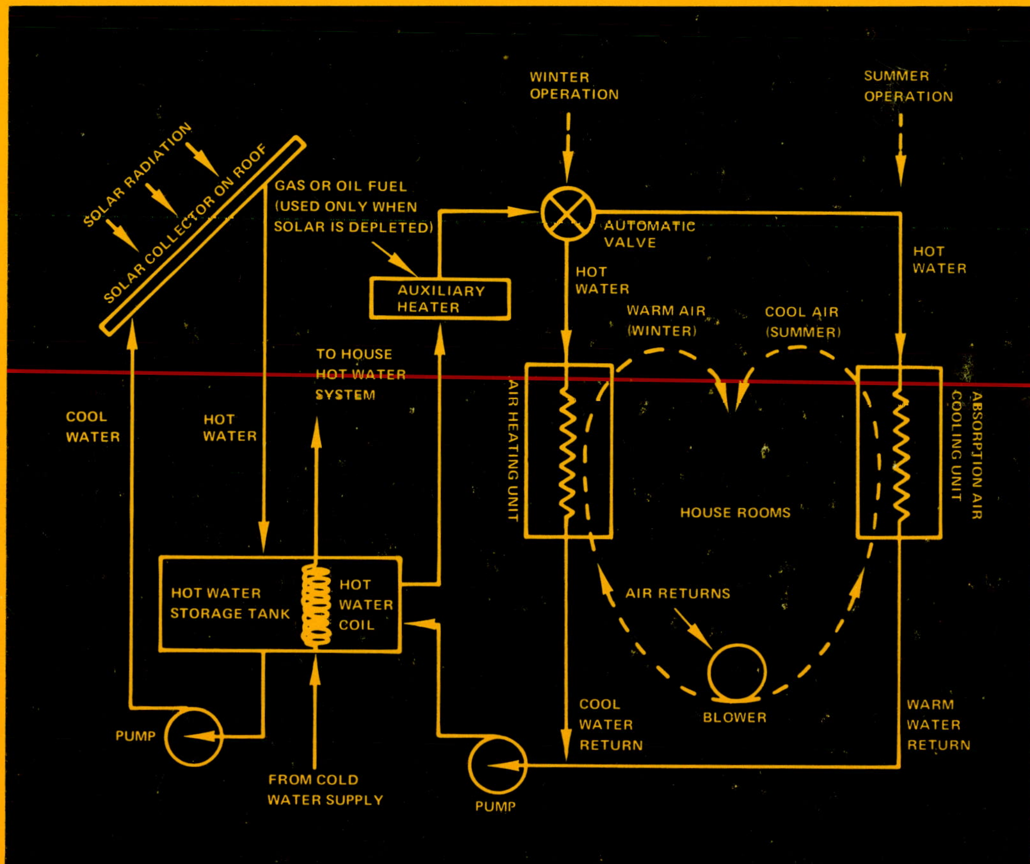
ENERGY: OPTIONS FOR THE FUTURE

CURRICULUM DEVELOPMENT FOR THE HIGH SCHOOL

Demand Scheduling & Electric Utilities



Institute for Energy Research
and
W. Averell Harriman College for Urban & Policy Sciences
State University of New York at Stony Brook
Stony Brook, New York 11794

T. Owen Carroll, *Project Director*
Robert Lewis, *Associate Project Director*
Herbert Berger, *Assistant Project Director*

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the Office of University Programs
Energy Research and Development Authority
Washington, D. C.

DEMAND SCHEDULING & ELECTRIC UTILITIES GROUP

Members: Anthony Barchuk
Barbara Brookmeyer
Henry Whitehead
Marvin Ohriner
Philip Merenda

I. Background

II. Student Activities

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INTRODUCTION

Recent state and regional energy crises demonstrate the delicate balance between the energy system, the environment, and the economy. Indeed, interaction among these three elements in our society is very complex. However, any permanent change in the directions of our energy demand and supply for the future involves the formation of a new "energy ethic". To do so requires a broad base of information and understanding of the energy system, and this needs to be developed, particularly among those still in school. You, the teacher, play a most important role in providing that base of information which will become part of the new generation's thinking about the energy system. These materials are intended to enhance your ability to provide energy-related education to students within your own academic setting and to provide students with a better understanding and awareness of fundamental principles of energy supply, conversion processes and utilization now and in the future.

Since it is not possible to cover all aspects of energy systems, the curriculum materials designed in this project were limited to a number of areas considered important from two points of view: energy developments which are now occurring but whose implications are not yet clearly recognized and/or that broad area of potential new developments which have important implications for the future. The specific areas of curriculum materaials are the following -

CONSERVATION. We are coming to realize, albeit slowly, that the supply of raw materials from which energy is produced is finite and decreasing rapidly. Not only is supply decreasing, but demand continues to grow. The most optimistic forecasts show that the world resources of petroleum and natural gas, the two main sources of energy today, will be gone within the next fifty years. Consequently, we need to explore ways to conserve energy by using fewer energy-intensive devices, reducing our life style to one less dependent on energy, and possibilities for substituting new technologies.

DEMAND SCHEDULING. Electricity, since its first introduction, has provided a cheap, clean, efficient source of energy. We have also come to expect that any required demand for electricity on our part as individual consumers, will be met. We turn on the switch and expect the lights to come on. Large investments in the electricity generating plant are required to satisfy increasing demand, particularly during "peak" periods. Consequently, the overall cost of electricity generation becomes quite expensive - a result we have seen in recent years. The issue is particularly important since utility companies are now testing, and will soon offer to the consumer, electric metering for homes on a demand-scheduled basis.

ENERGY IN THE FOOD SYSTEM. Our agricultural system has become increasingly dependent upon the use of energy-intensive fertilizers for large crop production. In addition, energy requirements for food processing continue to grow. It is estimated that about one half of U.S. freight transportation is involved in the movement of foods of one kind or another. With the decline in the supply of fuels, we must ask whether our current national pattern of energy consumption in the food industries, particularly the trend toward increasing use of energy in food processing and packaging, are desirable trends for the future.

NEW TECHNOLOGIES (Solar, Wind, Biomass). It can be argued that the problem in our energy system today is not that we use too much energy, but rather that we use the wrong kinds of energy. Oil and natural gas form important components for synthetic materials, chemicals, and the like. Wherever possible, they should be conserved for such long-term uses. Consequently, we should shift from a fossil fuel resource base to a renewable energy resource base, particularly the use of solar, wind, and biomass sources.

ENVIRONMENT. The direct use of energy involves various pollutant emissions. In addition, indirect use of energy in the creation of industrial goods has secondary environmental impacts in a number of areas. Of recent concern are long term trends in accumulation of carbon dioxide and other gases and particulate matter in the atmosphere. These seem to produce unfavorable atmospheric conditions involving "the greenhouse effect", thermal inversions, and the like.

The modules prepared in each of these areas consist of an introductory background statement and a series of one-day lesson plans, along with suggested bibliography and references to other materials. The background statements are intended to introduce the topic to you, the teacher, and should reduce your need for reading a number of original papers and other citations to the literature. However, the background statements are sufficiently short that they can not make you an energy expert, and we would hope that you pursue additional reading on your own. Single day lesson plans were designed for easy use within existing courses as well as in the construction of new courses. As a result, it is hoped these curriculum materials will be useful in a variety of courses.

A special note to you, the user of these curriculum materials, is in order. The materials are made available in draft copy because of widespread interest in energy issues. Where you encounter rough spots, loss of proper citations to the literature, or other problems, bear with us. A brief evaluation form is included in this document. We encourage you to give us your reactions and any improvements we might add to make these materials more useful to you and to other teachers. The names and school affiliation of the project participants are noted in the material so you can feel free to contact the individual teachers on specific questions. Finally, these documents reflect a concentrated effort over three weeks by the teachers associated with the curriculum development project, and their efforts to translate energy issues into high school course material for you.

LIST OF PARTICIPANTS

- William Baran, Chrmn/Science Dept.,Niagara Wheatfld Central School District, 2292 Saunders Ave,Settlement Rd.,Sanborn, NY 14132
- Anthony Barchuk, Westbury Public Schools, Westbury, NY 11590
- Barbara Brookmeyer, Francis Lewis High School,58-20 Utopia Prkwy,Flushing,NY 11365
- Malcolm Cooper, 69-07 223 St.,Bayside, NY 11364
- Everett Carr, Herkimer County B.O.C.E.S., Herkimer, NY 11350
- Vincent Corsall, 257 Caldwell Ave., Elmira, NY 14904
- Carole Escobar, Islip Jr. High School, Main St., Islip, NY 11751
- Sr. Jane Fritz, St.Patrick's School, 284 E.Main St., Smithtown, NY 11787
- Edward Greenwood, Forest Hills High School, Forest Hills, NY 11375
- Raymond Hahn, Massepequa High School, 4925 Merrick Rd.,Massepequa, NY 11758
- Henry Harvey, Schroeder Jr. High School, 875 Ridge Rd., Webster, NY 14580
- Louis Bancheri, Chrmn/Science Dept.,Sewanhaka Sr. High School,Floral Park,NY 11001
- Alfred Kausch, Windsor Locks High School, So.Elm St.,Windsor Locks, Conn. 06096
- Efsavia Krasilovsky, Central Islip High School,Wheeler Rd., Central Islip,NY 11722
- Edward McGreevy,Soc.Stud.Dept.,Board of Education,Niagara Falls, NY 14302
- Laura Maitland, Francis Lewis High School,58-20 Utopia Pkwy, Flushing, NY 11365
- Philip Merenda, Science Dept.,Lawrence Sr. High School, Cedarhurst, NY 11516
- Ruth Miner, Science Dept.,Floral Park Memorial High School, Floral Park, NY 11000
- Donald Nelson, Science Dept.,W.L.Boardman Jr. High School, Alice & Beatrice Avenues, Oceanside, NY 11572
- Marvin Ohriner,Science Dept.,Elmont Memorial High School,555 Ridge Rd.,Elmont,NY 11 0
- Richard Pav, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776
- Severino Santorelli, Wm.Floyd High School,Mastic Beach Rd.,Mastic Beach,NY 11951
- Gerald Slutsky, Hauppauge Sr. High School, Hauppauge, NY 11787
- James Stark, Chrmn/Science Dept.,Peabody High School,315 S.Bellefld Ave,Pittsburgh, Pa 15213
- George Urda, Chrmn/Science Dept.,Torrington High School,Major Besse Dr.,Torrington, Conn. 06790
- Chris Vigliotta, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776
- Harold Visner,Asst.Prin/Science Dept.,Hillcrest High School,160-05 Highland Avenue, Jamaica, NY 11432
- Henry Whitehead, Chrmn/Science Dept.,Locust Valley High School, Locust Valley,NY 115[illegible]

- - - -

Associate Program Director: Robert Lewis, 2611 Silverside Road,Wilmington, Delaware 19810

Assistant Program Director: Herbert D.Berger, #17 Harborview Drive,Northport, N[illegible] 1176[illegible]

DEMAND SCHEDULING AND ELECTRIC UTILITIES

Introduction

In the use of electricity, we have turned on switches with no doubt that the electricity will flow. Until recently this has been true but recurrent local power outages and two major East Coast blackouts in 1965 and 1967 d demonstrate that it may not always be true in the future. This brief report will analyze a major cause of this problem.

The rock group "The Rolling Stones" have a song entitled "You Can't Always Get What You Want ...." (when you want it). This may well exemplify the direction we are taking with our electrical use. For the time being at least, we have enough electricity. We do not always have enough electricity exactly when we want to use it. In addition to considering how much electricity we use, we must learn to think of <u>when</u> we use it. In short, we must work with demand for electricity as a <u>time-related thing</u>.

The following analogies will illustrate the problem:

What would happen if all the students in your building would demand to use the restrooms simultaneously?

In the summer of 1977, Glen Cove, New York lost over 50% of its water supply. There was enough water if it were used "evenly", but to achieve this it was necessary to restrict its use during certain hours; e.g., lawns could be watered only after 9 pm.

Both problems can be solved if cost is no object. Build one bathroom for each student - if you can get the taxpayer's approval. Rebuild Glen Cove's water supply to provide all the water needed at any time - again, what about the taxpayer? All it takes is money and if we extend the analogy to electricity, an unlimited supply of fuel.

Let's extend the analogy to electricity. We consumers compete for all our utilities, be it water, gas, the use of restrooms, or <u>electricity</u>. We can get it whenever we want it, but only at a price we may not be able to afford. The explanation has to do with the characteristics of base supply and demand.

Figure 1 shows consumer demand, as experienced by an average utility, over a 24 hour period. Note that demand is very low from midnight until about 4 am, then climbs steadily to a peak at about 6-7 pm. It shows that consumers demand a lot of electricity at certain hours and much less at others. Figure 2 shows optimum power generation by the utility in the same 24 hour period. This produces power most efficiently and at the lowest cost. Figure 3 shows the two superimposed, illustrating the great difference between how we use electricity and how best to produce it.

It is therefore clear that we cannot have all the electricity we want, at the time we want, at a cheap price! If we insist on all having power at the same time, we will have to pay for it!

Figure 1

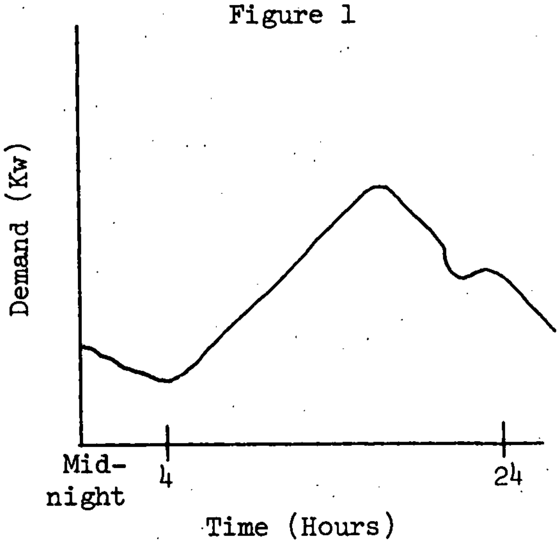


Figure 2

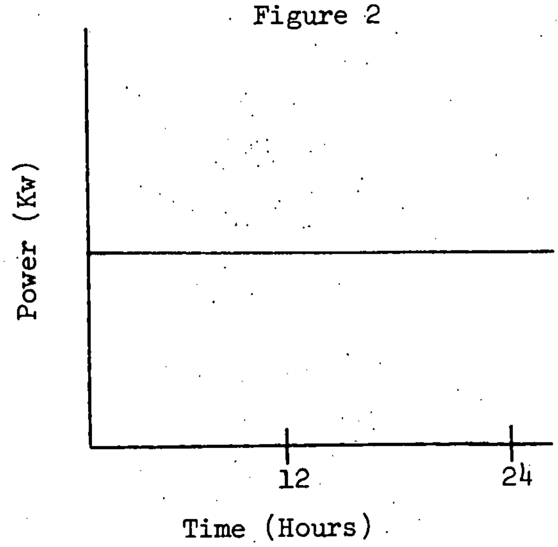
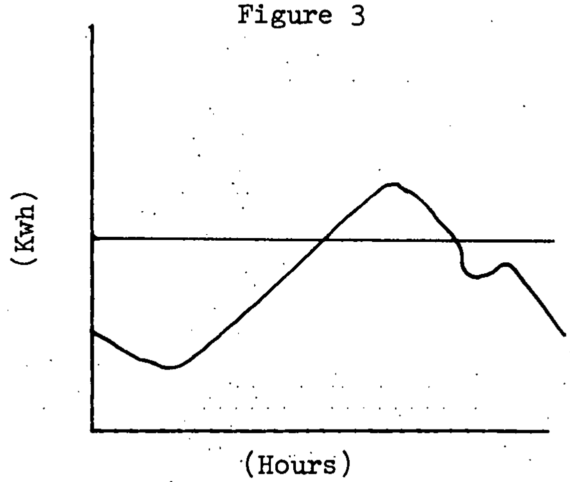
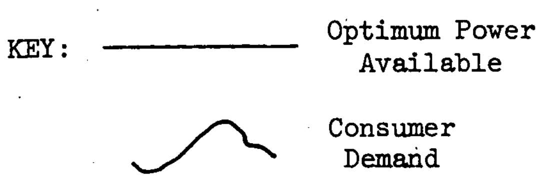


Figure 3





Cost Effect of Deviation From Optimum Power Generation Levels

There are different technologies for producing electricity. This area will be concerned with the three types used most widely by utilities in New York City, as a typical area: nuclear, fossil, and gas turbine. Each technology has certain economic advantages and disadvantages, which must be carefully considered by the utilities who must try to show a profit and keep customer rates low. In addition, these technologies differ in the amount of time it takes to "pick up load." This is another important consideration for utilities who must satisfy consumer demand for electricity whenever it occurs.

Below we list the advantages and disadvantages of each technology. (Fossil and nuclear for our purposes may be treated together.)

Fossil and Nuclear

Advantages

1. Low fuel cost
2. High efficiency

Disadvantages

1. High capital cost
2. Long time to pick-up load
3. Long time for conception to on-line status

Gas Turbine

Advantages

1. Low capital costs
2. Pick-ups load quickly
3. Short time from conception to actual implementation

Disadvantages

1. High fuel costs
2. Inefficient

At the present time, the utilities must utilize a mix of these methods because of the nature of consumer demand for electricity.

Let's take a closer look at consumer demand. It can be seen from Figure 3 that there is a great variation in the demand for electricity over a 24 hour period. From the utilities point of view, a decision must be made as to which mode of power generation to use, and when. No one mode is ideal for the entire 24 hour period.

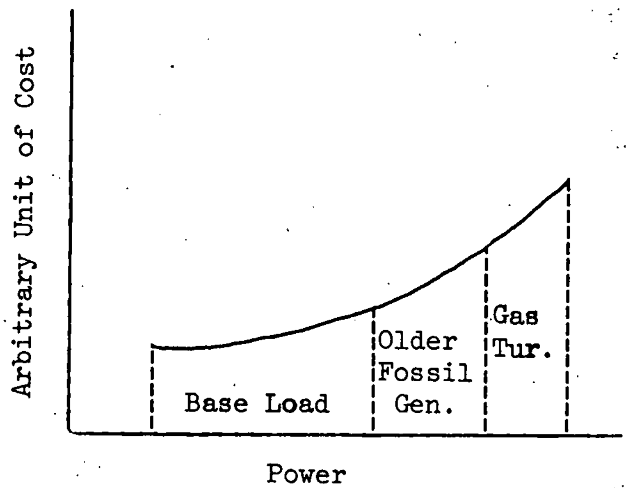
Inspection of Figure 3 shows that a certain level of demand is required almost constantly through-out the day. This level is called the

Base Load. This is supplied by the very large fossil and nuclear plants. When it is anticipated that demand will exceed this base load capacity, smaller and thereby less efficient fossil plants are brought into use. During peak periods, when consumer demand is highest, gas turbines must be used, which are the most inefficient means of producing power.

In Figure 4, we can see that price increases sharply as total power output increases. Therefore it shows why it would be economically advantageous to eliminate peaks in consumer demand.

On the other hand, plants supplying base load operate at a more or less constant power level. If consumer demand drops below this base level the excess power is wasted. Therefore, it is also advantageous to eliminate "valleys" in **consumer** demand.

Figure 4



One additional point should be mentioned. The construction costs for new power plants are astronomical, running into the billions of dollars. Amortization of capital costs represents a significant part of electrical rates. When a utility invests in additional generating capacity to handle increasing demand, a major portion of which may be peak load, the cost of our electricity goes up sharply.

Therefore, if we keep on using electricity during peak-load periods, we are increasing our electrical costs in two ways: it costs more for the fuel to produce the added peak load, and the utilities' capital costs are increased, which also shows up on the rate. It is very much to our advantage to level off electrical use.

Ways In Which Demand For Electrical Power Can Approach the Optimum Level of Generation

A. Public Utilities

1. Produce a rate schedule that encourages off-peak use, and discourages peak use.
2. Store energy generated during off peak hours for use during peak hours. Methods of doing this include:
   a) Conversion of electrical and chemical energy.
   b) Pumped water storage. (Transfer of electrical energy into gravitational potential energy).
3. Load limiting devices; utilities can install devices that limit the maximum use of electrical power.

B. Residential Customer

1. Voluntary restricting of electrical use.
2. Conservation during periods of high electrical demand.
3. Purchasing based on knowledge of appliance efficiency.

C. Industry

1. Rescheduling work hours.
2. Rescheduling activities that require high electrical power.

D. Government

1. Encourage education in efficient energy usage.
2. Tax incentive for demand scheduling.

Glossary

Energy - Ability to do work, in the mks system. The unit is the joule = newton x meter.

Power - Energy per unit time.

Watt - The unit of power in the mks system, commonly used to measure electrical power: watt = joule / sec.

Kilowatt - 1000 watts

Kilowatt Hour - Unit of energy commonly used to measure electrical energy, kilowatt hour = kilowatt x hour.

Demand - The amount of electrical power needed by consumers.

Demand Scheduling - Having consumers schedule their use of electricity so that electricity use is "evened out" as a function of time.

<u>Optimum</u> <u>Power</u> <u>Generation</u> - The level of power generation as a function of time, that minimizes total cost (capital + fuel).

<u>Capital</u> <u>Cost</u> - Cost of construction and machines for a power plant.

<u>Fuel</u> <u>Cost</u> - Cost of fuel (e.g., oil, coal, uranium) used in power plants.

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Rolling Stones -

WATTS IN A NAME

The Wattage of Common Household Appliances

Objectives

Students should be able to:

a) Define electrical current, voltage and power.

b) Correctly use units of amps, volts, watts, kilowatts.

c) Identify and record the power requirements of appliances in their own homes.

Overview

This lesson introduces students to the concepts of electrical current, voltage, and power. It then leads students through a survey of the power requirements of common household appliances.

Materials

For demonstration: battery, bulb, bell, DC motor

Transparency and overhead projector

Student Activity sheet

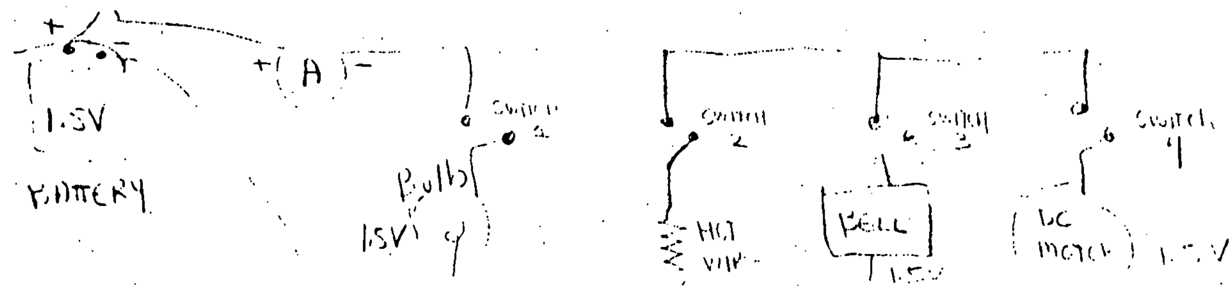
Strategy

Introduce the concept of electricity by analogy with water flowing through a pipe. We know that when water flows through a pipe we can measure its rate of flow and pressure. Similarly, as electricity flows through wires it flows at a certain rate and exerts a certain pressure. The rate of electrical flow is termed current and it is measured in amps (A). The pressure of electricity is termed voltage and it is measured in volts (V).

We know that electricity supplies power because our household appliances work when the electricity switch is turned "on". Electrical power is measured in watts. A larger unit of electrical power is the kilowatt which is equal to 1000 watts. The power in watts can always be calculated by multiplying the voltage (V) times the current (A).

Electrical Power Demonstration

Either set up the demonstration as shown, or connect the devices one at a time.



Teacher Notes

Never connect an ammeter in the circuit when no other devices are in series with it.

Power (from battery) = V(1.5) x A (measured on ammeter)

1. Turn switch 1 on only. Measure I_1 (current). Calculate P .

   $P = P_1 \times I_1 =$ _____ watts

2. Turn switch 2 on only. Measure I_2. $P_2 = V \times I_2 =$ _____ watts

3. Turn switch 3 on only. Measure I_3. $P_3 = V \times I_3 =$ _____ watts

4. Turn switch 4 on only. Measure I_4. $P_4 = V \times I_4 =$ _____ watts

Conclude the demonstration by noting that this shows that electrical power can be used to produce heat, motion, sound, or light. The battery supplies each item with the electrical power it requires. Similarly, the outlets in your home supply the necessary electrical power to appliances. How much power do household appliances require?

5. Give out the chart of household appliances. Fill out the power rating of the 2 sample entries with the students.

Large air conditioner	1200 w
Electric clock	2 w

   This should give students some feeling for the "ball park" that ratings are in. Let them fill in the "guess" column. Then go over the "typical" power ratings with them.

6. The power rating, in watts, is stamped right on each appliance. If it is not, the amps are given and so watts can be calculated using volt = 120v. As a homework assignment students should take a survey of the appliances in their own home, and fill out the last column on the chart: actual power ratings of appliances in their home.

Extension

Discuss the classical physics definition of power as P = W/T and W = F x D.

Do power calculations of a person running up steps. (F = 9.8 x mass in hg (1 kg mass has a weight of 2.2 lbs).

Either use the data in the chart below or have a student run up the steps and record his time, height of stairs, and mass.

Sample data (first entry in chart below)

$g = 9.8\ m/sec^2$

D = 3 meters, M = 50 kg, T = 30 sec

Sample Power Calcualtion

F = g x m = 9.8 x 50kg = 500 newtons

W = F x D = 500 N x 3 M = 1500 NM

P = W/T = 1500NM / 30 sec = 50 W

Sample Data (For extension)

Time to Run Stairs, Seconds	30	10	5	3	2
Mass, kg	50	50	50	50	50
Distance, m	3	3	3	3	3
Force, n					
Work, n x m					
Power, watts					

TRANSPARENCY

Category	Appliance	Power Ratings, Watts (Typical)
Kitchen	Electric range	8800
	Refrigerator-freezer	330
	Dishwasher	1200
	Broiler	1500
	Carving Knife	90
	Coffee maker	890
	Blender	390
	Electric frying pan	1200
	Toaster	1000
Air Control	Air conditioner	1200
	Fan	200
Personal Care	Hair dryer	325
	Shaver	14
Utilities & Household Maintenance	Washing machine	500
	Clothes dryer	4000
	Lamp (1 medium bulb)	100
	Iron	1000
	Vacuum	650
Entertainment	Black/white TV	150
	Color TV	300
	Radio	50
	Stereo	100
Miscellaneous	Clock	2

TRANSPARENCY

Category	Appliance	Power Ratings, Watts (Typical)
Kitchen	Electric range	
	Refrigerator-freezer	
	Dishwasher	
	Broiler	
	Carving Knife	
	Coffee maker	
	Blender	
	Electric frying pan	
	Toaster	
Air Control	Air conditioner	
	Fan	
Personal Care	Hair dryer	
	Shaver	
Utilities & Household Maintenance	Washing machine	
	Clothes dryer	
	Lamp (1 medium bulb)	
	Iron	
	Vacuum	
Entertainment	Black/white TV	
	Color TV	
	Radio	
	Stereo	
Miscellaneous	Clock	

YOU PAY YOUR MONEY AND YOU TAKE YOUR CHOICE

Energy and Power

Objectives

The student should be able to:

a) Describe the relationship between energy and power x time.

b) Define Kw · hr.

Overview

Energy is related to the product of power x time, in units of kw · hr.

Materials

Student activity sheets

Ditto sheets - Chart "Power and Energy Survey" (without column 2 filled in)

Strategy

For homework distribute Chart I without column 2 filled in. Tell students where to look on the nameplates, etc., for the watts used by an appliance. If only amps and volts are give, explain that watts are the product of amps x volts. The students are to fill in columns 3, 4, and 5. Column 4 and 5 are estimates. In class the next day, hand out a duplicate sheet of Chart I with column 2 already filled in. Have students compare with typical values. Have class agree on average values to fill in for column 4 and 5. Fill in column 6 (multiply 3 x 4 x 5). Compare these results with Chart 3 a.b. To find the cost (month, column 7), use the cost of a kwhr of electricity (best assume 10¢ to simplify) to multiply the number of kwhr by. Example: 30 kwhr by 10¢ / kwhr = $3.00.

Notes to Teacher

It is best to have the class all working the same problem at the same time so that each student can check his work each step of the way. Hence, after gathering individual data for homework, it is easier if all the students switch to the typical or average data.

Sample Response

Student responses should average out to the typical values shown on Chart I and 3a, 3b.

Notes: Chart I "Power and Energy Survey" and Chart 3a, 3b "Electrical Energy Use Chart" are reprinted from National Coordinating Center for Curriculum Development booklet "Electrical Energy Use in the Home."

POWER AND ENERGY SURVEY

Appliance	1 #	Column 2 Typical Watts	Column 3 Actual Watts (÷1000)=kw	Column 4 Time Used Hours/Day	Column 5 Days Used/Mo.	Column 6 Energy/Mo kWh (multiply columns 3x4x5)	Column 7 Cost/Mo.
Refrigerator/ freezer(14 cu. feet)		330					
Lg. Room A/C		1,200					
Med. Room A/C		900					
Sm. Room A/C		700					
Electric Range (in full use)		8,800					
Broiler		1,500					
Electric Dryer		4,000					
Washing Machine		500					
Dish Washer		1,200					
Toaster		1,000					
Iron		1,000					
Color TV		300					
B/W TV		150					
Stereo		100					
Lamps		100					
Clock		2					
Door Bell		0					
Radio		50					
Vacuum Cleaner		650					
Elec. Water Heater		2,500					
Window Fan		200					
Microwave Oven		1,500					
Frying Pan		1,200					
Blender		390					
Coffee Maker		890					

Totals: __________ __________

Actual Home Electric Bill __________

Electrical Energy Use Chart

Estimated Energy Consumed by Home Appliances in a Month

Food Preparation	Average wattage	Estimated kilowatt hours monthly
Blender	390	1
Broiler	1,440	8
Carving Knife	92	1
Coffee Maker	890	9
Deep Fryer	1,450	7
Dishwasher	1,200	30
Egg Cooker	520	1
Frying Pan	1,200	15
Hot Plate	1,260	8
Mixer	130	1
Oven, Microwave	1,500	25
Oven, Self-cleaning	4,800	95
Range	8,200	97
Roaster	1,340	17
Sandwich Grill	1,160	3
Toaster	1,150	3
Trash Compactor	400	4
Waffle Iron	1,120	2
Waste Disposer	450	3
Food Preservation		
Freezer (15 cu ft)	340	99
Freezer (Frostless 15 cu ft)	440	147
Refrigerator (10 cu ft)	240	60
Refrigerator (Frostless 12 cu ft)	320	110
Refrigerator/Freezer (14 cu ft)	330	94
(Frostless 14 cu ft)	620	152
Laundry		
Clothes Dryer	4,860	83
Iron	1,010	12
Washing Machine (automatic)	510	9
Washing Machine (non-automatic)	290	6
Water Heater (standard)	2,480	352
Water Heater (quick recovery)	4,470	401

Comfort Conditioning	Average wattage	Estimated kilowatt hours monthly
Air Cleaner	50	18
Air Conditioner (room)	1,570	114
Bed Covering	180	12
Dehumidifier	260	31
Fan (attic)	370	24
Fan (circulating)	88	4
Fan (rollaway)	170	12
Fan (window)	200	15
Heater (portable)	1,320	15
Heating Pad	65	10
Humidifier	180	14
Health & Grooming		
Germicidal Lamp	20	12
Hair Dryer	380	1
Heat Lamp (infrared)	250	1
Sun Lamp	280	1
Electric Shaver		
Home Entertainment		
Radio	71	7
Radio/Record Player	110	9
Television (b&w)	240	30
Television (color)	330	40
Housewares		
Light Bulb	100	15
Clock	2	1
Floor Polisher	310	1
Sewing Machine	75	1
Vacuum Cleaner	630	4

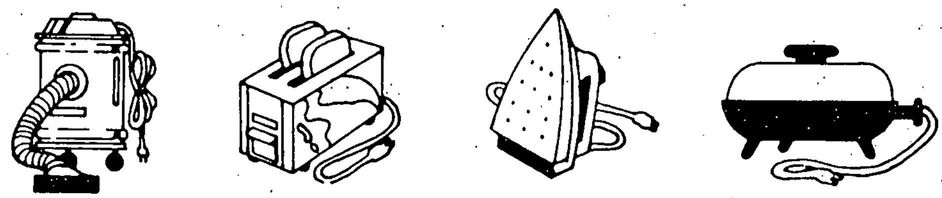
To calculate the number of KILOWATT HOURS (kWh) used per month multiply the wattage by the number of hours you expect to use the appliance in 1 month. This will be the number of watt hrs. Divide by 1000 to get kWh.

Electric Coffee Pot used 9 hours per month:

$$\frac{9 \text{ hrs/mo} \times 890 \text{ watts}}{1000} = 8.01 \text{ kWh/mo.} = 8 \text{ kWh/mo.}$$

YOU PAY YOUR MONEY AND YOU TAKE YOUR CHOICE

How much Energy Is Used by Household Appliances?



1. Which of the electrical appliances pictured above do you have in your home? ______________________________

2. Which do you consider necessary? ______________________

   Which could be replaced with something that doesn't use electricity?

   ____

3. In the table below, list the appliances that you now use in your home. In the column marked "this year," fill in the kWh that each of these appliances uses. Get the information from the chart on page 2. Ask your parents to look at the chart and tell you which appliances they had in their home 10 and 20 years ago. Put this informtion in the chart along with the number living in the home at each time period. Perhaps grandparents or some elderly people you know can help do the same for 30 and 40 years ago.

Appliance	kWh/mo This year	kWh/mo 10 years	kWh/mo 20 years	kWh/mo 30 years	kWh/mo 40 years
Total kWh/mo					
# living in home					
kWh/mo per person					

2. Now it's your turn!

Pick three items from list a-j and calculate the number of kWh of energy consumed by each per month. If you have a calculator, use it.

a. Air conditioner - 90 hours of use per month ____________

b. Refrigerator - 120 hours of use per month ____________

c. Washing machine - 8.5 hours of use per month ____________

d. Color TV - 150 hours of use per month ____________

e. Iron - 3 hours of use per month ____________

f. Toaster - 3.5 hours of use per month ____________

g. Clock - 720 hours of use per month ____________

h. Radio - 65 hours of use per month ____________

i. Clothes dryer - 30 hours of use per month ____________

j. Twelve 100-watt bulbs each in use 6 hours per month ____________

Now that you know how to calculate the kWh's used by appliances, you can get a rough estimate of what your own household's electrical energy bill will be by multiplying the number of kWh's your household appliances use times the average charge per kWh in your area. Fill out the chart in this this lesson to conduct a power and energy survey.

Directions for Survey

In the survey you are conducting to calculate the electrical energy used in your home, start by filling in column one, indicating whether you own one clock, two clocks, etc. Read the power requirements that are listed in watts on each appliance you have at home. You will find the information on the metal tag we told you about. You may have trouble finding the tag. If so, use the wattage from column 2 of the chart. Divide the wattage by 1000 to find the kilowatts used and put that number in column 3. In column 4, estimate the number of days per month the appliance is used. In column 6 calculate the energy used each month in kWh. When you total this column you will know the approximate number of kWh's you've used in a month and will be able to estimate your bill. In column 7, you will find the cost/month for each appliance by multiplying the kWh per month by the cost per kWh. Total these costs to estimate how much you pay a month to run these appliances.

POWER AND ENERGY SURVEY

Appliance	1 #	Column 2 Typical Watts	Column 3 Actual Watts (÷ 1000 = kw	Column 4 Time Used Hours/ Day	Column 5 Days Used/Mo	Column 6 Energy/ Mo, kWh Multiply Columns 3x4x5	Column 7 Cost/Mo
Refrigerator/ freezer(14 cu. feet)							
Lg. Room A/C							
Med. Room A/C							
Sm. Room A/C							
Electric Range (in full use)							
Broiler							
Electric Dryer							
Washing Machine							
Dish Washer							
Toaster							
Iron							
Color TV							
B/W TV							
Stereo							
Lamps							
Clock							
Door Bell							
Radio							
Vacuum Cleaner							
Elec. Water Heater							
Window Fan							
Microwave Oven							
Frying Pan							
Blender							
Coffee Maker							

Actual Home Electric Bill: ______________ Totals: __________ __________

YOU CAN'T ALWAYS GET WHAT YOU WANT

Demand Scheduling

Objectives

The student will be able to:

a) Describe the concept of demand scheduling.

b) State the need for demand scheduling.

c) Identify ways in which demand scheduling may be accomplished.

d) Modify his/her activities in an attempt to even out the demand for electricity.

Overview

The use of electric power in this country varies with time. It is inefficient and expensive to use large quantities at one time and small quantities at another. If our demand for electric power were constant (did not vary) we would not need as many power plants, and it would cost less, use less scarce fuel and pollute less.

Materials

Student **activity** sheet

Strategy

In order to give the student some idea of what demand scheduling is all about, use some analogies. First ask the question, "What would happen if all the students in the school wanted to use the lavatory at the same time?" It will be seen that some way must be found to spread their use over a longer period of time. In like manner discuss the natural gas shortage that occurred in the winter of 1976-77. Again it will be seen that large quantities of gas cannot be used by all users at the same time. In this case someone has to do without. In the summer of 1977, Glen Cove, New York had to close some of its wells due to contamination. Only half of its wells were usable. This necessitated restrictions being placed on the use of water. It was illegal to water lawns between the hours of 6 am and 9 pm. (Time of high use.)

Have the students discuss the possibility of this occurring with electricity.

Assume that it becomes necessary for some reason to set a limit on the amount of power that was used at a given time. Have students list what steps could be taken to meet everyone's needs and still not supercede the limit.

Notes to the Teacher

The students must see that demand scheduling exists in many areas of our society.

Sample Responses

1. Chaos would occur.
2. A natural gas emergency occurs.
3. Some industries were closed.
4. Yes.
5. Demand for water low, and the pumps could then be used to supply water for lawns.
6. Answers will vary.
7. Yes.
8. Delaying of activities until late in the night.
9. All activities would have to be scheduled to spread the load over the entire 24 hours in a day.

Extension Activities

Have students draw up a schedule for a hypothetical community for the use of all electrical energy.

Student Activity Sheet

Demand Scheduling

____
Name

____
Date

1. What would happen if every student in this school wanted to go the boys' room or girls' room at the same time? ____________________

2. What happened in the very cold winter of 1976-77 to the availability of natural gas? ____________________

3. What were the results of the above? ____________________

4. When many of the wells in Glen Cove were contaminated, was it proper for the Mayor to outlaw the watering of lawns at certain times of the day?

5. Why was the watering of lawns allowed at night and not in the day?

6. In what other ways could the water problem be solved? ____________________

7. Could the same situation develop with electricity? ____________________

8. If it does, what could be done to minimize difficulties? ____________________

9. Is there a way to schedule all electrical use so that a limited power supply could meet all the needs? ____________________

TIME IS OF THE ESSENCE

Student Survey of Time of Day Usage of Household Appliances

Objectives

Students should be able to:

a) Take survey of the time of day electrical appliances are being used in their home over a typical 24 hour period.

b) Use this information to make a graph of power demand vs. time of day for their own home.

c) Analyze their demand vs. time of day graphs for peaks and valleys of demand.

d) Compare their graphs with graphs of their classmates and discover similarities in the time of day "peaks" and "valleys" occur.

e) Compare their demand curve to the curve of an "average" residential consumer.

f) Infer that power demand on a community wide basis will be tremendous at certain peak hours of the day.

Overview

In our homes we use different amounts of electrical power at different times of the day. We turn the switch "on" of many appliances without ever thinking about the fact that our neighbors are probably doing exactly the same thing at exactly the same time. In this module, students will be made aware of the time of day that they use electrical power by taking a survey. This information will then be used to make a power demand vs. time of day curve. Finally, students will compare their graphs with those of classmates and realize that power is being used in large quantities in most homes at about the same time. This conclusion will help students understand the significance of the "Power Demand Curve of the Average Residential Consumer".

Materials

Student activity sheets

Overhead projector

Transparencies 1, 2, and 3 and pen

Strategy

Begin the lesson with a discussion of how little thought we give to turning the switches of electrical appliances "on." We hardly ever consider the fact, that at exactly the same moment, many of our neighbors may also be turning their switches "on." Just how do our electrical power needs vary with time? What time of day do you think your household needs the most electrical power? The least? Are your neighbor's power needs occurring at the same time as yours?

To accurately answer these questions we will have to study how electrical power is used in our homes on a typical day. First, look over Chart I and compare the appliances listed with the ones you use in your own home. If any are missing, add them under "others." If some on the list are not used in your home, cross them out.

Second, take a survey of the time of day each appliance is turned on and off in a typical 24 hour period in your home. Tonight, consult with the other members of your family about which appliances are in use during hours when you are away from home.

Now, enter this data on the chart in horizontal bars - starting and ending when the switches are turned on and off.

Do a few examples to illustrate on a transparency with the overhead projector. (Example; refrigerator - on all of 24 hours, iron - on from 8 am to 8:30 am, and from 7 pm to 8 pm.)

Appliance	Time of Day Appliance is Used
Refrigerator	
Iron	

mid night 1 2 3 4 5 6 7 8 9 10 11 noon 1 2 3 4 5 6 etc.

Students should complete as much of this chart as they can from their own "typical" (See teacher notes.) use of appliances. But it should be completed at home after consulting with other family members and also observing family activities.

Third, we will need the wattage requirement of each appliance in your home. Tonight, as you complete your survey, inspect each appliance to find its wattage. It should be stamped somewhere on the appliance. Enter this in the "Actual Wattage" column. (Example: Suppose for a refrigerator the wattage is 340 watts and for an iron, 1010 watts. Enter it on the chart (see previous diagram).

Second Day

Our chart shows us when appliances are turned on - but it does not readily show how much total power is being used at different times of the day. We call this used power - Power Demand - because consumers "demand" that it be available. We will now make a demand curve vs. time of day.

To make a power demand vs. time of day graph, sum the wattage of all appliances that are on at a given hour. (If you could not find the actual wattage of an appliance use the typical wattage given on the chart.) This is the total power demand in watts at that hour. Plot the hour on the x axis and the power in "watts" on the y axis. Illustrate the procedure by using the sample data sheet on the overhead projector.

Example (using sample data)

At 7am total wattage = 2500w (water heater) + 50w (radio) + 2w (clock) + 1200w (air cond.) + 330w (refrig)

= 4082w

Plot - 7am, 4082 watts

Students should complete their own graphs during class time and then answer the student activity questions by examining their own graphs and the graph of a classmate.

Sample Responses

1. a) Electrical power demand is greatest between 5pm and 8pm. (Responses will vary.)
   b) This is because everyone is home, dinner is being made, TV's are on, etc. (Responses will vary.)
2. a) Electrical power demand is smallest between midnight and 6am.
   b) This is because everyone is asleep and only the appliances that are on all the time are being used; e.g., refrigerator.
3. My classmate's curve is very similar to mine - it "peaks" at about the same time of day.
4. On a hot day, with more air conditioners going points would be higher on the graph. So, the peak demand would be even greater than it is now.

Fourth, after students have completed their curves and answered the questions, a class-wide comparison of data should be made. Take a quick class survey of a) times when curve was highest and b) times when curve was lowest. Be sure students realize that class-wide results are very similar for "peaks" and "valleys" of power demand.

Fifth, show the "average" demand curve for consumers for a winter and a summer day. Point out that this was compiled by a utility company by averaging the demand of many customers. (Use overhead.) Discuss differences between the graph and the student's own graphs. Have them suggest possible explanations for the differences.

Finally, discuss the implications of so many people in a community needing their peak power at about the same time of day. Will the utility company have trouble supplying such a large surge of power?

Tomorrow we investigate time of day power requirements from the utilities' point of view.

Notes to the Teacher

1. There are many appliances that are not used on a regular basis; i.e., an electric carving knife may be used only once every 2 or 3 weeks. Such appliances should be safely omitted from the survey. However, if an appliance is used 3 times a week or more, it should be included as used on a "typical" day.
2. In filling out the appliance list, be sure students list each appliance of a given type. For example, if 3 TV's are in the home, they should each be listed.
3. For certain classes, where gathering data at home might be a problem, the teacher can work with classes as a group to get "average" times of day that appliances are used. Then all students in the class can use this time data and the typical watts are given in the chart to draw the demand curve.
4. In plotting the power demand curve, students needn't be restricted to plotting points only on the hours. Intermediate points can be plotted by more ambitious students.

Extension Activities

In class, the power demand curves of residential consumers were discussed. Commercial consumers (businesses, factories, shops) have a slightly different "average" demand curve. Have students gather information from a working parent or friend about the time of day that electrical power is used at work. Make a chart of appliances at work and the time in use. Then convert this data to a power demand vs. time of day curve. Compare this commercial power demand curve to the residential demand curve made in class. The peak should be significantly earlier in the commercial curve.

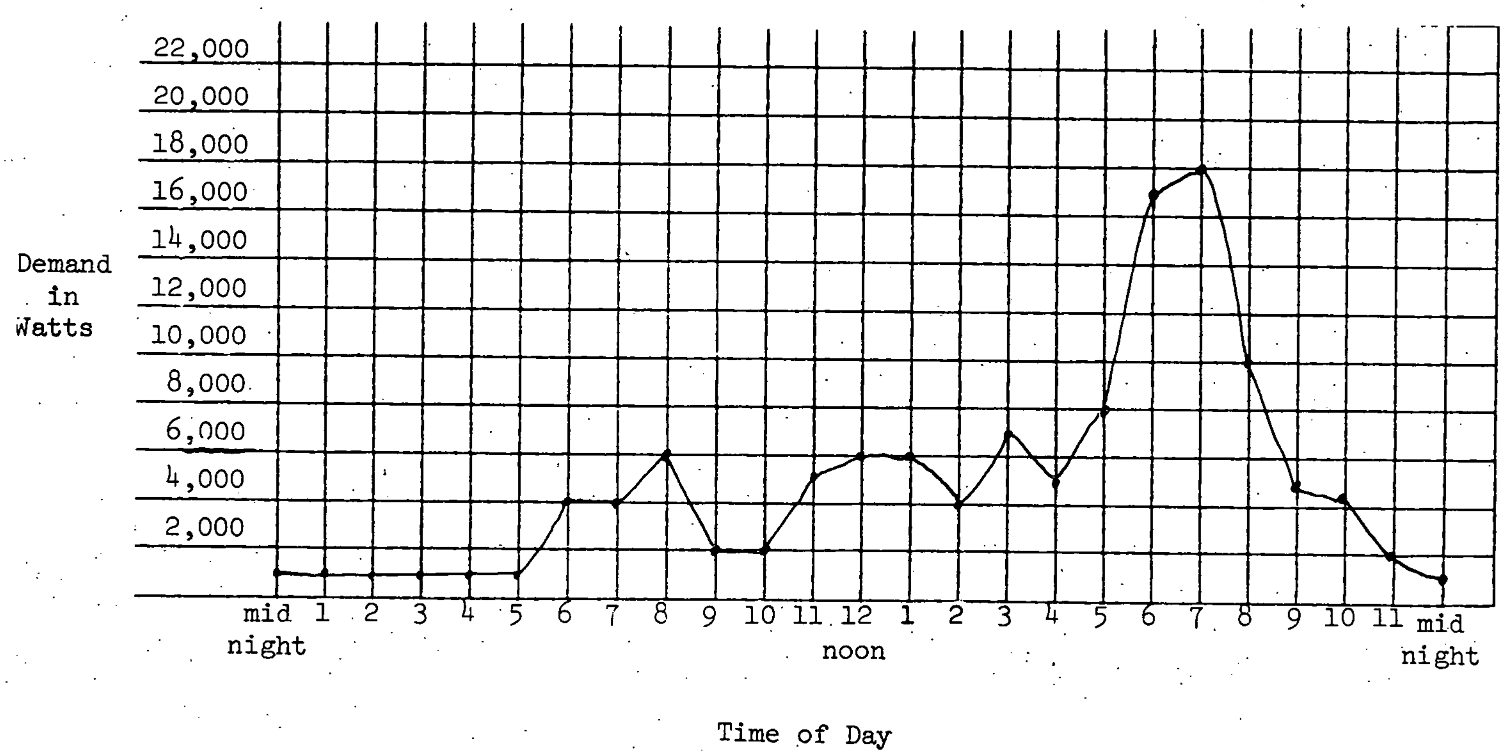
SAMPLE RESPONSE

Appliance	Time of Day Appliance is Used	Actual Watts	Typical Watts
Refrigerator			330
Air conditioner			1200
Electric range			8800
Broiler			1500
Clothes dryer			4000
Washing machine			500
Dish washer			1200
Toaster			1000
Iron			1000
Color TV			300
B/W TV			150
Stereo			100
Lamp			100
Clock			2
Radio			50
Vacuum cleaner			650
Water heater			2500
Window fan			200
Microwave oven			1500
Frying pan			1200
Blender			390
Coffee maker			890
Other: lamp			100
lamp			100

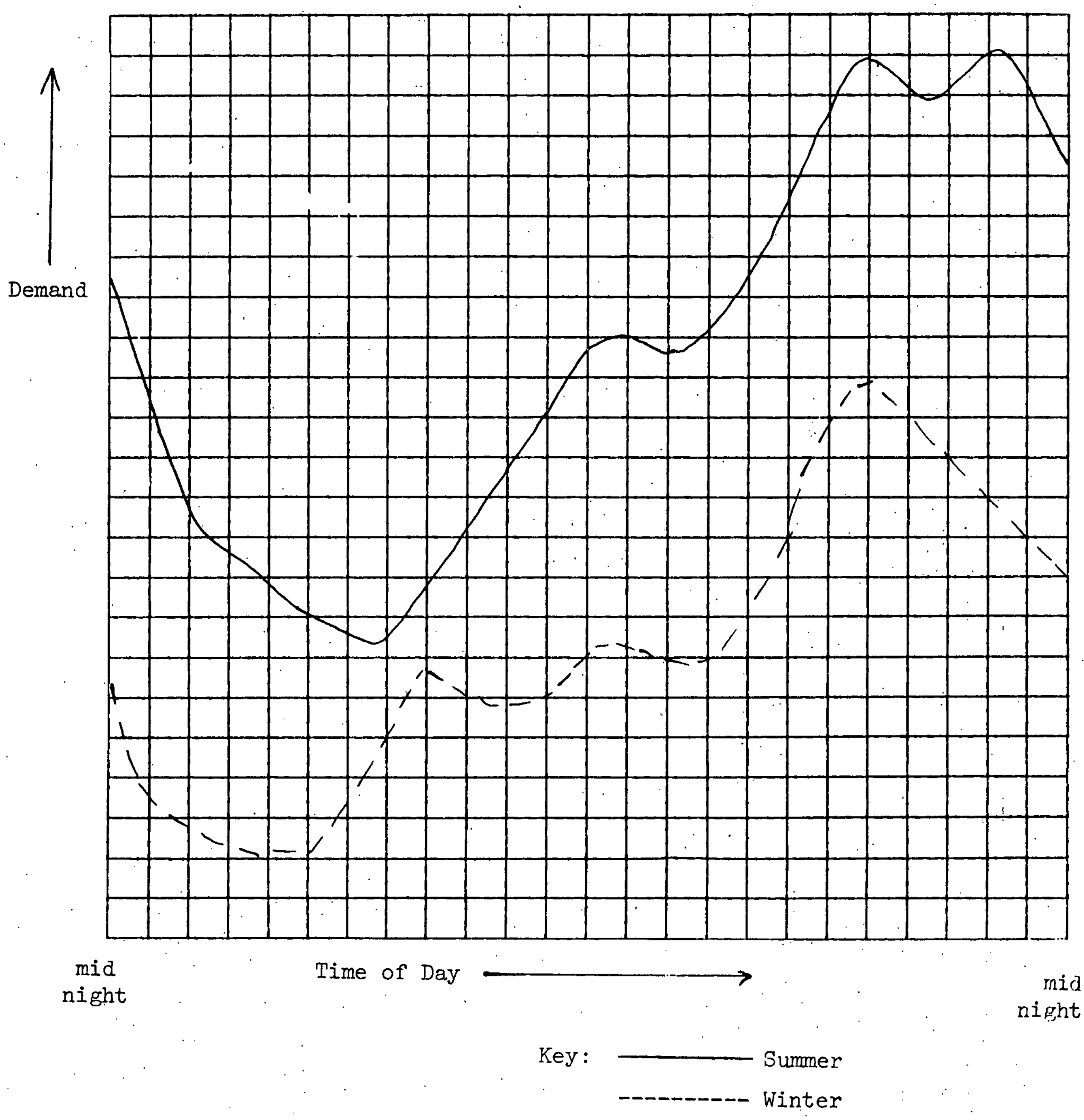
Midnight 2 3 4 5 6 7 8 9 10 11noon 1 2 3 4 5 6 7 8 9 10 11

SAMPLE RESPONSE

Electrical Power Demand and Time of Day



Electrical Power Demand of an Average Residential Consumer



Student Activity Sheet

Appliance	Time of Day Appliance is Used	Actual Watts	Typical Watts
Refrigerator			330
Air conditioner			1200
Electric range			8800
Broiler			1500
Clothes dryer			4000
Washing machine			500
Dish washer			1200
Toaster			1000
Iron			1000
Color TV			300
B/W TV			150
Stereo			100
Lamp			100
Clock			2
Radio			50
Vacuum cleaner			650
Water heater			2500
Window fan			200
Microwave oven			1500
Frying pan			1200
Blender			390
Coffee maker			890
Other: lamp			100
lamp			100

mid night 1 2 3 4 5 6 7 8 9 10 11 12 noon 1 2 3 4 5 6 7 8 9 10 11

Student Activity Sheet

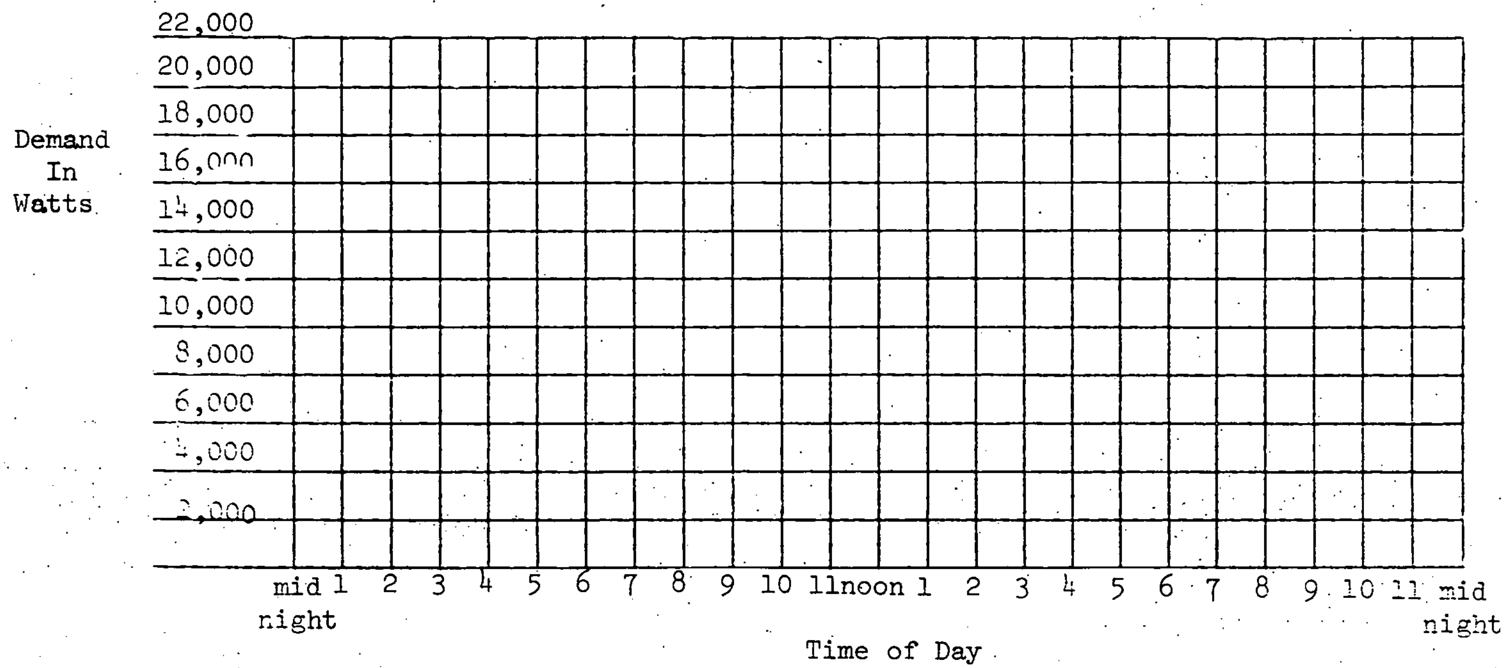
Name ______________________

Date ______________________

Calculations for the Total Power Demanded At Each Hour of the Day

Hour	Wattage of Each Appliance That is "On"	Total Power In Watts
12 midnight		
1 am		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12 noon		
1 pm		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Your Electrical Power Demand and Time of Day



THERE'S A TIME AND A PLACE

Rescheduling Activities in the Home to Even Out Electrical Demands

Objectives

The student should be able to:

a) Interpret a line graph.

b) Reschedule home use of electrical appliances so as to level the energy demand.

Overview

"You all can't have it at the same time". Point out the power failures in New York City in 1965 and 1977. Peak power is expensive power generated from gas turbines.

Materials

Student activity sheets

Graph of "Residential Customer Summer Peak Day Load Shapes"

Graph of "Load on System Peak Day"

Electric Energy Use Chart

Strategy

Explain that graphs 1 and 2 measure power in kilowatts (10^3) or megawatts (10^6) on the vertical axis against time of the day on horizontal axis. Students should see that peaks and valleys occur at about the same time of day. Relate these peaks to "brownouts" and other disadvantages. (expensive gas turbine power). Peaks represent overload, valleys under utilized capacity.

Students should realize that both these disadvantages could ideally be solved by a continuous level demand. Have the students develop the idea of chopping the peaks off to fill in the valleys. The need to reschedule the home use of electrical appliances should now be understood. Students may now refer to Chart 3 and list electrical appliances which might be turned off during peak hours of 4pm and 9pm. List the wattage of each such appliance and the feasibility of turning it off. Discuss the pros and cons of each decision from the individual as well as from the utilities point of view.

Sample Response

Students will usually agree that most people can delay use of dishwashers, washers, dryers, without undue inconvenience. Turning off electric clocks, doorbells, etc., contribute insignificantly to the problem. On the hottest day people will resent not being able to use their air conditioners and/or fans. However, air conditioners could have their thermostats raised 5° or more and thus reduce the demand. Homemakers could avoid using electric stoves and serve cold meals. Suggestions as to turning off the hot water during this period receive mixed reactions. Turning off TV's to conserve electricity will not be too well received.

Notes to Teachers

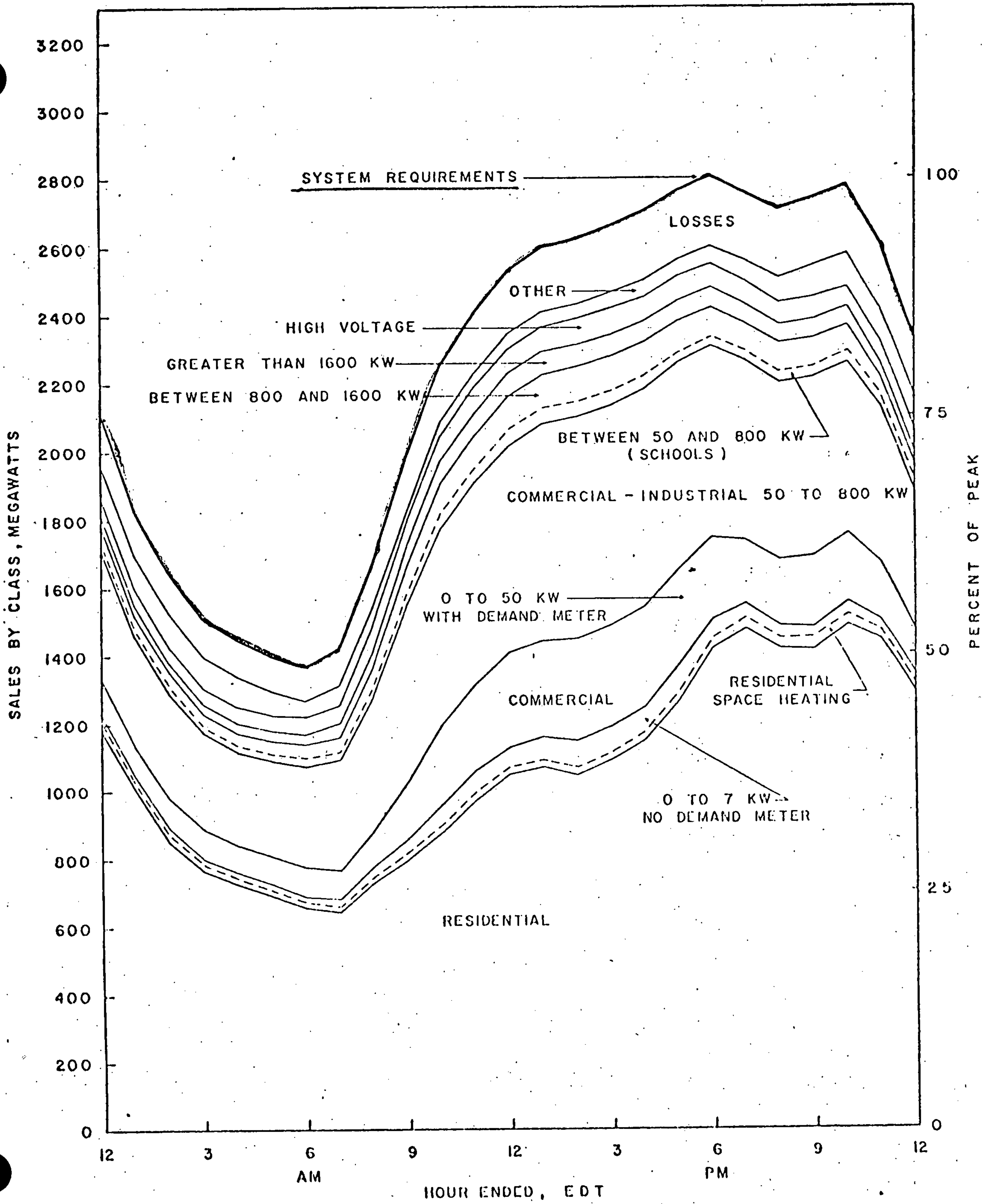
Encourage students to see for themselves the significance of the peaks and valleys on the power vs. time graphs. It should be noted that power companies, their commercial and industrial customers can do much more to level the power demand curve.

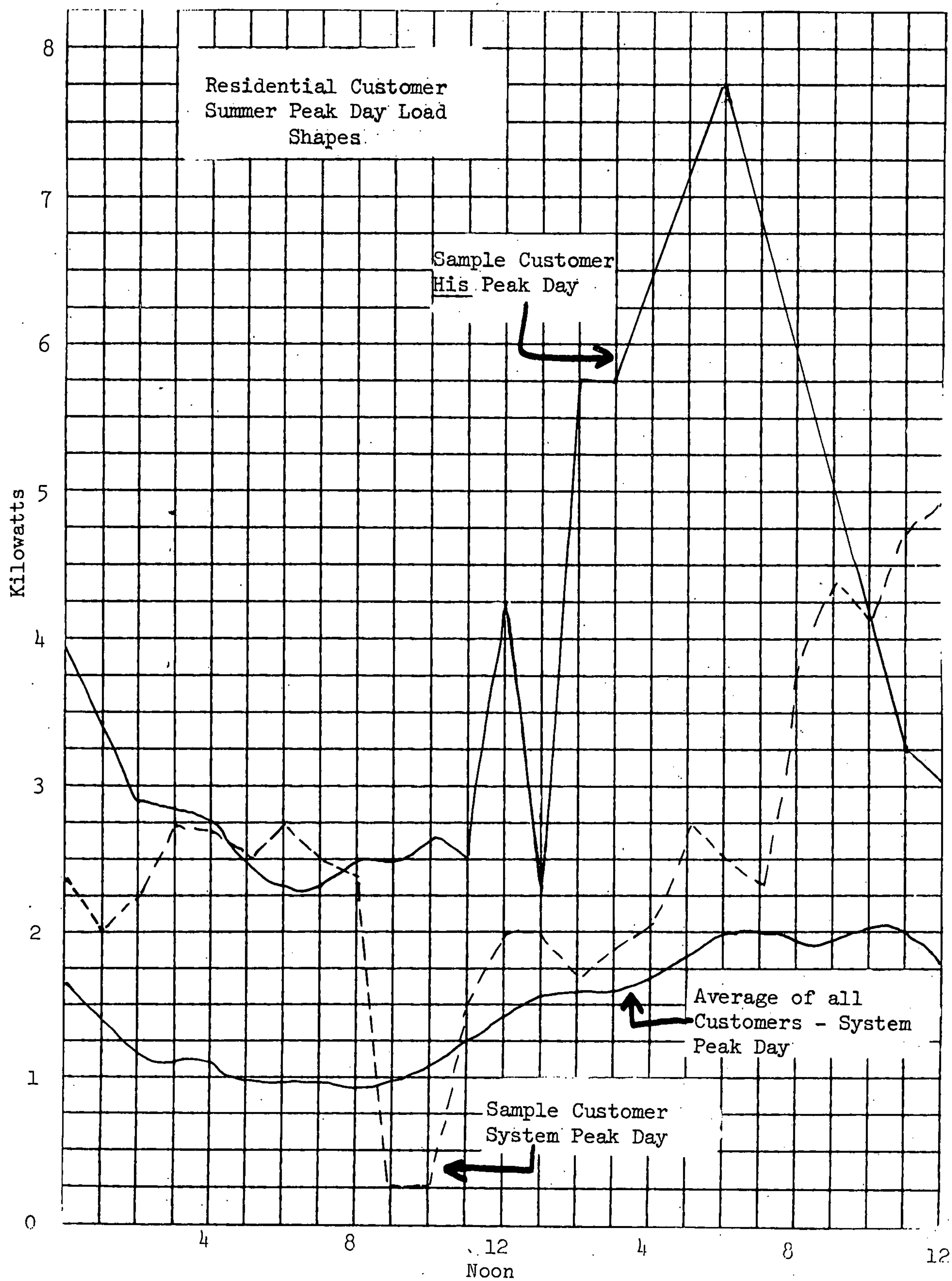
Note: Chart I "Power & Energy Survey" is reprinted from NC^3 Development Booklet "Electrical Energy Use in the Home". Graphs 1 and 2 are taken from a LILCO Load Management Report.

COMPONENT LOADS OF SYSTEM PEAK DAY

SUMMER

MONDAY, JULY 9, 1974

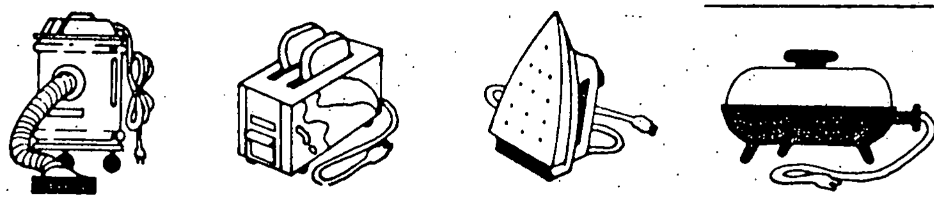



Residential Customer
Summer Peak Day Load
Shapes
Sample Customer
His Peak Day
Average of all
Customers - System
Peak Day
Sample Customer
System Peak Day
Kilowatts
8
7
6
5
4
3
2
1
0
4
8
12
Noon
4
8
12

Student Activity Sheet

Name ______________________

Date ______________________



1. Do you need to use all of the above appliances at the same time?

____

____

Your class has discussed peak demands for electricity. Make a list of all the electrical appliances in your home that you could use at an "off" peak period. List the wattage of each. Wattages are marked on the appliances. Look carefully for them.

Off Peak Appliances

Appliance	Wattage
	Total wattage used at off peak periods.

You will now discuss your choices with others in your class.

BOO-A-PEAK, IT'S BACKWARDS!

What Can Utilities Do To Reduce Load Peaks?

Objectives

The student should be able to:

a) Discuss how utility companies can induce use of electricity at off peak hours.

b) List alternate methods of electrical generation.

Overview

Con Ed "Push" Could Button the Cool

Call it a might-have-been scenario for Con Ed during a summar scorcher.

The temperature and humidity are clawing at the city. Eggs frying on the sidewalk; people broiling in the subway - all that steamy stuff. And over in the Con Edison's air-cooled control center somebody decides that several million air-conditioners are gobbling so much juice that we might have a brownout.

No problem. Con Ed power control pushes a big red button and whammo, by radio control air-conditioners all over the city clung to a stop.

Reports Brisk Sales

Con Ed says it tried a small pilot program with such a system in the summers of 1975 and 1976, and didn't like it. But more than two dozen power companies across the country feel differently.

Motorola, which manufactures the so-called radio-controlled load management system, says that utilities are buying them as fast as a barefoot boy runs on hot asphalt.

The system comprises a small FM radio transmitter and any number of little black boxes that can shut off central air-conditioners or electric water-heaters with a push of the transmitter button.

Power companies give their customers a $4 or $5 a month discount on their electric bill when they volunteer to have a black box installed. The utility then usually agrees to use the button no more than 10 or 15 minutes an hour for no more than five consecutive hours.

"One North Carolina utility made a mistake and left some water heaters off for six hours," Motorola's marketing vice president, Wally Miller said, "and they sure heard about it from their customers."

Motorola says that short interruptions in air-conditioning or water-heating "cause no discomfort to the customers." But Miller admits that some utilities have got no further than a test program because "people just don't like their air-conditioners turned off."

There were no reports of utilities using the radio controls to persuade deadbeats that they had better pay their bills.

Con-Ed says its pilot program was suspended "because the cost-benefit ratio was no good." But Motorola says there are still a hundred or so of those little black boxes lying around in some Con Ed warehouse.

Maybe, waiting for another sweltering week of power crises?

Materials

Chart "Current Residential Electric Rates", Lilco
Electric Company bill from teacher and student's home
Chart "Time of Use Residential Electric Rate", Lilco
Chart "Current Commercial Electric Rate Without and With Demand Meter"

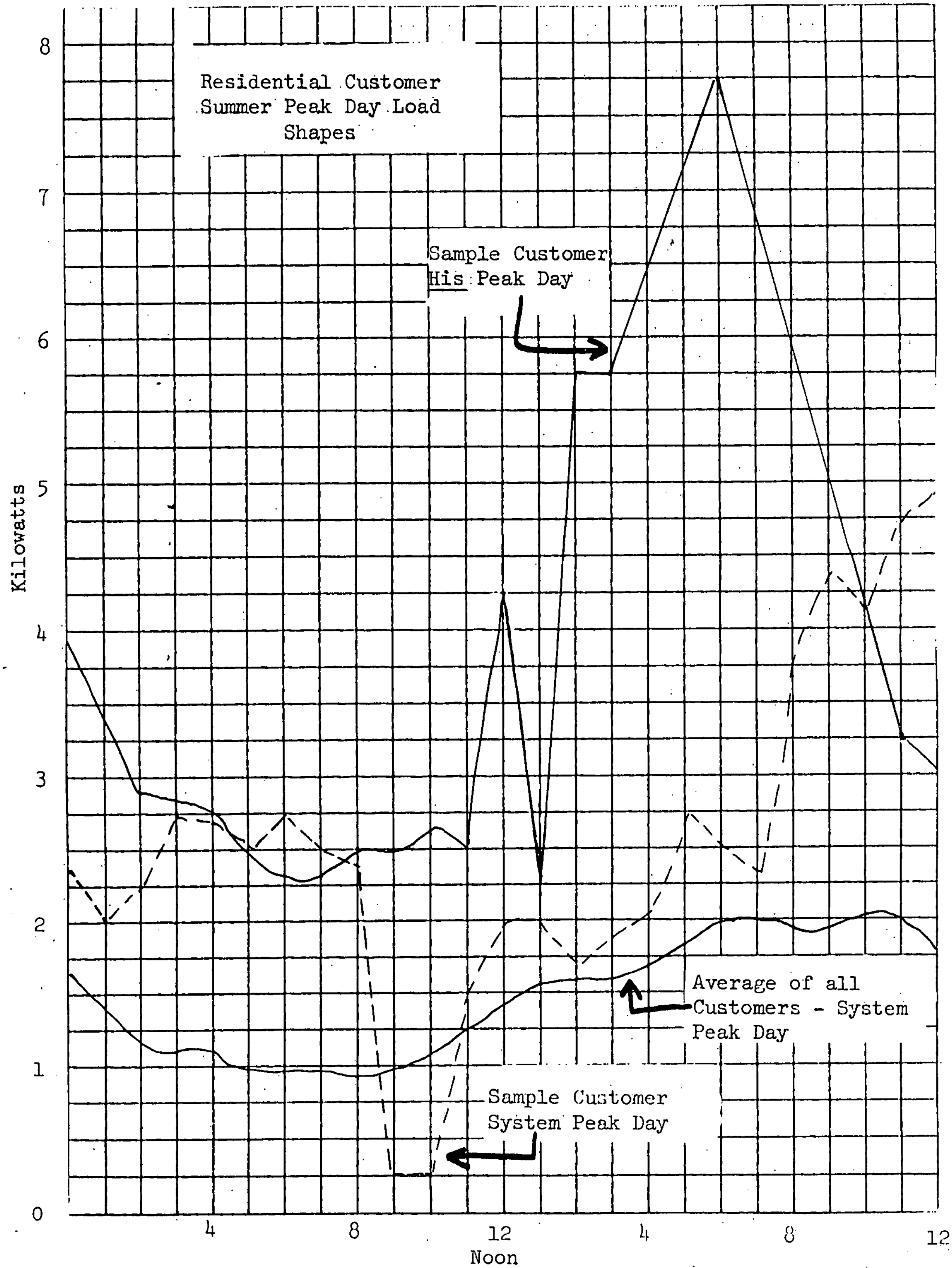
Strategy

Day 1. After a brief lecture on rate schedules, the class will compute their individual electric bill. Sample bills can be computed on the blackboard using standard residential rates. A second class group can compute bills using the same amount of kilowatt hours but with the demand schedule "Off peak hours rate". Compare the bills and discuss benefits to consumers and benefits to the electric company.

Day 2. Today lecture on the benefits of "pump storage" to the electric company and indirectly to the students' family bills. The prime objective is to make students aware of off peak hours as they apply to the electric company and the electric consumer. A film on the Co Ed Storm King Mountain Project may be obtained and shown.

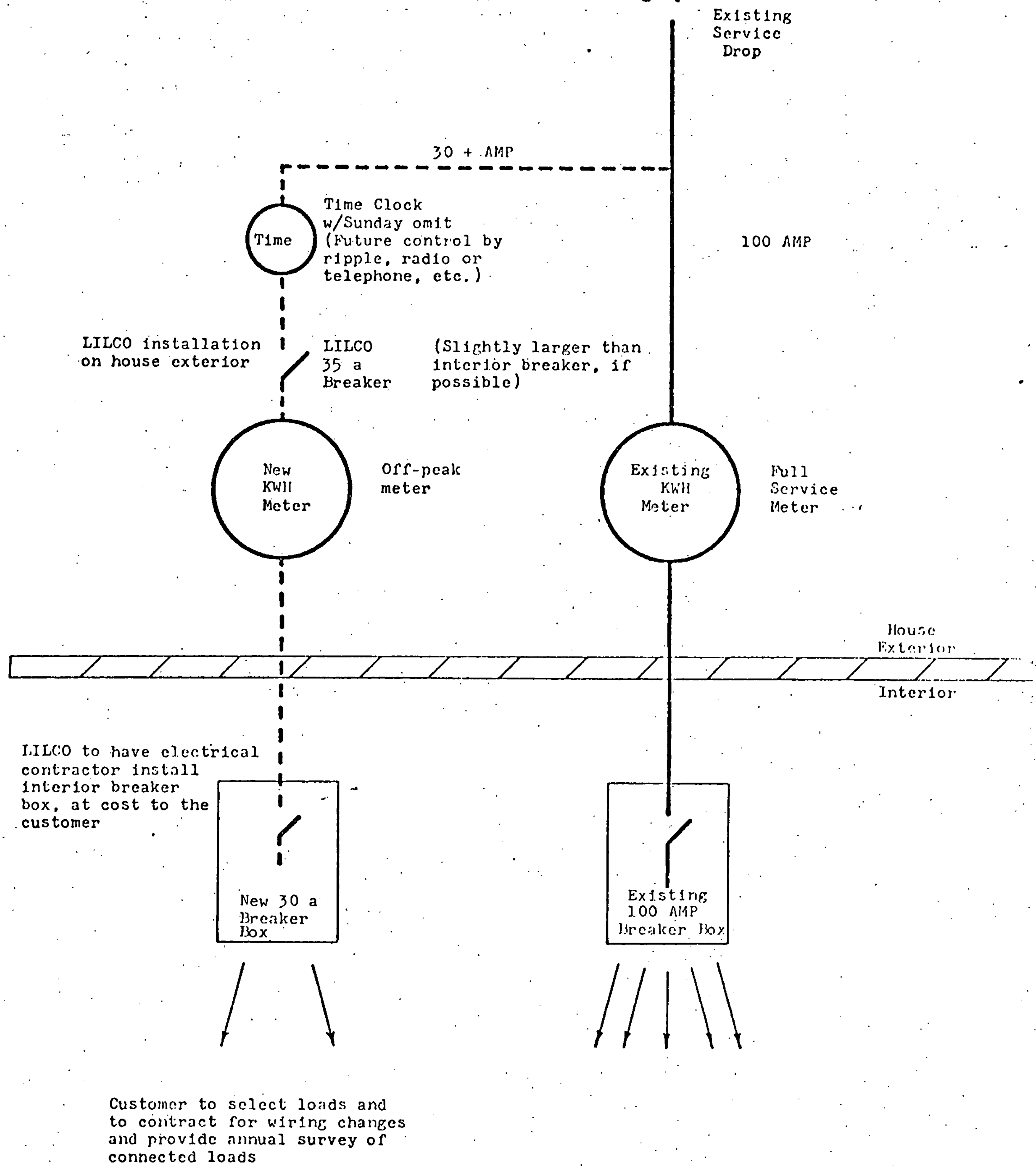
Other Readings

Report 149-B For Member Firms N.Y.S. Power Pool". See of PSC, Mr. Madison.



Residential Customer Summer Peak Day Load Shapes
Sample Customer His Peak Day
Average of all Customers - System Peak Day
Sample Customer System Peak Day
Kilowatts
0
1
2
3
4
5
6
7
8
4
8
12
Noon
4
8
12

Possible Residential Off-Peak Metering System



CURRENT COMMERCIAL ELECTRIC RATE

(Excluding Fuel Charge)

Primary Service

Monthly With Demand Meter

Demand Charge KW	July, 1977 Rate
0 to 50	$3.57/KW
Above 50	3.42/KW

85% ratchet applies based on summer demand

Energy Charge	
0 to 6,000	3.46¢/KWH
6,001 to 30,000	3.07¢/KWH
30,001 to 36,000*	2.61¢/KWH
Above 36,000	2.33¢/KWH

Minimum Charge of $13.80

*36,000 KWH level varies depending on demand

COMMERCIAL TIME OF USE ELECTRIC RATE

(Excluding Fuel Charge)

Primary Service

Monthly

	Midnight to 7:00 am All Months	10:00 am to 10:00 pm June to September Except Sundays	All Other Hours
Demand Charge	None	$5.60/KW	$1.40/KW
Energy Charge	1.71¢/KWH	3.18¢/KWH	2.61¢/KWH

July, 1977

BEAT THE PEAK!

What Can Be Done in Industry to Reduce Peak Usage?

Objectives

The student should be able to:

a) Describe the need for industry to reduce peak usage.

b) Realize the amount of energy industry uses during peak hours.

c) Discuss ways in which industry can use energy in off-peak hours.

Overview

Industrial use, as well as the national use, of electricity is rising at a rapid rate. In searching for optimum distribution of electrical use, the industries of our country must seek to equalize use during off-peak hours and peak hours. There are ways in which industry can reschedule electrical use without effecting production.

Materials

Student activity sheet

Film

Strategy

Lecture and Class Discussion:

In introducing the activity, discuss the importance of industries to the community and the country. But also ask if there are any ways in which industry can be of service to the area during our present energy crisis. Discuss here the fact that electrical use is limited during certain hours and that this may soon have an effect on each person's life style. For example, not being able to go home and watch TV and use other appliances.

Discuss what the hours of peak usage are and show by the graph what the curves for usage are during a 24 hour day.

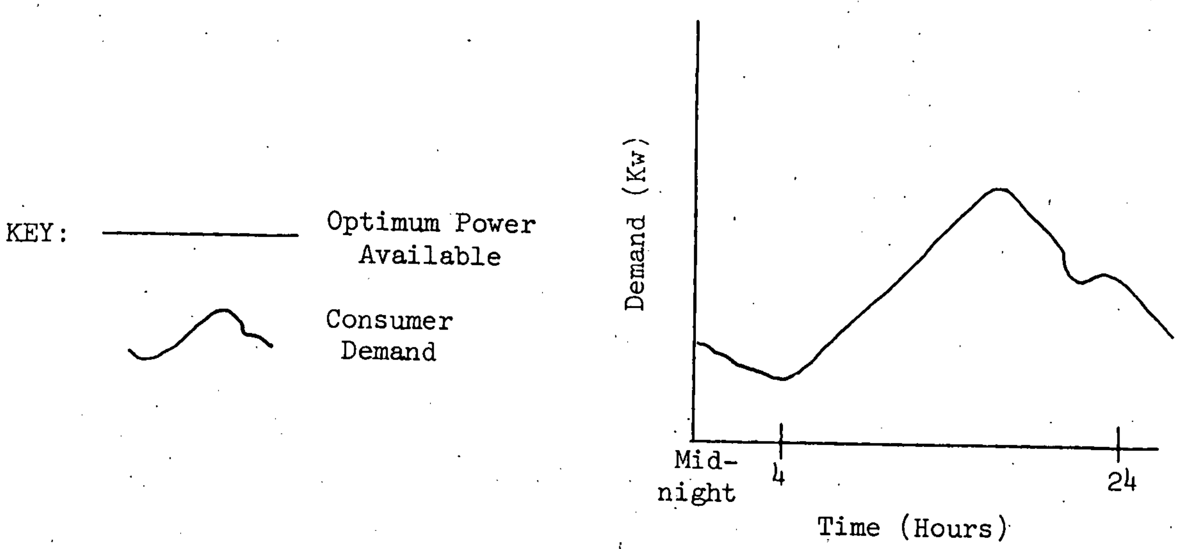
Explain what may happen if industry and the residential community turned all electrical power on at the same time. The students should now see that industry can help by maybe utilizing a schedule that will enable the plants to run during off-peak hours.

Another idea may be the rescheduling of the entire work day. Is this feasible or not? Leave room for discussion. Questions may arise as to what may happen to the family routine if mom or dad were to change their work schedules. Can industry handle the wage scales of night work?

Other aspects to discuss can be the idea of lights being left on in commercial buildings all night, air conditioning left on all night, etc.

Sample Responses

1. Yes - to even out the peak curve and use energy in a more uniform manner.
2. Brownouts and blackouts could occur.
3. Change in working hours. Companies could start workers earlier in the morning and dismiss them at 2:00 or 3:00 pm.
4. Answers will vary - example: new meal times, change in TV program times, etc.
5. Yes - both can attempt to use energy at "off" peak periods.
6. Ideally industry could use energy between 10 pm and 10am. This is not practical, though.
7. Answers will vary, but salaries for night work might be higher.
8. Yes - everyone must save energy.
9. Yes - everyone must learn to save energy.
10. Answers will vary. Turn off all energy users when not in operation (lights, air conditioning, etc.). Send people home early on hot days.



Student Activity Sheet

Name ______________________

Date ______________________

1. Is there a need for industry to reduce electrical usage during peak hours? ______________ Why? ______________________________

____

2. What would happen if industry and the residential community all turned on their electrical power during peak usage? ______________________

____

3. What can industry do to stop usage during peak hours? ______________

____

4. Can any of these changes have an effect on the family routine? ________

____

____

5. Is there an optimum way to schedule electrical use between industry and the residential community? ______________________________________

____

6. If so, what would that "optimum" schedule look like? ________________

____

____

7. How might this schedule effect the industry financially? _____________

____

8. Does industry have an obligation to conserve during peak usage? ______

______________________________ Why? ____________________________

____

9. Do you have an obligation to conserve during peak usage? _____________

Why? ____

____

10. Other than rescheduling major power usage for off peak hours, list some other ways industry, or commercial buildings can conserve the use of energy. ____

____

____

THE MEEK SHALL INHERIT THE PEAK

What Can Government Do To Reduce Load Peaks

Objectives

The student should be able to:

a) Describe how governments can induce people to use electric energy at "off" peak periods.

Overview

This activity is to introduce students to ways in which government - local, state and federal - can help induce use of electric current at off peak periods during day and night.

Materials

Chart, "Current Residential Electric Rate"

Chart, "Time of Use Residential Electric Rate"

Chart, "Current Commercial Electric Rate With or Without Demand Meter"

Chart, "Metering Installation Costs"

Chart, " Possible Residential Off Peak Metering"

Strategy

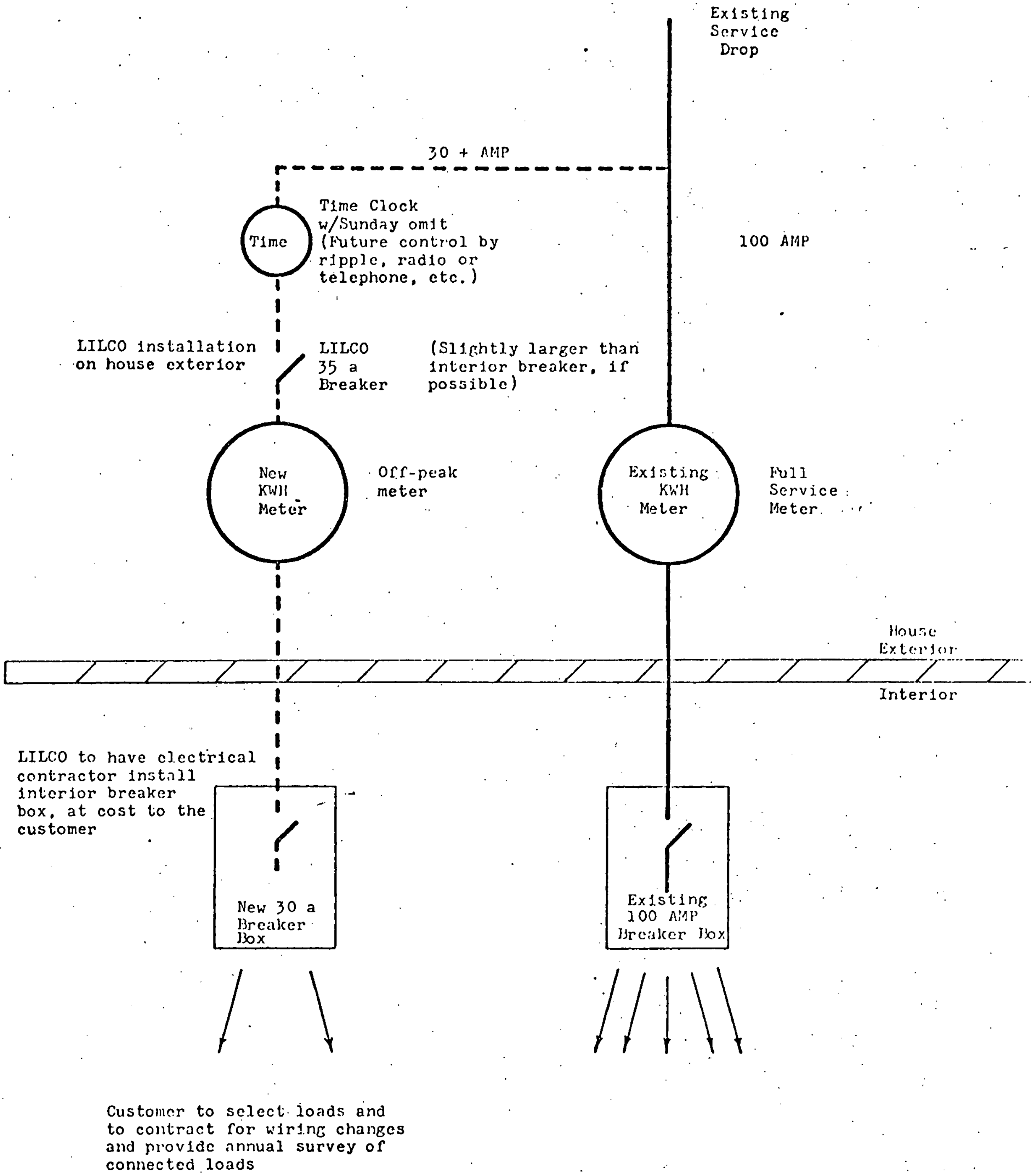
Day 1. Lecture and Discussion. Local, state and federal tax incentives - to be offered to customers and electric company to help induce off peak use and curtail peak electric demand.

Day 2. Lecture and Discussion. Federal loans and grants to defray the cost of new demand meters to residential customers.

Meter Installation Costs

Conventional	
Residential	$ 22
Small Commercial	22 - 50
Large Commercial	80 - 150
Time-of-Use	
Residential	$ 250 - 400
Small Commercial	400 - 1000
Large Commercial	1000

Possible Residential Off-Peak Metering System



COMMERCIAL TIME OF USE ELECTRIC RATE

(Excluding Fuel Charge)

Primary Service

Monthly

	Midnight To 7:00 am All Months	10:00 am to 10:00 pm June to September Except Sundays	July, 1977 All Other Hours
Demand Charge	None	$5.60/KW	$1.40/KW
Energy Charge	1.71¢/KWH	3.18¢/KWH	2.61¢/KWH

CURRENT RESIDENTIAL ELECTRIC RATE

(Excluding Fuel Charge)

Monthly

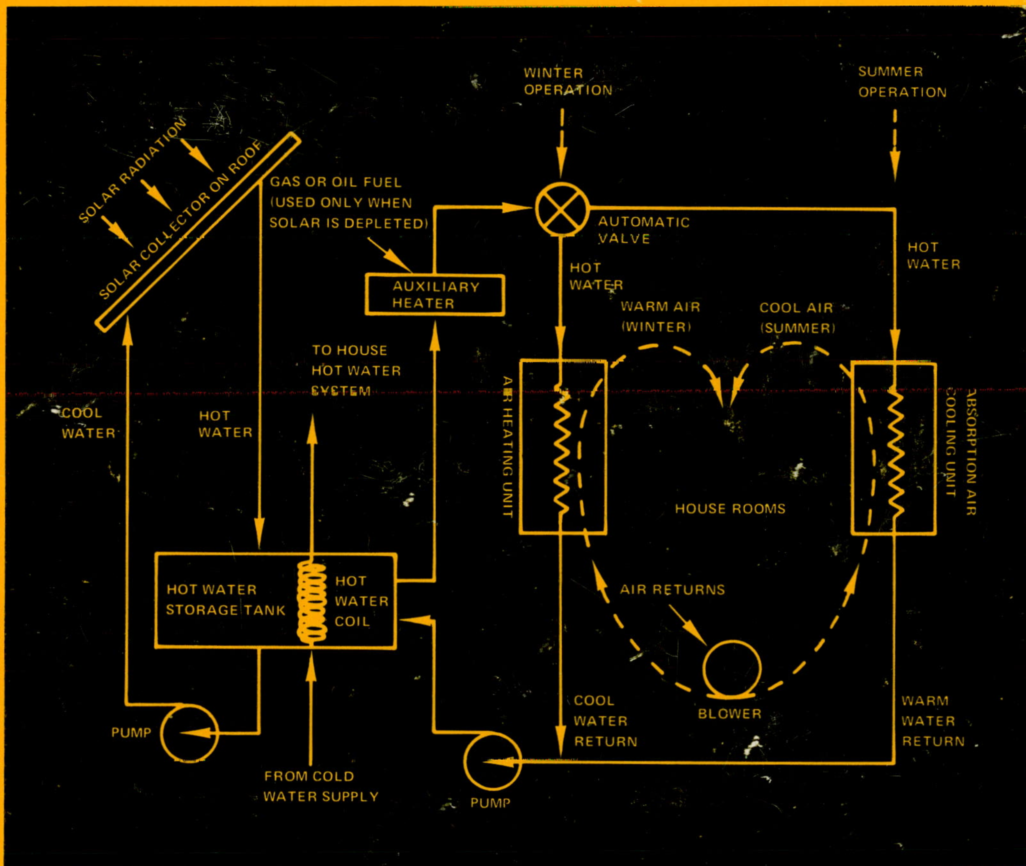
KWH	Summer	Winter
0 to 12	$2.40	$2.40
13 to 90	5.50¢/KWH	5.50¢/KWH
*91 to 600	4.99¢/KWH	4.38¢/KWH
*Above 600	4.99¢/KWH	4.05¢/KWH
*Alternate for water and space heat:		
400 to 850 water	2.93¢/KWH	2.93¢/KWH
Above 850 space	4.99¢/KWH	2.85¢/KWH

July, 1977

ENERGY: OPTIONS FOR THE FUTURE

CURRICULUM DEVELOPMENT FOR THE HIGH SCHOOL

Environment



Institute for Energy Research
and
W. Averell Harriman College for Urban & Policy Sciences
State University of New York at Stony Brook
Stony Brook, New York 11794

T. Owen Carroll, *Project Director*
Robert Lewis, *Associate Project Director*
Herbert Berger, *Assistant Project Director*

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the Office of University Programs
Energy Research and Development Authority
Washington, D. C.

ENERGY AND THE ENVIRONMENT

Members: Henry Harvey
Ruth Miner
James Stark

I. Background

II. Student Activities

ACKNOWLEDGEMENTS

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INTRODUCTION

Recent state and regional energy crises demonstrate the delicate balance between the energy system, the environment, and the economy. Indeed, interaction among these three elements in our society is very complex. However, any permanent change in the directions of our energy demand and supply for the future involves the formation of a new "energy ethic". To do so requires a broad base of information and understanding of the energy system, and this needs to be developed, particularly among those still in school. You, the teacher, play a most important role in providing that base of information which will become part of the new generation's thinking about the energy system. These materials are intended to enhance your ability to provide energy-related education to students within your own academic setting and to provide students with a better understanding and awareness of fundamental principles of energy supply, conversion processes and utilization now and in the future.

Since it is not possible to cover all aspects of energy systems, the curriculum materials designed in this project were limited to a number of areas considered important from two points of view: energy developments which are now occurring but whose implications are not yet clearly recognized and/or that broad area of potential new developments which have important implications for the future. The specific areas of curriculum materaials are the following -

CONSERVATION. We are coming to realize, albeit slowly, that the supply of raw materials from which energy is produced is finite and decreasing rapidly. Not only is supply decreasing, but demand continues to grow. The most optimistic forecasts show that the world resources of petroleum and natural gas, the two main sources of energy today, will be gone within the next fifty years. Consequently, we need to explore ways to conserve energy by using fewer energy-intensive devices, reducing our life style to one less dependent on energy, and possibilities for substituting new technologies.

DEMAND SCHEDULING. Electricity, since its first introduction, has provided a cheap, clean, efficient source of energy. We have also come to expect that any required demand for electricity on our part as individual consumers, will be met. We turn on the switch and expect the lights to come on. Large investments in the electricity generating plant are required to satisfy increasing demand, particularly during "peak" periods. Consequently, the overall cost of electricity generation becomes quite expensive - a result we have seen in recent years. The issue is particularly important since utility companies are now testing, and will soon offer to the consumer, electric metering for homes on a demand-scheduled basis.

ENERGY IN THE FOOD SYSTEM. Our agricultural system has become increasingly dependent upon the use of energy-intensive fertilizers for large crop production. In addition, energy requirements for food processing continue to grow. It is estimated that about one half of U.S. freight transportation is involved in the movement of foods of one kind or another. With the decline in the supply of fuels, we must ask whether our current national pattern of energy consumption in the food industries, particularly the trend toward increasing use of energy in food processing and packaging, are desirable trends for the future.

NEW TECHNOLOGIES (Solar, Wind, Biomass). It can be argued that the problem in our energy system today is not that we use too much energy, but rather that we use the wrong kinds of energy. Oil and natural gas form important components for synthetic materials, chemicals, and the like. Wherever possible, they should be conserved for such long-term uses. Consequently, we should shift from a fossil fuel resource base to a renewable energy resource base, particularly the use of solar, wind, and biomass sources.

ENVIRONMENT. The direct use of energy involves various pollutant emissions. In addition, indirect use of energy in the creation of industrial goods has secondary environmental impacts in a number of areas. Of recent concern are long term trends in accumulation of carbon dioxide and other gases and particulate matter in the atmosphere. These seem to produce unfavorable atmospheric conditions involving "the greenhouse effect", thermal inversions, and the like.

The modules prepared in each of these areas consist of an introductory background statement and a series of one-day lesson plans, along with suggested bibliography and references to other materials. The background statements are intended to introduce the topic to you, the teacher, and should reduce your need for reading a number of original papers and other citations to the literature. However, the background statements are sufficiently short that they can not make you an energy expert, and we would hope that you pursue additional reading on your own. Single day lesson plans were designed for easy use within existing courses as well as in the construction of new courses. As a result, it is hoped these curriculum materials will be useful in a variety of courses.

A special note to you, the user of these curriculum materials, is in order. The materials are made available in draft copy because of widespread interest in energy issues. Where you encounter rough spots, loss of proper citations to the literature, or other problems, bear with us. A brief evaluation form is included in this document. We encourage you to give us your reactions and any improvements we might add to make these materials more useful to you and to other teachers. The names and school affiliation of the project participants are noted in the material so you can feel free to contact the individual teachers on specific questions. Finally, these documents reflect a concentrated effort over three weeks by the teachers associated with the curriculum development project, and their efforts to translate energy issues into high school course material for you.

LIST OF PARTICIPANTS

- William Baran, Chrmn/Science Dept.,Niagara Wheatfld Central School District, 2292 Saunders Ave,Settlement Rd.,Sanborn, NY 14132
- Anthony Barchuk, Westbury Public Schools, Westbury, NY 11590
- Barbara Brookmeyer, Francis Lewis High School,58-20 Utopia Prkwy,Flushing,NY 11365
- Malcolm Cooper, 69-07 223 St.,Bayside, NY 11364
- Everett Carr, Herkimer County B.O.C.E.S., Herkimer, NY 11350
- Vincent Corsall, 257 Caldwell Ave., Elmira, NY 14904
- Carole Escobar, Islip Jr. High School, Main St., Islip, NY 11751
- Sr. Jane Fritz, St.Patrick's School, 284 E.Main St., Smithtown, NY 11787
- Edward Greenwood, Forest Hills High School, Forest Hills, NY 11375
- Raymond Hahn, Massepequa High School, 4925 Merrick Rd.,Massepequa, NY 11758
- Henry Harvey, Schroeder Jr. High School, 875 Ridge Rd., Webster, NY 14580
- Louis Bancheri, Chrmn/Science Dept.,Sewanhaka Sr. High School,Floral Park,NY 11001
- Alfred Kausch, Windsor Locks High School, So.Elm St.,Windsor Locks, Conn. 06096
- Efsavia Krasilovsky, Central Islip High School,Wheeler Rd., Central Islip,NY 11722
- Edward McGreevy,Soc.Stud.Dept.,Board of Education,Niagara Falls, NY 14302
- Laura Maitland, Francis Lewis High School,58-20 Utopia Pkwy, Flushing, NY 11365
- Philip Merenda, Science Dept.,Lawrence Sr. High School, Cedarhurst, NY 11516
- Ruth Miner, Science Dept.,Floral Park Memorial High School, Floral Park, NY 11000
- Donald Nelson, Science Dept.,W.L.Boardman Jr. High School, Alice & Beatrice Avenues, Oceanside, NY 11572
- Marvin Ohriner,Science Dept.,Elmont Memorial High School,555 Ridge Rd.,Elmont,NY 1[illegible]
- Richard Pav, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776
- Severino Santorelli, Wm.Floyd High School,Mastic Beach Rd.,Mastic Beach,NY 11951
- Gerald Slutsky, Hauppauge Sr. High School, Hauppauge, NY 11787
- James Stark, Chrmn/Science Dept.,Peabody High School,315 S.Bellefld Ave,Pittsburgh Pa 15213
- George Urda, Chrmn/Science Dept.,Torrington High School,Major Besse Dr.,Torrington, Conn. 06790
- Chris Vigliotta, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776
- Harold Visner,Asst.Prin/Science Dept.,Hillcrest High School,160-05 Highland Avenue Jamaica, NY 11432
- Henry Whitehead, Chrmn/Science Dept.,Locust Valley High School, Locust Valley,NY 115[illegible]

- - - -

Associate Program Director: Robert Lewis, 2611 Silverside Road,Wilmington, Delaware 19810

Assistant Program Director: Herbert D.Berger, #17 Harborview Drive,Northport, NY 1176[illegible]

ENERGY AND THE ENVIRONMENT

Statement of the Problem

Education has an enormous responsibility for generating environmental awareness in society. Our commitment must be to make the best use of the educational resources available to us, in order that young people, as they leave the educational system and become decision-making adults, may be adequately prepared to assess their actions in terms of what constitutes the "good life" and how it may be achieved and maintained for the greatest number of people. This, of course, requires that people be equipped with basic analytical skills and with information about human life and the environment.

Statement of Principles

1. The earth is a closed system as to matter, and budgeted as to energy. Waste matter does not leave the earth. Energy is being used faster than it is being stored.
2. The earth is dynamic. Everything moves, affects other places. Some changes are cyclic, in balance; others lop-sided.
3. The earth uses the sun's energy. Past build-up of fossil fuels and ongoing build-up of biomass, hydropower, and wind. Other energy is in the tides and the nucleus of the atom.
4. The earth is ruled by Natural Law, but the effect of people has been increasing and off-balance. Sir Francis Bacon said, "Nature is not governed except by obeing her."
5. Our environment is the planet Earth - atmosphere, hydrosphere, lithosphere, biosphere, and man-made structures.
6. Environment is changed by people, during energy production and use.
7. Environment is changed by people distributing matter differently and by changing it in form (PCBs, radioisotopes).
8. Environmental changes vary, depending on economy, life-style, philosophy, custom, and religion.
9. Adverse environmental changes are called pollution.
10. Pollution continues due to ignorance of its existance, and of its degree of hazard. Pollution continues due to the cost of prevention and clean-

up. Pollution continues due to the trade-offs involved; "energy need" versus pollution.

Principles 6 and 7 deal most directly with the effect of energy production and use on the environment. Some additional aspects are:

Environment is changed by people distributing matter in a way different from nature.

- Depleting some (oxygen in water).
- Increasing others (carbon dioxide in the air).
- Releasing new or exotic materials into the air, water and soil - some toxic; some carcinogenic; some radioactive; some atoms which never existed on earth before.
- Raising the temperature of air and water; sometimes causing a shift in rain areas; probably causing future climate changes due to the greenhouse effect.

Energy use is expected to:

- Increase with increasing population.
- Increase with increasing standard of living, both in developed and developing countries.
- As the quality of energy used increases, quality of pollution can increase.

Energy is expected to come from:

- New sources as current fuels become more difficult to obtain.
- These new sources can bring new pollution problems, some that cannot yet be determined.

Life on earth evolved within a limited range of environment of matter and energy and its needs and tolerances are to a great extent the result of this evolution.

There are ongoing debates about tolerable maximums for pollutants.

- Many substances are harmful in incredibly tiny amounts.
- Some pollutants show effect only after a long time.

What are the trade-offs being considered?

- Price vs. purity.
- Energy "needs" vs. hazards.

What is tolerable damage to people? to their possessions?

Conservation provides more available energy without more pollution by using the same energy more efficiently.

Overview of the Problem

Note: This overview is designed to give the teacher an idea of the full scope of the problem - Energy and the Environment. The problem covers almost all areas of our environment. It is not intended that the activities which follow it will hit upon all areas mentioned. It is presented with the intent that the teacher may understand the full scope of the problem, and hopefully, pass this understanding on to the students. Class discussion and teacher-designed activities will hopefully bring out other important ideas pertinent to this topic.

The first problems arise in securing the fuel. Oil wells may "blow out" leading to spills and burning. Underground mining is dangerous, harmful to health (coal, uranium) and pollutes water (coal). Strip mining destroys valuable land, pollutes water with chemicals, and kills fish and wildlife. Low sulphur fuels are not readily available and cost more to obtain, resulting in the use of higher sulpher content fuels. Hydroelectric is good, cheap, clean energy, but problems arise in damming streams and rivers. There is siltation behind dams, blockage to fish spawning areas, and flooding of valuable land.

Solutions to these problems almost always add to the cost of fuels causing lower profits for business and higher prices for consumers, so environmental protection and cost factors have to be weighed. Mine safety standards must be strictly adhered to. This is difficult for small operators. Land must be reclaimed after strip mining. Low sulpher fuels must be used or sulpher must be cleaned from exhausts. Alternatives are solar energy, biomass energy, geothermal energy, and maybe nuclear energy. Conservation is the ultimate solution.

The next problem area is in transportation of the fuel. Air pollution is created by the vast numbers of trucks and ships which transport the fuels. Water pollution results from oil spills and ship traffic. Noise pollution is increased with increased ship and truck traffic. Land pollution is a problem in relation to pipelines and spilled oil. Problems also arise in transporting nuclear fuels and wastes.

Solutions to these problems are difficult and often costly. Use fuels near source, if possible. Control of shipping is not always desirable. Pipeline projects should be carefully considered, weighing environmental impact against benefits.

The final problem area is the use of the fuel to produce power. No energy production system, with the possible exception of hydropower, does not add to air pollution.

- Automobiles are a major source of air pollution, adding much of the NO_2, CO_2, and particulates found in the air.
- Fossil fuel plants add large amounts of sulfur oxides, carbon dioxide and particulates to the air, plus thermal pollution from cooling water.
- Nuclear plants add very small amounts of radioactivity, as compared with background levels, during operation. They contribute more thermal pollution than fossil plants and present the long-range problems of storage of radioactive wastes.

A key solution is to conserve all forms of energy. This cuts the amount of transportation needed and therefore solves many problems.

Americans consume energy at an alarming rate in transportation, as electrical energy in many applications, in high energy food production, and in high energy industrial production. Transportation contributes about 42% of the air pollution with other energy uses contributing most of the rest. Thermal pollution is increased with almost all forms of energy use. Water pollution and noise pollution are increased, but to a lesser extent.

Air pollution problems are all technologically solvable. Do we measure the cost in dollars or in human health and life? Thermal pollution may be partly solved by using waste heat in space heating applications. A ficious cycle exists in that mining, transporting and consuming energy all require use of more energy. Mass transit can help solve problems, but in only limited areas.

Final solutions to these consumption problems are, again, conservation and use of energy sources which are less damaging to our environment.

What Are the Environmental Effects of Producing and Using Natural Gas?

Natural gas in general has few harmful effects on people or the environment. It is basically a clean fuel, with practically no sulfur impurity and, therefore, contributes little to sulfurous smog. Like any fuel, when it is burned it will produce some of the nitrogen oxides that are part of the "photochemical" smog present in places like Los Angeles.

While safe for household use, natural gas does have explosive potential as the occasional leak-caused home explosion attests. It is not poisonous but can cause death by carbon monoxide poisoning if burned in a poorly ventilated room. About 100 people per year lose their lives from gas explosions and another 230 suffer from carbon monoxide poisoning due to gas fires.

Although many people prefer natural gas because it is clean and environmentally safe, it is presently our most limited fossil fuel resource and cannot be considered the answer to our long-term energy problem.

What Are the Environmental Effects of Producing and Using Oil?

Oil can harm the environment when it is produced, shipped, or burned. Although land-based wells and land transportation of oil can be messy, offshore or Arctic drilling for oil and its shipment by sea causes most of the environmental worries. Wells leak oil into the ocean or spill it in the occasional blowout. Tankers cleaning out their holds dump oil into the sea or spill it in an accident. In the Arctic, oil spills on the ice take a long time to disappear and pipes, such as the one being built across Alaska, can cause many changes in the land they cross.

Oil refineries, which process the oil to produce gasoline, heating oil, asphalt, and other products, create air and noise pollution as well as waste products, such as sludge and brine, that can create land and water pollution unless controlled.

Air pollution is a major problem. The burning of oil in furnaces adds harmful gases to the environment unless emission controls are added to the system. The Clean

Air Act of 1970 has set standards for oil refineries and other manufacturing plants in an attempt to control the emission of harmful gases into the atmosphere. Plants may be fined or closed if they do not comply with state regulations. At present no legislation has been passed to regulate air pollution from individual home furnaces. These harmful gases contribute to a variety of respiratory problems in people and animals.

The Water Quality Act of 1970 was passed to help regulate water pollution caused by oil spills and offshore oil drilling. The Federal Government has authority to conduct water clean-up operations and bill the responsible party later.

Energy - Environment Mini-Unit Guide, NSTA, 1975, p. 135, 137.

What Are the Environmental Effects of Producing and Consuming Coal?

Coal mining is harmful to the environment in a number of ways. When strip or surface mining is used, huge shovels — 200 feet tall, weighing millions of pounds — and other equipment move trees, shrubs, grass, and topsoil to get at the coal underneath. This is a cheaper way to harvest coal than underground mining and usually yields a higher percentage of the coal in the seam, 80 to 90 percent, than the 50 percent yield from underground mining.

Strip mining leaves the ground turned up and desolate. The exposed, bare ground, if it is on a hillside, is easily eroded and the silt and acid (formed when water combines with sulfur impurities) damage vegetation and stream life. On arid land it may take years for any vegetation at all to return.

The strip-mining picture is improving in this country. All states now have laws that require the restoration of mined lands, and the enforcement of these laws is becoming more vigorous.

Coal mining has also been costly in terms of human life. It is considered the most hazardous occupation in this country, 152 miners were killed in 1973. New coal mine health and safety regulations are being enforced, making the mines safer. The 152 miners killed in 1973 was a much better record than the 250 killed in 1970.

In addition to the mine accidents, many miners have been afflicted with black lung disease. It is estimated that as many as 125,000 miners may have this life-shortening illness and that it contributes to some 3,000 to 4,000 deaths per year. The new health and safety laws call for regulation in this area and measurement of dust levels in mines already show that coal dust is below the designated maximum level.

Coal also causes problems when it is burned. Most coal contains a chemical called sulfur that, when it is burned, creates a gas which escapes up the smokestack and contributes to the smog we sometimes see over cities in the winter. This smog can be harmful to people and other living things. And soot from burning coal is one of the causes of the dirt and grime that cover our cities. The new clean air laws cause utility companies to employ emission control devices. Most electric power plants now have equipment that removes 99 percent of the soot from the smokestack fumes and equipment is coming into use that can take out most of the sulfur also.

Since our supplies of coal are much greater than the supplies of the other fossil fuels, oil and natural gas, scientists and engineers have developed means for creating synthetic or manufactured gas from coal. While the environmental effects of mining coal would not be reduced, the "gasification" of coal could add to our supplies of natural gas and decrease the contribution coal makes to our air pollution.

What Are the Environmental Effects of Producing and Consuming Electricity?

Electric energy today depends largely upon the fossil fuels — coal, oil, and gas. Whenever a fuel is burned to create the steam which produces electricity, much of the heat created by burning the fuel is lost. The best electric plants convert 40 percent of the fuel's energy into electric energy, allowing 60 percent to become wasted heat. About 10 percent of this heat loss leaves the plant as hot gas while the rest is discharged into the cooling water and enters nearby rivers or lakes. This increase in water temperature does not directly affect the health of people, but it can affect the marine life in the body of water it enters. Some of these effects are considered beneficial for the marine life, but most are considered harmful. At a certain stage of development, an increase in water temperature can help eggs and young fish grow faster.

However, increased temperature often results in a loss of the more desirable species of fish and stimulates the less desirable. Higher temperatures can also affect the migratory habits of fish.

In addition, higher temperatures increase water evaporation and help concentrate the minerals already present in water. In cold areas, the warmer waters would stimulate recreational use; while in already warm waters, they would make the waters' use undesirable.

The Water Quality Act sets the standards for water quality. This includes temperature regulation of our rivers, streams, and lakes. Each state specifies the allowable rate-of-change of water temperature. Most states set the maximum water temperature change at less than 5°F.

Utilities are seeking practical ways of using their waste heat for such things as heating commercial buildings or in industrial processes. It may also be employed in desalting water and in agriculture. They are also turning away from direct use of river or lake water to cooling towers. In these towers a smaller amount of cooling water is recirculated and cooled either by evaporation (the "wet cooling towers") or by cooling fins in contact with air (the "dry cooling towers"). The use of such towers might increase the cost of electric power 5 to 10 percent.

Besides increasing water temperatures, power plants burning fossil fuels add sulfur dioxide and other gases to the air, forming smog that is harmful to man, materials, and crops. It contributes to diseases such as bronchitis and emphysema. The Clean Air Act establishes and maintains regional, state, and local air pollution control programs and enforcement of its provisions is bringing about more control over utility emissions.

In addition to gases and heat, fly ash enters the air and deposits dirt on surrounding homes and factories. This can also affect health and possibly even the climate of a given region. Gases and fly ash are controlled by equipment capable of removing 99 percent of the particles from the air.

How Does Nuclear Energy Affect the Environment?

Nuclear energy affects the environment in two main ways. On the one hand, there are environmental effects of mining and processing uranium. On the other hand, there are dangers to the environment and to people from the reactors themselves.

Effects of mining uranium: Uranium mining problems are similar to those of other types of mining. The miners are exposed to dust, accidents, fumes, and intense noise. The major concern, however, is the added presence of radioactive gas. Uranium is slightly radioactive and the U.S. Public Health Service has connected the relationship between exposure to radioactivity and lung cancer in humans. Uranium miners have higher rates of lung cancer than the general population. Controls for reducing the amount of radioactivity in the mines are being investigated. The waste materials from uranium mining are also dangerous and must be kept out of contact with living things.

Effects of nuclear reactors: There are two dangers from the reactors themselves. The leftover fuel material is highly radioactive and must be kept out of contact with living materials. There are about 45,000 gallons of radioactive waste produced for every 1,000 megawatts of electricity produced, and this must be stored somewhere for hundreds of years.

Large doses of radiation can seriously injure or kill human beings. Much less is known about the effects of the very small doses associated with the discharge from nuclear plants. Scientific opinion is, however, that even small doses do some amount of genetic damage and carry a low cancer-causing probability. Radiation levels from nuclear plant discharge are considerably smaller, at present, than are the levels we are exposed to from other man-made and natural sources.

The radioactivity associated with nuclear waste is potentially much more dangerous than that from plant discharge and for that reason it must be safely and securely stored. The final disposition of this material has not yet been decided, and more and more accumulates as the number of operating reactors increases.

The major concern about nuclear reactors is the possibility of an accident. While present-day reactors cannot explode like a nuclear bomb, there are possible malfunctions that can result in a small explosion. The spread of radioactive debris over the countryside would be a catastrophe.

In a recent study funded by the Atomic Energy Commission (this agency no longer exists and most of its functions are absorbed in the Energy Research and Development Agency, ERDA), the probabilities of such accidents were estimated. The conclusion was that serious accidents are not very likely — only one chance in one billion of an accident causing some 2,000 deaths. Such an accident, however, could do as much as $2 billion in property damage. These are risks which must be weighed into the cost of nuclear power.

Energy-Environment Mini-Unit Guide, NSTA, 1975, p. 140-141, 145.

The Automobile and Air Pollution

Sulfurous smog is the classical smog which, we read, offended the eyes and noses of 19th-century English royalty. In this country we have, along with our invention of the automobile, invented a new kind of smog. It is this so-called "photochemical smog" that Los Angeles has made famous. It is, unfortunately, now in evidence everywhere that automobiles are clustered.

In photochemical smog the indirect and synergistic effects that we have just described are even more obvious. The troublesome smog components, ozone and the PANs (for peroxyacetyl nitrates), for instance, are not "primary"pollutants emitted by the auto but are "secondary" pollutants formed from the primary ones by action of sunlight (hence *photo*chemical)

The necessary ingredients for this solar stew are the hydrocarbons and the nitrogen oxides from auto exhaust. By a series of complicated reactions, which depend on the energy provided by sunlight, ozone (O_3), a molecule made up of three oxygen atoms, along with a group of complicated organic molecules, and the PANs are produced. These latter are the most irritating components. Ozone is responsible for the sharp, unpleasant odor of smog and with the PANs contributes to eye irritation. It is one of the NO_xs, nitrogen dioxide (NO_2), which gives smog its typical brownish color. Because of the dependence on sunlight, the photochemical smog usually shows up in the afternoon, after sunlight has worked on the lingering exhaust of the morning and previous evening's rush hour.

The hazards of photochemical smog: The irritating effects of photochemical smog are easily demonstrated. It is harder to demonstrate more serious damage to health. Because photochemical smog rarely occurs in intense single periods that can be studied, and does not lead to an easily marked increase in deaths, statistical evidence connecting this smog to deaths is difficult to obtain. It is expected that the more thorough studies under way will tell us more about its effects.

It is the photochemical smog that causes most of the damage to vegetation. Levels of PAN as small as 0.01 or 0.05 parts per million can produce damage within an hour, and ozone is almost as bad. Leafy vegetables are the most sensitive, but even trees can be damaged. It is no wonder that they are replacing real trees with plastic ones along the Los Angeles freeways (and ozone will eventually destroy them).

Carbon monoxide: Another troublesome pollutant from the automobile that co-exists with photochemical smog is carbon monoxide. This odorless, but deadly gas is produced by the incomplete burning of the carbon atoms in hydrocarbon molecules. It is, as we have seen, the major pollutant on the basis of weight: six times as much is produced in auto exhaust as NO_x. It is lethal at levels of 600 parts per million (ppm) and can cause headaches and other problems at 100 ppm. It acts by reducing the mobility of oxygen in the blood, replacing the oxygen molecule in hemoglobin and causing nearby hemoglobin molecules to hold on to their oxygen. It is found wherever automobiles congregate; levels of 50 and even 100 ppm have been found in heavy traffic, automobile tunnels, etc.

Lead: Lead is another poisonous contaminant the automobile favors us with (although there are some industrial sources of lead, and it is released by incinerating certain waste materials). In gasoline, a lead atom is hooked on to a hydrocarbon molecule to slow down the rate of burning and thus prevent premature firing or "knocking." It was the addition of lead that gave automobile engines the sharp efficiency increase in the 1940s that is shown in Figure 3-10, Volume II. It is now an additive to the environment. Studies on the ice sheets in Greenland show its year-by-year increase. It is also found in a city's air in proportion to the gasoline its cars consume. There seems no question of its source.

Its effects, like those of the other pollutants, are difficult to predict. We know it accumulates in bone and in large enough quantity can cause "lead poisoning." We now have, unfortunately, a large exposed population and will soon be able to determine its effects with some precision.

Lead may be the first pollutant to go. It has run into the powerful opposition of the automobile industry because it damages the "catalytic converters" with which they hope to control the other pollutants.

Emission controls: The sources of the various pollutants within the automobile's anatomy are shown in Figure 4-4. Some of these can be handled easily. Evaporation from the carburetor has been reduced by better seals, and the "blowby" gases are being fed back through the engine. The exhaust, however, remains a problem.

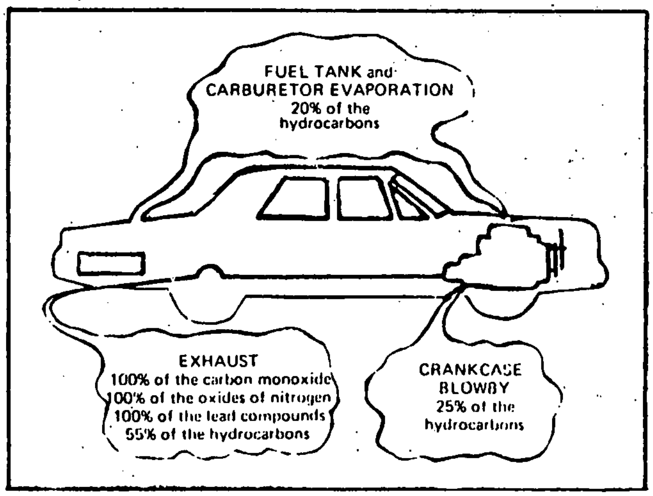
It looked easy at first. Since CO and the HCs both result from incomplete burning, their production can be reduced if a "leaner" mixture (increased air to fuel ratio) is used. This, incidentally, is a more efficient mixture (more miles per gallon). The cars in the 1960s were adjusted to leaner mixtures and their CO and HC emissions were reduced. Unfortunately, the leaner mixtures burned at a higher temperature thus increasing the production of the NO_x. The NO_x levels in California did increase in the 1960s while the CO and HC levels dropped. In 1971 the restrictions were extended to include NO_x.

The Clean Air Act of 1970 specified that the 1975 car emit no more than 10 percent of the CO and the HC of 1970 models, and that 1976 models emit no more than 10 percent of the NO_x of 1971 models. Auto companies resisted this edict and implementation was postponed until at least 1977.

Emission reduction in the near future will be accomplished by add-on devices rather than by engine redesign. The current choice is the catalytic converter, which converts CO to carbon dioxide (CO_2) and hydrocarbons to water. They will not at the same time remove NO_x, but the engine can be adjusted to a "richer" mixture to reduce these emissions.

The richer mix and the converters themselves lower gasoline mileage by 7 percent or so, a major argument in the campaign against the restrictions. In fact the mileage penalty is about the same as that imposed by air conditioning and considerably less than that caused by the increasing weight of cars.

Approximate Distribution of Automobile Pollutants by Source



Source: "The Automobile and Air Pollution: A Program for Progress," Part II, U.S. Department of Commerce, December, 1967.

Energy-Environment Source Boo, NSTA, 1975, p. 34-35..

Chapter 4, pages 31-43, entitled "The Environment and Energy Consumption" is worthwhile to include. Pages 34 and 35 are excerpts above.

ENERGY AND THE ENVIRONMENT

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I DIDN'T KNOW IT WAS THERE TIL I WAS BIT

Environmental Awareness

Objectives

The student should be able to:

a) Distinguish activities or processes that have environmental impact from those that do not.

b) Identify the source of pollution in the activity.

c) Distinguish the relative rank of the environmental impacts of the several activities or processes.

d) Describe one or more ways to lessen the environmental impact.

e) Conduct an environmental opinion poll with a large number of participants.

f) Distinguish between an environmental right and an environmental responsibility.

Overview

We currently face the prospect of endangering our chance of a better life through the very measures we employ to achieve it. No nation has abused its environment more extensively than the United States. In 200 years, the people of the United States have surpassed most of the industrialized nations of the world in the degradation of their land, air, and water while striving through the years to continually improve the quality of life at the expense of the environment.

Beginning with the 1930's, concerns slowly and steadily grew about land abuse, the availability of water, air pollution, pesticides and solid wastes. April 22, 1970, designated as the first "Earth Day", signalled the opening of the decade marked for environmental recovery.

In these activities, the individual student may develop an environmental awareness and an environmental ethid, and have it shown in daily life.

Materials

List of environmental issues to use as an inventory of student's concerns.

Table of projects and environmental impacts to match.

Reading references: "The Background for Teachers" provided with this unit on Energy and the Environment.

Pamphlets, articles, books available in the school library or in the classroom, on Energy and the Environment.

Strategy

Direct the students to:

1. Read reference materials and lists of processes and environmental impacts.
2. Individually rank the environmental impacts as to relative importance.
3. Individually match the various activities with various types of pollution.
4. Have discussion with their group members about the ranking.
5. Conduct a poll of student ratings and matchings.
6. Search for solutions.
7. Research and report to the group on information that might influence a group decision.

Notes to the Teacher

Discuss how to rank by relative importance by thinking of intensity of effects, of relative ease of correction, of numbers of persons affected, etc.

After the whole group has made their rankings, discuss the reasons for the rankings.

Discuss possible inter-relationships among these issues. Are some dependent on others?

Extension Activities

Numbers 2 and 3 proceed from Number 1.

Other Readings for the Teacher

From the bibliography for the Energy and Environment unit.

Student Activity Sheet

Name ____________________

Date ____________________

Use the list of environmental issues provided here as an inventory of the students' relative concern for each by having them rank the issues from the most serious (1) to the least serious (12). Discuss with them their reasons for these rankings.

( ) Chemical, biological, and radiological contamination (pesticides, detergents, pests, diseases, radiation).

( ) Consumerism (advertising, status products, poor information).

( ) Economic/social/cultural environments (lifestyles, housing, poverty, jobs).

( ) Energy (reduced resources, excessive demands).

( ) Health (pollution affects, drugs, stress, food additives).

( ) Land Use (abuse, poor planning).

( ) Natural environments (destruction of wildlife habitats, extinct and endangered species).

( ) Pollution (air, water, noise, visual/aesthetic).

( ) Resources (lack of recycling; loss of renewable resources, such as soil, water, forests, wildlife; and nonrenewable resources, such as minerals, fossil fuels.).

( ) Solid waste (lack of recycling, poor disposal methods).

( ) Transportation (congestion, lack of safety, need for mobility).

Is there a concensus among the class members regarding the 12 issues?

How many of these issues are interrelated? Briefly describe several of these interrelationships.

Direct the students to convert the class results to percentages.

- How reliable are the results of this classroom poll?

In cooperation with the teaching staff, have the students conduct a similar "Environmental Concerns Poll" with a larger population of people:

all the science or social science students in the school; members of the community; etc.

Activity 2

Use a chart similar to the one on the next page with the class as a means of dealing with the concept of environmental impact. The suggested projects will give students an idea of the range of human activity which affects the environment which is represented, in turn, by the areas of impact listed in the left-hand column.

Ask students to fill in the chart using the symbols in the key on this page.

+ = a beneficial effect is anticipated for the environmental characteristic noted (e.g., improved transportation (11.) under column (H), airport expansion).

- = an adverse environmental effect is anticipated (e.g., noise levels (3) increase and thus are adversely affected under column (H), airport expansion).

0 = no appreciable change anticipated (e.g., water table (8.) under column (H), airport expansion.

Once decisions have been made for every impact feature in a project column, a simple comparison of + and - responses will suggest whether or not the project seems feasible. Many students will wish to qualify some of their decisions, particularly those using the symbol 0. Comments of this nature may be added on another sheet by simple references such as H.11., H.3., H.8.

This exercise should be repeated in Unit 14, at which time you may wish to ask students to particularize the project column headings to specify issues and projects in their own community. Having completed work in a number of units, they should be considerably more informed and logical when justifying their decisions about environmental impact.

Activity 3

Have each student compose an "environmental ethic" after a brief review of the 12 environmental concerns cited in Procedure 2. The statement should consist of:

- The students' personal assessment of the status of these concerns today in our nation.

- Differentiation between a right and a responsibility.
- Listing of at least five "environmental rights."
- Listing of at least five "environmental responsibilities."
- Personal assessment of the worth or value of the natural environment.
- Indication of the importance of our modern, technological way of life.
- Prediction of the eventual solution to the environmental crisis in general.

Student Activity 2

Project Impact	A. Sewage Treatment Plant	B. Highway Construction	C. Apartment Complex	D. Tract Housing	E. Shopping Center	F. Nuclear Power Plant	G. Zoning Change: Commercial To Agricultural	H. Airport Expansion
1. Air Quality								
2. Water Quality								
3. Noise Levels								
4. Natural Habitats								
5. Mineral Deposits								
6. Solid Waste								
7. Contaminants (radioactive; chemical, etc.)								
8. Water Table								
9. Topography								
10. Aesthetic Quality								
11. Transportation								
12. Scenic Areas								
13. Economic Condition								
14. Population Density								
15. "Quality of Life"								

AFTER BURN

CO_2 Levels in the Atmosphere

Objectives

The student should be able to:

a) Be aware that the levels of CO_2 in the air are increasing.

b) Discuss why the levels of CO_2 are increasing.

Overview

The level of CO_2 in the atmosphere is on the increase and the rate of increase is getting faster. This is mainly the result of burning fossil fuels. In discussing this investigation, be sure the student understands where this CO_2 level is coming from.

Materials

Student Activity Sheet

Graph Paper

Strategy

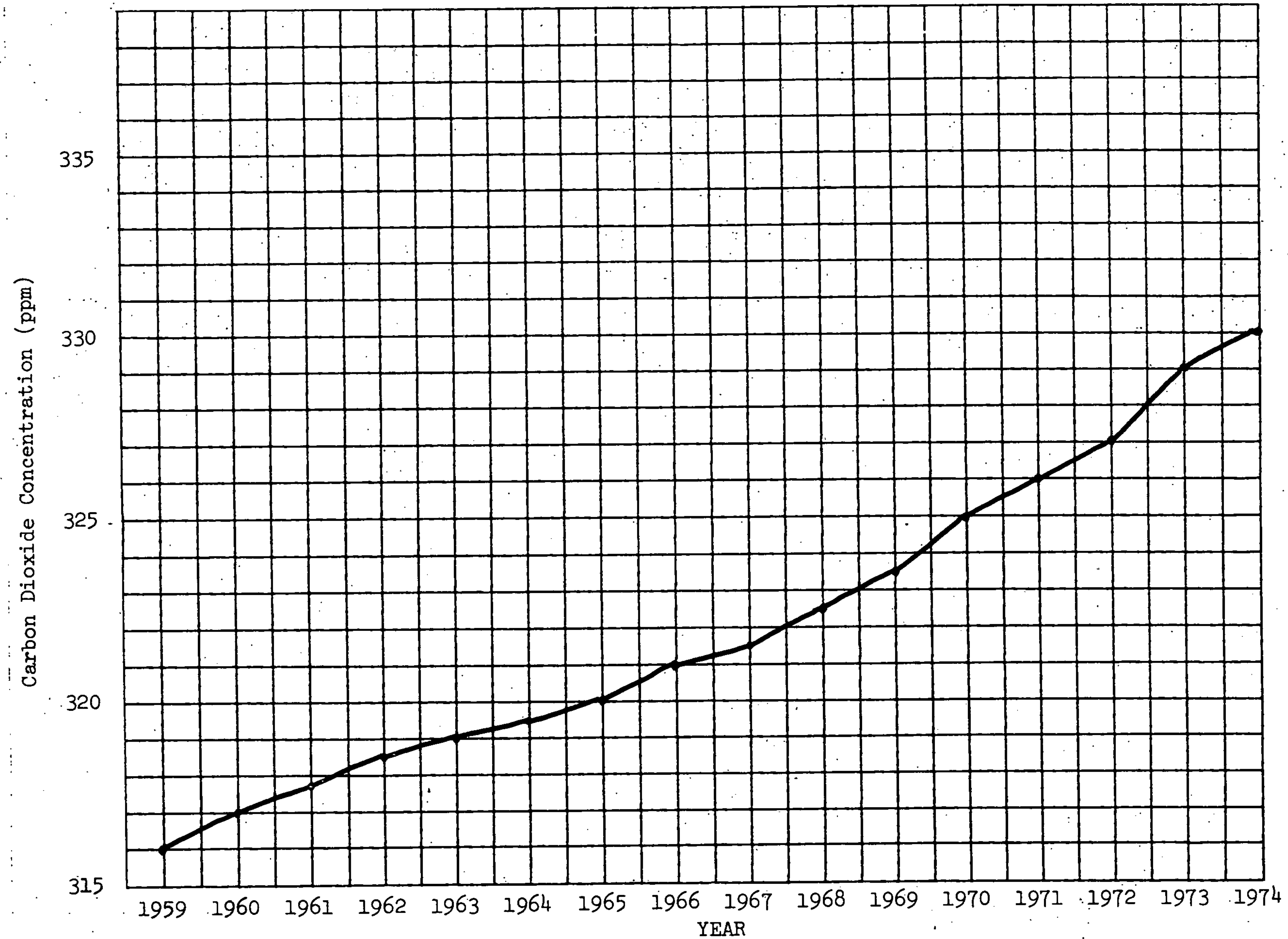
Have the students graph the information. A sample graph is included with this material. Bring out as much information in discussion as you feel is necessary. Another lesson, CO_2 #2 - The effect of increased CO_2 in the atmosphere, is designed to follow this lesson.

Notes to the Teacher

The amount of help needed in setting up and doing the graph will depend on the students' abilities in graphing.

Sample Responses

1. It has increased.
2. In more recent years the rate is increasing.
3. Increased population and increased dependence on fossil fuels.


Carbon Dioxide Concentration (ppm)
335
330
325
320
315
1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974
YEAR

Student Activity Sheet

Name ______________________

Date ______________________

The amount of carbon dioxide in the atmosphere has been measured at an observatory at Mauna Loa. In this activity you will graph these measurements to see how levels have changed from 1959 through 1974. In the next activity you will see how CO_2 levels in the atmosphere might effect our environment

Graph the following information on levels of CO_2 in ppm from 1959 through 1974.

Year	1959	1960	1961	1962	1963	1964	1965	1966
Level	316.1	317.0	317.7	318.5	319.0	319.6	320.2	320.9
Year	1967	1968	1969	1970	1971	1972	1973	1974
Level	321.7	322.6	323.6	325.0	326.0	327.1	329.3	329.9

Questions:

1. What has happened to the amount of CO_2 in the atmosphere from 1959 through 1974?

2. Has the rate of change remained constant over this period?

3. What might account for the trend that you see here?

AFTER AFTER BURN
Greenhouse Effect

Objectives

The student should be able to:

a) Discover how CO_2 can effect climate.

b) Realize that small changes in the environment can cause large scale problems.

c) Recognize that pollution can have long-term effects.

Overview

See student overview on the activity sheet.

Materials

Student activity sheets

Lamp with an incandescent bulb - 100 to 200 watt (heat source)

Clear plastic hemisphere or large beaker

Two thermometers - 0 to at least 50°

Strategy

Have the students set up the equipment as shown on the activity sheets. The distance between the thermometers and the light bulb must be determined and given to the students. This distance varies with size of the light bulb. Average distance is about ten centimeters. If this distance is properly established, the graph lines should level off as equilibrium is approached.

Notes to the Teacher

Watch carefully to make sure the students don't bring the bulb into contact with the hemisphere, desk or each other.

Sample Response

1. The thermometer under the hemisphere should reach a higher temperature and will probably show a better leveling off.
2. The earth's average temperature should be increasing.
3. Yes. Particulates.
4. Higher sea level, flooded low lands, changing weather and climate.

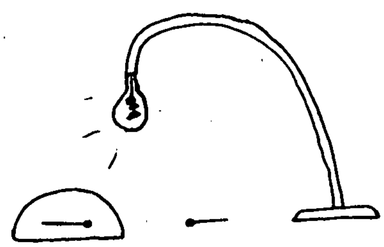
Student Activity Sheet

Name ____________________

Date ____________________

The earth's average temperature is the result of a balance between the amount of solar energy which is absorbed by the earth's environment and the amount which is radiated back to space. When these two factors are equal or in balance, the earth's average temperature will remain constant. Some of the energy which is radiated from the earth's surface is blocked by the atmosphere and therefore becomes part of the energy which remains in our environment. This blocking is known as the greenhouse effect. An increase in carbon dioxide (CO_2) in the air will increase the greenhouse effect. Some scientists say that all of the CO_2 which is going into the air from burning fossil fuels will cause the earth's average temperature to go up. A rise in temperature of only 2 or 3 degrees Celcius would cause the polar ice caps to melt.

Set up the equipment as shown in the diagram. Both thermometers must be exactly the same distance away. This distance is given by your teacher.



Turn the light on and record the temperature of each thermometer when you start and every minute after that for fifteen minutes. Make a graph of your results.

Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hemisphere																
Open																

Questions

1. How did the final temperature of the thermometer which was under the hemisphere compare with the final temperature of the thermometer which was not? Try to explain your results.

2. The earth's atmosphere acts much like the plastic hemisphere to regulate average temperature. CO_2 in increasing amounts tends to increase this effect. How would these factors affect the earth's average temperature?

3. Are there any factors in the burning of fossil fuels which might help to offset the effect of CO_2 and cause average earth temperature to go down?

4. How would the earth be affected if the ice caps were to melt completely?

THEY BREATHE IT IN L.A.

Air Pollution and Possible Change

Objectives

Student should be able to:

a) Recognize that a pollutant may be a harmful gas released into the atmosphere.

b) State that a pollutant may be a harmful material formed by a chemical reaction taking place after the pollutant is in the atmosphere.

c) Discover that the atmosphere is mainly gases.

d) Discover that all gases are transparent; most are colorless.

e) Discover that visible material such as fog or cloud is liquid in droplets and that smoke is solid in tiny particles.

f) Discover that gases diffuse and mix.

g) Discover that colored material is rarely natural to the environment.

h) Gases may undergo chemical change spontaneously or with energy from the atmosphere.

Overview

Energy conversion and use can result in pollution of atmosphere. The harmful material may be emitted directly and/or may be the result of a later chemical change.

Examples are the nitrogen oxides that are released as a result of the high temperature combution of fuels such as gasoline in automobiles. These nitrogen oxides later undergo further change in sunlight resulting in the smog-forming nitrogen dioxide.

Sulfur containing fuels release sulfur oxides when burned and these later change into a variety including sulfur acid, sulfite and sulfates.

Materials

Student activity sheets

Small reagent bottles (or small covered flasks) of HCL (aq) and NH_4CH (aq)

Litmus paper (pink and blue)

Water to wet litmus paper as needed

Student sheets to record observations

Strategy

Without any awareness of the students, two gases will be allowed to diffuse and mix in the atmosphere of the room. The product of their interaction will become visible after some time as a white smoke above the container of HCl (aq). (The length of time depends on the distance between the containers and air currents in the room, and the concentrations of their solutions.)

The teacher directs the students to observe the environment: the atmosphere (the world that is mainly gases) within the room and by looking out through the windows. Students are to describe the invisible portion as gases, clouds and fog as mainly droplets of liquid, and smoke as containing tiny particles of solid.

Now we will change the environment in the room by allowing some gases to come into the air. At one end of the demonstration counter, there is a closed container of hydrochloric acid which is a solution of a very soluble gas in water. To detect HCl gas in the air: wet the blue litmus paper, uncover the hydrochloric acid, hold the blue litmus over the open container and the blue turns to pink (acid reaction), and LEAVE THE CONTAINER UNCOVERED. At the other end of the counter, demonstrate ammonium hydroxide solution as a very soluble gas dissolved in water (household "ammonia" is a very dilute solution). To detect ammonia gas in the air: wet the pink litmus paper, uncover the ammonium hydroxide container, hold the pink litmus over the open container and the pink turns to blue (basic reaction), and LEAVE THE CONTAINER UNCOVERED.

Students will discover that white smoke is forming above the container of hydrochloric acid and they are told that the formation of this visible (solid) material was expected.

The containers are to be covered now and disucssion can proceed.

Notes to the Teacher

Precautions: Avoid inhaling fumes. Rinse with water if contact is made with the reagents.

Determine the direction of the air flow in the room so that it may be arranged that the air current is from the ammonia solution to the hydrochloric acid. Also, it helps to know air flow to avoid inhaling fumes.

Keep containers closed until the actual demonstration begins and close the containers right after the interaction is seen.

Keep a distance of six or more feet between the reagents to get a time span for diffusion.

USE THE LOWEST CONCENTRATIONS THAT WILL BE EFFECTIVE FOR THE ROOM.

Samples Responses

1. Clouds, fog, haze, etc.
2. a) Invisible
   b) Cloud, fog
   c) Smoke
3. a) Pink
   b) Blue
4. a) Opaque
   b) Solid
5. Solid or liquid.
6. Answers will vary.
7. Litmus - white smoke.
8. Ammonia NH_3 - HCl
9. $T \propto$ Average K.E. $\propto \frac{1}{2} MV^2 \therefore V^2 \propto 1/M$ NH_3
10. Sunlight

Extension Activities

Go over the list of visible material observed in the atmosphere and try to find out for each item: from what is it produced, of what is it made; and what happens to it during a day, month, and year.

Make a list of things that use or convert energy and what do they release to the atmosphere; also what happens to these emissions. (Examples: automobile, electric company, incinerator, oil burner)

The observations of the atmosphere can open up the subjects: Which is from "NATURE" and which are from "PEOPLE"?

Use of Fuel and Pollution of Atmosphere:

High temperature of combusion causes nitrogen to react with oxygen to form nitrogen oxides which change in sunlight to brown smog-forming nitrogen dioxide.

Sulfur in fuels (some oil, coal) burns to sulfur oxides and changes to acids and sulfates, affecting buildings, statues, clothing, and people.

Catalytic converters in cars.

Protection of buildings (B.N.L., M. Steinberg patent)

Effect of air pollutants combined with other substances, such as sulfur dioxide or nitrous oxide enhances carcinogens. Work is in progress at B.N.L. (NEWSDAY, July 26, 1977, re: Robert T. Dres and Marvin Kuschner - "could lead to stricter national air pollution standards").

What are current air-pollution standards?

Student Activity Sheet

Name ______________________

Date ______________________

Objectives of this activity are to observe the atmosphere and changes in the atmosphere, to observe the physical and chemical behavior of two gases, and to draw inferences about behavior of atmospheric pollutants.

Procedure

CAUTION -- DO NOT INHALE GASES OR FUMES FROM THE REAGENTS!

a) Observe the out-of-doors through a window and record your observations. Then observe the appearance of the air in the room.

b) Observe the changes taking place in the room atmosphere and describe the physical emission of different gases, and the chemical reactions of the gases.

1. List what you see. Some terms to use are transparent or translucent or opaque to light, colorless or color.

2. Describe the appearance of the atmosphere as to gases, liquid or solid.

3. Detect changes in the room's atmosphere:

   a) Release of $HCl(g)$: wet, blue litmus turns ______________.

   b) The presence of $NH_3(g)$: wet, pink litmus turns ______________.

   The formation of a NEW substance is a result of a CHEMICAL change.

4. Describe the new stance: the location; its color; whether it is opaque, transparent or translucent; whether it is a gas, liquid or solid.

RESULTS AND CONCLUSIONS:

5. The atmosphere has some visible material which is finely divided: tiny bits of ______________ or ______________.

6. The atmosphere has some visible material other than natural clouds. Observed through the window were: (give color and items such as brown haze, black smoke, etc.)

7. The gases released in the classroom were detected by testing with ______________________. However, even if the tests were not done, there was a clue to their presence as shown by the formation of ____.

8. The released gas that traveled faster was ________________. We saw the product form over the _________________________ container.

9. Gas will travel in the prevailing wind but it will diffuse faster if its relative molecular mass is less because:

10. The chemical reaction between the gases in the classroom was spontaneous -- we did not need to supply any energy to it. If a chemical reaction needs energy out-of-doors in the atmosphere, it might get the energy from _______________________________.

THE TEMPERATURE'S RISING THAT'S NOT SURPRISING

Thermal Pollution

Objectives

The student should be able to:

a) Describe environmental changes which may be invisible, may be small in amount or degree and can be lethal; and if not lethal may be reversible.

b) State when water is heated its dissolved gases are less soluble and all the oxygen can be driven out. To live, fish need the oxygen dissolved in water. Thermal pollution of natural waters means higher temperatures and hence less oxygen for the fish.

Overview

The hydrosphere (world of water) is part of the environment. Energy conversions and energy use usually release much heat and in order to cool, natural waters may be used resulting in thermal pollution. Nuclear plants are being designed with natural waters as the coolant. The lesson shows that raising the water temperature drives off air and that a fish in airless water cannot live, but can be revived.

Materials

One or more lively goldfish in water in a container that can hold an additional pint (or ½ liter) of water

Small fish net

One pint (or ½ liter) jar

"Vacuum sealed" airless water, at room temperature, previously prepared by waterbath canning method boiling at least 10 minutes, removing all air bubbles. (Make 3 jars. See "Ball Blue Book" 29th ed., 1974, Ball Corp.)

Freshly drawn cold tap water (about ½ liter)

Beaker for tap water

Bunsen burner or other heating device to heat tap water slowly.

Strategy

Students are reminded (with questions in discussion) while observing fish swimming in water that:

1. Fish need oxygen to live, just as most living creatures do.
2. Fish get oxygen that is dissolved in the water.

3. The oxygen in the water comes from the air touching the surface.
4. The appearance of water in three containers is compared and all look alike: water with fish, vacuum sealed water, and fresh cold tap water.
5. Fresh cold water standing in a beaker will be warming up to room temperature and bubbles will be observed.
6. Heat is supplied to the tap water gently.
7. Bubbles seen in tap water that is warming will form at sides, grow as they rise and escape until no more form.
8. When the water is hot enough to boil, different kinds of bubbles will form. They form at the bottom, get smaller as they rise, and escape. These bubbles are water vapor. Water vapor bubbles do not supply oxygen.
9. Observations show that cold water contains air, warm water has less air.
10. The jar of airless water is opened and without delay, students should watch closely the fish as they are removed with the net and placed into a jar of airless water.
11. The fish are observed briefly and then poured back to their original container of water.
12. Another jar of airless water is opened, poured back and forth to air and then the fish are placed in the water. No change is seen. There was no harmful material in the water.

Notes to the Teacher

Water without air must be kept vacuum sealed while stored until the time that the fish will be inserted. If surface of water is uncovered, the air will begin to dissolve.

The fish must be rescued promptly from the airless condition in order to survive; pouring fish and airless water back to the original fish container serves to aerate the water.

Students may cry out, "It's drowning - Save it!" (They are right.)

Extension Activities

1. Use tables of solubility of oxygen in water vs. temperature and graph.

2. Investigate oxygen needs of different fish and other aquatic life.
3. Investigate impact of thermal pollution directly on aquatic life, indirectly on people.
4. Investigate sources of thermal pollution and methods of dealing with it.
5. Observe uncovered soda pop as it warms up. (Dissolved CO_2 is much more soluble - carbonic acid). CO_2 dissolving in oceans relates to CO_2 increasing in the atmosphere which comes from greater use of fossil fuel combustion. This can lead to studies of CO_2 greenhouse effect and future climate changes.

Sample Responses

1. They look the same.
2. Plain water, bubbles at sides, more bubbles, no more bubbles, all escaped, bubbles at bottom (boiling).
3. Lively, unconscious, alive
4. Bubbles in it.
5. Pollution by heat.
6. No.
7. Bubbles out.
8. Dissolved in water.
9. Dies.
10. Death may result.
11. More bubbles form.
12. CO_2.

NOTE: If this is the students' first experience working with laboratory animals, then some kind of preparatory lesson or discussion of standard laboratory requirements for working with experimental animals is necessary. It is important that students learn that laboratory animals are not to be used in any way that we wish and for any reason whatsoever, but rather under very specific and humane conditions.

Student Activity Sheet

Name ______________________

Date ______________________

The objective of this activity is to observe water, the effect of heating it to drive out the air, and the effect of airless water on fish; to re-aerate water; and to observe thermal pollution.

Cold tap water is poured into empty beakers. The appearance of the water is compared with the water in the sealed jar and the water in which the fish are swimming. Describe this.

Next, watch the appearance of the tape water as it stands. It is warming up to room temperature; bubbles are appearing at the sides and growing. Now, using the Bunsen burner, the tap water is heated gently to speed up the process (of driving out the air).

When no more bubbles appear, the heat is increased to make the water boil. Describe the appearance during the three stages.

Next, the jar of airless water is unsealed. (It was prepared by boiling to drive off all the air and sealed before cooling.) Watch very closely as the fish are picked up in the net and placed in the airless water. Observe and then immediately pour the fish back into its previous container. Describe this.

Another jar of airless water is unsealed and poured back and forth using an emptied jar. Then a goldfish is placed in this water. Describe this.

Answer the follosing questions:

1. Compare the appearance of the water: cold fresh tap water, room temperature airless water in a sealed jar, water in which fish are swimming.

2. Appearance of tap water: fresh poured ______________________
standing and warming to room temperature ______________________
Bubbles get bigger or smaller: ______________ Gently heating:
______________ after a while ______________________
Strongly heated ______________________

3. Observation of fish before transfer: ______________________

After being placed in airless water: ______________________

After return to original container: ______________________

4. Appearance of water from second "airless" jar as it is poured back and forth: ______________________

5. What is thermal pollution? ______________________

6. Can air that is dissolved in water be seen? ______________________

7. What happens to dissolved air when the temperature of the water is raised?

____

8. From where does a fish receive oxygen in order to live? ______________________

____

9. What happens to a fish in water with no dissolved air? ______________________

10. What happens to aquatic life when some of its natural water is run through a nuclear utility plant for use as coolant? ______________________

____

11. What happens when soda pop is allowed to become warm? ______________________

____

12. What gas comes off? ______________________

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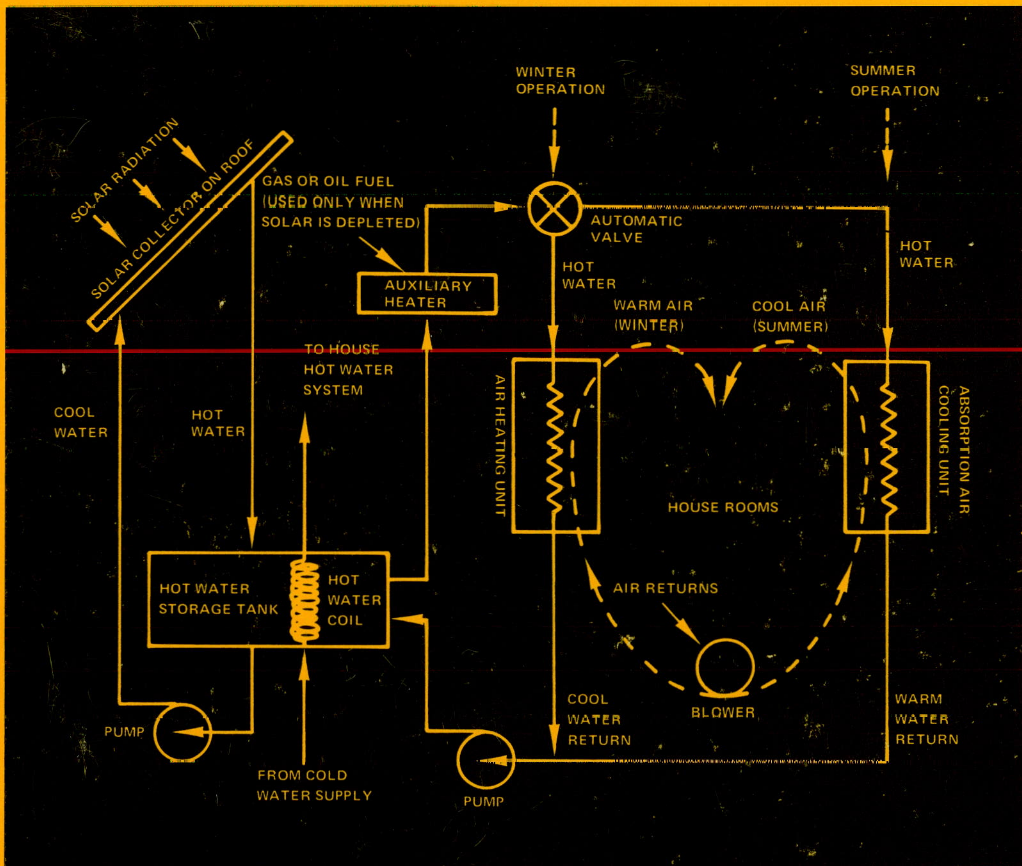
ENERGY: OPTIONS FOR THE FUTURE

CURRICULUM DEVELOPMENT FOR THE HIGH SCHOOL

Solar, Wind & Biomass



Institute for Energy Research
and
W. Averell Harriman College for Urban & Policy Sciences
State University of New York at Stony Brook
Stony Brook, New York 11794

T. Owen Carroll, *Project Director*
Robert Lewis, *Associate Project Director*
Herbert Berger, *Assistant Project Director*

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Energy Research and Development Authority
Washington, D. C.

DRA

SMALL TECHNOLOGIES

Members: Louis Bancheri
Carole Escobar
Edward Greenwood
Donald Nelson
Richard Pav
Chris Vigliotta

I. Background: Introduction, Solar, Biomass, Wind

II. Student Activities

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INTRODUCTION

Recent state and regional energy crises demonstrate the delicate balance between the energy system, the environment, and the economy. Indeed, interaction among these three elements in our society is very complex. However, any permanent change in the directions of our energy demand and supply for the future involves the formation of a new "energy ethic". To do so requires a broad base of information and understanding of the energy system, and this needs to be developed, particularly among those still in school. You, the teacher, play a most important role in providing that base of information which will become part of the new generation's thinking about the energy system. These materials are intended to enhance your ability to provide energy-related education to students within your own academic setting and to provide students with a better understanding and awareness of fundamental principles of energy supply, conversion processes and utilization now and in the future.

Since it is not possible to cover all aspects of energy systems, the curriculum materials designed in this project were limited to a number of areas considered important from two points of view: energy developments which are now occurring but whose implications are not yet clearly recognized and/or that broad area of potential new developments which have important implications for the future. The specific areas of curriculum materaials are the following -

CONSERVATION. We are coming to realize, albeit slowly, that the supply of raw materials from which energy is produced is finite and decreasing rapidly. Not only is supply decreasing, but demand continues to grow. The most optimistic forecasts show that the world resources of petroleum and natural gas, the two main sources of energy today, will be gone within the next fifty years. Consequently, we need to explore ways to conserve energy by using fewer energy-intensive devices, reducing our life style to one less dependent on energy, and possibilities for substituting new technologies.

DEMAND SCHEDULING. Electricity, since its first introduction, has provided a cheap, clean, efficient source of energy. We have also come to expect that any required demand for electricity on our part as individual consumers, will be met. We turn on the switch and expect the lights to come on. Large investments in the electricity generating plant are required to satisfy increasing demand, particularly during "peak" periods. Consequently, the overall cost of electricity generation becomes quite expensive - a result we have seen in recent years. The issue is particularly important since utility companies are now testing, and will soon offer to the consumer, electric metering for homes on a demand-scheduled basis.

ENERGY IN THE FOOD SYSTEM. Our agricultural system has become increasingly dependent upon the use of energy-intensive fertilizers for large crop production. In addition, energy requirements for food processing continue to grow. It is estimated that about one half of U.S. freight transportation is involved in the movement of foods of one kind or another. With the decline in the supply of fuels, we must ask whether our current national pattern of energy consumption in the food industries, particularly the trend toward increasing use of energy in food processing and packaging, are desirable trends for the future.

NEW TECHNOLOGIES (Solar, Wind, Biomass). It can be argued that the problem in our energy system today is not that we use too much energy, but rather that we use the wrong kinds of energy. Oil and natural gas form important components for synthetic materials, chemicals, and the like. Wherever possible, they should be conserved for such long-term uses. Consequently, we should shift from a fossil fuel resource base to a renewable energy resource base, particularly the use of solar, wind, and biomass sources.

ENVIRONMENT. The direct use of energy involves various pollutant emissions. In addition, indirect use of energy in the creation of industrial goods has secondary environmental impacts in a number of areas. Of recent concern are long term trends in accumulation of carbon dioxide and other gases and particulate matter in the atmosphere. These seem to produce unfavorable atmospheric conditions involving "the greenhouse effect", thermal inversions, and the like.

The modules prepared in each of these areas consist of an introductory background statement and a series of one-day lesson plans, along with suggested bibliography and references to other materials. The background statements are intended to introduce the topic to you, the teacher, and should reduce your need for reading a number of original papers and other citations to the literature. However, the background statements are sufficiently short that they can not make you an energy expert, and we would hope that you pursue additional reading on your own. Single day lesson plans were designed for easy use within existing courses as well as in the construction of new courses. As a result, it is hoped these curriculum materials will be useful in a variety of courses.

A special note to you, the user of these curriculum materials, is in order. The materials are made available in draft copy because of widespread interest in energy issues. Where you encounter rough spots, loss of proper citations to the literature, or other problems, bear with us. A brief evaluation form is included in this document. We encourage you to give us your reactions and any improvements we might add to make these materials more useful to you and to other teachers. The names and school affiliation of the project participants are noted in the material so you can feel free to contact the individual teachers on specific questions. Finally, these documents reflect a concentrated effort over three weeks by the teachers associated with the curriculum development project, and their efforts to translate energy issues into high school course material for you.

LIST OF PARTICIPANTS

- William Baran, Chrmn/Science Dept.,Niagara Wheatfld Central School District, 2292 Saunders Ave,Settlement Rd.,Sanborn, NY 14132
- Anthony Barchuk, Westbury Public Schools, Westbury, NY 11590
- Barbara Brookmeyer, Francis Lewis High School,58-20 Utopia Prkwy,Flushing,NY 11365
- Malcolm Cooper, 69-07 223 St.,Bayside, NY 11364
- Everett Carr, Herkimer County B.O.C.E.S., Herkimer, NY 11350
- Vincent Corsall, 257 Caldwell Ave., Elmira, NY 14904
- Carole Escobar, Islip Jr. High School, Main St., Islip, NY 11751
- Sr. Jane Fritz, St.Patrick's School, 284 E.Main St., Smithtown, NY 11787
- Edward Greenwood, Forest Hills High School, Forest Hills, NY 11375
- Raymond Hahn, Massepequa High School, 4925 Merrick Rd.,Massepequa, NY 11758
- Henry Harvey, Schroeder Jr. High School, 875 Ridge Rd., Webster, NY 14580
- Louis Bancheri, Chrmn/Science Dept.,Sewanhaka Sr. High School,Floral Park,NY 11001
- Alfred Kausch, Windsor Locks High School, So.Elm St.,Windsor Locks, Conn. 06096
- Efsavia Krasilovsky, Central Islip High School,Wheeler Rd., Central Islip,NY 11722
- Edward McGreevy,Soc.Stud.Dept.,Board of Education,Niagara Falls, NY 14302
- Laura Maitland, Francis Lewis High School,58-20 Utopia Pkwy, Flushing, NY 11365
- Philip Merenda, Science Dept.,Lawrence Sr. High School, Cedarhurst, NY 11516
- Ruth Miner, Science Dept.,Floral Park Memorial High School, Floral Park, NY 11000
- Donald Nelson, Science Dept.,W.L.Boardman Jr. High School, Alice & Beatrice Avenues Oceanside, NY 11572
- Marvin Ohriner,Science Dept.,Elmont Memorial High School,555 Ridge Rd.,Elmont,NY 110
- Richard Pav, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776
- Severino Santorelli, Wm.Floyd High School,Mastic Beach Rd.,Mastic Beach,NY 11951
- Gerald Slutsky, Hauppauge Sr. High School, Hauppauge, NY 11787
- James Stark, Chrmn/Science Dept.,Peabody High School,315 S.Bellefld Ave,Pittsburgh, Pa 15213
- George Urda, Chrmn/Science Dept.,Torrington High School,Major Besse Dr.,Torrington, Conn. 06790
- Chris Vigliotta, Comsequoque High School,400 Jayne Blvd,Pt.Jefferson Sta.,NY 11776
- Harold Visner,Asst.Prin/Science Dept.,Hillcrest High School,160-05 Highland Avenue, Jamaica, NY 11432
- Henry Whitehead, Chrmn/Science Dept.,Locust Valley High School, Locust Valley,NY 115

\- - - -

Associate Program Director: Robert Lewis, 2611 Silverside Road,Wilmington, Delaware 19810

Assistant Program Director: Herbert D.Berger, #17 Harborview Drive,Northport, NY 11768