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ABSTRACT

This is the student guide in a set of five computer-oriented environmental/energy education units. Content of this guide: (1) introduce the unit; (2) describe the "ENERGY" simulation; (3) give instructions for running the simulation; (4) give exercises for the unit; and (5) present sources of information on the energy crisis. (MR)

[illegible] TECHNOLOGY PROGRAM
[illegible] ENVIRONMENTAL EDUCATION UNITS

A Computer Simulation of the U.S. Energy [illegible]

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E       NN  N   E       R   R   G   G    Y Y
E       N N N   E       R   R   G         Y
EEEE    N N N   EEEE    RRRRR   G         Y
E       N N N   E       R R     G GGG     Y
E       N  NN   E       R  R    G   G     Y
EEEEE   N   N   EEEEE   R   R   GGGGG     Y
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STUDENT GUIDE

NORTHWEST REGIONAL EDUCATIONAL LABORATORY
710 S.W. Second Avenue, Portland, Oregon 97204
Telephone (503) 248-6800

This edition is based on earlier developmental work conducted with a limited test sample. The material was reviewed in order to correct any noted technical errors prior to printing of the October 1977 edition. However, purchasers are urged to first run the sample simulation program provided in order to determine any needed or desired adjustments prior to actual use. The Laboratory would appreciate hearing from users concerning any suggestions for corrections to subsequent editions.

First Printing, October 1977

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TABLE OF CONTENTS

INTRODUCTION TO THE UNIT

Preview of the Unit

In this unit, you will study some of the major factors involved in our current energy crisis and some of the means available for solving the steadily growing problems of shortages, pollution, and waste. You will be confronting complicated issues and their interrelationships, which make solutions extremely complicated.

In this unit, you will experiment with a computer simulation called ENERGY which will allow you to try different measures to solve the energy problems in the U.S. Using ENERGY you will be able to test a variety of energy-use patterns and pollution standards to see their effects on pollution levels and energy supplies. The simulation will also show you the effects which your measures have on the country's economic well-being and the people's general satisfaction.

When you have finished this unit, you should have a better understanding of the nature and causes of our current energy crisis and of the complex effects of various measures for solving our energy problems.

Background on Energy Use

Human beings began, early in their career on earth, to put energy to work for them. Of course, at the very beginning, food was a vital source of energy for human growth and activity, as were the life-sustaining sun and water. But, probably the first conscious use of energy was made when humans discovered and used fire--to warm themselves, to cook food, to run down herds of animals, and to melt metals to be fashioned into tools and weapons.

Much later came the use of domesticated animals to plow and to haul, and the use of running water and winds to drive various kinds of primitive machines.

In very recent times, the history of man's ingenious use of energy has reached a pinnacle of success and elaboration.

Energy is used today to run furnaces, air conditioners, cars, planes, pollution control devices, machinery, electrical appliances, toys, space ships, and thousands of other things in our daily lives.

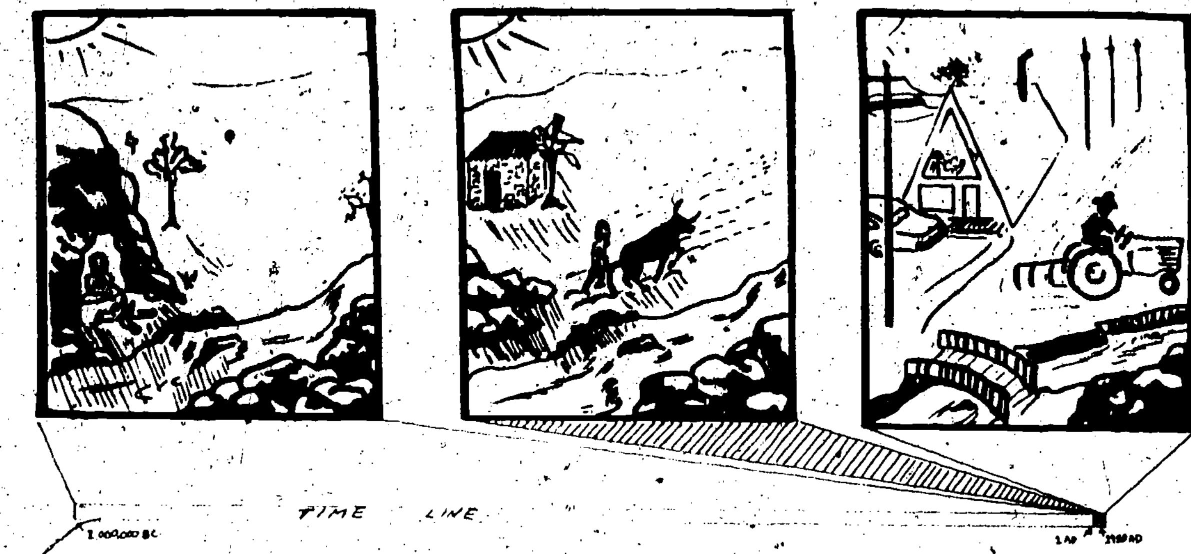

Fig. 1. Energy use past and present.

How much use do you and your family presently make of energy in your daily life? For example--

1. How many electricity-driven entertainment devices do you and your family own?

   ___Radios ___TV's ___Phonographs ___Tape Recorders

   ___Toys ___Others

2. How many communication and transportation devices do you have?

   ___Telephone Extensions ___Cars ___Motorbicycles

   ___Other

3. How many modern convenience-appliances does your family use in addition to the basic stove, refrigerator, and hot water heater?

   ___Freezer ___Air Conditioner ___Iron

   ___Vacuum Cleaner ___Hair Dryer ___Portable Heater

   ___Portable Fan ___Electric Razor ___Sun Lamp

   ___Electric Air Freshener ___Heating Pad ___Electric Blanket

___Electric Exerciser

___Garage Door Opener

___Automatic Dishwasher

___Automatic Clothes Washer

___Electric Can Opener

___Garbage Disposal

___Power Lawn Mower

___Automatic Clothes Dryer

___Electric Skillet

___Front Door Bell

___Electric Clock

___Power Saw

___Electric Comb

___Toaster

___Electric Hair Curlers

Back in 1930, the average family in the U.S. probably had regular use of four or five energy-driven conveniences (car, phone, radio, clothes washer, and perhaps one other.) The average American family today probably has at least 18-20 conveniences that use energy to make life more comfortable and tasks easier.

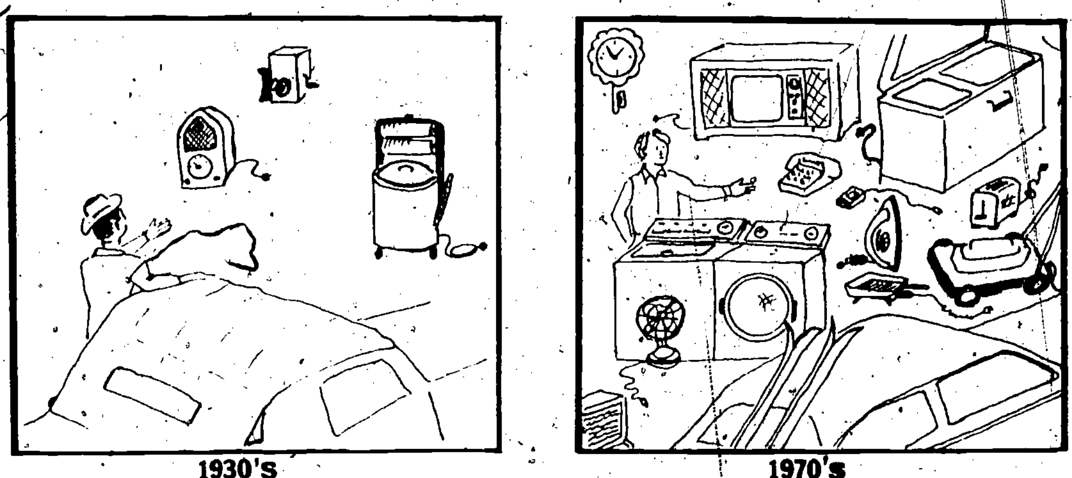

Fig. 2. Energy driven conveniences in the 1930's and the 1970's.

During the last few decades, in which we have rapidly increased our use of electricity, oil, and gas powered conveniences, energy has been taken for granted. To most Americans it has seemed cheap, abundant, and inexhaustibly useful for achieving our ever-expanding personal and national goals of comfort, progress and enjoyment. As a result, we have all developed lifestyles which are supported by massive energy consumption.

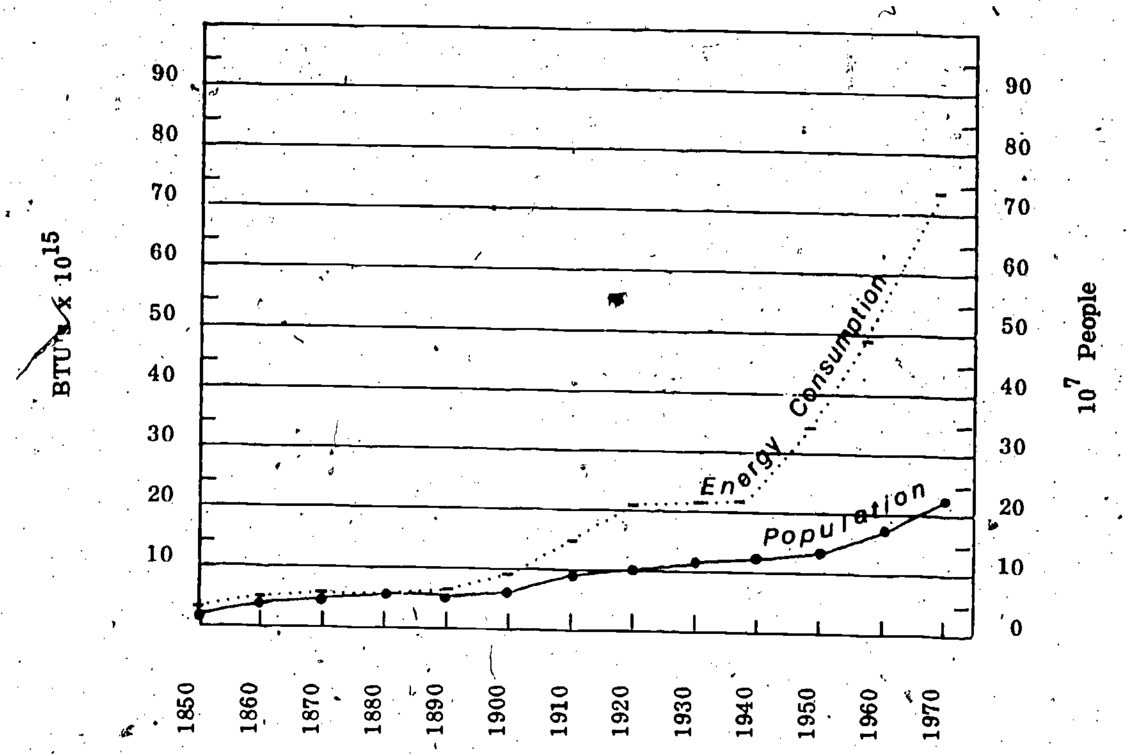

Fig. 3. Consumption of U.S. energy and population growth, 1850-1970.

Hasn't everyone else on earth developed this kind of energy-based lifestyle? The answer is "No." In fact, while the U.S. has only 6% of the world's population, it currently uses nearly 40% of the total energy produced in the world. On a per capita basis, each American consumes 25 times as much energy as a Chinese.

Is there any problem with that, outside of the fact that we may be using more energy than our per capita share? Up until the last few years, the American answer seems to have been "No, there is no real problem." As late as 1966, many knowledgeable people estimated that our nation's total energy resources could satisfy our energy requirements to the end of this century at moderate cost levels.

Since about 1973, however, every American has experienced some effects of energy shortages:

- Average temperatures in offices, schools, and public buildings, as well as in private homes, have been reduced from 72° F to a cooler 68° F, to conserve oil, natural gas, and electricity.

- Gasoline prices have doubled and limited supplies of gasoline have caused a trend towards more fuel-efficient automobiles.

- Airline schedules, which were once increasing in numbers of flights and cities served for greater customer convenience, are reducing the number of flights to conserve fuel.

- Highway speed limits have been reduced from 70 miles per hour to 55 miles per hour in an effort to reduce fuel consumption.

Even with the experience of these shortages, our energy consumption is increasing by several percent each year in America. At this rate, our consumption of energy in the U.S. will double by the 1990's.

Many people are seriously asking: "Will there be a large enough energy supply to fill our needs, and how much will it cost us to obtain that energy?" Those who have held to our national philosophy that "material growth is prosperity--the more the better," have felt the answer to shortages and the future needs is to increase the number of refineries and energy plants. "After all," the argument has run, "we certainly don't want to reduce our standard of living or our rate of growth. If we need twice the energy to run our prosperous lives, we'll have to produce twice the energy."

However, the energy shortages, the fear of oil embargoes by foreign oil producers, and dangerous depletion of certain raw energy materials challenge the feasibility of such a solution. And, our energy-driven standard of living is already being threatened by the pollution and environmental degradation created by our massive energy consumption and waste. In short, it is now clear to everyone that we have a serious energy crisis and environmental problem upon us. The crisis can be summarized:

1. The world is experiencing more and more energy shortages due to increasing consumption, and in some cases the natural resources themselves are being depleted at dangerous rates.

2. Even when energy is available, its cost has increased substantially. The price of energy has become a burden to individuals, businesses, and countries.

3. Consumption of energy is resulting in serious air, water, and land pollution.

4. The massive consumption of energy in the U.S. often appears to be irresponsibly wasteful; Americans waste in a year as much energy as is consumed by the populations of many countries.

The growing realization of the limited nature of our present energy sources and of the environmental problems caused by their use are causing us to reconsider the wisdom of our cultural "growth" premise. We are beginning to see the great and unnecessary waste in our ways of doing things, and to see the necessity of looking at ways to accomplish our dreams with less energy.

What are Our Alternatives?

Most people today are aware that there are so many interrelated issues in the energy-and-pollution problems that solutions will be far from easy to see or to implement. The complexity of the situation is illustrated in the cartoon on page 8 in which some well-meaning Martians, hoping to solve the problem in one Earth city, make matters a lot worse.

While the final solution to the energy-pollution crisis will be complex, there are things which can be done to move toward the resolution of the problems.

According to the U.S. News and World Report, Inc., in 1973, our current massive consumption of energy was being used in the following proportions in our country.

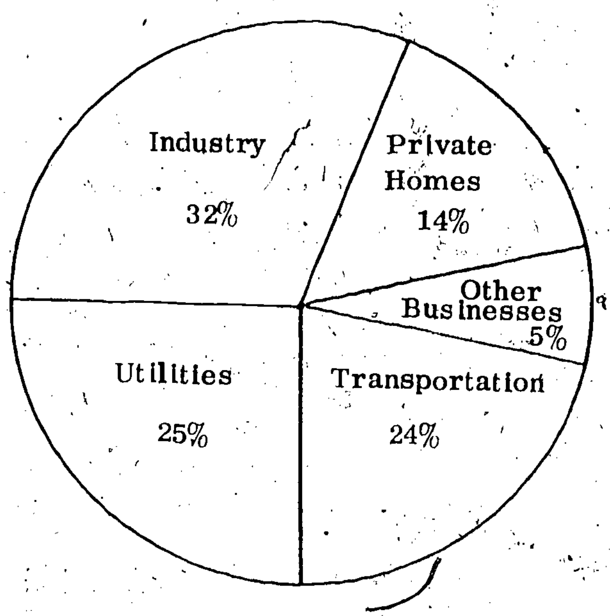

Fig. 4. U.S. energy consumption in 1973.

In spite of our national philosophy of "the more the better," there has recently been less energy available at reasonable cost than we need. Conservation of what is available is necessary in all sectors of our society. Some effective measures toward this goal include: turning down thermostats, driving at the speed limit, using more public transportation, and reducing the hours that offices and industrial plants operate. Of course, these measures will have serious side effects--for example, increased inconvenience, decreased comfort, and decreased production and employment.

Many people advocate stepping up construction of nuclear power plants; but many others fear the effects of radioactive waste products from such plants. Others advocate stepping up our efforts to use our large coal supply, but many of the problems associated with mining and burning coal still need to be solved. Still other people would like to see greater effort expended towards harnessing solar, geothermal, and other kinds of "clean" energy.

Pollution control devices are energy-expensive on the whole. They often cause engines, and industrial machinery and furnaces to use more fuel to accomplish their work. Some people have felt that pollution standards should be relaxed so car engines, industrial operations, and so forth will use less energy. The price to be paid is, of course, an increase in pollution.

A growing number of experts are focusing on energy conservation through reducing our waste of energy. It has been estimated that reducing just our waste of energy would allow us to cut our projected 1985 energy consumption by 30%, and to reduce our consumption growth rate from 5% to 3%, without affecting our present standard of living. For example, if the average car in the U.S. weighed 1,000 pounds less, we would save about two million gallons of gasoline every day in this country; this gasoline savings is equivalent in energy content to what the Alaskan pipeline delivers. Another example-- it is estimated that in our homes and buildings we waste about one quarter of the energy consumed for heating and lighting due to inefficient design, insulation, and heating and lighting systems. Recycling materials, especially metals, is another major way of saving energy. It takes about half as much energy to produce usable aluminum or steel from recycled metal as it takes to produce it from raw ores.

It is important to realize, however, that none of these alternatives is simple to implement and all have negative as well as positive consequences. For one thing, many of the alternatives would require tremendous amounts of money and might involve great inconveniences for people. Where, for example, would we put the old heavy cars? Who would pay to convert the machinery in auto manufacturing plants to manufacture lighter automobiles? What would happen to people who could not afford to buy new lighter cars, or who simply did not want one?

It is clear that solutions are needed. Our energy consumption is outstripping our supply and depleting our natural sources, environmental pollution is a growing hazard, and waste continues at unacceptably high rates.

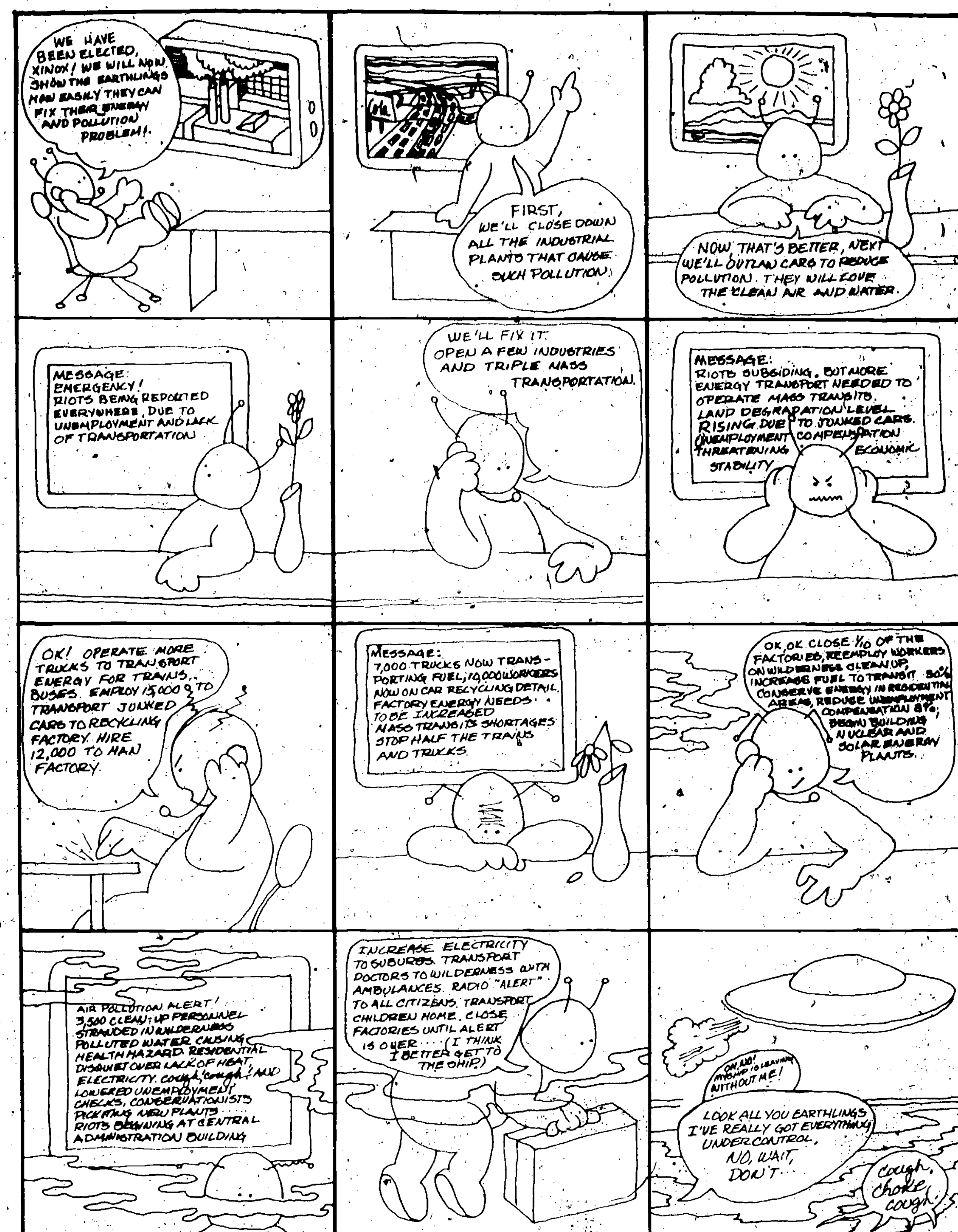

Fig. 5. Solving the energy problem isn't that easy. 8

Do you think you could figure out how to solve the energy and pollution problems better than the Martians in the cartoon on the preceding page? In this unit, you'll have the chance to try out your ideas on the computer using the simulation/game called ENERGY. The ENERGY program is discussed in the next two sections of this manual. For more background information on the energy crisis, you may want to consult some of the sources listed in the last section on page 27.

THE "ENERGY" SIMULATION

Description of the Program

The ENERGY program begins by printing out a short description of the simulation and giving 1975 energy demand figures for the five sectors of society which use our energy. It also lists the ten factors within these sectors which most influence energy use. Here is an example of this first printout from ENERGY.

```
ENERGY

USING THIS ENERGY SIMULATION, YOU CAN TRY
TO SOLVE THE ENERGY PROBLEM BY CHANGING THE RATE AT WHICH
ENERGY IS USED.  YOUR GOAL IS TO KEEP THE DEMAND FOR ENERGY
WITHIN THE AVAILABLE SUPPLY.  AT THE SAME TIME YOU SHOULD
TRY TO
   > REDUCE THE LEVEL OF POLLUTION
   > INCREASE THE ECONOMIC CONDITION OF THE NATION
   > INCREASE THE GENERAL SATISFACTION OF THE PEOPLE

YOU CAN CONTROL THE RATE AT WHICH ENERGY IS USED BY CHANGING
FACTORS IN TEN DIFFERENT AREAS.  EACH FACTOR AFFECTS THE
TOTAL AMOUNT OF ENERGY USED.

START OF YEAR - 1975

     CURRENT ENERGY DEMAND:                            FACTORS IN AREAS
     BTU TIMES 10 TO THE 15TH                    ID#   YOU CAN CHANGE

       22          INDUSTRY                       1    PRODUCTION LEVEL
                                                  2    POLLUTION STANDARDS

       19          UTILITIES                      3    PRODUCTION LEVEL
                                                  4    POLLUTION STANDARDS

       18          TRANSPORTATION                 5    POLLUTION STANDARDS
                                                  6    MASS TRANSPORTATION
                                                  7    AUTOMOBILE EFFICIENCY

       9           HOMES                          8    APPLIANCES
                                                  9    HEATING / LIGHTING

       6           BUSINESS AND SCHOOLS          10    HEATING / LIGHTING

WANT RESULTS GRAPHED?NO
```

Then the program lists or graphs (as the user prefers) 1975's total energy supply and demand and gives the related levels of pollution, economic well-being, and general satisfaction. Here is an example of the 1975 figures printed out by the program.

ENERGY SUPPLY - 80	POLLUTION LEVEL 19.79
ENERGY DEMAND - 74	ECONOMIC WELL-BEING 15
SURPLUS ENERGY - 6	GENERAL SATISFACTION 26

From this point on, the user can introduce changes in the energy-use pattern and can watch the effects these changes have on energy conditions, year after year. Changes are made by the user's entering percentage increases or decreases in the energy used in any or all of the ten energy-use factors listed at the beginning of the printout. Where the user introduces no change in a factor, the program calculates an automatic change for that year. As soon as changes are entered, the program calculates the effects and lists or graphs the results.

Below is an example of changes introduced for the year 1979 and their results in one students' run. Notice that, when a graph is requested, the program prints out a cumulative graph showing energy supply and demand levels from the starting year, 1975, to the present.

```
DO YOU WANT TO CHANGE ANY FACTORS? ?YES

TO MAKE A CHANOE, ENTER THE FACTOR ID NUMBER, A COMMA
AND THE PERCENT CHANGE.

FOR EXAMPLE,  TO REDUCE THE USE OF APPLIANCES IN THE HOME
BY 25%  YOU ENTER  8,-25

WHEN YOU ARE DONE ENTERING CHANGES, ENTER  0,0
?1,-1
?2,6
?3,-1
?4,6
?5,8
?6,8
?7,8
?8,2
?9,2
?10,2
?0,0


WANT RESULTS GRAPHED?YES

END OF YEAR - 1979


 135    I                                                 POLLUTION LEVEL
        I                                                       19.78
        I
        I
        I                                               ECONOMIC WELL-BEING
        I                                                       15.96
        I
 95     I
        I                                               GENERAL SATISFACTION
        I         D                                             22.54
        IS S E E    D
        ID D      S
        I           S                                  S = SUPPLY OF ENERGY
        I                                              D = ENERGY DEMAND
 55     I                                              E = DEMAND EQUALS SUPPLY
        I- - - - - - - - - - - - - - - - - - - -
        1975 76  78  80  82  84  86  88  90
```

After a year's results have been graphed or listed, the user has the option of seeing a list of the current energy demands in the five sectors of society.

```
DO YOU WANT A LIST OF CURRENT ENERGY DEMANDS? ?Y

CURRENT ENERGY DEMAND:                             FACTORS IN AREAS
BTU TIMES 10 TO THE 15TH                    ID#    YOU CAN CHANGE

 25       INDUSTRY                           1     PRODUCTION LEVEL
                                             2     POLLUTION STANDARDS

 22       UTILITIES                          3     PRODUCTION LEVEL
                                             4     POLLUTION STANDARDS

 22       TRANSPORTATION                     5     POLLUTION STANDARDS
                                             6     MASS TRANSPORTATION
                                             7     AUTOMOBILE EFFICIENCY

 11       HOMES                              8     APPLIANCES
                                             9     HEATING / LIGHTING

 6        BUSINESS AND SCHOOLS              10     HEATING / LIGHTING
```

Then, changes can be entered for the next year and the cycle is repeated.

In the midst of each run, the program will randomly introduce unexpected "news flashes" announcing such events as the development or discovery of new energy sources. For example--

```
* * * *  NEWS FLASH * * * *

BULLETIN--DEVELOPMENT OF CONCENTRATING
SOLAR COLLECTORS
HAS BEEN SUCCESSFUL IN
INCREASING THE YEARLY ENERGY SUPPLY  9   %
```

The program will continue to accept changes in factors and to print out the results until the user wishes to stop. Hence, the user can experiment with changes over as many years as he or she wishes.

ENERGY allows you to control many realistic factors involved in the ENERGY situation; however, there are a number of factors relevant to the real-life energy problem which you cannot manipulate using ENERGY, such as energy is based on a simplified model of the real-life situation. Before going on to use the program, you will need to know what the scope and limits of the model are, what assumptions it is based on, and what the factors (variables) you'll be controlling actually mean. This information is given in "The ENERGY Model" section below.

The ENERGY Model

The Scope and Limits of the Model

As we have seen, there are an almost unlimited number of issues involved in the current energy-and-pollution crisis. In order to create a 'model' of the situation which one can understand and interact with, the situation must be simplified. For the purposes of this computer model, five main characteristics of the current energy situation were selected as the central elements in the simulation. They are listed below.

1. Demand for energy is growing exponentially.
2. Energy supply depends, in the main, on nonrenewable resources, such as oil, natural gas and coal.
3. Changes in patterns of consumption can extend the life of present resources, and technological advances and new energy sources may come to our aid.
4. Changes in consumption patterns directly influence our quality of life.
5. Pollution levels are effected by consumption patterns and by the pollution standards which are enforced.

As a consequence, the ENERGY simulation is limited to modelling only the relationships between energy supply, consumption, pollution levels and quality of life, and to illustrating possible impacts of new energy sources.

What elements of the real energy crisis are outside the limits of this model? Many! For example, weather conditions, population growth rates and political interferences with energy supplies such as oil embargoes, are not taken into consideration by the program. There are also limits in the model itself and those are the specific, limited relationships among elements which are used. The elements, or variables, and their relationship are described below.

The Variables

The independent variables in the ENERGY simulation which the user can increase or decrease yearly (from 1 to 75%) are:

INDUSTRY	1.	PRODUCTION LEVEL The output of the nation's manufacturing plants and factories.
	2.	INDUSTRIAL POLLUTION STANDARDS The pollution standards industries must meet.
UTILITIES	3.	UTILITIES PRODUCTION LEVEL The output of electricity from power generating plants.
	4.	UTILITIES POLLUTION STANDARDS The pollution standards power generating plants must meet.
TRANSPORATATION	5.	TRANSPORTATION POLLUTION STANDARDS The pollution standards that automobiles must meet.
	6.	MASS TRANSPORTATION The availability and condition of mass transportation system, i.e., buses, trains, etc.
	7.	AUTOMOBILE EFFICIENCY Increased efficiency means you can transport the same non-vehicle weight using less fuel.
HOME	8.	APPLIANCES The use of appliances such as dishwashers, air conditioners, and dryers in the home.
	9.	HOME HEATING AND LIGHTING The amount of heat and light used in homes.
BUSINESS AND SCHOOLS	10.	HEATING AND LIGHTING The amount of heat and light used in schools and businesses.

Changes which the user makes in the independent variables will cause changes in the following dependent variables:

- ENERGY DEMAND

  A measure of the amount of energy consumed in the ten areas listed above

- ENERGY SUPPLY

  A measure of how much energy is produced in a given year added to the previous year's remains after demand has been filled

- POLLUTION INDEX

  A measure of air and water pollution

- ECONOMIC WELL-BEING

  A measure of the economic health of the nation

- GENERAL SATISFACTION

  A measure of the psychological well-being of the citizens

Two final variables have been incorporated into this model to make it approximate the real world energy situation more closely. First, a variety of unexpected events providing new energy supplies are included in the program. These events are activated randomly by the program in the process of its running.

Second, there is an automatic change factor built in for the ten independent variables. Whenever the user does not specify an intentional change for any of these variables, the program will calculate an automatic change for those variables.

Relationships Between Variables

The ENERGY model operates on the assumption of certain direct relationships holding between the independent variables and the dependent variables. These relationships are summarized in the following table.

INCREASES IN INDEPENDENT VARIABLES	RESULTING EFFECTS ON DEPENDENT VARIABLES				
	Energy Demand (ED)	Energy Resources (ES)*	Pollution Level (PL)	Economic Well-Being (EWB)	General Satisfaction (GSL)
1. Industrial Production Level (IPL)	Inc.	Dec.	Inc.	Inc.	Inc.
2. Industrial Pollution Standards (IPS)	Inc.	Dec.	Dec.		
3. Utilities Production Level (UPL)	Inc.	Dec.	Inc.	Inc.	
4. Utilities Pollution Standards (UPS)	Inc.	Dec.	Dec.		
5. Transportation Pollution Standards (TPS)	Inc.	Dec.	Dec.		
6. Mass Transportation (TMT)	Dec.	Dec.			
7. Automobile Efficiency (TE)	Dec.	Dec.			
8. Appliances (A)	Inc.	Dec.			Inc.
9. Home Heating and Lighting (HH)	Inc.	Dec.			Inc.
10. Schools and Business, Heating and Lighting (BSH)	Inc.	Dec.			Inc.

* Energy resources will constantly decrease unless all energy demand ceases. The only variable which can increase the resources is an "unexpected event" which is randomly introduced by the program itself.

When any independent variable is decreased the effects on dependent variables will be the opposite of those shown above. For example, if Industrial Production Level is decreased, the energy demand, pollution level, economic well-being and general satisfaction will all decrease. As the footnote to the table indicates, however, even with decreases in energy use, energy resources will continue to decrease because any energy used at all decreases the non-renewable supply.

The mathematics of these relationships are described below.

1. Equations for Energy Use Levels

When the user enters a percentage change for a factor (see the sample run), the new energy use level for the factor is calculated by the following equation:

New Value = Old Value + (Old Value)(% Change)

When the user does not enter a change for a factor, the energy use level for the factor changes automatically by the following percentages:

Factor	Percentage Change
Industrial Production Level (IPL)	6%
Industrial Pollution Standards (IPS)	6%
Utilities Production Level (UPL)	4%
Utilities Pollution Standards (UPS)	6%
Transportation Pollution Standards (TPS)	6%
Mass Transportation (TMT)	4%
Automobile Efficiency (AE)	8%
Appliances (A)	6%
Home Heating and Lighting (HH)	4%
School and Business Heating and Lighting (BSH)	2%

The equation for the new automatically changed values is:

New Value = Old Value + Old Value (Percentage)

2. Equations for Current Energy Demands (CED)

The energy use levels (in the equations shown in 1) are used to calculate current energy demands. There are five equations for current energy demands, one for each of the five categories in which energy is used, each of which has one or more energy use factors:

Industrial Energy Demand (IED)
Utilities Energy Demand (UED)
Transportation Energy Demand (TED)
Homes Energy Demand (HED)
Business and Schools Energy Demand (BSED)

The simplified equations are:

$$\text{IED } \alpha^{*} \text{ IPL} + \text{IPS}$$
$$\text{UED } \alpha \text{ UPL} + \text{UPS}$$
$$\text{TED } \alpha \text{ V}^{**} + \text{TPS} - \text{TMT} - \text{AE}$$
$$\text{HED } \alpha \text{ A} + \text{HH}$$
$$\text{BSED } \alpha \text{ BSH}$$

Total current energy demand (CED) is, of course, the sum of the energy demand in all five categories, or

$$\text{CED} = \text{IED} + \text{UED} + \text{TED} + \text{HED} + \text{BSED}$$

* "α" is the symbol used to represent "is proportional to."

** V is a measure of automobile use. Its initial value can be changed within the program. It is automatically increased 7% each year.

The intial energy demand values, for the starting year 1975, in these five categories are:

$$IED = 22 \text{ BTU's} \times 10^{15}\text{*}$$

$$UED = 19 \text{ BTU's} \times 10^{15}$$

$$TED = 18 \text{ BTU's} \times 10^{15}$$

$$HED = 9 \text{ BTU's} \times 10^{15}$$

$$BSED = 6 \text{ BTU's} \times 10^{15}$$

$$1975\ CED = 74 \text{ BTU's} \times 10^{15}$$

3. Equations for Pollution Level (PL), Economic Well-Being (EWB) and General Satisfaction Level (GSL)

Energy use levels from equations in 1 above are also used in equations that calculate pollution level, economic well-being, and general satisfaction. The equations for these dependent variables are:

$$PL \quad (UPL + IPL) - (IPS + UPS + TPS)$$

$$EWB \quad IPL + UPL$$

$$GSL \quad A + HH + BSH + IPL$$

4. Equations for Calculating Yearly Energy Supply

The energy resources in this simulation are characterized as automatically decreasing by 1% a year; that is, total energy available each year will be 1% less than the year before. Each year's energy supply is, of course, added to the surplus energy from the year before to make the total energy supply for the year. The equation is

New Supply = Old Supply - Current Demand + (Old Supply)(.99)

or

New Supply = Surplus + 99% of Old Supply

* BTU stands for British Thermal Unit which is the amount of heat required to raise the temperature of one pound of water 1° Fahrenheit.

5. Unexpected Events

Unexpected news flashes about new energy sources, randomly introduced by the program, increase the energy available by a randomly selected amount from 2% to 10%.

INSTRUCTIONS FOR RUNNING "ENERGY"

1. How to Answer 'Do You Want' Questions

- Enter YES or NO

2. <u>To Enter Changes in Energy Use Factors</u>

- <u>To Specify Changes</u>: When asked 'DO YOU WANT TO CHANGE FACTORS,' answer YES, and read the instructions that will be printed out. They will tell you to enter changes by typing the factor ID number (1 to 10), a comma, and the percent change; for example, to reduce the appliance factor (ID number 8) by 25%, enter 8, -25. Wait for the '?' to be printed, then carefully type in each change. If you make a change that is more than 75%, the program will automatically calculate the change at 75%. When you are through entering changes, type 0,0.

For example,

```
1,7
4,16
5,-4
0,0
```

- <u>Automatic Changes:</u> For each factor not deliberately changed in any one year, the program will calculate an automatic change.

- <u>To Eliminate Automatic Changes:</u> Type ID number, comma, zero--for example, 8,0 will eliminate automatic changes in factor number 8. This means the energy use for this factor will remain the same as the year before.

3. <u>Alternate Kinds of Output</u>

- <u>Total Energy Supply and Demand--Graphed or Listed:</u> At the end of each year, the total energy supply and demand can be output in graph or list form. In both cases, year-end levels of pollution, economic well-being, and general satisfaction are printed at the right.

  For a graph, answer YES to the question: WANT RESULTS GRAPHED? (Whenever a graph is printed out, it will show energy supply and demand totals for all years from the beginning of the run up to and including the current one.)

For a list, answer NO to the question: WANT RESULTS GRAPHED? The list of total energy supply and demand for only the current year will be printed out.

- List of Current Energy Demands in Five Areas: After the graph or list of total energy supply and demand is printed out, you can obtain a breakdown of the current energy demand in each of the five energy-use categories by answering YES to the question: DO YOU WANT A LIST OF CURRENT ENERGY DEMANDS?

4. To Correct Changes You've Typed in Incorrectly

- To Correct Incorrectly Entered ID Number (e.g., 8,2 should have been 9,2), first return factor 8's value to the correct new one by typing 8, and the correct new value (or if you do not have a new value, type 8,0 to return it to its old value). Then type 9,2.

- To Correct Incorrectly Entered Percentage (e.g., 6,-5, should have been 6,-15), simply retype the entry correctly on the next line.

Note: If incorrect entries are discovered after you have typed 0,0, there is no way to correct them. A new run must be made.

5. To Stop the Program

- Type STOP in answer to any question.

Sample Run

```
ENERGY

USING THIS ENERGY SIMULATION, YOU CAN TRY
TO SOLVE THE ENERGY PROBLEM BY CHANGING THE RATE AT WHICH
ENERGY IS USED.  YOUR GOAL IS TO KEEP THE DEMAND FOR ENERGY
WITHIN THE AVAILABLE SUPPLY.  AT THE SAME TIME YOU SHOULD
TRY TO
     > REDUCE THE LEVEL OF POLLUTION
     > INCREASE THE ECONOMIC CONDITION OF THE NATION
     > INCREASE THE GENERAL SATISFACTION OF THE PEOPLE

YOU CAN CONTROL THE RATE AT WHICH ENERGY IS USED BY CHANGING
FACTORS IN TEN DIFFERENT AREAS.  EACH FACTOR AFFECTS THE
TOTAL AMOUNT OF ENERGY USED.

START OF YEAR - 1975

     CURRENT ENERGY DEMAND:                          FACTORS IN AREAS
     BTU TIMES 10 TO THE 15TH                 ID#    YOU CAN CHANGE

       22          INDUSTRY                    1     PRODUCTION LEVEL
                                               2     POLLUTION STANDARDS

       19          UTILITIES                   3     PRODUCTION LEVEL
                                               4     POLLUTION STANDARDS

       18          TRANSPORTATION              5     POLLUTION STANDARDS
                                               6     MASS TRANSPORTATION
                                               7     AUTOMOBILE EFFICIENCY

       9           HOMES                       8     APPLIANCES
                                               9     HEATING / LIGHTING

       6           BUSINESS AND SCHOOLS       10     HEATING / LIGHTING

WANT RESULTS GRAPHED?YES

 135    I                                              POLLUTION LEVEL
        I                                                    19.79
        I
        I
        I                                            ECONOMIC WELL-BEING
        I                                                    15
        I
  95    I
        I                                            GENERAL SATISFACTION
        I                                                    26
        IS
        ID
        I                                           S = SUPPLY OF ENERGY
        I                                           D = ENERGY DEMAND
  55    I                                           E = DEMAND EQUALS SUPPLY
        I- - - - - - - - - - - - - - - - - -
        1975 76  78  80  82  84  86  88  90

DO YOU WANT TO CHANGE ANY FACTORS? ?YES

TO MAKE A CHANGE, ENTER THE FACTOR ID NUMBER, A COMMA
AND THE PERCENT CHANGE.

FOR EXAMPLE,  TO REDUCE THE USE OF APPLIANCES IN THE HOME
BY 25%  YOU ENTER   8,-25

WHEN YOU ARE DONE ENTERING CHANGES, ENTER  0,0
?1,-2
?3,-4
?5,3
?6,-2
?7,5
?8,-1
?9,-2
?10,-1
?0,0
```

```
WANT RESULTS GRAPHED? YES

END OF YEAR - 1975

 135    I                                          POLLUTION LEVEL
        I                                               19.78
        I
        I
        I                                        ECONOMIC WELL-BEING
        I                                               14.52
        I
  95    I
        I                                        GENERAL SATISFACTION
        I                                               25.63
        IS S
        ID D
        I                                        S = SUPPLY OF ENERGY
        I                                        D = ENERGY DEMAND
  55    I                                        E = DEMAND EQUALS SUPPLY
        I- - - - - - - - - - - - - - - - - -
        1975 76  78  80  82  84  86  88  90

DO YOU WANT A LIST OF CURRENT ENERGY DEMANDS? ?YES

    CURRENT ENERGY DEMAND:                          FACTORS IN AREAS
    BTU TIMES 10 TO THE 15TH                  ID#   YOU CAN CHANGE

     22         INDUSTRY                       1    PRODUCTION LEVEL
                                               2    POLLUTION STANDARDS

     18         UTILITIES                      3    PRODUCTION LEVEL
                                               4    POLLUTION STANDARDS

     18         TRANSPORTATION                 5    POLLUTION STANDARDS
                                               6    MASS TRANSPORTATION
                                               7    AUTOMOBILE EFFICIENCY

     9          HOMES                          8    APPLIANCES
                                               9    HEATING / LIGHTING

     6          BUSINESS AND SCHOOLS           10   HEATING / LIGHTING

DO YOU WANT TO CHANGE ANY FACTORS? ?YES
USE THE SAME FORMAT AS BEFORE FOR ENTERING CHANGES
?6,10
?0,0

WANT RESULTS GRAPHED? YES

END OF YEAR - 1976

 135    I                                          POLLUTION LEVEL
        I                                               19.76
        I
        I
        I                                        ECONOMIC WELL-BEING
        I                                               15.22
        I
  95    I
        I                                        GENERAL SATISFACTION
        I   S                                           26.83
        IS S
        ID D D
        I                                        S = SUPPLY OF ENERGY
        I                                        D = ENERGY DEMAND
  55    I                                        E = DEMAND EQUALS SUPPLY
        I- - - - - - - - - - - - - - - - - -
        1975 76  78  80  82  84  86  88  90

DO YOU WANT A LIST OF CURRENT ENERGY DEMANDS? ?STOP

DONE
```

EXERCISES USING "ENERGY"

1. Make one trial run of ENERGY for a 10-year period and analyze the effects of your energy measures to determine which appeared most effective in solving the energy problems and which the least effective.

    a. On the basis of the analysis of your first run, decide on the most effective strategy for a 10-year period and make a new run using this strategy.

    b. Analyze the results of your second run, and decide on a more effective strategy yet, then try it out in a third 10-year run.

2. What were the limits and scope of the ENERGY model as you experienced them in your runs of the program?

    a. How many factors could you change in your efforts to solve the energy problem?

    b. Which changes did you make, if any, that resulted in an increase in total energy supply?

    c. Did you find it easy to keep the energy demand within the available energy supply over a 10-year period?

    d. What effects did the unexpected "news flash" events have on the overall energy situation?

    e. Was the nation's economic well-being affected by changes in appliances, home heating and lighting, or schools' and businesses' heating and lighting?

    f. What changes had the clearest effects on the general satisfaction of the populace?

    g. When pollution level went up, did the general satisfaction of people consistently go up or down? Or was there no apparent relationship between the two? What (if any) relationship should exist between the two?

3. Assume you are a politician who wishes to see the pollution level go down by 10% and the general satisfaction of the public go up by 50% between 1975 and 1980.

Study the information given on pages 14-20 about the ENERGY model and design a strategy to accomplish this goal. Then try out your strategy by making one run of the ENERGY program.

a. Analyze your results to determine how well your strategy worked and what its strong and weak points were.

b. Optional: Write a "Report to the People," explaining the outcome of your measures and proposing a new and more effective strategy which you would implement if you are re-elected.

4. Assume you are an ecologist whose main interest is in reducing the pollution level by 20% and not increasing energy demand over 10% between 1975 and 1980. Study the information on pages 14-20 about the ENERGY model. Then design your strategy to accomplish your goal and try your strategy out using ENERGY.

a. Analyze the results of your 1975-80 strategy and develop an even more effective strategy to present in a "Report to the People." In your Report, defend your 1975-80 strategy and try to persuade the people that your new strategy is even better.

SOURCES OF INFORMATION ON THE ENERGY CRISIS

Books

Energy and Power, W. H. Freeman, San Francisco: Scientific American Books, 1971. (Eleven easy-to-read articles about energy today.)

Energy: Demand Vs. Supply. Diana L. Reische, Ed. New York: The H. W. Wilson Company, 1975.

Energy: The Continuing Crisis. Norman Metzger. New York: Thomas Y. Crowell Co., 1976.

Energy for Survival. Wilson Clark. Garden City, New York: Anchor Books, 1974. (An analysis of alternate energy sources whose development might provide a partial solution to our energy problems.)

Energy Crisis--Volume 1, 1969-73. Lester A. Sobel, Ed. New York: Facts on File, Inc., 1974. (This book traces the development and events of the energy crisis through a series of news articles written as weekly coverage of news events.)

A Time to Choose--America's Energy Future. Final Report of the Energy Policy Project of the Ford Foundation. Cambridge, Massachusetts: Ballinger Publishing, 1974. (An examination of the future shape of the energy shortage, this report is very well documented with up to date data.)

Newspapers

Everyday newspapers carry new stories about the energy crisis, including local and national problems and plans.

Periodicals and Reference Works--Subject Headings

A wealth of information on the energy crisis is contained in periodicals and standard reference works like encyclopedias. Subject headings which you can use to locate information through card catalogs, Encyclopedia Yearbook Indexes, and other standard indexes are:

Atomic energy
Atomic power
Atomic research
Automobiles

Coal mines and mining
Coal research
Conservation of energy
Conservation of natural resources

Diesel engines

Economics
Electric power
Electric utilities
Electricity
Energy crisis
Energy crisis--U.S. Foreign Policy
Energy crisis--sources

Fuel
Fuel research
Fuel supply

Gas, natural
Gas, industry
Gas manufacture and works
Gasoline
Geothermal energy

Hydroelectric plants
Hydrogen, liquid

Industry and state
Industry and the environmental movement
Insulation
International Atomic Energy Agency

Nuclear fuels
Nuclear fusion
Nuclear reactors

Petroleum
Petroleum industry
Petroleum refineries
Petroleum supply
Power resources

Solar energy
Solar furnaces (heating)
Strip mining

United States Energy Agency
United States Federal Power Commission

Wind power