DOCUMENT RESUME

ED 097 212 SE 018 218

TITLE	Electrical Production and Pollution Control. Environmental Education Curriculum.
INSTITUTION	Topeka Public Schools, Kans.
SPONS AGENCY	Bureau of Elementary and Secondary Education (DHEW/OE), Washington, D.C.
PUB DATE	Mar 74
NOTE	120p.; Best copy available; Occasional marginal legibility
EDRS PRICE	MF-$0.75 HC-$5.40 PLUS POSTAGE
DESCRIPTORS	Conservation Education; *Curriculum Guides; Electricity; *Energy; *Environment; *Environmental Education; Instruction; Instructional Materials; Learning Activities; Lighting; Natural Resources; *Secondary School Science; Technology
IDENTIFIERS	Electrical Production; Elementary Secondary Education Act Title III; ESEA Title III; *Pollution Control

ABSTRACT

Citizen use of our nation's industrial products has led to increased pollution problems and demand for diminishing energy reserves. In an attempt to encourage intelligent cooperation among science, industry, government and all citizens, this unit was developed to introduce secondary science students to the many facets of the electrical production industry. It focuses on one plant--the Lawrence Kansas Power and Light generating station--which provides examples of the machinery used to produce electricity and methods for controlling much of the resulting pollution. The module discusses uses of electricity, problems and solutions of pollution control, economics and the electrical industry, nuclear energy and energy shortages. A suggested time line is provided sequencing events leading to the trip to the plant. Also included are lists and descriptions of materials needed and suggestions of appropriate methdologies and guidelines for the field trip. Appendices include a glossary of terms and patterns for developing relating transparencies. (MLB)

environmental education curriculum

ENVIRONMENTAL EDUCATION PROJECT
ESEA TITLE III, SECTION 306

Topeka Public and Parochial Schools
1601 Van Buren, Topeka, Kansas 66612
Phone: 913-232-9374

A unit developed by the Environmental Education Project Staff, March, 1974, for secondary science students.

Donald French, Project Coordinator
Robert King, Program Specialist - Secondary
Glenn Clarkson, Program Specialist - Elementary
Thad Whiteaker, Program Specialist - Special Education

ELECTRICAL PRODUCTION AND POLLUTION CONTROL

The work presented or reported herein was performed pursuant to a grant from the United States Office of Education. However, the opinions and material expressed herein do not necessarily reflect the position or policy of the U. S. Office of Education, and no official endorsement by the U. S. Office of Education should be inferred.

ELECTRICAL PRODUCTION AND POLLUTION CONTROL

Foreword

The development of our nation's industries has played a crucial role in providing us increasingly high qualities of food, housing, transportation, and recreation. Industrial development has also increased our air, water, sound, and solid waste pollution problems. Citizen use of the products of the industrial age had led to a growing environmental crisis and an increasing demand for diminishing energy reserves. Intelligent cooperation between science, industry, government, and all citizens will be required if man is ever to achieve and maintain a stable balance with his environment and his energy needs.

In an attempt to encourage this cooperation, the Environmental Education Project and its target teachers developed this module to introduce students to the many facets of the electrical production industry. The module focuses on one plant--the Lawrence Kansas Power and Light generating station.

In the production of electricity, this generating station creates air, heat, and solid waste pollution. It also creates electricity, which is used to control pollution, raise our standard of living, and provide jobs. The plant shows good examples of the machinery used to produce electricity and methods for controlling much of the resulting pollution.

This module focuses on five broad topics:

1) What is electricity? How is it made? How is it used?
2) Pollution control: problems and solutions.
3) Economics and the electrical industry.
4) Practical applications of electrical theory.
5) Energy shortages--causes and predictions.

These topics are developed with class and individual activities, films, papers, and a trip to the Lawrence Kansas Power and Light generating station, and the University of Kansas engineering laboratories and nuclear reactor center.

The achievement of the stated goals is guided with behavioral objectives, teacher suggestions, and questions to the students with each activity, film, and paper. The achievement is measured with carefully written and evaluated tests based on the behavioral objectives.

Robert E. King

Robert E. King
Secondary Program Specialist

ACKNOWLEDGMENT

The Environmental Education Project for the Topeka Public and Parochial Schools began operation June 29, 1971. The following individuals deserve recognition for the interest, time, and devotion they gave during the difficult stages of planning and writing the project proposal:

Mr. John Ganger, Coordinator of Curriculum for Special Education
Mr. W. I. Green, Director of Special Education
Dr. Quinton Groves, Director of Health, Physical Education, Safety, and Athletics
Mr. Clarence "Tuffy" Kellogg, Assistant Director of Health, Physical Education and Safety
Mr. Stanley Martin, Science Supervisor
Mr. Calude Ritchie, Principal, Gage Elementary School
Mr. William Wagaman, Principal, Avondale East Elementary School
Mr. Lawrence R. Gaston, Director of Federal Programs
Dr. Gilbert Wehmeier, Principal, Curtis Junior High School

The needed support given the project by Dr. Merle R. Bolton, superintendent of schools, other members of the central administrative staff; the instruction department; personnel office; business office; data processing department; maintenance department; and Lawrence Gaston, director of federal programs, is gratefully acknowledged.

Special recognition is given to the Board of Education for the Topeka Public Schools, who approved and are supporting this creative, exemplary, and innovative project.

My sincere gratitude is extended to the program specialists for their tireless efforts in developing this secondary module. Curriculum development and revision has extended the working days for these staff members. My personal thanks are given to Bob King, Glenn Clarkson, and Thad Whiteaker for an outstanding job.

Assistance given by the following individuals in developing materials and/or coordinating of field trips is sincerely appreciated. Kansas Power and Light Company - H. L. Hudson, M. D. Funston, W. E. Brown, M. L. Brunton, T. A. Kostanski, L. R. Nicholson, and W. L. Perdue: University of Kansas - Art Breipohl, Claude Summers, Russ Messler, and Hobart Woody: Kansas State University - J. Kenneth Shultis and N. D. Eckhoff: and the Gas Service Company - Jess Ewing.

The enclosed curriculum is the result of input from the project's paraprofessionals (Norma Hurd, Marlys Strobel, Prue Hendrix, Lynn Wilkerson, and Sue Beattie), and many volunteers, science teachers, Community Council members, parents, students, and interested lay citizens.

With the deepest appreciation, I acknowledge the work of the secretarial team. The constant revision, pressures, deadlines, and demands for quality work were handled in a most outstanding manner by Dorothy Booher, Rita Dreiling, Sue Beattie, Joyce Hartman, and Linda Hough. T. W. Mack is responsible for the sketches.

Donald French

Donald French
Project Coordinator

TABLE OF CONTENTS

Title Page. i
Foreword. ii
Acknowledgement. iii
Table of Contents iv
Module Goals 1
Use of Teaching Materials 1
Suggested Time Line for Module Activities 2-3
Module Materials List 4
Film Descriptions 4
A Word About Behavioral Objectives. 5-6
Behavioral Objectives 7-9
Class Performance Summary Sheet 10-18
Student Papers and Teaching Suggestions:
    Introduction . . . . A: 1-2
    Energy and Today's Society . . . . B: 1-3
    What is Electricity. . . . . C: 1-5
    Making Electricity . . . . D: 1-12
    Making Electricity - Seven Ways. . . . . E: 1-5
    Environmental Costs of Producing Electricity . . . . F: 1-9
    Economics of the Kansas Power and Light Company. . . . . G: 1-9
    Energy in the Future . . . . H: 1-7
    Nuclear Reactors . . . . I: 1-7
    Your Role in the Future. . . . . J: 1-4
The Field Trip
    Topics and Concepts. . . . . K: 1
    Suggestions for use of the two Field Trip Forms. . . . . K: 1
    "Requests to Principal for Field Trip" form. . . . . K: 2
    "Parental Permission" form . . . . K: 3
    Planning for the Substitute. . . . . K: 4
    Pre-Field Trip Lecture Suggestions . . . . K: 4
    Field Trip Time Line . . . . K: 4
    Directions for Trip Guides . . . . K: 5-14
    Field Trip Diagrams . . . . K: 15-16
Glossary. . . . . .Appendix 1,G: 1-3
Transparencies
    Ways the United States Uses Its Energy . . . . .Appendix 1,T-1
    Comparison of the Same Data on Two Types of Graphs . . . .Appendix 2,T-2
    Comparison of Two Graphs of Electricity Consumption. . . .Appendix 3,T-3
    Composite Energy Usage Graphs. . . . . .Appendix 4,T-4
    Steam Flow in a Generating Station . . . . .Appendix 5,T-5

ELECTRICAL PRODUCTION AND POLLUTION CONTROL

Module Goals: The module seeks to reinforce and expand knowledge and values in the following areas:

1) What is electricity? How is it made? How is it used?

2) Pollution control: problems and solutions.

3) Economics and the electrical industry.

4) Nuclear energy: what is it?

5) Energy shortages: causes, predictions, and suggested actions.

USE OF TEACHING MATERIALS

The suggested time line (pages 2-3) for this module is provided to allow easier planning.

The "Module Materials List" (page 4) indicates the supplies you need to obtain to teach the module.

Film descriptions (page 4) describe suggested and optional films and filmstrips.

Pages 5 and 6 provide a brief summary of the development and use of the behavioral objectives in this module. The behavioral objectives (pages 7-9) indicate the concepts and abilities that most of your class should gain from studying this module.

The posttest (pages 10-17) for this module is included with the correct answers circled. This allows you to see the types of questions keyed to the behavioral objectives. Please do not teach the questions, but use the behavioral objectives. Many objectives concern concepts which require interpretation and extrapolation. Teaching the test questions requires only rote memorization. Student pre and posttest results are reported using this form.

The rest of this manual contains the papers available in the student manual. Following each one of the student papers, you will find sheets of green paper. These pages contain: 1) behavioral objectives tied to the paper; 2) suggestions for presenting the papers; and 3) answers to the student self-test questions. Particular attention should be given to the film material <u>before</u> presenting the film.

SUGGESTED TIME LINE FOR MODULE ACTIVITIES

The time line below is written in the ideal sequence of events with the average time required for teaching each activity indicated in parentheses. The times, of course, will vary from class to class. The day, or days, planned for each activity may be noted in the blank spaces to the left of each paper to be used.

Day	Before the Field Trip
	Arrange the field trip date with the project staff, and obtain the student pre-tests. Obtain approval for the field trip dates from the building principal (use Paper K-2). Invite him to visit the field trip.
____30 min.	1. Give the pre-test. Return all tests and answer sheets as soon as possible to the project for scoring.
____30 min.	2. Hand out student books, read, and discuss the "Introduction," Paper A.
	Obtain an overhead projector for use with Transparencies 1-4 and Paper B.
____55 min.	3. Read Paper B, "Energy and Today's Society." Use the transparencies while discussing the student self-test questions as a class. If the class tires of working with graph interpretation, reserve questions 8-17 for discussion following Paper E.
	Organize a power pack, compass, insulated wire, copper sulfate, and other materials as appropriate for teaching students about properties of electricity.
____55 min.	4. Read Paper C, "What is Electricity." Do appropriate class demonstrations and experiments. Do the self-test questions.
____55 min. (Optional)	5. If time and materials allow, students can enjoy and profit from experiments with electromagnets, electroplating metals, and so on. Most physical science source books have a variety of ideas.
	Obtain and clean a metal can with a screw cap lid, a pyrex Florence flask, with a one-holed stopper and thermometer, and a good heat source. Obtain an overhead projector for use with Transparency T-5.
____75 min.	6. Read and discuss Paper D, "Making Electricity." Demonstrate the role of the condenser in promoting efficient use of steam, and discuss the steam cycle followed at KPL using the transparency.
	Duplicate Page K-3. Send parental permission slips home.

____40 min.	7.	Read and discuss Paper E, "Making Electricity Seven Ways." Finish discussion of Paper B, "Energy and Today's Society," if time remains.
		Obtain the 16 mm film projector.
____55 min.	8.	View the film, Environment, and promote a class discussion of the conflicts between man's needs, comfort requirements, and environmental quality.
____55 min.	9.	Read and discuss Paper F, "Environmental Costs of Producing Electricity."
____55 min.	10.	Read and discuss Paper G, "Economics of the Kansas Power and Light Company."
		Obtain a record player and filmstrip projector. Obtain the filmstrip record "The Energy Crisis" from the Environmental Education Office.
____30+ min.	11.	Show appropriate portions of the filmstrip-record combination "The Energy Crisis."
____30 min.	12.	Read and discuss Paper H, "Energy in the Future."
		Call the Environmental Education Office (232-9374) to confirm arrangements for the substitute, the times of departure and number of students participating. Remind students to return parental permission slips and notify other teachers of the field trip.
____55 min.	13.	Read and discuss Paper I, "Nuclear Reactors."
____10 min.	14.	Give students the appropriate set of field trip rules and regulations, as contained on Page K-4. Prepare your lesson plans for the substitute.
____3 hours 25 min.	15.	Field trip - 3 hours and 25 minutes. Give the substitute her instructions. Bring student permission slips on the trip with you.
____30 min.	16.	Read and discuss Paper J, "Your Role in the Future."
____30 min.	17.	Review the field trip and module objectives using the behavioral objectives (pages 7-9).
____30 min.	18.	Give the post-module test. Fill out the unit evaluation forms, and return the tests and forms to the project office. Test results should be returned in 10 school days.

Module Materials List

The time line indicates when materials are needed for teaching the papers and exercises in this module. One class of 30 students requires the quantities below.

Curriculum Materials

1 Teacher's Guide
30 Student Booklets
30 Pre and Posttests
60 IDH Answer Sheets

Experimental and Demonstration Materials

Basic

1 Battery
1 Compass
2-foot Wire
1 Nail
Copper Sulfate
1 Powerpack

Optional

Class sets of the above
1 metal can with a screw lid
1 Florence Flask
1 one-hole Stopper
1 Thermometer
1 Burner

Audio-Visual Requirements

Basic

Overhead Projector
16 mm Film Projector
Filmstrip Projector
Record Player

Audio-Visual Descriptions

The 16 mm film below may be obtained from the Topeka Public Schools' Audio-Visual Department.

Environment - color, 28 min.

Following an effective introduction, the human race is placed on trial with a prosecutor, defense attorney, and judge who consider the evidence provided by five common citizens. Arguments for and against urban expansion, power generation, modern farming practices, purchasing practices, and environmental attitudes are presented in a stark and gripping fashion. The film provides an excellent springboard for a balanced class discussion of environmental problems.

The filmstrip-record combination described below can be obtained from Eisenhower Junior High or from the Environmental Education office.

The Energy Crisis - 3 sets, 30 minutes each

Three sets of filmstrips present why we have an energy crisis, examine our current problems, and look at futuristic solutions. Set 3 is the best of the three and should be used first if you are pinched for time.

A Word About Behavioral Objectives

The goals of this module are defined through the use of behavioral objectives. The behavioral objectives establish a predetermined goal toward which learning is to be directed and by which attainment may be measured. This unit is intended to develop student changes in both the cognitive (knowledge) and the affective (attitude) domains. The behavioral objectives for this unit contain these basic parts:

1) The concept, or skill being evaluated.
2) The expected criterion (percent of students who should correctly respond).
3) The Bloom's taxonomy level at which the concept will be tested.

All concepts will be evaluated using multiple choice questions with only one correct answer.

The present trend in education is toward stricter educational accountability. Behavioral objectives help define some of the desired outcomes for which education can be accountable.

Student learning is not all at the same level. For example, direct recall of a fact requires fewer mental manipulations than applying a concept to a new situation. One system for indicating the level of difficulty of a desired response is through the use of Bloom's taxonomy. The higher the Bloom's number assigned to an objective, the higher the level of desired competence with a particular concept. Following are descriptions of Bloom's levels assigned to each objective.

Cognitive Objectives

<u>Knowledge Level</u>

1.11 Knowledge of Terminology
1.12 Knowledge of Specific Facts
1.21 Knowledge of Convention
1.22 Knowledge of Trends and Sequences
1.23 Knowledge of Classifications and Categories
1.24 Knowledge of Criteria
1.25 Knowledge of Methodology
1.30 Knowledge of Universals and Abstractions in a field
1.31 Knowledge of Principles and Generalizations
1.32 Knowledge of Theories and Structures

<u>Intellectual Level (Cognitive)</u>

2.10 Translation
2.20 Interpretation
2.30 Extrapolation
3.00 Application
4.10 Analysis of Elements
4.20 Analysis of Relationships

Affective Objectives

1.0 Receiving Level

- 1.1 Awareness
- 1.2 Willingness to Receive
- 1.3 Controlled or Selected Attention

2.0 Responding Level

- 2.1 Acquiescence in Responding
- 2.2 Willingness to Respond
- 2.3 Satisfaction in Response

3.0 Valuing Level

- 3.1 Acceptance of Value
- 3.2 Preference for a Value
- 3.3 Commitment

4.0 Organization Level

- 4.1 Conceptualization of a Value
- 4.2 Organization of a Value System

Affective Objectives
(Continued)

The following behavioral objectives are intended to give teachers direction during the teaching of this unit. The behavioral objectives define only key concepts basic to the entire unit. They do not define all the learning experiences that will occur. The objectives will be revised as more student data becomes available. This data will provide the necessary information to calculate realistic criterion levels.

Please teach with the objectives, not the test questions in mind. For the knowledge level objectives, students are expected to know specific things. However, for the intellectual level objectives, students are expected to take knowledge, apply it to an unfamiliar situation, and determine the best answer. Teaching the test question turns a level 2, 3, or 4 test question into a level 1, or knowledge level question.

Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
1		Attitude questions are answered completely and truthfully (as measured by a and b below). a) Ninety percent of all students will respond to each opinion question. b) No more than 10 percent of the students will use patterned responses to unit evaluation questions.	2.2a		all
2	60	Environmental Education Project Modules are worth studying. *Posttest question only.	3.2a	70%	all
3	22	All schools should teach more about the ways the environment affects people and people affect the environment.	3.2a	10%	all
4	33 34	For the good of our country, large amounts of energy must always be available.	3.3a 3.3a	10%	B,F,J
5	1	Electrical usage rates correlate closely with the Gross National Products of modern societies.	1.22c	20%	B
6	11	Given semi-log graphs of energy usage rates, translate the information into a verbal description.	2.20c	20%	B
7	23	The average U.S. citizen uses much more energy than do most of the people in the world.	1.1a	20%	B
8	24	Students shall indicate that they feel able to interpret most charts and graphs.	2.3a	10%	B,F,K
9	12	Electric currents are a stream of moving electrons.	1.30c	25%	C,D,E
10	2	Electric currents flow in circles, and may be initiated by moving magnetic forces.	2.20c	55%	C,D
11	13	Given the amps and volts of an appliance, students shall be able to determine its wattage and kilowatt hour requirement.	3.00c	35%	C

Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Actities Developing the Objectives
12	3	Match the portion of a power plant with the energy transformation it accomplishes.	1.31c	25%	C,D,E
13	14	Select the best explanation for the inability to convert all heat energy in steam to mechanical energy in the turbines.	1.31c	10%	D,I
14	4	Select the description of a process used in KPL to improve energy use efficiency.	1.12c	10%	D
15	15	Given these words - fire, spinning magnet, coils of wire, steam, and turbine blades - indicate the sequence followed by energy as electricity is made.	1.25c	25%	D,E
16	5	Steam is used to turn turbine blades in all nuclear powered generating stations.	1.25c	20%	E
17	16	Fossil fuels will cease being major sources of energy during the coming centuries.	1.30c	20%	E,H
18	6	The sequence of steps which reduce the ash and sulfur dioxide emitted from the KPL plant.	1.25c	30%	F
19	17	Select a graph showing the relationship between costs of pollution control and the percentage of pollutants controlled.	2.20c	20%	F
20	25 26 36 37	In a series of attitude questions, students shall indicate that: a) Creating and installing effective pollution control equipment requires much time, money, and research. b) Pollution controls should be used if pollution significantly damages the environment. c) Costs of controlling pollution should be part of all product's costs.	1.1a 2.1a 2.1a 3.1a	10% 10% 10% 10%	F,I
21	7	Select a sentence summarizing the past and projected future growth rate of KPL.	1.22c	20%	G,H
22	18	Select the most realistic distribution of KPL's income for raw materials purchase, labor costs, and taxes.	1.12c	20%	G

Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
23	8	Select the best use for capital in business.	1.11c	25%	G,H
24	19	From a list of six select three restrictions placed on KPL by Kansas.	1.12c	20%	G
25	9	Select the best summary of the reasons for expecting energy costs to rise for many years.	1.30c	20%	H
26	20	Select the best summary of the differences between thermal and breeder reactors.	1.12c	20%	H,I
27	10	Select the best sentence differentiating between radioactive decay and nuclear fission.	1.12c	30%	I
28	21	Select the best definition of "half-life."	1.12c	20%	I
29	27 28 29	Non-returnable and excessive packaging, purchases based on style changes, and the use of poorly insulated homes all waste large amounts of energy.	3.1a 3.1a 3.1a	10% 10% 10%	J
30	30 31	Indicate a committment to asking others to conserve energy when flagrant abuse is observed.	3.1a 3.3a	10% 10%	J
31	38 39 40	Society should encourage all forms of production of energy from non-fossil fuel sources so long as the by-products of the energy production do not damage the environment significantly.	3.1a 3.1a 3.1a	10% 10% 10%	J
32	32	Given a list of five occupations, select jobs which will have the highest potential for making a good living ten to twenty years from now.	1.1a	10%	J

CLASS PERFORMANCE SUMMARY SHEET

The following pages indicate how your class(es) responded to the pre and post-module tests. The following code is used throughout the test.

A -- Percentage of students responding correctly on the pre-module test.

B - Percentage of students responding correctly on the post-module test.

C -- Percent growth expected between pre and post-module tests.

D - Phi score for the test item. This score shows the quality of the test questions. Phi scores below 25 indicate either a poor test item or a topic that was not taught well in the unit. Phi scores above 40 indicate a very good test item which was well taught.

The opinion questions have two scores listed for each test result. "+" scores indicate the percentage of students agreeing with the statement and "-" scores indicate those disagreeing. The students with no opinion make up the remaining and unreported percentage.

The correct answers are circled.

____ A	____ B
20% C	____ D

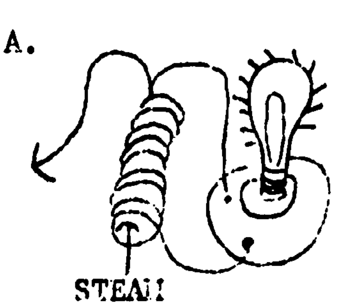
1. The GNP of a country is a measure of the total worth of all the things produced by its people. How much electricity does the average person use in countries with a high GNP per person?

   A. The average electrical usage is <u>high</u> in every country with a high average GNP's.
   B. The average electrical usage is <u>high</u> in <u>most, but not all,</u> countries with high average GNP's.
   C. The average electrical usage is <u>high</u> in <u>only a few</u> countries with high average GNP's.
   D. The average electrical usage is <u>low</u> in <u>all</u> countries with high average GNP's.

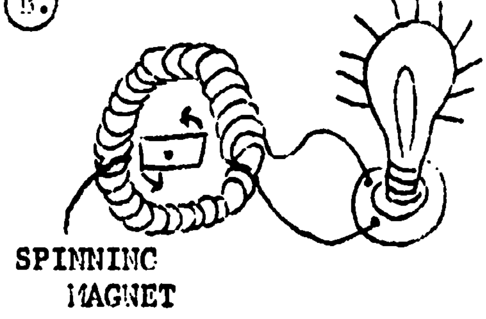
____ A	____ B
20% C	____ D

2. Select the picture which best shows how KPL makes electricity.

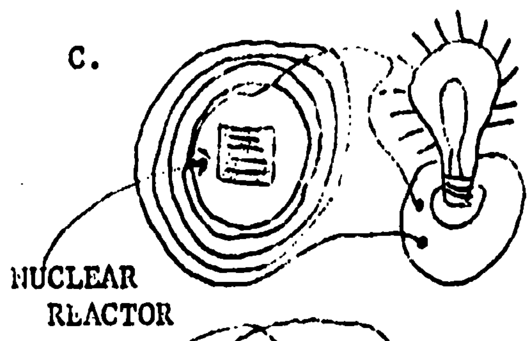
A.



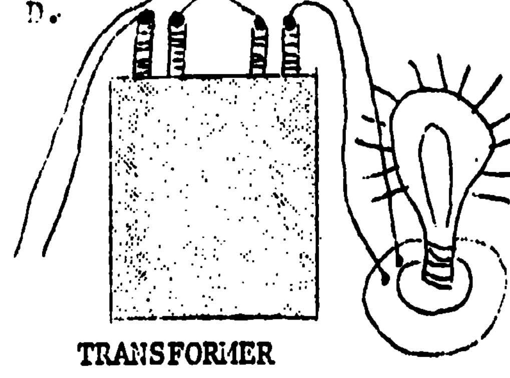
B.



C.



D.



A	B
25%	
C	D

3. Select the most accurate statement about fossil fueled power plants.
   A) Heat energy is created in the turbine and lost in the generator.
   B) In the boiler, nearly all of coal's chemical energy is changed into heat energy in steam.
   C) In the turbine, chemical energy becomes electrical energy.
   D) Mechanical energy in steam is changed to chemical energy before electricity is made.

A	B
20%	
C	D

4. Which one of the processes listed below helps KPL get the maximum electricity from its fuel energy?
   A) Hot gases are blown through the scrubber to remove ash.
   B) Steam is super-heated in the boiler before going to the turbine.
   C) Limestone is burned with coal in the boiler to remove sulfur dioxide.
   D) Medium pressure steam is re-pressurized in small tubes.

A	B
20%	
C	D

5. Electricity is made in nuclear powered generating stations by:
   A) using nuclear radiation to force electricity out of coils of wire.
   B) using steam to turn turbines hooked to generators.
   C) using fission to make thermal electricity inside the reactor.
   D) using radioactive atoms to power condenser batteries.

A	B
30%	
C	D

6. Select the correct <u>sequence</u> of steps used to remove most ash and sulfur dioxide from KPL exhaust gases.

   A) 1,3,4,5 B) 6,2,4,5 C) 1,6,2,5 D) 2,3,4,5

   1. Limestone is burned with coal.
   2. Limestone marbles are coated with water.
   3. Exhaust gases move through a water bed of marbles.
   4. Exhaust gases have water droplets removed.
   5. Exhaust gases are heated and blown out the stack.
   6. Air is blown through ash tunnels.

A	B
20%	
C	D

7. Which sentence is true?
   A) Electrical industries have been growing slowly but expect to grow faster.
   B) Electrical industries have been growing rapidly and expect to grow even faster during the next 20 years.
   C) Electrical industries now produce 60 percent of the energy used in the United States and expect to increase to 80 percent.
   D) Electrical industries have been growing very rapidly but expect to grow much more slowly during the next 20 years.

A ___ B ___ C ___ D ___

3. A well-run business should use capital to:

A) pay labor costs.
B) buy new equipment.
C) pay taxes.
D) buy fuels and raw material.

25% A ___ B ___ 20% C ___ D ___

9. Select the three biggest reasons for power companies raising the costs of electricity.

A. 1,3,5 B. 1,2,5 C. 1,2,4 D. 1,3,4

1. Fuels are becomming more expensive.
2. Controlling pollution requires large amounts of money.
3. Nuclear fuel costs much more than fossil fuel.
4. Borrowing money is costing much more money.
5. Electrical companies are cutting production to force the price up.

A ___ B ___ 20% C ___ D ___

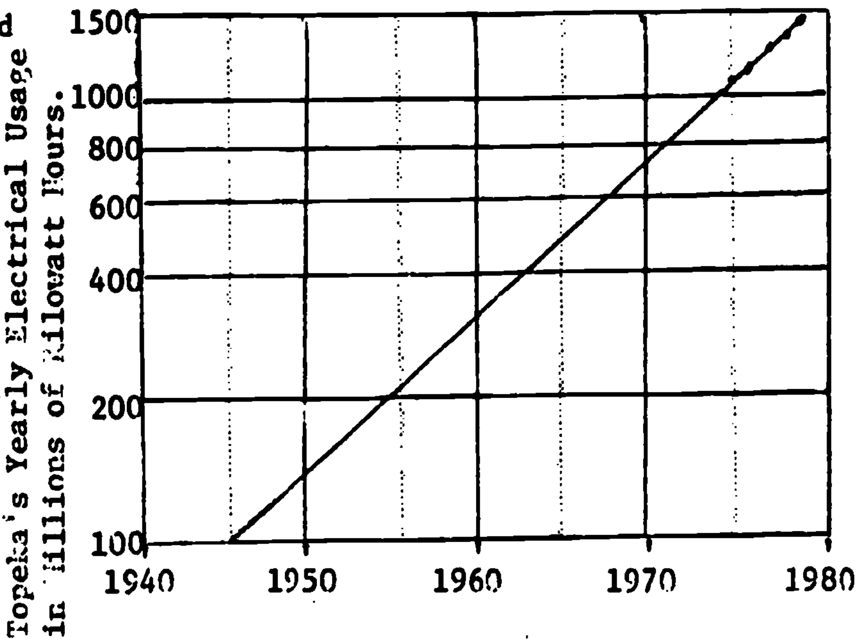
10. Select the true sentence.

A) Fissioning atoms split into two new atoms and release particles and energy.
B) Only radioactive atoms split to produce energy and particles.
C) Radioactive atoms produce only heat; fission produces light and particles.
D) Fission occurs naturally in most atoms; very few kinds of atoms are radioactive.

A ___ B ___ 20% C ___ D ___

11. The graph below shows the amount of electricity used in Topeka during the last 35 years. Select the best sentence.

A) Topeka has used about the same amount of electricity every year.
B) Topeka's use of electricity is increasing slowly.
C) Topeka's use of electricity has more than doubled every 10 years.
D) From 1965 to 1970, Topeka increased its use of electricity by the same amount as from 1950 to 1955.



A ___ B ___ 20% C ___ D ___

12. Electric currents are formed by:

A) moving copper wires.
B) neutrons moving in one direction.
C) electrons moving in one direction.
D) nuclear reactions in coiled wires.

A	B
35%	
C	D

13. An electric blender requires a 110 volt current and uses 3 amps. How many watts does it use, and how many kilowatt hours of energy would be used in four hours of operation?

    A) watts = 36.7; kilowatt hours = 146.8
    B) watts = 9.90; kilowatt hours = 39.6
    C) watts = 3.0; kilowatt hours = 132
    D) watts = 330; kilowatt hours = 1.32

A	B
20%	
C	D

14. Select the main reason that all the energy in steam cannot be turned into mechanical energy in the turbines.

    A) Only the weight of falling steam turns turbine blades, so most heat energy is not used.
    B) Low pressure steam has very little "pushing" ability, but contains much energy.
    C) Friction from steam heats the turbine blades to high temperatures.
    D) Much steam energy is lost pushing against turbine walls and steam pipes.

A	B
20%	
C	D

15. Energy moves through several steps as electricity is made. Which answer below has the steps arranged correctly?

    A) 1,3,4,5,2 B) 1,3,5,2,4 C) 1,5,2,4,3 D) 1,5,2,3,4

    1. fire
    2. spinning turbine blades
    3. coils of wire
    4. moving magnet
    5. steam

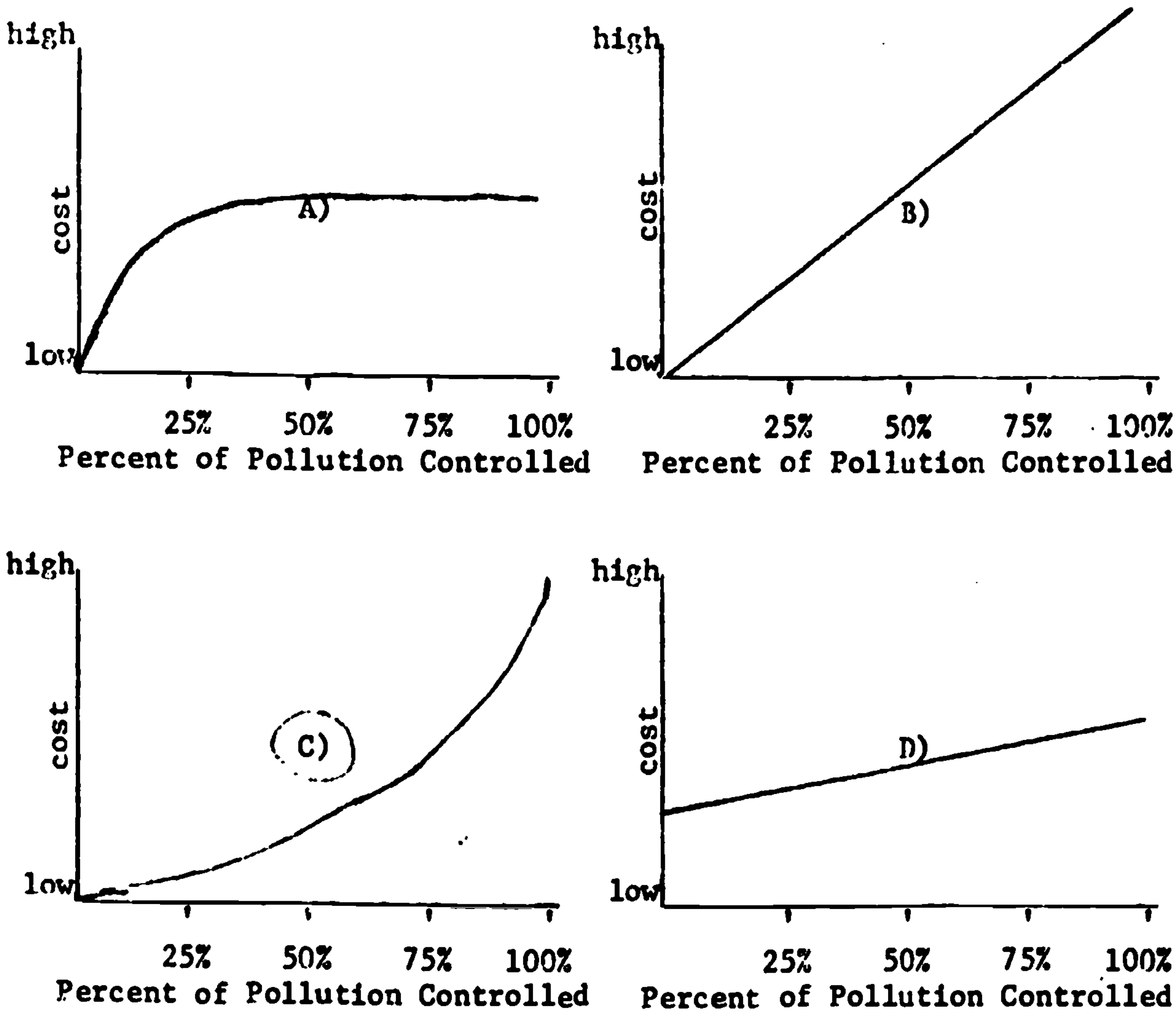
A	B
20%	
C	D

16. Which kind of electrical power plant will lose its source of energy within 400 years?

    A) hydroelectric
    B) geothermal
    C) fossil fuel
    D) fast breeder

A B
20% C D

17. Which graph below best shows how the cost of controlling pollution changes as larger and larger amounts of pollution are controlled?



A B
25% C D

18. Which line below best shows how KPL spends its income?

A) Fuel and Raw Materials 40% - Labor 20% - Taxes - 30%.
B) Fuel and Raw Materials 50% - Labor 30% - Taxes 10%.
C) Fuel and Raw Materials 50% - Labor 10% - Taxes 5%.
D) Fuel and Raw Materials 40% - Labor 10% - Taxes 20%.

A B
20% C D

19. From the list below, select the three ways that Kansas directly controls KPL policies.

A) 1,2,5 B) 1,3,5 C) 2,4,5 D) 1,5,6

1. KPL electrical rates are controlled.
2. KPL wages are controlled.
3. KPL must accept all paying customers in its service area.
4. KPL rate of growth is controlled.
5. KPL can only release certain amounts of pollution.
6. The kinds of fuels used by KPL are controlled.

A B
20% C D

20. Select the true statement about thermal and breeder reactors.

A) Thermal reactors make radioactive atoms, breeder reactors do not
B) Thermal reactors use fission, breeder reactors do not.
C) Breeder reactors make more fuel than they use, thermal reactors do not.
D) Breeder reactors make electricity directly, thermal reactors use steam.

A	B
20%	
C	D

21. Select the true sentence.

A) Half life is the time needed for half of a group of radioactive atoms to change to new atoms.
B) Half life is the time needed for a radioactive atom to shrink to half its size.
C) Half life is used to measure the speed of a company's growth.
D) Half life is the time needed for electrical generating equipment to lose half of its value.

PART B

Your answers on the last part of this test will be used to determine what you think about some of the ideas discussed in the "Electrical Production and Pollution Control" module.

Please use this code for questions 22-31.

A. Yes (or I agree)
B. I'm not sure
C. No (or I disagree)

+A- +B- 22. All schools should teach more about the ways the environment affects people and people affect the environment. A B C

+A- +B- 23. The average U. S. citizen uses much more energy than do most of the people in the world. A B C

+A- +B- 24. I think I can understand most kinds of charts and graphs. A B C

+A- +B- 25. Companies cannot solve pollution problems without spending large amounts of time, money, and research effort. A B C

+A- +B- 26. Laws should require adequate pollution controls, but should give companies several years to meet the requirements. A B C

+A- +B- 27. I avoid buying new clothing when old clothing still fits and can be repaired. A B C

+A- +B- 28. I try to buy things in containers which can be returned. A B C

+A- +B- 29. I encourage my parents to make sure that our home is well insulated. A B C

+A- +B- 30. I do not enjoy riding with someone who wastes gasoline. A B C

+A- +B- 31. I ask others who waste energy to use it more wisely. A B C

+A- +B- 32. Which of the jobs below do you think would provide someone the most money over the next 30 years?

A) Automobile mechanic
B) Traveling salesperson
C) Dental Assistant
D) Electrical lineperson
E) Long-haul trucker

Mark the direction society should take on each of the statements below. Use this code to answer questions 33-40.

A. Society should take strong steps toward the goal.
B. Society should move toward this goal, but slowly.
C. Society should remain as it is.
D. Society should move slowly to oppose this goal.
E. Society should take rapid steps to oppose this goal.

___ +A-	___ +B-	33.	The United States should work very hard to make sure that large supplies of energy will be available at all times, no matter how much environmental damage is caused.	A B C D E
___ +A-	___ +B-	34.	The United States should work very hard to make sure that large supplies of energy are available at all times <u>if</u> the environment is not damaged in a major way.	A B C D E
___ +A-	___ +B-	35.	Private companies should be able to produce things as they wish without government interference.	A B C D E
___ +A-	___ +B-	36.	Pollution control devices should be required for all industries and the things they produce whenever the environment is damaged significantly.	A B C D E
___ +A-	___ +B-	37.	Industries should be allowed to add pollution control costs to the costs of their products.	A B C D E
___ +A-	___ +B-	38.	We must encourage safe but rapid growth in the use of nuclear energy.	A B C D E
___ +A-	___ +B-	39.	We must encourage safe but rapid growth in the use of solar energy.	A B C D E
___ +A-	___ +B-	40.	We must encourage safe but rapid growth in the use of oil and natural gas.	A B C D E

PART C

Your answers to questions 41-61 will help us determine what you think of the module in general. Please use this key:

A = Yes (or I agree) B = I'm not sure C = No (or I disagree)

____ +B-	41.	I might enjoy engineering as a career.	A B C
____ +B-	42.	I think we had to go through this module too fast.	A B C
____ +B-	43.	I think our class discussions were interesting and informative.	A B C
____ +B-	44.	I think our substitute teacher was adequately prepared to present the material. (Mark D if you had no substitute.)	A B C
____ +B-	45.	My teacher helped answer most of my questions about ideas presented in this module.	A B C
____ +B-	46.	I think we used the self-test questions in a way that helped me learn and think.	A B C
____ +B-	47.	We discussed the films in a way that helped each of us learn and think.	A B C
____ +B-	48.	I think my teacher enjoyed teaching this module.	A B C
____ +B-	49.	I think most other students enjoyed studying this module.	A B C
____ +B-	50.	Most of the necessary papers and supplies were ready when we needed them.	A B C
____ +B-	51.	I think that most of the questions asked by this test were fair.	A B C
____ +B-	52.	I think the papers in this module contain useful and interesting information.	A B C
____ +B-	53.	I think the papers in the module could be easily read.	A B C
____ +B-	54.	I think the ideas covered in this module fit together pretty well.	A B C
____ +B-	55.	The films used in the module were interesting and useful.	A B C
____ +B-	56.	I enjoyed taking the trip, and I learned a lot.	A B C
____ +B-	57.	The trip leaders did a good job helping me learn on the trip.	A B C
____ +B-	58.	I discussed some of the things in this module with my family or friends.	A B C
____ +B-	59.	I think the activities and exercises in this module were interesting and useful.	A B C
____ +B-	60.	Overall, I think this module was well worth the time we spent studying it in class.	A B C
____ +B-	61.	I would like to study other modules developed by the Environmental Education Project.	A B C

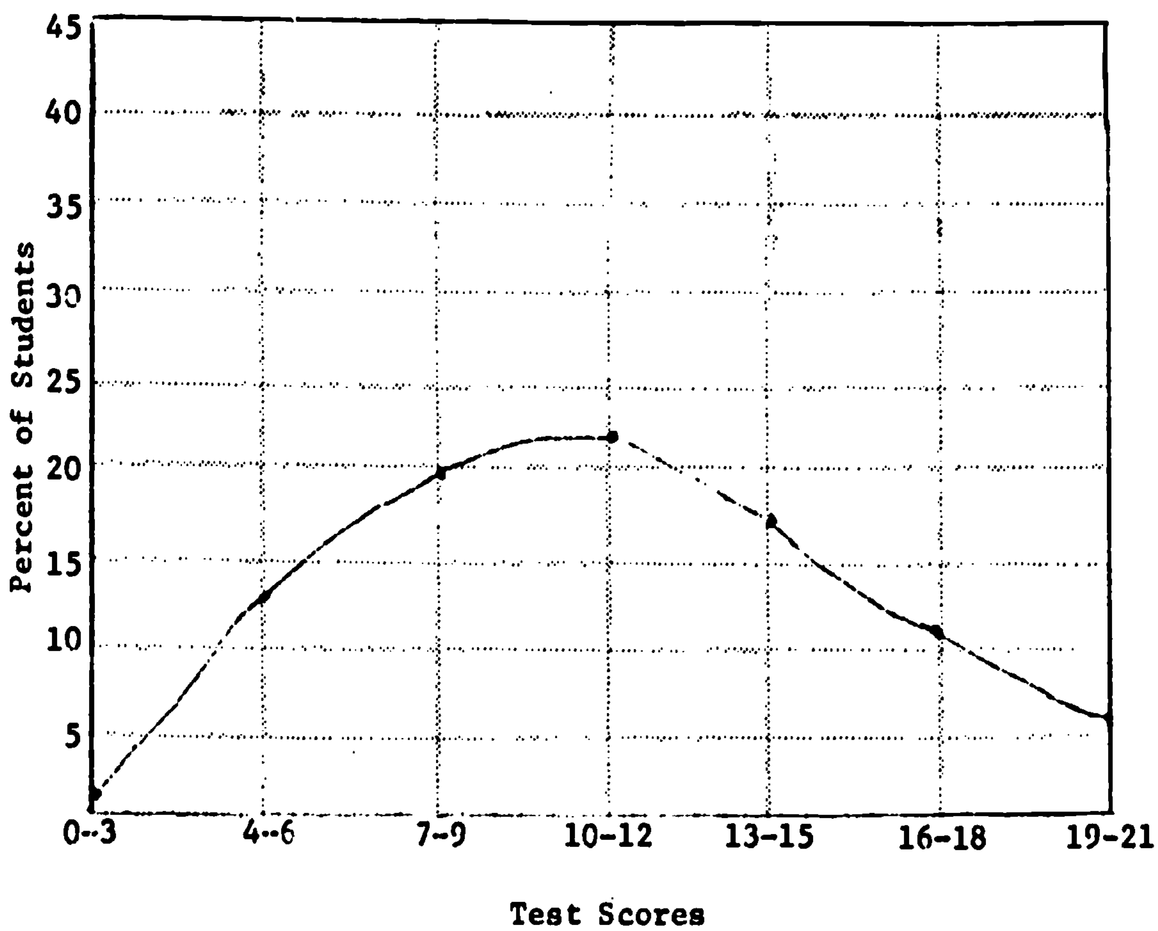
BEST COPY AVAILABLE

Percent of students answering the least answered attitude question_______.

Percent of students using patterned responses on the attitude questions_____.

Class Mean____________ Standard Deviation_________

Frequency Polygon (--- = pre, —— = post, -·-· = predicted post-score based on 1974 results)



The Topeka Public and Parochial Schools
Unified School District No. 501
Environmental Education Demonstration Project

INTRODUCTION

The Environmental Education Project was created by the Topeka School Systems to help you learn about your environment. The project develops and tests materials for classroom and field trip activities. This module is about electricity. You will study how electricity is made, and how its use affects your life.

The module is built around five main ideas:

1) What is electricity? How is it made? How is it used?
2) Pollution control: problems and solutions.
3) Economics and the electrical industry.
4) Electrical facts that everyone should know.
5) Energy shortages--causes and predictions.

Following your study of this module, your class will study the Kansas Power and Light plant in Lawrence and the engineering laboratories and nuclear reactor in the University of Kansas.

The Environmental Education Project will use test results to determine what you learned from the module and what you think about different parts of it. You will be given tests over the module before and after you study it. The tests will be used to determine what changes should be made in the material. Whether or not the teacher grades you using these test results is a decision to be made by your teacher. Test questions will be drawn from student self-test questions with each paper and the field trip.

All of your answers to the factual test questions will be reported to your teacher for use in grading. The test will also contain a set of questions about your opinions. Your answers to these questions will be used by the Environmental Education staff to improve the material you are studying.

Green pages in the teacher's material usually will contain three sections:

1) "Topics and Concepts" - lists the ideas from the student papers and exercises that will be on the final test. The numbers of the topics correspond with the behavioral objectives listed in the front portion of this module.

2) "Teacher Suggestions" - provides background material and suggestions for presenting the paper or exercise.

3) "Answers to Student Self-Test Questions" - provides answers and follow-up material to help in a discussion and review of the self-test.

This introductory paper is concerned with the following three attitudes. They will be nurtured throughout the next two weeks as the students work with this module.

TOPICS AND CONCEPTS TESTED

1) Students should read each opinion question on the final test and try to respond truthfully.

2) Upon completion of this module, students should indicate a desire to study other modules developed by the Environmental Education Project.

3) Upon completion of this module, students should indicate a desire to study more material about man's relationship to his environment.

TEACHER SUGGESTIONS

Please bring out three points during the introduction:

1) This module is about the electrical industry that plays a very large role in everyone's life. The module focuses on Kansas Power & Light as one electricity producing company. The module teaches the production processes used at the plant, solid waste and air pollution control methods, and financing of the company. The module also examines nation-wide energy usage patterns and projections.

2) The project is <u>very</u> interested in student and teacher opinions, criticisms, and compliments. We get these comments during the field trip, from teachers; verbal and written comments, and from opinion questions on the student test. Please encourage students to react to the material being presented. Pass their reactions and yours on to us.

3) You should make it clear if students will be graded using the factual part of the posttest. The tests are fair, and are strictly based on the behavioral objectives included in this module. If the students understand each paper's student self-test questions and the field trip material, they should do very well on the posttest.

ENERGY AND TODAY'S SOCIETY

Energy is the ability to do work. Energy has been used whenever movement, change, heat, light, force, or work has occurred.

Power is the rate at which energy is used. Two men weighing the same, use the same energy to run 100 yards, but the man running faster is using more power since he uses energy at a faster rate.

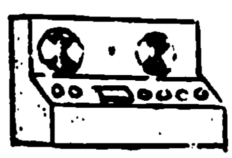
Energy is measured in Calories, Watt hours, BTU's, and other units of measure. Each of these energy measures can be changed into many other forms, but this module will use only these three terms.

The average human needs to eat food containing 2,500,000 calories, or 10,000 BTU's, or 3,000 Watt hours of energy each day. In other words, 1,000 calories contain the same energy as 4 BTU's or 1.2 Watt hours. We should note that 1,000 "small" calories for the electrician equal 1 "large" Calorie for the dieter.

Two prefixes - "kilo" and "mega" will also be used in this module. "Kilo" means thousand and "mega" means million. Therefore, 1 kilowatt equals 1,000 watts, and one megawatt equals 1,000,000 watts.

Human Use of Energy

One human cannot do very much work by himself. Early man learned to use animal energy to pull plows, harvest crops, and supply transportation. Industrial man began to use the energy of water, wood, and coal to heat homes and run machines which made clothing, housing materials, and new buggies. Technological man harnessed the power of electricity, petroleum, and natural gas to carry messages, make cars, raise food, and make new types of clothing. Less than one percent of the work now done in America's factories is done by human effort. Engines, computers, electrodes, and furnaces supply energy that man alone could never produce.



Primitive man had to use all of his energy just finding food, keeping warm, and surviving.

The average American now has the energy of over 900 human slaves working to produce food, warmth, transportation, and equipment for him. These "energy slaves" have given us better health and an easier life than our ancestors--even 50 years ago--could have dreamed possible.

The chart on the next page shows how man's use of energy has grown as our life-style changed.

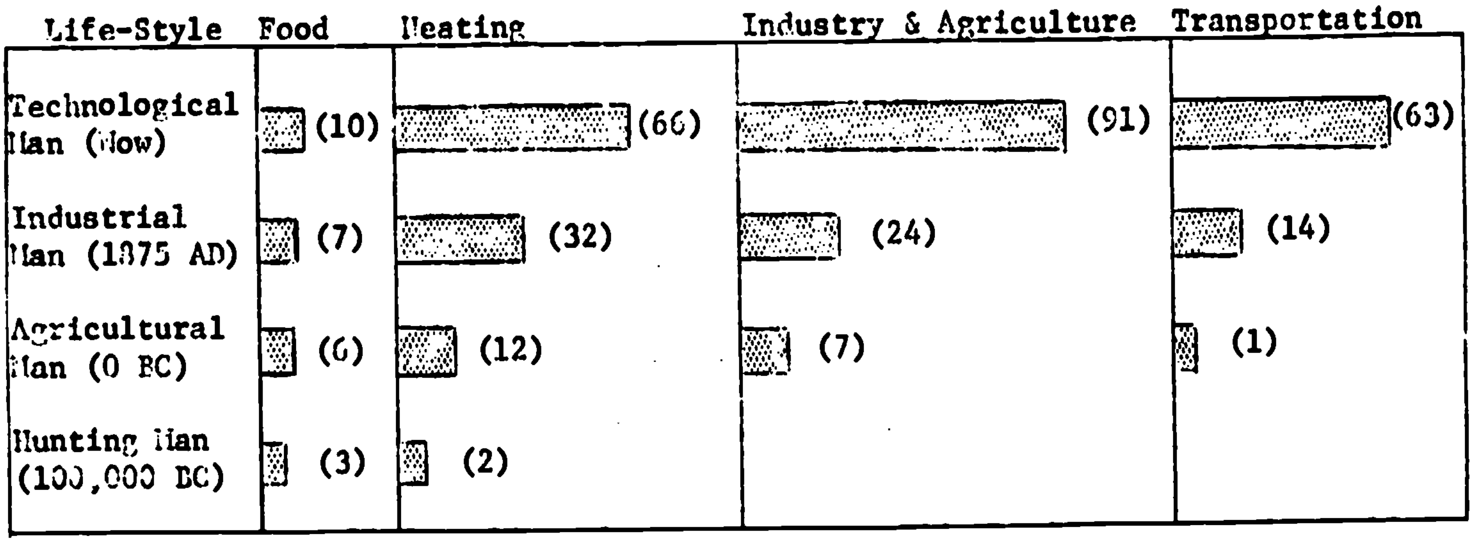


Figure 1. Life-style and energy usage. Numbers in parentheses equal the megacalories used each day to support the average citizen's life-style. (This chart was adapted from a September, 1971, Scientific American article.)

ELECTRICAL ENERGY

Of all the forms of energy used in America today, the use of electricity is growing the most rapidly. Since the first electrical generating station was built in 1882, electricity has grown to supply 25 percent of our energy needs, and is expected to supply over 40 percent of our energy requirements within the next 20 years.

Electricity offers several advantages over other energy sources used today:

A) Much electricity is produced from coal, which is a more common fuel than oil or gas.

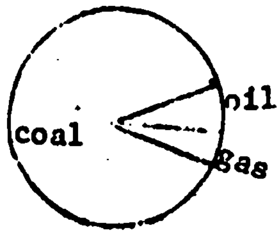
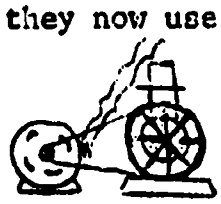
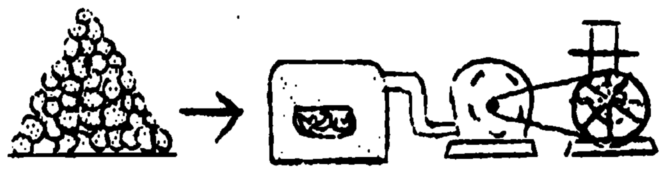


Figure 2. Available United States Fossil Fuels.

B) If industries used coal for energy, they would require much storage room and would need to unload coal cars continuously to replace the electrical energy they now use.

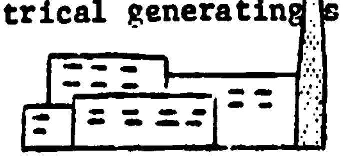


OR



C) Manufacturing plants would need to be much bigger and employ more people if coal and oil powered their engines. Electrical engines are safer, smaller, and easier to run.

D) More pollution from burning fuels in the city would occur, since it is much harder to stop pollution from many small engines than it is from one big electrical generating station.



OR

Many chemicals, such as chlorine and sodium hydroxide, are manufactured using electricity. Industry uses enormous amounts of electrically manufactured chemicals, so electrical use has increased rapidly for this purpose.

E) Pollution control equipment uses much electricity, and the need for pollution control is increasing as our population and economy grows.

Thus electricity offers advantages over other energy uses, and its use has increased rapidly.

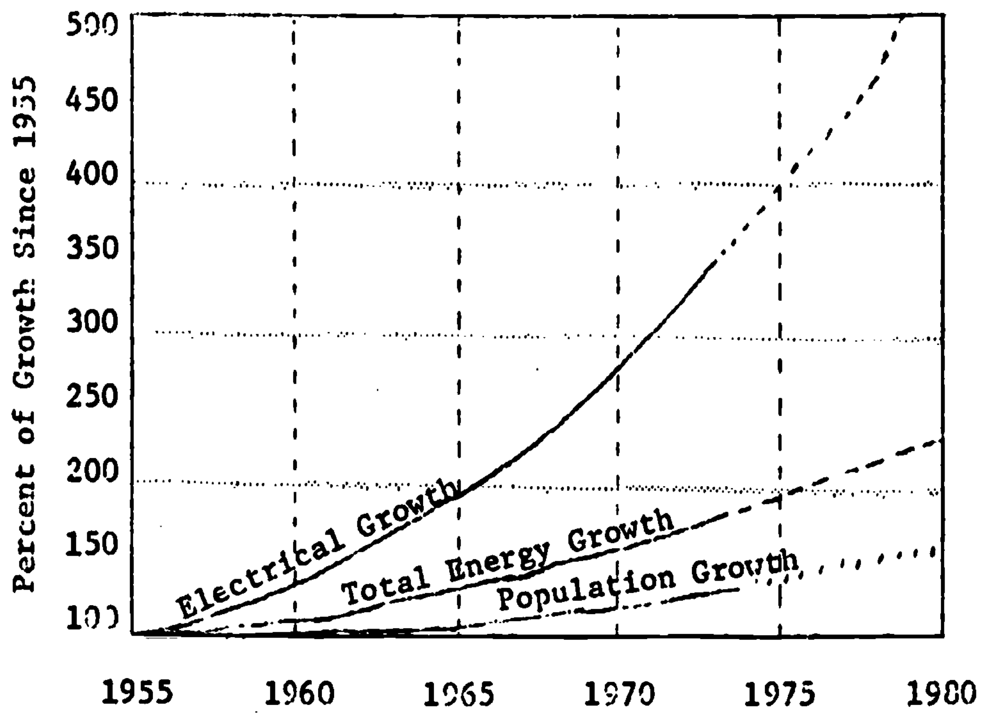


Figure 3. Percentage growth in population, energy, and electrical usage. (Adapted from the National Energy Policy: Directions and Development, a manuscript published in July, 1973, by John N. Nassikas.)

One way of summarizing all of these uses of electricity into one picture, is to look at the relationship between a country's Gross National Product (GNP) and its use of electricity. The "Gross National Product" (GNP) of a country is a measure of the goods and services produced by its citizens. In general, a high GNP means that many things are available for purchase at a price that people can afford. A low GNP means that most of each family's income goes for survival, and little is left to spend on the things that make living comfortable.

When a country's GNP is divided by its population size, a measure of the average person's wealth, or buying power, is obtained. If the average GNP per person is compared with the average use of electricity per person in a country, an interesting chart can be made.

The chart uses a special log scale that allows small and large numbers to be shown on the same piece of paper.

The chart's straight line indicates that the amount of electricity used in a country is very closely linked to the wealth of the country. Although only a few countries are shown on the chart, many have been examined, and all are close to the line.

Similar straight lines could be drawn comparing the electrical usage rates and disease or literacy rates of countries. Thus, countries with high electrical usage rates usually have citizens that are better educated, healthier, and more comfortable than in countries with low electrical usage rates.

In short, electricity is a very convenient form of energy, it is being used at a faster and faster rate, and its availability is closely associated with the health and wealth of the people in countries throughout the world. Later papers in this module will examine how electricity is made, how it is wasted, and what the future of energy production holds for Americans.

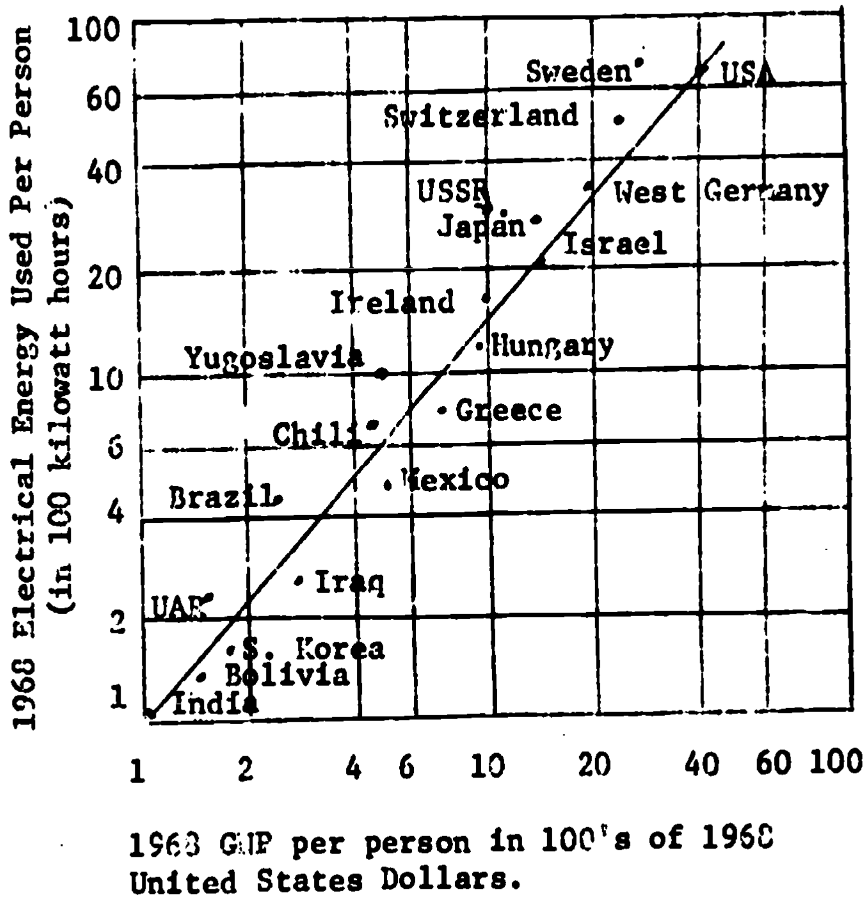


Figure 4. Comparison of GNP and electrical usage per person for various countries. (Adapted from The U. S. Energy Problem, Inter Technology Corp. PB-207518 (1972).

Student Self-Test Questions

1) Name one nonliving thing in your home that was not produced, prepared, or transported using electricity.

2) How would you change your life-style if you had to reduce your energy usage by 50 percent? Remember that anything you buy uses energy to produce and to transport to you.

3) Which two areas of Technological Man's life-style consume much more energy than the Industrial Man's life-style? Why do we require so much more energy?

4) Why will the use of electricity continue to grow rapidly in the United States?

5) Do all countries with high average GNP's also have high rates of electrical usage? Why?

6) Do any countries with low average GNP's have high rates of electrical usage? Why?

7) What are the main advantages and disadvantages of using log scales instead of linear scales for graphing?

Look at the chart below, and indicate whether the statements in questions 8, 9, and 10 are true or false.

Figure 5. U. S. and World Raw Energy Consumption in 1970. (Adapted from two charts in Energy and Power, a Scientific American Book.)

	Fuels Used For Energy		Energy Contained in Fuels Still in the Ground		Fuel Now Used For Making Electricity
	World	USA	World	USA	USA
Coal	53%	22%	88%	80%	55%
Oil	41%	40%	7%	10%	16%
Gas	1%	37%	5%	10%	28%

8) Much of the energy used in the United States comes from gas, but the rest of the world gets most of its energy from coal. True False

9) The most abundant fuels make up most of the fuel used for energy in the United States. True False

10) Most of the fuel for electrical production comes from coal, but most of the fuel for other energy uses in the United States comes from oil or gas. True False

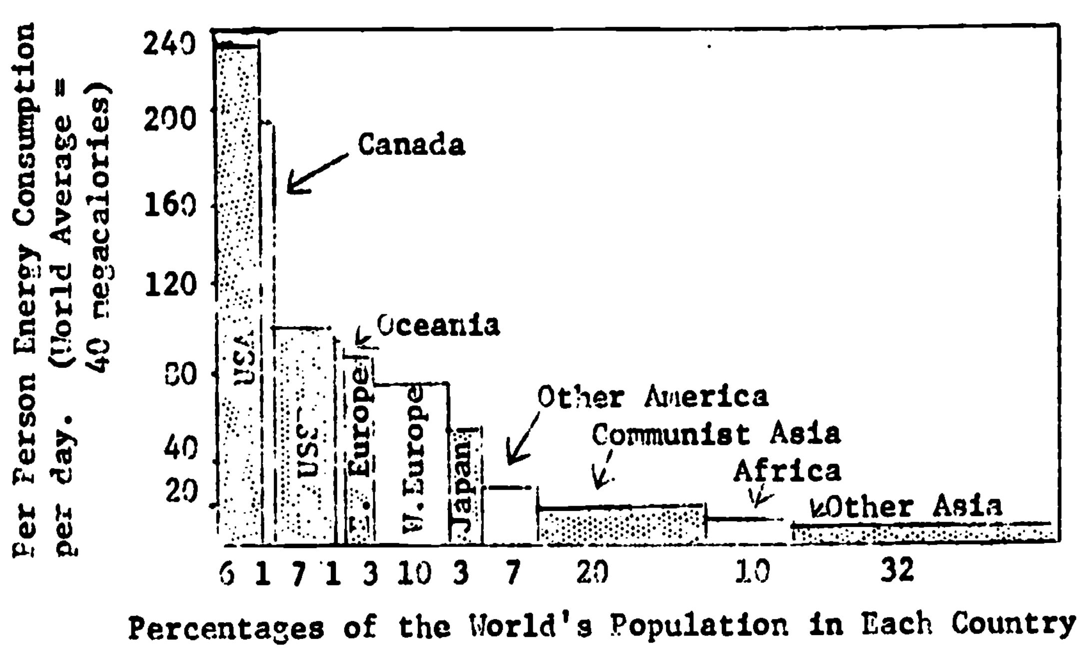


Figure 6. Per person daily energy use in megacalories compared with the world's population. (Adapted from New Energy Technology, by Hottel and Howard, MIT Press.)

Examine Figure 6 and decide whether the statements in questions 11 and 12 are true.

11) Half of the people in the world use less energy in a year than Americans do in a month. True False

12) The average person in the United States uses more than twice as much energy as the average Russian, three times as much energy as the average West European, and four times as much energy as the average Japanese citizen. True False

Examine Figure 7 and decide if questions 13 and 14 are correct.

13) Most uses of energy are becoming more efficient, but over 50 percent of the energy released from fuels is still being wasted by man. True False

14) For each BTU of energy used, more is wasted doing work (running cars or electric motors) than in heating homes. True False

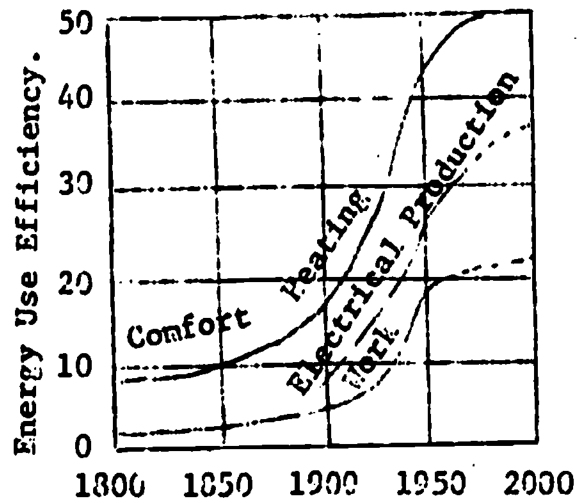


Figure 7. Efficiency of Energy Usage Since 1800. (Adapted from Energy and Power, a Scientific American Book)

Examine transparency number 4, which contains four charts. Determine whether or not the statements below are true.

15) In the last 100 years, America has started using over three times as much energy on machines which do ten times as much work with the energy they use. Therefore, compared with our ancestors, we are getting 30 times more work done without human effort. True False

16) According to energy usage rates, most of the people in the world are still in the "Agricultural Man" life-style. True False

17) How can total energy growth (which includes electricity) increase slowly while electrical growth increases rapidly?

Behavioral Objective Numbers	Topics and Concepts
4	Students shall indicate that it is extremely important to all Americans that rich supplies of energy be available for our use now and for many decades to come.
5	Students shall indicate that electrical usage rates correlate strongly with the Gross National Products of modern societies.
6	Students shall be able to select a correct interpretation of a semi-log graph dealing with energy usage rate increases.
7	Students shall indicate that the average United States citizen uses much more energy than do most of the people in the world.
8	Students shall indicate that they feel comfortable reading and interpreting most graphs and charts.

Teacher Suggestions

No single factor will determine the life-styles of your students more than the availability of energy. The quantities, kinds, and costs (both economic and environmental) of obtaining energy will change dramatically over the next 50 years. This is one statement with which all environmentalists, technologists, politicians, and businessmen will agree.

Throughout the previous 200 centuries of human life in North America, we existed on the renewable energy resources of wood, animal labor, plant, and animal food. Suddenly, in the last century, our numbers have mushroomed and our per capita use of energy has grown by three-fold. We are now tapping the non-renewable resources of the fossil and atomic fuels at an ever-increasing rate. Later papers will look toward our future, but for now, keep the students' attention focused on the past and present.

You are probably the last teacher that will try to teach the majority of your students to interpret graphs and charts. Most energy data, whether in the "Wall Street Journal," "Time Magazine," or the evening TV news, is presented in graph form. Most long-term and predictive work is displayed in log-log or semi-log form. Yet, students do not understand logarithms until after they have completed formal instruction in graph interpretation. Therefore, this module contains a wealth of charts in a variety of forms, including logarithmic form. Please use the transparencies, papers suggested for duplication, and suggestions included with the students self-test answers to increase student graph interpretation skills. Few skills are more necessary for understanding the trends which concern environmentalists, economists, energy producers, and businessmen.

Note: Some students may wonder how the calculation indicating that "the average American now has the energy of over 900 human slaves working to produce for him" was derived. The calculation was based on this data:

> 1970 U.S. Energy Consumption was the equivalent of 18.9×10^{12} kilowatt hours,
> 1970 U.S. Population was about 200 million.
> One human can produce about 40 watts of power on a sustained basis. The slave worked 10 hours a day, 5 days a week.
>
> $$\frac{18.9 \times 10^{12} \text{ kw-hrs} \times 1000 \text{ watts/kilowatt}}{2.0 \times 10^{8} \text{ Americans} \times 260 \text{ days/year} \times 10 \text{ hours/day} \times 40 \text{ watts/slave}} =$$
>
> $$\frac{18.9 \times 10^{15} \text{ slave years}}{2.08 \times 10^{13} \text{ American}} = 910 \text{ slave years/American}$$

If you chose to work the slave 365 days per year and 24 hours per day, each American only uses the energy of 280 slave years every year.

Student Self-Test Questions

The student self-test questions are designed to promote discussion, emphasize the objectives of the paper, and prepare for material covered in later papers. Whether or not students write their responses to the question is not as important as a healthy class discussion of the questions.

Q 1) Name one nonliving thing in your home that was not produced, prepared, or transported using electricity.

A Most things use electricity if they have been cut, polished, refrigerated, painted, dried, produced from man-developed chemicals, or made with mass production methods. Few students will, therefore, be able to name one nonliving thing which does not owe at least part of its existance to electricity.

You should follow this discussion by pointing out that the first commercial electrical generating station was built less than 100 years ago in 1882, and electrical usage rates have been growing at ever faster rates since that date.

Q 2) How would you change your life-style if you had to reduce your energy usage by 50 percent? Remember that anything you buy uses energy to produce and to transport to you.

A Transparency 1 in Appendix 1 may be used as a transparency, or duplicated for individual student use. Point out to the students that a reduction in our energy usage by 50 percent would <u>still</u> have the U. S. using more energy per person than 93 percent of the world's people.

The circle graphs should make it clear that a 50 percent energy usage reduction would affect all segments of our lives. Students should realize that cutting industrial usage will result in fewer job opportunities for themselves, as well as fewer options for their purchase. Energy cuts would strike particularly hard at such high-energy consumers as the plastics and aluminum industries, which play a key role in many of the things we now purchase.

Use a washable marking pencil to shade in the areas students would cut on the transparency. Keep forcing cuts until 50 percent of the center circle has been shaded. As you shade try to make it clear how the cut would affect the student.

Q 3) Which two areas of Technological Man's life-style consume much more energy than Industrial Man's life-style? Why do we require so much more energy?

A Transportation, with a 450 percent increase and industry and agriculture, with a 300 percent increase are the sectors with the most rapid increase in energy usage. This energy has been used in two major ways: (1) it has allowed tremendous freedom of movement--we can now drive 10 miles a day and have no second thoughts. In 1875, a ten-mile trip was something to plan carefully and do infrequently. (2) We can buy cars, refrigerators, televisions, aluminum windows, ranch-style homes, 10-speed bicycles, aluminum cans, and electric can openers which all require large amounts of energy to make. A new car, for instance, requires more energy to produce than it will burn for the first 15,000 miles of its life. Producing a six-pack of aluminum beer cans consumes enough energy to heat the water in a bath tub to a comfortable temperature for bathing.

In short, we require more energy (1) because our increasing populations are using much more energy to move materials and people, and (2) because we enjoy the convenience and comforts the energy usage provides.

Q 4) Why will the use of electricity continue to grow rapidly in the United States?

A
(1) Coal and nuclear energy (which will become our primary fuels) can be used to create a clean energy for use in cities.
(2) Pollution from coal and nuclear reactors can be contained in large units better than in many small units.
(3) Electricity is extremely important in pollution control, recycling materials, and producing synthetic materials. A growing population has been using ever-larger amounts of energy for these ends.
(4) Electricity is extremely important in running compact, efficient, quiet, and responsive factory machines.

Q 5) Do all countries with high average GNP's also have high rates of electrical usage? Why?

A Use Transparency 2 and/or duplicate class sets of the transparency for this discussion.

The answer is yes--all countries with high average GNP's have high electrical usage rates. In the United States, we are allowed an income tax deduction of $750 per person. Ask students to find any country using less than 600 kilowatt hours of electrical energy and having an average GNP above $750 per person.

For the why part of the question--refer back to question 4--why is the electrical usage growing so quickly in the USA?

Q 6) Do any countries with low GNP's have high rates of electrical usage? Why?

A No. If they had the technology to produce and use high levels of electricity, they would have high GNP's.

Q 7) What are the main advantages and disadvantages of using log scales instead of linear scales for graphing?

A Use transparency 2 to explain the difference between log-log and standard graphs. Ask students to compare the two graphs on transparency 2 and note the differences. These should be noted.

(1) Log graphs have unequal distances between lines.
(2) Log graphs go from 1 to 10, then add a zero and go from 10 to 100 in the same distance. Ask students what the next line would be above this graph (200).
(3) Log scales allow you to accurately plot small and large numbers on the same graph.
(4) Linear graphs show the relationship between numbers in more realistic terms. For instance, USA, Sweden, and Switzerland all look pretty similar on the log-log graph, but the linear graph makes it clear that wide distances separate the GNP's and energy usage rates of these countries.

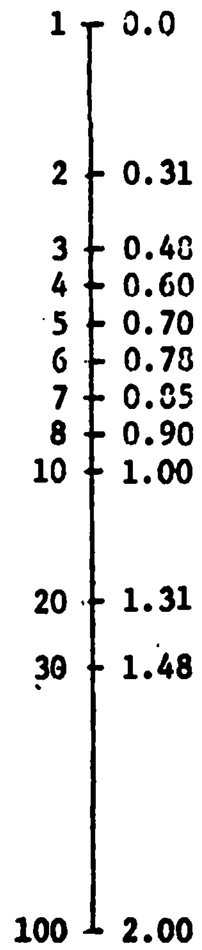
Use transparency 3 to further illustrate the use of semi-log graphs. Ask students to note the differences between these graphs.

(1) The semi-log graph takes a rapidly climbing line and "straightens" it out.
(2) The straight line can be used to predict future growth needs, the rapidly climbing curve cannot.
(3) The same advantages and disadvantages noted with transparency 2 should be re-noted.

Point out that log scales are used to show things that are growing at steady percentages which double and re-double periodically. A linear graph cannot accurately show both small numbers and very large numbers on the same piece of paper.

If you wish to try to explain how logarithmic scales are created, the chart on the following page may help.

Number	Logarithms
$1 = 10^{0} =$	0.00
$2 = 10^{0.31} =$	0.31
$3 = 10^{0.48} =$	0.48
$4 = 10^{0.60} =$	0.60
$5 = 10^{0.70} =$	0.70
$6 = 10^{0.78} =$	0.78
$7 = 10^{0.85} =$	0.85
$8 = 10^{0.90} =$	0.90
$9 = 10^{0.96} =$	0.96
$10 = 10^{1.0} =$	1.00
$20 = 10^{1.31} =$	1.31
$30 = 10^{1.48} =$	1.48
$100 = 10^{2.00} =$	2.00
$1000 = 10^{3.00} =$	3.00



Note that the graphing distances on the scale represent the logarithms of the numbers shown on the graph.

Look at Figure 5, and answer questions 8, 9, and 10.

Q 8) Much of the energy used in the United States comes from gas, but the rest of the world gets most of its energy from coal. True False

A True--much of our energy (37 percent) does come from gas, while coal supplies 56 percent of the energy to the rest of the world.

(Per person, U.S. citizens use 104,000 cubic feet of gas each year. The rest of the world averages less than 3.5 cf of gas yearly.)

Q 9) The most abundant fuels make up most of the fuel used for energy in the United States. True False

A False--coal is by far our most abundant fossil fuel.

Q 10) Most of the fuel for electrical production comes from coal, but most of the fuel for other energy uses in the United States comes from oil or gas.
True False

A True--electrical generation fuel patterns do fit the available fuel supplies better than does the total United States fuel use.

Use Figure 6 to answer questions 11 and 12.

Q 11) Half of the people in the world use less energy in a year than Americans do in a month.
True False

A True. Communist Asia, Africa, and other Asia account for 52 percent of the world's population, but use less than 1/12 the energy per person that Americans use.

Q 12) The average person in the United States uses more than twice as much energy as the average Russian, three times as much energy as the average West European, and four times as much energy as the average Japanese citizen.
True False

A True

Examine Figure 7 and decide if questions 13 and 14 are correct.

Q 13) Most users of energy are becoming more efficient, but over 50 percent of the energy released from fuels is still being wasted by man.
True False

A True--students should perceive that man has become much more efficient with energy usage but that scientists feel that we are reaching the limits of improving our efficiency.

Q 14) For each BTU of energy used, more is wasted doing work (running cars or electric motors) than in heating homes.
True False

A True--but ask students how most of the energy is wasted in doing work. They should realize that most of the energy is lost as heat. Therefore, recovery of waste heat from work increases over-all efficiency. Thus, many factories use the waste heat of engines to heat the plant during the winter.

Use transparency 4, which contains four charts, to help students answer questions 15, 16, and 17.

Q 15) In the last 100 years, America has started using over three times as much energy on machines which do 10 times as much work with the energy they use. Therefore, compared with our ancestors, we are getting 30 times more work done without human effort.
True False

A Figure 1 on transparency 4 indicates that, over-all, Americans have trebled their use of energy (and increased the transportation and industry sections by fourfold).
Figure 4 indicates that work efficiency has grown from 2 percent to over 20 percent. Thus, the answer (true) indicates that we are getting about 30 times as much done for us as our ancestors did just 100 years ago.

Q 16) According to energy usage rates, most of the people of the world are still in the "Agricultural Man" life-style. True False

A True and false. Figure 3 indicates that the majority of the world's people use around 20 megacalories of energy daily. Figure 1 indicates that Agricultural Man used energy at about the same level. These two graphs would place most of the world's people in the Agricultural Man life-style.

However, the technology of America and other countries has shared efficient machines, electrical generators, and so on with all countries, so that they too are getting 10 times more work out of many of their machines. This has changed their life-style without increasing the total energy input. Therefore, the majority of the world's population would need to be classified somewhere between Agricultural and Industrial Man, with some parts of all life-styles thrown in.

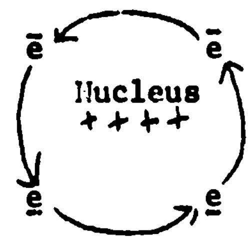
Q 17) How can total energy growth (which includes electricity) increase slowly while electrical growth increases rapidly?

A In 1955, electricity supplied only a small part of the total energy used in the United States. Therefore, its growth could double and redouble without driving the total energy usage up at a rapid rate. Moreover, much of the use of electricity is in replacing other energy forms, and this usage will increase as oil and natural gas become harder to supply and more expensive.

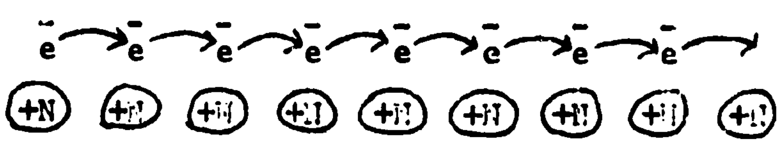
The important thing to emphasize is that graphs such as this based on percentage growth can distort relative size of growth. An analogy could help here: if a town had 100 families, and 99 families produced one child, while one family produced 7 children, the town's population would grow by 52 percent. However, the one family's population would grow by 350 percent. This is pretty much the picture shown by electricity, which grew 350 percent while total energy usage, grew about 50 percent between 1955 and 1974. Thus one family's (electricity's) rapid growth did not significantly change the over-all picture in the short term. Of course, in the long haul, if each of those seven children had seven more, they would quickly affect the town's growth rate. In the same manner, if electrical demand continues to grow exponentially, its growth rate will dramatically affect the over-all energy picture.

WHAT IS ELECTRICITY?

All things are made of very small particles, called atoms. Atoms are so small that just one gram of copper contains 10,000,000,000,000,000,000,000 (ten billion, trillion) atoms. Each atom has a nucleus surrounded by rapidly moving electrons. Each electron has a negative charge, and the atom's nucleus carries positive charges. The number of negative charges around each atom usually equal the positive charges in its nucleus.

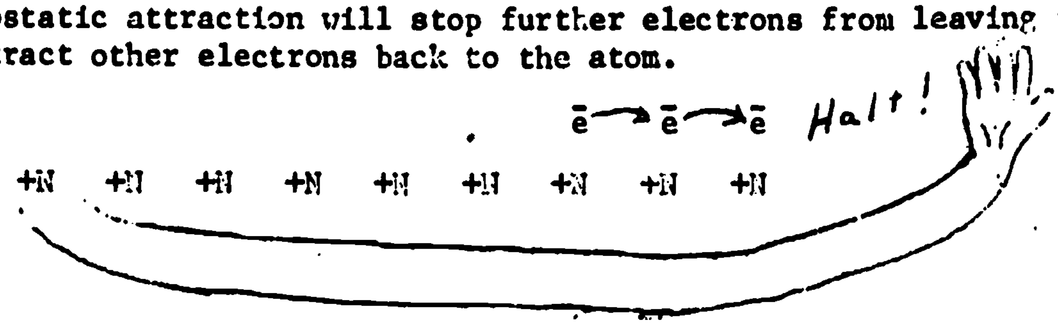


Electrons are in continuous motion. Some materials (iron, copper, aluminum, etc.) allow their electrons to move easily from atom to atom. When more electrons in a wire are moving one direction than are going the opposite way, an electric current is created. Other materials, such as rubber, glass, plastics, and oxygen do not allow easy electron movement. We use these materials to resist or insulate against the easy movement of electrons.

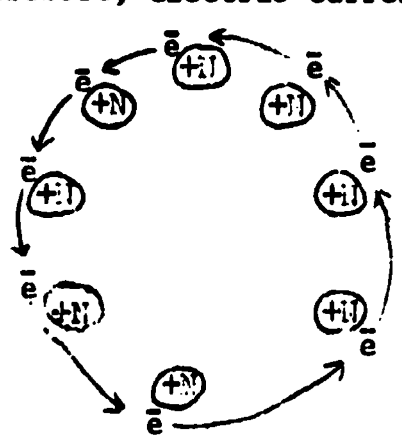


To move anything, whether it is a truck or an electron, requires energy. Once things are moving, they carry energy, as can be seen in a truck collision. Thus, it takes energy to start a stream of electrons moving one direction, and the moving electrons carry energy.

Electrons cannot all move in one direction for long. When an electron leaves the atom, the attraction between the nucleus and the remaining electrons becomes greater. This electrostatic attraction will stop further electrons from leaving the atom, and will attract other electrons back to the atom.

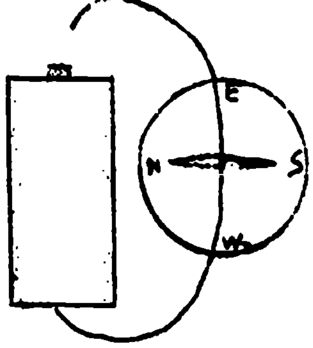


Therefore, electric currents must always move in circles if they are to move at all. In this manner, the electrons are in motion, but each atom receives new electrons as fast as they lose old ones.

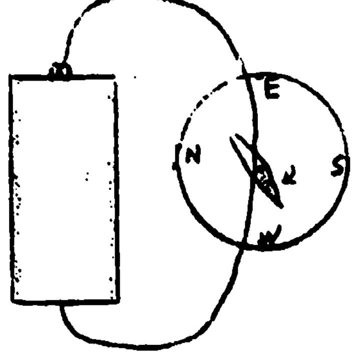


Each electron makes a magnetic field around it as it moves. This can be seen by placing a wire over a compass needle and connecting the wire to a flashlight battery. The moving electrons in the wire cause a magnetic field which forces the compass needle to change directions.

No Electron Movement

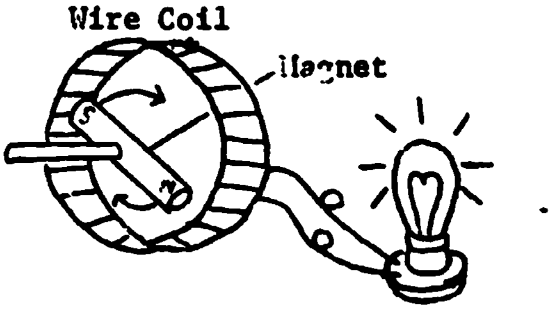


Electron Movement



In the same way, a moving magnet can cause electrons to move. If a magnet turns inside a coil of wire, electrons will move through the wire under the force of the magnet.

This relationship between magnetic force and moving electrons is used to create electricity, run motors, make magnets, and so on.



Moving electrons may carry so much energy that they can release part of their energy into new forms of energy such as light, heat, or radio waves.

The energy carried by electrons may also be used to change materials chemically. Chlorine, aluminum, hydrogen, and many other materials are prepared by energy carried by electricity.

Five terms describe the energy carried in electricity. To understand these terms, it is best to view electricity as water in a pipe. The faster the water moves, the greater the energy contained in each drop. The more drops that are carried, the greater the total energy of the water.

Volts are like the pressure pushing the water. If the voltage is great, then the pressure pushing each drop is great. Thus, each electron in a 220 volt line is under more pressure than electrons in a 110 volt line.

Amps indicate the amount of electrons (water) moving down the pipe. If the voltage is constant, many amps (a large pipe) would produce more energy than a few amps.

Watts are produced when amps are pushed by volts. One amp pushed by one volt = 1 watt. The formula which connects these three terms is this:

Amps X Volts = Watts

A watt-hour is produced when one amp is pushed by one volt for one hour. A watt-hour is the unit of energy used with electricity.

Resistance indicates the pressure needed to push electrons from atom to atom. Something with high resistance will allow only a few amps to be pushed by many volts of pressure. An important fact to remember is that the earth can accept large numbers of electrons and offers little resistance to their flow. Touching a 110 volt line when you are standing in a bath tub will send electricity through you, the tub, the pipes hooked to the tub, and into the ground very rapidly. Many amps will rapidly move through you to the ground under the pressure of 110 volts. If you were wearing resistant gloves and shoes and were standing on a wood floor, only a fraction of an amp could move through you to the ground. You would be shocked, but alive because the materials between you and the ground resisted the flow of electrons.

In summary, electricity is the kind of energy carried by moving electrons. Some materials allow electricity to flow easily, some resist it. Moving electrons create a magnetic field, which can influence other magnets, produce light, or change chemicals. Finally, the rate of flow (amps) of electric current multiplied by the pressure of the line (volts) equals the power of the electricity (watts).

Student Self-Test Questions

1) What is an electrical current, and how is it created?

2) Why must electricity flow in a circle if man is to make continuous use of it?

3) Energy is the ability to make changes. It can be demonstrated by movement, light, etc. Name four forms of energy which can help make, or be made by electricity.

4) If a 60 watt bulb is used for five hours, how many watt-hours of energy are consumed? ____________________

5) If an electric motor operates on 110 volts of electricity and requires 10 amperes to operate it, what is its wattage requirement? ____________________

If the motor is used eight hours per week, how much energy (kilowatt-hours) does it use in a YEAR? ____________________

6) Instant-on model televisions are constantly using electricity to keep the set warm. Many models use about 25 watts of power to do this. How many watt-hours will the set use in a year? ________________ If one man (an "energy slave") can only produce 40 watts of power per hour, how many man-hours of work a day would be needed just to keep this television warmed up? ____________________

7) An electric clothes dryer uses about 5,000 watts of power when its heating coils are on, and 1,000 watts when just the motor is running. How many kilowatt-hours of energy is required to dry six loads during the week if it takes one-half hour to dry each load and the heating coils work 10 minutes of each half hour? ____________________ What is the weekly cost to operate the dryer if it costs three cents for each kwh of energy? ________________

8) A frost-free refrigerator uses about 1,217 kwh of electricity in a year, but a standard model uses only 728 kwh. How much extra energy does the frost-free refrigerator use each year? ____________________

At a cost of three cents per kwh, what does each type of refrigerator cost to operate for a year? ____________________

How many <u>extra</u> hours of the energy slave's time would be required to keep the refrigerator frost-free, if each slave can only work at a 40 watts per hour pace? ____________________

Behavioral Objective Number	Topics and Concepts
9	Students shall indicate that an electric current is caused by moving electrons.
10	Students shall indicate that electrical currents must flow in a circle, and that this flow may cause, or be caused by, magnetic forces.
11	Students shall be able to determine the wattage and kilowatt-hours of energy used by an appliance.
12	Students shall indicate that energy is changed from one form to another when electricity is made and used.

Teacher Suggestions

The main thrust of this module is to teach about energy, its conversions, and use in society. No experiments involving electricity have been prepared for student participation since few classrooms have the required equipment. The material below may suggest some possibilities if you wish to pursue them as demonstrations or class experiments.

To show the magnetic properties of moving electrons, use the current in a wire running between the (+) and (-) poles of a flashlight battery to deflect a compass needle. If the current is run through the wire in the same direction above and then below the needle, deflection will occur in opposite directions. This occurs because the magnetic field around the wire is circular, and the force above the wire pushes in an opposite direction to the force below.

Magnetic lines of force around a wire.

An electro magnet may be made by wrapping coils of insulated wire around an iron nail and running a direct current through the wire.

To demonstrate the use of electrical energy to affect chemicals, plate copper onto a nickel by suspending two nickels in a copper sulfate solution, and hooking each pole of a well charged 6 volt battery to each nickel. Note which nickel is being plated with copper. Reverse the poles and run the current again.

The series of problems in the student self-test section are designed to introduce students to the skills needed to determine electrical usage in the home, and to re-emphasize the amount of energy used to provide the conveniences of modern life.

Answers - Student Self-Test Questions

Q 1) What is an electrical current and how is it created?

A An electrical current is a stream of moving electrons. It may be created by moving a magnet by a wire connected in a circle. (Students may also indicate that it may be created by moving electrons from one chemical, through a wire, and to another chemical, as occurs in batteries.)

(They may also indicate that an electrical current may be created by removing electrons from one substance to a more attractive substance, then allowing the electrons to flow back. This is the basic method used to power static electricity, lightning and Van de Graaf generators.)

Q 2) Why must electricity flow in a circle if man is to make continuous use of it?

A Atoms will not continue to release their electrons unless another electron can be returned within a split second. Thus, the electric current will not move for long unless the electron flow is circular.

Q 3) Energy is the ability to make changes. Its presence can be demonstrated by movement, light, etc. Name four forms of energy which can help make, or be made by electricity.

A Heat energy, Light energy, Movement (mechanical) energy, Magnetic energy, and Chemical energy are all related to electrical energy.

Q 4) If a 60 watt bulb is used for five hours, how many watt-hours of energy are consumed? 300 watt-hours.

How many kilowatt-hours is this equal to? 0.3 kilowatt-hours.

Q 5) If an electric motor operates on 110 volts of electricity and requires 10 amperes to operate it, what is its wattage requirement? 1100 watts.

If the motor is used eight hours per week, how much energy (kilowatt-hours) does it use in a YEAR? 457.6 kilowatt-hours.

Q 6) Instant-on model televisions are constantly using electricity to keep the set warm. Many models use about 25 watts of power to do this. How many watt-hours will the set use in a year? 219,000 watt-hours. If one man (an "energy slave") can only produce 40 watts of power per hour, how many man-hours of work a day would be needed just to keep this television warmed up? 15 hours a day.

Q 7) An electric clothes dryer uses about 5,000 watts of power when its heating coils are on, and 1,000 watts when just the motor is running. How many kilowatt-hours of energy are required to dry six loads during the week if it takes one-half hour to dry each load and the heating coils work 10 minutes of each half hour? 7 kilowatts. What is the weekly cost to operate the dryer if it costs three cents for each kwh of energy? 21 cents.

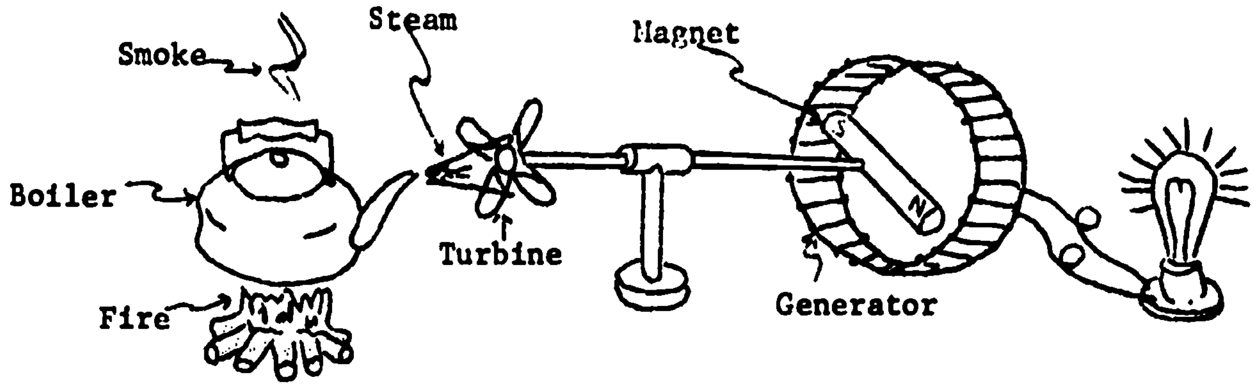
Q 8) A frost-free refrigerator uses about 1,217 kwh of electricity in a year, but a standard model uses only 723 kwh. How much extra energy does the frost-free refrigerator use each year? 439 kilowatt-hours.

At a cost of three cents per kwh, what does each type of refrigerator cost to operate for a year? Standard - $21.84 Frost-free - $36.51

How many extra hours of energy slave's time would be required to keep the refrigerator frost-free, if each slave can only work at a 40 watts per hour pace? 12,225 extra hours per year (nearly 34 hours per day).

Making Electricity*

Power plants change energy from many forms into electrical energy. In their simplest form, power plants consist of a turbine which turns a magnet inside a coil of wires. Nuclear and fossil fuel power plants use heat to create steam which turns the turbines. Hydroelectric plants use falling water to turn the turbines.



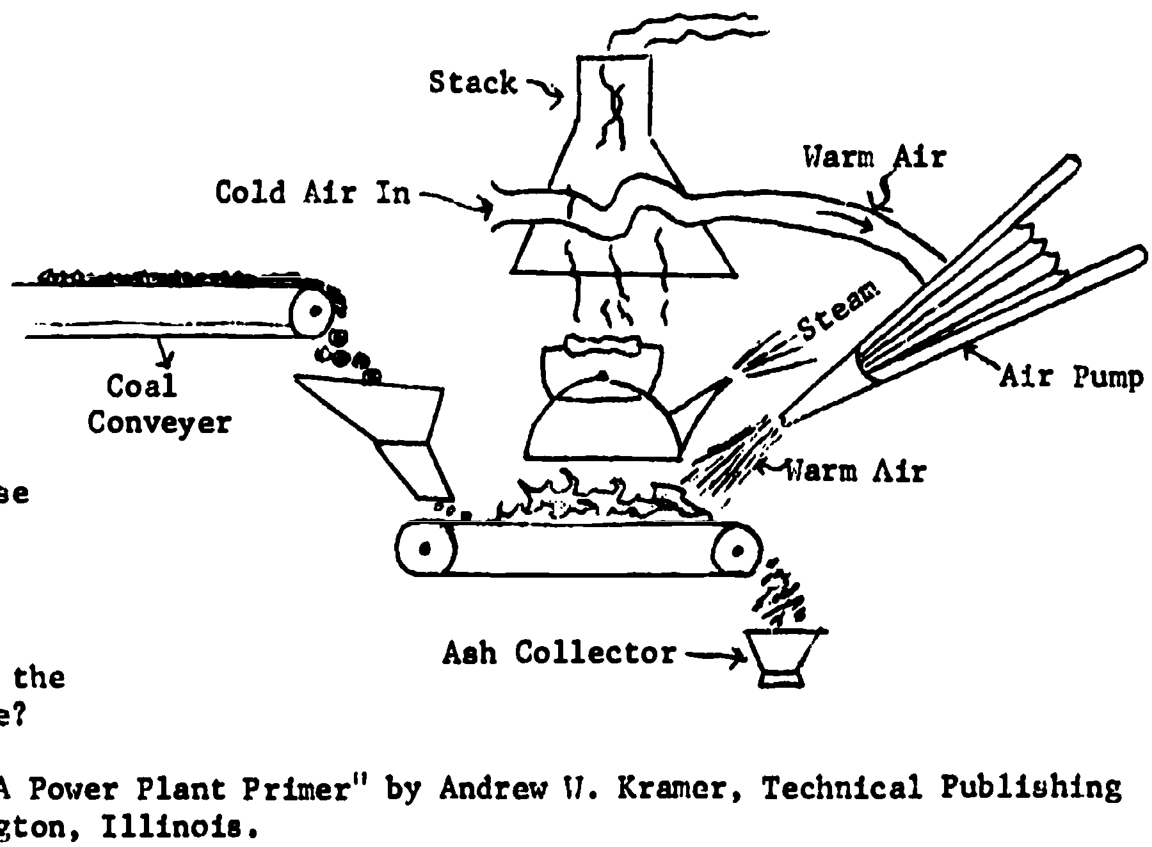
The sketch above shows all of the parts needed to create electricity, but a power plant with this design would not be profitable. Nearly all of its heat and magnetic energy would be wasted before electricity could be made. Engineers have designed improvements to make the plant more efficient, and this paper will explain some of those improvements.

The electrical generating system can be divided into three basic parts - the boiler, turbine, and generator. The boiler is the first place where efficiency can be improved.

Boiler Design

One pound of coal requires about 13 pounds of air to burn completely, so efficient burning requires large amounts of air to blow over the coal. As the coal burns, it produces ashes and gases which must be removed. Finally, each pound of air absorbs heat and takes it away from the boiling water, so the air should be preheated and carefully measured. To solve all of these problems, the boiler could be redesigned to include these improvements.

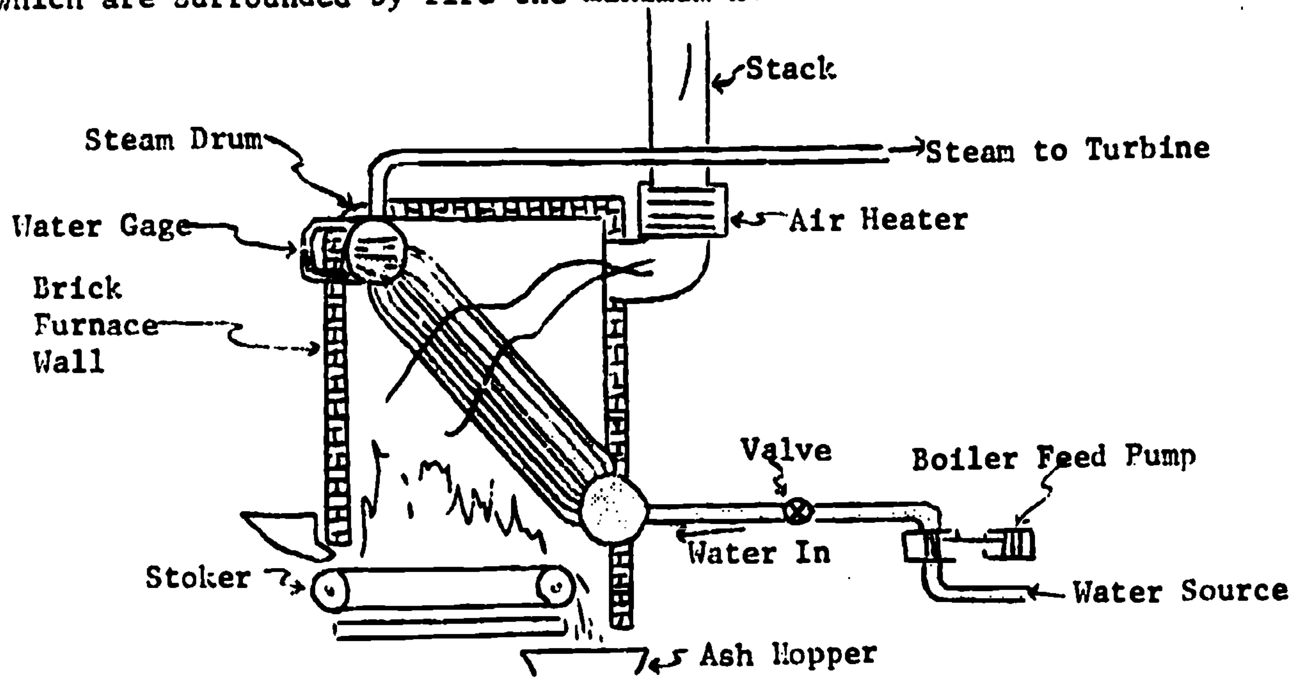
This design may still look very simple, but it is used to show how an engineer improves the efficiency of any system - step by step. Each of these improvements, simple as they appear, can cause problems. For instance, what pipe design in the stack would heat the air to the best temperature?



*...pted from "A Power Plant Primer" by Andrew W. Kramer, Technical Publishing ...any, Barrington, Illinois.

What is the best temperature for the air? How tall should the stack be? Each question requires a lot of engineering work, and each change usually causes a new problem to arise.

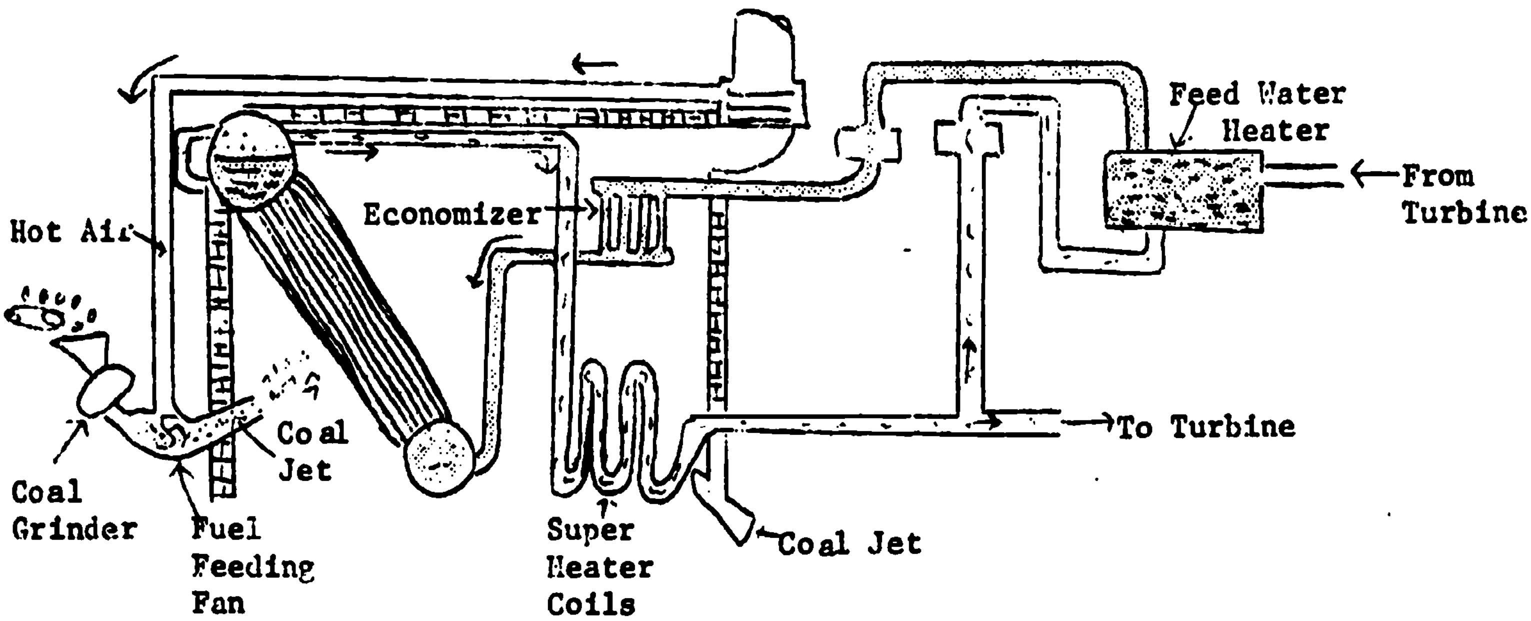
Now, back to improving the boiler design. The tea kettle is not a very efficient boiler, since it lets most of the heat escape around its edges, so why not enclose the fire and water in an insulated container? Then, if the water is run inside pipes which are surrounded by fire the maximum heat should be absorbed.



Two other improvements have been added to the design above. First, two steel drums are hooked to the pipes. As steam bubbles form, they rise to the upper drum where they collect before going to the turbine. Second, since a large boiler like KPL's can boil away 24 tons of water in less than a minute, a water pump must force in new water all the time. Since the water does not always boil at the same rate, a man or machine must always watch the water gauge to make sure that the top water drum is about half full of steam and half full of water.

The next step is to improve the burning of the fuel. Coal lumps do not burn quickly, and the burning rate is hard to control. By grinding the coal to dust, mixing it with heated air, and blowing the mixture into the furnace, the coal will burn almost instantly.

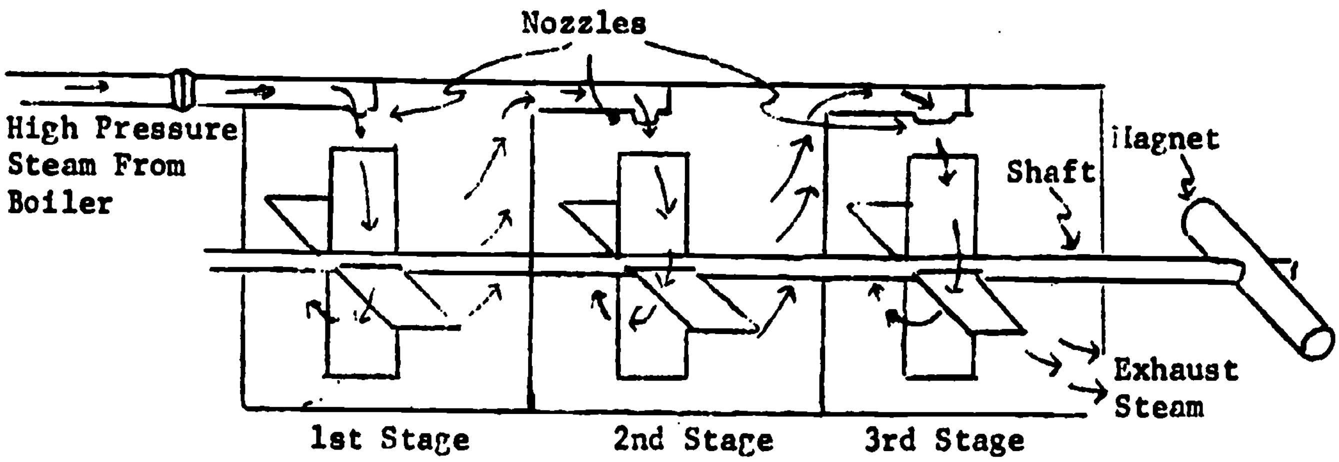
Much more useful energy can be removed from steam if it is under high pressure. This can be achieved by using very strong pipes and by super-heating the steam before it travels to the turbine. KPL uses steam at 540 Celsius degrees under tremendous pressure. However, cold water cannot be pumped into the hot steam drum without causing the drum to contract and eventually split, and much heat is still lost in the exhaust gas. To solve the problems, a little of the hot steam is used to heat the feed water before it goes into the boiler. A special bank of tubes runs through the exhaust gases to heat the water to about 290 degrees before it goes to the boiler drum. These tubes are the economizers, since they help save every bit of heat possible inside the boiler.



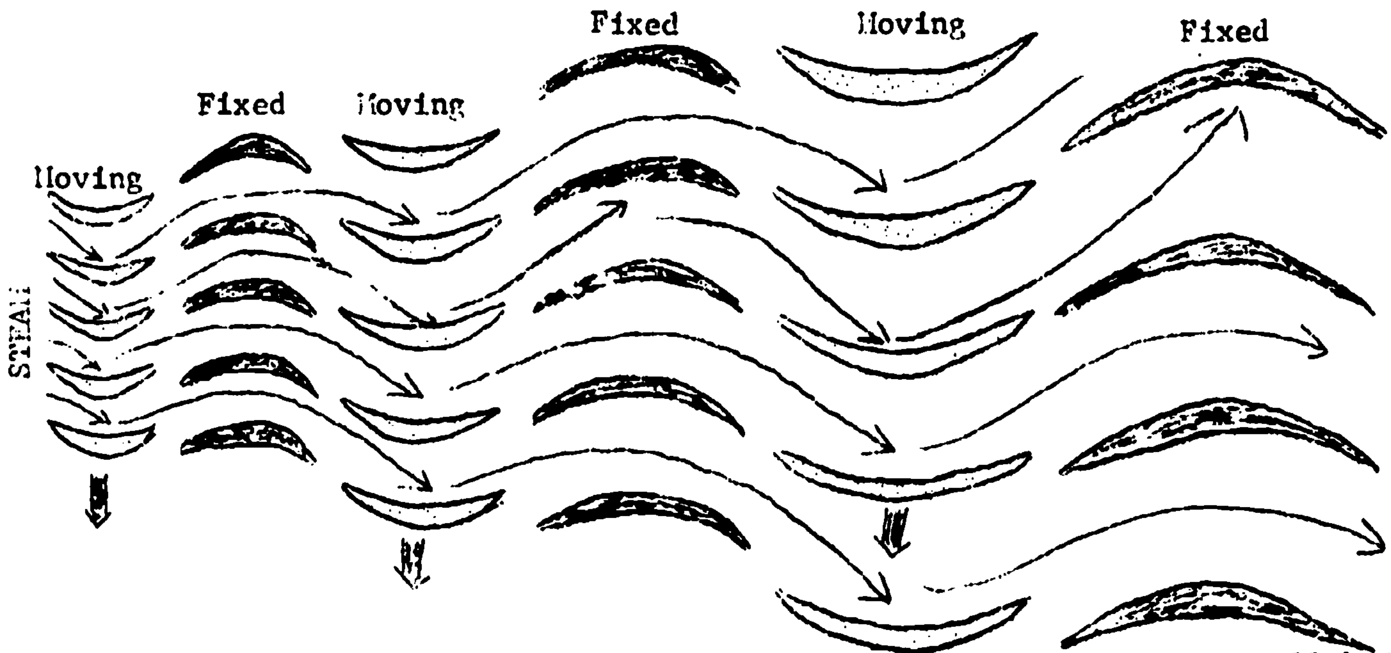
Thus, the water is heated to 250° Celsius in the feed water heater, to 290° Celsius in the economizer, and to 360° in the boiler tubes. Steam leaving the top drum is heated to 540° in the super-heater coils. This boiler design collects between 83 and 89 percent of the BTU's of heat from the coal.

Turbine Design

The simple fan shown for a turbine when this paper started, will not be very efficient in using all of the energy in super-heated steam. The first design change is to enclose the turbine and force the steam to go over and over turbine blades to get the maximum energy. Most turbines run steam through up to 30 stages before the maximum energy has been removed.

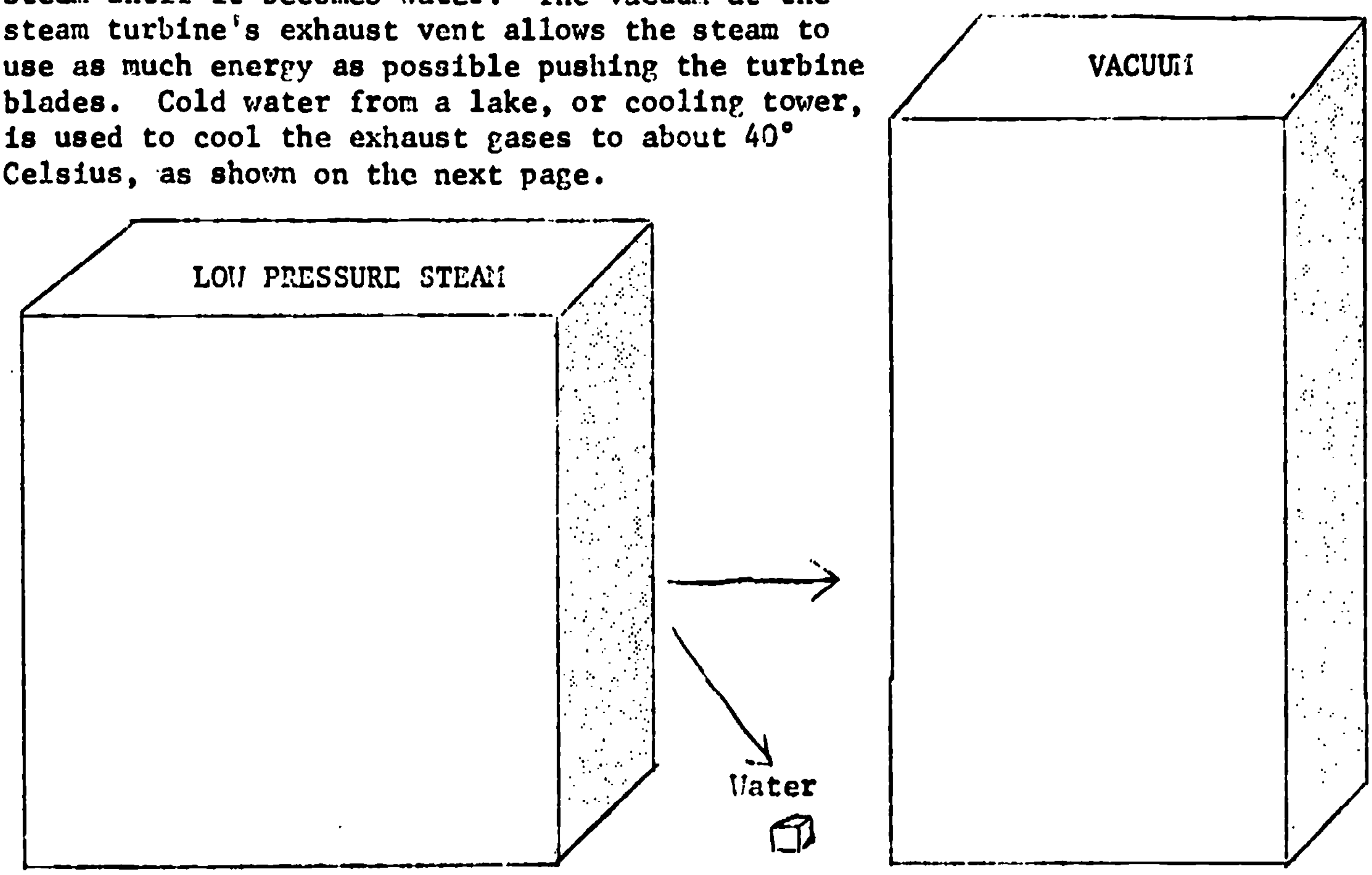


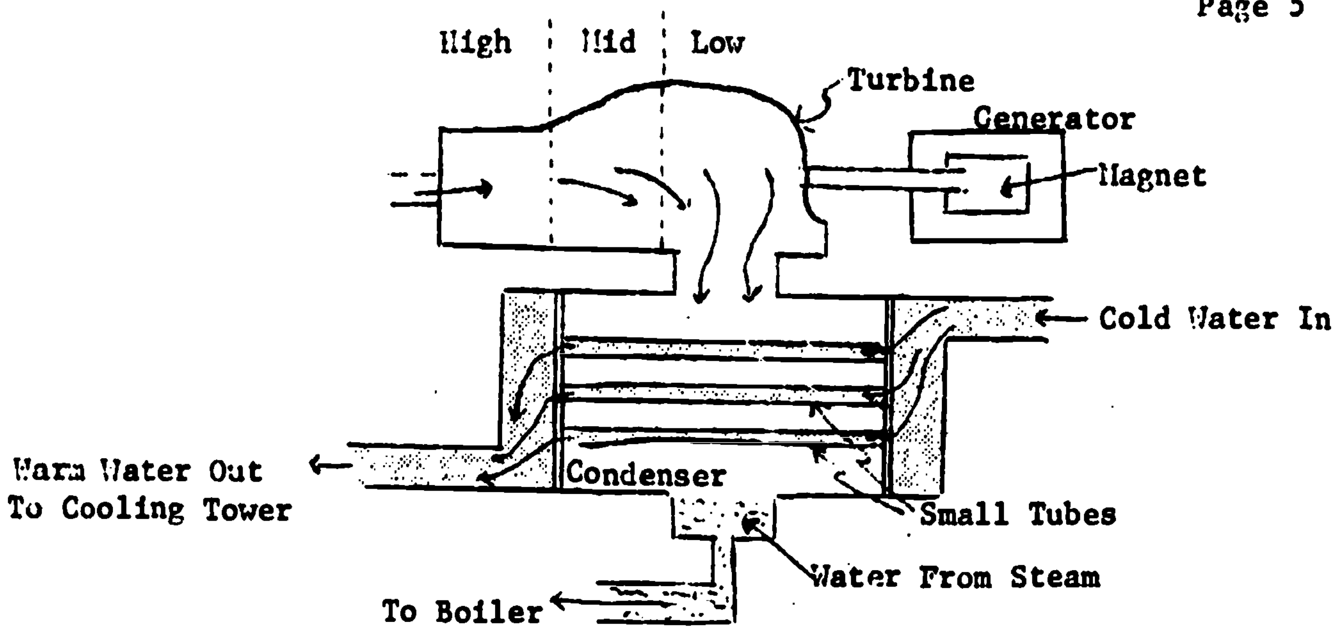
This arrangement is better than the simple fan blade, but even better blades could be designed. Modern turbines have thousands of blades with thousands of nozzles directing steam against the blades. As the steam works, its pressure drops and it fills more and more room. Therefore, turbines start with small blades and expand to large blades as the steam pressure drops.



One big trouble remains - 80 percent of the energy added to the steam is still being wasted. The waste comes from two causes. First, the steam must push its way out of the turbine against the pressure of the atmosphere. At 15 pounds of pressure for each square inch, the atmospheric pressure causes a lot of wasted energy which could have been used to push the blade.

To avoid this problem, the steam leaving the turbine is cooled. Since one pound of steam at atmospheric pressure fills 26 cubic feet of space, and one pound of water fills 1/60th of a cubic foot, a very large vacuum can be created by cooling the steam until it becomes water. The vacuum at the steam turbine's exhaust vent allows the steam to use as much energy as possible pushing the turbine blades. Cold water from a lake, or cooling tower, is used to cool the exhaust gases to about 40° Celsius, as shown on the next page.





Just the addition of the condenser at the exhaust vent of the turbine allowed an increase in efficiency of nearly 10 percent, but the steam cycle is <u>still</u> very inefficient.

Better efficiency can be obtained by taking the steam out of the high pressure turbine and reheating it. This reheating adds energy to the steam but not pressure. This additional energy is then available to spin the intermediate and low pressure turbine wheels. The steam soon loses so much pressure that it no longer can help push the spinning wheels. When this stage is reached, the steam is sent to the condenser where it is turned to water and the high vacuum is created.

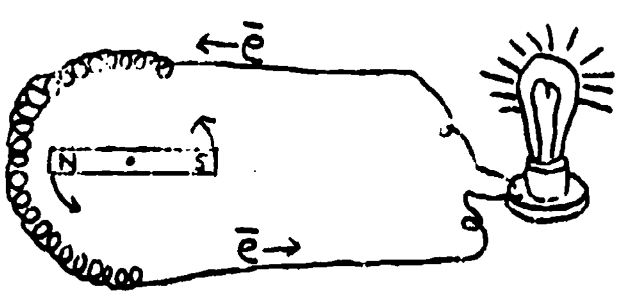
Engineers have also used low pressure steam from the turbine to heat the feed water instead of using high pressure steam. This improves efficiency a little.

Still, the problem of using all of the energy in steam before it turns to water has not been solved. As the pressure drops and the steam expands, its energy becomes less and less available for work. The most efficient steam cycle used today loses 60 percent of the steam's energy. This energy is transferred to the cooling water as the steam cools. Engineers know that most of this 60 percent loss will always occur in running steam cycles.

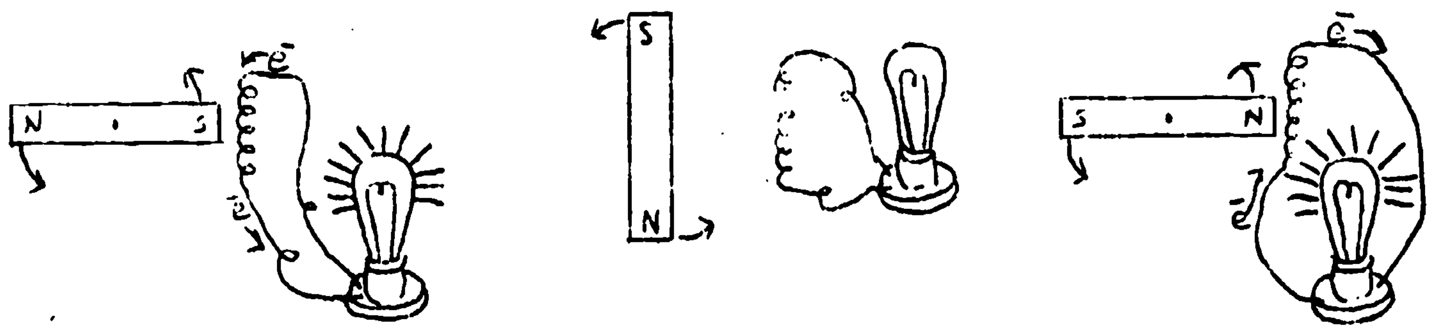
Electric Generator

Electricity is generated (made) by forcing a magnet to turn past a coil of wires. As the magnet moves by the wires, it forces many of the electrons in the wire to move, if the wire is connected to form a complete circle.

However, electrons all moving in one direction do not travel far before losing energy. They create a long magnet down the wire, and this causes some energy loss. Electrons also use energy from interference by slower moving electrons. The further the electron moves, the more energy it loses.

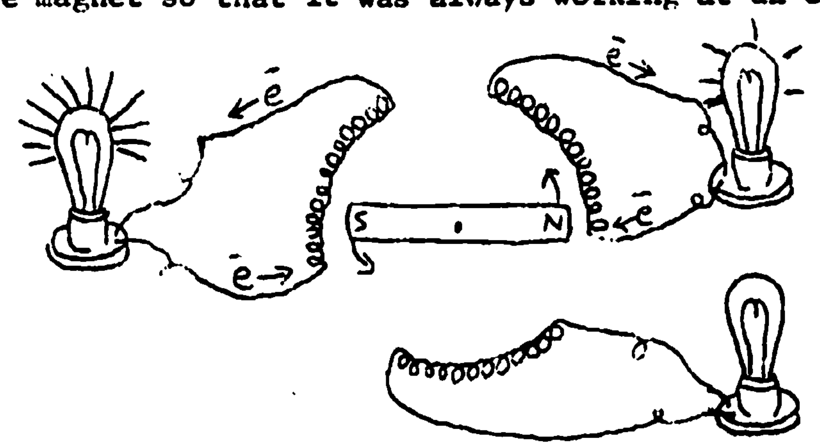


To solve this problem, engineers developed generators which make alternating current. Alternating current allows each electron to move back and forth rapidly.

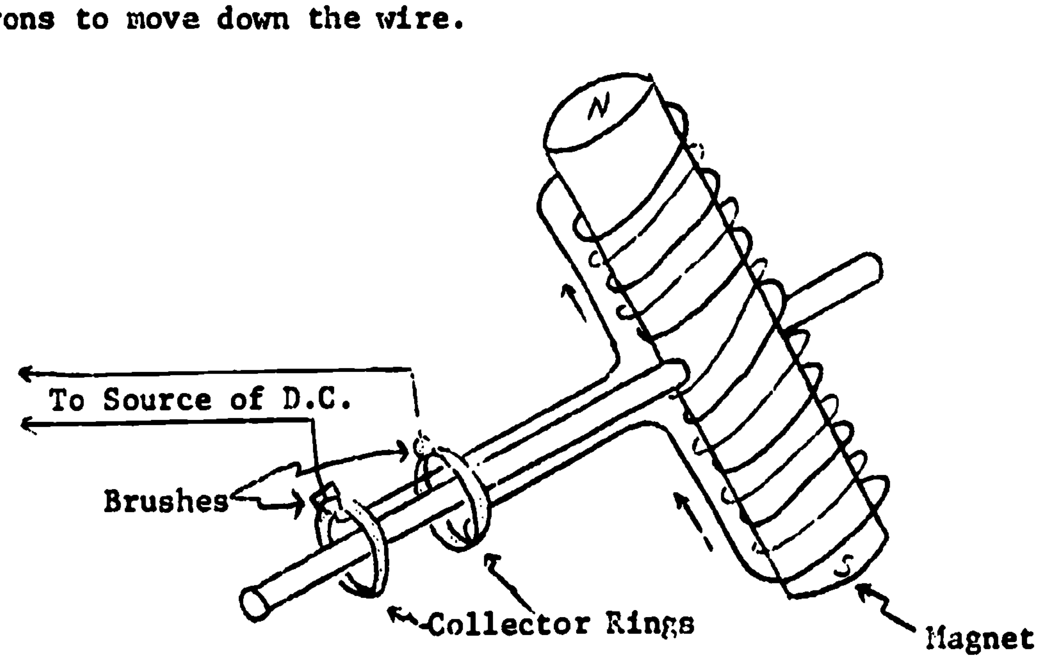


This current change occurs because the two poles of the magnet affect electrons in the opposite way. The north pole pulls electrons one direction, and the south pole moves them the other way. Two problems remained to be solved. The first one was that the magnet was pulling unevenly in this setup. The turbine would wear out quickly, and energy was being wasted.

This problem was solved by creating three different coils of wire, carefully spaced around the magnet so that it was always working at an even rate.



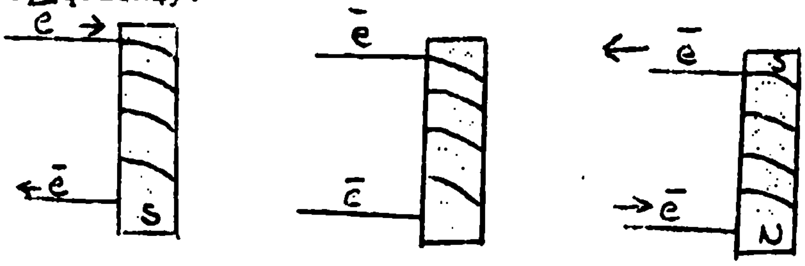
The second problem was that no permanent magnet can be made strong enough to run the generators of today's power plants. This was solved by using a direct current to run an electromagnet. This direct current creates a magnet, and the force of the turning turbine forces the magnet by the coiled wires. The moving magnet forces the electrons to move down the wire.



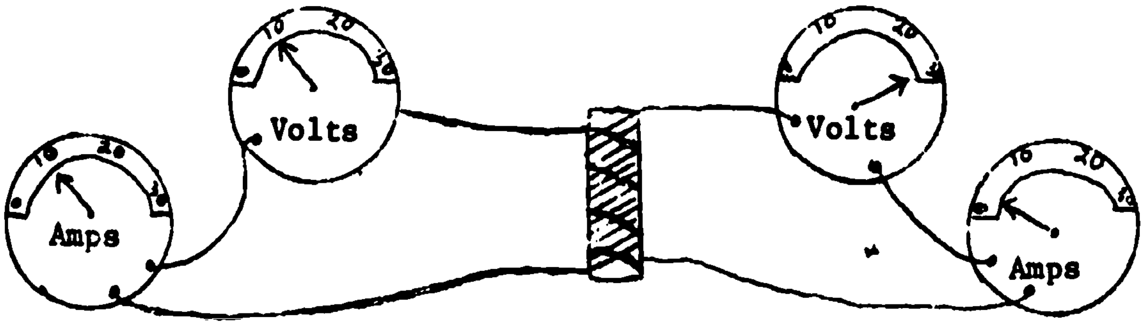
When all of these changes are made, the generator becomes a very efficient engine and can convert 97 percent of the energy of the turbine into electricity.

The Transformer

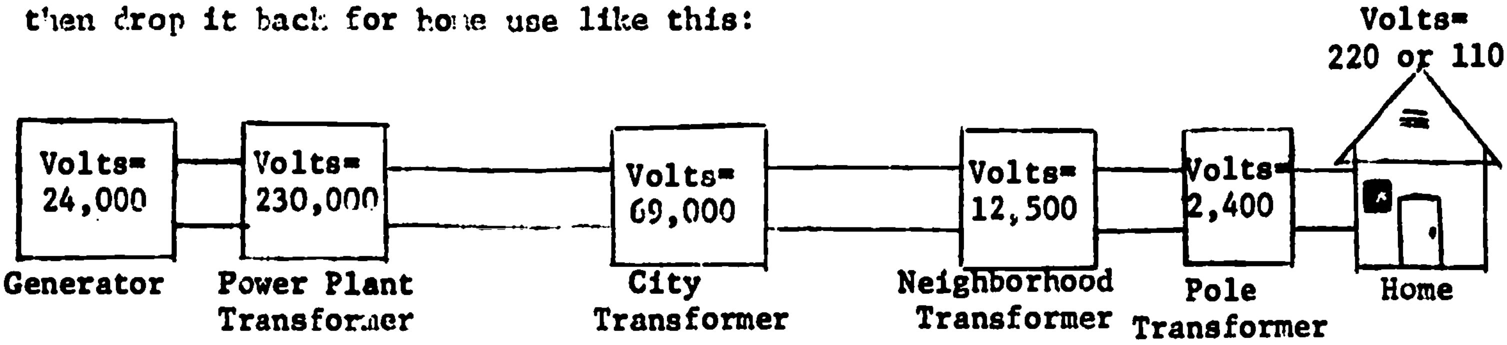
The final step in sending electricity to the house is the transformer. If a wire with an alternating current is wrapped around a piece of iron, the electrons moving first one way, then the other, will make a magnet which has the north pole up, then down, then up quickly.



If another wire is wrapped around the same piece of metal, then the rapidly moving current will create a rapidly changing magnet which will make the electrons in the second wire move. If the second wire has three times as many coils, then its voltage will be three times higher and its amperage will be one-third as great.



Because lines carrying high voltage and low ampers can push electricity much further than low voltage lines, KPL may boost the voltage up at the plant, and then drop it back for home use like this:



Transformers are very efficient (99%+), but transmission lines lose power the further they must run. Therefore, no company builds a generating station and plans to send its electricity more than 200 miles unless very high voltage lines are used. If too much energy is lost by the lines, profits would soon disappear.

Summary

An electric power plant operates on a simple idea involving only a boiler, a turbine, a generator, and a transformer. It becomes more complicated as engineers work to get every possible kilowatt hour of energy out of the fuel they burn. It is interesting to see how energy changes forms, and the efficiency of each change in the large generator.

Fuel (Chemical Energy) 100%	Burns ⟶	Heat Energy 99.5%	enters ⟶ water and air	Heat Energy 83%	turns ⟶ turbine	Mechanical Energy 35%

runs ⟶ generator	Moving Magnetic Energy 34.8%	moves electrons ⟶ in wire coils	Electrical Energy 34.6%	causes magnetic ⟶ energy in transformer	Magnetic Energy 34.3%	moves electrons ⟶ in wire coils	Electrical Energy 34%

Student Self Test Questions

1. What are the most basic steps in making electricity from coal?
2. Which step in the electrical production process loses the most energy? Why?
3. Why is coal crushed before it is burned?
4. Why is water heated before it goes into the boiler?
5. Why is steam super heated, and under high pressure?
6. Why is exhaust steam in the low pressure turbine turned to water?
7. How are generators and transformers the same? How are they different?

Behavioral Objective Number	Topics and Concepts
9	Students shall indicate that a stream of moving electrons is called electricity.
10	Students shall indicate that electrical currents must flow in a circle, and that this flow may cause, or be caused by, magnetic force.
12	Students shall indicate that energy is changed from one form to another when electricity is made and used.
13	Students shall be able to indicate why much of the energy in steam cannot be converted to mechanical energy.
14	Students shall be able to select from a list of seven, five ideas used in the KPL Generating Plant to obtain maximum efficiency.
15	Given these words - fire, spinning magnet, coils of wire, steam, and turbine blades - students shall be able to indicate the sequence followed by energy in forming electricity.

Teacher Suggestions

This paper introduces the major design characteristics which will be discussed on the KPL tour. It focuses on the designs which most improve the efficiency of the generating system.

The material below provides some background to questions which students might ask.

1. Steam is produced when molecules receive enough energy (heat) to leave the water and become a gas. As the steam pressure increases, the temperature of the water must increase to create more steam. Thus, the comparative level of steam and water in the top boiler drum is dependent on the steam pressure (which depends on how hard the turbine is working) and on the water temperature (which varies as the flow rates of water and fuel change).

2. Coal burns more efficiently than natural gas, because the hydrogen in gas turns to water, which removes energy from the boiler as it vaporizes to form steam.

3. The maximum mechanical energy that can be obtained from heat is explained by the Carnot cycle (the second law of Thermodynamics), which holds that the maximum efficiency of an engine is determined by this equation:

$$\text{Efficiency} = \left[\frac{\text{High temperature } (C^{o}) - \text{Low Temperature } (C)}{\text{High temperature } (C) + 273^{o}}\right] \times 100$$

In verbal terms, this means that as the gas does useful work, it expands and its temperature drops. Eventually, the gas pressure is so low that it will no longer "push" effectively, but the gas still contains large amounts of heat energy.

Thus, if all the steam in the generator moved from 540° to 40° C, a maximum of 61% of its total heat energy would transfer to the moving turbine blades.

Since only 83% of the BTUs in the fuel were transferred to the steam originally, this leaves a maximum theoretical efficiency of only 61% X 83% = 54%. In practice, of course, this efficiency is not approached since steam is far from an ideal gas and turbines are real, not ideal machines. To reach even the achieved efficiency of 34%, requires removing the steam from the high pressure turbine, reheating it, and using the reheated, low pressure steam in medium and low pressure turbines. Following one re-heat, the pressure is so low, that the only alternative remaining is to condense the steam and create a strong vacuum at the turbine's exhaust port.

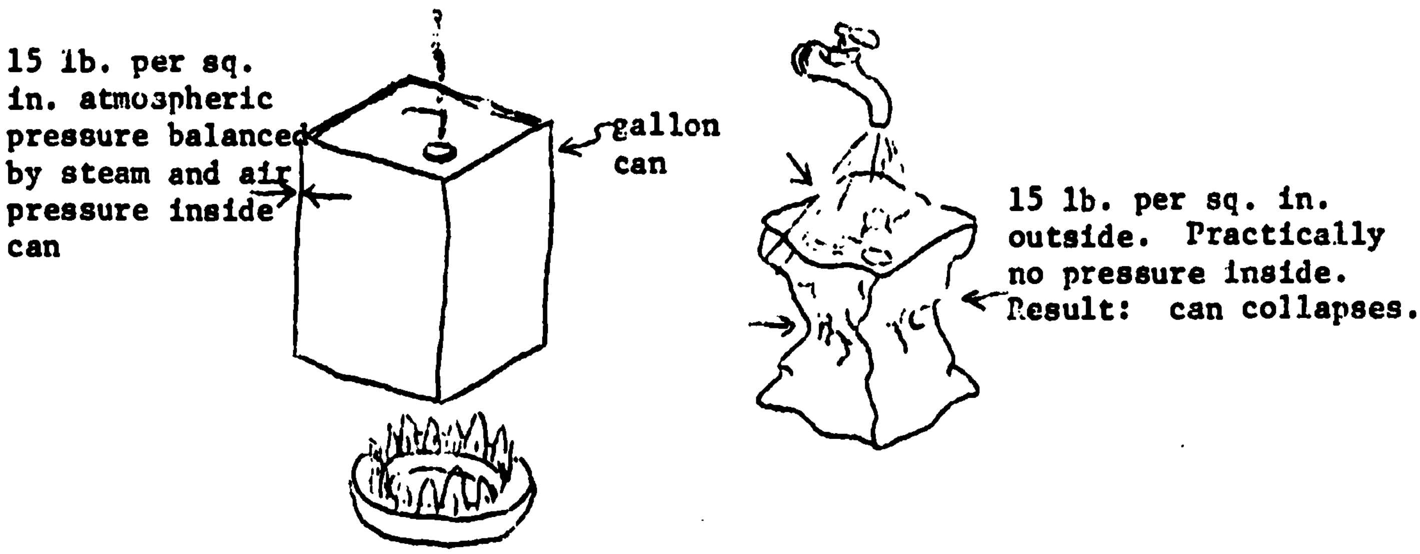
Finally, at least a third of the steam is removed as low temperature steam and is used to heat the boiler feed water, thus using the remaining heat in the steam to heat the condensed water.

The schematic presented in Transparency 5 provides information for a class discussion of this topic.

4. Transformers work for alternating currents because each time the electrons change direction, the magnetic field switches, and moves the electrons in the adjoining coils of wire. Direct currents will not cause the magnetic field changes, and can move electrons in adjacent wire coils only when the D.C. coils are, themselves, moving. You should make it clear that transformers do not <u>make</u> electricity, but simply transform incoming currents to new voltages.

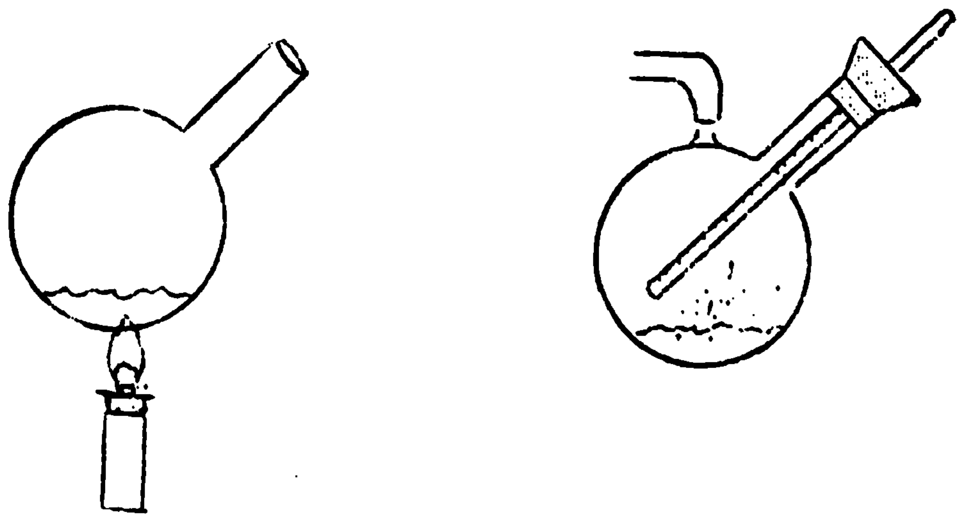
5. Two demonstrations will dramatically show (A) the creation of a vacuum by cooling steam in a closed container and (B) the fact that steam will continue to exist at a low temperature under a vacuum.

Use a clean metal can (Coleman fuel containers are great, but <u>thoroughly</u> clean the container before using) with a screw cap. Place a two cm or less layer of water in the can's base, heat the can until it is boiling vigorously, cap it, and cool it under running water. The 15 pounds per square inch of atmospheric pressure will crush it quickly.



Use a pyrex Florence or Erlenmeyer flask equipped with one hole stopper. Insert a thermometer into the stopper such that its bulb can reach near the base of the flask and the temperature can be read down to 50° C.

With the stopper removed, boil vigorously a layer of water about two cm deep. Insert the stopper and cool in running water. Note that the water continues to boil until the temperature is well below 100° C.



ANSWERS - STUDENT SELF-TEST QUESTIONS

Q 1. What are the most basic steps in making electricity from coal?

A. Burning coal, making steam, turning turbines, turning magnets in generators.

Q 2. Which step in the electrical production process loses the most energy? Why?

A. Converting energy in steam into mechanical energy in turbines. Energy is lost because much of the energy in steam is not released until it returns to water, and turbines cannot use that heat energy.

Q 3. Why is coal crushed before it is burned?

A. So it will burn quickly, and the amount of fuel can be controlled.

Q 4. Why is water heated before it goes into the boiler?

A. So cold water will not damage pipes, so energy from low pressure steam can be used efficiently, and to pull all possible energy from the boiler exhaust gases.

Q 5. Why is steam superheated, and under high pressure?

A. So that the maximum heat energy can be transferred to the turbine blades. If it were not superheated, the efficiency would be lower.

Q 6. Why is exhaust steam from the low pressure turbine turned to water?

A. So that a vacumm will allow steam to remain as gas at a lower temperature and allow the maximum energy to transfer to the turbine.

Q 7. How are generators and transformers the same? How are they different?

A. Generators start electrons moving back and forth with a moving magnetic force. Mechanical energy from the turbines moves the magnet. In the transformer, the moving electrons in one wire coil make the moving magnetic force which causes the electrons in the second coil of wire in the transformer to move.

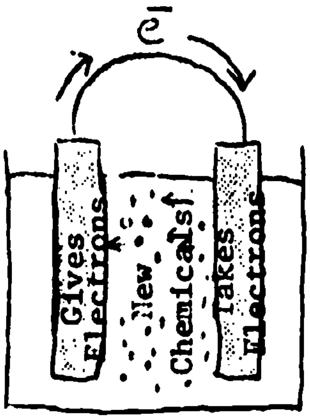
Both transformers and generators are the same because moving magnetic fields cause electrons to move. They are different because generators use mechanical energy to make electricity. Transformers only change the voltage and amperage of electricity.

Making Electricity - Seven Ways

Electricity from large generating stations which burn fossil fuels (oil, gas, and coal) provide almost all of our electricity today. However, seven other methods are also producing some electricity today.

Batteries

All batteries use two different chemicals. One solid chemical gives electrons and the other takes electrons. When a wire connects the two chemicals, the electrons move from one material to the other.

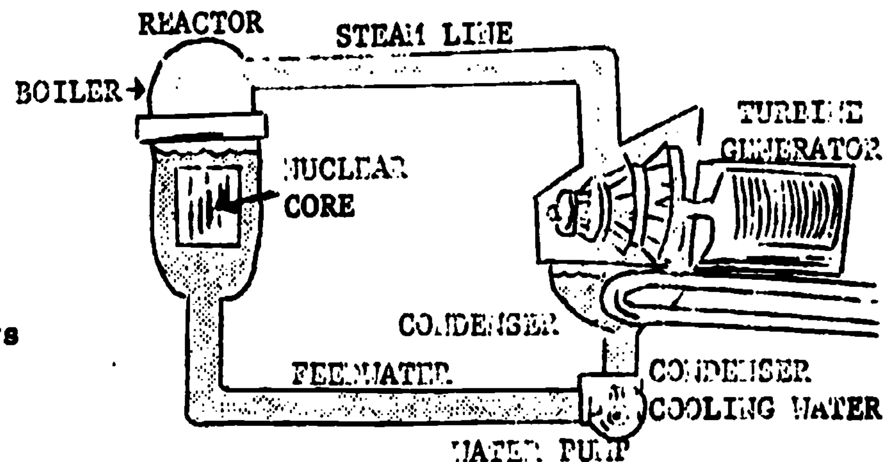


Making and recharging batteries uses much more energy than the battery can release. Therefore, batteries are used to provide electricity only when portable electrical energy is needed.

Nuclear Reactors

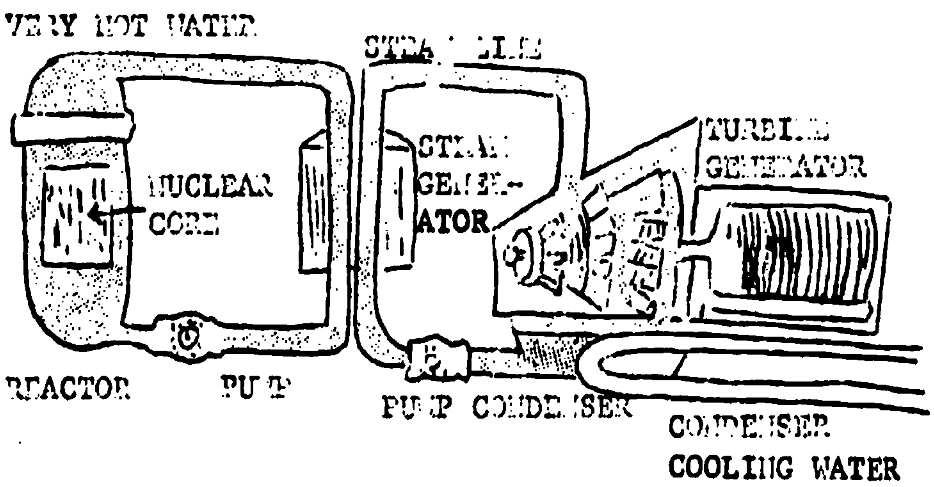
Three basic types of nuclear reactors are being used to make electricity. Each uses nuclear reactions to heat materials which turn turbines. A later paper will explain how the nuclear reactions release heat.

<u>Boiling Water Reactors</u> use the nuclear core to boil water and can change about 34 percent of the heat energy into electricity. The cooling water carries away the rest of the energy released by the reactor. This reactor has <u>very</u> tight containers around the nuclear core and around the turbine, steam line, water line, and cooling water. The containers keep radioactive materials from escaping into the environment.

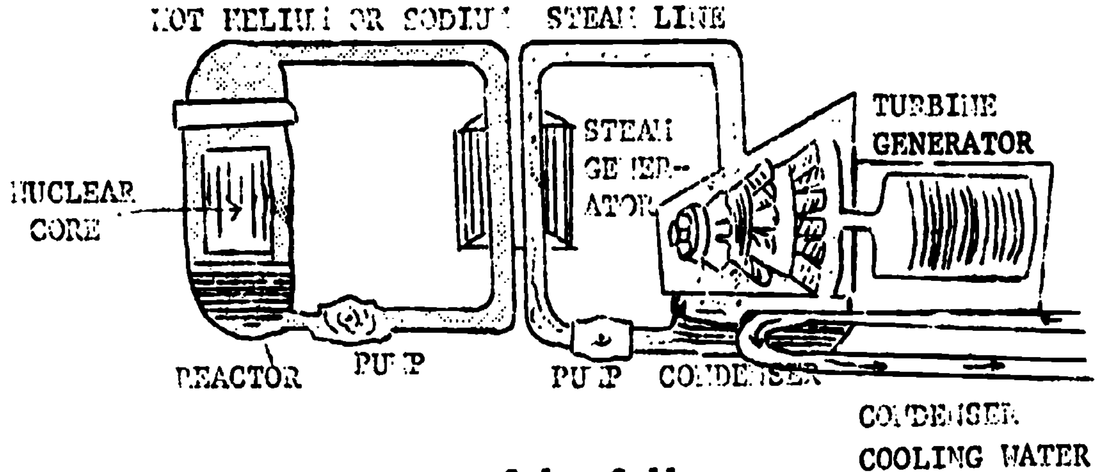


<u>Pressurized Water Reactors</u> separate the heating water from the water which turns the turbine blades. This allows the temperature and pressure of the steam line to be raised without fear of losing radioactive materials into the environment.

This reactor can change about 32 percent of the heat energy from the reactor into electricity

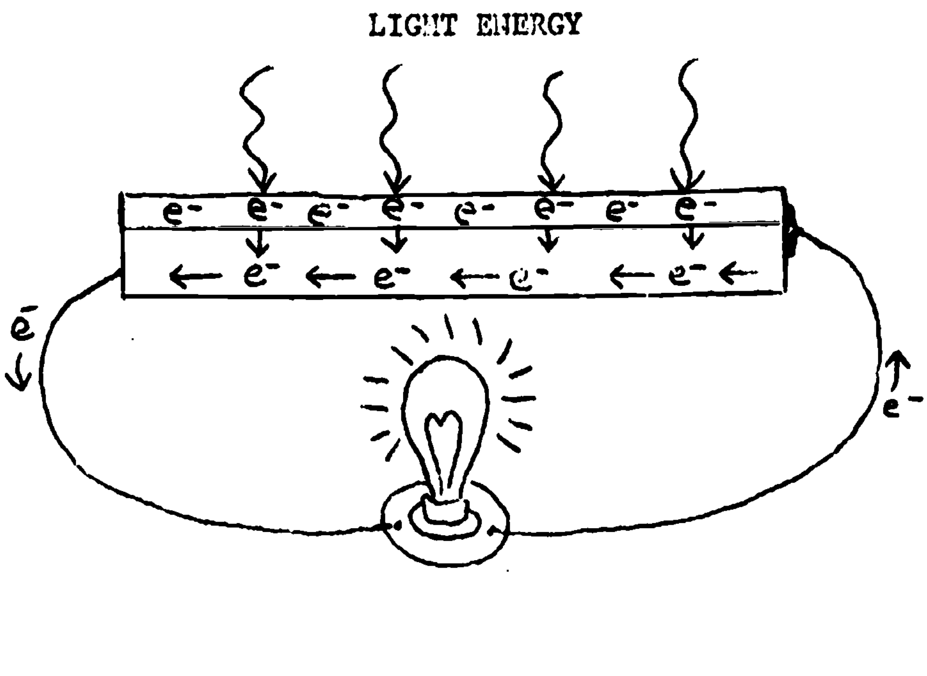


High Temperature Gas and Molton Metal Reactors use heat carried by helium gas, or molton sodium, to make steam which turns the turbine. Since the helium or molton metals can be heated to a very high temperature (740° C or higher), it can heat the steam to a higher temperature than in the pressurized water reactors, and 32 to 40 percent of the heat energy can be changed into electricity.



Solar Cells

Today, solar energy is being used to make electricity in one basic way - solar cells. However, the cells are much more expensive than other means of electrical production now being used. They work because sunlight striking an electron can give it a great deal of energy. If a weak electron current is flowing past the energetic electron, it will join the other electrons and increase the power of the current. If enough electrons are energized by rays of sunlight, a good electric current can be created.



This same principle applies to photo cells, which use light energy to make weak electric currents. These cells make use of between 5 and 15 percent of the sun's energy, depending on the materials used to make the electron holding and carrying layers of the solar cell.

Geothermal Power Plants

Geothermal means "heat of the earth." Geothermal power plants use the heat from deep within the earth to boil water to turn turbines. In a sense, a geothermal power plant just creates a geyser, like Old Faithful, and runs the boiling water past a turbine to create electricity. Several of these geothermal power plants are now running in California, Iceland, New Zealand, and Italy.

Hydroelectric Power Plants

Hydroelectric power plants use the energy of falling water to turn turbines. Some hydroelectric power plants are set below dams blocking rivers. Others use the power of rising and falling tides to turn the turbine blades. These turbines are very efficient (90 percent) since they depend only on the force of falling water to spin the blades.

Student Self-Test Questions

1) What is the basic difference between the three designs used for nuclear power plants?

2) Which of the seven methods for producing electricity uses energy which continues to arrive on the earth's surface every year?

3) Every common method of producing large amounts of electricity uses the same things to make electrons move. What are they?

4) Which method of producing electricity is the most efficient user of available energy?

Behavioral Objective Number	Topics and Concepts
9	Students shall indicate that an electric current is caused by moving electrons.
12	Students shall indicate that energy is changed from one form to another when electricity is made and used.
13	Students shall be able to select the best explanation for the inability to convert all heat energy to mechanical energy in turbines.
15	Given these words - fire, spinning magnet, coils of wire, steam, and turbine blades - students shall be able to indicate the sequence followed by energy in forming electricity.
16	Students shall indicate that all nuclear powered generating stations use steam to turn turbine blades.
17	Students shall indicate that geothermal and hydroelectric plants use energy which will be available to man for eons.

Teacher Suggestions

As can be seen from the objectives above, the basic goal of this paper is to increase student awareness of the options and energy conversion efficiencies now available for producing electricity. We do not expect students to know all of the design characteristics of the many different options.

Students may ask why batteries are so inefficient. This arises from two physical principles. (1) The chemicals (zinc, copper, cadmium, sulfuric acid, lead, and so on) used to make batteries require a high energy input to refine and (2) electricity produced by other means is used to recharge batteries. The battery can never return all the energy used to charge it, since some energy is diverted to heat, nonproductive chemical reactions, and so on.

In regard to the nuclear reactor discussion - the efficiencies reported could not be obtained from the simple designs shown. Just as in the case of the fossil fuel plants, the Carnot cycle would limit the designs shown to efficiencies of less than 20 percent. In the nuclear plants, as in the fossil fueled plants, steam is both re-heated and is used to pre-heat the feed water. These steps improve the efficiencies to the levels shown.

Answers - Student Self-Test Questions

Q 1) What are the basic differences between the three designs used for nuclear power plants?

A) Steam produced by water around the nuclear core powers the turbine in the boiling water reactor.

Water heated by the nuclear core never touches the turbine, but is used only to create steam in a separate system of pipes in the high pressure water reactor. Gas or molton metal is heated by the nuclear core and is used to create steam in a separate system of pipes in the high temperature gas and molton metal reactors.

Q 2) Which of the seven methods for producing electricity uses energy which continues to arrive on the earth's surface every year?

A Solar cells use sunlight.

Hydroelectric plants using energy contained in rain as it flows toward the ocean.

Geothermal plants use heat energy from the earth's core. Boiling water from this energy reaches the earth's surface.

Q 3) Every common method of producing large amounts of electricity uses the same things to make electrons move. What are they?

A High-pressure steam or falling water turns turbine blades which force magnets by coils of wire.

Q 4) Which method of producing electricity is the most efficient user of available energy?

A Hydroelectric plants use about 90 percent of the energy available from the falling water used to turn the turbine blades.

Environmental Costs of Producing Electricity

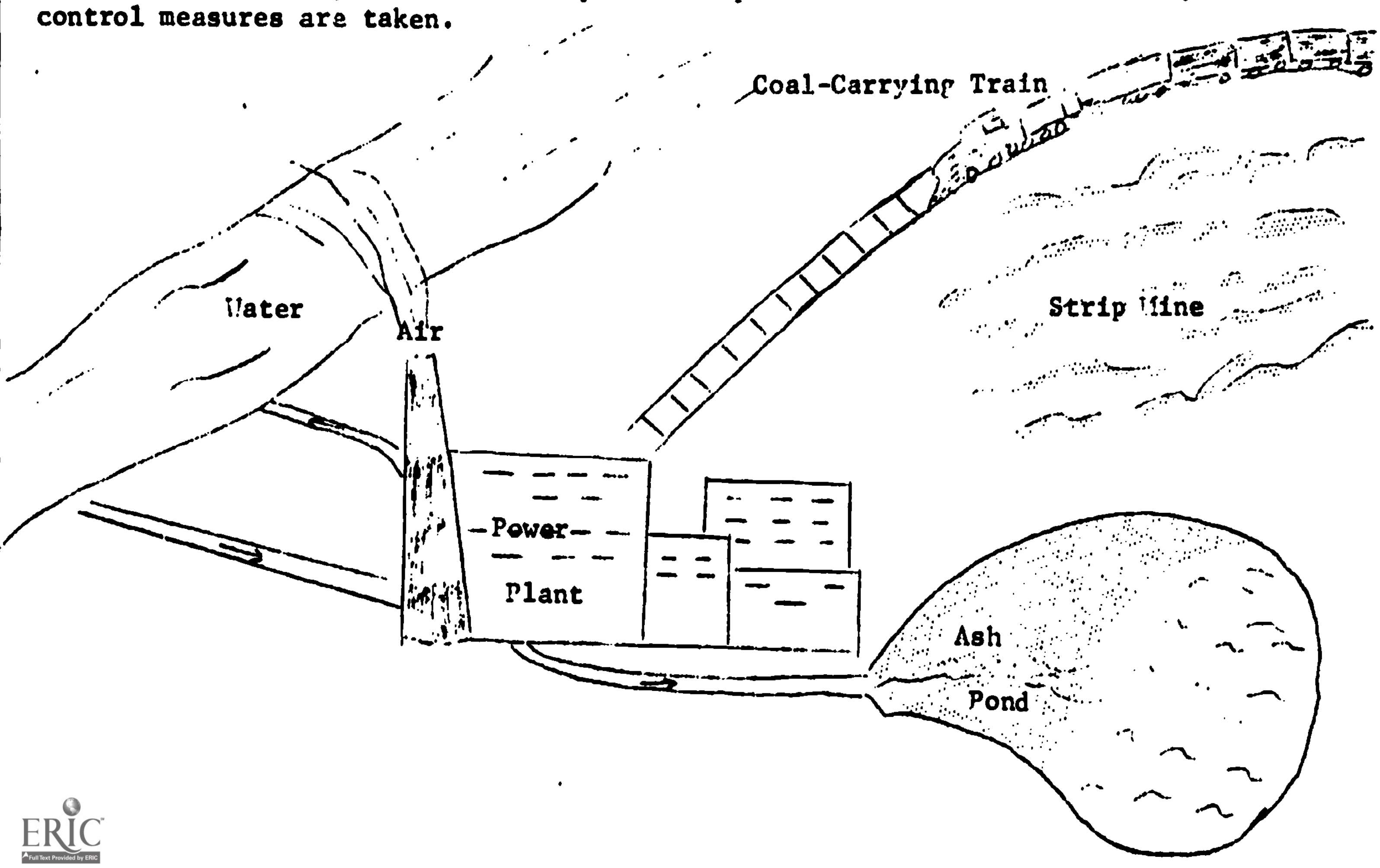
Earlier papers in this module have shown that energy from electricity is very important to most Americans and that making electricity is a complex operation. This paper looks at the environmental costs of producing electricity. In studying environmental costs, you should realize that every time you use energy, you change your environment. When you killed a cow or potato to obtain food energy, or burned a dead log to cook food, you changed the environment. Even your use of the sun's energy for a sun tan changed the environment, because the sand you covered did not receive its normal warmth.

When energy is used to produce electricity, the environment is also changed. Whether the environment changes in large or in small ways depends on the fuels burned and the pollution control equipment in the plant. Air, land, and water quality may be affected as electricity is made.

Air Quality and Electricity

Burning fuels release gases, pieces of unburned fuel, and heat. Some of these products of burning fuel, such as heat and water vapor, may have very little effect on the air's quality. Other products, such as dusts and sulfur dioxide, are definite air pollutants which may damage human, animal, and plant health around a plant with no pollution controls. Still other pollutants, such as carbon monoxide, nitrogen oxides, lead, and mercury, may or may not cause noticeable changes in the environment. Good research proof has not shown that these materials have caused environmental damage near power plants, but when many other cars and industries are also adding pollutants in a small area, the damage may occur.

When natural gas is burned, very little air pollution occurs. This can be seen by observing the dust and fumes that are not released when natural gas burns in your home stove. When oil is burned, more pollution is released, and the environment around a large oil burning power plant with no pollution controls may be damaged. When coal is burned, a serious air pollution problem can be created if no pollution control measures are taken.



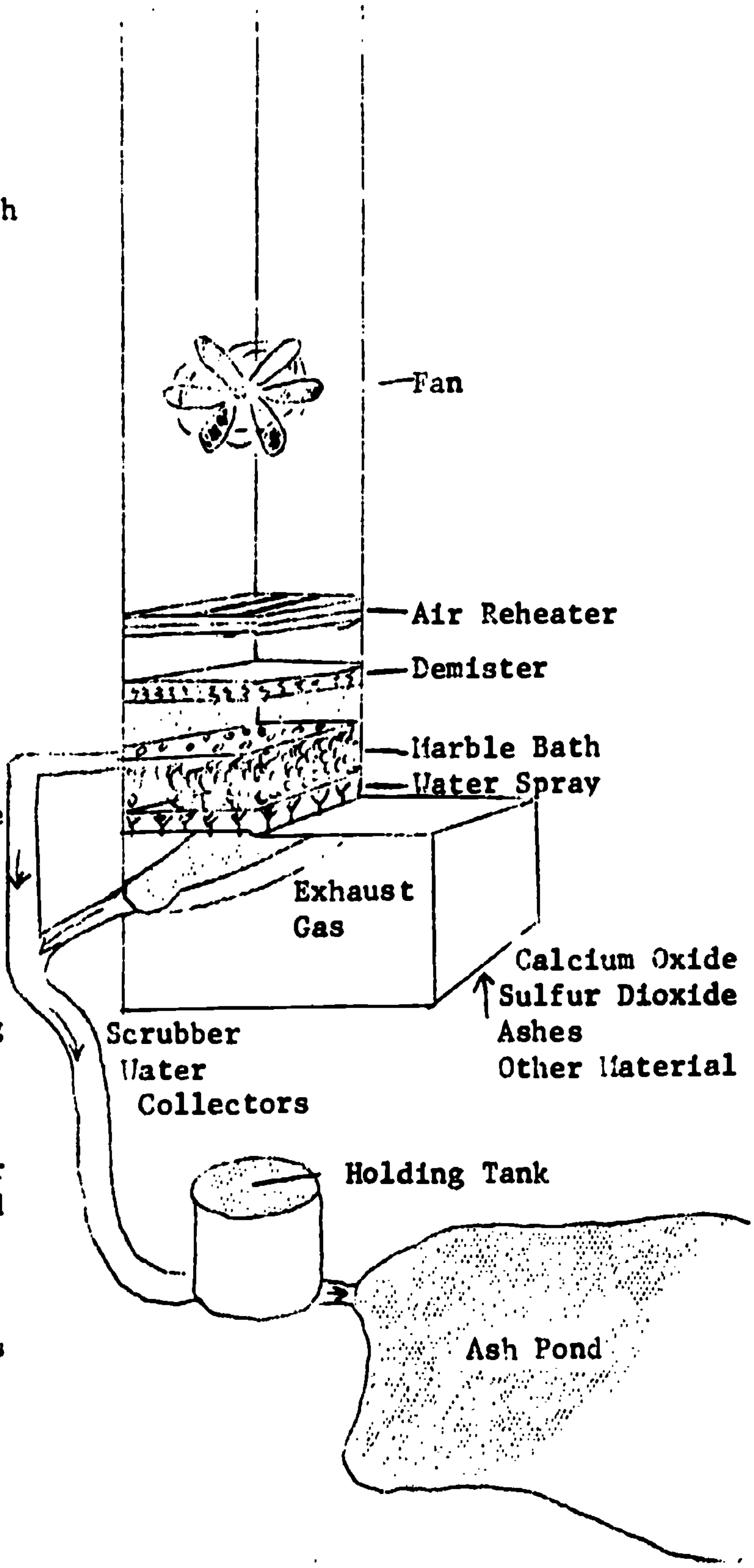
The Lawrence KPL plant has one of the best air pollution control systems in the country, and it is continually changing and improving its system. It now consists of four basic parts:

A) In the boiler, limestone is burned with coal to produce a very active chemical called calcium oxide.

B) The air from the boiler is blown through a layer of water in the scrubber. In the water, the air bubbles are broken up and mixed with water by millions of vibrating glass marbles. Ninety-nine percent of the ashes in the air are trapped by the water. The calcium oxide hooks to water and then removes 60 percent of the sulfur dioxide gases from the air. This forms a compound containing calcium and sulfur which slowly turns into calcium sulfate, or plaster of paris.

C) The scrubber water, now carrying a heavy load of ashes and dissolved calcium-sulfur compound, is piped to a holding tank where calcium sulfate is formed. In the tank, the calcium sulfate forms crystals. Large mixers keep the ashes and calcium sulfate stirred up and in the water until it reaches the ash ponds. The method used keeps calcium sulfate from forming layers on the pipe walls and plugging the system with plaster of paris.

D) The cleaned gases rising from the water have most of the water droplets removed in a demister. The air from the demister is reheated to remove water droplets and blown out the top of a very tall stack. By the time the gases from the tall stack return to earth, the Kansas winds will have scattered them over hundreds of square miles of land and no measurable damage will be caused.

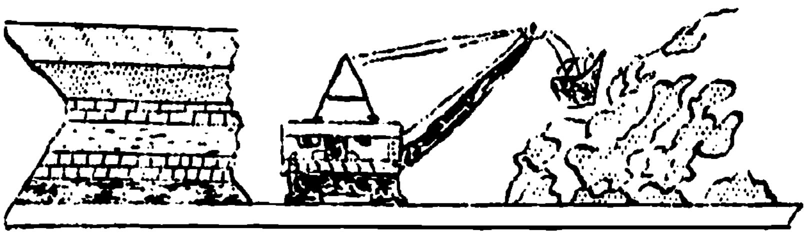


Air pollution is also a minor problem from nuclear power plants. As uranium atoms break up to make the heat needed to create steam, some new atoms are formed. Some of these atoms are gases which must be removed from water to keep the reactor working well. These gases are removed and stored for enough time to let most of the radioactive atoms disintegrate. When most of the radioactivity is gone, the air is filtered to remove most of the remaining radioactive atoms and released high in the air. The regulations controlling radiation air pollution from nuclear plants are so strict that you would receive more radiation each year by moving to the mountains than you would by living next to a nuclear plant in Kansas. As you move higher, radiation from the sun and from granite rocks occurs at a slightly higher level than found in Kansas and lower states.

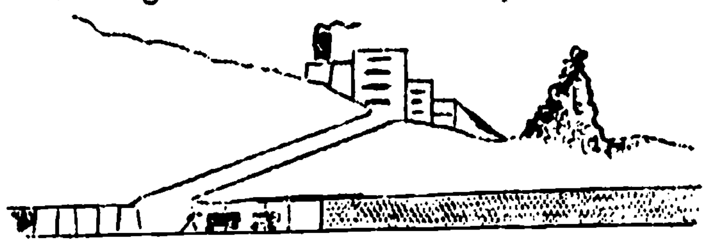
Land Pollution and Electricity

Making electricity by burning oil or natural gas does not change the land much. Some land must be used for pipe lines, power lines, and to supply the materials for the oil wells, power lines, generating stations, etc. None of these changes affect large areas of land in major ways.

However, when coal or uranium is used to make electricity, land must be mined to obtain the fuel. The mining may be strip mining, which removes many feet of rock and soil to expose the fuel, or it may be shaft mining. When mine shafts are dug, large piles of rock (tailings) are usually stored above ground. Unless strip mines



Strip Mine



Shaft Mine

are leveled and covered with topsoil, large ditches and very poor soil may replace what was once productive land. Shaft mines may cave in and the large piles of waste may dam creeks and destroy land.

Coal and oil-burning plants also change the land's environment when ashes and (with air pollution control) calcium sulfate must be stored. As the air is purified, ponds must be dug to hold the solid wastes. Someone may discover a use for these materials, but for now, KPL has a huge pond filling up with ashes and plaster of paris that costs more to ship than it is worth.

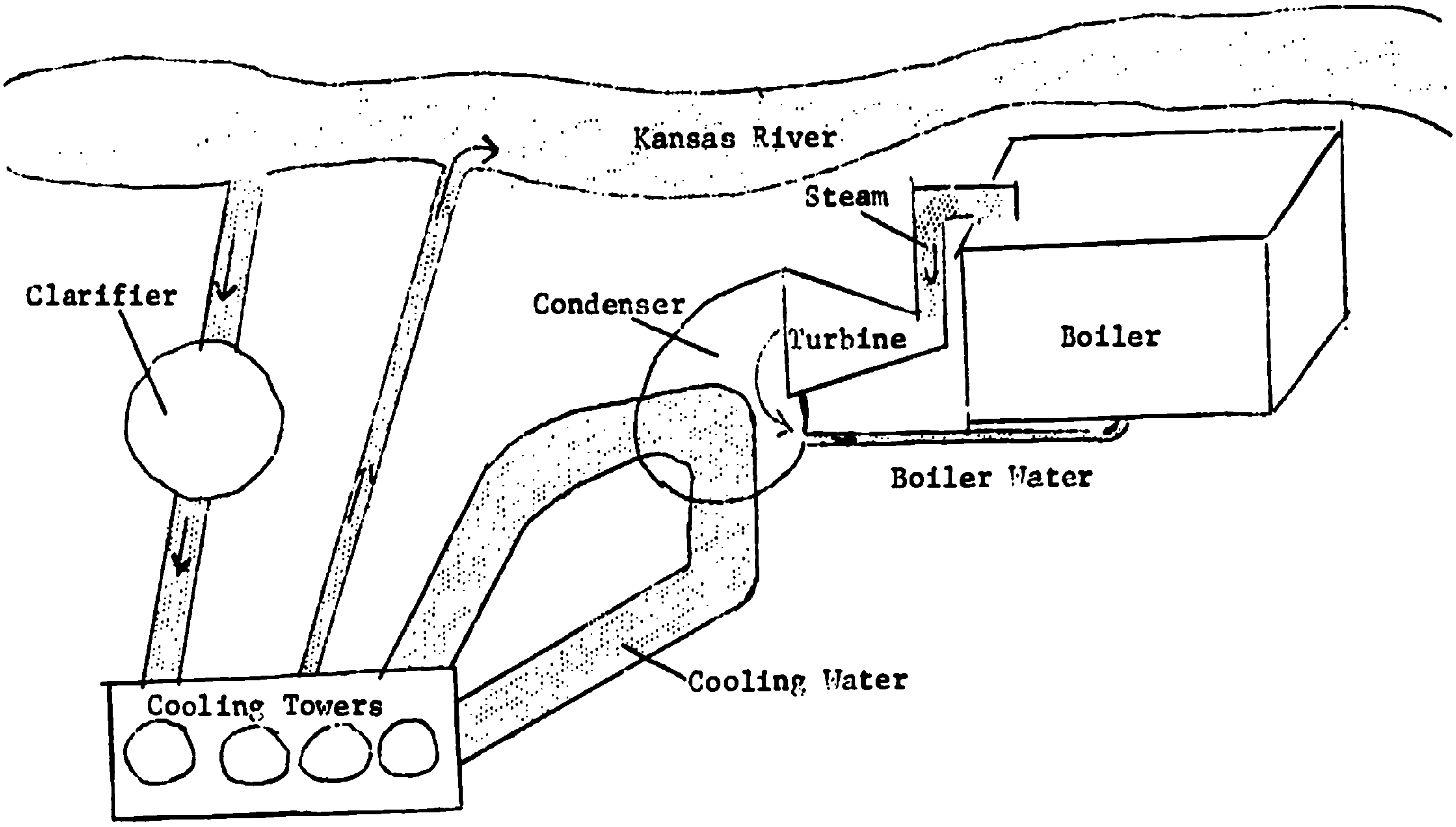
Nuclear power plants also have a large pollution problem when their wastes are considered. As the uranium atoms break down, new radioactive atoms are produced. Many of the atoms will remain radioactive for centuries, and a good storage method has yet to be found. The problem does not involve large storage areas, but it does involve very long times and materials which could really damage water if they escaped from storage.

Water Pollution and Electricity

Making electricity also helps create three kinds of water pollution; 1) heat, 2) mine drainage, and 3) oil spills.

At the power plant, much of the heat in the steam is transferred to the condenser water. If this condenser water is returned to the river or lake from which it came, the hot water may change the environment of the natural water. KPL has tackled this problem by using cooling towers to cool the river water so that it can be used over and over again in the condenser. As it cools, some of the water evaporates and must be replaced by new river water. The Lawrence plant is so big that if its cooling towers were not used, the plant would require more water than the Kansas River carries on some summer days. With the cooling towers, the plant only needs to have a stream that is two feet deep, two feet wide, and moving at one mile per hour to take care of its needs.

WATER FLOW AT KPL



Mine drainage is the second major water pollution problem connected with making electricity. Coal often is mixed with materials containing sulfur. When water seeps through the coal mine, sulfuric acid may enter the water and ruin it for human and animal use. Streams and ponds in several areas have been ruined by acid seeping from the coal mines. In addition, rain water may wash tons of silt out of strip-mined areas and into rivers and lakes.

The final major cause of water pollution connected with electricity comes from oil spills as large tankers unload imported oil and off-shore drilling rigs bring up oil from underground layers. Man is working to learn how to control these spills, but much work remains to be done.

Pollution Controls and You

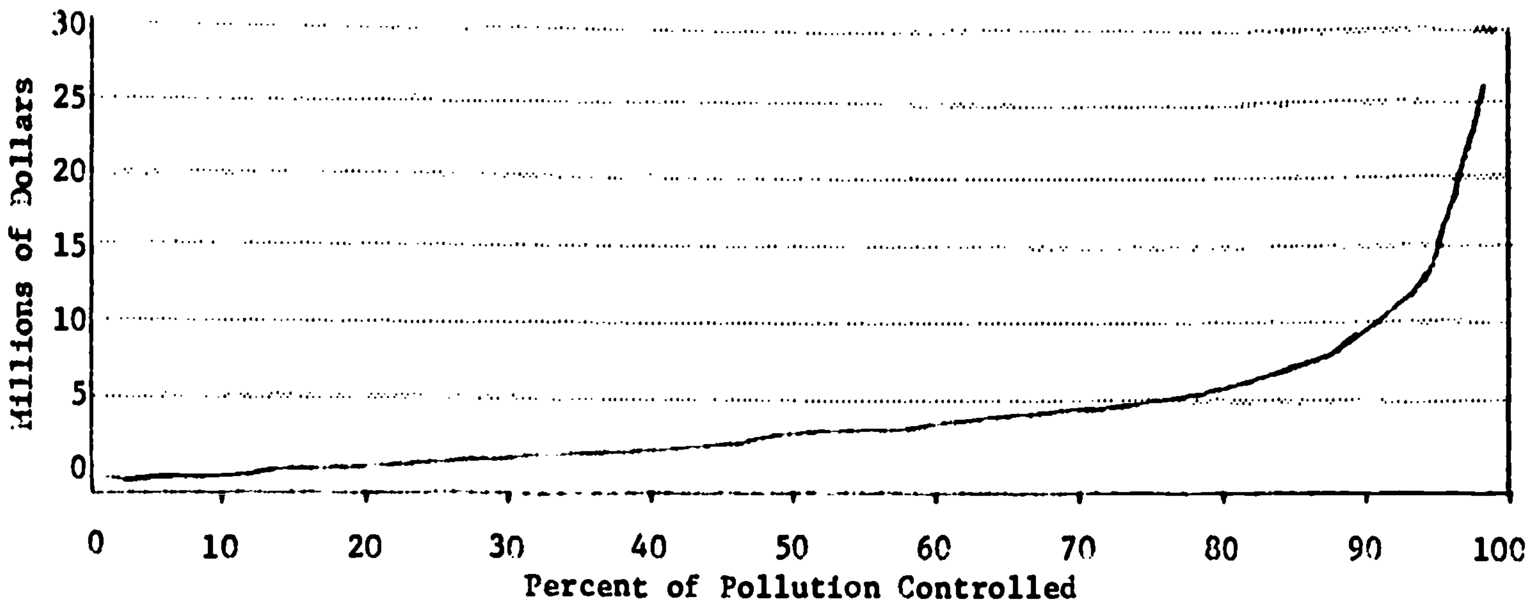
Five very important ideas should be understood about pollution caused by electricity.

1) Today, if we are to get the energy we want, we must mine coal, pump oil, and burn fossil fuels somewhere. Burning the fuels in small plants in the same area where many cars, factories, and homes are also burning fuels may turn air and water pollution from a mild to a serious problem. Burning the fuels far from cities in electrical plants with good pollution control equipment can turn many problems from serious to almost nothing.

2) Pollution control costs money--lots of it. The cost of leveling the land and replacing the topsoil will push the mining company in Southeastern Kansas out of business. They move thousands of tons of soil to reach an 18 <u>inch</u> layer of coal. They cannot afford to restore the land and still sell coal at a price others can afford. In Wyoming, on the other hand, the same amount of land must be moved to reach a layer of coal over 50 <u>feet</u> thick. Their mining companies can afford to replace the soil and to return it to productive use. In both cases, the cost of pollution control is passed on to KPL who pays as they buy their coal.

The cost of building cooling towers and scrubbers and fans to blow air out of tall stacks adds 15-20 percent to the cost of building generating stations. The pay for the men and electricity needed to run the pollution control equipment in the Lawrence plant adds 3-6 percent to the cost of producing electricity. Finally, more fuel must be burned just to run the machinery needed to control the pollution caused when fuel is burned. KPL passes these costs on to you in your electric bills. If they did not, they could not afford to make electricity and to control pollution at the same time.

3) It is much harder to control <u>all</u> pollution than it is to control <u>most</u> of it. This applies to ashes, sulfur dioxide, carbon monoxide, heat pollution, or any other type of pollution. The Brown's Ferry Nuclear Plant shows this well, since it added better radiation control of its air pollution in several steps, and the cost can be easily compared. To control 80 percent of the radiation from the plant cost 6 million dollars. To increase pollution control by 15 percent, to a 95 percent level, cost another 9 million dollars. To control just 2 percent more of the radiation cost another 11 million dollars. Thus, to control the first 2 percent of pollution cost $150,000. Improving control from 95-97 percent cost $11,000,000. Engineers do not even see how the last 3 percent could be controlled.



Radiation control costs of the Brown's Ferry Nuclear Plant

All pollution control faces similar cost increases as better and better controls are used.

You can easily see why this works when doing experiments in class. To avoid spilling most of the material isn't too hard--to avoid more than one mistake a year is quite difficult--and to avoid making <u>any</u> mistakes is almost impossible. We must learn what level of pollution will not damage the environment, and control it to that level. Greater control than needed will just cost much more money without helping the environment.

4) Learning how to control pollution takes time and dollars. The scrubbers used at KPL are a many million dollar experiment, and money continues to pour into the scrubbers as engineers work to correct problem after problem. No one can sit in a laboratory and predict all of the problems that will occur when scale models turn into giant fans and stacks. Someone must build a working model and spend years working out the bugs. When KPL gets the problems worked out of their scrubber, then other companies will install their system and save most of the money and time spent figuring out how to make the original scrubber work.

5) Pollution controls are essential. Man must protect the air, land, and water quality of this planet if we and the animals and plants around us are to live decent lives. If the demand for energy continues to grow as fast as it has, and when the supplies of natural gas begin to decline, the need for good pollution controls will become even more important.

Student Self-Test

1) List the two kinds of pollution KPL could cause in Kansas and two kinds which could be caused outside of the state because KPL is making electricity.

2) If no electricity was made, would we have a society with less pollution?

3) How is air pollution from ashes and sulfur dioxide controlled at KPL?

4) KPL now controls 99 percent of their ashes and 60 percent of their sulfur dioxide. Should a law be passed requiring 100 percent control of these materials? Why?

5) Why are water cooling towers very important to electrical producing plants in dry states?

6) Who should pay for controlling pollution in strip mines?

Behavioral Objective Number	Topics and Concepts
18	Students shall be able to select the basic sequence of actions taken to reduce ash and sulfur dioxide levels in the air surrounding the KPL plant.
19	Students shall be able to select a graph showing the relationship between costs of pollution control and percentage of pollutants controlled.
20	Students shall indicate that a) creating and installing effective pollution control equipment requires much time, money, and research, b) this effort should be made if pollution is significantly damaging the environment, and c) the costs of controlling the pollution should be part of all products' costs.

Teacher Suggestions

All too often, public discussion of poll[illegible]n control is based on four very weak assumptions:

1) Pollution control can be accomplished overnight if science says it can be done.

2) Total control is possible and desirable.

3) Someone other than the user of the product will bear the cost of controlling pollution.

4) Environmental costs of producing a product should not be part of the product's cost.

The film, Environment, can help bring out these student assumptions and could be well used at this point. About five minutes of the film deals directly with pollution control problems in the electrical industry.

A good discussion of the student self-test questions should help students begin to question the four basic assumptions, and paper G should further their understanding of why pollution control costs will--and must--be passed along to the consumer.

Answers - Student Self-Test Questions

Q 1) List two kinds of pollution KPL could cause in Kansas and two kinds which could be caused outside of the state <u>because</u> KPL is making electricity.

A Air pollution (particularly sulfur dioxide and fly ash); water pollution (particularly heat); and land disruption (acres of land are used for coal mining and ash storage). Note that most of these <u>are</u> controlled now.

Outside Kansas--land pollution near strip mines; water pollution from strip mine run-off and oil spills; and air pollution from oil refineries are all possible because of KPL's fuel requirements. Note that most of these would probably occur whether or not KPL made electricity, unless each Kansan cut down his energy demands.

Q 2) If no electricity was made, would we have a society with less pollution?

A The answer depends on how much energy is used. Theoretically, we could eliminate all machines now using electricity, use natural gas to heat homes, etc., and have less pollution. We would also have a much lower standard of living. On the other hand, if we maintained our material standard of living without electricity, we would have much more air pollution as oil and coal burning replaced electricity in heating homes, running engines, and providing light. The point of this question is that energy usage, not electrical production, is at the root of most pollution control problems.

Q 3) How is air pollution from ashes and sulfur dioxide controlled at KPL?

A First, gas is burned most of the time, so ash and sulfur dioxide is controlled by choosing the cleaner fuel. Second, when coal is burned, limestone is burned with it. The furnace heat turns this calcium carbonate into calcium oxide.

The exhaust gases are blown through a bed of water and the calcium oxide combines with water and sulfur dioxide to make calcium sulfate (plaster of paris). The water also picks up most of the ash and removes ash and calcium sulfate to the holding tank. In this tank, the solids sink down and are pumped to the ash ponds.

Q 4) KPL now controls 99 percent of their ashes and 60 percent of their sulfur dioxide. Should a law be passed requiring 100 percent control of these materials? Why?

A No! 1) The only way one week's worth of air pollutants could be 100 percent controlled is to pump the exhaust gas into a box larger than Topeka and 50 feet deep. The box would, of course, need to be a complete vacuum initially. In this manner, the exhaust gas could not mix with the air. This is, of course, ridiculous, but so is 100 percent control of anything all the time. Even humans pass a few grams of sulfur dioxide (and much smellier hydrogen sulfide) weekly as their intestines break up compounds containing sulfur.

Students should realize that 1) total control is not necessary, since most pollutants exist at a low level from natural production, and we need not strive for a level of pollutants lower than that found in the natural environment near the plant; 2) tall stacks normally allow a tremendous dilution of materials before they reach the level occupied by plants and animals; and 3) the costs (in money and energy) of pollution control accelerate dramatically as the last 20 percent of the pollutant is sought. It would probably take most of the electricity produced at KPL to control 99.9 percent of the SO_2 and ash--even if engineers could figure out a method.

On the other side of the coin--companies should control their pollution to a level causing no significant environmental damage. If this cannot be done at a cost which allows the product to be sold, then other products produced with less pollution should be purchased. We should not expect future and present generations of humans, animals, and plants to suffer because we want to purchase products produced at a major cost in environmental damage.

Q 5) Why are water cooling towers very important to electrical producing plants in dry states?

A A large volume of cooling water is essential for efficient operation of the turbines via condenser cooling. If a large body of water is not able to supply the cooling water and receive the heated water without damage, then cooling towers must be supplied. These allow most of the cooling water to be recycled.

Q 6) Who should pay for controlling pollution in strip mines:

A The mining company, which bills the coal users, which bill the consumers. Ultimately, the environmental costs must be borne by the person who decides, "I will, or will not purchase this product at this price."

ECONOMICS OF THE KANSAS POWER AND LIGHT COMPANY

The Kansas Power and Light Company is a unique business. It is a privately owned, state-regulated industry. This means that: 1) the company is owned by stockholders; 2) people in the KPL service area can purchase electrical service only from KPL; and 3) the state of Kansas regulates KPL's prices, profits, and many of its policies.

Reasons for Allowing Only One Electrical Company

Our basic economic system is based on free competition between businesses and between individuals. You have the choice of many kinds of grocery or clothing stores when you shop, but you are limited to only one possible company to supply electricity to your home. Why are you allowed only one choice of electrical power supplier?

Producing electricity requires a tremendous investment in poles, wire, transformers, generating stations, repair equipment, and repair men. If two or three companies had to compete for your money, each company would need to have its own poles, wires, etc., running side by side so that you could have a choice. This duplication would raise the price of electricity for everyone and increase the chances of accidents and damage from storms.

Producing electricity requires energy, and big plants can produce electricity more efficiently than small plants. In addition, power is lost for every mile of electrical line, and small lines lose more energy than large lines. Three small companies running lines side by side would waste tremendous amounts of energy compared to one large company with one network of lines.

In short, Kansas allows just one company to sell electricity in each area in order to save money, energy, and material for other uses in the state.

How is KPL Regulated?

In the grocery store, you can refuse to buy one product and purchase another. Your decisions help control a company's prices and products. KPL does not need to worry about competition from electrical companies, so what keeps its services good and its prices low? Four things make sure that KPL meets your needs:

1) KPL is required by law to supply energy to meet the needs of all customers seeking electricity and paying their bills. This energy supply must be reliable, and all KPL costs must be shared fairly by all customers. Any customer not receiving satisfactory service may appeal to the Kansas Corporation Commission. If the Kansas Corporation Commission finds that service is unsatisfactory, it can require KPL to stop serving the area and allow a competing electrical company to take over the customers.

2) The Kansas Corporation Commission controls KPL rates. Before any rate can be changed, the Commission must be convinced that the rate change will provide only a reasonable profit for the company and a reasonable cost to the consumers. Open hearings are set and opponents and supporters of the rate change are allowed to present evidence for the Commission's consideration.

3) People must purchase stocks or loan KPL money if it is to build new facilities. Companies with poor reputations may lose these sources of money as people invest in other companies with better reputations for good environmental controls, profits, or service. This keeps KPL working to keep its customers happy.

4) People, and particularly industry, can purchase energy in other forms, such as coal or gas, if the price of electricity is too high.

In short, a combination of state regulation and competition from other energy suppliers substitutes for the direct competition usually found in other businesses in this country.

Our economy works because people trade freely. For instance, someone with 50 cents could spend it on many things. If he buys a hamburger, he decides that it will help him more than anything else which could be purchased for 50 cents. The person selling the hamburger chooses to use his time and knowledge selling hamburgers for 50 cents, even though other jobs and places are possible. If the buyer receives a good-tasting and nourishing hamburger, and if the seller made a reasonable profit from the hamburger, a good trade was made. If the trade leaves either side dissatisfied, a poor trade was made.

In a similar manner, KPL traded its freedom to set its own rates and to select its customers to the people of Kansas. Kansas, in return, allowed KPL to be the only electrical company in the area it serves. This allows rates to be lower and less energy and material to be wasted. Over the years, both sides have traded well.

During 1973, which was a typical year, KPL traded its electricity for about 88 million dollars, and they reduced their cost to the residential user to 2.3 cents per kilowatt hour. A man working at top speed can generate about a one-tenth of a kilowatt of energy in an hour, so this rate allows you to purchase four "energy slaves" for only one penny per hour. Just ten years earlier, in 1963, KPL sold only 48 million dollars worth of electricity at a higher rate of 2.8 cents to the residential user. In fact, KPL rates now are much lower than they were in 1924 when electricity cost 15 cents per kilowatt hour.

KPL's Profits

To really understand the trades made by Kansans and KPL, it is best to look at how the company spends its total sales receipts of 121 million dollars. Since this much money is hard to think about, we will simplify the example and talk about just one of those sales dollars, with the understanding that every dollar was spent the same way.

Fuels and Materials: KPL traded 41 cents from each sales dollar to companies who supply the corporation with fuel and materials used to produce and distribute electricity and natural gas. Fuels, which are the largest expense in electrical production, include gas, oil, and coal. Other materials include wires, poles, and production machinery.

Employees: KPL traded 11 cents from each sales dollar to employees in exchange for their knowledge, ability, and effort. Employees ran the generating stations, designed new equipment, repaired equipment, and billed energy users.

Government: KPL paid 20 cents from each sales dollar in taxes to governmental units. KPL taxes help support judicial and educational services, as well as the protection of property by police and fire departments. KPL serves as a tax collector, with the taxes collected on electric bills going to all levels of government.

BEST COPY AVAILABLE

<u>Interest</u>: KPL paid 4 cents from each sales dollar as interest on money borrowed from banks and other companies. The borrowed money was used to build new generating plants and equipment.

<u>Depreciation</u>: KPL traded 10 cents from each sales dollar to manufacturers for new machinery and equipment to replace that which wore out during the year.

<u>Profits</u>: After other companies were paid 41 cents for fuels and material, employees were paid 11 cents, governments were paid 20 cents, lenders were paid 4 cents, and replacement equipment manufacturers were paid 10 cents (a total of 86 cents), 14 cents was left for the stockholders. This 14 cents from each 100 cents worth of sales was the corporation's profit. In 1973, KPL stockholders reinvested 5 of their 14 cents for building new plants and for buying new equipment. The remaining 9 cents were paid as dividends (profit) to the stockholders. In addition, because of reinvestment of 1972 profits during 1973, the value of each share of stock grew.

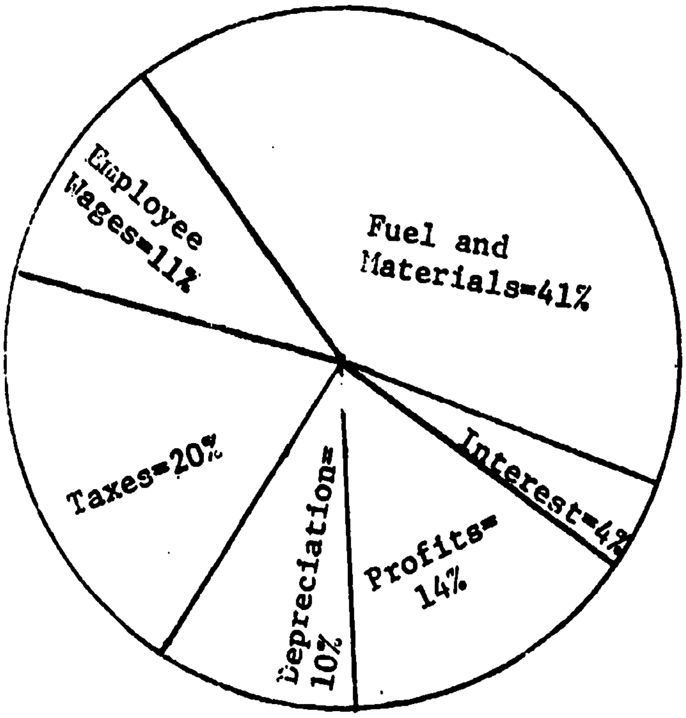


Figure 1. Distribution of KPL's 1973 Income

If you owned one of the 6,400,000 shares of KPL stock in 1973, your real dollar "economics" would have looked like this:

> January, 1973, one share of stock had a book value of $18.52;
> December, 1973, one share of stock had a book value of $19.41,
> and you would have received 1.48 dollars in dividends (profits).
> Your investment would have grown by about 13 percent.

Profits for Kansas

Kansas also profited from its trade with KPL. Most of the company's payroll, taxes, and profits went to Kansas citizens. In addition, KPL can produce 19 percent more power than it has ever had to make on the hottest day in summer. This means that we do not need to worry about turning off air conditioners or industry when equipment must be repaired. Other states, with less available energy suffer "brown-outs" or "black-outs" when their power fails. Finally, KPL's rate of 2.3 cents for each kilowatt hour allows you to plug in an air conditioner, electric motor, or light and u much more energy than a man could produce for less than one cent an hour. In short, KPL has provided plenty of inexpensive energy to everyone who wanted to purchase it in Kansas.

Economics In More Depth

<u>Capital</u>: Surplus money that can be used to purchase new buildings and equipment is called capital. Money used to pay labor and purchase supplies is <u>not</u> capital. Men, materials, and energy could not produce electricity unless capital was available to build generating plants, transformers, and distribution lines.

Companies obtain capital to build new plants in three basic ways: selling stocks, obtaining loans, and producing profits. Stocks are sold by the company when it wishes to grow. They are purchased by investors who trust the company's ability to grow and produce a profit. If the company grows well, the stocks grow in value and can be sold at much more than the original cost. If the company does not prosper, the stocks may decrease in value. When KPL needs large amounts of capital, it may sell new stocks to investors. Thus, investors may bid for new stocks, or may purchase stock from other traders who own shares. Investors share the company's profits and have a vote in selecting the company's board of directors.

Loans may be obtained by mortgaging equipment and buildings which are already owned. Thus, the value of past investments may be used to obtain capital for new investments.

Profits provide the third major source of capital to a company. Profits not only are used to pay dividends to stockholders but are also used as capital to finance new enterprises. Without profits, no company can continue to exist in a capitalistic system.

KPL requires large amounts of capital to make a little electricity. In order to sell the 88 million dollars worth of electricity in 1973, they had to own 361 million dollars worth of equipment. When the profits from electricity are compared with the capital invested in equipment, the company's profit drops to about 5 cents for each dollar invested. This return on investment is about what a bank would pay for a regular savings account.

Electrical Rates: Many people ask why KPL charges industry and big electrical users lower rates per kilowatt hour of energy. KPL must do this because they are told to share their costs fairly with each customer. One industry with one mile of line, one transformer, and one bill per month may purchase one million kilowatts of electricity. To sell the same amount of energy to homes may require 70 miles of line, 1,400 meters, at least 300 transformers, 1,400 bills, and many more repairmen, meter readers, and so on. Both industry and the residential user pay the same rate for the cost of the fuels to make electricity, but the residential user will have a higher total rate because all of the other expenses are higher.

Supplying the Required Energy: KPL is required to provide all the energy you wish to purchase if you are in their service area. This requirement has meant that KPL had to double their size every 10 years since 1924 just to keep up with demand. As the United States begins to face a shortage of oil and natural gas, the demand for electricity may more than double in the next 10 years. This means that during the last 50 years KPL has built 360 million dollars worth of electrical generating and delivering facilities. In just the next eight years, they must double that investment and build another 360 million dollars worth of generating stations, lines, etc. If they build too slowly, we will suffer brown-outs and poor service. If they build too quickly, equipment will not be used and profits will shrink.

SUMMARY

Businesses are like people. They must continue to improve or they stagnate and die. Capital is needed if KPL is to build new plants with better equipment to meet the expected energy demand.

If KPL still used the small coal-burning power plants of the 1940's, the air would be much dirtier and electricity would be more expensive and harder to buy.

New technology, competent men, and capital produced from profits, loans, and stock sales allowed the development of large boilers, generators, and better pollution control equipment.

Science and technology have produced abundant and inexpensive energy, but our economic system influences the quantity and price of the energy actually available for our use. As energy and raw material supplies change, science, technology, industry, and our total economic system will face a new and large challenge if our standard of living is to remain high.

Student Self-Test Questions

1) Why must businesses make profits in order to provide the service we want?

2) List at least two reasons that KPL must follow different rules than required of owners of restaurants or grocery stores.

3) If you were asked to loan KPL money, would you compare its profits with its total sales or its total investment? Why?

4) Why has KPL always required large amounts of capital, and why will it continue to need large amounts of capital?

5) What proportion of KPL's income is spent on wages, taxes, and fuels and material? Can you think of an industry with a very different division of expenses?

Behavioral Objective Numbers	Topics and Concepts
21	Students shall be able to select a sentence summarizing the past and projected growth rate of KPL.
22	Students shall be able to select the most realistic distribution of KPL's income for raw material purchases, labor costs, and taxes.
23	Students shall be able to apply the definition of "capital" to select the best use for it in business.
24	Students shall be able to identify several restrictions placed on KPL by Kansas.

Teacher Suggestions

This paper was prepared to provide a brief introduction to the economic system which governs our electrical industry. Objectives 21-24 can be met through a discussion of the Student Self-Test Questions and will be further developed during the field trip.

The material below provides background for potential discussions of some aspects of economics brought up in the student paper.

State Regulated Industries: Students should realize that Bell Telephone, the Gas Service Company, railroads, and bus lines are all privately owned, state regulated industries. All have been granted privileges and placed under restrictions by government for similar reasons.

Distribution of KPL's Income: The data used in the students' paper was obtained from KPL's annual report of 1973. Past years' reports have had very similar patterns.

Taxes: KPL pays much higher taxes in proportion to its sales dollar than do most other companies. The table below shows the tax breakdown for 1973.

	Millions of Dollars	Percent of Sales Receipts
Federal Income	13.09	10.8%
State Income	2.00	1.7%
Property Tax	7.97	6.6%
Company's Share of Social Security Tax	0.67	0.6%
	23.73	19.7%

State and local sales taxes of 2.2 million and city franchise taxes of 2.1 million were also collected. However, these taxes were passed right on to the appropriate governments without being figured into either KPL's income or taxes.

In addition, taxes on the fuels and material purchased are included within that portion of the company's expenses.

It is inter-^ting to note that about one-fourth of your total electric bill goes toward taxes. It can easily be seen that KPL serves as a tax collector for government at all levels.

KPL's Profits: One key distinction which should be made is the difference in figuring profits based on the sales dollar and based on the invested dollar. Goodyear, which produces things which require much effort, but not so much capital, has about a 5 percent profit based on the sales dollar but about a 20 percent profit based on the invested dollar. KPL, in contrast, is a capital intensive industry and has a 14 percent profit based on the sales dollar, but only a 5 percent profit based on the invested dollar. Grocery stores with a very high turnover of goods may run a 2 percent profit on the sales dollar, but 20 percent on the invested dollar.

The key point to make is that people who purchase stocks are investing those "invested dollars." Therefore, Goodyear stock is an attractive stock because of its high return on the invested dollar, and KPL is less attractive because of its low return. However, if the energy crisis worsens, KPL will become more attractive because people will still need electricity but will cut down on the use of tires.

"Book Value" of a stock is the value of a company's holdings, minus its liabilities and divided by the number of stocks owned. In KPL's case, a common stock's book value of $19.41 is determined by dividing the company's net value (124 million dollars) by the number of common stock shares (6,413,000). In theory, if the company disbanded, the book value is what each share of stock would be worth. The market value of the stock is, of course, determined by what other people think of the company's potential.

Capital: When government regulates profits (as they do with utilities), limits prices, or taxes profits heavily, business has trouble obtaining capital to expand or to meet demand for energy. When governmental regulations affect energy costs and availability, troubles are multiplied.

As the availability of capital or energy decreases, the options available to consumers also decrease. Businesses will not be as able to try new products, build new plants, or replace faltering equipment as readily. In addition, some businesses will fail. Presently, their products are replaced by new products from other companies. If energy or capital becomes too tight, the range of consumer choices will just decrease with each business failure.

In addition, as the U. S. population growth rate slows, it will make the traditional growth rate of successful businesses dependent on non-population factors, such as new technology, changing material and fuel markets, and so on. Economists are not sure of how this problem will affect our future economy. One thing is certain, however: our economy's ability to make the transition from cheap energy, plentiful resources, and growing markets to the future as indicated by present trends will depend largely on the availability of capital and the freedom to use it. Government and business policies determined by the students we are teaching will play a large role in this transition--whatever its outcome.

Electrical Rates: The basic electrical rate is determined by three factors: A) the cost of the equipment divided over the approximate life of the equipment (usually 30 years); B) the cost of the fuels used to produce electricity; and C) the cost of providing service. All customers share the fuel costs about equally on a per kilowatt hour basis, but since the cost of the equipment and service per kilowatt hour is higher for small users, their rates are higher. Their overall rate is, of course, lower than it would be if no large electrical users were on the line, since savings are made in the construction of larger generating stations and mass purchases of fuels.

Supplying the Required Energy: One point which the field trip will bring home forcefully is the fantastic growth rate of electrical usage. The fact that the Lawrence KPL plant has doubled its productive capacity every 8 to 10 years can be followed easily by observing the doubled capacity and building dates of the generators from the smallest to the largest.

Answers - Student Self-Test Questions

Q 1) Why must businesses make profits in order to provide the services we want?

A Companies which pay their bills, but make no profit, will not create capital. Therefore, they will be unable to modernize and take advantage of new technological discoveries. Only profits can attract stockholders and produce the capital needed to expand or to discover and produce new products. KPL, of course, would have remained at its 1924 size if profits had not been made and reinvested. This original size would hardly supply the electrical needs of Topeka's schools, let alone the needs of half of Kansas.

Q 2) List at least two reasons that KPL must follow different rules than required of owners of restaurants or grocery stores.

A 1) KPL doesn't need to advertise to attract customers from other electrical companies. (However, they do advertise to attract customers from other energy suppliers. They are particularly anxious to increase power used during evening and winter when much of their equipment is not used to full capacity.)

2) KPL has extensive governmental controls. The Kansas Corporation Commission regulates everything from rates and service to the required filing of detailed records on the company's overall operation.

3) KPL must provide service to all who are willing to pay for it. In theory, at least, a billionaire could ask to purchase a billion kilowatts an hour to electrocute earthworms, and KPL would be expected to furnish it.

In a more serious vein, Santa Fe is seeking to run an electrical train line through Kansas and has asked KPL for service. This will cause a tremendous, periodic, moving drain on one phase of the three-phase electrical current. KPL is expected to supply this electricity and to maintain their quality of service to other customers along the line.

Q 3) If you were asked to loan KPL money, would you compare its profits with its total sales or its total investment? Why?

A Its total investment, for your dividends would be determined by dividing the profits among all of the other stockholders. Mortgage holders would be paid before dividends would even be declared. An extreme example will make this clear.

Would you buy a stock for $1,000 from a man who planned to build a machine which would make false teeth for cats? The owner expected to make two pairs per year, sell them for 20 dollars, and make a profit of $10 per pair after paying the costs of the material, wages, taxes, and so on. The answer is no--although the profit is 50 percent of the sales dollar, the maximum return you could expect would be $20 on your $1,000 investment. This 2 percent profit on the invested dollar could not compete with rates offered by other companies or banks.

Q 4) Why has KPL always required large amounts of capital, and why will it continue to need large amounts of capital?

A Capital is required to purchase new equipment. KPL has doubled in size every 8-10 years and must obtain enough capital to grow at that rate. Since most of the cost of production is equipment, this means that tremendous amounts of capital are required, and the need is accelerating as shown on the graph below.

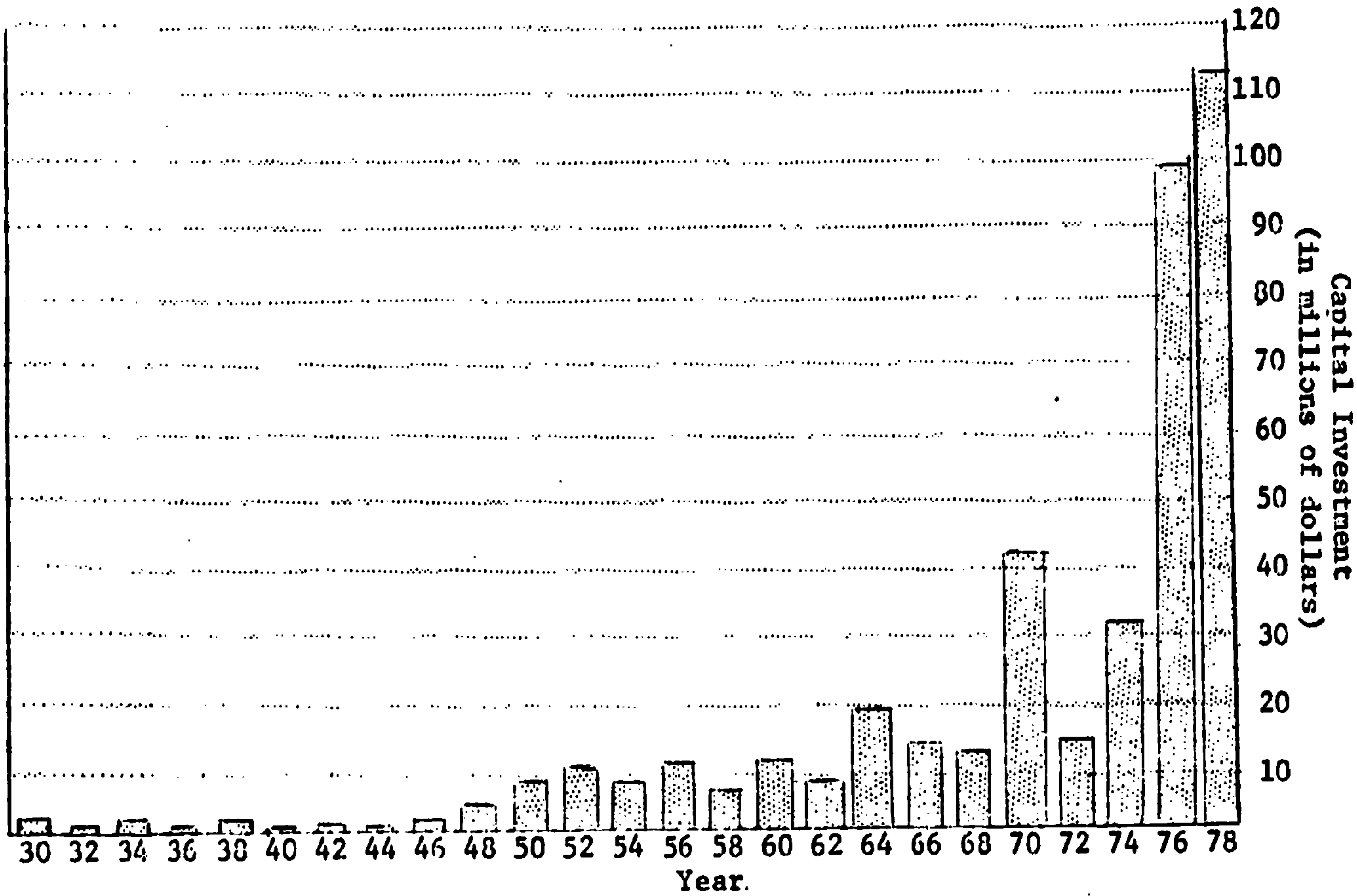


Figure 2. Capital Requirements of KPL

Q 5) What proportion of KPL's income is spent on wages, taxes, and fuels and materials? Can you think of an industry with a very different division of expenses?

A Wages - 11%; taxes - 20%; fuel and materials - 41%.

Most industries pay much lower taxes. Banks would have much lower fuel and material costs and higher wage costs. A shirt or transistor radio manufacturing firm would have high labor costs and low fuel and materials cost.

Energy in the Future

Mankind has used more energy in the last 30 years than was consumed in the previous 2,000 years of human existence. We expect to use more energy in the next ten years than was used in the last 30. Almost all the energy now being used comes from plants which died millions of years ago and became the fossil fuels--coal, oil, or natural gas. We have already taken the fossil fuels which are easy to obtain in the United States and must now dig deeper mines, larger strip mines, oil wells in Alaska and in the oceans, and less productive, deeper wells throughout the United States. As the effort needed to obtain fuel rises, the cost must also rise. In addition, the fossil fuels are disappearing and will never be replaced. If we are to continue using large amounts of energy, other sources of energy must be tapped.

Government, power companies, and each of us have ideas we believe about the energy crisis now, and for the future. In many cases, these ideas cannot be proven and are quite different. For instance, we don't know how much oil is in an area until wells are drilled, and we don't know how much energy the United States will buy in 1980. Yet, graphs are made of our energy needs in 1980, and charts are made showing oil that experts expect to find after exploration. Some of these predictions are very different, and many will be wrong.

General Trends

Four basic ideas are agreed to by most people studying energy.

1) The price of energy is going to rise. We are using up the fuels that are easy to obtain, ship, and burn, and the harder to obtain fuels will cost more money.

2) We will run out of fossil fuels. As we run out, the last supplies of fuel will be harder and harder to obtain. When we run out can be debated--natural gas may disappear in 15 years--or 40 years. Coal may last 100 to 300 years, and oil will last from 30 to 60 years, depending on the facts and assumptions used by the people making predictions. Oil shale may supply more oil, and coal may be turned into gas, but the important thing is that we <u>will</u> run out of the fuels which now supply nearly all of our energy, and we <u>will</u> continue to have more and more trouble obtaining fossil fuels <u>in your lifetime</u>.

3) New ways of obtaining most of our energy must be found or our life-style will collapse and many people will die. We may have 10 years, or 30 years to develop major new energy supplies, but we must start now. Our society is <u>very</u> dependent on large amounts of fuel for raising food, transporting, and making the things we buy. If new energy sources are not developed to replace the fossil fuels, our food supplies will shrink, factories will stop, and cars, trucks and trains will no longer roll.

4) Most new energy sources will be turned into electricity. Energy in wind, garbage, waterfalls, sunlight, and splitting atoms cannot be poured into a gas tank. Their energy can be used to make electricity which can be carried to homes, factories, and battery powered vehicles. Electricity may also be used to break up water, and release hydrogen to be burned in cars.

What Will Supply Energy?

Many things will replace the fossil fuels. The list below is based on the maximum amount of energy which can be obtained from various energy sources, according to the work of several scientists writing for the Scientific American.

1) Garbage and farm wastes could be burned or turned into methane and burned. These could supply as much as three percent of our energy needs by the year 2000, but will never supply much more than that level. As the cost of energy rises and the price of food rises, the availability of trash and farm wastes may even go down.

2) Water power is now supplying about four percent of our energy. More dams will be built, but hydroelectric plants will not grow as fast as our need for energy. We cannot expand our use of water power much more, since most of the areas with deep canyons and large changes in tide level are already dammed and used for power. However, rain will continue to fall, and hydroelectric power could continue to supply energy long after our fossil fuels are gone.

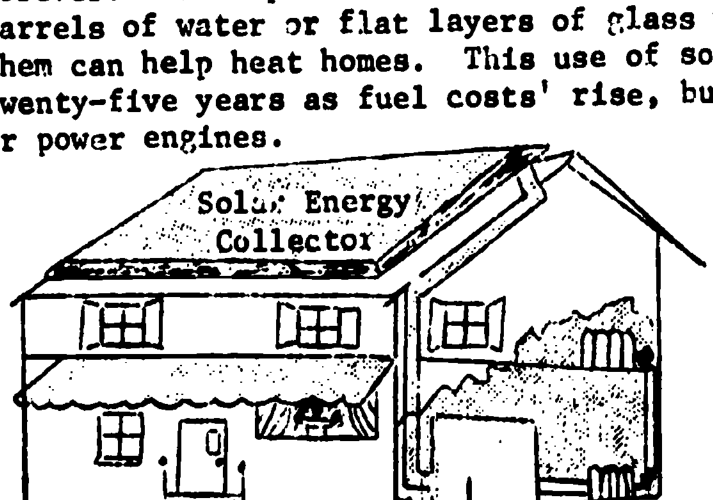
3) Wind power may begin to supply as much as one percent of our energy. However, windy places for windmills large enough to produce enough energy to pay for their cost are not too easily found.

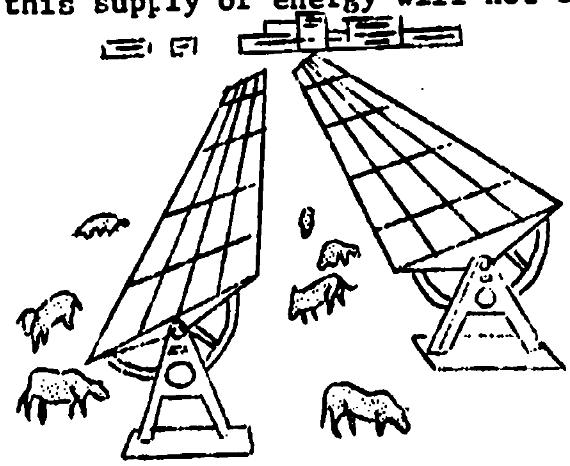
4) Geothermal power can supply up to two percent of our national energy needs. We are already tapping much of this power, and unless very different hole drilling methods are used, most areas will be unable to obtain more of this power.

5) Burning wood and other plants may be able to supply as much as five percent of our energy needs, but their production would subtract from housing material and food production. In twenty years, we may need land to produce food more than we need it to produce energy.

In short, when all of these fuel supplies are added up, we get a lot of energy (maybe as much as 15 percent of our needs in 25 years). We use much more power than that today, and our population is still growing. The fossil fuels will still be able to supply 50 percent of our energy in 25 years, but other sources must be found.

The sun supplies the United States with 1,600 billion watts of power every day. If this energy could be easily tapped, our energy worries would be over forever. Solar power can be used effectively in home heating today. Large black barrels of water or flat layers of glass with black backs and liquid flowing through them can help heat homes. This use of solar energy will grow rapidly over the next twenty-five years as fuel costs' rise, but this supply of energy will not run cars or power engines.





Solar Cell Energy Farm

Home Using Solar Energy

To get sunlight energy turned into usable electrical power, scientists are developing solar cells and large heat collectors able to boil water to turn turbines. However, using the best methods available today, to supply just 35% of the total energy needs of the United States would require 35,000 square miles of power stations in Arizona, Florida, and every other sunny area in the United States. At today's prices, it would cost 35 trillion dollars for just the crystals used in the power cells for these stations. Since this would cost every person in the United States $175,000 for just 35% of our energy needs, we could not afford to build the plant or buy the electricity.

Thus, today we can not afford to plan to obtain the energy we need by using solar power. As scientists and engineers work on this problem, new solutions may appear and solar energy may someday power our homes and industries. If scientists never harness solar power cheaply, we have but one option left to obtain the energy needed for survival.

Nuclear Energy

Nuclear power is the final remaining source of large amounts of energy. At this time, it is the only energy source (other than fossil fuels) able to supply large amounts of energy at costs we can afford. Nuclear reactors, which supply power to make electricity can be divided into three groups:

A) Thermal reactors use up uranium as electricity is made. If only thermal reactors are used, we do not have enough uranium to last more than 50 years with today's techniques.

B) Breeder reactors make more fuel than they use. In these reactors, part of the nuclear energy is used to turn non-reactive atoms into atoms which can supply more nuclear energy than the original fuels. These reactors are harder to build, harder to control, and theoretically able to supply all the energy we need for thousands of years. No large breeder reactor is being used in the United States today, but a large one is being built.

C) Fusion heat is the last known source of large amounts of power. To obtain fusion, small atoms must be placed in an environment much like that found inside the sun. So far, after years of work, man is far from duplicating the sun's environment inside anything other than a hydrogen bomb. If we ever do harness fusion to supply energy, it will supply an endless amount of very clean energy.

In summary, we must begin to develop sources for energy other than fossil fuels. Whether we have five years, or 50 years before the supply of fossil fuels begins to grow tight, we must plan on using our time wisely. If American society is to switch from limited to endless sources of energy, we must plan far ahead. If the preparation is not begun now, you and your children will face the results.

Student Self-Test Questions

1) What sources of energy will be available to man for years to come using present technology?

2) What sources of energy may be available if scientists and engineers can learn how to use the energy?

3) Why do new supplies of energy appear when the cost of energy rises?

4) In 50 years, why will most things using energy be powered by electricity?

5) If you controlled Saudi Arabia's oil, would you sell all the oil the United States wanted to buy? Why?

6) Why is it important that large energy producing companies make good profits and invest those profits in new energy sources in years ahead?

Behavioral Objective Numbers	Topics and Concepts
4	Students shall indicate that, for the good of our country, we must plan to keep large amounts of energy available.
17	Students shall indicate that geothermal and hydroelectric plants use energy which will continue to be available to man for eons.
21	Students shall be able to select a sentence summarizing the past and projected future growth rate of KPL.
23	Students shall be able to select the best use for capital in a business.
25	Students shall be able to select a sentence best summarizing the reasons for expecting energy costs to rise for many years.
26	Students shall be able to select a sentence best summarizing the differences between thermal and breeder reactors.

Teacher Suggestions

Let three broad goals guide student discussion of this paper:

A. Modern society needs large amounts of energy. As more land is covered by cities, and more countries seek our food, energy is essential for producing fertilizer; planting, cultivating, harvesting, transporting, and preparing food; preparing substitutes for but rare natural materials; mining hard to obtain metals; and so on.

We can lower our standard of living, as the price of energy goes up. We can curtail travel, stop buying precooked meals, stop using dryers, curtail heating large homes, and so on. However, as our standard of living goes down, fewer people will have jobs, the wages we do have will not buy as much, and the spiral downward would continue.

Thus, the United States is faced with the prospect of either finding large new energy sources or slowly cutting down on energy usage and its accompanying benefits as the fossil fuel supply drys up over the coming decade. A path between these two extremes will probably be followed.

B. We cannot predict technological break throughs. Furthermore, producing a new type of engine or electrical generating plant involves years of work, even after the initial discovery is made. Thus, we cannot predict when, if ever, large scale usage of solar energy or fusion will occur. Many non-scientists confidently predict the tapping of both these energy sources as soon as enough money is poured into research. However, ten years ago, we were a factor of 100 away from achieving the high temperatures and pressures required to obtain fusion. Today, we are still a factor of 100 away, and only the discarding of many good ideas has occurred.

C. Given the two ideas above, energy producing companies have had to choose energy sources which are feasible now and able to supply large amounts of energy. Nuclear energy is the only source of large amounts of non-fossil fuel energy technologically feasible today. Since all trends point toward a very large demand for non-fossil fuel energy by 1990, and it now takes 10 years just to license and build nuclear plants, plans for their construction are being made throughout the United States.

If a break through in solar energy does occur soon, then 15-20 years later we can expect the first large commercial plant to begin operation. In the meantime, the electrical industry, whose demand is doubling every 3 years, must place their bets on the only new horse around.

The next paper will explain how nuclear reactors work, and how their pollution is controlled.

The filmstrip-record combination, "The Energy Crisis," provides an audio-visual summary of this paper. Its content is somewhat different than this paper's, and could be well utilized. We would recommend filmstrip #3, "Futuristic Solutions," if your time is limited.

Answers - Student Self-Test Questions

Q 1. What sources of energy will be available to man for years to come using present technology?

A Energy from coal, breeder reactors, hydroelectric plants, and geothermal plants should all be able to supply energy throughout the next 100 years. Energy from oil shale and coal gasification may also be available for much of this time, depending on economics and environmental controls.

Q 2. What sources of energy <u>may</u> be available <u>if</u> scientists and engineers can learn how to use the energy?

A Energy from the sun, wind, garbage, deep geothermal wells, and fusion <u>may</u> become available.

Q 3. Why do new supplies of energy appear when the cost of energy rises?

A Energy which cost more to produce than it was worth becomes profitable again when the price rises. Thus, if the price of oil gets high enough, oil from high grade oil shale can be extracted. If the price of oil goes even higher, oil from lower grades of oil shale can be tapped. The same concept applies to any energy source which is technologically and environmentally able to be tapped.

We do not suggest getting into the fight of "who is to blame" for the current oil shortage. Governmental regulation of natural gas prices, national and international politics, taxing policies, environmental policies, corporate decisions, and consumer demand <u>all</u> play a role in our current problems, and no one party is "the" guilty one. Whether or not we learn from our present plight is the important thing.

Q 4. In 50 years, why will most things using energy be powered by electricity?

A Right now, electricity is the only portable and clean method for transferring the energy of coal or nuclear power to the energy user. Since these two sources are expected to supply most of our energy in 50 years, most things will be powered directly or indirectly by electricity.

Q 5. If you controlled Saudi Arabia's oil, would you sell all the oil the United States wanted to buy? Why?

A Probably not. Once Saudi Arabia's oil is gone, the country has few resources left to feed its people. Therefore, the wise thing to do would be to sell less oil at higher prices and to invest the money in industries and projects designed to sustain the country when the oil runs out in 50 years or so.

Q 6. Why is it important that large energy producing companies make good profits and invest those profits in new energy sources in the years ahead.

A The only way to obtain the capital needed to build new plants, drill new wells, and develop new energy sources is through profits. If companies do not make enough profit to invest in new sources of energy, then the energy will not be available when needed in a few years. The graph on page G-9 shows why KPL must obtain high enough profits to invest in the future. Many students do not understand this concept, and will indicate that the government provides most of the money to obtain new energy sources. This is not true in the United States, and one of the major reasons for our large supplies of inexpensive energy (compared with all other countries) has been the fact that our energy supplies are competing and financing their own operations.

Nuclear Reactors

People often confuse two ideas when they discuss nuclear reactors: Radioactivity and nuclear fission. This paper will explain these concepts and show how a nuclear reactor works.

Radioactivity is the natural, uncontrolled release of small particles or high energy X-rays (called gamma rays) from the nucleus of an atom. As a result of this release (radioactive decay) the atom changes slightly and becomes a new atom. This new atom may or may not be radioactive.

There are many radioactive atoms in the world, and your body probably contains a few atoms of radioactive carbon, phosphorus, iodine, and strontium.

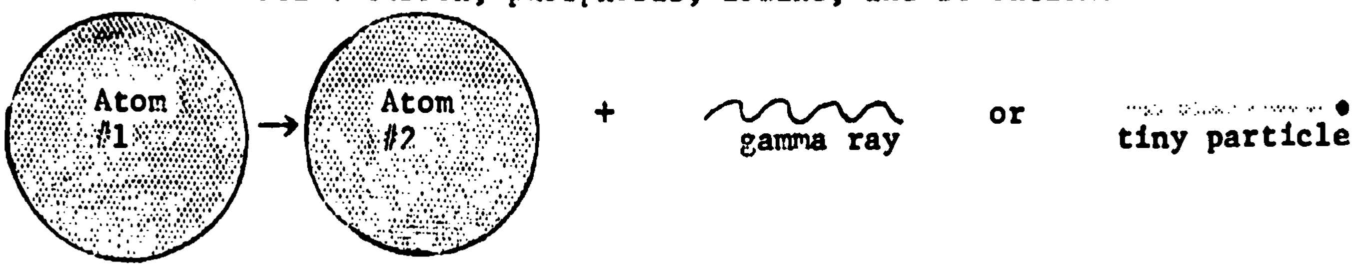


Figure 1. Radioactive Decay.

If one of these radioactive atoms breaks up, it will send a particle or gamma ray through your cells. The particle or gamma ray may pass right out of you, or it may damage a cell. If the cell is damaged, the body will usually repair the damage. If the body does not repair the damage, the cell may die, produce a new kind of cell, or become a cancer cell. Low levels of radiation have always existed in the natural world, and our bodies are well equipped to handle most radiation damage.

Carbon 14 is a particular type of radioactive atom. If 1000 C 14 atoms were left in a box, only 500 would remain after 5,700 years. If you waited another 5,700 years, only 250 atoms would remain.

On the other hand, 1000 radium 221 atoms would be down to 500 atoms in 30 seconds, 250 atoms after 60 seconds, 125 atoms after 90 seconds, and 62 atoms after two minutes. After five minutes, only one atom would remain of the original 1000.

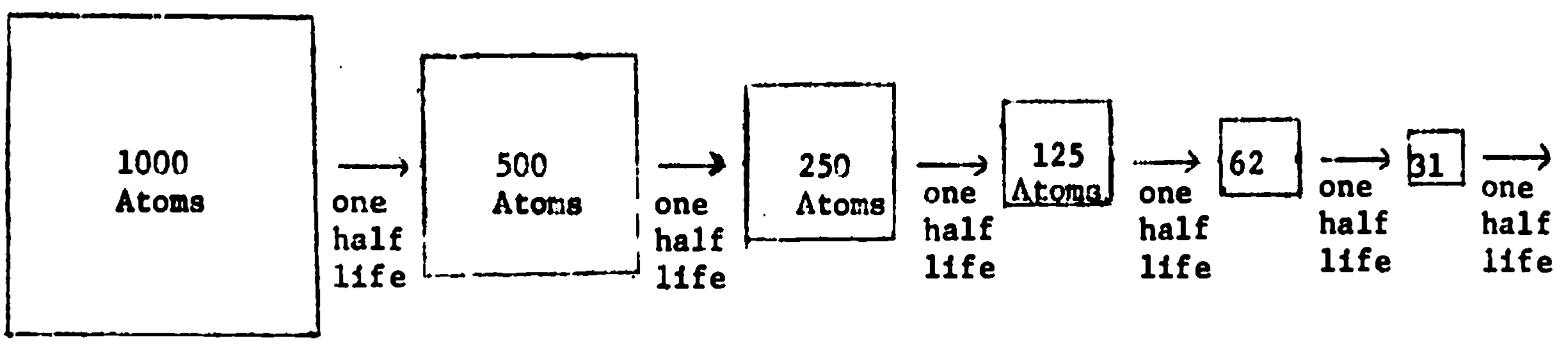


Figure 2. Radioactive decay of any group of identical radioactive atoms.

The length of time needed for half of any group of radioactive atoms to decay is called the half life of the atom. Carbon 14 has a long half life. Radium 221 has a medium half life, and some atoms formed during nuclear reactions break up so quickly that scientists cannot measure their half lives.

Nuclear fission occurs when the nucleus of an atom collides with a particle and breaks up, releasing energy. This energy may occur as heat, gamma rays, speeding neutrons, and a host of other kinds of rapidly moving particles. At least two new and smaller atoms are formed following fission, and these new atoms amy be radioactive.

The fissioning atom acts much like a stock car which hits a wall. It explodes and spews heat and flying materials all over the track. The radioactive atom acts like a car which loses its wheel or muffler, and becomes a slightly different car.

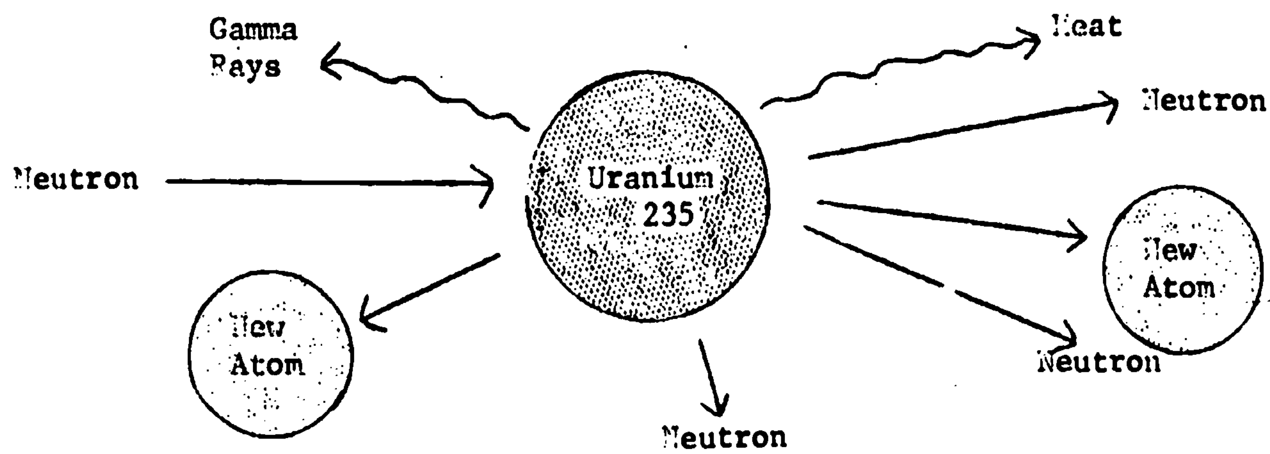


Figure 3. Uranium 235 Fission.

Only a few kinds of atoms fission when hit by neutrons. Most atoms just become radioactive. Uranium 235, is one of the few atoms which will fission, or break up, when a neutron of the right energy hits it. These atoms power nuclear reactors. When the uranium breaks up, it usually produces three neutrons which are able to cause other atoms to fission. Thus, to make an atomic bomb from U 235, you must just pile a few trillion, trillion, trillion atoms together, then wait until a neutron from the sun or other source strikes one atom and causes it to fission. The three neutrons from this atom hit three other atoms which explode and send out 9 neutrons which strike 9 atoms which break up and send out 27 neutrons and so on. In the space of less than a second, trillions of neutrons will be creating trillions of fissions if enough atoms were stacked together.

Since electrical producers do not want to make a bomb, they simply spread the uranium atoms apart and control the number of neutrons which can hit the uranium atoms. When a reactor is running correctly (at a critical state) only one neutron from each fissioning atom will hit a U 235 atom and cause a new fission. The other two neutrons are absorbed by other materials (such as boron or concrete).

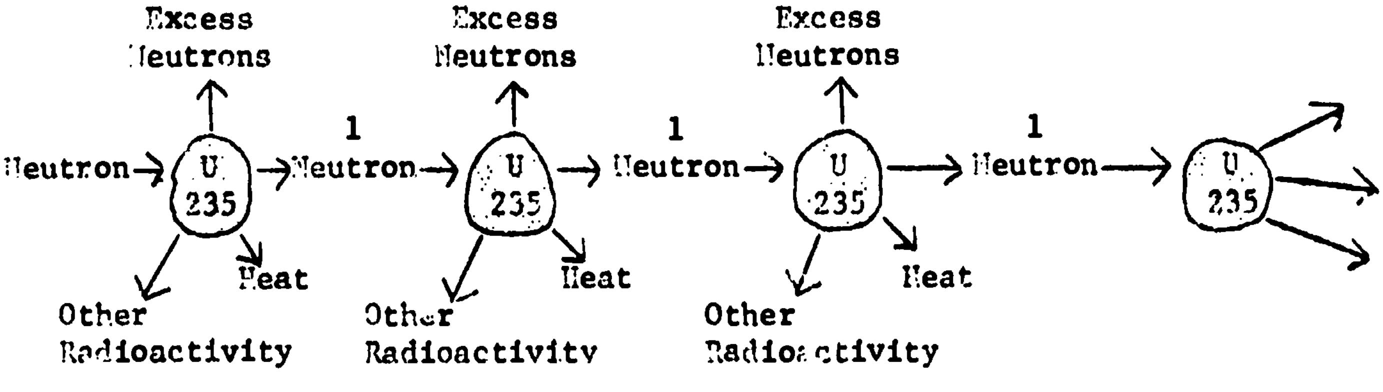


Figure 4. A neutron chain reaction at the critical level.

Nuclear Reactors

Two basic types of nuclear reactors are being developed. Thermal reactors slow down the neutrons which leave a fissioning atom until the neutron carries only the energy of an infrared light. Thus, the reactor is called a thermal (heat) reactor. The neutrons lose their energy as they bounce off water or carbon atoms which surround the uranium atoms. When the slow moving neutron collides with a uranium atom, a nuclear fission occurs, and more neutrons and heat are released.

Breeder reactors do not use water or carbon to remove energy from the neutrons. Instead, the U 235 atoms are mixed with atoms of Thorium 232 and U 238. Neither Th 232 or U 238 will fission when hit by a neutron. High energy neutrons from U 235 fissions strike these large atoms and other atoms in the reactor. Two things can happen: A) Th 232 and U 238 will capture some of the high energy neutrons and turn into new kinds of atoms. B) Other neutrons will lose energy by bouncing off other atoms until a U 235 atom captures the neutron and fissions.

If Th 232 or U 238 atoms capture the neutron, they both become more radioactive and soon change into new atoms. Thorium becomes U 233 and U 238 becomes Plutonium 239. These new atoms (U 233 and Pu 239) are able to capture slow moving neutrons and fission just like U 235. Thus, in a breeder reactor, U 235 fissions, releases energy, and turns two kinds of atoms into new atoms which can fission. Therefore, nuclear fuel is created faster than it is destroyed, and the reactors must have fuel removed to remain running over the years. This extra fuel will be shipped to thermal reactors to be used like U 235. The name breeder reactor comes from this reactor's ability to "breed" or create new fuel from atoms which would not fission in a thermal reactor.

5 grams U 235 + 5 grams Thorium 232 → Heat + Radioactive Material + 5 grams U 233 Breeder Reactor
5 grams U 233 → Heat + Radioactive Material Thermal Reactor

A very important idea to understand at this point is that atoms which fission are usually not very radioactive before they fission. The half life of U 235 is 710 million years, and you could probably carry a chunk of this material in your pocket throughout your life without damage. After fission, many kinds of radioactive atoms are formed, and until these atoms breakup, man will need to control these new atoms carefully.

Once the nuclear reactor is built, water is heated by the heat from fission, and steam is produced to run turbines and generators. Thermal reactors usually heat water directly from the reactor heat, and breeder reactors use gas or liquid metal to carry the heat used to create steam. Thermal reactors have run for years without hurting the lives of people living near or working in them. Small breeder reactors have also run safely, but their design is still being improved and the first large breeder is just beginning to be built in the United States.

Both kinds of reactors produce gases, liquids, and solids which can release radioactivity. Almost all of the gases have short half lives. The reactor captures these gases and holds them until most of the radioactive atoms have decayed and little radioactivity remains. However, liquids and solids from the reactors frequently contain radioactive materials with very long half lives. These materials will eventually be turned into ceramic pellets and stored. By storing the material as pellets in carefully designed storage areas, mankind should be able to safely contain the radioactivity for as long as we exist. However, the design of the storage area and the creation of the ceramic pellets is still being worked out, and much work remains to be done before the storage of radioactive wastes will be solved.

The other major pollution problem with nuclear reactors is that of cooling the condensor water. Since nuclear reactors release much heat per kilowatt hour of energy produced, they must have more cooling water than generating plants using fossil fuels. To avoid using too much water, engineers are working to design dry cooling towers which use very little water from rivers and still recycle cool condensor water.

Student Self-Test Questions

1) What is radioactive decay?

2) What is nuclear fission?

3) List two differences between thermal and breeder reactors.

4) Would you receive more radiation by standing near a pound of radioactive material with a long half life or with a short half life?

5) Look back to Paper E. Three designs of nuclear reactors are shown. Which designs would work for thermal reactors? Which would work for breeder reactors? Why?

6) Why should very careful studies of radioactive waste storage be done before many nuclear reactors are built?

7) Why do thermal nuclear reactors need more cooling water than fossil fuel generating plants producing the same amount of electricity?

Behavioral Objective Number	Topics and Concepts
13	Students shall be able to select the best explanation for the inability to convert all heat energy in steam to mechanical energy in the turbines.
20	In a series of attitude questions, students shall indicate that a) creating and installing effective pollution control equipment requires much time, money, and research; b) pollution controls should be used if pollution significantly damages the environment; and c) costs of controlling pollution should be part of all products' costs.
26	Students shall be able to select the best summary of the differences between thermal and breeder reactors.
27	Students shall be able to select the best sentence differentiating between radioactive decay and nuclear fission.
28	Students shall select the best definition of "half life."

Teacher Suggestions

This paper may be one of the hardest to teach; but as public furor grows over nuclear energy, some public education must be done. Few students ever reach high school physics and few of these students really study nuclear reactions.

One key concept not developed directly in the paper is this: no industry will intentionally develop a power plant which will cause enough damage to the environment to warrant massive lawsuits. The nuclear industry is no different, and it has one of the best safety records of any industry.

Several comments about nuclear reactors may be appropriate for discussion. The reactors are made in several independent layers of heavily reinforced concrete. They are designed to resist all outside forces short of atomic bombs and to contain all conceivable internal problems. The possibility of one of these reactors turning into a bomb is extremely remote, since the nuclear material is not packed tightly together, and even if it melted and ran together, the reactor is designed to not let a critical mass be formed.

The biggest problems with nuclear reactors are threefold.

1) Human error may unintentionally release radioactive gases or liquids to the environment. This is controlled by stringent AEC guidelines, a general and deep fear of public reaction, and regulations which keep the allowed releases far below radiation levels expected to cause damage.

2) Large amounts of heat are wasted, and adequate cooling towers must be installed. This is discussed in question 6.

3) Radioactive wastes must be transported, processed, and stored. The containers used during transportation are very carefully tested and designed to resist all feasible accidents, but some localized spillage may still occur when many plants begin operation.

Storage of radioactive materials is a harder problem--but solvable. The AEC has adequate storage areas for another decade, and by then, scientists expect to perfect the production of ceramic pellets to contain radioactive materials with long half lives and to locate a good storage area. The release of radioactivity during ore processing and waste re-processing has been the biggest control problem, but it seems to be coming under better control.

The use of nuclear reactors is not a subject to be lightly accepted, for many potential problems exist. However, these problems do appear solvable and should damage the health of this continent much less than man's reaction to the lack of energy if nuclear reactors are not built in time.

Answers - Student Self-Test Questions

Q 1) What is radioactive decay?

A It is the natural, uncontrolled release of a high energy particle or gamma ray from the nucleus of an atom. It is analogous to the loss of a small part of a car which creates a car with new characteristics.

Q 2) What is nuclear fission?

A The splitting of an atom's nucleus to form at least two smaller atoms and a variety of energetic particles and light rays. This does not occur spontaneously on earth but requires initiation by a neutron (or alpha particle) with appropriate energy levels.

Q 3) List two differences between thermal and breeder reactors.

A Thermal reactors use water or carbon to absorb energy from neutrons in order to cause fissioning of U 235 (or other fissile isotopes).

Breeder reactors use collisions with U 238 and Th 232 to capture part of the neutrons and to absorb energy from the rest.

Breeder reactors create more nuclear fuel than they use, thermal reactors use more than they create.

Q 4) Look back to Paper E. Three designs of nuclear reactors are shown. Which designs would work for thermal reactors? Which would work for breeder reactors? Why?

A Boiling water reactors and pressurized water reactors would work <u>only</u> for thermal reactors. The water in these reactors would slow the neutrons so much that they would not cause U 238 or Th 232 to undergo radioactive decay.

The high temperature gas and molton metal reactors can work with either process. In the thermal reactor, carbon (graphite) is used to control neutron energy. In the breeder reactor, layers of U 238 and Th 232 serve the same function.

Q 5) Why should very careful studies of radioactive waste storage be done before many nuclear reactors are built?

A Small amounts of waste can be stored safely in liquid form with careful human attention for several decades. Large amounts of waste will need to find a large permanent storage facility which does not require large amounts of human effort to insure against leakage. Designs and plans for this storage need to be completed soon.

Q 6) Why do thermal nuclear reactors need more cooling water than fossil fuel generating plants producing the same amount of electricity?

A In order to control radioactive leakage, steam is maintained at a lower temperature and pressure in the nuclear reactors compared with fossil fuel plants. Since steam enters the turbine with less pressure, the Carnot cycle (see page D-9) is less efficient, and more energy is turned into waste heat.

Your Role in the Future

Energy is an extremely complicated topic. Politics, economics, population growth, food production, and life-style all play large roles in determining the amount of energy you will have today, next year, and 30 years from now. You should leave your study of this unit with four basic understandings.

1) Having sufficient energy is vitally important to your health, your future job, and your life-style. We can make cuts and grow more efficient in our use of energy, but large amounts will still be required.

2) We cannot continue our 93 percent dependence on fossil fuels for our energy. We must <u>strongly</u> support efforts to safely utilize nuclear power, solar power, and other forms of power if sufficient power is to remain available for your use.

3) We must work to make sure that power is produced in such a way that the environment is not damaged enough to hurt human, plant, and animal health in a major way now or in the future.

4) We must understand that long range planning is essential for achieving these goals. No undertaking designed to provide billions of watts of clean, economical energy can be accomplished in one year or in 10 years.

How Can You Help

Energy supplies are not something decided only by the "big-wigs." Consumer demand determines KPL's growth rate and no electricity is produced if none is used. Politicians do respond to letters, public opinion, and votes. Laws they write influence the availability of energy and the environmental controls followed by the industry. You can help assure a good future by your actions and your words. You should plan to work in four general areas.

<u>Reduce energy usage</u>: The less energy used now, the more will be available next year, and the longer we will have to plan for the future. To save energy, follow the guidelines below.

1) Do not buy poorly made goods, and <u>really</u> try to use the things you do buy as long as possible! It takes nearly as much energy to make a car which falls apart in three years as it does for one which lasts 10 years. Poorly made chairs, homes, stereos, and clothes all waste much more energy then well made items which last a longer time. <u>Do not be style conscious</u>--new styles are just a way to force buyers to discard good old things and waste money and energy buying new things.

2) Avoid buying things with excessive packaging that cannot be recycled. TV dinners, plastic wrapped cooky boxes, and throw away cans and bottles cost much more money and energy than items with less packaging. If Americans just refused to buy soft drinks and beer in non-returnable containers, enough energy would be saved to increase the speed limit to 60 miles per hour!

3) Do not drive or fly unless you have to. Use car pools, legs, bikes, buses, or trains for transportation whenever possible.

4) Insulate homes, heaters, and coolers well, and use heat and cooling as little as possible. Much energy and money is wasted on poorly insulated and over-heated and over-cooled homes.

5) Use some of the excellent free guides to saving energy in the home. KPL has a good guide which can be received free and many other companies publish suggestions.

6) Complain to store owners about overheated and over-cooled stores. Tremendous amounts of energy are wasted in stores with high ceilings, large amounts of glass, and poorly adjusted thermostats.

7) Remember that anytime anyone wastes energy from fossil fuels, that energy will never again be available for anyone's use. The gallon of gas a friend wasted today may be the gallon which was not available for a tractor or ambulance next year. Saving energy is everyone's responsibility and is in everyone's best interest.

Be informed: As energy supplies grow short, your knowledge is the best insurance for survival. Scare tactics will be used to promote nuclear power and to stop nuclear power. Gadgets by the hundred will flood the market and guarantee better gas mileage, better heating and so on. Many of these are, and will be, worthless. Only the people who are actively reading and learning will avoid wasting money or getting caught with homes without heat, cars without gas, and jobs without a future.

Communicate: Once you know what is happening, write letters and call. If you are sold a worthless gadget, call the Kansas Consumer Protection Commission and help get it off the market. Write your congressmen, governors, and city commission members when you understand the best solution to controversies. Help your friends adjust to a changing world with rising fuel costs, and rising prices of all kinds. These changes are bound to happen as the availability of energy decreases, and humans who cope, rather than mope, will come out ahead.

Select your career carefully: Engineers designing new energy sources and more efficient machines will be very much in demand. If you enjoyed studying this module, you should consider engineering as a career. Industries making cars, tires, air-planes, recreational vehicles, and other high energy users will probably lose employees throughout most of your life. People producing, packaging, and selling food will probably do well, as will those that make and service buses and trains. Make any career decision with two things in mind: (1) for the good of yourself and your country, try to develop and use your skills to the utmost; (2) for your own good, go into areas which will profit as the cost of oil and gas rise and the availability of food declines.

Student Self-Test Questions

1) Do you feel that this module was optimistic, pessimistic, or realistic? Why?

2) Can American society use only half of the energy it now uses and still be the place you want to live in?

3) List three good reasons for saving as much energy as you can.

4) List two good reasons for asking others to save energy.

Behavioral Objective Numbers	Topics and Concepts
4	Students shall indicate that, for the good of our country, large amounts of energy must always be available.
29	Students shall indicate that non-returnable and excessive packaging, purchases based on style changes, and the use of poorly insulated homes all waste large amounts of energy.
30	Students shall indicate a committment to asking others to conserve energy when flagrant over usage is observed.
31	Students shall indicate that society should encourage production of energy from non-fossil fuel sources, so long as the by-products of the energy production do not damage the environment significantly.
32	Given a list of five occupations, students shall indicate jobs which will have the highest potential for making a good living ten to twenty years from now.

Teacher Suggestions

This paper is designed to help develop student attitudes which will help our nation, and themselves. The behavioral objectives indicate the concepts to be stressed as the paper is discussed.

This would be a very good opportunity to emphasize the great importance of working in school now, and in looking toward the future. Many knowledgeable men are saying three things about the remainder of this decade: 1) a world wide food crisis may make the energy crisis insignificant; 2) if the food crisis does not drastically affect the United States economy, the energy shortage will worsen yearly through 1978, at least; 3) people who do not obtain intellectual, social, or complex judgemental and mechanical skills will be unemployed most of their life. These predictions are based on the decreasing per capita food production which is now appearing, the lack of enough refinery capacity in the world to satisfy American petroleum needs, and the increasing white collar and decreasing blue collar employment trends. In short, the high school graduate with no ability or intention to become skilled in some area will have a rough road ahead.

One way all of us should, and can, help alleviate the possibility of eliminating many jobs later, is to save energy now. Our saving now will help discourage wasteful energy uses and encourage habits needed in the future.

If you wish to use copies of KPL's tips for saving energy in the home, call KPL, 233-1351, and ask Mr. Hal Hudson for as many copies of Reddy Reserves Member's Guide as you need.

Student Self-Test Questions

Q 1) Do you feel that this module was optimistic, pessimistic, or realistic? Why?

A Promote a good discussion of this question by asking several students to state and explain their views. Students should realize that this module was written at a time when the future of our life-style is hanging in the balance.

If long range planning, and immediate conservation is used and encouraged, then the over-all module is optimistic. If we refuse to consider the future results of present trends toward wasted energy, vacillating governmental policies, rapidly growing world wide populations, and so on, then the over-all module is pessimistic. We feel that, in balance, the module is realistic.

Q 2) Can American society use half the energy it now uses and still be the place you want to live in?

A Remind students of their work on question 2, Paper B, page 4. Their answer then, should be the same now.

Q 3) List three good reasons for saving as much energy as you can.

A (1) The energy saved now will be available for use later (if you also help others save energy).
(2) The money saved can be used for other things.
(3) Small savings now may help the society adjust gradually to growing fossil fuel shortages so that a catastrophic adjustment need not be made later.

Q 4) List two good reasons for asking others to save energy.

A (1) Many people will begin to save energy if their consciences are jogged.
(2) Many people are not aware of the need for, or ways to, save energy.
(3) Some people waste energy to impress you favorably (hot rodders, overheated stores, large car owners, etc.) and will change their habits when they find out that most people are not impressed favorably.

The Field Trip

Topics and Concepts

Behavioral objectives 4-32 will all be reviewed during the trip, as guides follow the directions contained in this paper.

TEACHER SUGGESTIONS

Table of Contents

Topics and Concepts . . . . See pages 7-9
Suggestions for use of the two field trip forms. K-1
"Requests to Principal for Field Trip" form. K-2
"Parental Permission" form K-3
Planning for the substitute. K-4
Pre-field trip lecture suggestions K-4
Field trip time line K-4
Directions for trip guides K-5

Using Field Trip Forms

"Request to Principal for Field Trip" form

Three copies of this form must be submitted for each field trip. They should be submitted as early as possible and at least one week prior to the trip. You may use the form on page K-2 in either of two ways: duplicate it the proper number of times, fill in the required information, and turn in to your principal; or obtain the proper number of request forms from your principal and transfer this information to it.

Please invite your principals to attend this trip with you. It will provide them a much better picture of the value of field trips than could be conveyed in any number of words.

"Parental Permission" forms

Duplicate page K-3, and strongly urge your students to have their parents read and sign these sheets. They are quite important to the continued success of this project and in establishing some communication from you to the parents. We need the volunteers that are occasionally picked up with this form, and the community should be aware of what the project and its teachers are doing with their students. We also need the emergency phone numbers in case a student should be hurt.

Have the class fill out the first three blank lines before sending the forms home. Please bring the forms with you when boarding the bus.

THE TOPEKA PUBLIC SCHOOLS
REQUEST TO PRINCIPAL FOR FIELD TRIP
Secondary Schools

Community resources are valuable aids to the instructional program. Careful planning and proper follow-up are necessary in order to make the trip most worthwhile. This form should be properly completed in TRIPLICATE and signed by the teacher and principal. The original copy is filed in the principal's office. The principal shall send duplicates to the office of instruction and departmental supervisor.

School__________ Department Science Subject and Class__________

Date of Trip________ Leave______ Return______ Number of Pupils______

Description of Trip The class will study the Lawrence Kansas Power and Light plant and will make a half-hour stop at the KU electrical engineering laboratories and nuclear reactor center. The trip will last three hours and 25 minutes. Students will be divided into groups of 10 or fewer students and will be led by trained guides.

Objectives of the Trip All students will study KPL's production process, safety precautions, economics, and pollution control facilities. The field experience will expand and reinforce concepts developed through class experiments, papers, and films used during the pre-trip and post-trip study of the "Electrical Production and Pollution Control" module. Behavioral objectives, classroom material, pre and post-trip tests are included in the module developed by the Environmental Education Project.

Means of Transportation Environmental Education bus

Required Student Cost none

Teacher Signature________________ Date________

- -

I approve the above request and accept the responsibility for the field trip as stated in the guidelines on the reverse side.

Principal's Signature________________ Date________

The Topeka Public and Parochial Schools
Unified School District No. 501
Environmental Education Demonstration Project
Phone: 232-9374

The ____________________ school science students in ____________________ class will be participating in a three and a half-hour field trip through the Lawrence KPL plant, the KU electrical engineering labs, and the KU nuclear reactor center on ____________________. For two weeks, the class will study scientific, social, and economic concepts followed in producing electricity and controlling pollution. This trip will illustrate the new concepts. Transportation and leaders for the trip will be supplied by the federally funded Environmental Education Project.

NOTE: A 5-10 minute portion of the trip will involve walking on grating 23 stories in the air. Students are protected from falling by fences, and the well constructed grating, but the height and open air below the grating may upset some students.

Do you grant permission for this portion of the trip? Yes ☐ No ☐

If you give ____________________ permission to take this trip, plear answer the following questions, and give your signature below.

____
Signature of Parent

Emergency Information:

Home Phone____________________

Alternate Phone____________________

Doctor's Name____________________

Doctor's Phone____________________

- -

The Environmental Education Project takes students from all over Topeka on many different kinds of field trips. If you would be interested in being trained to serve as a volunteer to lead students on any of our trips, please indicate your interests below. You would be trained for any trip before being put in charge of a small group of students. You are also welcome to visit any trip. Please call the Environmental Education Office, 232-9374, during the day if you wish to visit any of our trips.

With training, I could help lead a field trip. Yes ☐ No ☐

I would like to work with: Sixth Graders ☐ Junior High ☐ Senior High ☐

I would like to help on these types of trips:

Museums ☐ Nature Study ☐ Water Study ☐

Geology ☐ Industry ☐ Laboratories ☐

Name____________________

Address____________________

Planning for the Substitute

The substitute provided by our project is able to present Papers F, G, H, I, and J and the accompanying films. Provide the substitute with lesson plans for each class which would allow her to present meaningful and interesting material.

Notify both the substitute and the students of the various discipline tools at her disposal, for many classes prefer to harass rather than learn from a substitute.

Pre-trip Lecture Suggestions

1. Remind students where they will meet the bus and the time for departure and return to the school.

2. Students will be walking indoors and outdoors for two hours and will walk over two miles during the trip. They should wear slacks and comfortable walking shoes.

3. Eat a nutritious breakfast and (in case of afternoon trips) lunch. Students with inadequate meals tire out quickly, and grumbling stomachs provide strong competition for constructive learning.

4. Behavior during the trip: a) Groups may be assigned or selected at random by the Environmental Education staff. b) The trip is an intensive learning experience, so come prepared to work and learn. c) No horseplay is allowed. The heights and machinery are too dangerous to allow inattentive behavior. The guides are under strict orders to terminate the trip after issuing one warning. Students will not be allowed to endanger themselves or others.

Field Trip Time Line

The trip requires a full three hours and 25 minutes to reach every objective. If less than that time is available, portions of the trip will be trimmed from the agenda.

Travel to KPL and disembarking time.	45-50 minutes
Tour of the plant.	1 hour, 15 minutes
Travel to KU Engineering Labs.	10 minutes
Tour of Electrical Engineering Lab and Nuclear Reactor	30 minutes
Travel to the school and disembarking time . .	45-50 minutes

LEADER_________________________EVALUATOR_______________________DATE_______________

Directions for Trip Guides

Electrical Production and Pollution Control

The field trip for each group will be unique. The class will be divided (arbitrarily) into groups of ten students or less. Each group will have a different leader and a different route, but all will try to meet the same basic goals.

These suggestions should help make the field trip as profitable as possible.

1. Learn the students' names as quickly as possible, and call them by name throughout the trip.

2. Vary your topics and pace.

3. Do not talk to the group until all can hear and see what is being discussed.

4. Frequently ask a question, let students think awhile, then pick a specific student (on a semi-rotating basis) to answer the question. Keep questions moving and random enough that students never know who may be called upon next.

The list which follows describes the activities, allotted times, and suggested topics to be discussed at each point on the trip circuit. A check sheet format is moving to help focus attention on the specific trip objectives.

General Safety Precautions: before entering the working area of the plant, give students this information.

_____1. Students must stay close to the guide at all times.
H

_____2. Students must not touch machinery or switches unless requested by the guide.
H

_____3. No horseplay is allowed. One warning may be given, then the trip will stop for the entire group unless a teacher is available to remove the offending student.
H

_____4. Point out that you are employed by Topeka Public Schools, and have studied the unit for many hours.
H

STOP I - Transformers

_____5. Ask what a transformer does (raises or lowers voltage, lowers or raises amp. .
H

_____6. Ask how a transformer works (rapidly switching electron flow in a coil of wire creates a moving magnetic field. The moving magnetic field causes electrons in a second coil of wire to move.)
H

_____7. Ask students why the large fans are on the sides of transformers. (The changing magnetic field releases some energy as heat in the transformer's iron core. The moving electrons in the copper coils also release some energy as heat. The fans remove the heat.)
L

_____8. Ask students why the transformers are grounded (so that any electrical leakage across insulators will be sent to the ground).
L

_____9. Ask students why the snake and large animal fence surrounds the transformers (to keep animals from crawling into the transformers and shorting out the system).
L

STOP II - Move down the walk 30 yards, and turn to look at the three large air cooled leads going to the transformer, and the three transmission lines leading up the hill.

_____10. Ask why three wires come from the generator. Why not two or four?
H

_____11. If the generator produces 24,000 volts, and the transmission lines carry 230,000 volts, which line is hooked to more coils of wire inside the transformer?
H

_____12. Which line carries more amperes of current?
H

STOP III - Elevator

_____13. Point out that the class will go to the twelfth floor to view the boiler, and make sure that all students are ready to go. If one is going to get sick, leave him with the teacher's group.
H

STOP IV - Top of the Boiler

Note - (14-20, and 28-30 may be done at level 6)

_____14. Note the substation below and the high power transmission lines. Ask why the poles are painted gray.
L

_____15. Note the coal pile--point out that it is a 90-day supply and is Southeastern Kansas coal. (Price has risen 20% in one year.)
H

_____16. Ask students what is good and bad about Southeastern Kansas coal. (Good--high energy content, short shipping distance; bad--high sulfur content, stripmined--but reclamation being done now, higher cost than natural gas.) Emphasize that overall, there is much more coal than gas or oil in the world.
H

____17. Note the limestone pile. Ask its purpose in making electricity.
H

____18. Note the oil storage tanks, which hold a 15-day supply of oil. This oil looks like asphalt. (Price has risen 300% in one year.)
L

____19. Ask what oil, coal, and natural gas all have in common. (Fossil fuels made millions of years ago--when they are gone, they may never be replaced; all are going up in price.)
H

____20. Point out the stacks of the #2, #3, and #4 units. These units produce 30, 60, and 125 megawatts of power. You are standing beside the boiler of the #5 unit, which produces 400 megawatts.
H

STOP V - Walk to the north side of the boiler.

____21. Point out the Kansas River, the sewage unit, and the cooling tower blow down outlet.
L

____22. Have students locate their position on the #5 generating unit diagram.
H

____23. Ask students to suggest normal changes which would change the water level inside the boiler drum. Trace the changes through the cycle; (i.e. when Goodyear turns on its machines Monday morning, strain is put on the generator, which uses more steam, which causes fuel and water flow rates to increase, which causes the boiler feedwater pump to work harder, which brings the water level back up in the drum).
H

STOP VI - Move into the boiler drum room.

____24. Point out the water level gauge on the drum and the heat. The steam is at only 360° C., and is protected by three inches of insulation in most areas.
H

____25. Demonstrate the temperature of 360° by touching an exposed pipe with a piece of paper. Note that the water will be superheated to 540° before it travels to the turbine.
H

____26. Point out the fact that 24 tons of water turn into steam and move through the boiler every minute. The boiler could run dry in less than a minute if the many automatic and manual safeguards did not exist.
H

____27. Point out that, except for spring and fall overhauls, the boiler runs continuously. Ask where KPL would obtain water to make steam?
L

STOP VII - Move around the boiler to the south side.

____28. Point out the metal straps which support the boiler, and ask students the reason for this suspension.
L

____29. Point out the reheat and superheat pipes, and ask students why the reheat pipe is larger, when the plant diagram indicates that it carries less steam.
H

____30. Point out the expansion curves in the steam pipes and ask students to explain the reason for these curves.
L

STOP VIII - Move down to level six. Move to the #3 feedwater heater.

____31. Ask students to locate the source of heat for the #3 feedwater heater in the plant diagram.
L

____32. Point out the five coal storage bins, which each hold six railroad carloads of coal. Show students a sample of the coal dust which is injected into the furnace.
H

____33. Explain the procedure used to start the boiler's furnace. (Natural gas is lit with a lighter much like a spark plug. For three hours, the heat is gradually increased until the boiler walls, steam, and water pipes expand. Finally, coal mills begin to grind, heat, and dry the coal. When these mills are working well, the coal dust is blown into furnace which is now hot enough to light the dust and sustain burning.)
L

____34. Note the small natural gas pipes and large coal pipes leading into the boiler.
L

____35. Note the large pre-heated air intake vent.
H

STOP IX - Move to the west side of the boiler, and stand between the exhaust gas and heated air intake tubes.

____36. Use the power plant diagram to show the relationship between the economizer pipes, the heated air intake pipes, and the main body of the boiler. Have students feel the walls of the two air vents, and note that two inches of insulation are between the wall and the heated gases.
H

____37. Point out the scrubbers and ask their purposes (scrubbers remove 60% of the sulfur and 99% of the ash from the flue gas).
H

____38. Ask how the scrubbers work (limestone is heated with coal to produce a chemical (calcium oxide) which dissolves in water and grabs SO_2 molecules. As flue gases are forced through a water bath, this reaction occurs. Gypsum (calcium sulfate) and ashes accumulate in the water, and are sent to the ash pond.)
H

STOP X - Move up beside the exhaust fans and stack.

____39. Use the plant diagram to point out that the air coming out of the scrubber is heated to evaporate water droplets, and is then blown out of the stack. Fans are needed to suck the exhaust gases out of the boiler.
H

____40. Ask why the stacks must be so tall. (So that any remaining gases will be so diluted that the environment will not be hurt.)
H

____41. Point out the cooling towers, and ask their purpose. (They cool condenser water to the wet bulb temperature of the air.)
H

____42. Ask why Kansas Power and Light doesn't just filter river water, run it through the condenser and return it to the river. (Not enough water in the river in summer and the waste heat would change the river's environment.)
H

____43. Point out water treatment basins and ask where the treated water is used. (Water goes to the condenser to replace evaporated water.)
H

____44. Ask where water used to make steam is obtained. (Very little boiler water is needed compared with the condenser water. City water is used after it is distilled to remove impurities.)
H

____45. Point out the ash ponds, which contain material from the base of the boiler and from the scrubbers. This is solid waste, created by air pollution controls and by the ashes which are always produced when coal is burned.
H

____46. Point out the fact that adding limestone to the furnace, using the scrubbers, stack gas reheat coils, and the cooling towers all reduce efficiency. The total energy drain is about 6% for use at the generating station. This means that 6% of the electricity produced is used to control pollution, and 94% is sold. In addition, the costs of building the pollution control equipment make up around 15-20% of the plant's cost and the cost of the lost energy, additional fuel and maintenance expenses run about 15-20% of the total production costs.
H

STOP XI -Stop briefly at level IV and look into the boiler. If gas is being burned, note the ashes, boiler pipes, and super heater pipes in the boiler.

STOP XII - Turbine Room--in the northwest corner of this room, review the things you will see, using the power plant diagram.

____47. Point out the feedwater heater and the reheat steam lines and ask how these are used to increase efficiency. (Using heat from low pressure steam in the feedwater heater saves the heat contained in the steam by heating the water to make new steam. Reheating medium pressure steam allows greater energy transfer to the turbine blades.
M

____48. Point out the main turbine with its increasing dimensions from front to back. Reemphasize the expansion of steam as its pressure drops.
H

____49. Touch the low pressure turbine exhaust case and contrast its temperature ≅ 40° C. with the temperature of the superheated steam (540° C.).
M

____50. Point out the generator, and ask what is inside the cover. (A spinning magnet and three very large coils of wire.)
H

____51. Point out the D-C generator and ask what its use would be in an A-C generator (powers the electromagnet).
L

____52. Point out the separate foundations for the turbine and generator and ask why. (Vibration would destroy building and the mass of the generator and turbine requires their own support.)
L

____53. Point out the boiler feed pumps which place water under 2,400 lbs/inch of pressure and send it to the boilers.
L

____54. Ask why the turbine and generator are so loud. (Turbine is loud from vibration and the rush of steam as 24 tons a minute enter under 2,400 pounds of pressure, move through the 30 wheels and 4,000 blades at 400 miles per hour. During this rush, the steam expands to 700 times its original volume and makes noise. In the generator, hydrogen gas is used to cool the coils and provide the spinning magnet with less resistance, and less noise potential.
L

____55. Ask why all of the heat energy in steam is not changed to mechanical energy in the turbine. (After the steam loses most of its pressure, it still contains much energy, but the ability to push is nearly gone.)
M

STOP XIII - Move upstairs to the control room.

_____56. Point out the generator and boiler control panels. Note that red means "inservice" and green means "out of service."
H

_____57. Point out the TV receivers, and emphasize their value in terms of the instant feedback needed to control the boiler.
H

_____58. Point out the alarm panels, and ask the shift foreman to run a test of the alarm system.
H

_____59. Introduce the requirements to work in this plant: high school education, color vision, mechanical interest and ability, and a stable psychological profile.
H

_____60. Point out that most KPL jobs require extensive training. In this plant, almost everyone starts as a shift foreman's helper. This pays about $3.50 per hour. Eventually after five promotions, a few men reach the level of shift foreman, and make $6.50 per hour. Men on shift, work two weeks during the day, move to two weeks of evenings, and finally to two weeks of nights.
H

_____61. To get higher pay requires an engineering degree, or some very specialized skills. Two engineers have over-all control of this plant. KPL hires about 250 semiskilled laborers (janitors and apprentices); 800 very skilled craftsmen (linemen, welders, etc.); 300 secretaries; and about 150 people with college educations, such as lighting designers, professional engineers, and office managers. Most jobs require good math ability and the willingness to start low and work up. About 200 new people are hired each year.
H

_____62. Ask how much of KPL's budget goes to labor, taxes, and fuels and materials.
H

_____63. Ask where KPL's profits go. (To stockholders as dividends, and as capital to purchase new equipment.)
H

_____64. Ask the shift foreman to explain the hold cards.
L

_____65. Ask the shift foreman to explain the sequence followed when an alarm goes off. Be sure to bring out the point that the foreman must stay at the panel <u>at all times</u>, and that he dispatches the number 2, number 3, and lower-level operators to do the repair work in the plant.
L

STOP XIV - Move down to the condenser level

_____66. Point out the condenser and circulating water pipes. Review their function in producing electricity. (Create a very strong vacuum at the exhaust port of the turbine.)
H

_____67. Point out the separate foundations for the generator and turbines, and note the electrical lines leaving the generator.
L

_____68. Note the water control gauges.
H

STOP XV - Move near the 1937 generator.

_____69. Ask students why the boiler water must be extremely pure. (As water boils, it leaves behind any impurities. When 24 tons a minute boils, impure water would quickly leave behind deposits. KPL continually checks the boiler water to make sure that the condenser water is not leaking into it.)
H

_____70. Ask students to trace the flow of water through the plant using the diagram and to indicate how KPL improves the plant efficiency at each point.
L

_____71. Point out that the 1937 generator runs on the same low temperature and low pressure steam which powers the low pressure turbine of the number 5 generator.
L

_____72. Note that this is a 10 MW generator, and in its day, it was a modern, up-to-date power station able to supply most of the electricity to this area until 1951.
L

_____73. Use the bar graph showing the Lawrence KPL generating capacity, and point out the generators added during each time period. Stress the average doubling period of 8-10 years.
H

_____74. Ask students where KPL obtains the money to build the new generators. Stress that capital is the money left over <u>after</u> taxes, wages, fuels, etc., are purchased. Capital comes from profits, stocks, and loans.

STOP XVI - Move to the bus, and ask these review questions.

_____75. Energy is transformed through many forms as the chemical energy of coal turns into the electrical energy in your home. Ask students to give the sequence of energy changes and the places they occur. (Chemical energy in fuel ⟶ heat energy in the furnace ⟶ heat energy in the steam ⟶ mechanical energy in the turbine ⟶ moving magnetic energy in the transformer ⟶ electrical energy in the transmission line.)
H

_____76. List four things that help increase the plant's efficiency. (Using high pressure, super-heated steam; using the condenser to create a vacuum; using the feed water heaters to transfer steam heat to the boiler water; using the economizers; and preheating the boiler air.)
H

_____77. List four things which lower the efficiency of the plant. (Scrubbers; exhaust gas re-heat coils; stack gas fans; water cooling towers; and hot temperatures which raise the condenser temperature.)
H

KU Engineering laboratories, split into your original g[illegible] and quickly move into the laboratories. One group should move to the electrical laboratory, one to the control panel of the nuclear reactor, and one to its base.

STOP XVII - Base of the nuclear reactor.

______78. Point out that some materials contain radioactive atoms, and that other materials can be made much more radioactive. Review the diagram of the neutron chain reaction. Point out that many atoms will change after being hit by a neutron.
M

______79. Explain how the nuclear reaction rate is measured (by allowing neutrons to strike atoms of Boron. The Boron atoms produce alpha rays which create a flow of electricity between two charged plates in a geiger counter. The greater the flow of electricity, the more neutrons are present.)
L

______80. Measure the radioactivity of a new style and old style dime. Then insert them into the reactor, and remeasure their radioactivity. Point out that the increased radioactivity was caused by neutrons hitting the silver and changing the silver atoms. The dimes will soon return to normal.
H

______81. Move to the top of the reactor, and caution students about dropping pencils (etc.) into the water.
M

______82. Point out the control rods, fuel elements, water, and concrete thickness. Explain the function of each part. (Fuel rods contain uranium, or plutonium; control rods contain boron which readily absorbs neutrons; water slows down neutrons so they may be more readily captured by uranium atoms to cause fission; and the concrete walls and water absorb most nuclear radiation which could damage people.)
H

______83. Ask what would happen if the water was drained away from the core. (Nothing--the water would not slow the neutrons, and no chain reaction would occur).
M

______84. Watch the Cerenkov Glow, and explain that gamma rays hit electrons in the water, and the energized electrons release light, which produces the glow.
L

______85. Point out the log and indicate that extensive records are kept. The Atomic Energy Commission demands a detailed explanation of every deviation from the rules agreed to when the plant was licensed.
H

______86. Point out that four neutron detectors continuously monitor the population of neutrons in the reactor. Three automatically shut off the reactor if too many neutrons are present.
H

_____87. Indicate that this reactor is used for biological and chemical research. as well as for one of the few programs which train health physists. Health physists help plan reactor operation to eliminate danger to people, and they help in nuclear emergencies. Some examples of current research include using the reactor to analyze oil for sulfur content, and measuring the sodium content in various parts of animals. In both cases, chemicals which are quite hard to measure accurately are bombarded with neutrons, become radioactive, and release particles which allow accurate determination of the chemical's population.
H

STOP XVII - The electrical engineering laboratory.

_____88. Explain how an oscilloscope works (a beam of electrons shoots through the machine. As they pass between two charged plates, the beam can be bent if the charges are not balanced. This bending force (electrostatic force) changes as the electrical characteristics of the input line vary.
H

_____89. Show students that a magnet can deflect the electron beam.
H

_____90. Show that the electron beam can be set to sweep across the screen. This allows changes in the electrical input to be shown as a function of time.
H

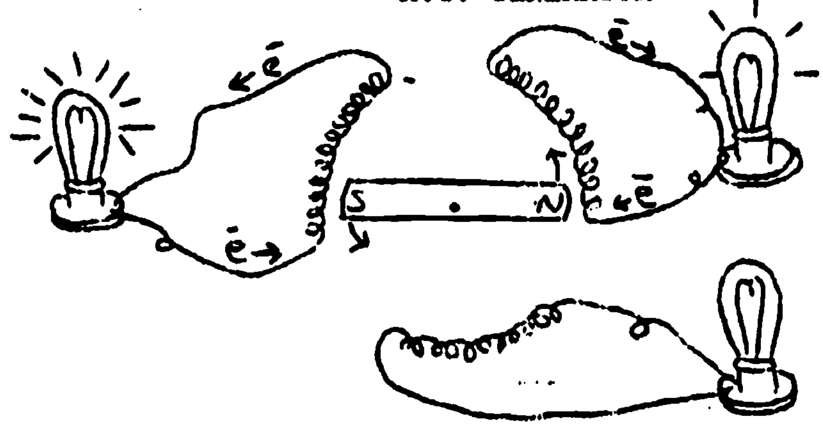
_____91. Move a bar magnet back and forth through a coil of wire hooked to the oscilliscope. Show the alternating direction of the electron flow as the electron beam is deflected first one way then the other. This occurs because the electrostatic charges on either side of the electron beam reverse when electron flow direction reverses in the generator.
H

_____92. Hook up a generator and make the same demonstration. Point out that in this case, wires are moved through the magnetic field instead of vice versa, as out at KPL.
L

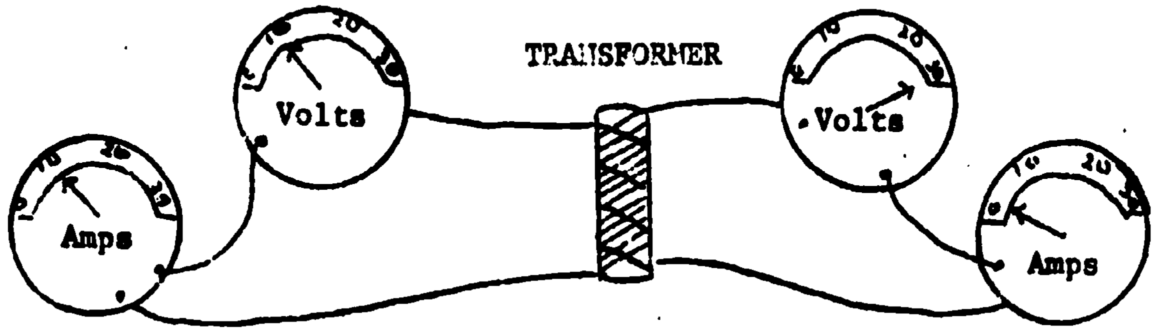
_____93. Hook up an AC current to show the wave characteristics of its electron flow.
H

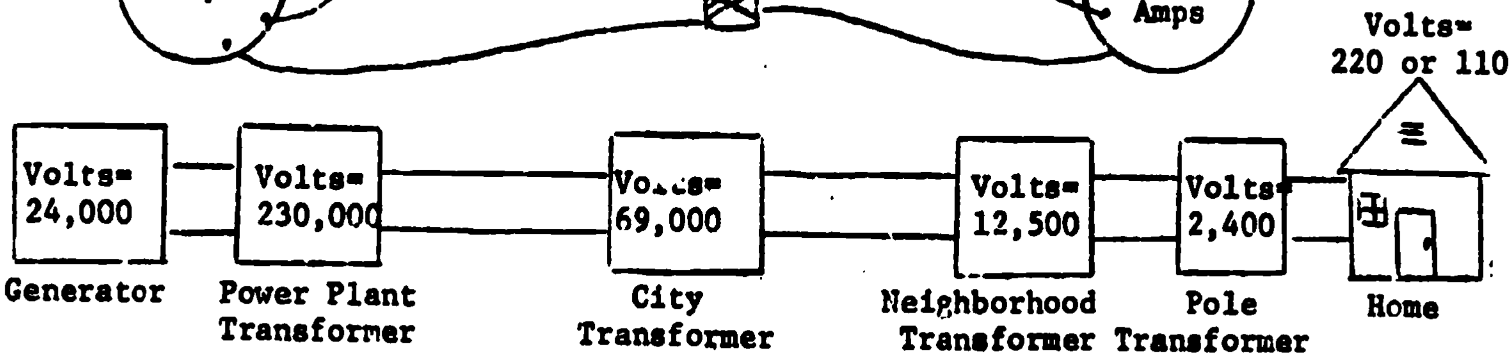
_____94. Point out that, if the students enjoyed working with all parts of this unit, have above average math ability, and enjoy solving practical problems, they might wish to become engineers. Engineers make up only 5% of the KU graduates, but have some of the highest salaries and a very consistent job market. In addition, many of the top executives of large corporations are engineers.
H

A.C. GENERATOR

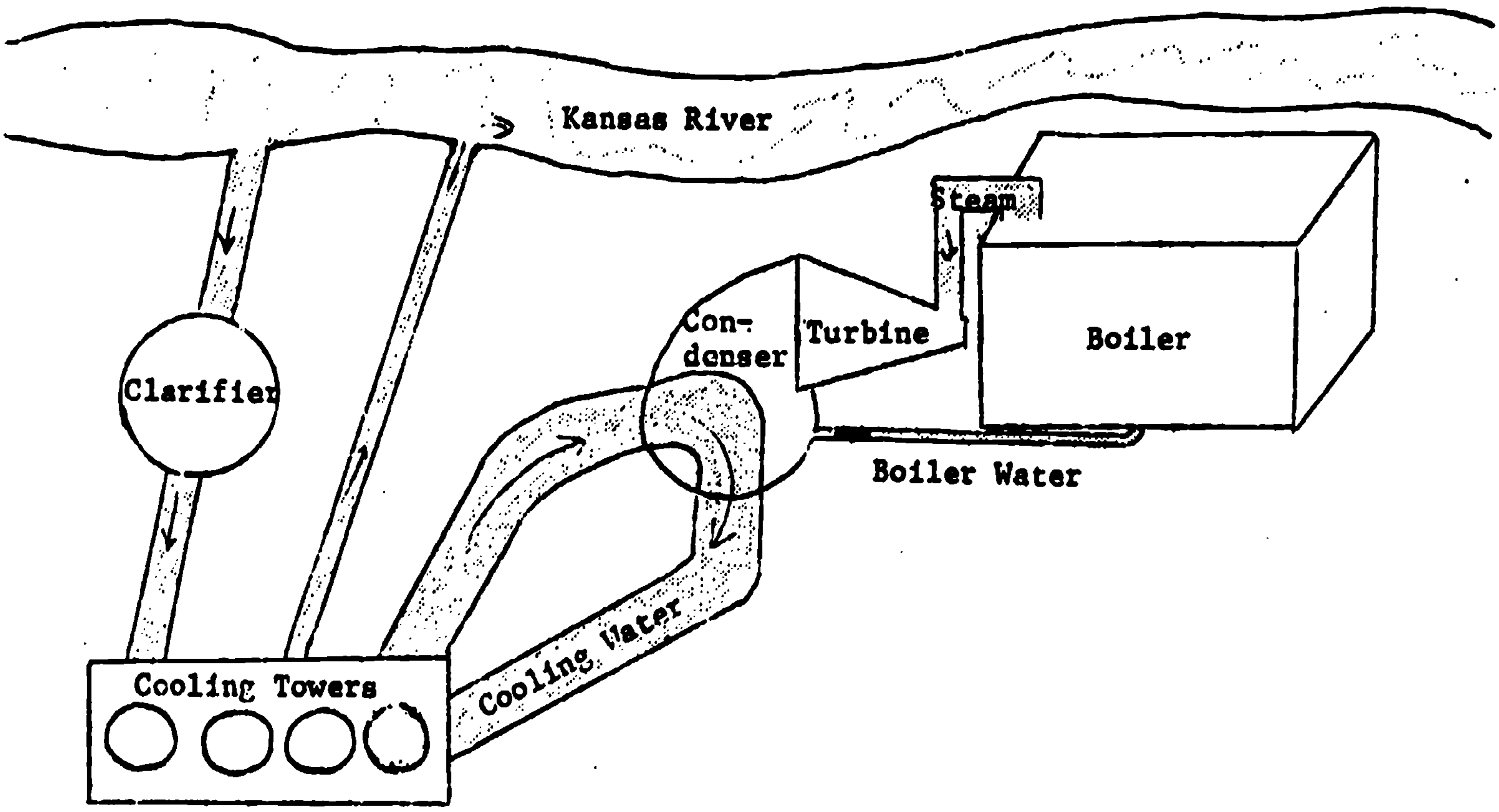


TRANSFORMER

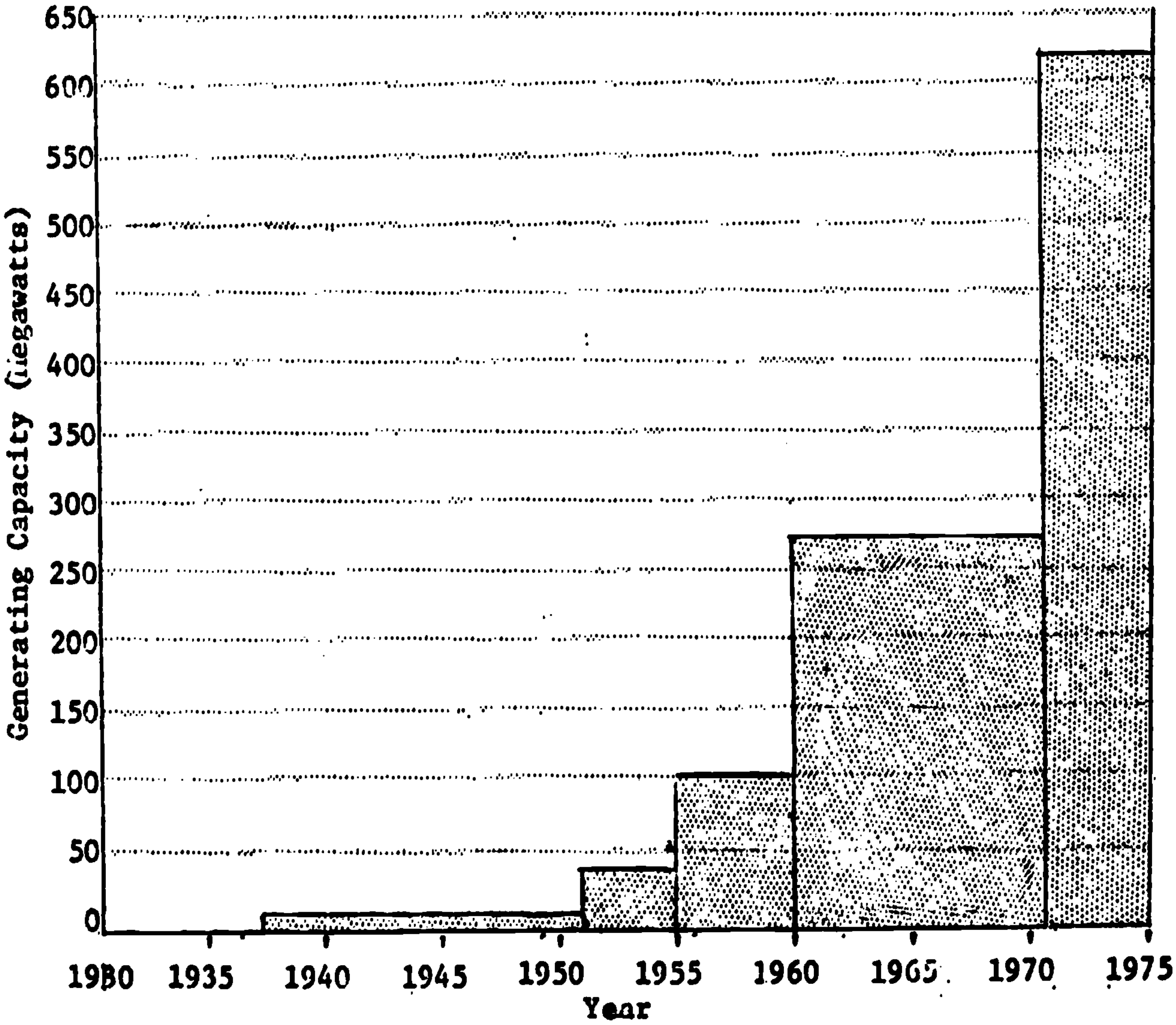




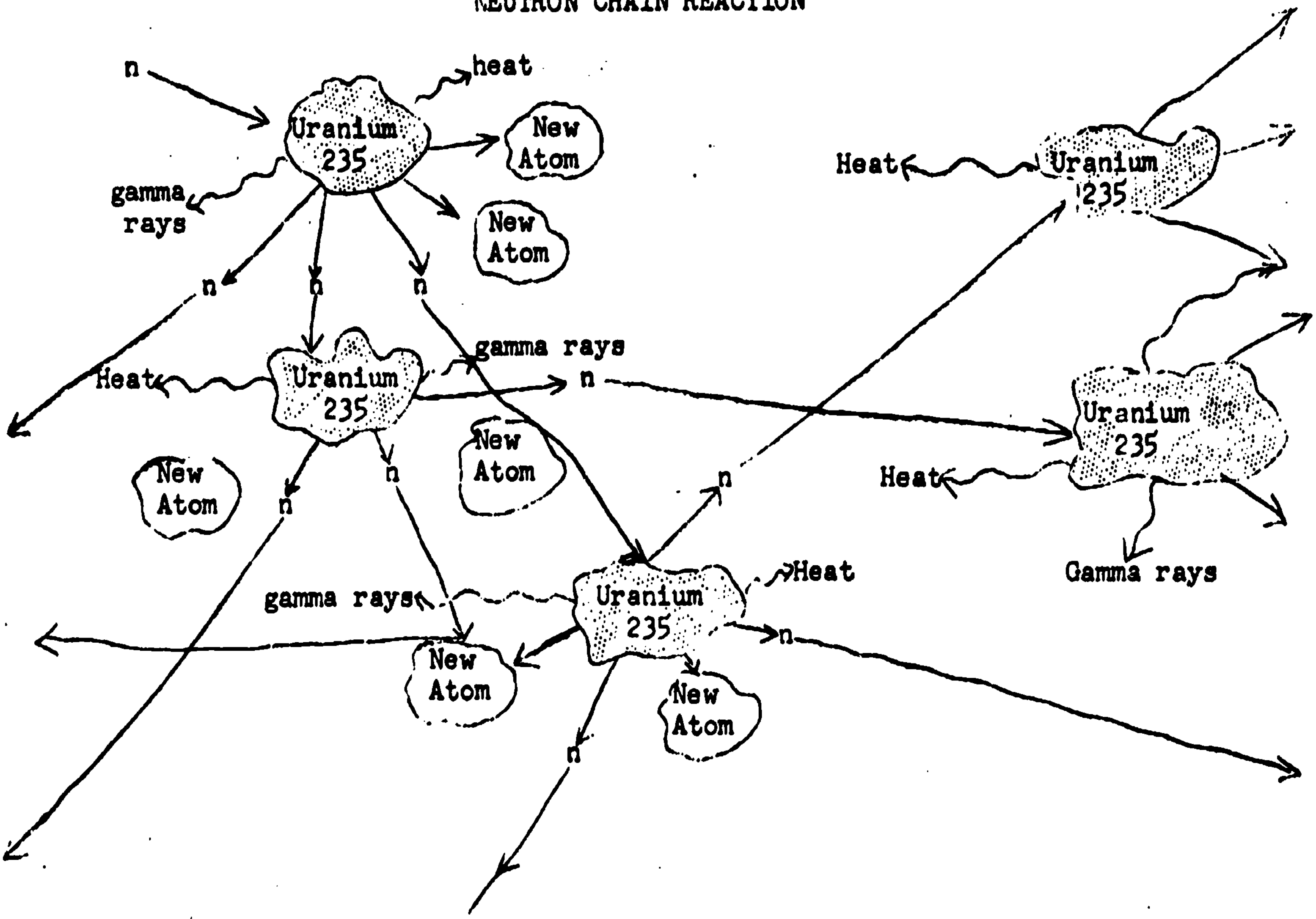
WATER FLOW AT KPL



GROWTH IN LAWRENCE KPL GENERATING CAPACITY



NEUTRON CHAIN REACTION



GLOSSARY

Alternating Current: An electron current which reverses its direction of flow rapidly.

Ampere: The rate of electron flow. One ampere = a flow of 6.25×10^{18} electrons per second.

Atoms: The tiny particles which make up all chemical elements. All atoms have one nucleus and one or more electrons.

Boiler: The portion of the power station in which heat is released from fuel and water is boiled.

Boiler Feedpump: The water pump which controls the pressure and rate of water flow in the boiler.

Breeder Reactor: A nuclear reactor which produces heat energy and new atoms which are able to fission using neutrons released from uranium 235.

BTU: The quantity of energy needed to raise one pound of water one Fahrenheit degree.

Calorie: The quantity of energy needed to raise one gram of water one degree Celsius.

Capital: Money remaining after wages, material costs, taxes, depreciation, and interest is paid in a business. Capital is used to modernize and expand the business.

Condenser: The portion of the generating station which cools low pressure steam to create a vacuum at the turbine's exhaust port.

Direct Current: An electron current in which the electrons flow only one direction.

Demister: The set of plates which remove most water in air coming from the marble bed in the scrubber.

Depreciation: The loss in value which occurs as equipment wears out.

Economizer: The bank of tubes used to transfer boiler exhaust gas heat to the water entering the main part of the boiler.

Electricity: The flow of electrons from one point to another.

Electron: Tiny particles which act like magnets, carry a negative charge, and move around the nucleus of an atom.

Electrostatic Attraction: The force which pulls two objects with opposite charges (+ and -) together.

Energy: The ability to do work. Whenever anything happens, energy has been used.

Fission: The splitting of an atom into at least two smaller atoms. A large amount of energy is released as this division occurs.

Fossil Fuels: Fuels composed of partially decayed, highly compressed, and very old plants.

Generator: A machine which consists of a magnet spinning by coils of wire to create an electric current.

Geothermal: Heat from the earth. Geothermal energy reaches the earth's surface in volcanoes and hot springs.

Gross National Product: The value of all goods produced by a country.

Hydroelectric Plant: An electrical plant which uses energy from falling water to turn turbine blades which power the generator.

Linear Scale: A scale with equal space between each identical increase in quantity.

Log Scale: A scale with space assigned according to the number of times 10 must be multiplied by itself to equal each increase in quantity. Two divisions of the scale separate 10 and 1,000, or 100 and 10,000.

Magnetism: The ability of one uncharged material to affect another thing's electrons.

Neutron: An uncharged particle found inside the nucleus of an atom.

Nucleus: The very dense core of an atom which contains positive charged protons, and uncharged neutrons.

Pollution: Materials out of place and damaging life, insulting senses, or threatening to harm the environment.

Power: The rate of energy usage. Powerful things use much energy in a short time.

Profits: The money and goods remaining when all bills due are paid.

Radioactive Decay: The change in a nucleus when small particles or light rays are emitted and one new atom is created.

Resistance: The opposition to the flow of electricity.

Scrubber: The air pollution control unit which removes most ashes and sulfur dioxide from exhaust gases by "scrubbing" the gases in a water filled marble bed.

Thermal Reactor: A nuclear reactor which reduces neutrons released from uranium fission to an energy level equal to heat rays in order to cause new atoms of uranium to fission.

Technology: Science applied to industry to create new products and new ways of controlling production.

Transformer: A machine which allows the moving magnetic field around one coil of wire with an alternating current to create a new alternating electric current in another wire.

Turbine: The machine with blades designed to turn under the pressure of steam as it expands and cools.

Volts: The pressure which pushes electrons through a wire.

Watt: The amount of power used to push one amp with one volt of pressure.

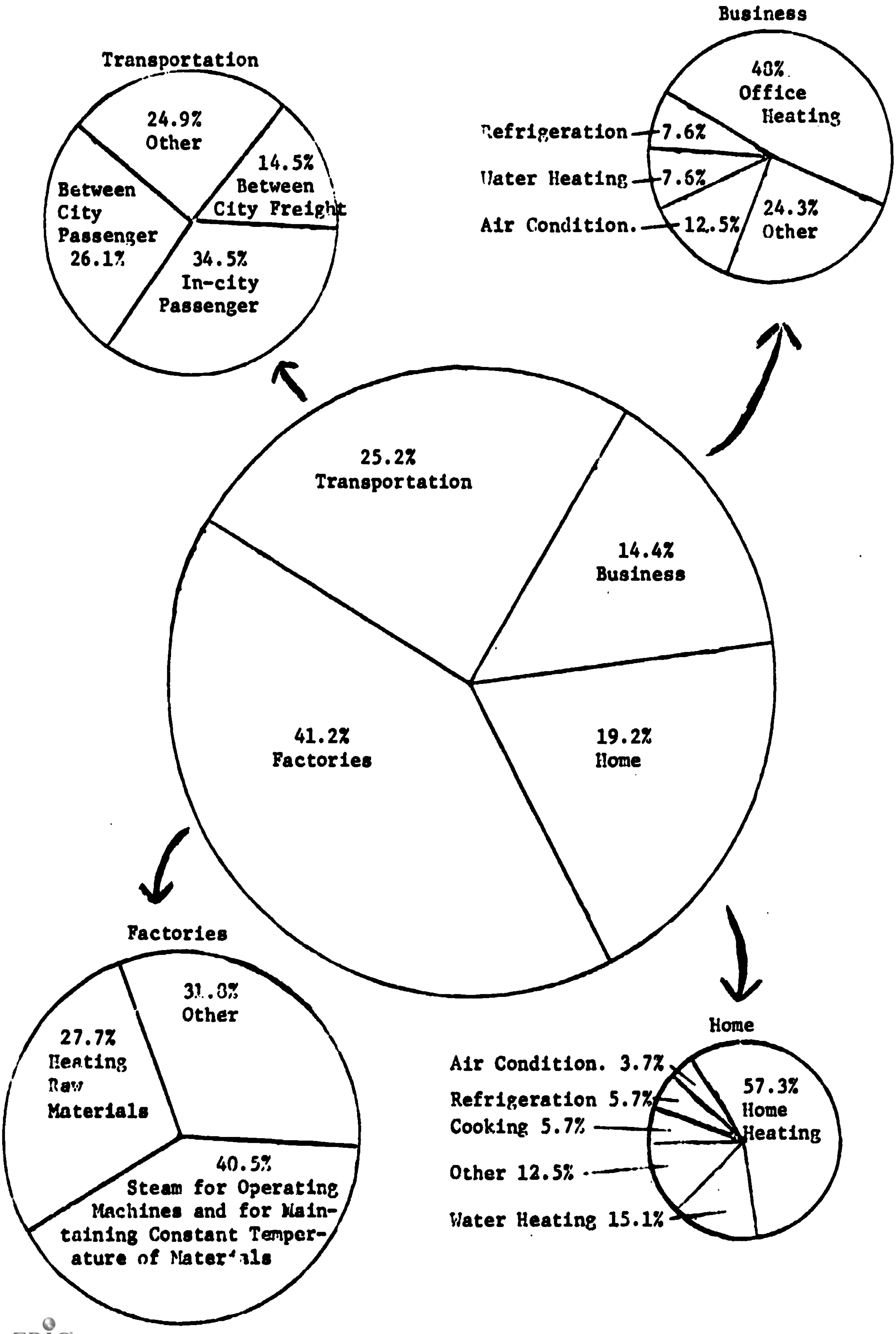
Watthour: The amount of energy needed to push one amp with one volt for one hour.

Module: 7

BEST COPY AVAILABLE

Appendix 1
Transparency 1
Paper B

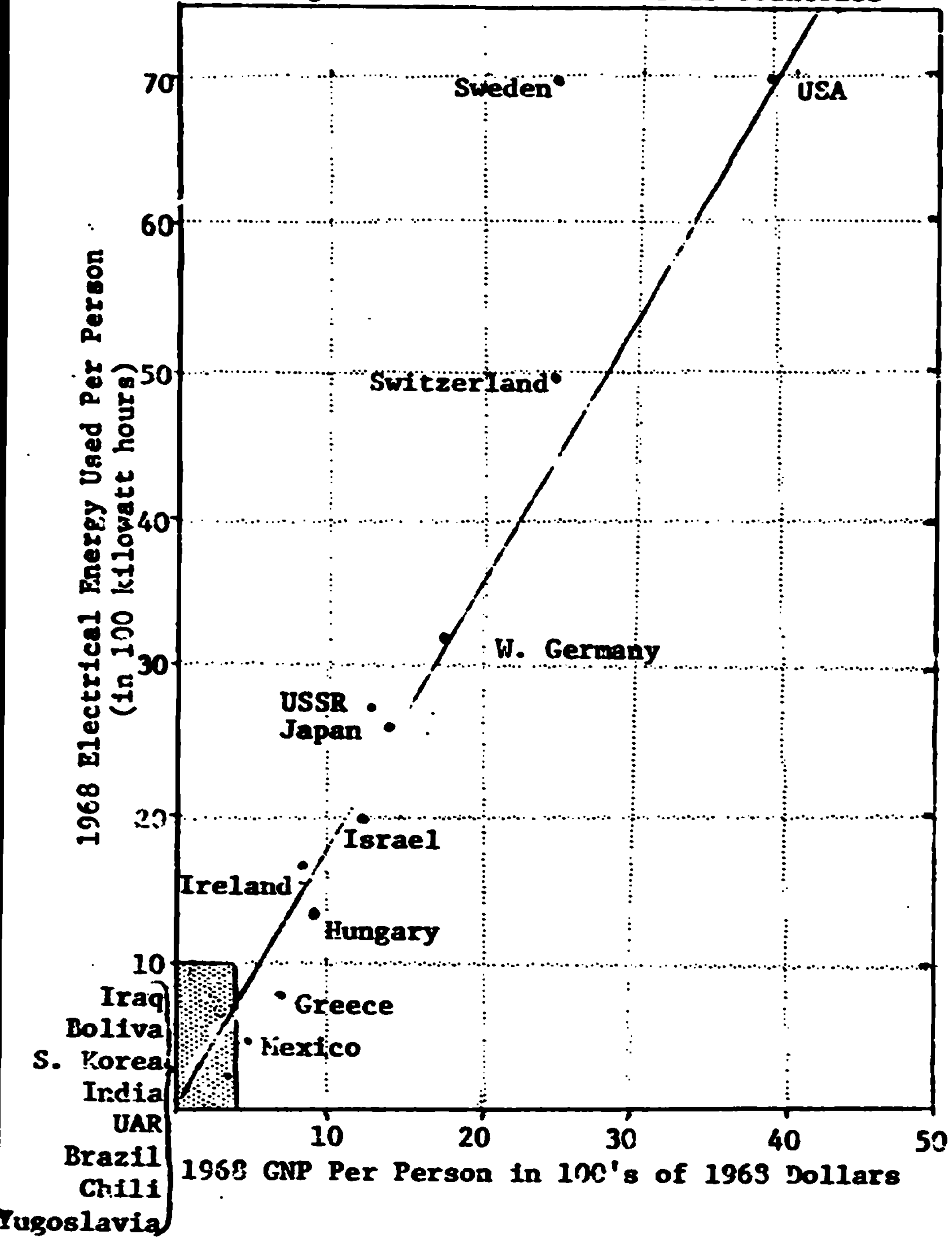
WAYS THE UNITED STATES USES ITS ENERGY



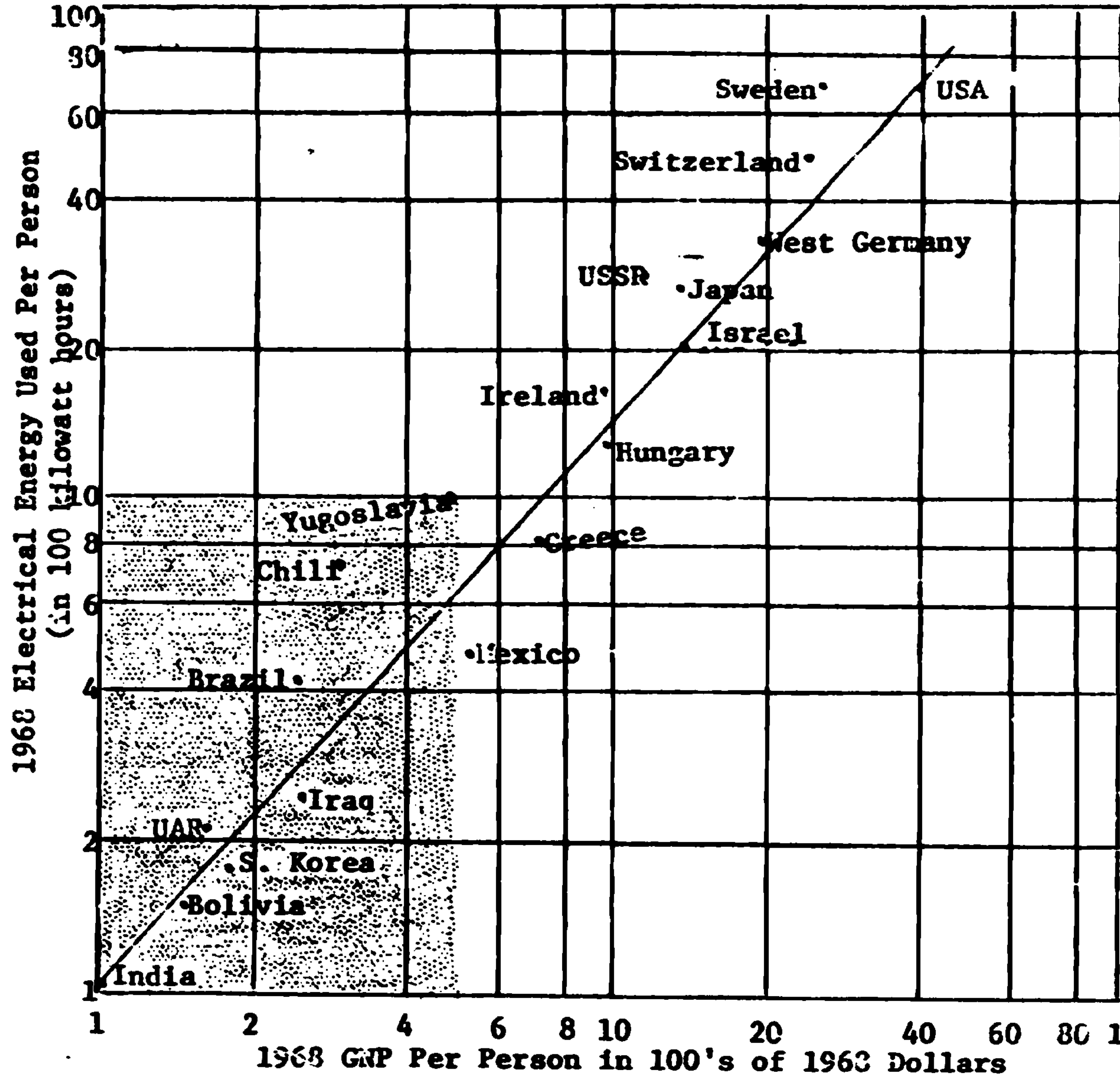
BEST COPY AVAILABLE

COMPARISON OF THE SAME DATA ON TWO TYPES OF GRAPHS

Linear Comparison of GNP and Electrical Usage Per Person for Various Countries



Log-Log Comparison of GNP and Electrical Usage Per Person for Various Countries



Comparison of Two Graphs of
Electricity Consumption
in Topeka

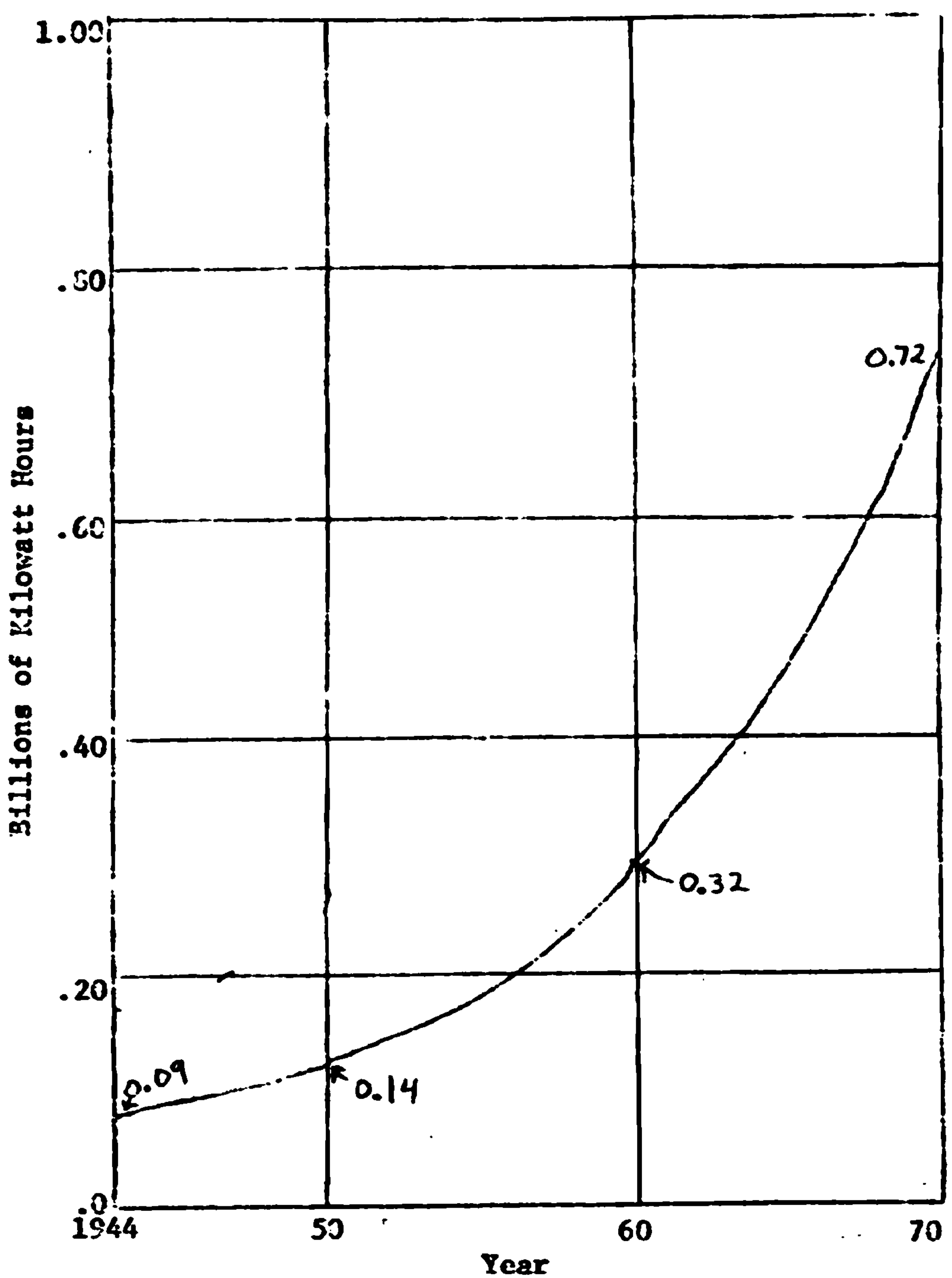


Figure 1 - Linear Graph

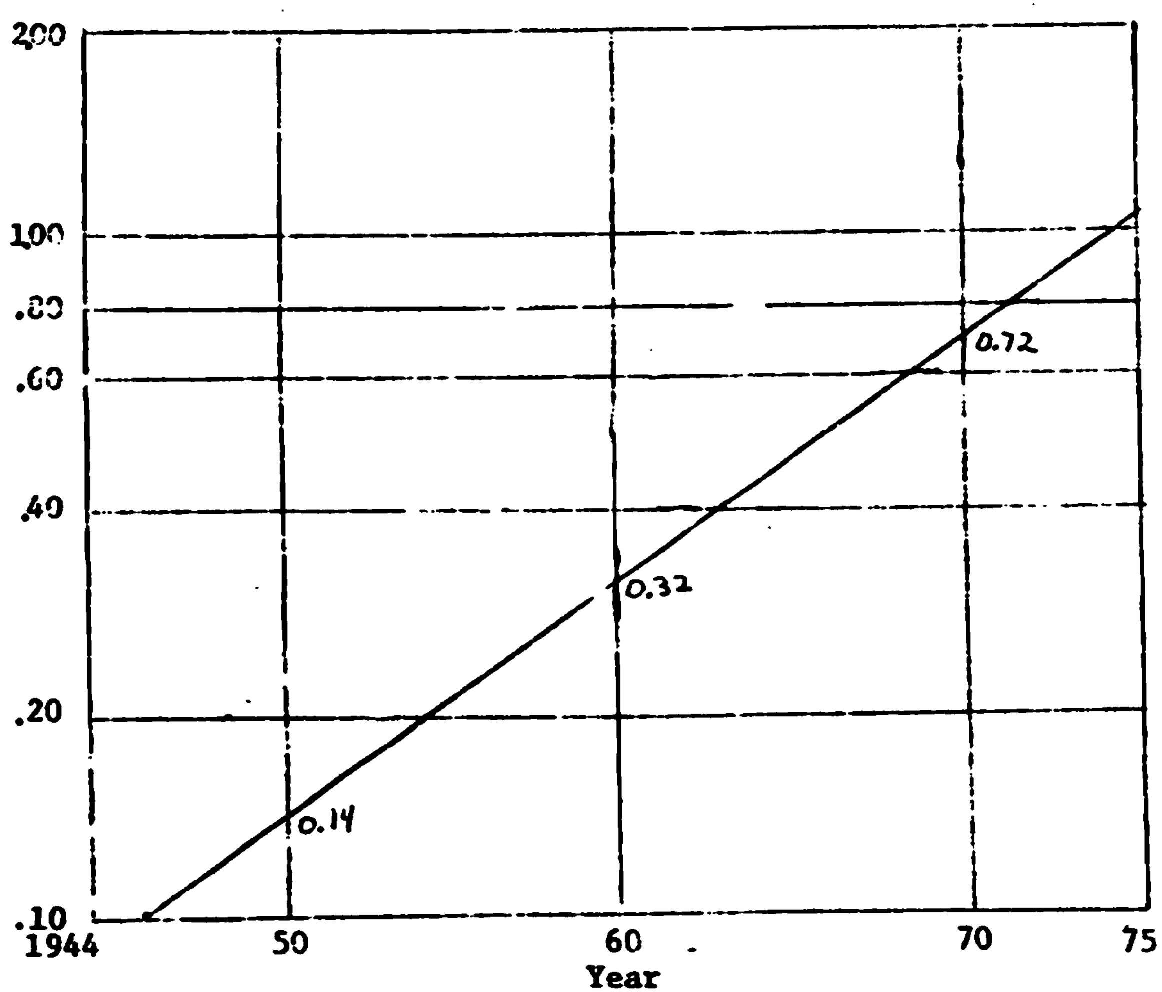


Figure 2 - Semilog Graph

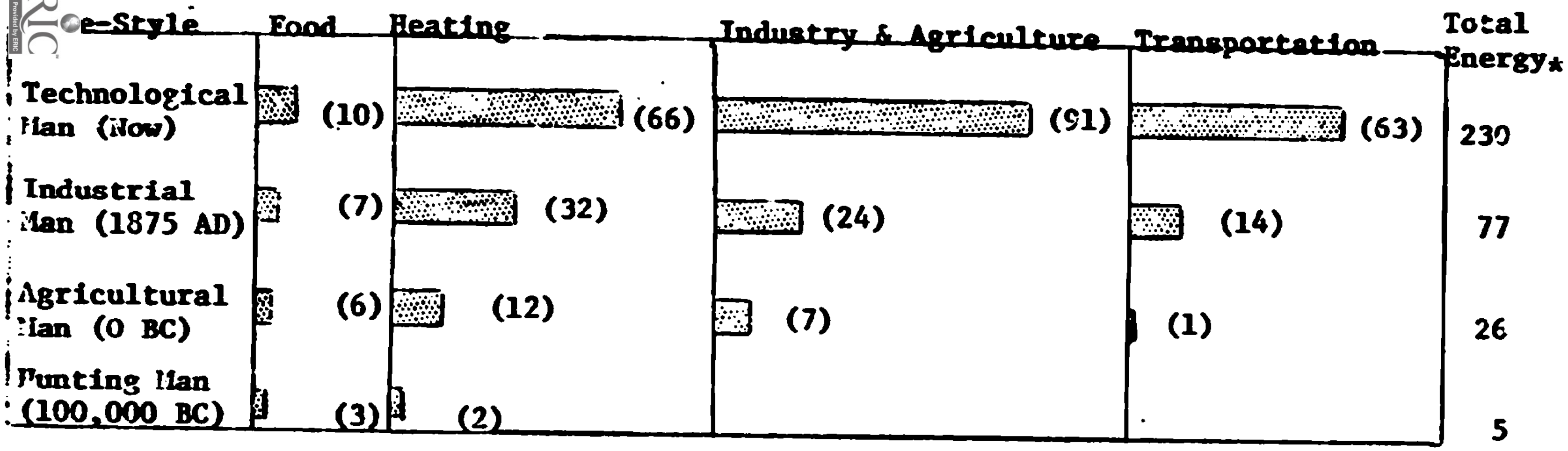


Figure 1. Life-style and energy usage. (Numbers in parentheses = the megacalories used daily to support the average citizen's life-style.)

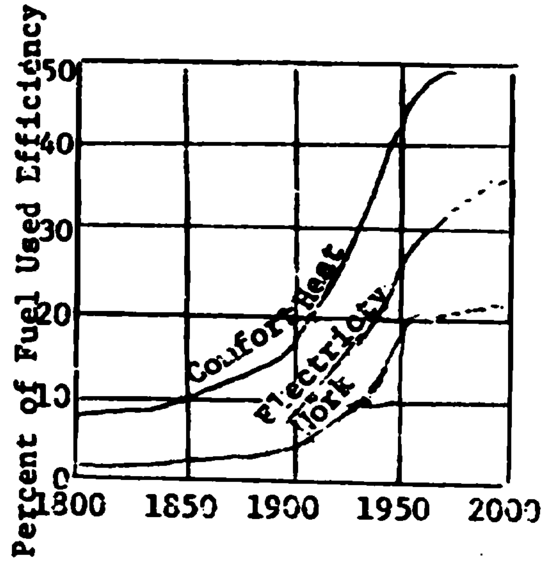


Figure 4. Efficiency of Energy Usage Since 1800.

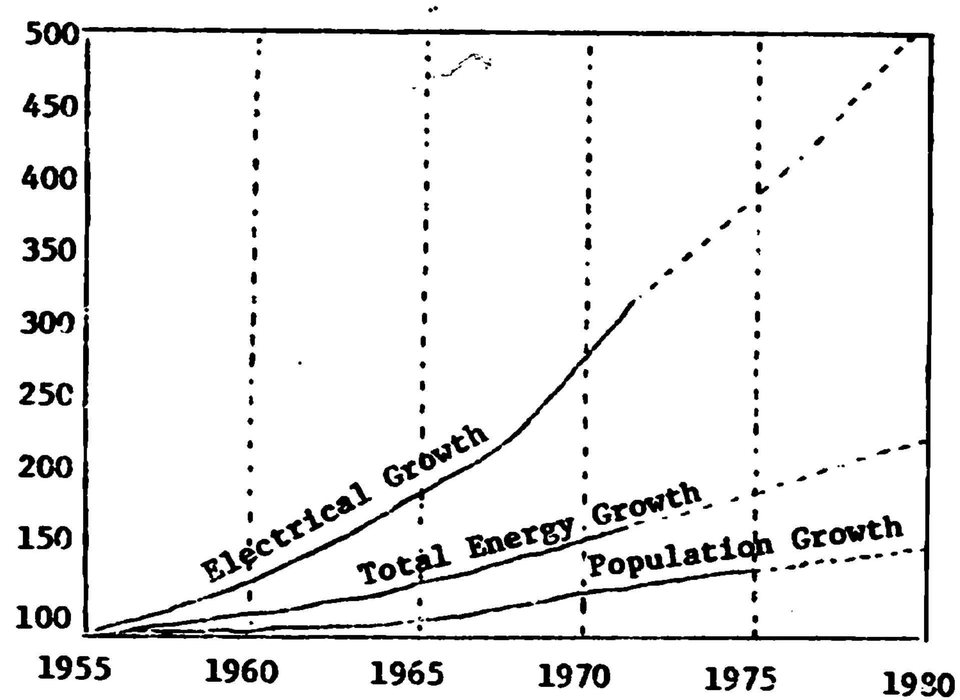


Figure 2. Percentage growth expected in population, energy, and electrical usage.

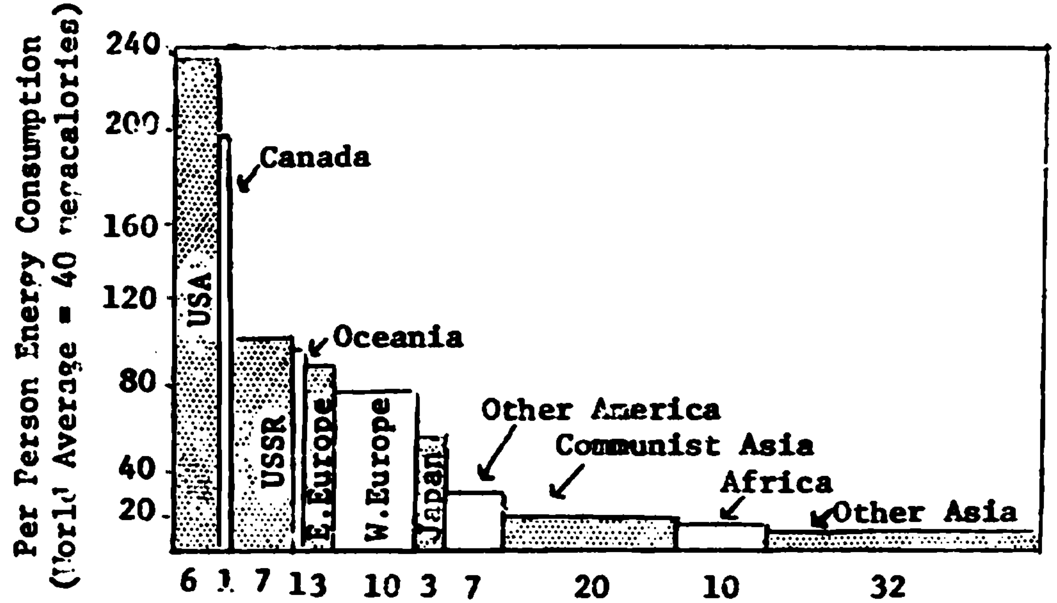
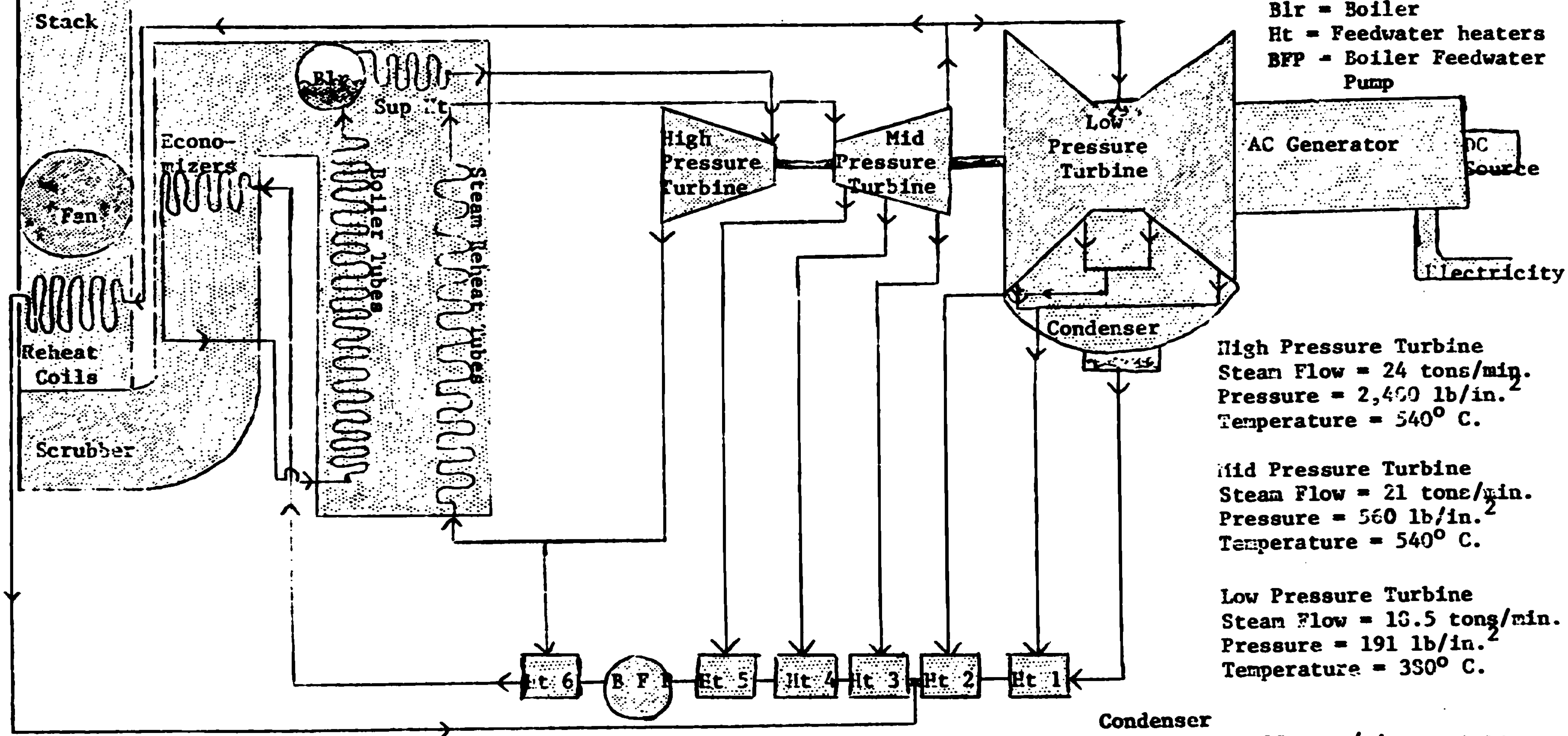


Figure 3. Per person daily energy use in megacalories compared with the world's population.

Trace the flow of the steam in a generating station.

Abbreviations:
Sup Ht = Superheater
Blr = Boiler
Ht = Feedwater heaters
BFP = Boiler Feedwater Pump



High Pressure Turbine
Steam Flow = 24 tons/min.
Pressure = 2,400 lb/in.^{2}
Temperature = 540° C.

Mid Pressure Turbine
Steam Flow = 21 tons/min.
Pressure = 560 lb/in.^{2}
Temperature = 540° C.

Low Pressure Turbine
Steam Flow = 16.5 tons/min.
Pressure = 191 lb/in.^{2}
Temperature = 380° C.

Condenser
Steam Flow = 13 tons/min.
Pressure = 1 lb/in.^{2}
Temperature = 40°

Feedwater Heaters
Steam Flow = 11 tons/min.
Water Flow = 13 tons/min.

Appendix 1
Transparency 5
Paper D

Diagram of the #5 Generating Unit - Lawrence KPL Plant