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AUTHOR Clinard, Lil; Collins, Nancy
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ABSTRACT

This guide was designed for Home Economics teachers as a source of information, instructional materials and suggested references about the energy situation. The contents in this loose-leaf guide are organized according to the most common divisions in home economics curricula. Educational objectives are provided for decisions as well as for each activity. Energy basics are provided at the end of the guide and energy facts and statistics are footnoted for further reading. A bibliography is also provided which gives publisher address and publication cost for each entry. Some of the "activities" merely present information. (MR)

Energy Conservation in the Home

An Energy Education/Conservation Curriculum Guide for Home Economics Teachers

U.S. Department of Energy

Prepared by
The University of Tennessee
Environment Center
and
College of Home Economics
Knoxville, Tennessee

October, 1977

ENERGY CONSERVATION IN THE HOME

EDM-1028

AN ENERGY EDUCATION/CONSERVATION CURRICULUM GUIDE FOR HOME ECONOMICS TEACHERS

BY
THE UNIVERSITY OF TENNESSEE
ENVIRONMENT CENTER
AND
COLLEGE OF HOME ECONOMICS
KNOXVILLE, TENNESSEE

U.S. DEPARTMENT OF ENERGY

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The authors wish to thank Mr. Bart J. McGarry, Assistant Director, and Mr. Don Duggan, Branch Chief for ERDA Educational Programs for assistance and support. Their concern that this guide be a valuable and convenient tool for home economics teachers has guided us throughout the course of the project.

This guide was reviewed by a number of professionals in the fields of energy, engineering, architecture, home economics, and education for general consistency with current codes, guidelines, and good practice for residential energy use. Through dialogue with and written critiques by reviewers, the authors have been greatly assisted in the resolution of many technical issues dealt with in this guide.

PRINCIPAL AUTHOR: Lil Clinard, Ph.D., Principal Investigator

Contributing Author: Nancy Collins, Research Associate, UTEC

Project Staff:
- John H. Gibbons, Ph.D., Project Director
- Joyce Finney, UTEC Librarian
- Robbie G. Blakemore, Ph.D., Home Economics Specialist

Consultants:
- Jonathan Wert, Ed.D.
- Albert Bedinger, Sr., P.E.
- Dan Fenyn, Reg. Architect

Student Assistants:
- Rose Ellis
- Terri Jory
- Sherry Beard

Artists:
- Joyce Troxler
- Scott Jory
- Mary Yoder

UT Reviewers:
- Madge Guffey
- Kayla Carruth, Ph.D.
- Etta Westbrook
- LaVerne Farmer
- Helen Rader
- Geneva Potter
- Marion Mariner
- Lyle Mamer

Manuscript Typists:
- Pam Stewart
- Becky Henry

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INTRODUCTION

INTRODUCTION

OBJECTIVE: TO ACQUAINT THE HOME ECONOMICS TEACHER WITH THE PURPOSE AND INTENDED USE OF THE GUIDE.

ENERGY--so basic to all existence that we have come to take it for granted. Only recently have we begun to realize the economic, social, and environmental implications of energy resources and usage. The prime motivating force among citizens for the conservation of energy ever since the oil embargo in the winter of 1973 has been "to save money"! Unfortunately, few people are aware of the underlying need for [illegible]. Conserving energy resources goes far beyond the desire to see our utility bills go down. It means providing future energy needs for our children's society so that they will be able to enjoy a comfortable lifestyle just as we have. It is time, then, for us to make the transition from economic expedients to intelligent energy ethics. Such a change is not possible without changes in attitudes, decision-making methods, and lifestyles. Such a change *is* possible through conservation without curtailment . . . *if we start now!* The material presented in this guide will help educators and their students understand the problems, options, and costs involved in such decisions so that they can take appropriate actions in using energy.

Purpose

This guide was designed for Home Economics teachers as a source of information, instructional materials and suggested references about the energy situation as a whole, energy concepts and the use of energy in the home. The Guide provides a synthesis of current energy information from a multitude of sources which are not readily available to home economics teachers in an effort to better prepare the teacher to instruct students, especially about their role in conserving energy.

Intended Use

The guide is a combination of: (1) a comprehensive overview of the energy situation and important background material on energy concepts and terminology; and (2) a complete guide to the energy uses and practices in the home, with emphasis on measures which could be taken to conserve energy. The guide is intended for use by teachers as a reference tool and teaching aid as well as by students who might use it as self-instructional material. The guide contains a number of features which make its use simple and effective:

1. The guide is presented in loose leaf form to allow the teacher to remove sections, activities, illustrations, or reference lists for overhead projection or duplication. This format also permits convenient updating and editing of material.

2. An expanded table of contents is provided for easy reference to topics of interest and for use of the guide as supplemental material throughout the home economics curriculum.

3. The divisions correspond to the most commonly used curriculum divisions for [illegible], for example, [illegible], clothing, housing, personal care. This [illegible] the [illegible] material when appropriate as a part of the regular home economics curriculum. The guide may be also used in its entirety for the teaching of [illegible] energy conservation [illegible].

4. [illegible] and objectives are provided for every major division of the guide as well as [illegible].

5. The illustrations and references to activities appear within the guide where appropriate for easy reference. Also a list of activities with [illegible] is provided in the table of contents.

6. Energy facts are provided at the end of the guide to provide the teacher and student with a handy reference.

7. Key terms are italicized and defined within the text as well as in the glossary which appears at the end of the guide.

8. Energy facts and statistics are carefully footnoted to allow teachers or students to refer to the primary source for additional information. (A list of footnotes/references is at the end of each section.)

9. An extensive bibliography is provided which includes the address of the publisher, the number of pages, type of cover, and cost of each item listed.

SECTION 1 — ENERGY: THE AMERICAN PERSPECTIVE

OBJECTIVE: TO PROVIDE THE HOME ECONOMICS TEACHER WITH INFORMATION ON THE HISTORICAL USE AND DEVELOPMENT OF AMERICAN ENERGY RESOURCES (1800-1974) AND TO PROVIDE THE TEACHER WITH INFORMATION ON PRESENT AND PROJECTED PATTERNS OF ENERGY CONSUMPTION (1975-1990)

HISTORICAL PERSPECTIVE

[illegible]

[illegible] of energy in the U.S. for most of the nineteenth century were wood, water, and wind. Wood was important to both home and industry as a source of fuel and heat. It was the principal fuel for railroads and steamboats until about 1870, and was used in the [illegible] charcoal by about half the iron producers in 1850. The abundance of wood during the first half of the nineteenth century resulted in a great deal of misuse. Most of it was consumed in open fireplaces rather than in the more efficient Franklin stove. (As much as 90 percent of the heat produced by burning wood in old-style fireplaces goes up the chimney—not a very efficient way to use fuel!) There are no statistics on the number of waterwheels and windmills that existed across North America in the 1800's, but both were significant sources of power for farms and industries.

[illegible] was the major source of energy for the U.S. well into the second half of the nineteenth century and, in absolute [illegible] continued to increase until 1910. The following table compares [illegible] inanimate work output in terms of billion horsepower hours.

Year	Work Output (billion horsepower hours) From Work Animals	From All Inanimate Energy Sources
1850	5.4	3.6
1860	7.6	5.9
1870	8.4	8.5
1880	11.1	16.0
1890	14.4	30.3
1900	16.9	57.6
1910	19.0	142.8
1920	[illegible]	268.1

One horsepower is defined as the work performed or energy consumed by working at the rate of one horsepower for one hour; it is equal to 1,980,000 foot-pounds (one foot-pound is equal to the work done in raising one pound avoirdupois against the force of gravity the height of one foot) and is approximately equal to the output of a motor consuming 750 watts of power for one hour.

Although coal was used by the Hopi Indians in Arizona as early as 1000 A.D., American Colonialists did not mine it because wood was so abundant. America, unlike Britain, did not use coal during its early industrialization until, by the middle of the nineteenth century, it was realized that two tons of wood could be replaced by half a ton of coal at half the cost. As wood became scarce and more expensive, and with techniques for burning coal resulting in greater efficiency (such as coal-fired steam generators), the use of coal increased. By 1895 half of America's energy came from wood, and half from coal.

By the middle of the nineteehth century, efficient and cheap lubricants and illuminants were needed to replace scarce and expensive whale oils. The Pennsylvania Rock Oil Company struck oil in 1859. During that year, 4,215,000 barrels of oil (the equivalent in energy content to nearly a million tons of coal) were produced in the U.S. Only 30 years later, fuel oil accounted for 35 percent of total petroleum sales. During the nineteenth century, petroleum production increased at a faster rate than domestic consumption.

Natural gas has not always been a valuable energy source. During the first half of the nineteenth century it was considered a nuisance whenever it was encountered in water and salt wells. Gas was often found during searches for petroleum, but it was still considered a waste product and was burned off at the well; wood and coal provided necessary heating, and kerosene was used for lighting. There were, however, exceptions to the general attitude toward natural gas. Fredonia, New York, was using natural gas as fuel for lights in 1821, and by the late 1860's it was used on a small scale for making firebricks and as a source of lampblack for printers' ink. Furthermore, isolated experiments were being made on natural gas by iron and steel works near Pittsburgh to determine whether or not gas could be used for space heating and steam generation.

In 1878, a large gas well was discovered near Murrysville, Pennsylvania, and in 1883 a pipeline running from this well to Pittsburgh was opened. In the early 1880's serious searches for natural gas were conducted in Ohio, and in 1884 the searches resulted in the discovery of large gas reservoirs which were subsequently tapped in order to supply local industrial plants with cheap fuel. But natural gas still could not be used extensively because an adequate way to transport it had not been developed.

With the new energy sources came many new technologies. The electric light was invented in 1879, but more important was the world's first electrical power generating and distribution system built in 1882 by Thomas Edison in New York. Less than a month later, the first hydroelectric power facility began generating on the Fox River in Appleton, Wisconsin. The hydroelectric plant at Niagra Falls began operating in 1896, and by 1900 hydroelectric power accounted for about 2.6 percent of all U.S. energy consumption, or about 52 percent of all the electricity generation.

The following table shows the total U.S. energy consumption in 1850 and 1900:

Energy Resource	1850	1900
Coal	9.3%	71.4%
Oil	---	2.4
Natural Gas	---	2.6
Hydropower	---	2.6
Fuel Wood	90.7	21.0

Source: Clark, p. 36.

Energy Resources From 1900 to World War II

From 1900 to World War II, wood comprised only a small fraction of the total energy pool, but the amount of wood used was still substantial and surpassed hydropower as an energy source well into the 1940's. It was used mostly for heating and cooking in rural homes. Hydropower before 1900 accounted for 57 percent of all electricity generated but by 1950 accounted for only one third; in 1975 it provided less than 4 percent of our electricity. Electricity generation, however, increased slowly but steadily until the end of World War I when it began to accelerate rapidly; since the mid-1930's the annual per capita growth rate for electricity has been seven to nine percent, except for the years of World War II.

A dramatic shift also had occurred in the use of coal in the early twentieth century. Between 1885 and World War I its production had doubled, but after 1920 it began to drop rapidly. In 10 years the ratio of coal-to-oil consumed dropped from six-to-one (1918) to two-to-one (1930).

The demand for petroleum products began to outstrip petroleum production between 1900 and 1955. During this period, consumption expanded 70 times, while production expanded to 40 times above the 1900 level. After World War II, the increase in U.S. demand began to surpass domestic production, with the amount of net oil imports greater than the amount of net coal imports. The natural gas production rate also rose 40 times above the 1900 level by 1955. From 1900 to 1920 natural gas was mostly used for home and commercial purposes, but from 1920 until the end of World War II industrial consumption surpassed residential and commercial consumption. In 1955, the consumption of all liquid and gaseous fuels began to exceed domestic output. By 1955 the U.S. was a net importer of fossil fuels.

A new energy era was born on December 2, 1942, when the first nuclear chain reaction was demonstrated at the University of Chicago by Enrico Fermi and his associates. Less than 10 years later, electricity was produced from atomic energy. Today, approximately two percent of this nation's energy needs (almost 10 percent of our electricity) are provided by nuclear power.

Energy Resources from World War II until 1974

By the end of World War II, petroleum fuel consumption had caught up with coal consumption. From 1940 until 1971, crude oil consumption tripled and natural gas consumption increased more than eight-fold. Although oil and gas together accounted for approximately 70 percent of aggregate U.S. energy consumption in 1960, coal is still the preferred fuel in the production of ferrous metals and in the generation of electricity. Since 1960, the use of oil and natural gas has continued to grow. The following table shows the status of U.S. energy resources in 1974:

Energy Source	Percent of Energy
Petroleum	46%
Natural Gas	30
Coal	18
Nuclear	2
Hydro	4

Source: *National Energy Outlook*, p. xxii.

The total energy consumption in the U.S. has more than doubled since 1950 while the population has increased by approximately one-third. Two decades ago, this country was a net exporter of energy; in 1974 it was importing 15 percent of its total energy fuels and 35 percent of its oil.

The American Energy Crisis of 1973-1974: Background and Summary

Around 1954, the major American petroleum companies began to see their profits on crude production as well as their share of the international crude oil market start to decline. In 1960, the Organization of Petroleum Exporting Countries (OPEC) was formed. Initial membership consisted of five leading petroleum producers: Iraq, Iran, Kuwait, Saudi Arabia, and Venezuela. Their goals were to gain full control over the development of their oil resources and over the rate of oil production and the oil market price. OPEC's leverage was not strong in the 1960's but during the period from 1971 to 1973, OPEC members began to force oil prices upward. By 1973, 13 states in the Arab Middle East, Africa, Asia, and South America were members of OPEC and accounted for 86 percent of the

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world's oil trade. During this period, a series of participatory agreements were negotiated by OPEC countries with companies operating within their borders. The situation changed, however, when the Arab-Israeli war broke out on October 6, 1973. Eleven days later, a conference of Arab oil ministers in Kuwait decided to use the "oil weapon" in support of the Arab cause. Petroleum-consuming countries were treated according to their stands on the Arab-Israeli issue. On October 19, King Faisal decided to impose an oil embargo when he learned that the U.S. government planned to send $2.5 billion in arms aid to Israel. A complete embargo was declared against the U.S. and the Netherlands; "friendly states" were exempted. Two months later, the OPEC governments were posting prices of $11.65/barrel for crude oil--almost four times the posted price that prevailed before the war began. The embargo ended with Americans waiting at the gasoline pumps, still in shock over the sudden realization of our growing dependence on foreign powers, but not yet truly convinced that anything could or should be done about it.

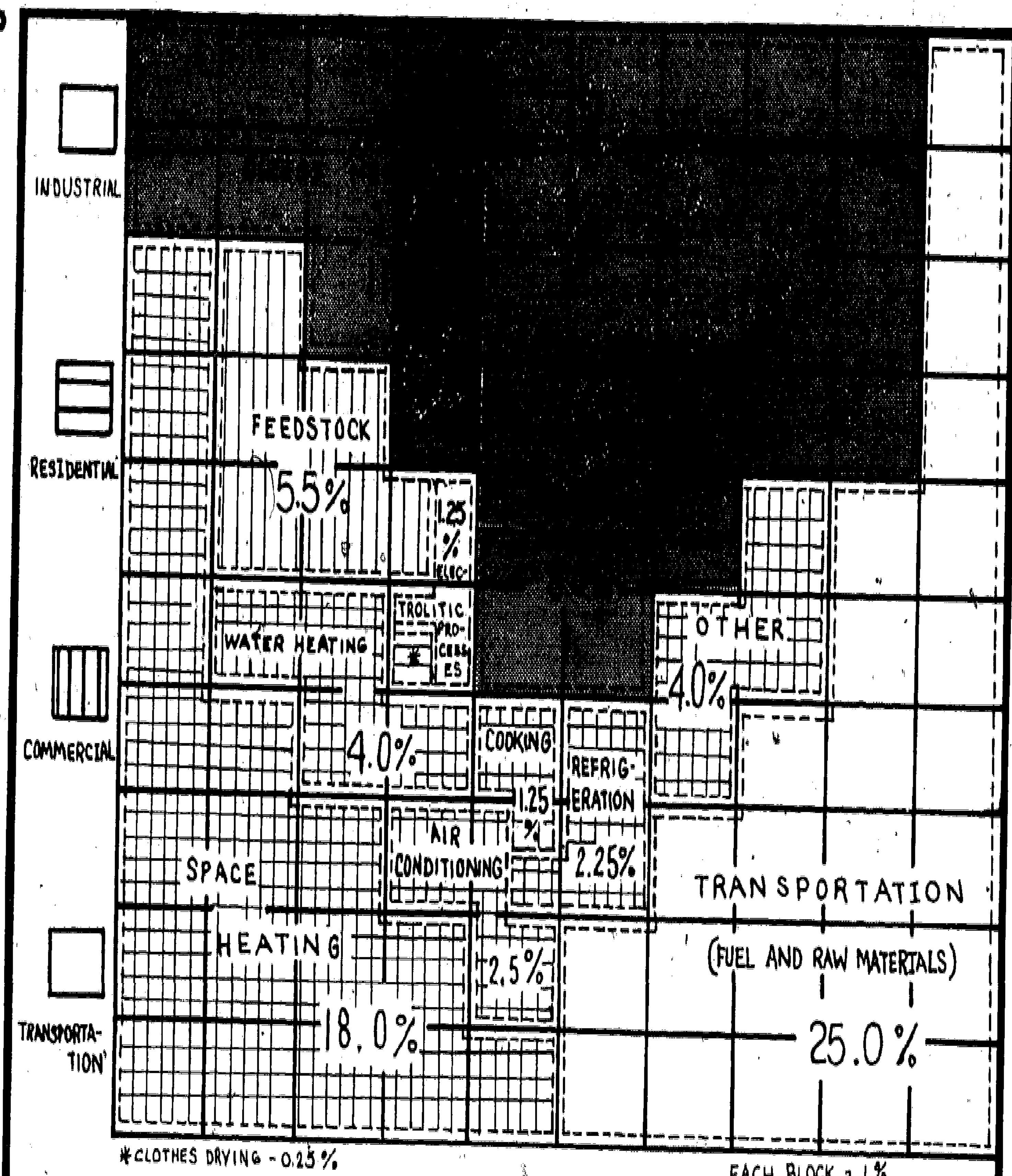
The international oil crisis of 1973-1974 precipitated an "energy crisis" for the U.S. and other industrial countries. The Arab (Middle East) countries, an important source of our petroleum products, suspended shipments of oil to the U.S. for several months. But the Arabs did not *cause* the "energy crisis"--they merely showed us that we have a serious energy problem. The roots of the problem go back to patterns of consumption and production of nonrenewable resources which began in the U.S. during the mid-nineteenth century.

PERSPECTIVE: PRESENT AND FUTURE ENERGY USE

The American high-energy society not only consumes more total energy than any other country, but also uses more energy per capita (individual) than any other nation in the world. On the average, U.S. citizens consume seven times the energy of other world citizens. Clearly, energy use is an important part of every segment of the U. S. economy. This country's energy supply is based largely upon dwindling fossil fuels--petroleum, natural gas, and coal. Alternate energy sources must be found. It is of the utmost importance to examine the present and future uses of energy.

Patterns of Consumption: Trends for Sectors

Percentages of the total 1968 U. S. consumption attributable to the four major categories or sectors of energy usage were: industrial, 41.2%; transportation, 25.2%; residential, 19.2%; and commercial, 14.4%. Any item that uses energy might contribute to more than one sector; for example, the energy used by an electric blanket appears in the residential category. But energy was required to manufacture the blanket (industrial sector); energy was required to move the blanket from the manufacturer to the shopkeeper (transportation sector); and energy was required to run the shopkeeper's operation (commercial sector). Details of energy consumption by sector are shown in the chart on the next page.



ENERGY CONSUMPTION BY SECTOR

Industrial. Industry, the producer of the materials and products used by society, is the largest consumer of fuel energy, and in 1968 industry used energy in the following ways:

Industrial End Use	Percent of National Total
Process steam	16.7%
Electric drive	7.9
Electrolytic processes	1.2
Direct heat	11.5
Feedstock	3.6
Other	0.3
Total	41.2%

Source: Fergason, p. 3.

About half of industrial fuel consumption went for heating processes, either by directly burning fuel or by manufacturing steam. The rest was used for running machines, lighting, electrolysis, and feedstocks. (Feedstocks are fuel resources--oil, gas, and metallurgical coal--used as raw materials rather than as fuel for burning. Feedstocks are used to manufacture products such as asphalt, steel, and wax.) The major industrial groups are: food-processing; paper; chemicals; petroleum refining; stone/clay/glass products; and primary metals (steel and aluminum).

Transportation. Transportation--moving people and goods across the country--is the second largest sector, and in 1968 used energy in two basic ways: (1) 24.9 percent as fuel for burning; and (2) 0.3 percent as raw materials. Consumption can be broken down in the following manner:

Transportation Mode	Energy Consumption
Automobiles	55.0%
Trucks	20.0
Buses	1.0
Other (including motorcycles)	.5
TOTAL HIGHWAY TRANSPORTATION	76.5%
Airplanes	9.9%
Railroads (freight)	3.5
Railroads (passenger)	.1
Shipping (inland and coastal barges and ships)	4.8
Fuel pipelines	5.2
TOTAL TRANSPORTATION	100.0

Source: *Exploring Energy Choices*, p. 4.

Oil accounts essentially for all energy consumed in the transportation sector. By contrast, gas is the predominant fuel in the industrial sector.

While transportation is the second greatest sector in terms of total fuel consumption, an additional 15 percent of total fuel consumption come from the other three sectors to support the transportation complex: energy is required not only to fuel transport machines but to build and maintain them. *Thus 40 percent of total U.S. energy consumption is associated with transportation.* Half the 40 percent is used in automobile-related activities; the other half is used for planes, buses, trains, and ships. It is easy to understand why the automobile portion of the transportation sector absorbed most of the shock of the 1973-1974 oil shortage and why much attention is given to improved energy efficiency by the automobile industry.

Residential. The residential sector is the third largest consumer of energy, and in 1968 used energy in the following ways:

Residential End Use	Percent of National Total
Space heating	11.0%
Water heating	2.9
Cooking	1.1
Clothes drying	0.3
Refrigeration	1.1
Air conditioning	0.7
Other	2.1
Total	19.2%

Source: *Exploring Energy Choices*, p. 4.

Over half of the energy used in private residences is for space heating and, although residential air conditioning accounts for only 0.7 percent of total energy consumption, it is the most rapidly growing item in the residential usage list. In hot weather, air conditioners often tax electrical generating facilities so much that utility companies must reduce the line voltage by up to five percent, causing a brownout; that is, the load on generating facilities may become so great that the amount of power delivered to each consumer must be reduced. A total power failure (blackout), can be caused by overloaded utility equipment, storm damage, or equipment failure.

Approximately 25 percent of residential energy consumption is in the form of electricity; with half produced by coal-fired steam plants. Natural gas accounts for about 40 percent of all residential energy.

[illegible]. The commercial sector is the smallest consumer of the four sectors. It includes stores, businesses, restaurants, hotels, offices, hospitals, and schools. In 1968 the commercial sector used energy in the following ways:

Commercial End Use	Percent of National Total
Space heating	6.[illegible]
Water heating	[illegible].1
Cooking	0.[illegible]
Refrigeration	1.1
Air-conditioning	1.8
Feedstock	1.6
Other	1.4
Total	14.4

Source: [illegible]

Again, space heating was the major user of energy, and air conditioning was the second, but fastest growing, user.

Between 1960 and 1974 commercial energy use grew at the average rate of 5.4 percent per year. This rapid growth rate reflected not only the growth of commercial activities but also the construction of buildings which used more energy. For example, glass curtains across window walls allow higher levels of heat loss and gain causing higher energy bills. Attempts have been made to check these high energy costs; some "glass buildings" are now constructed of mirrored glass, which reflects 40 per cent of incoming solar radiation, or of double-glazed windows (double-paned glass which uses an inner layer of air as insulation).

Like the other three sectors, the commercial sector is heavily dependent on oil and natural gas for its energy and, like the residential sector, derives little of its energy directly from coal.

[illegible]

The U.S. now uses four times as much energy per capita as it did in the 1870's, and the rate at which electrical energy is used is six times what it was in the late 1930's. How will the pattern of energy consumption change in the future? It seems certain that growth in energy usage will continue during the twentieth century, but how large will the increase be? What energy consumption sector will show the greatest demand growth?

In an attempt to answer these questions, a forecast made by Exxon Company ("Looking Ahead to 1990") has been compared to future trends suggested by the Federal Energy Administration (FEA). It was found that the predictions by a large international petroleum company (Exxon) were similar to those made by a government agency (FEA); in other words, oil companies' ideas are not, as many believe, always contrary to government ideas or data. [illegible] both estimates may be wrong.

[illegible] Many factors must be considered in order to formulate energy consumption forecasts; these include population trends, future technological changes, past consumption trends, price trends, and future government policies. Exxon assumed the following [illegible] in their forecasts:

1. That government will not mandate curtailment of energy consumption below levels necessary for adequate national economic growth or [illegible] use of certain fuels in preference to others.

2. That government policies will facilitate expanded energy development, increase the leasing rate of offshore acreage as well as [illegible] and coal acreage, accelerate the delays in nuclear plant licensing and siting, maintain a realistic balance between energy, economic, and environmental goals.

3. That government policies will not reduce the availability of [illegible] capital funds required by the energy [illegible].

4. That the [illegible] will continue its recovery from the 1974 [illegible] recession.

5. That there will be long term growth toward full employment.

6. That higher energy costs will divert more capital investment [illegible] resulting in lower than [illegible] productivity.

7. That [illegible] the reason above, long term growth in the [illegible] will be somewhat below the historic growth rate.

8. That [illegible] air quality standards will be [illegible] greater use of coal.

9. That [illegible] will be available as needed.

10. That energy prices will increase at the U.S. inflation rate (7%).

11. That high energy prices will significantly affect energy consumption, both depressing demand growth and influencing the [illegible] fuel utilized.

Note that Exxon assumed that higher energy prices will decrease the rate at which energy is demanded by sectors. Given the above assumptions, Exxon described future trends for four sectors: industrial, transportation,

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residential/commercial, and nonenergy. (Note that the residential and commercial sectors are combined and that a new sector is mentioned: "nonenergy." Actually, the nonenergy sector was included before in the industrial and commercial sectors under the title "feedstock." Exxon's difference in format does not conflict with the data presented previously.)

Industrial Energy Consumption. Exxon predicted that industrial energy demand growth rate will decline sharply through 1980, efficiency in energy use will rapidly increase, and economic growth will be slower. Then from 1980 to 1990, the demand growth rate will increase, the rate of efficiency improvement will slow, and economic growth will continue.

In April, 1976, FEA reported that industrial energy consumption in 1975 was 9.4 percent less than the 1974 consumption level and 10.9 percent less than the 1973 level. Furthermore, the 1975 level was 16.8 percent less than the projected level for 1975, based on 1964-1973 data.

The industrial energy consumption decrease in 1975 was primarily the result of economic downturn factors: industrial production from January to October, 1975, was 18.3 percent below the projected trend for that year. However, during the same time period, energy inputs per unit of industrial output were 1.2 percent more than the projected trend for that year; in other words, the decrease in energy consumption for 1975 did not reflect an increased energy efficiency. This apparent loss of efficiency probably was due to losses that occur when industry's production rate is considerably below optimum rates. However, those energy intensive companies which were visited and aided by staff members of FEA's Office of Energy Conservation showed marked improvement in energy efficiency. It is clear that energy efficiencies can be improved. In fact, despite falling (real) energy prices, industrial energy use per unit output fell steadily in the Fifties and Sixties at a rate of over one percent per year. With steadily increasing prices, the rate of improved efficiency should be at least maintained, if not increased significantly.

Exxon's forecast for the industrial sector was supported by FEA statistics. In the future, higher energy prices, among other economic factors, most likely will continue to occur. Higher energy prices will slow energy growth, but not necessarily economic growth.

Transportation Energy Consumption. Exxon forecasted that the annual energy consumption in the transportation sector would drop significantly below the historic rate. FEA statistics indicated that the 1975 transportation energy consumption was only 0.7 percent higher than the 1974 level and 3.3 percent below the 1973 level. On the basis of the small 1974 increase, it appears that the U.S. was recovering from the 1973-1974 international oil crisis, with the transportation energy consumption demand rate slowly increasing. Keep in mind, however, that the 1975 transportation energy consumption level was 12.1 percent below the projected trend for that year. Recall that the projected FEA trend was based on 1964-1973 statistics and that gasoline consumption per capita, though 1.0 percent higher than the 1974 level, was 8.5 percent below the projected trend for 1975. The FEA statistics revealed that higher gasoline prices (2.8 percent above the 1974 level) and greater automobile efficiency helped reduce transportation energy consumption.

According to FEA statistics, the combination of a new conservation awareness (a by-product of the 1973-1974 international oil crisis) and higher energy prices reduced the transportation energy consumption demand rate. Furthermore, the present growth rate is significantly less than the growth rate projected by FEA based on 1964-1973 data and new regulations will insure that autos become more efficient in the years to come.

Bearing in mind that domestic oil supplies are dwindling and that oil import prices can be expected to increase to as much as $15/barrel by 1985 if domestic alternatives are not developed, there is little reason to doubt Exxon's prediction that demand growth rate in the transportation sector will drop significantly below the historic rate. In fact, it may not grow at all.

Residential/Commercial Energy Consumption. Exxon projected that the growth rate in the residential/commercial sector would decline after 1975, that energy demands would be met primarily by gas and electricity, and heating oil consumption would increase only moderately. According to FEA data, 1975 energy consumption in buildings (residential and commercial) though 2.2 percent above the 1974 average level, was the same as the 1973 level; and the 1975 building energy consumption was 9.7 percent below the projected trend for that year; in other words, the growth rate declined based on the 1964-1973 data.

The FEA data also showed that: (1) 1975 electrical energy usage by the commercial/residential sector rose above the 1973 and 1974 levels; and (2) electrical usage decreased 10.9 percent from the projected trend in the commercial sector and 11.2 percent per household. The 1975 per capita energy usage in the residential/commercial sector was 6.6 percent below the 1973 average level, 3.6 percent below the 1974 level, and 12.4 percent below the projected trend for 1975. As in the transportation and industrial sectors, reduction in the rate of energy consumption was partly the result of conservation measures and partly the result of economic factors: 1975 household energy prices were 18.7 percent above the 1973 level and 5.6 percent above the 1974 level. It seems likely that, over the long term, the slowdown in population growth and improved efficiency of energy use in housing will result in a demand growth that is significantly less than two percent per year.

It is clear that there are reliable government data to support Exxon's projection that the energy consumption demand rate for the residential/commercial sector will decline from that of the 1964-1973 period; as mentioned above, the growth rate for 1975 was 9.1 percent less than the projected trend (based on 1964-1973 figures). Since 1973, demand for electricity and natural gas increased, while demand for heating oil has decreased since 1974 (though it had moderately increased since 1973).

Summary and Conclusion. Exxon forecasted that the demand growth rate in the industrial sector would first decline sharply through 1980, then increase; that the demand growth rate in the transportation sector would drop significantly below historic rates; that the demand growth rate in the residential/commercial sector would decline from the 1960-1974 period; and that the demand growth rate in the nonenergy sector would remain about the same. FEA statistics support Exxon's forecast: the data show that the 1975 energy consumption in industry, transportation, and buildings was below the level projected on the basis of 1964-1973 data on consumption levels in those areas.

Increased conservation awareness as well as increased energy prices, due to dwindling easy-to-recover domestic energy supplies and to increased imported fuel costs, will result in further reductions in energy consumption. Total energy consumption for 1975 was 2.8 percent below the 1974 level and 5.2 percent below the 1973 level. If the U. S. aggregate energy consumption can go below the pre-embargo level, as it did in 1975, perhaps it can go below the consumption level for 1972 or even 1971.

As population growth slows and as we have time to make a full response to higher energy prices, the efficiency with which everyone uses energy will increase in importance. The combined effects of individual consideration of energy efficiency could result in a nearly level demand for energy before the turn of the century.

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SECTION 2 ENERGY CONSERVATION

OBJECTIVE: TO CONVEY TO THE HOME ECONOMICS TEACHER THE SEVERITY OF THE U.S. ENERGY PROBLEM; TO URGE THE NECESSITY OF IMPLEMENTING CONSERVATION AS A PARTIAL SOLUTION AND RATIONAL ECONOMIC RESPONSE TO THE ENERGY PROBLEM.

THE U.S. ENERGY PROBLEM

The energy problem is not new. In 1744, Benjamin Franklin observed:

> *. . . since fuel is becoming so expensive, and (as the country is more cleared and settled) will of course grow scarcer and dearer; and new proposals for saving the wood, and lessening the charge and augmenting the benefit of fire, by some particular method of making and managing it, may at least be thought worthy consideration.*

Over 92 percent of the U.S. energy consumption in 1976 was accounted for by three nonrenewable fossil fuels. This country may have only a few decades of petroleum and natural gas left at current price levels and, although there may be enough coal to last several hundred years, coal (as currently mined and burned) pollutes at levels that many Americans are not willing to tolerate. Breeder reactors, if used in the future, will produce plutonium, an extremely toxic element. Fusion power may not arrive for at least another 25 years--perhaps much longer--and therefore cannot be considered a solution to our current energy problem. Other nonrenewable energy sources (solar, wind, geothermal) may be used to a greater extent in the near future, but not in sufficient quantities to be considered solutions, either.

Of course, the energy dilemma is not a strictly American experience; its scope is worldwide and its resolution will cut across international boundaries, for energy resources are not uniformly scattered around the earth but rather lie in highly localized deposits. Nevertheless, as Clark stated:

> *To maintain the average American at present comfort levels requires 21,600 pounds of nonmetal resources such as sand and gravel and salt, 1,450 pounds of metal substances and 18,000 pounds of fossil fuels, a little less than one ounce of uranium each year. That amount of energy, nearly twice what the average European uses in a year, is the equivalent of each citizen having 300 slaves working 24 hours a day.* (Clark, pp. 86-87)

In terms of energy resources, the U.S. is the most spoiled, self-indulgent, and extravagant nation in the world. The U.S. consumes more energy than West Germany, Japan, Great Britain, and the U.S.S.R. combined. Although the U.S. has only six percent of the world's population, it consumes about 33 percent of the world's energy.

Clearly, this country has a special problem--first, because it consumes so much energy and, second, because so much of the energy consumed is nonrenewable. The U.S. has five choices: (1) increased dependence on foreign oil; (2) increased use of environmentally damaging coal; (3) increased use of nuclear and other alternate energy resources; (4) more effective and efficient use of energy; or (5) reduced standards of living due to curtailing (cutting back) energy use. No one of these alternatives alone will suffice; only careful consideration of the first four will enable America to avoid the fifth.

ENERGY STRATEGIES

Several broad strategies can be used singly or in concert to resolve our energy problems:

Strategy 1: Develop "successor sources" to replace oil and gas over the next several years.
Strategy 2: Develop an energy economy not based on fossil fuels.
Strategy 3: Increase efficiency of energy generation and use.
Strategy 4: Change from a "disposable" to a "durable" society.

Over the next several decades, coal, nuclear, solar, geothermal, and other energy resources can be developed to replace oil and gas. Of course, these developments present technical challenges, and time and capital will be required. At the present time, "Strategy 1" is receiving the overwhelming attention and commitment of government and industry.

"Strategy 2" is similar to "Strategy 1." Both require the same government commitment. But "Strategy 2" (developing a non-fossil fuel energy economy) forecloses the use of coal because it pollutes. This strategy emphasizes the development of fission *and* fusion as well as solar energy resources. A long lead time is needed for this strategy.

"Strategy 3" (increasing efficiency) can "trim the fat" off current energy generation and use over the short run, while saving money. Over the long run, efficiency can be increased by perhaps 50 percent, saving even more money and fuel.

"Strategy 4" concentrates on overall energy use patterns rather than specific methods. It suggests that the high-energy American society can change to a less energy-intensive society. Some changes in behavior would have to come about under this strategy, possibly requiring rationing or taxing of resources in order to slow the consumption rate of materials and energy.

While the professionals implement Strategies 1, 2, and 3 through research and development, citizens can implement Strategies 3 and 4--both of which depend upon wise use of energy. Conservation is the only viable solution for the *immediate* future.

DEFINITIONS OF CONSERVATION AND CURTAILMENT

Both conservation and curtailment are activities which lead to reduced energy demand. *Conservation* is defined as the wise use of energy which results from a rational response to price changes or a shift from less to more available fuel resources. Conservation does not connote a denial of the "American dream," though many people believe that this is so. Rather, conservation attempts to change citizens from being high energy users to low energy users by reinforcing "saver" values in pragmatic, money-saving terms.

Curtailment, on the other hand, is a short-run strategy that is used to cope with acute energy shortages; for example, an oil embargo would induce curtailment or cutting-back of petroleum consumption among those affected by the embargo. Curtailment requires denial. If we conserve our energy resources now, we can avoid possible curtailment of these resources in the future.

Conservation is a long-term necessity that should be implemented for five basic reasons:

1. Conservation saves money; lower cost material resources can often be used to achieve the same ends as high cost energy resources.
2. Conservation can expand our range of energy choices because it permits us to select those energy supply technologies that are most acceptable (for example, solar energy) and reject those that are relatively objectionable (for example, coal energy).
3. Scarce energy resources can be freed for use in developing countries by conservation. The value of an incremental supply of energy in a developing country may be much greater than in a developed country.
4. The U.S. dependence on unreliable and costly supplies of foreign oil can be reduced by conservation measures.
5. Conservation measures will help provide energy resources for future generations; they will help to prevent future generations from having reduced standards of living.

[adapted from Moss, pp. 1-26]

Conservation is not an end in itself. A 1976 FEA conservation paper entitled "Group Discussions Regarding Consumer Energy Conservation" found that energy conservation is generally viewed as a "time-buying" strategy that will be implemented only until some new, infinite, inexpensive source of energy is found. The American society can then continue to be spoiled, self-indulgent, and extravagant. Many pre-teenagers romantically believe that a "Star Trek" world, with its "new" energy resources, will be theirs or at least their children's. But the "new" energy resources (fusion, for example) may not be implemented for quite a long time and, when they are, will probably be more expensive than we think. Until such resources are developed, we must act with the belief that "new" resources may never be available.

Citizens must become aware of the need for and economic rationality of energy conservation. *It's simply a strategy for getting the most for our money.* Home economics teachers especially are in a position to promote this understanding, but they should take note of the following warning in the *Citizen Action Guide to Energy Conservation:*

> *It should go without saying that if you are not practicing energy conservation, you can't very well ask others to do so--your enthusiasm and success will be the best reason that others will want to join you.* [p. 55]

After home economics teachers have put into practice their conscious decisions to practice good conservation before they urge conservation measures on their students, they must carefully formulate for class presentation a whole range of reasons to justify their support of energy conservation. Their support of conservation measures should be based not only on national, social, political, and economic reasons, but also on a moral sense of waste and the need for stewardship--*an energy conservation ethic.*

AN ENERGY CONSERVATION ETHIC

One hundred years ago, the Industrial Age swooped down upon us without warning. It tantalized with promises and visions of prosperity forever in a nation overabundant with natural resources. The Protestant Work Ethic that had established this country gave way under pressure to the demands of a "Consumer Society." Concern with production rates became paramount; concern with use of energy and natural resources was ignored. "Real" costs of manufacturing were misleading in a time when energy costs were artificially low and/or government subsidized. Products were *designed* to be tossed out after one use or *replaced* by newer models each year (planned obsolescence). New technologies were instituted in our factories, homes, and offices without regard to energy use or efficiency. Such attitudes and practices quickly led to complacency and false security in our highly energy-intensive society.

A growing number of Americans are beginning to realize the value and necessity of a revised lifestyle which includes both "Voluntary Simplicity" and an "Energy Conservation Ethic." Such changes in attitude and thought can carry us *beyond* cost-saving responses. Home economics teachers must make clear to their students that this new ethic is based on a realistic comprehension that many of the raw materials on which current living standards rely will be expended in the foreseeable future. If but for the sake of future generations, teachers must awaken in themselves and their students "a moral sense of waste and greed" that will lead to the acceptance of an Energy Conservation Ethic.

Conservation is a rational act to achieve and maintain an amenable lifestyle at minimum price. Such an achievement cuts waste. For example, wasteful use of heating oil can be decreased by adding more insulation to a home. In the long run, money will be saved. Also, conservation measures increase efficiency. For example, you can buy an air conditioner that is more energy efficient that another air conditioner of comparable size and quality. The air conditioner may be more expensive to buy than the less efficient model, but in the long run more dollars will be saved in operating the more efficient model than the difference in cost between the two models.

It is true that conservation can affect employment, but it is not necessarily true that conservation *cuts* employment. For example, decreasing the production of disposable bottles leads to a decrease in the number of people required to produce the disposable bottles, a decrease in the number of people needed to pick them up, and a decrease in the number of people needed for hand-filling the bottles. But on the other hand, returnable bottles must be transported to the factory and washed. Actually, returnable bottles require more net jobs than disposable "one-way" bottles. Another example: jobs lost in the oil or electrical industry due to a lower consumption of heating oil or electricity are more than off-set by jobs installing insulation.

Because an Energy Conservation Ethic may be a difficult concept to grasp, teachers must make a major effort to help students understand our energy situation and foster in them an awareness of the difference between essential needs and nonessential desires. The individual who possesses an Energy Conservation Ethic gives great thought to the following questions before buying *any* product, whether it be an air conditioner, can opener, or synthetic fabric:

1. *Do I really need it to be happy?*
2. *What could be used as a substitute or alternative?*
3. *Will buying it promote a more materialistic lifestyle?*
4. *Is it inexpensive, yet efficient, in terms of total cost?*
5. *How long will it last?*
6. *Can it be recycled?*
7. *What resources are in it?*
8. *Are the energy resources scarce or nonrenewable?*
9. *From what countries do the resources come?*
10. *Are there other resources which could be used to make it?*
11. *Did its production result in significant environmental/ecological damage?*
12. *Will its use result in significant environmental/ecological damage?*

An "Energy Conservation Ethic" is a conscious effort on the part of the individual to think in terms of wise and efficient use of resources when developing, buying, or consuming them. It reminds one of the "stewardship" responsibility to maintain an ecological balance for survival, that the natural environment is not limitless in its capacity to assimilate waste and abuses.

Several types of energy conservation activities are implied by an Energy Conservation Ethic:

1. Activities that can save energy as well as money.

2. Activities that save energy and have no apparent disadvantages.

3. Activities that save energy but have some minor associated disadvantages.

Keeping thermostats set in the winter at 65 degrees and in the summer at 78 degrees falls in the first category; not only does this action save money, but it can improve one's health. Installing storm windows and doors is also in this category; these items can quickly pay back their initial costs through lower utility bills. The same is true in the case of additional insulation, especially in older homes; the cost of insulation is normally less than the amount of money the resident will save over time on energy bills. Carpooling is another way to save both money and energy. Buying fresh produce rather than canned, frozen, or dehydrated produce is yet another way; for example, the production of one pound of white potatoes (excluding packaging) requires:

6,250 Btu's - fresh
9,000 Btu's - canned
14,950 Btu's - frozen
26,700 Btu's - dehydrated
[Energy and Food, p. 1]

Besides, fresh potatoes cost less at the store.

Appliances that save energy because they are more efficient than comparable products have no apparent disadvantages for the homeowner; therefore these products fall in the second category. For example, the possible additional price of a more energy efficient air conditioner may be offset by lower energy bills. Furthermore, there is no apparent disadvantage to avoiding products with excessive packaging. Every supermarket plastic bag adds approximately 170 Btu's to the product's total energy expenditure.

Using returnable beverage containers saves energy and creates only minor disadvantages for the homemaker. A 16-ounce RC Cola returnable bottle requires 7,836 Btu's to produce and can be reused 10 to 15 times. On the other hand, a 16-ounce, non-returnable RC Cola bottle requires 6,002 Btu's to produce and can be used just once.

The following "Energy Conservation Creed" is a possible expression of the energy conservation ethic:

> *I pledge that I will learn to participate automatically in all those conservation activities which have no apparent disadvantages to myself and which require minimal energy on my part.*
>
> *I further pledge that although certain conservation activities may have minor personal disadvantages, I will volunteer to participate in them.*
>
> *And in the event that these activities are not sufficient, I will tolerate those activities which may produce serious disruptions in my lifestyle.*
>
> *I pledge all this in the interest of future generations.*

It is hoped that teachers will instill this or a similar creed in themselves and in their students and that students will urge their parents to participate in conservation activities. Educators can help the Energy Conservation Ethic become a way of life; educators can help create a more efficient, durable society that cares about the energy inheritance it will bequeath to future generations.

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OBJECTIVE: TO ENABLE THE TEACHER AND STUDENT TO RECOGNIZE BOTH ENERGY-WASTING AND ENERGY-CONSERVING CONSTRUCTION FEATURES FOR RESIDENCES AND TO BE ABLE TO DETERMINE MEASURES WHICH COULD BE TAKEN TO IMPROVE A RESIDENTIAL STRUCTURE'S ENERGY EFFICIENCY.

Many design and construction features exist which can be incorporated into residential structures to reduce their energy consumption. The shell of a home (its roof, sides, and foundation) protects the occupants from the outside elements and influences what goes on in the house by defining the interior space. Since the primary use of energy in the home is for heating and cooling, considerable energy savings can be achieved by improving the shell of the home. A savings of 20 to 40 percent of current energy consumption in an average home could be economically achieved by improving the shell with insulation, caulking, weatherstripping, and storm windows.[1]

The primary function of the residential shell is to provide a *comfort zone* (the proper temperature, humidity, and air movement to create a feeling of comfort) for the inhabitants. As an example, for moderate zone inhabitants, the comfort zone ranges from 68°F to 82°F and 18 to 77 percent relative humidity in shaded areas (inside the house) with negligible air movement. There are times when the weather will provide interior comfort and there are means of adapting the home to utilize the outside air. However, there are times, especially in winter, when energy needs to be used to maintain reasonable comfort. Figure 1 defines the relationships of humidity and temperature in maintaining a comfortable atmosphere.

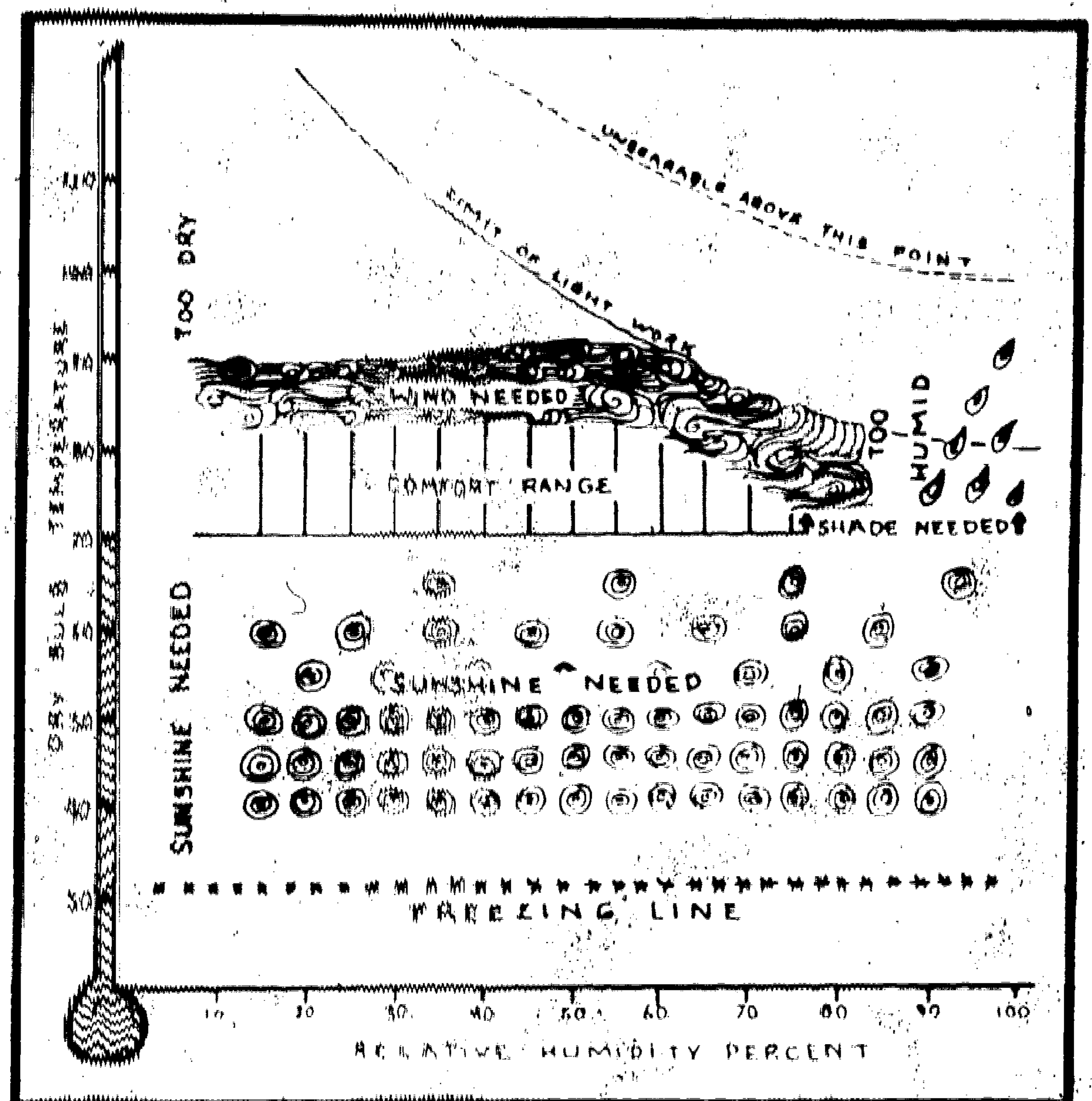


Figure 1: Comfort Zone.

OBJECTIVE: TO ENABLE THE TEACHER AND STUDENT TO RECOGNIZE ENERGY-CONSERVING AND ENERGY-WASTING EFFECTS OF SITE ORIENTATION, VEGETATION USES, AND ROOM LOCATION.

To conserve energy, maximum use should be made of natural means to produce a healthful and livable home environment with minimum use of mechanical equipment for climate control. A primary consideration is the *site*--the place where the home is to be built or where it already stands. The site features may be positive or negative factors in terms of energy requirements and are always unique. The major factors of climate and vegetation determine the proper *orientation* (position with relation to the compass) of the home's features as well as that landscaping which might reduce mechanical heating and cooling costs. General orientation considerations include:

1. The building should be oriented to maximize exposure to solar radiation during the heating season.

2. The relationship of the building to outdoor spaces should be designed to maximize, within limits, air movement in hot weather, and minimize air movement in cold weather.

3. Orientation must recognize the effect of nearby buildings and topography.

4. The relationship of the building to outdoor spaces should maximize solar impact for snow melting, heating in winter, sunning in spring and fall, etc.

5. Orientation should permit the use of outside air movement for natural ventilation.

6. Orientation should provide for the advantageous use of trees, topography, water, and views.

7. Orientation should be suited to the lifestyle of the building occupants.

Climate Patterns

The United States is made up of four regional climate zones (as shown in Figure 2): cold; temperate; hot-arid; and hot-humid.[3] Each area has characteristic constituent elements, such as temperature, relative humidity,

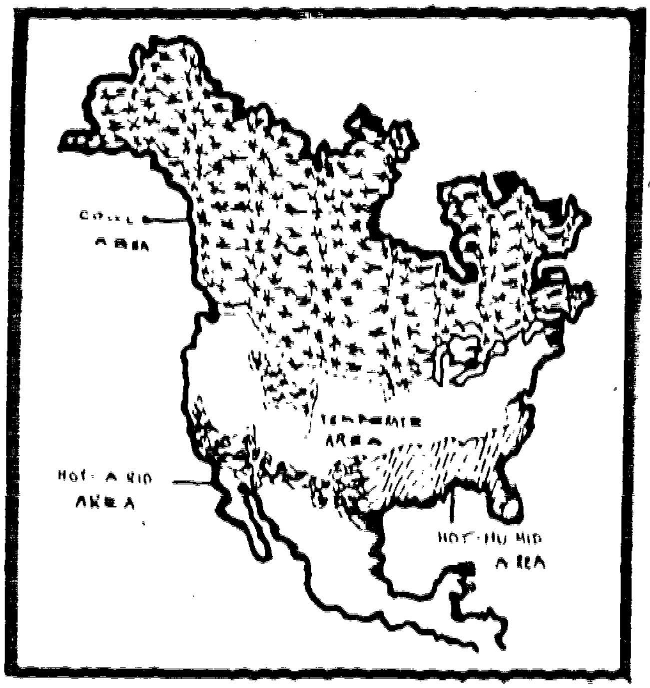


Figure 2: Regional Climate Zones.

radiation, and wind effects. It is the total effect of these elements which should influence the orientation of the home and landscaping of the site for optimal energy conservation.

Of major concern are the ways the sun and wind affect a given home and the ways in which these effects may be modified to conserve energy. The sun provides "free energy" during cool periods and excess heat during warm periods. The wind, on the other hand, increases heat loss in cool periods but can be used to remove unwanted heat in times of excess warmth. These relationships are shown in Figure 3.

To better understand the effects of the sun, it is helpful to understand its path and position at different times and seasons for a given geographic location. Although the sun rises in the east and sets in the west, the exact points of the compass at which it rises and sets vary with the geographic location. Also, in the northern hemisphere, the sun is higher in the sky in the summer than in the winter. As shown in Figure 4, a south-facing wall receives maximum sun in the winter. It is difficult to make orientation generalities due to the many variables to take into account: the wind, seasonal changes, regional climatic differences in the United States, local topography, etc. In the northern latitudes there is a need to orient the building toward the sun as in Figure 4. However, in southern regions, the axis of the building should be turned to avoid direct solar radiation and oriented toward cooling breezes instead.[4] In the more temperate zones, where winter heating and summer cooling are both important, orientation becomes more difficult. Generally, homes should be oriented to the southeast to maximize solar heat gain in the mornings and winter and to minimize the impact of the low, hot afternoon sun.[5] The north side will be the coolest side with the least opportunity for direct natural light penetration.

The effects of wind are less predictable; they vary with season and location, and may be offset by barriers such as nearby planting and terrain. The effects of wind on housing have to be considered both on the outside (because of *[illegible]* and *infiltration*--see Glossary for definitions) and within the structure itself. Winds should be blocked during cold weather, but admitted and utilized in hot weather. For example, in a cold climate homes should be shielded from winter winds and oriented to receive cooling summer breezes.

[SEE ACTIVITY A.]

A significant contribution to the field of climatically responsive architecture has been the experimental work of Victor Olgyay of Princeton University. Olgyay resolved some long debated principles relating to climatic environment to housing. Figure 5 depicts the effects of wind on housing as revealed through Olgyay's research.

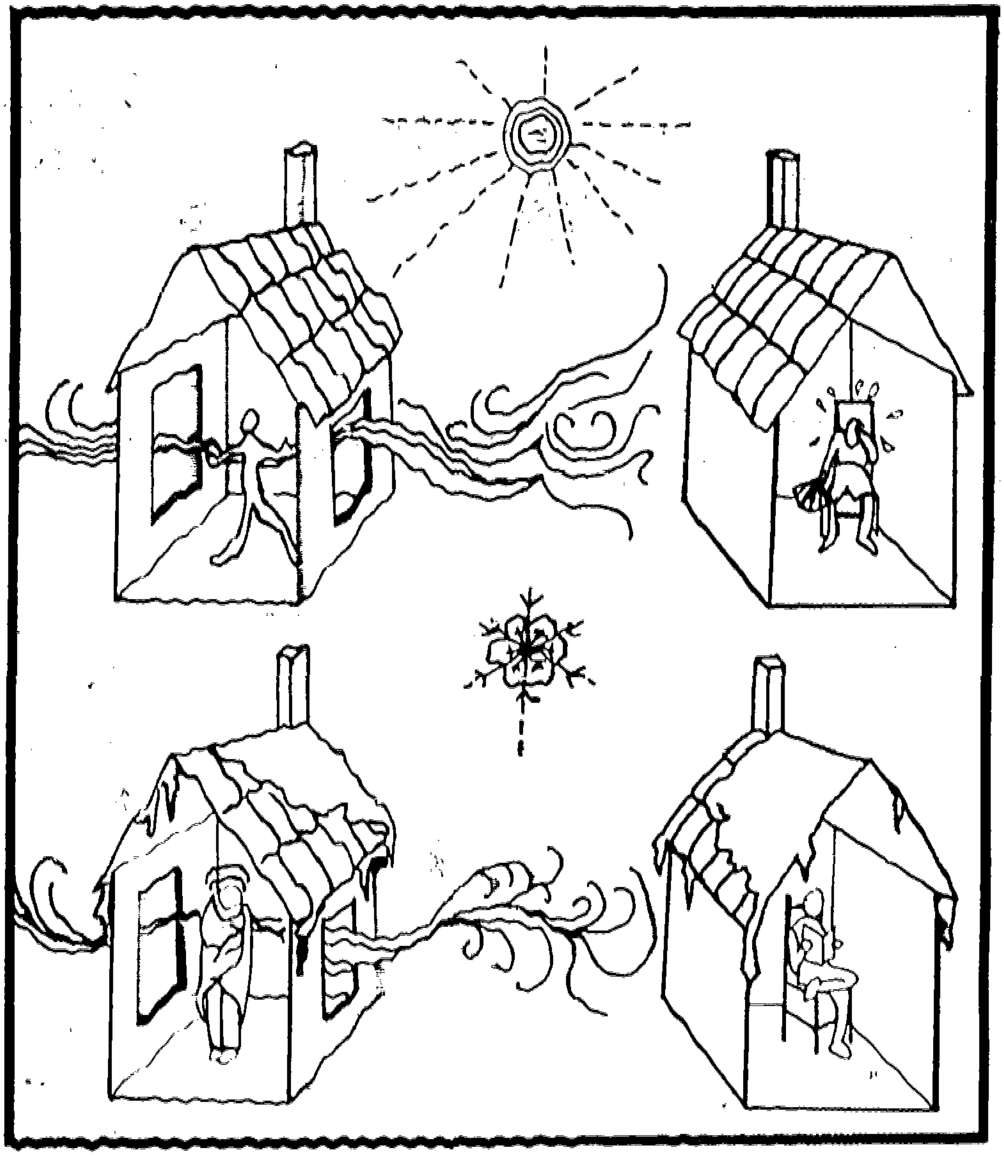


Figure 3: The Climatic Effects of Wind and Sun.

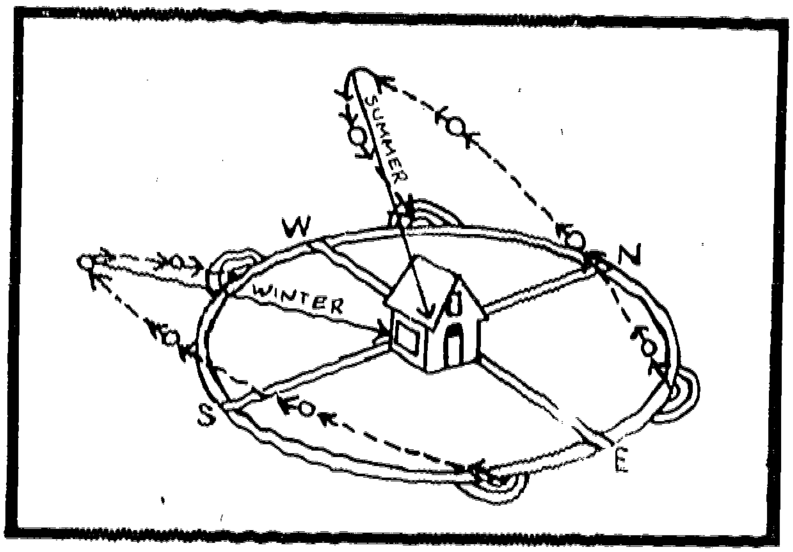
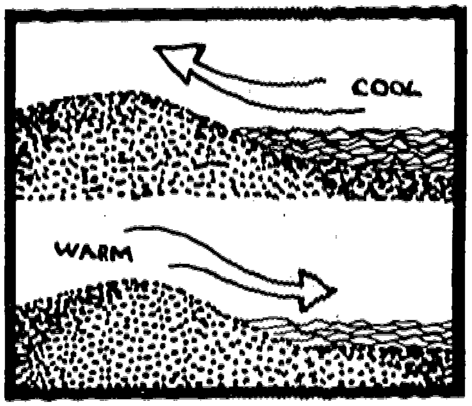
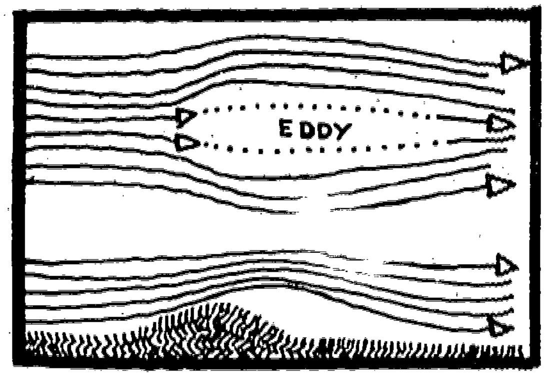


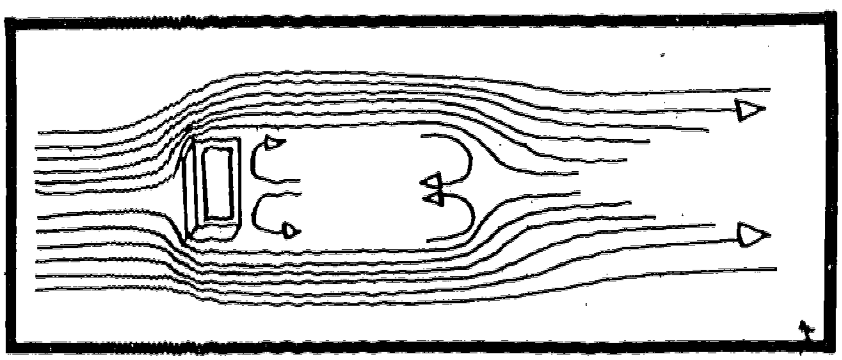
Figure 4: Sun Angles for Winter and Summer.



Proximity to bodies of water has a moderating effect: during cool periods (at night or in winter), the air moves from the warmer water to the cooler land; the reverse occurs during warm periods.

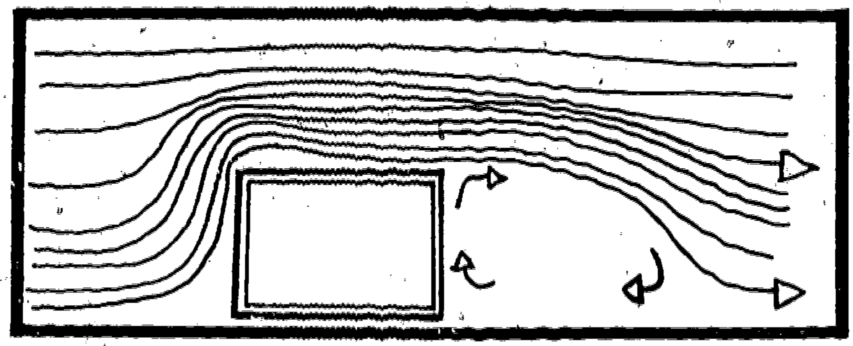


Higher wind speeds occur at the tops of hills, thus creating a greater cooling effect on the windward side and less turbulent wind conditions on the lee side. *(Note: The closer the lines, the greater the wind speed.)*

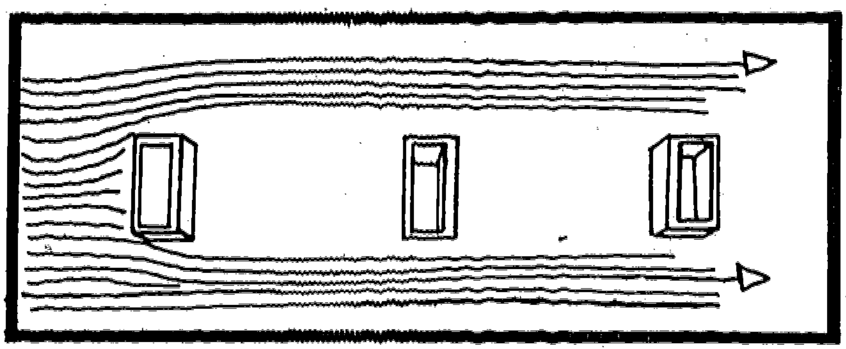


Wind effects around buildings are most pronounced on the windward side at the corners and roofline. *(View from above.)*

Figure 5. Wind Effects.



Wind effects around buildings are most pronounced on the windward side at the corners and roofline. *(View from side.)*



In a housing row, the first windward home takes the brunt of the wind, reducing the impact on the others.

Figure 5. Wind Effects (continued).

Source: Olgyay, pp. 51, 50, 103, 101.

Vegetation Factors

In addition to the esthetic value of having trees on a home site, trees can have a beneficial thermal effect on the home. In winter, evergreens can be used as windbreaks to reduce heat loss from the building. In summer, leaves absorb radiation and cool the surrounding air through evaporation. But above all, trees and shrubs can provide shade at the right season. This trait makes *deciduous* trees (those that shed their leaves) especially valuable when placed close to buildings since they can limit the impact of the sun in summer without interfering with winter sunshine as shown in Figure 6.

Leafy vines are also valuable for sunny walls in hot weather. The proper selection of vegetation is important to insure effective results. The shape of the shadow as well as the shape and character of the vegetation itself in winter and summer must be kept in mind. For example, a shade tree may be too low to permit cooling breezes to reach the home, or a row of evergreens used as a windbreak may also block the benefits of the morning sun.

[SEE ACTIVITY B.]

Room Orientation

In the evaluation of room orientation, the most important consideration is to secure desired conditions in living areas during the times they are used. There are many determinants in selecting room exposures for a particular site (e.g., view, traffic, topography). For best thermal control, solar orientation should be a major consideration. The matrix shown in Figure 7 was developed by Jeffrey E. Aronin suggesting sun orientations for various rooms in a residential building in a temperate or cool climate zone.[6] He suggested orienting those rooms which are used primarily in the daytime toward the east, southeast, south, southwest, or west in order to receive the most sun, particularly in the winter. It is not recommended that bedrooms be oriented to the west or northwest because of the glare and heating effects of the late afternoon sun.

The treatment of the outside walls is also important since proper solar orientation is not always possible or desirable. If an exposed wall is properly protected or equipped with shading devices, the negative effects of solar radiation can be avoided.

Another important consideration for thermal control is wind orientation. The goal is to protect living areas from winds in cool periods but to admit and utilize breezes in warm periods. Therefore, it is best to orient areas with least use (garage, utility, closets, storage, laundry) toward winter winds and those which receive the most daytime use toward summer breezes (see Figure 8).

[SEE ACTIVITY C.]

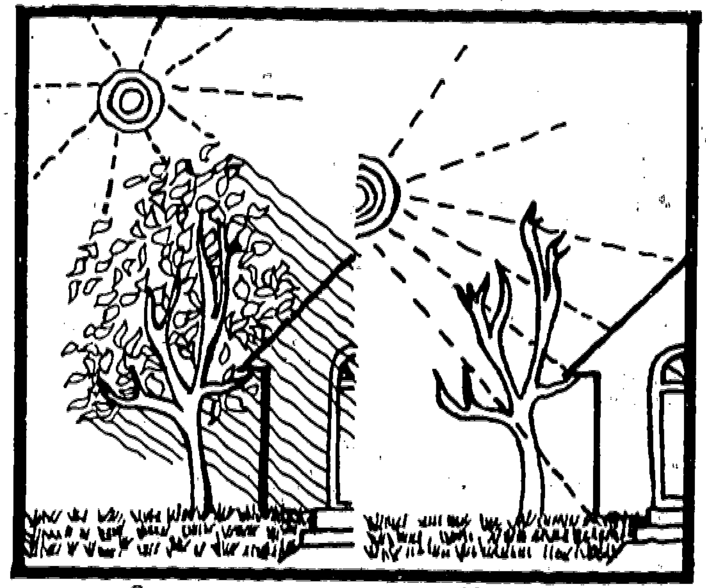


Figure 6. Climatic Impact of Deciduous Trees.

	N	NE	E	SE	S	SW	W	NW
Bedrooms	◎	◎	◎	◎	◎	◎		
Living				◎	◎	◎	◎	
Dining			◎	◎	◎	◎	◎	
Kitchen			◎	◎	◎	◎		
Library	◎	◎						◎
Laundry	◎	◎						◎
Play				◎	◎	◎	◎	
Drying Yard				◎	◎	◎	◎	
Bathrooms	◎	◎	◎	◎	◎	◎	◎	◎
Utility	◎	◎						◎
Garage	◎	◎	◎	◎	◎	◎	◎	◎
Workshop	◎	◎						◎
Terraces			◎	◎	◎	◎	◎	
Sun Porch				◎	◎	◎	◎	

Figure 7. Sun Orientations for Individual Rooms.

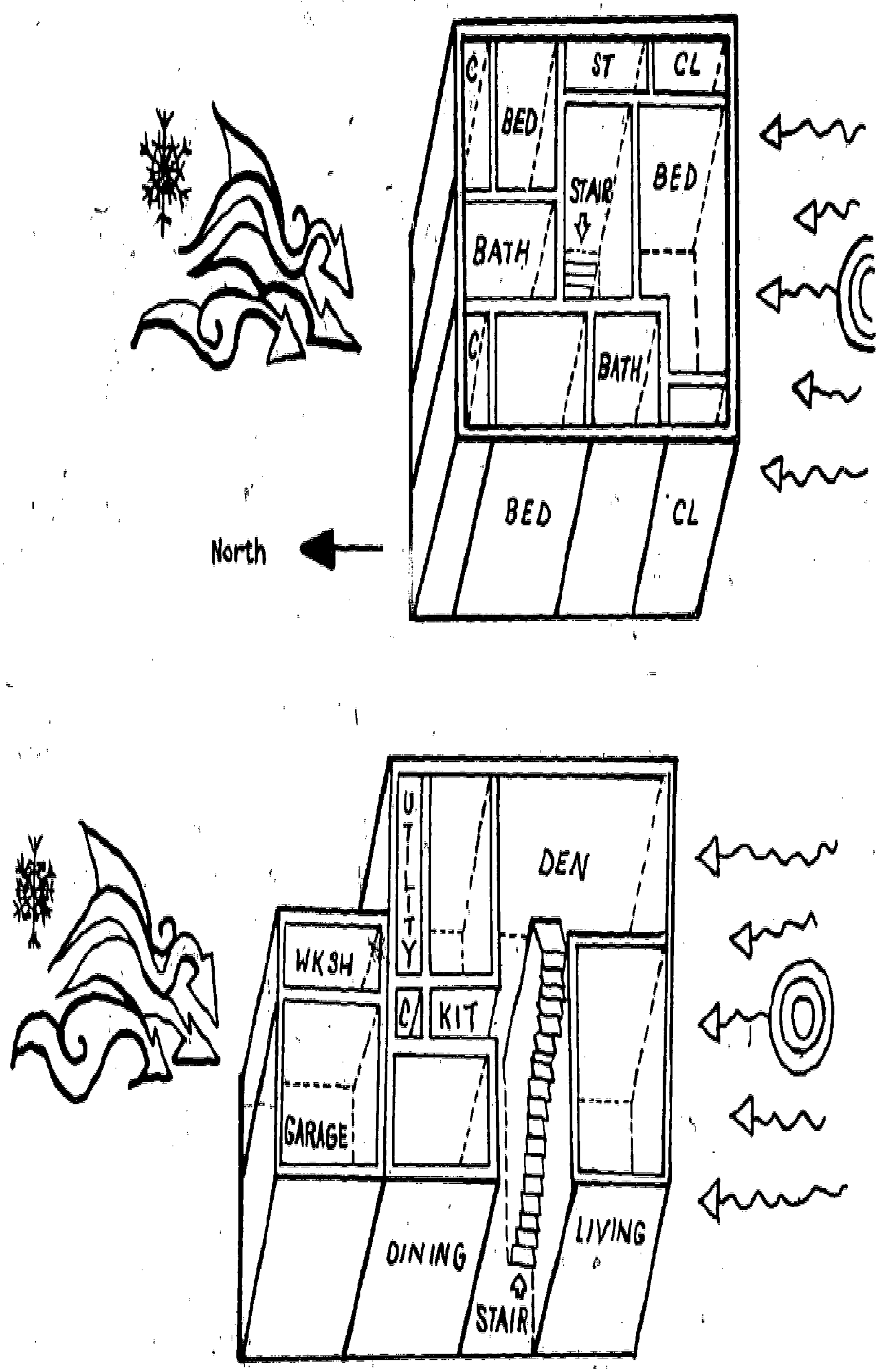


Figure 8: Room Orientation for Wind.

OBJECTIVE: TO ENABLE THE TEACHER AND STUDENT TO RECOGNIZE ENERGY-CONSERVING AND ENERGY-WASTING CONSTRUCTION FEATURES IN A HOME AND HOW THEY MIGHT BE IMPROVED TO INCREASE ENERGY EFFICIENCY.

In a federally sponsored study, an analysis of heating and cooling losses for a typical, single-family residence in the Baltimore/Washington, D.C. area revealed details of where heat flows through the shell.[7] The table below shows the distribution of *heating and cooling loads* (the amount of heat loss or gain per unit time imposed on the heating or cooling equipment) by major components. Evidently, there is great potential for energy conservation in the improved design and construction of a home's shell. In view of rapidly rising energy costs, there are many energy-saving design opportunities. However, it should be noted that a feature which may be worthwhile in one geographic region, may *not* be in another.

Components	Percent of Heating Load	Percent of Cooling Load
Ceiling	3.7*	2.3
Floor	2.2	2.4
Total Window	13.6	4.1
Total Door	1.4	0.4
Total Wall	23.9	14.2
Infiltration Load	55.2	41.5
Internal Load	--	35.1
Total	100.0	100.0

*The ceiling was well-insulated. If it had not been, this would have been much greater.

Size and Shape of Home

The square footage of a house affects the cost--both initial outlay and continuing maintenance and operation. Larger homes require more construction materials and larger capacity heating and cooling equipment than do smaller homes, as well as more fuel to maintain a comfort zone within the house. It makes sense to try to satisfy the occupant's needs within a minimum area.

The optimum shape is one which has minimal heat gain in summer and minimal heat loss in winter. Therefore, the form of a house depends upon the climatic region. Three factors help determine optimum shape: volume-to-surface ratio; solar exposure; and potential for insulation. The volume-to-surface ratio of homes is important, but cannot be considered alone in determining shape. It might appear that a cubical house would have the least heat loss and gain because it is compact, but this is not the case. The optimum shape for thermal impact for every climate is a rectangle with differing degrees of elongation along the east-west direction.[8] Through experimentation, the optimum shape for each climate has been determined by Olgyay. These shapes are illustrated in Figure 9. However, Olgyay was concerned solely with thermal impact and did not consider the potential for insulation. The National Association of Home Builders (NAHB) has shown that the potential for insulation is a very important factor in determining the optimum shape of a home for thermal efficiency.[9] For example, the NAHB has disproved the impression that a two-story house affords less heat loss and gain than a one-story house of the same square footage. In this case, the ceiling area makes the difference since ceilings can be more effectively insulated than walls. If six-inch wall studs were used and if the insulation had an "R-value" equal to that of the ceiling, the one-and two-story houses, all other factors being equal, would have equal heat gain and loss.

The volume effect (as the volume of a cube increases, its volume-to-surface-area ration increases, as shown in Figure 10) plays a more important role in large buildings such as apartment houses or condominiums. The climate affects large buildings much less than small buildings because of the volume-to-surface area ratio. Figure 11 indicates that an interior apartment may have a lower heating and cooling load because it has less surface area exposed to the weather.

Insulation

The energy efficiency of a home can be increased 20 to 30 percent with proper insulation which will reduce the load on heating and cooling equipment.[10] Insulating is one of the most important energy conservation measures for a home; it makes possible the use of smaller capacity heating and cooling equipment as well as saving on operating costs. For example, in a 1500 square foot home in a temperate climate at three cents per kilowatt hour, six inches of ceiling insulation could save $520 annually on heating and cooling costs; 3.5 inches of wall insulation could save $100 annually; and 3.5 inches of floor insulation could save $170 annually.[11] Placement of this insulation is shown in Figure 12.

On a cost-benefit basis, the money and effort spent to heavily insulate a home will be repaid in just a few years through lower heating and cooling bills. It is more cost-effective and easier to insulate during construction, but it is beneficial to insulate existing homes as well.

Insulation is any material that provides resistance to the flow of heat from one surface to another. Different materials have different insulating value. For example, one inch of mineral wool or fiberglass has the same

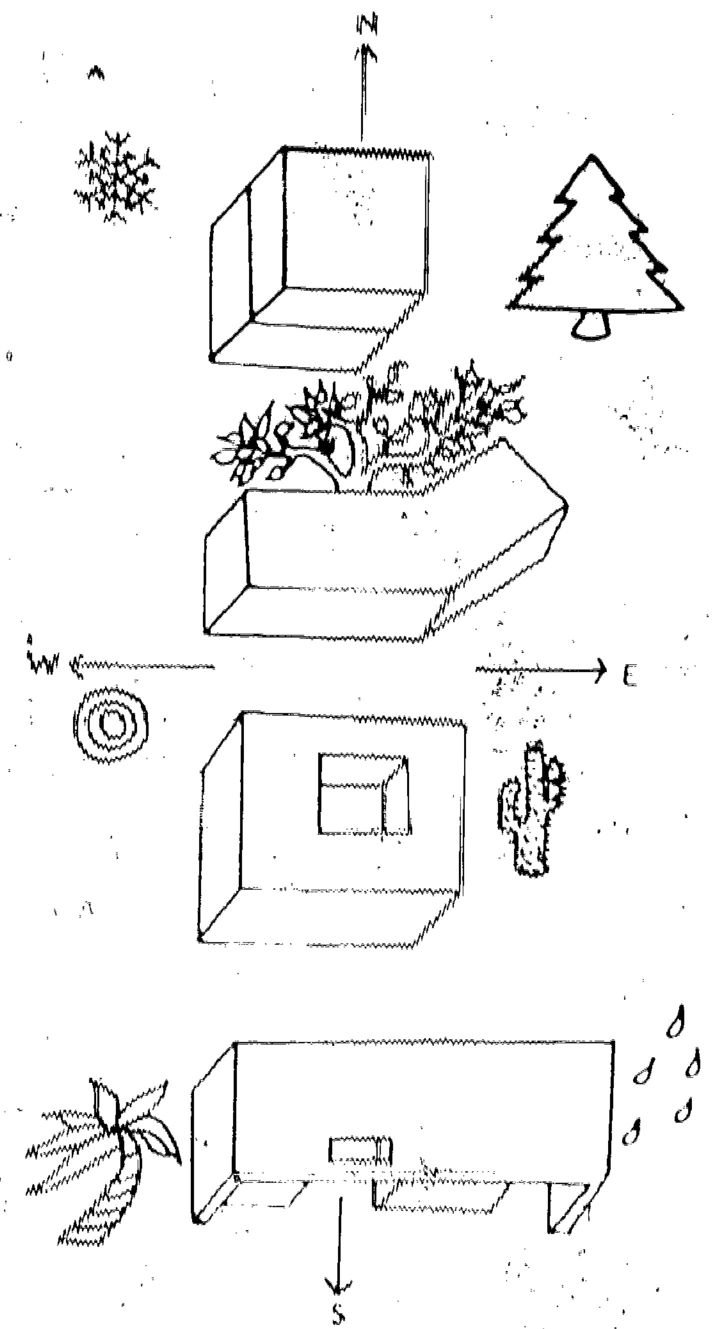


Figure 9.
Homes
Shaped to
Accommodate
Climate

Figure 10: Volume Effect.

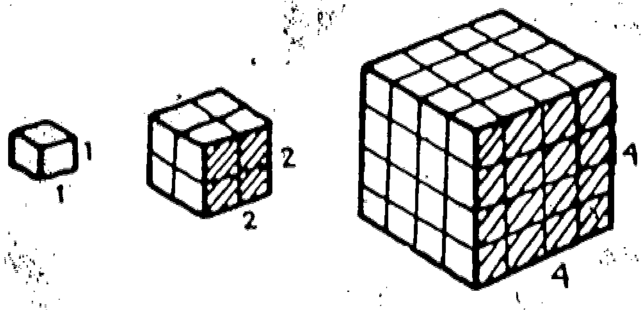
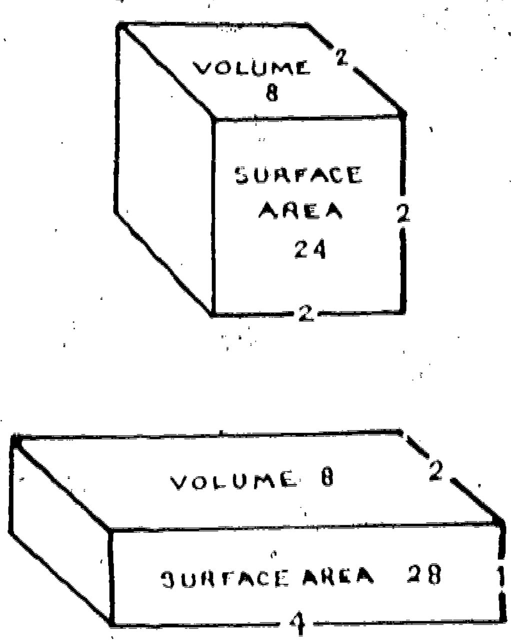


Figure 11: Surface-to-Volume Ratios.



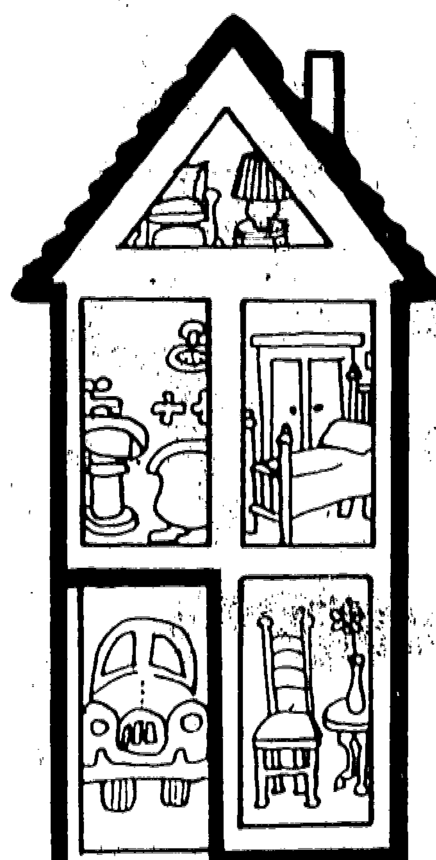
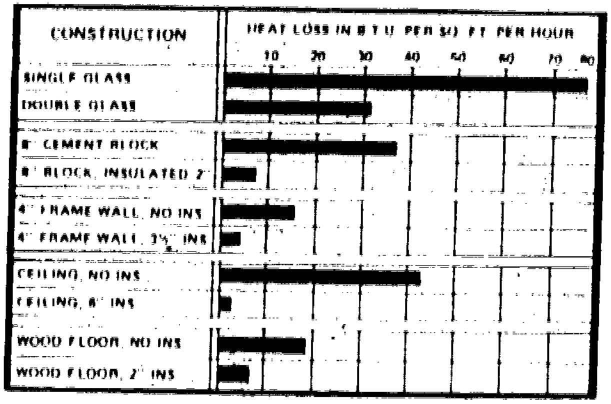


Figure 12: Insulation in a Home.

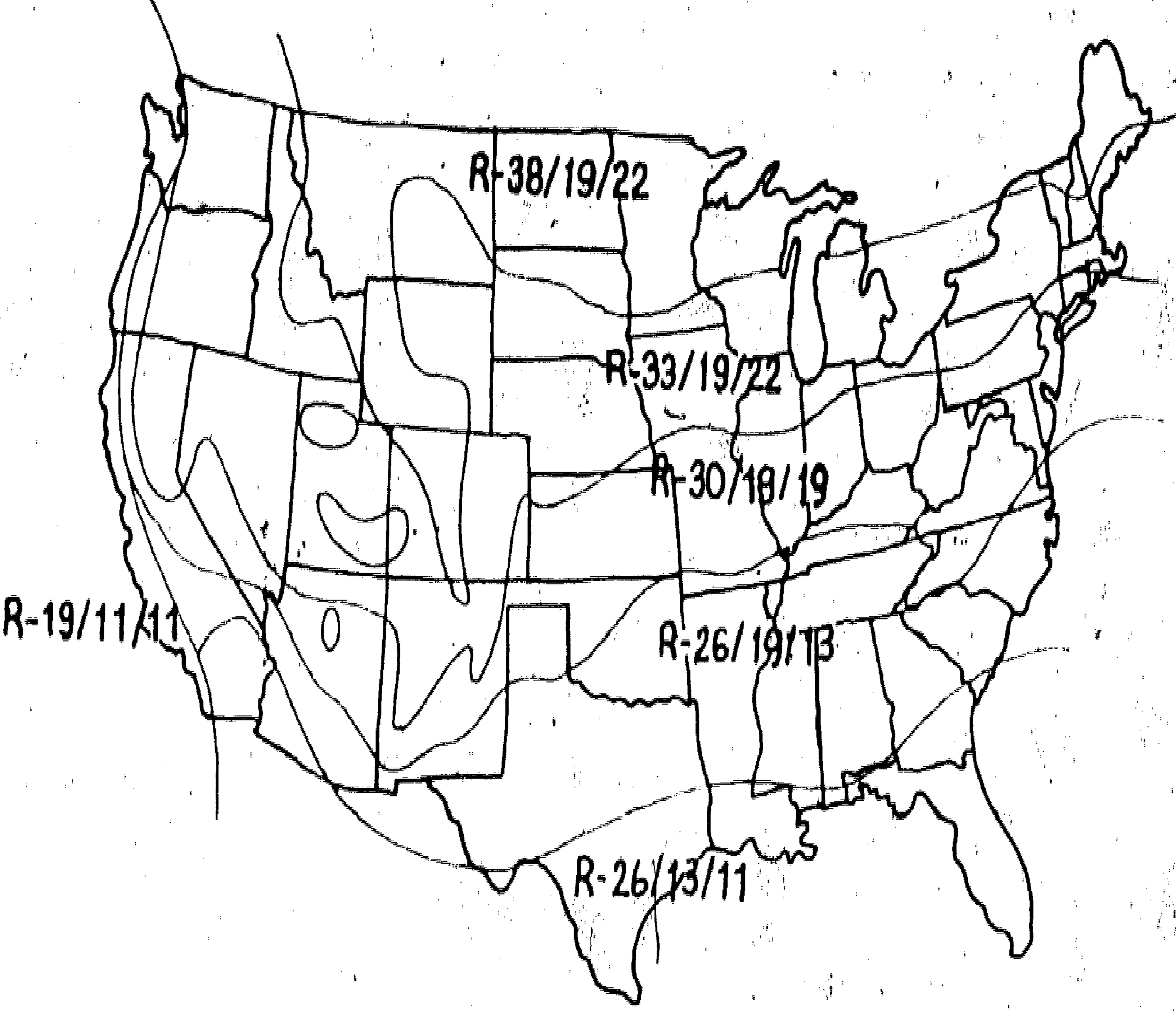
insulative value as 34 inches of brick![12] The table below shows the insulative qualities of housing construction components. It points out the poor insulative quality of glass as opposed to a ceiling with six inches of insulation which has a good insulative quality.



SOURCE: TVA, "Insulate for Savings & Comfort"

The ability to insulate is not determined solely by thickness but also by weight and density. The effectiveness of insulation is usually measured in thermal resistance (the ability to stop heat flow) or "R-value." The higher the R-value, the better the resistance and the performance of the insulation. The R-value is marked on all insulation on the market. The recommended minimum R-value for homes varies from area to area. In most areas, ceilings should have an R-value of 19-38; outside walls and floors, R-11-22. The Tennessee Valley Authority's (TVA) "Super Saver Homes" project for the Tennessee Valley Region recommends R-30 insulation value in the ceiling and R-19 in the walls and floors. The Farmers Home Administration (FmHA), the largest single financing agency for housing in the State of Maine, recommends R-38, ceilings; R-19, walls; and R-22, floors for optimum insulation. These recommendations are consistent with those given in Figure 13, illustrating the recommended "R-Values" for six U.S. climate regions.

Many kinds of insulation are available--fiberglass, mineral wool, cellulose, fiber-blown, vermiculite, polystyrene, and polyurethane--and commonly used in homes and may be either blanket or loose fill. *Blanket* or *batt* insulation is constructed of mineral wool or fiberglass and is available in continuous lengths in various widths with optional vapor barrier. *Loose fill* insulation is made from mineral wool, glass fibers, wood fibers, or vermiculite and can be installed in new or existing homes by machine blowing or hand pouring. *Foam* insulation, which is available in rigid boards and liquid spray, is also used in homes. It is particularly suited for applications where very little space is available or for insulating existing buildings. Of the above, the blown and liquid spray foam insulaions require special equipment. The batt and loose fill types of



Source : Owens-Corning

Figure 13. New Recommended "R-Values": Ceilings/Walls/Floors for six U.S. climatic zones.

insulation are easier to install and can be done by most anyone.

The optimum insulation of a home would include all surfaces exposed to the outside temperatures--ceilings, walls, floors, and roof. The diagram in Figure 14 illustrates the proper location of insulation. The greatest impact on energy savings is ceiling insulation. Insulating an uninsulated attic with six inches of mineral wool, glass fiber, or cellulose can result in a 20 percent savings on heating costs. If five million homes with inadequate attic insulation were upgraded, the U.S. demand for residential heating fuels would decrease four percent.[13] Installation of insulation in walls also yields a large energy savings but is more difficult to install.

Infiltration

Infiltration is the passage of air into and out of a residence through a variety of openings (doors, windows, cracks, vents, dampers, etc.). (Figure 15). As was noted in the HUD single-family residence report on the heating and cooling of homes, infiltration was the largest load factor for both heating and cooling, about 55 and 42 percent, respectively.[14] The amount of infiltration varies greatly from house to house because of differences in construction and the habits of the occupants. ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers) researchers determined that the optimum rate of infiltration for residences should be about one complete air change every 10 hours with no wind or indoor-outdoor temperature difference.[15] With differences in temperature and slight winds, the air change could be as great as 1.5 or one-and-a-half complete air changes per hour! Some people fear a "too tight" house that won't admit fresh air. This is not the case even in the tightest homes. Sometimes the interior air may seem stale; if it does, open a window for a few minutes. The number of door and window openings and closings, the use of exhaust fans, the use of fireplaces, the movement of air within the house all affect infiltration. Aside from these sources of infiltration are the narrow openings around doors and windows, as well as within ceilings, walls, and floors.

There are two approaches to decreasing infiltration. One is to foster conserving habits in occupants. The other is to seal cracks. Several tips for reducing infiltration are included below:

1. Keep all exterior doors--as well as those on garage, attic and basement--tightly closed and weatherstripped.

2. Close damper when fireplace is not in use.

3. Use exhaust fans sparingly.

4. Close central heating vents when using room air conditioner and vice versa.

5. Keep all windows tightly closed when heating or cooling equipment is operating.

1. *Exterior walls.* Sections sometimes overlooked are the wall between living space and an unheated garage or storage room, dormer walls, and the portion of wall above the ceiling of an adjacent section of a split-level home. Pack insulation in narrow spaces between jambs and framing.

2. *Ceilings with cold spaces above and dormer ceilings.* An attic access panel can be insulated by spaling a piece of mineral wool blanket to its top.

3. *Knee walls when attic space is finished as living quarters.*

4. *Between collar beams, leaving open space above for ventilation.*

5. *Around the perimeter of a slab on grade.*

6. *Floors above vented crawl spaces.* When a crawl space is used as a plenum, insulation is applied to crawl space walls instead of the floor above.

7. *Floors over an unheated or open space such as over a garage or a porch.* The cantilevered portion of a floor.

8. *Basement walls when below-grade space is finished for living purposes.* Mineral fiber sill sealer between sill and foundation provides an effective wind infiltration barrier.

9. *In back of band or header joints.*

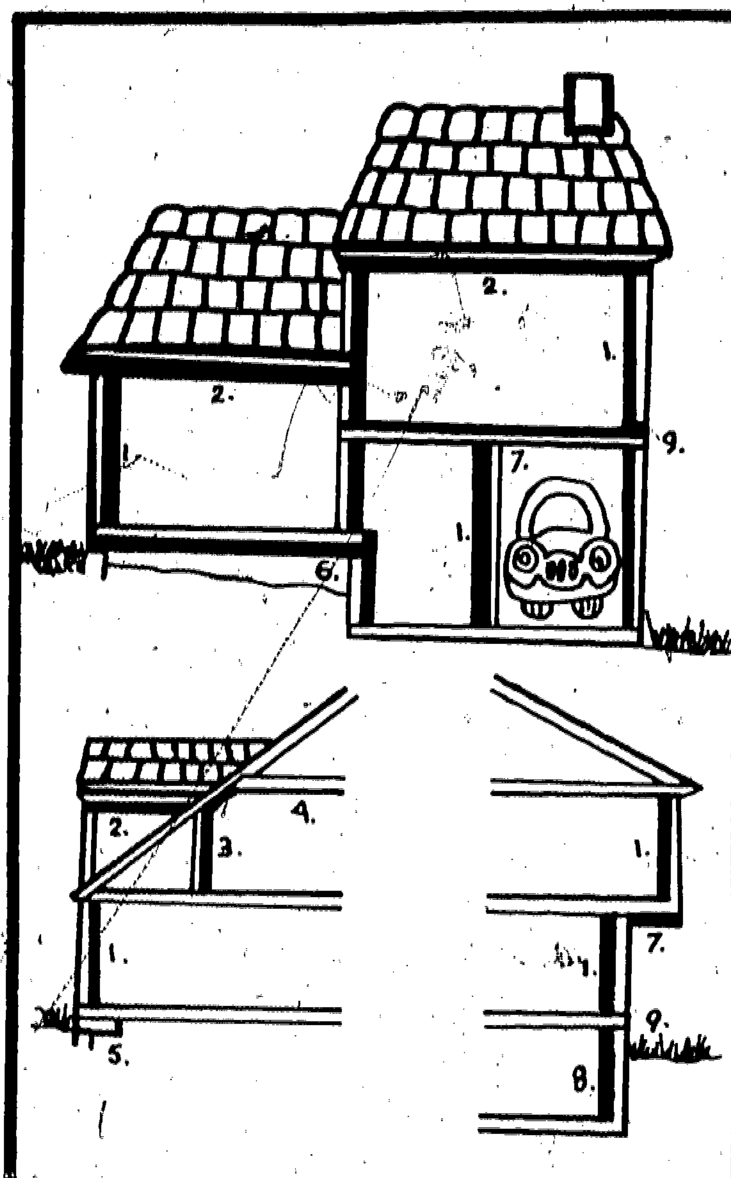


Figure 14. Proper location of Insulation.

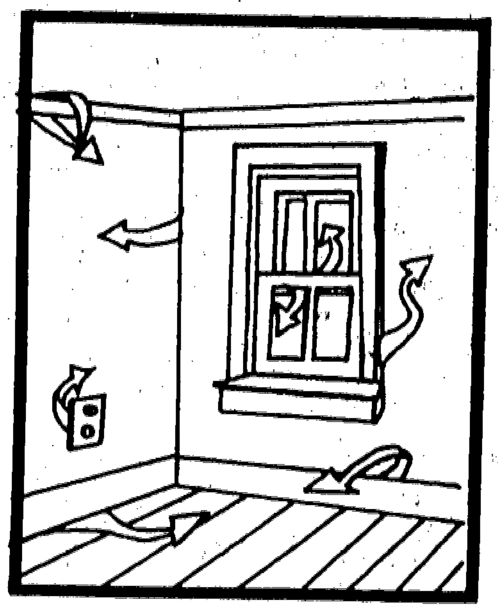


Figure 15: Infiltration Sites in the Home.

6. Use fireplaces on cool days but not cold days.

7. Plan ahead; make as few trips as possible in and out of exterior doors.

To seal openings, a number of measures may be taken, including weatherstripping, caulking, sealing, and painting. Weatherstripping closes off the space around doors or windows. Different types of weatherstripping are available. Most are inexpensive and easy to install, as shown in Figure 16.

Caulking is a putty-like material which is squeezed into cracks and openings with a pressure gun. The outer layer hardens and can be painted while the inner part stays soft and flexible to allow for expansion and contraction. Caulking should be used to seal cracks in walls and joints. All holes in exterior walls, roof, or flooring should be patched. Broken or cracked window glass should be replaced. All dampers and vent closures should be tight. Of course, the fewer windows and doors in a home, the less infiltration. Figure 17 shows where to make repairs on the exterior of the house.

Foundation

When it comes to insulation, foundations and floors are frequently overlooked. However, even if walls and ceilings are well-insulated, large quantities of heat can be passed through uninsulated floors and foundations. Insulation should be included in floors, above unheated spaces, around the perimeter of slabs on a grade, and in crawl space and basement walls except in hot weather climates.

An uninsulated foundation is a good design for hotter climates because it allows heat to flow into the ground below, thus providing free cooling. Masonry foundation walls have very poor thermal resistance qualities so they should not be overlooked. Figure 18 shows the location and application of insulation for slabs, crawl spaces, and foundation walls. Rigid insulation plus a vapor barrier should be used with slabs. The vapor barrier (usually a sheet of foil or plastic) should be on the interior face of the insulation (the side facing the interior of the house) to avoid condensation problems. Condensation inside the structure will cause rotting and deterioration. No one type of foundation has better thermal properties than another if each is properly insulated; however, crawl space foundation provides ventilation and separation from ground moisture in warm climates.

Roof

The roof and ceiling structures provide excellent opportunities for insulation and shading. The greatest heat loss in uninsulated homes is through the ceiling. (This is to be expected since heat rises.) Usually there is ample room above ceilings in the unheated attic space to accommodate several inches of insulation. The average requirement for ceiling

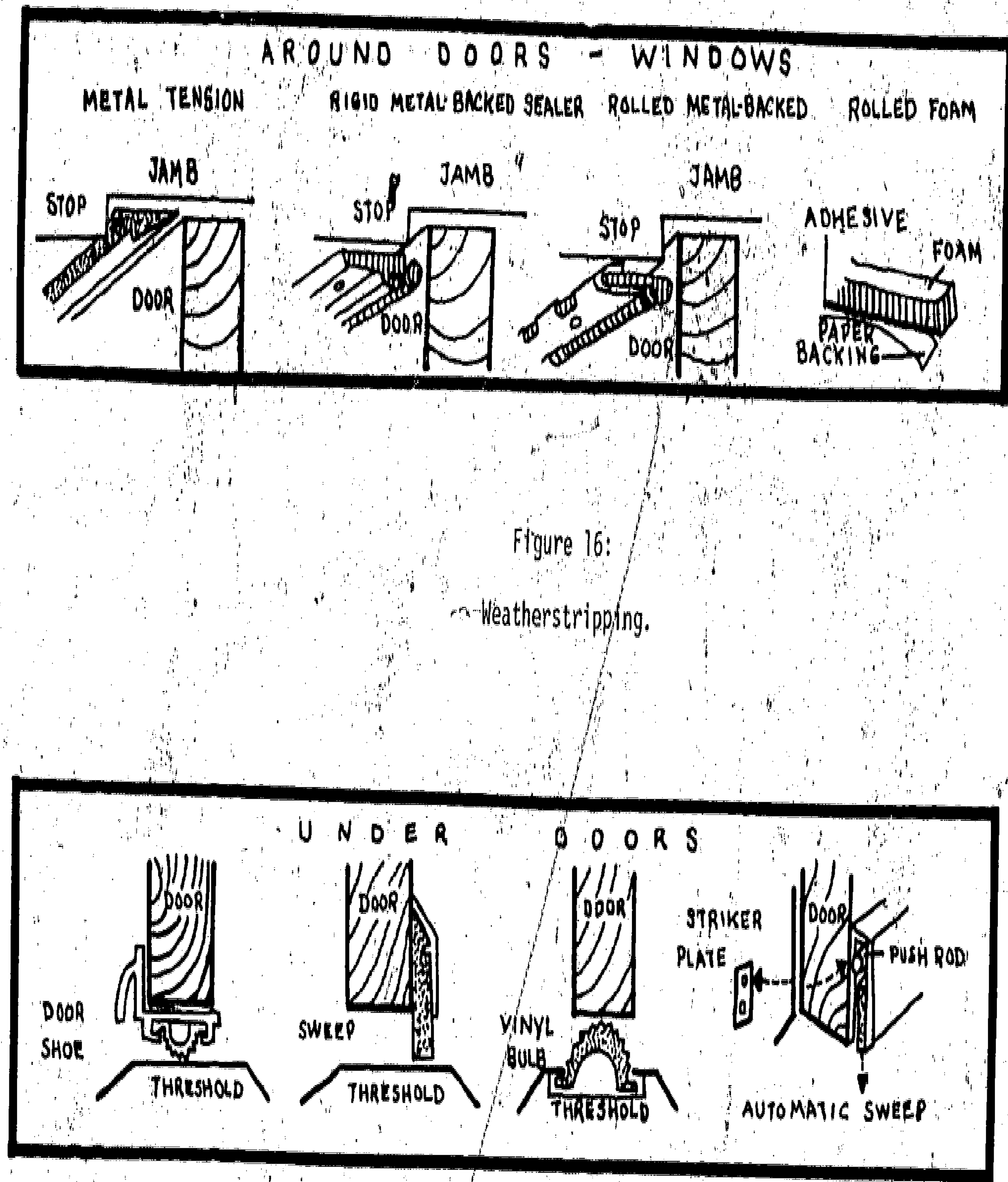


Figure 16:

Weatherstripping.

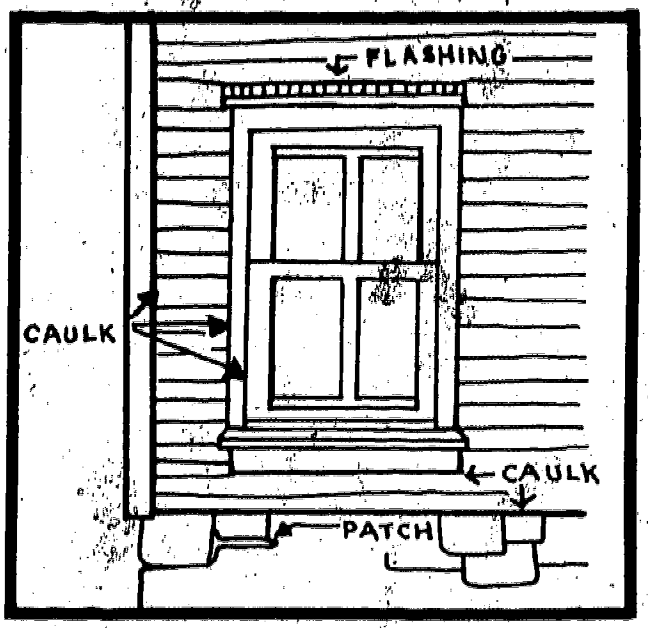
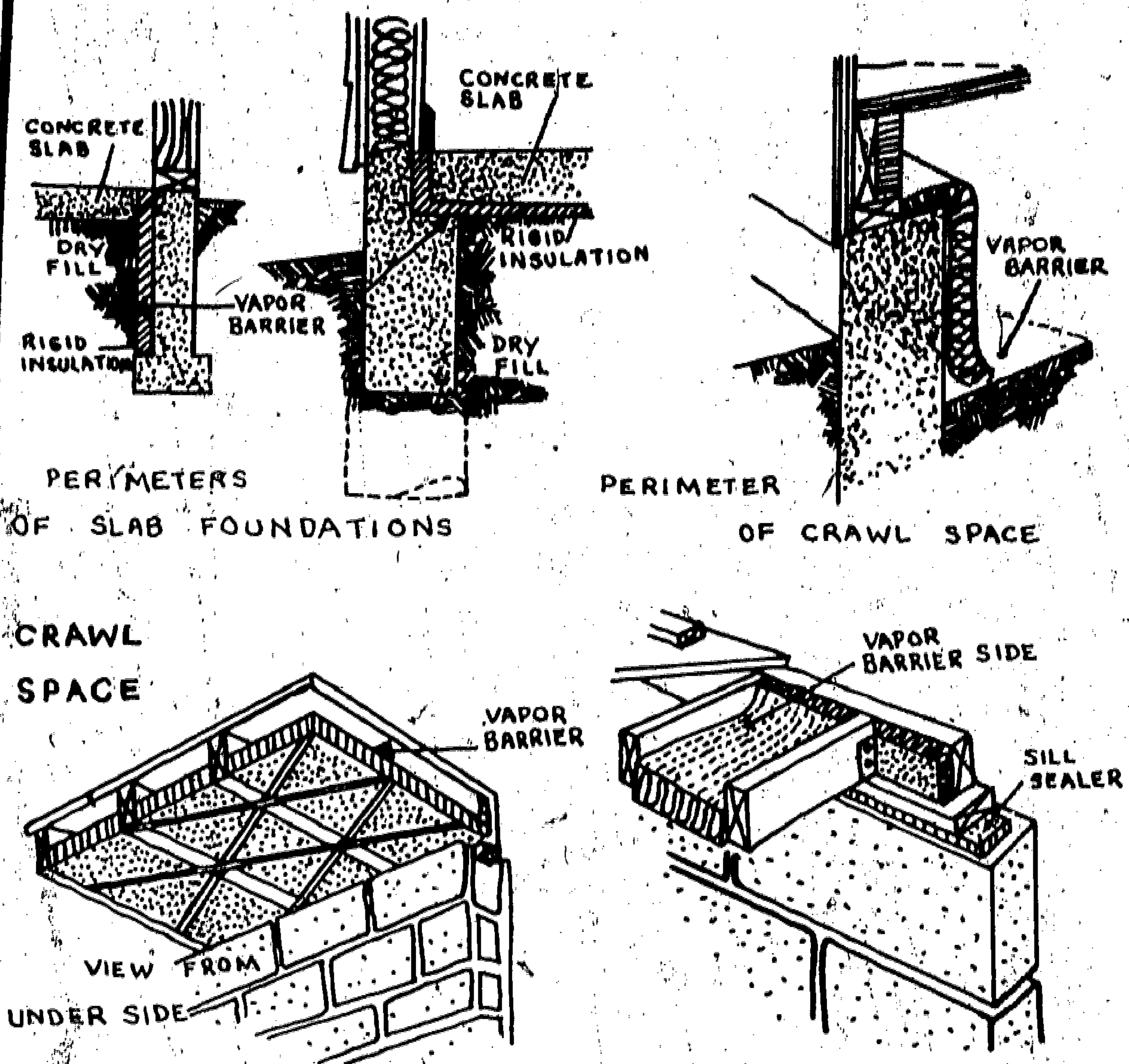


Figure 17: Exterior Repair Sites to Reduce Infiltration.



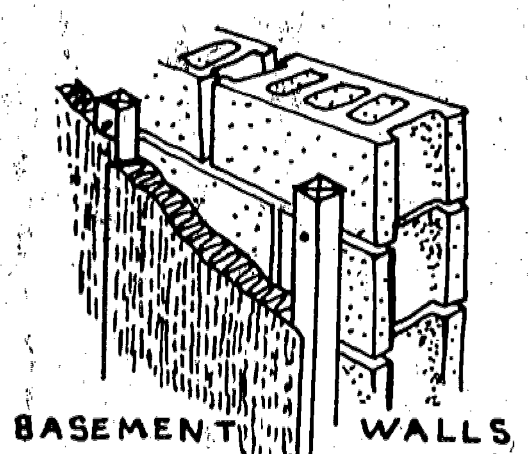


Figure 18: Insulation for Slabs *(Above top)*
Insulation of Crawl Spaces *(Above middle)*
Insulation of Foundation Walls *(Bottom left)*

insulation is R-19 which amounts to about six inches of glass fiber or mineral wool insulation. However, to be a "Super Saver" the ceiling may need an "R-Value" as high as 30. If the ceiling construction does not permit several inches of insulation, such as concrete ceilings and mobile home ceilings, rigid foam board insulation can be applied either above or below the existing ceiling. (See Figure 19.) It should be noted that attics require ventilation in both winter and summer; in winter, the vents let moisture vapor escape; in summer, the open vents carry warm air out. (See Figure 20.)

The most commonly used shading device in home construction is the overhang. Through the use of properly designed overhangs, the home can be protected from the sun in overheated periods and exposed in underheated periods. Since the use of overhangs is determined by climate and orientation, it varies from one area to another. Generally, it is desirable to protect the home from summer sun and permit the winter sun to warm the home, as shown in Figure 21.

Another important aspect is roof color. ASHRAE and HUD studies have shown that light-colored roofing material is best, but that the degree of effect on interior heating and cooling load is greatly influenced by the amount of ceiling or roof insulation. In the HUD test of single family residences the change from a white roof to a black roof only slightly reduced the heating load while increasing the cooling load substantially.[16]

Walls

In the single-family residence studied by the federal government, the walls contributed approximately 24 percent of the heating load and 14 percent of the cooling load.[17] The thermal resistance of a wall is determined by how readily heat passes through it. Heat is lost on cold days by conduction through the walls and by actual infiltration of cold air through cracks and openings. Heat is gained in the same manner with the additional effect of solar radiation. These types of heat transfer are shown in Figure 22.

Conduction and infiltration through walls can be reduced by using insulation, making walls air tight, and by minimizing the adverse effects of wind and sun. Uninsulated masonry and concrete walls are relatively poor thermal barriers; therefore, insulation must be added. Rigid or granular insulation is used in the masonry cavity or rigid insulation is applied to the interior of the wall. The frame wall is easier to insulate and can provide the same protection. It is important to remember that walls are easiest to insulate at time of construction. As illustrated in Figure 23, an energy conserving wall should have these elements:

1. A weather surface: to shed water and protect the other wall elements, prevent moisture and air infiltration.

2. Structural support: to support the wall and other building elements.

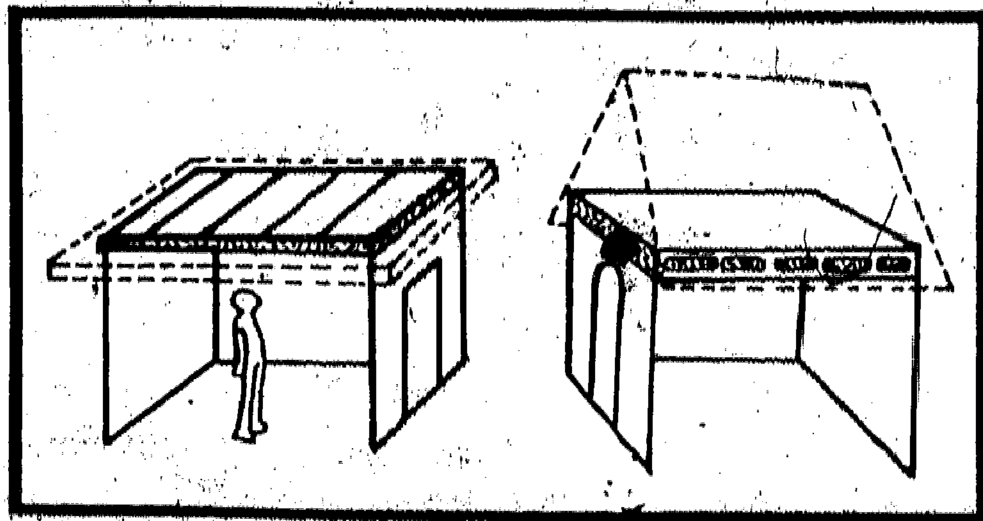


Figure 19. Ceiling Insulation Applications.

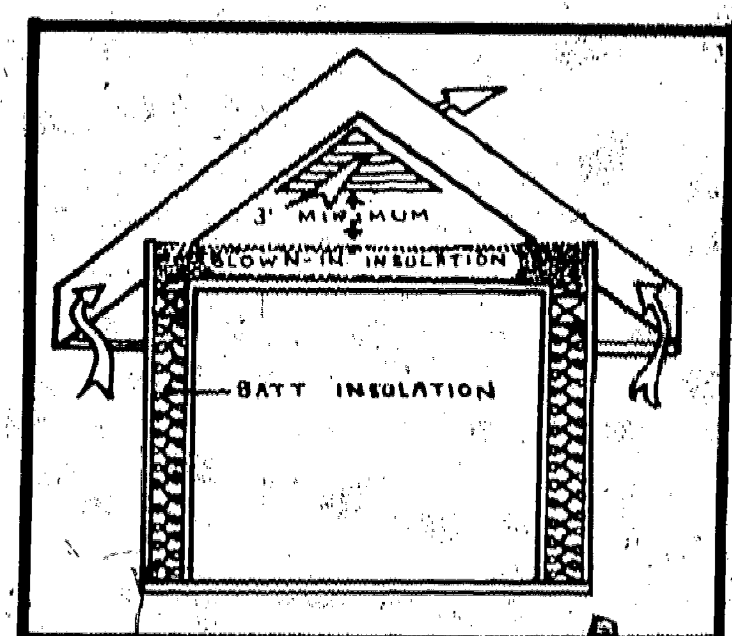


Figure 20. Combining Attic Ventilation with Two Types of Insulation.

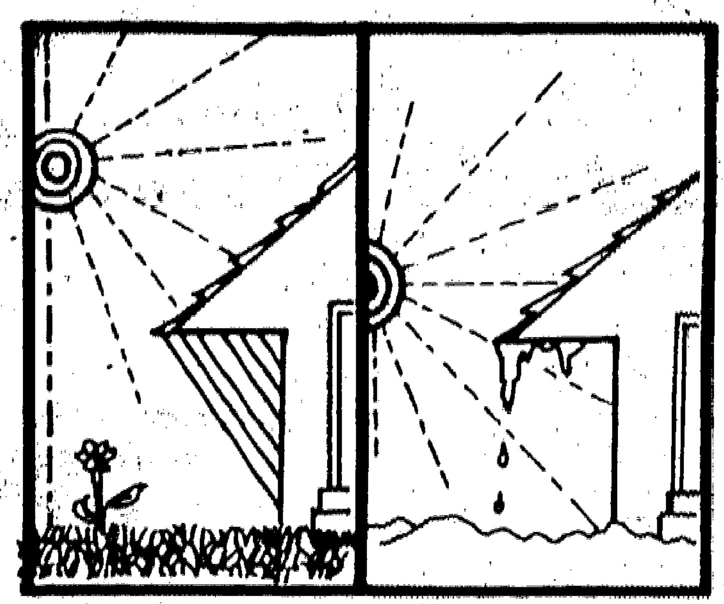


Figure 21.
Summer and
Winter Sun.

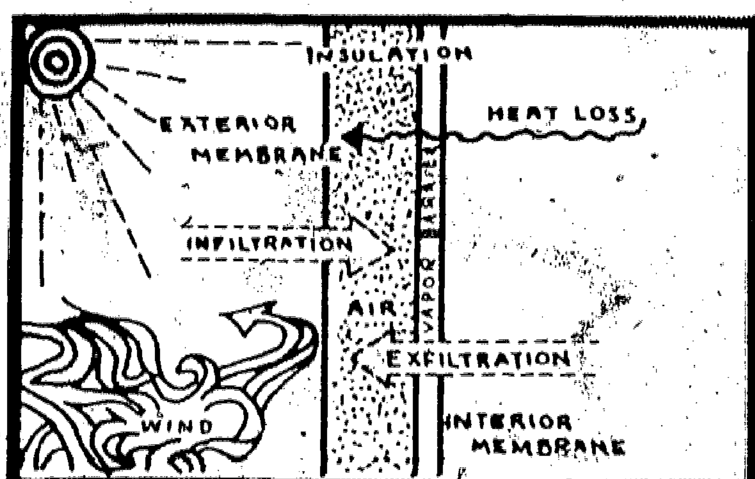


Figure 22.
Heat Transfer
Through a
Wall.

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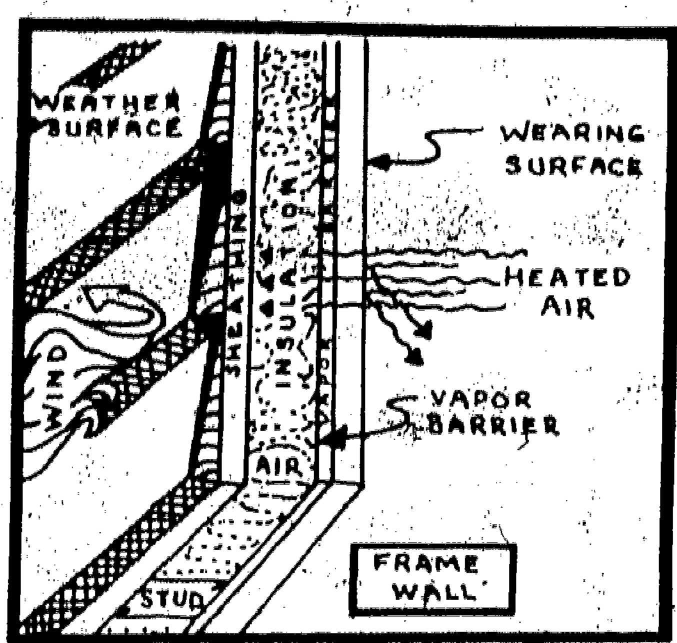
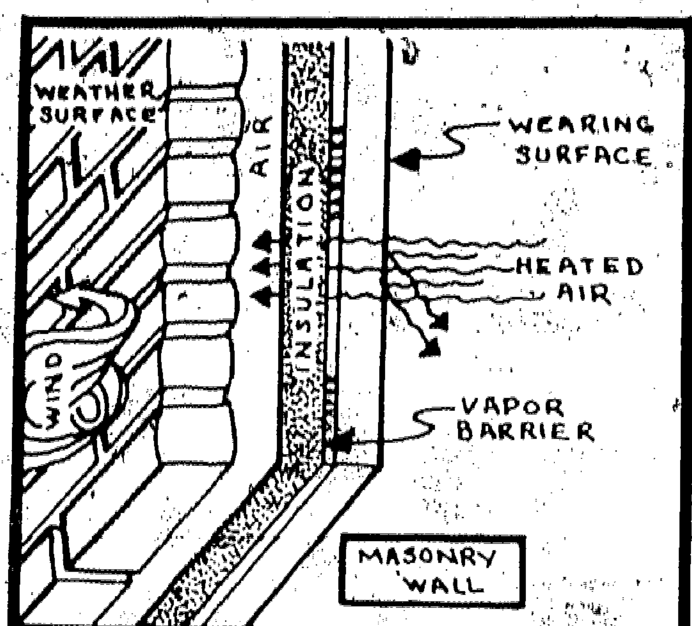


Figure 23. Energy Conserving Walls.



3. Insulation: to prevent conduction of heat.

4. Air space: to provide ventilation within wall elements and serve as increased insulation.

5. Vapor barrier: to prevent moisture from entering the wall and to prevent infiltration.

To control the effects of solar radiation, light paint or materials on exterior walls should be used in most areas.[18] Wooden trellises, horizontal and vertical louvered panels, or grills may be used to prevent solar heating of the house in warm climates, as illustrated in Figure 24.

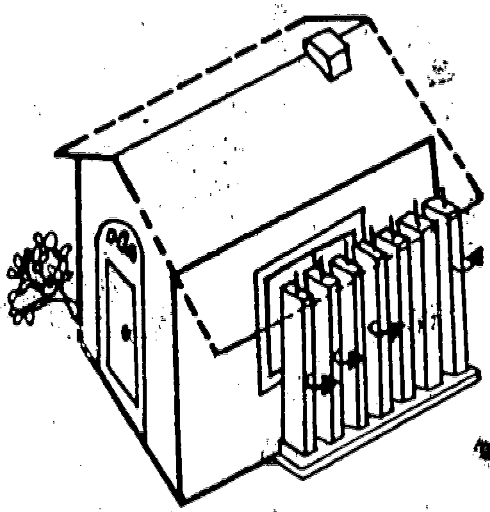
Windows and Doors

Openings in a home (such as windows and doors) allow heat to escape in winter and enter in summer, creating a load on the heating or cooling system. Eight times as much heat will pass through one square foot of window area as will pass through one square foot of wall area. This assumes that the wall is insulated and the window has a storm window.[19] Even a two-inch solid door with a wood storm door has a heat loss 3.5 times greater than a typical wall.[20]

A government report on single-family residences indicates that 15 percent of the home's heating load and 4.5 percent of the cooling load was attributed to the windows and doors, with the windows contributing 13.6 percent of the heating load. Heat loss and gain through windows and doors can be reduced by storm panels, weatherstripping, double-glazing, vestibules, shading devices, and wise placement. It is estimated that a 20 percent reduction in heating bills could be realized by adding storm doors and windows. They are also effective in warm weather where they do not prevent the utilization of natural ventilation.

A storm door or window is actually an additional door or window with an air space between it and the existing door or window (see Figure 25). Storm windows will cut in half the heat that passes through windows in your house. In addition, they cut in half the difference between room temperature and window temperature. This prevents the drafty feeling around windows and reduces condensation.[21] (See Figure 26.)

Similar reductions can be achieved with double-glazed windows or plastic applied to windows. Double-glazed windows have two panes of glass factory-sealed together with a small air space between them (see Figure 27). Double-glazing has about twice the R-value of single glazing. The increase in R-value is due primarily to the air or vacuum between the two layers of glass.[22] Heat transfer can be further reduced by triple-glazing (Figure 28). However, this is cost-effective only in the most severe climates. Clear plastic over windows can accomplish much the same purpose as storm windows or glazing for very little cost. The plastic is taped, stapled, or tacked on the inside or outside of windows but usually lasts only one year.



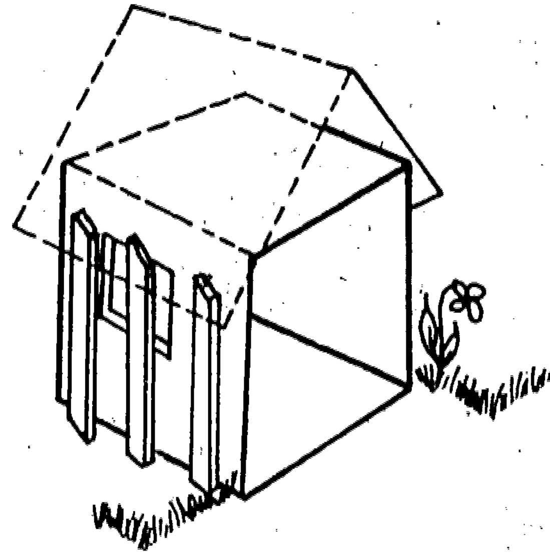
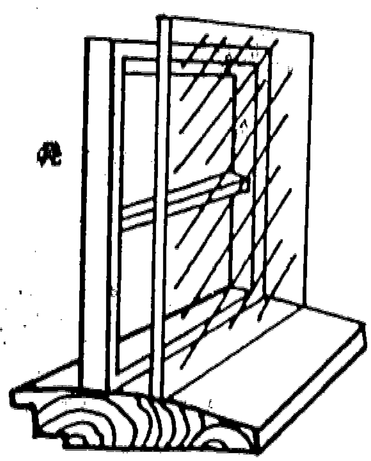


Figure 24. Exterior Sun Shades: Louvres *(left)* and Baffles *(right)*.



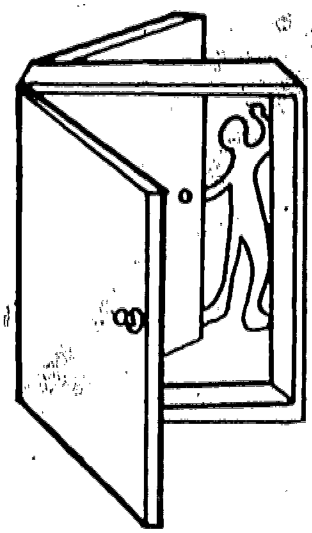


Figure 25. Storm Window Panel *(left)* and Storm Door *(right)*.

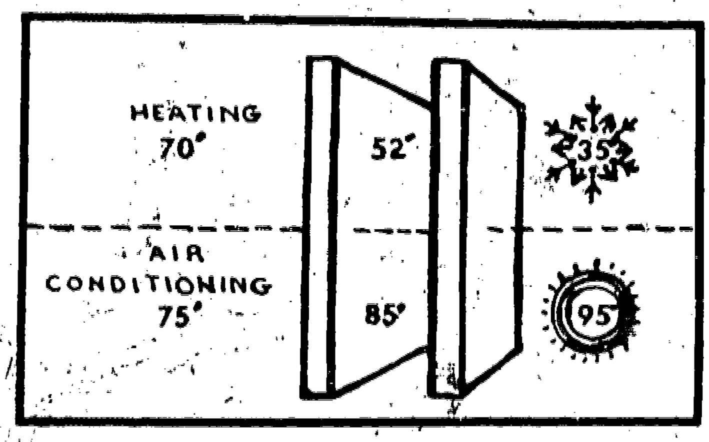


Figure 26. Storm Window Effect on Temperature.

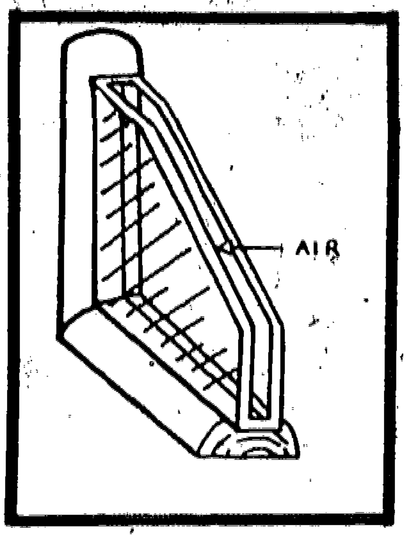


Figure 27. Double-Glazed Window.

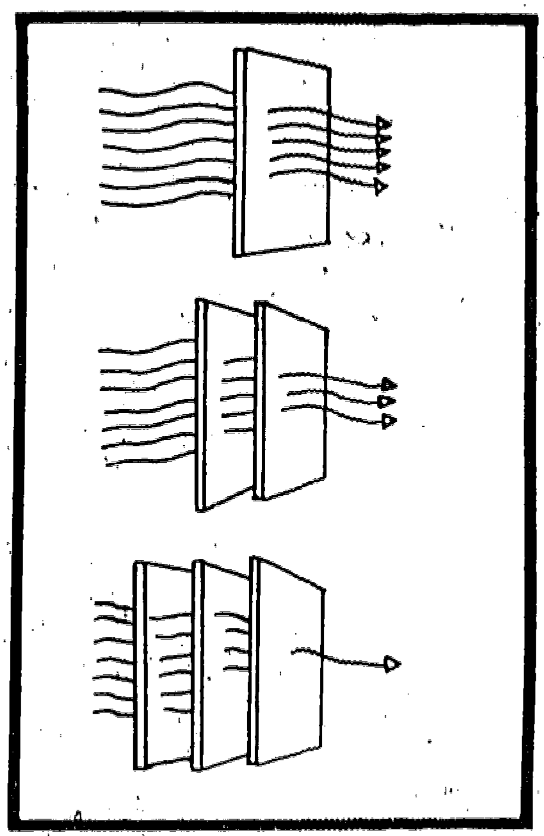


Figure 28. The Effect of Triple-Glazing.

The government study also found that wood window frames reduce heat loss about three percent more than aluminum frames.[23] This is simply because aluminum is a very poor insulator compared with wood. However, aluminum frames with thermal "breaks" are also effective because direct thermal conductance has been broken.[24]

The heat transfer through a door is determined by its R-value. A hollow-core wood door has a very low R-value and should not be used as an exterior door, but an insulated metal door, solid wood door, or the addition of a storm door is better. (See Figure 29.)

In addition to heat transfer through doors and windows, there is the very important problem of infiltration. As described previously, the use of weatherstripping, storm panels, and caulking reduces the infiltration around windows and doors and makes life more pleasant as well as less energy intensive. However, every time a door is opened, air moves in or out of the house. The type of door one has affects the amount of infiltration per opening.

ASHRAE has issued the following comparative values:

TYPE OF ENTRANCE	INFILTRATION--CUBIC FEET PER DOOR OPENING
Swinging door	900
Vestibule	550
Manual Revolving door	60
Motorized Revolving door	32

Of course, the fewer openings, the less infiltration.

The government study found that, in addition to reducing heat loss through the glass area, storm windows reduced infiltration by 50 percent.[25] The reduction of infiltration through doors with the addition of storm doors is not dramatic because the major source of the infiltration is the actual opening of the door. A more effective way to reduce infiltration through doors is by the use of an air lock--an air space large enough to permit the closing of one door before opening the second. This can be accomplished by using a vestibule or "mud room," as shown in Figure 30. Regardless of the type of window or door selected, it is important to select quality products that are well weatherstripped and tightly constructed to cut down air infiltration.

The wise use and placement of windows and doors can also reduce the heating and cooling load of a home. The fewer windows and doors, the less the load. Window areas should not exceed 20 percent of the total outside wall area or 10 percent of the interior floor area (except in some limited areas of the country).[26] (SEE ACTIVITY D.) Windows and doors should be protected from the forces of winter wind. Avoid placing openings on the winter windward side of the house; use baffles, plantings, and overhangs to protect them from the full force of rain, wind, and snow while permitting the maximum natural ventilation in warmer seasons. (Figure 31.) Solar radiation through windows and doors (particularly sliding glass doors) is

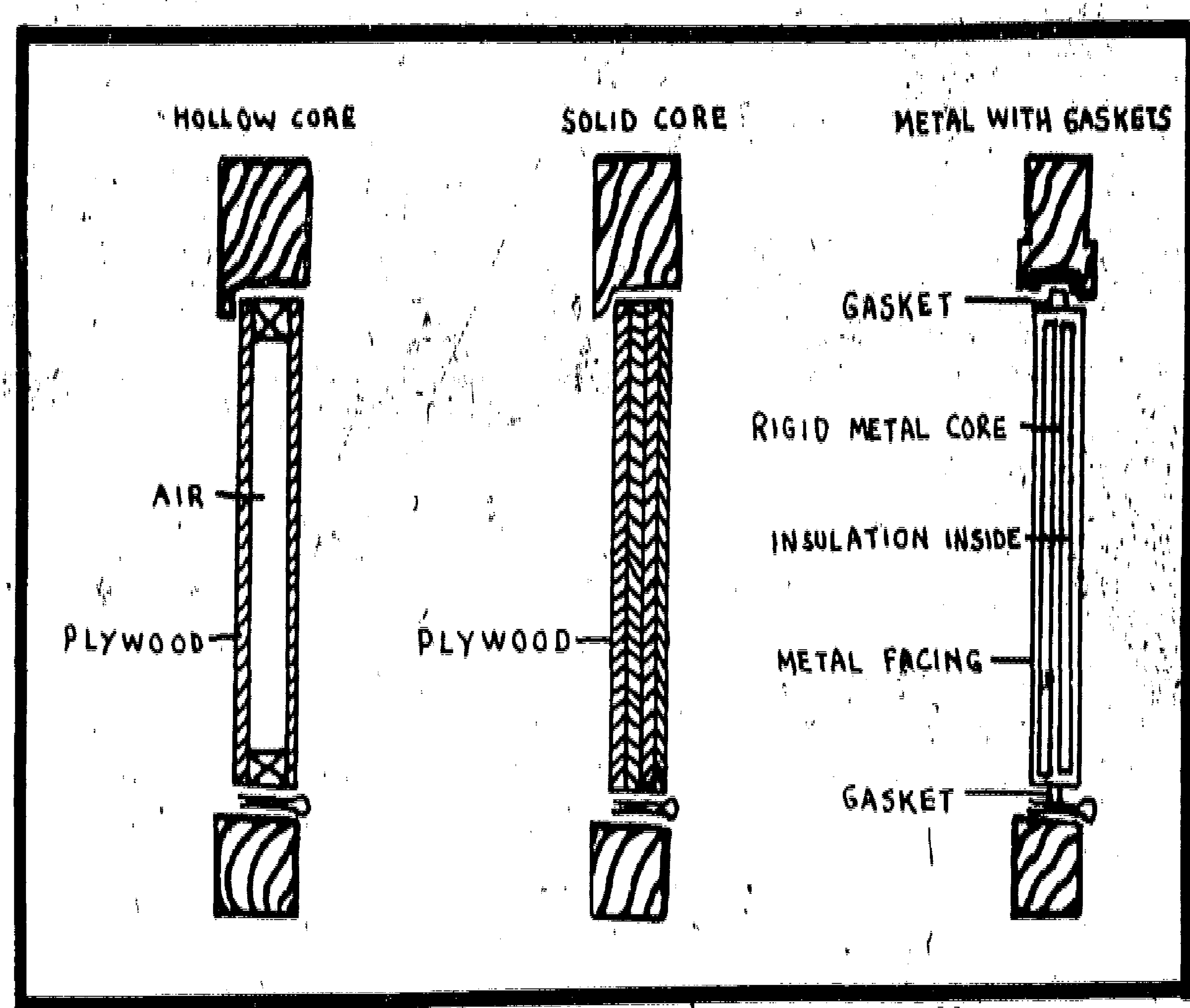


Figure 29. Construction of Doors.

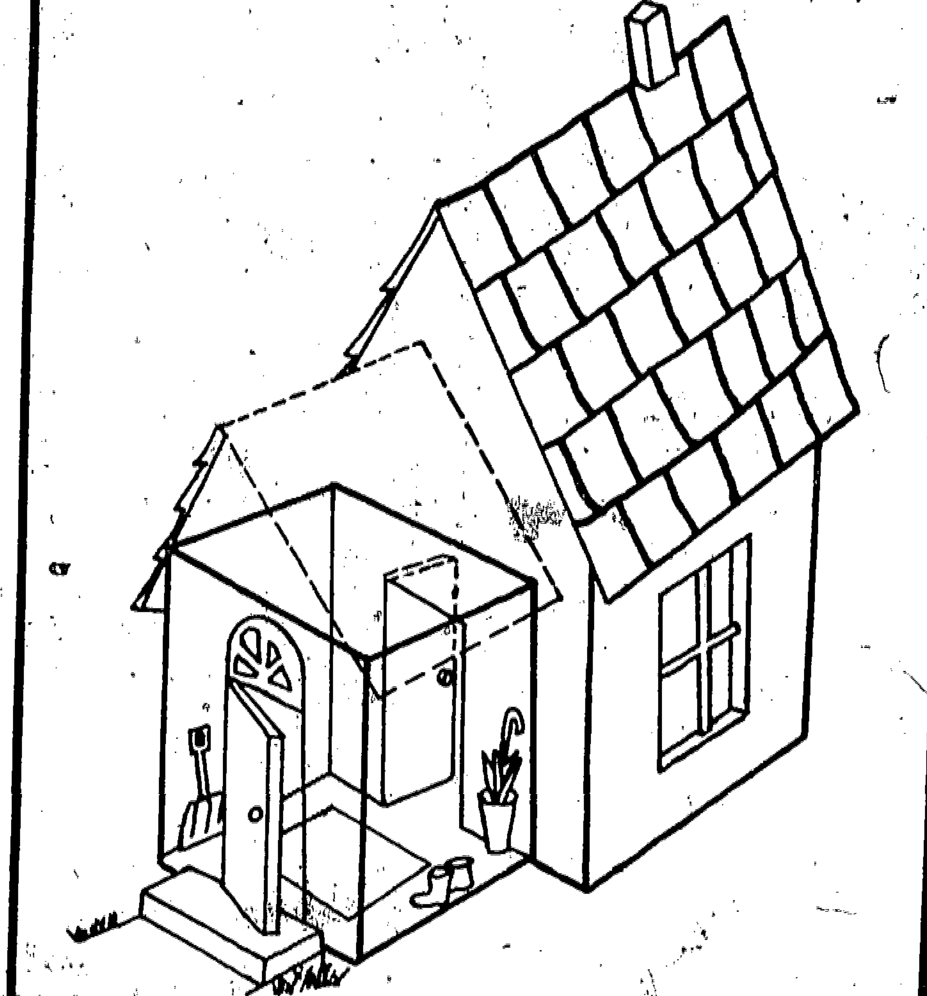


Figure 30. Vestibule Entry.

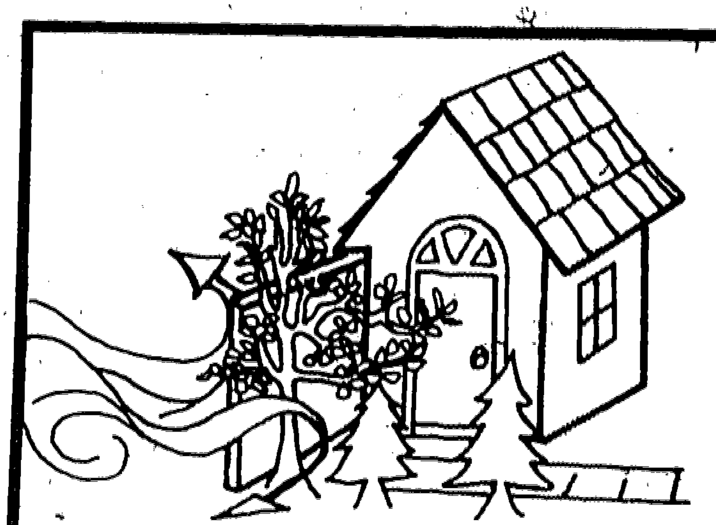


Figure 31. Protected Entry.

another important consideration. The use of roof overhangs can take advantage of radiation to heat in cool periods and avoid radiation in warm periods. The results of the government study have shown that the use of windows and doors on the north, south, east, and west walls have very different effects on the heating and cooling load of the home.[27] Windows and doors on the east and west side of the house represent great difficulty in controlling low-lying sun and should be shielded and limited in size and number. Openings on the north should be small and carefully designed to conserve heat since this side gets very little sun, particularly in the winter. South-facing windows and doors have the greatest potential for controlling the impact of the sun and utilizing its heat in winter, with the use of overhangs or awnings. If possible, the majority of a home's windows and doors should face south. Figure 32 illustrates these principles.

Windows and doors not only serve as a source of light and heat (from the sun), but also as a source of natural ventilation. Properly planned openings can provide cross-ventilation to cool the house in warm weather. The location and size of the openings can be manipulated to give the optimum ventilation for a specific need. Natural ventilation patterns are shown in Figure 33.

In conclusion, the heating and cooling load of a home may be reduced by:

1. Installing storm doors and windows.
2. Properly weatherstripping and caulking windows and doors.
3. Reducing the area and number of windows and doors.
4. Using wood or insulated and/or thermal work metal for windows and doors.
5. Using a vestibule area.
6. Locating openings so as to avoid cold winds.
7. Properly locating and shielding openings to optimize the effects of solar radiation.
8. Properly locating openings for natural ventilation.

Lighting

Lighting is the third largest energy consumer in the home, using about 10 percent of the total.[28] This amount can be reduced by using fluorescent in place of incandescent lights, reducing the level of illumination, and by more energy-conscious lighting habits. By using fluorescent lighting in place of incandescent lighting, residential energy consumption for lighting could be reduced 50 percent.[29] Fluorescent lights are about three times more efficient, last longer, and contribute less to the internal

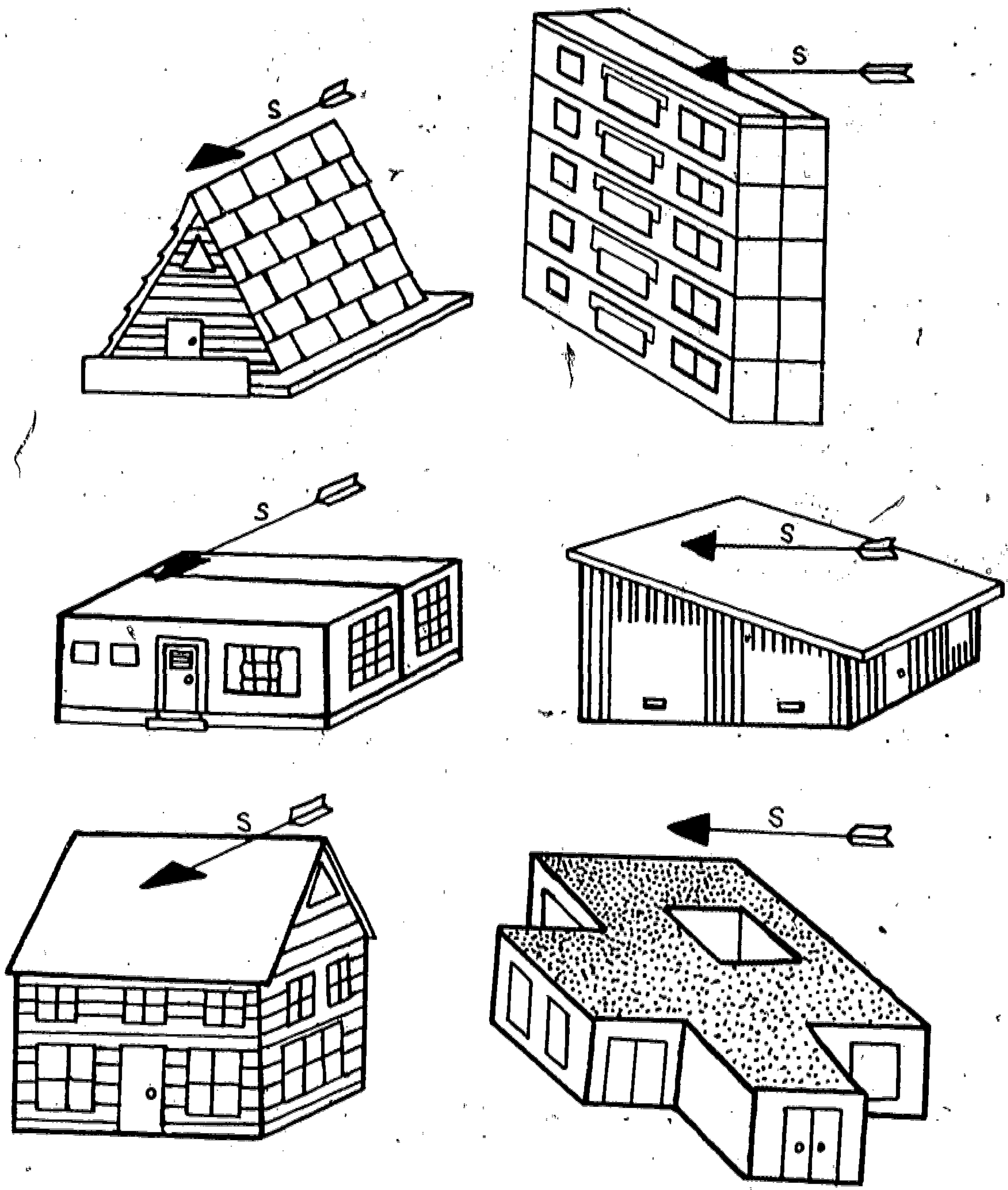


Figure 32. South-Facing Windows and Doors.

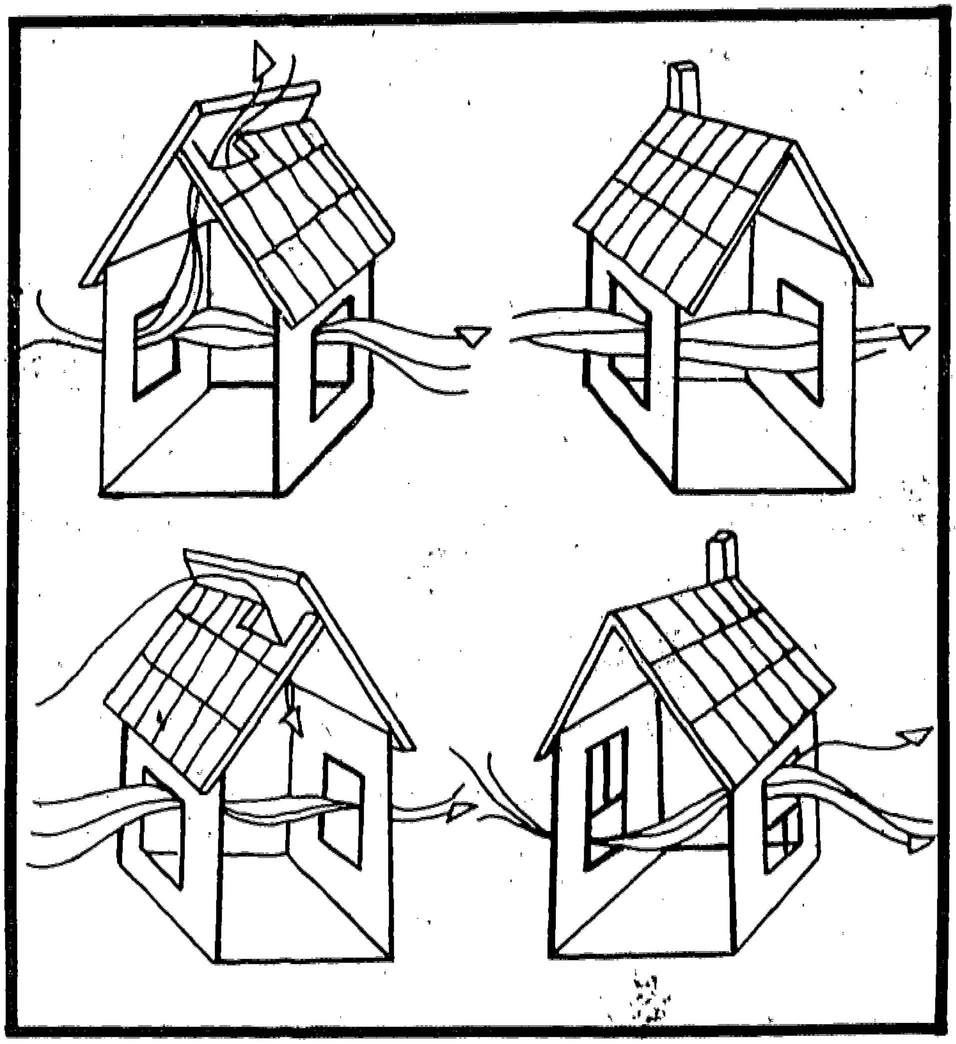


Figure 33. Natural Ventilation Patterns.

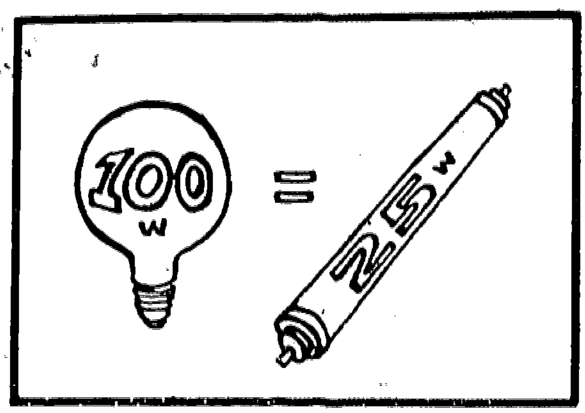


Figure 34. Fluorescent vs. Incandescent Lighting.

heating load of a home. A 25-watt fluorescent bulb gives off as much light as a 100-watt incandescent bulb and costs one-fourth as much to operate.[30] (See Figure 34.) The efficiency of a light is not determined by its wattage but by lumens/watt. *Lumen* is the name given to the flow of light (the more lumens, the brighter the light); *watt* is the unit of electric power. Although incandescent lights increase in efficiency with increased wattage,[31] fluorescent lights last seven to ten times as long.[32] Incandescent lighting creates an internal cooling load of four times that of fluorescent lighting.[33] Currently, there are adequate fluorescent fixtures on the market for baths, kitchens, and task lighting, but they are not generally accepted for other uses in the home. The "warm" fluorescent lights now available are a great improvement over the "cold" fluorescents most of us are familiar with. However, a new fluorescent bulb may soon be commercially available which can be directly substituted for an incandescent bulb. The new electrodeless fluorescent bulb being refined and readied for market looks like a conventional incandescent bulb and can be substituted without replacing existing fixtures. The new bulb will use one-third the energy needed for incandescent lighting and will waste less energy as heat. The new bulb will have a much longer operating life (20,000 hours) than a conventional incandescent bulb (about 750 hours). The initial cost of the new bulb will be greater, but its lifetime operating cost should only be about 35 percent of that of the 26 100-watt incandescent bulbs it could replace.

Another important lighting consideration is the amount of light used. Although few quantitative data are available, it is generally agreed that residential illumination is often greater than necessary.[34] The levels of light needed to illuminate a residence are approximately 5 to 60 lumens for outdoors at night, 60 to 125 lumens indoors, and 600 to 1000 lumens for most tasks (see Figure 35).[35] However, most homes are lighted well beyond these ranges. In addition to reducing the quantity of light, there is a need to light more effectively. Task lighting (bringing the light source close to the task) should be used where possible to provide adequate light for less than ceiling fixtures. Task lighting should be used in kitchens, baths, desk areas, work areas, and entries. (See Figure 36.) Solid-state dimmer switches can also be used to reduce energy consumption while creating a pleasing esthetic effect.

The convenient location of switches also is an effective measure in reducing energy consumption since they encourage the frugal use of light. (If you don't need it, turn it off!) One 100-watt bulb burning for 10 hours uses the equivalent energy of one-half pint of oil.[36] Even if a light is turned off for as little as 15 minutes, money and energy are saved. Additional energy reduction measures for lighting are listed below:

1. Keep fixtures clean.

2. Don't use ornamental lights.

3. Replace outdoor gas lights with switch-controlled electric lights.

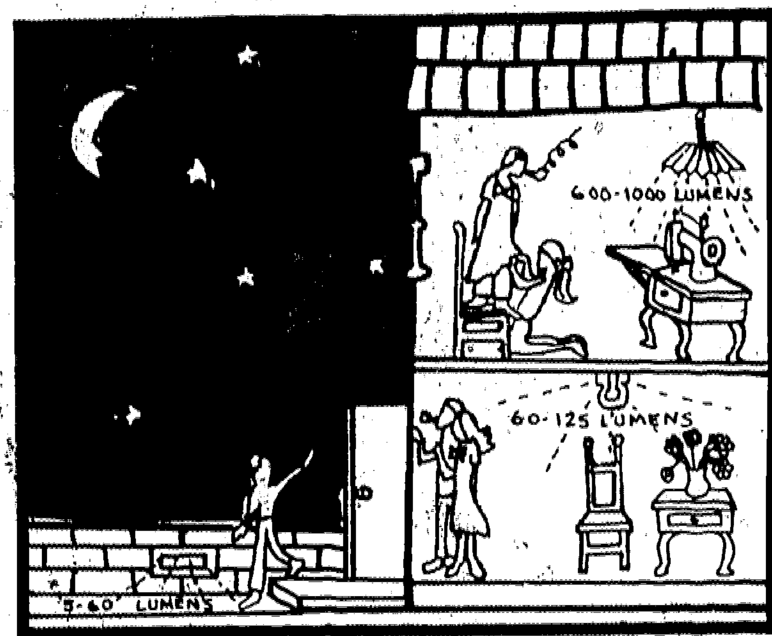


Figure 35: Lumen Requirements.

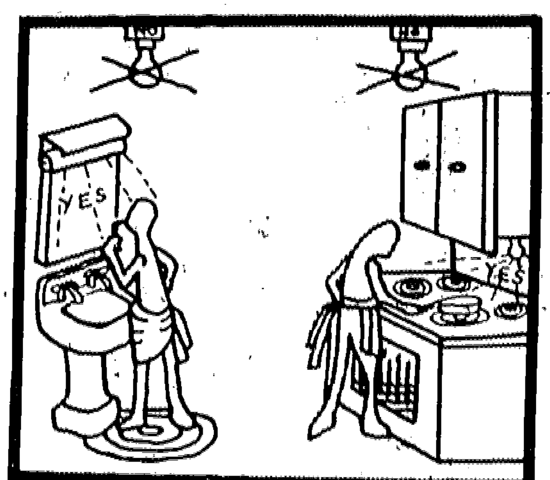


Figure 36. Task Lighting.

4. Long-life incandescent bulbs are less efficient than ordinary bulbs, so only use them for hard-to-reach places (if at all).

5. Reduce the amount of needed light by creating light-colored interiors.

6. Use one large wattage incandescent bulb instead of several small ones if needed (larger bulbs are more efficient).

7. Increase natural illumination where possible.

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THE ENERGY-CONSERVING VALUE OF INTERIOR FURNISHINGS AND TO BE ABLE TO SELECT AND UTILIZE INTERIOR FINISHING MATERIALS, FURNITURE, AND WINDOW TREATMENTS TO CONSERVE ENERGY.

The insulative value of interior furnishings has often been overlooked. In a time of plentiful resources, there was no impetus to select interior furnishings for their energy savings capabilities. The savings afforded by enlightened choice and use of furnishings can be significant. Furnishings can augment the insulative value of the home, can help control the impact of the sun, and can reduce loads on heating and cooling equipment.

Finishing Materials

Interior finishing materials include the permanent finishes or furnishings, such as wallboard, paneling, paint, flooring, wallpaper, tile, ceiling tile, acoustical tile and wall-to-wall carpeting, which are applied to the inside of a home. These materials are usually installed or applied by the builder and are included in the cost of the home. The interior finishing materials can reduce energy consumption in three ways: (1) by adding insulative value to the shell of the house; (2) by helping to cut infiltration losses; and (3) by serving as reflective surfaces on the interior of the home to reduce the need for artificial lighting.

Any material that is added to the shell of the home will add some insulative value; however, some interior finishing materials have much greater insulating value than others:[37]

Material	R-Value
plasterboard 1" thick	0.45
paneling, softwood 1" thick	1.25
paneling, hardwood 1" thick	0.95
cork wallcovering 1/8" thick	0.44
acoustic tile	2.75
terrazzo 1" thick	0.08
concrete 1" thick	0.08
linoleum flooring	0.05
vinyl flooring	0.05
rubber floor tiles	0.05
carpet with fibrous pad	2.08
carpet with foam rubber pad	1.23
(for comparison) 1" fiberglass	3.30

With the addition of acoustic tile to the ceilings, cork to walls, and carpet with fibrous pad to floors, the R-value of the housing shell could be increased significantly. Unfortunately, the R-value of interior finishing materials is not readily available to the consumer.

Carpeting, a widely used and marketable interior finishing product, can make an esthetic contribution and save energy, too. Floors, particularly those over uninsulated crawl spaces and on slabs, tend to be uncomfortably cool. Carpeting, which acts as insulation against the cool floor increases comfort and is an energy-saving alternative to raising the thermostat.[38] (See Figure 37.) Research at Kansas State University has shown carpeted buildings to be 5 to 13 percent cheaper to heat than uncarpeted buildings.[39] In Monsanto's research, "Thermal Conductance of Carpeting vs. Hard Surface Floorings," carpeting with a pad proved to have 53 percent more insulative value than any hard flooring tested because the pile construction of carpet is a highly efficient insulator.[40] The pile and pad of carpeting forms a dead air space much like that in fiberglass insulation, as shown in Figure 38.

The advantages of carpeting as an "insulative" finishing material are: (1) it is often cheaper to install than other flooring materials; (2) it may be installed in new or existing homes; and (3) it is easily maintained. Of course, fiberglass insulation under the floor is more effective than carpeting as an insulator.

Finishing materials such as vinyl wallcoverings, paint, and carpeting with a waterproof backing are beneficial as sealers for ceilings, walls, and floors. They help fill, seal, or cover cracks in a home which allow air infiltration. Another method to decrease infiltration is to add interior moldings where walls join ceilings and floors and around windows.

The proper selection of interior finishing materials can also reduce the need for artificial lighting. Light colors and smooth unshiny surfaces reflect the most light without glare and, therefore, make possible the use of minimal lighting. This is particularly important in the kitchen and bath areas where higher levels of illumination are desired.

Furniture Selection and Arrangement

Furniture selection can aid energy conservation in two ways: (1) by selecting furniture items that will augment the insulation of the home; and (2) by choosing space-conserving furniture such as multipurpose units, folding pieces, or pieces that can be stored until needed, thus reducing the interior space needs of the family. The placement of furniture can add insulative value to the home and prevent the obstruction of the heating and cooling system.

To add insulative value to a home, large multipurpose wall units, storage units, and cabinets can actually add up to an additional 18 to 24 inches of insulative material or air when placed along exterior walls. Of course, the less space you have to heat and cool, the less energy it will require.

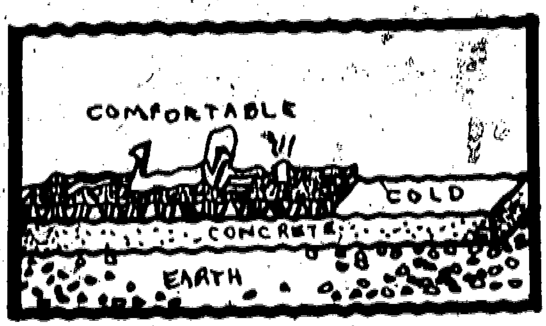


Figure 37. Carpeting for Comfort.

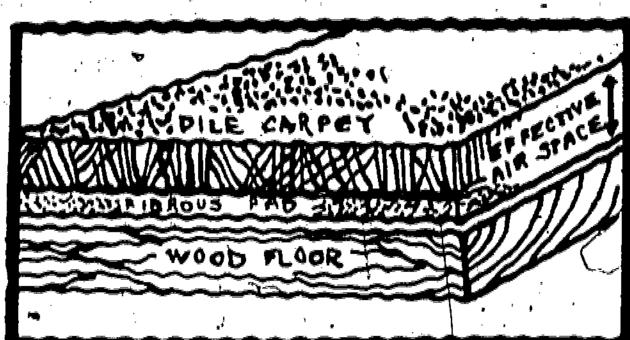


Figure 38. Insulative Value of Carpeting.

If multipurpose units (such as a sofa-bed) are selected, a substantial reduction in space requirements in the home may be achieved.

Furniture should not block hot or cold air registers or intake vents. Obstructions reduce the heating and cooling efficiency of the system. Seating areas and beds should not be placed near drafts as the tendency of the occupant is to compensate by turning up the thermostat.

Window Treatments

Energy transfer (loss or gain) at the windows may be reduced by blinds, shades, draperies, or shutters. These decorative items or devices can also control solar radiation. The insulative value of draperies and other window treatments vary from "negligible" for metal blinds to "quite good" for insulated fiberglass draperies. However, blinds are very effective shading devices. The insulative value of the window treatment is greatly increased if it is tight-fitting and forms a dead air layer between itself and the window. If the window treatment is not tight-fitting, particularly at the top, the room air will move freely by convection into and out of the space between the window and the window treatment, leaving little energy-saving effect.[41] (See Figure 39.) The window treatment serves as a buffer between the temperature at the inside of the window and the room temperature and will, therefore, increase thermal comfort appreciably near a window.

During the cooler season, window treatments should be opened during sunny periods of the day; during the night and other times when the sun is not shining, the window treatment should be closed to prevent interior heat from escaping. During the warmer seasons, the use of window treatments can reduce the effects of incoming solar heat considerably. The window treatments should be closed during the sunny portion of the day and opened at night to take advantage of cooler temperatures. Exterior treatments can be more effective than interior treatments. Exterior louvres, shutters, or awnings should be considered in climates where appreciable air conditioning is used. (Figure 40.)

Plans and "do-it-yourself" kits are now available for insulating window shades. Out of wood, polyester batting, and common hardware, you can make attractive shades with an "R-Value" up to 5 and at a cost of only $1.50 to $2.50 a square foot of window space.[42]

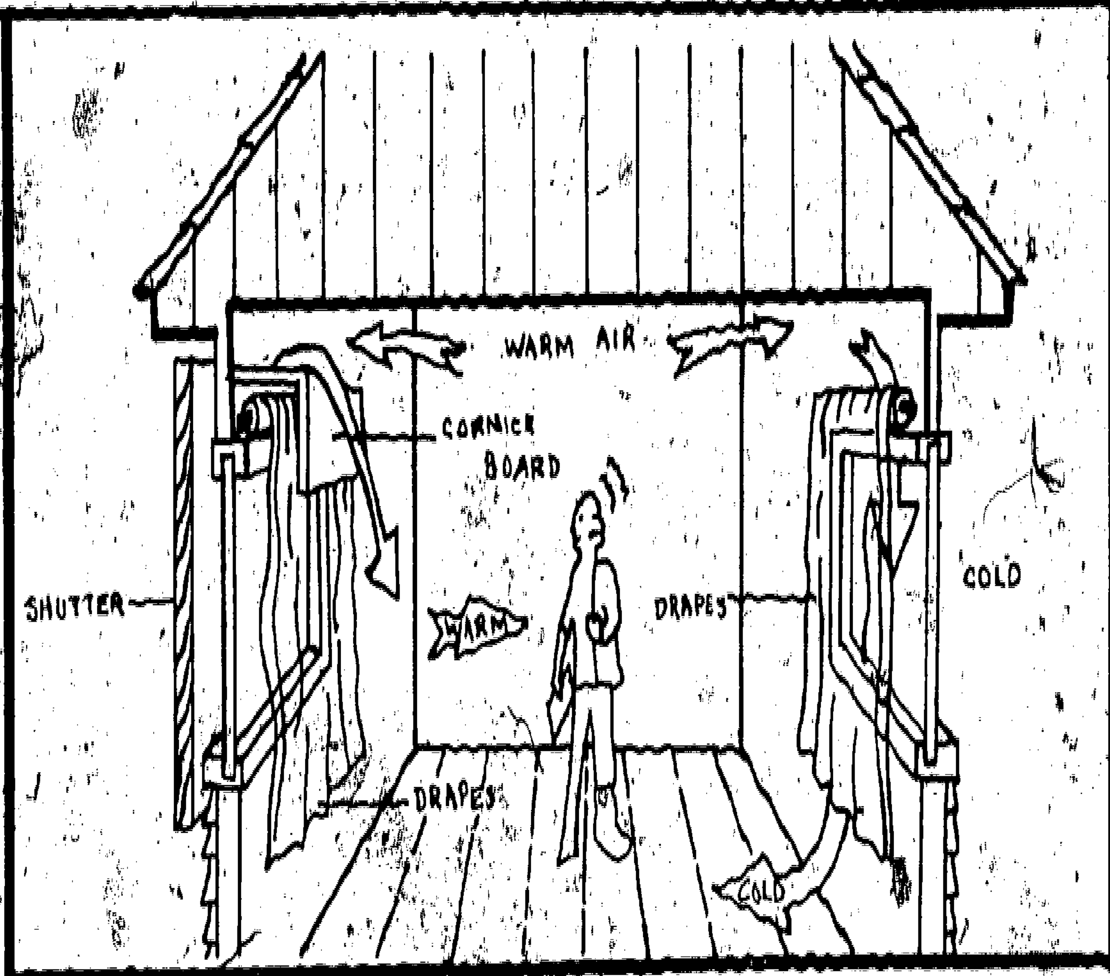


Figure 39. Thermal Effects of Window Treatments.

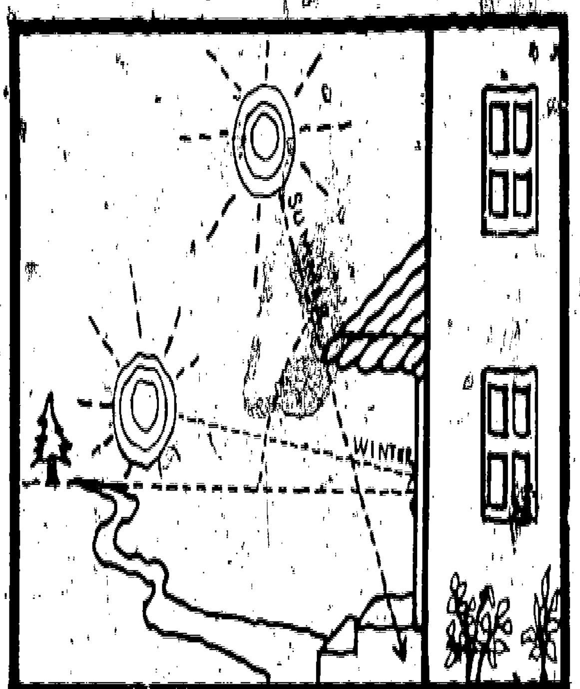


Figure 40. Exterior Window or Door Treatment.

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FOOTNOTES

[1]FEA, "Speaking of Energy...," (Washington, D.C.: GPO, 1975), p. 2.

[2]Victor Olgyay, *Design with Cl*[illegible] (Princeton, New Jersey: Princeton University Press, 1963[illegible] 23.

[3]Ibid., p. 4.

[4]National Association of Home Builders (NAHB), *The Builder's Guide to Energy Conservation* (Washington, D.C.: National Association of Home Builders, 1974), pp. 13-14.

[5]Olgyay, pp. 132-152.

[6]Jeffreye Aronin, *Climate and Architecture* (New York: Reinhold, 1953), pp. 94-99.

[7]*Residential Energy Consumption: Single-Family Housing* (Washington, D.C.: GPO, 1973), p. 32.

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[10]FEA, "Tips for Energy Savers" (Pueblo, Colorado: Public Document Center, 1974), p. 6.

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[20]NAHB, *The Builder's Guide to Energy Conservation*.

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[22]NAHB, *The Builder's Guide to Energy Conservation*, pp. 32-33.

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[24]NAHB, *The Builder's Guide to Energy Conservation*, p. 33.

[25]*Residential Energy Consumption*, p. 56.

[26]NAHB, *The Builder's Guide to Energy Conservation*, p. 15.

[27]*Residential Energy Consumption*, pp. 35-37.

[28]FEA, "Speaking of Energy," p. 70.

[29]*Residential Energy Consumption*, p. 46.

[30]Abt Associates, *In the Bank. . . or Up the Chimney?* (Washington, D.C.: GPO, 1975), p. 68.

[31]NAHB, *The Builder's Guide to Energy Conservation*, pp. 22-25.

[32]Potomac Electric Power Company (PEPCO), "All Year Energy Savings; All Around the House," (Washington, D.C.: PEPCO, [n.d.]

[33]*Residential Energy Consumption*, p. 45.

[34]Ibid., p. 46.

[35]Anthony Adams, *Your Energy Efficient House* (Charlotte, Vermont: Garden Way Publishing, 1975), p. 86.

[36]"Speaking of Energy," p. 9.

[37]Charles G. Ramsey and Harold R. Sleeper, *Architectural Graphic Standards* (6th ed.; New York: John Wiley and Sons, Inc., 1970), pp. 320-321.

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SECTION 4 ENVIRONMENTAL CONTROL

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO BE AWARE OF DIFFERENT TYPES OF ENVIRONMENTAL CONTROL SYSTEMS, THE ADVANTAGES AND DISADVANTAGES OF EACH, PROFESSIONALS AND ORGANIZATIONS WITH HELPFUL INFORMATION, AND WAYS IN WHICH ENERGY CAN BE CONSERVED.

In 1929, the American Society of Heating and Ventilating Engineers defined "comfort air conditioning" as the process of treating air so as to control simultaneously its temperature, humidity, cleanliness, and distribution.[1] This definition still applies today, but has been further refined to include acceptable limits for each of these variables and the addition of a noise level restriction. Comfort air conditioning is referred to in a number of ways: heating and cooling; heating, ventilating, and air conditioning (HVAC); air conditioning and environmental control. Often these terms are used loosely, and do not include control of all the variables mentioned above.

A great deal of residential energy consumption is for environmental control (the Federal Energy Administration estimates nearly 60 percent).[2] Energy could be used more efficiently if environmental control systems were selected and installed more carefully and used and maintained more wisely.

Environmental control usually requires fuel. The common fuels, also called "fossil fuels," are coal, fuel oil, natural gas, and propane. Because the burning of coal results in the formation of considerably more sulfur dioxide, carbon monoxide, dirt, and ashes than its competitors, it is not desirable as a residential fuel.

Residential heating and cooling have experienced a revolution in the past 50 years. In the 1920's, the major source of home-heating fuel was coal. Coal was then replaced by oil. After World War II, the era of natural gas began and in the 1960's electrical installations appeared. With the current energy crunch, the question is "What will be the fuel of the future?" There is no guarantee, but, as oil becomes reserved for transportation and industry, as propane becomes reserved for areas without natural gas, and as natural gas becomes curtailed and prices rise, many believe electricity will play an important role. With the increased production of electricity from nuclear fuel and the increased use of heat pumps and advanced environmental control systems, electricity very well may become the dominant means of heating and cooling homes over the next 30 years.

OBJECTIVE: TO ENABLE TEACHERS OR STUDENTS TO BE AWARE OF DIFFERENT ENVIRONMENTAL CONTROL SYSTEMS, THE ADVANTAGES AND DISADVANTAGES OF EACH.

The choice of a system for a specific home depends on several factors: occupant's personal needs; size and structure of home; fuel available locally and its price; equipment and service available locally. Regardless of the type of system, however, two factors are important for energy conservation: (1) the capacity and efficiency of the equipment; and (2) the distance of transfer from the generating equipment to the point of actual use.

Equipment should not be larger than required. Oversized equipment results in short periods of operation, poor comfort condition, and lower seasonal efficiency.[3] Although the proper size increases efficiency, environmental control systems have inherent unit efficiencies; that is, the work the unit does (Btu's per hour) per unit of energy expended (watt). This is referred to as the Energy Efficiency Ratio (EER) of the unit. The higher the EER number, the more efficient the unit.

Another consideration is the duct or delivery system. The type of duct system depends on the type of structure, equipment location, and layout of the building. Ideally, the furnace or air conditioner should be located near the center of the house to minimize duct lengths. Considerable energy loss can occur along the ducts unless they are carefully insulated. In some cases, room units should be considered since they have no ducts.

Electric Resistance Heaters

Although electric resistance heaters are 100 percent efficient in a house, the overall fuel efficiency is only about 30 percent because of losses in generating and transmitting the electricity.[4]

Electric resistance heaters take many forms: furnaces, baseboard heaters, wall heaters, radiant cable, radiant ceiling panels, and auxiliary heaters (see Figure 41). Electricity is sometimes used as a fuel for forced-air furnace systems. The system may be central or zoned (for example, one furnace for the first floor and one for the second floor of a home). The forced air system requires ductwork which, if properly sized, may be used for air-conditioning as well. The most commonly installed environmental

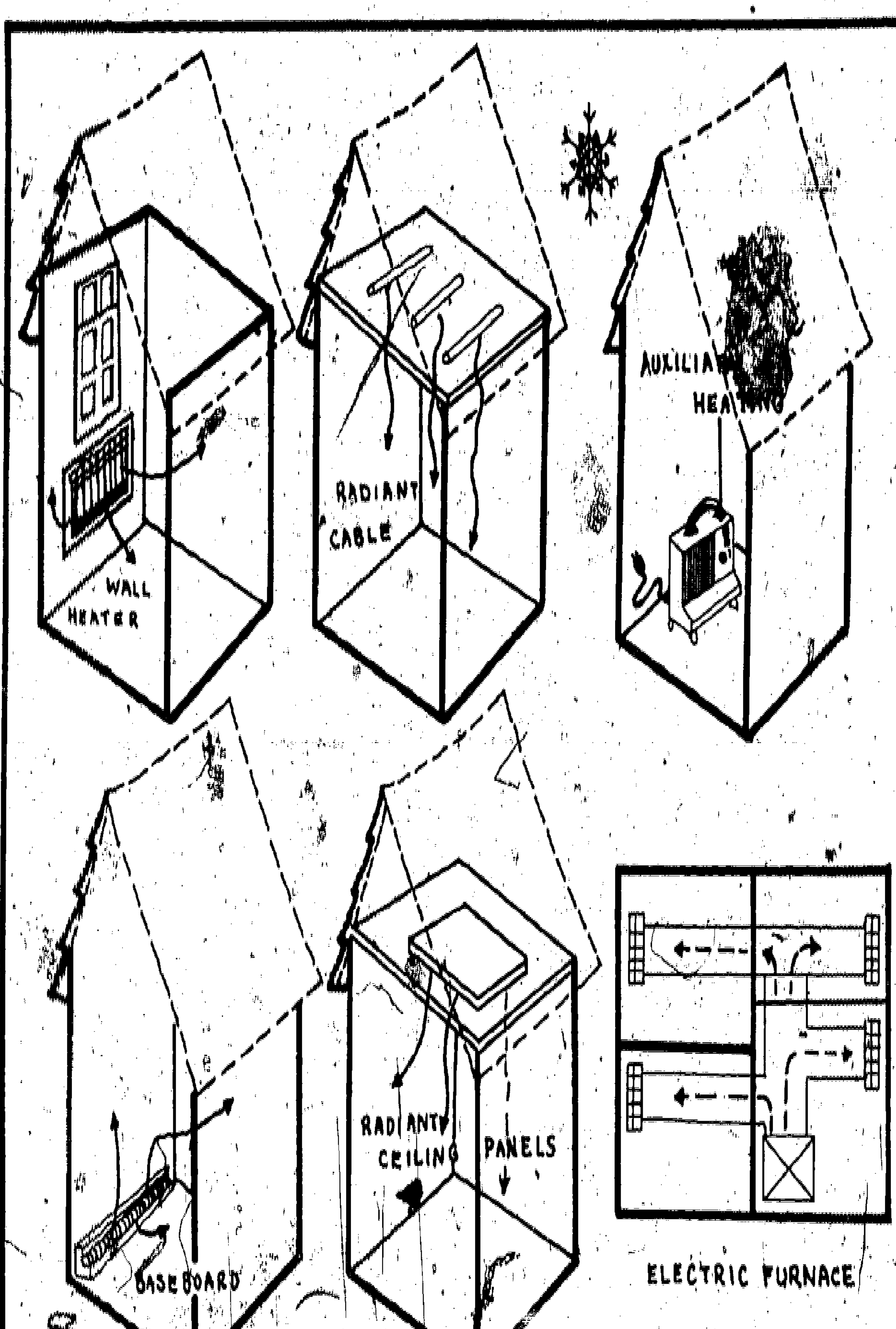


Figure 41. Types of Electric Resistance Heaters.

control systems for new residential construction are split systems which consist of an outdoor condensing unit combined with an indoor cooling coil used with a furnace. Gas, oil, or electric furnaces may be used with split systems.[5] A typical split system is shown in Figure 42. Ductwork can be a source of considerable heat loss unless properly installed and insulated. The forced air system provides central (or zone) heat control, air filtering, and air circulation. This system must be properly maintained for efficiency by changing or cleaning filters frequently. Additional equipment may be easily installed in the system such as: electronic filters, humidifiers, and air conditioners.

Baseboard heaters provide heat by convection from strip electric heaters placed at floor level along outside walls. The heat circulation must not be disturbed by the furniture or window treatments. Its advantages include easy and quick installation in new or existing homes and individual room control.

Wall heaters provide radiant heat and heat by convection. The units should be placed on an outside wall. Due to high temperature, units should not be located close to draperies, furniture, or inside doors. These units also present a hazard to children. The advantages are individual room control and use where heat is required only occasionally.

Radiant cable heat provides radiant heat from cables embedded in ceilings or floors. Its major advantages are virtually no maintenance, silent operation, individual room control, and complete invisibility.

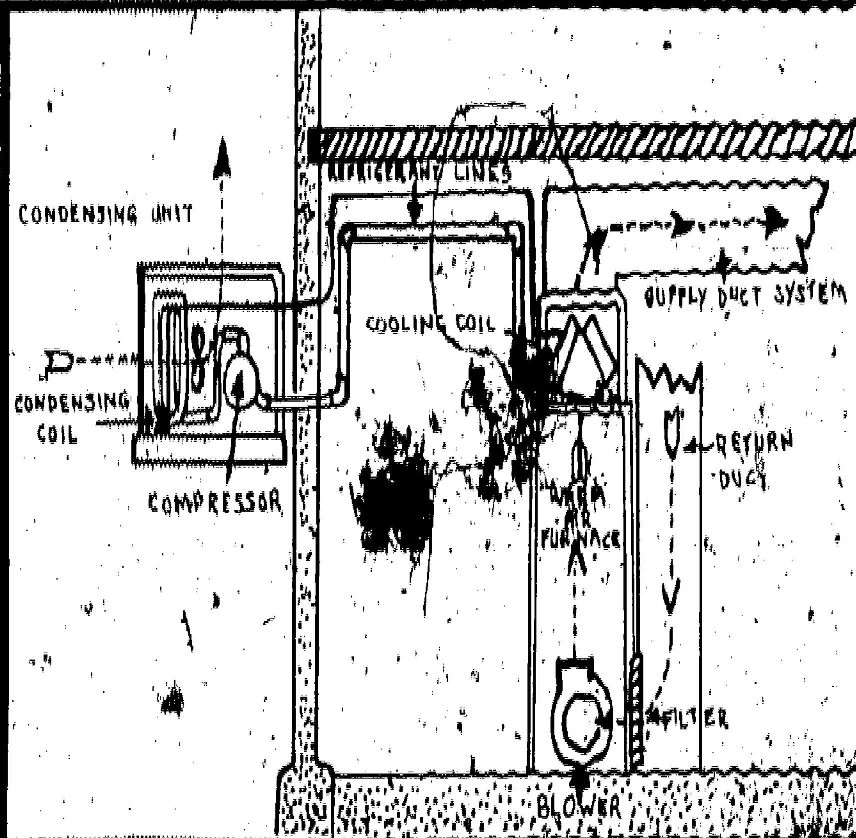
Radiant ceiling panels provide radiant heat [illegible] wire embedded in panels which are flush with or suspended [illegible] the ceiling. Its major advantages are that it may be used for the entire house or a specific area for supplemental or regular heating; it also allows for individual room control and easy installation in new or existing homes.

Auxiliary or portable heaters should be used only where temporary heat is needed or where permanent installations may be impractical. The main advantage is portability. Although portable heaters are efficient, their light weight creates the possible hazard of being tipped over by children or pets. Many portable heaters are provided with "tip-over" switches. A good auxiliary heater will have passed the rigid safety standards of the Underwriters' Laboratories. (Look for the UL symbol on the heater itself).

Air Conditioners

Since World War II, the American people have looked increasingly at air-conditioning as a necessity, not a luxury.[6] A great deal of research has been done over the years to determine the most practical device for air conditioning homes. Presently, the compressor-type unit is most practical. Compressor units may be utilized in different ways in the home: a central system, through-the-wall, or window unit (see Figure 43).

Figure 42.
Typical Split System.



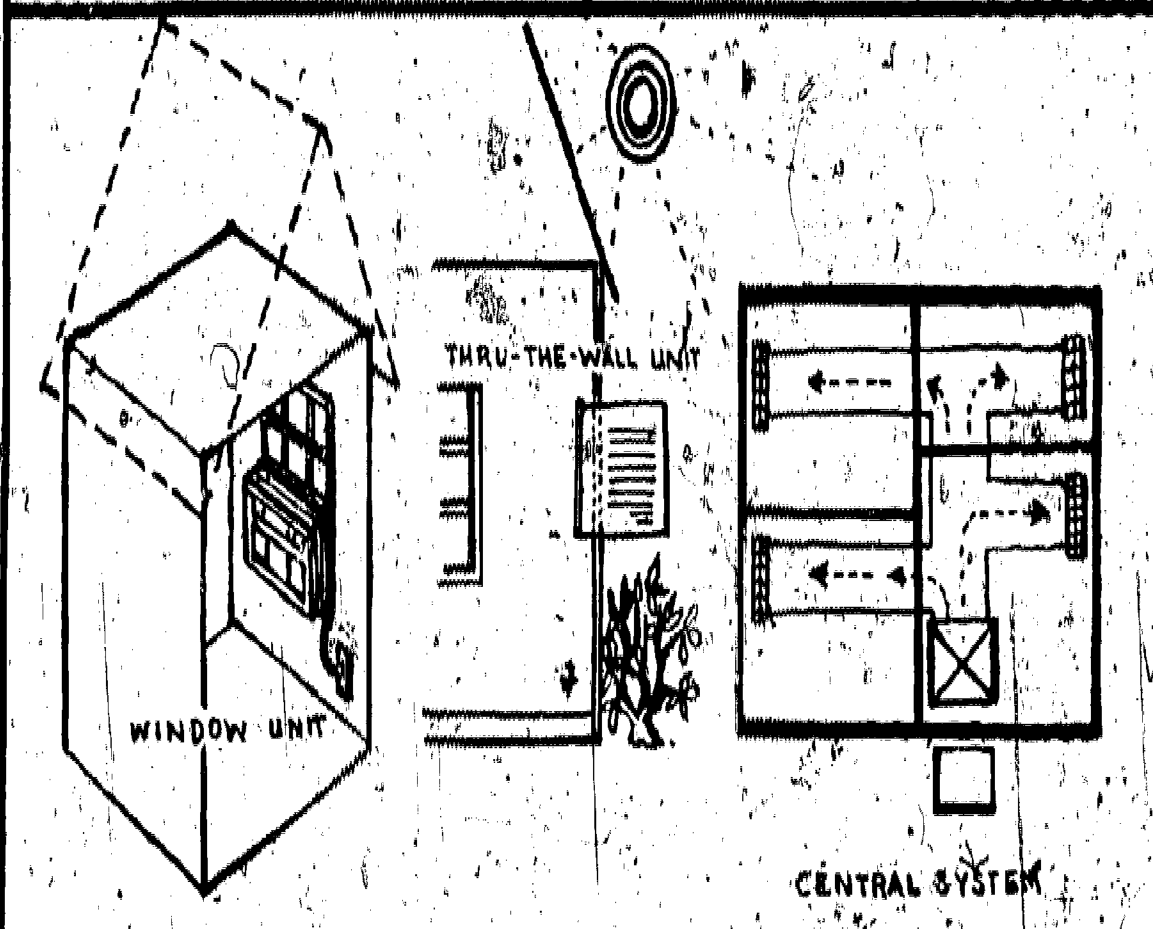


Figure 43.
Types of Air
Conditioners.

Each system cools, dehumidifies, and filters the air. A central system distributes cool air through a duct system to every room. The same ductwork may be used for heating and cooling provided the ductwork is properly sized. Air conditioning ducts must be larger than ducts used solely for heating. A central system more efficiently cools an entire home than several window or through-the-wall units; however, a great deal of energy may be wasted if the ductwork is not properly insulated. In many cases, it is difficult and costly to install a central system in an existing home.

The through-the-wall unit can be installed in new or existing homes. It should be placed as high on an outside wall as practical. Due to the limited source of cool air, uneven cooling throughout the home may occur.

The window unit may be inexpensively installed in any home where adequate wiring is possible. The units have limited capacity and several may be required to cool an entire home. If only one room is to be cooled, a window unit is sufficient and often preferrable to a central system.

All air-conditioning units should be shielded from direct sunlight. Placement of units on the north side of the home is usually best. Air conditioners should be sized to hold inside temperatures at 75°F when outside temperature reaches 90°F. Experienced air-conditioning dealers, contractors, and industry-related professionals can size units for specific needs.

In addition to proper capacity, air conditioners should be selected for their performance. A higher performance unit will give considerably greater efficiency. Check the unit's EER rating as well as its capacity. Many manufacturers give the EER value for their unit. The Air-Conditioning and Refrigeration Institute (ARI) publishes a *Directory of Certified Unitary Air-Conditioners, Unitary Heat Pumps, Sound-Rated Outdoor Unitary Equipment, and Central System Humidifiers* which lists EER's for each unit.[7] The EER for air conditioners ranges from 4 to 12. If the EER number is not given, it can be easily calculated as shown below:

$$EER = \frac{Btu/hr}{Watts}$$

Example A: Comparing two 36,000 Btu air conditioning units:

#1 requires 7200 watts #2 requires 4500 watts

$\#1\ EER = \frac{36,000}{7,200} = 5$ $\#2\ EER = \frac{36,000}{4,500} = 8$

#2 is more efficient.

Example B: Comparing a 45,000 Btu unit requiring 5000 watts to a 36,000 Btu unit requiring 4500 watts:

$$\#1\ EER = \frac{45,000}{5,000} = 9 \qquad \#2\ EER = \frac{36,000}{4,500} = 8$$

#1 is more efficient, but do you need 45,000 Btu/Hr? If you only needed 36,000 Btu hr, the #2 unit might prove to be more efficient in actual use since #1 would be oversized for the job.

It is not a simple matter to properly size an air conditioning unit. There are subjective as well as objective factors to be considered. When installing a central system, a reputable air-conditioning contractor should be consulted. The contractor or an air conditioning engineer will carefully calculate the required cooling load of the home using American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) criteria and calculations. He will also consider such subjective concerns as the amount of shade on the home, the number and age of the occupants, the insulation of the home, the amount and orientation of windows, and the financial means of the occupant.

A rule of thumb (which should only be used as a check on calculations and to avoid gross errors) for sizing residential central air-conditioning units is:

For a "normal" house (eight-foot ceilings, insulated, no more than 20 percent of wall area glass):*

12,000 Btu/hr. or 1 ton for every 500 to 600 sq. ft. of floor space.

For a house with extremely high ceilings or excessive glass area or poorly insulated:

12,000 Btu/hr. or 1 ton for every 350 to 400 sq. ft. of floor space.

*This "rule of thumb" for a "normal" house may change for "tomorrow's" house, if homes become better insulated and their occupants practice energy conservation habits.

When purchasing a through-the-wall unit or window unit, the consumer must usually rely on the salesperson's recommendations. Due to the lack of distribution, several units are usually needed to cool an entire home; however, one unit can be used for spot cooling such as a living area. A two-ton or 24,000 Btu/hr unit would probably be required to spot cool a living area with a through-the-wall or window unit. For complete home cooling, as many as five units may be required with a total tonnage in excess of 60,000 Btu/hr.

Heat Pump

As homes increasingly use electricity for heating and cooling, the heat pump offers an important opportunity to conserve energy, especially compared with "electric furnaces." If electricity is used for both heating and cooling, heat pumps should be considered. The initial cost of a heat pump is slightly higher than a conventional electric resistance system, but it uses about 50 percent less energy.[8] Heat pumps are especially efficient in mild climates where heating and cooling requirements are roughly equal. The heat pump works as a standard air conditioner for cooling and as a reverse air conditioner for heating; that is, it absorbs heat from the outside air and "pumps" the heat into the house.[9] (See Figure 44.)

There can be some disadvantages in using heat pumps. First, since heat pumps provide both heating and cooling, their use may become uneconomical unless both are needed. Secondly, the efficiency of heat pumps varies with the climate. The EER value for a heat pump is given for optimum operation of steady state at full load; the actual seasonal performance will usually be less. The National Bureau of Standards reported a 20 percent drop in the actual efficiency from the steady state EER for a typical residential heat pump operated in the Washington, D.C., area.[10]

One big advantage of electric heat pumps is that they do not need to exhaust air since no combustion occurs. This greatly decreases the amount of fresh air otherwise required in the house, thus reducing heat loss and gain from infiltration.

Oil Furnaces

Fuel oil for homes comes in two grades. Number 1 oil is burned primarily in pot-type burners. Number 2 oil, which is heavier and more efficient, is used in gun burners. The burners are used in a furnace or boiler from which heat is transferred to the rooms of the house by pipe (water) or duct (air). It is usually a central or zone system.

The efficiency of the system is diminished if the oil does not burn properly. The oil filter should be cleaned regularly and the oil nozzle should be checked and cleaned every year. If the nozzle becomes clogged or sooty, unstable combustion occurs which reduces efficiency, soils the equipment, and creates a safety hazard.

Gas Furnaces

Gas furnaces are another variation of central heating systems. Natural gas and liquified petroleum gas (LPG, propane) stored in a tank outside the home are the most commonly used home fuel gases in this country. Natural draft gas burning furnaces or boilers must pass rigid tests by the American Gas Association and have a unit efficiency of at least 75.[11] Forced draft gas furnaces, which are available but not marketed, could be 85 percent

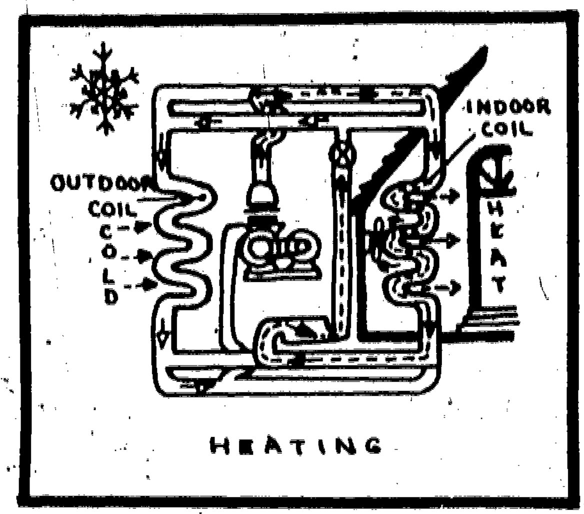
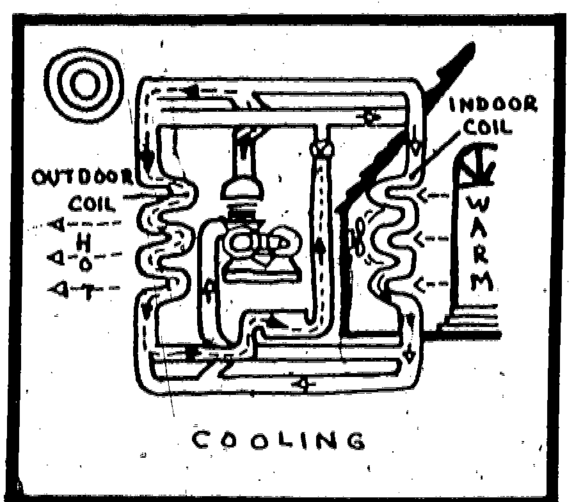


Figure 44.
Heat Pump for
Heating (above) or
Cooling (below).



efficient. This efficiency measures only the energy conversion efficiency of gas into heat. (This is different from EER.) Little can go wrong with a gas burner once it is properly adjusted. Problems that arise should be left to competent servicemen.

The energy waste problems associated with other central systems (duct loss; infiltration loss such as that created by the use of outside air for the process of burning and exhaust; equipment loss; and cyclic loss) are also inherent with gas, but, in addition, gas furnaces consume up to 10 percent on pilot lighting.[12] This loss could be avoided through the use of an electric ignition system, or reduced by turning off the pilot during non-heating seasons. Heat losses for a gas control system are shown in Figure 45.

Coal Furnaces and Stoves

Although coal is less efficient and dirtier than other residential heating fuels, it is still in use in many areas of the country, particularly in rural areas and older homes. A stoker-fired coal furnace has an overall efficiency of around 65 percent.[13] A great deal of heat is lost up the chimney. Coal should be allowed to burn slowly since the heat from a roaring fire goes up the chimney before it can be used.[14] A heating stove has the advantage that heat lost from the stove and flue pipe is directly recovered by the room being heated; however, heat is still lost out the stack.

Coal furnaces or heating stoves must be cleaned each year. The flues and chimneys must be cleaned as well. This job can be done by the occupant or a professional. As the system is cleaned, check for joint leaks. Duct tape can be used to seal pipe joints.

A small stove can be a low-cost way of getting some extra heat. Small flat top stoves, "chuck stoves," "tin stoves," "Dover stoves," or "Warm Morning heaters" are available at varying costs. The recent rise in sales and prices for second hand stoves indicates an increase in their use.

Humidifiers and Dehumidifiers

During the heating season, the relative humidity of homes is normally low. (See Figure 46.) The low moisture content increases the likelihood of static electricity sparks, itching, throat and nasal irritation, and body moisture loss creating a cold feeling. If moisture is added by a humidifier, comfort may be achieved at a considerably lower inside temperature. For example, with a relative humidity of 10 percent, comfort cannot be achieved even at 80°F. Humidifiers may be attached to central forced air systems or a portable humidifier may be used. Although the permanent humidifier services the entire house, a portable model can work just as well if the house has adequate air circulation. A portable model is less expensive, but may not have an automatic water refill or control. The savings resulting from the reduced room temperature through the use of

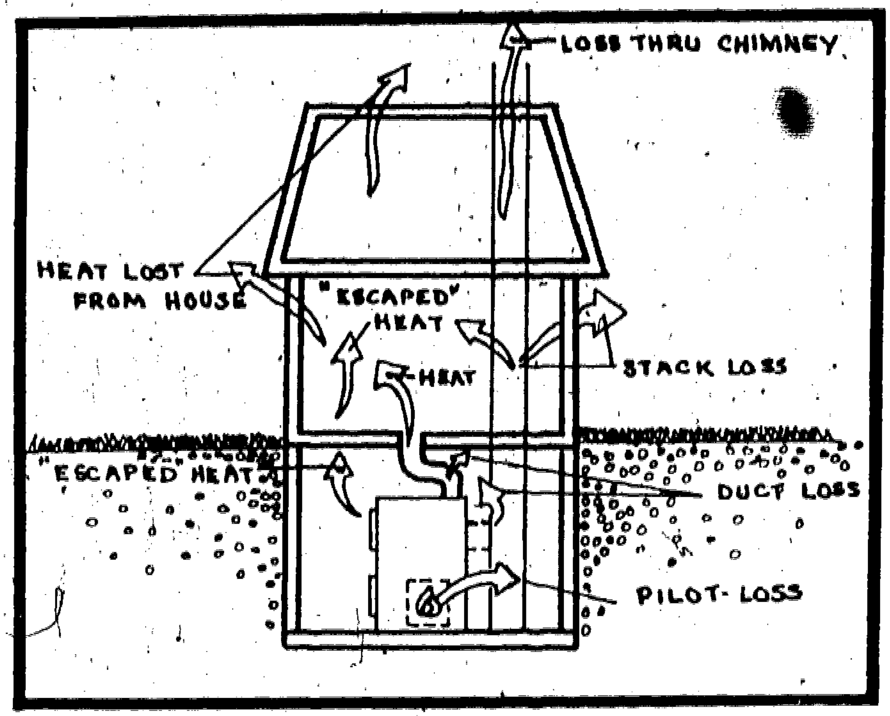


Figure 45. Gas Furnace Heat Losses.

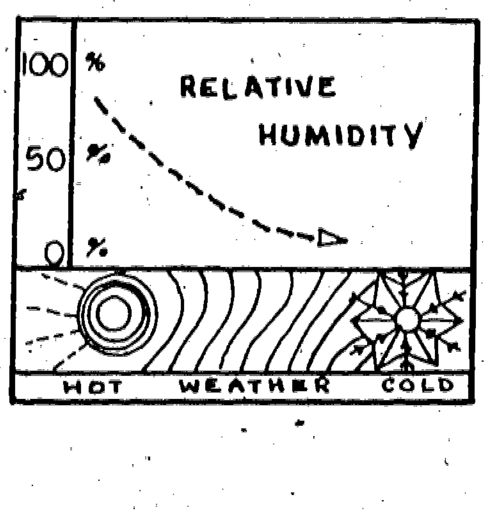


Figure 46. Relative Humidity.

humidifiers can amount to eight percent of the total annual fuel cost for a home.[15]

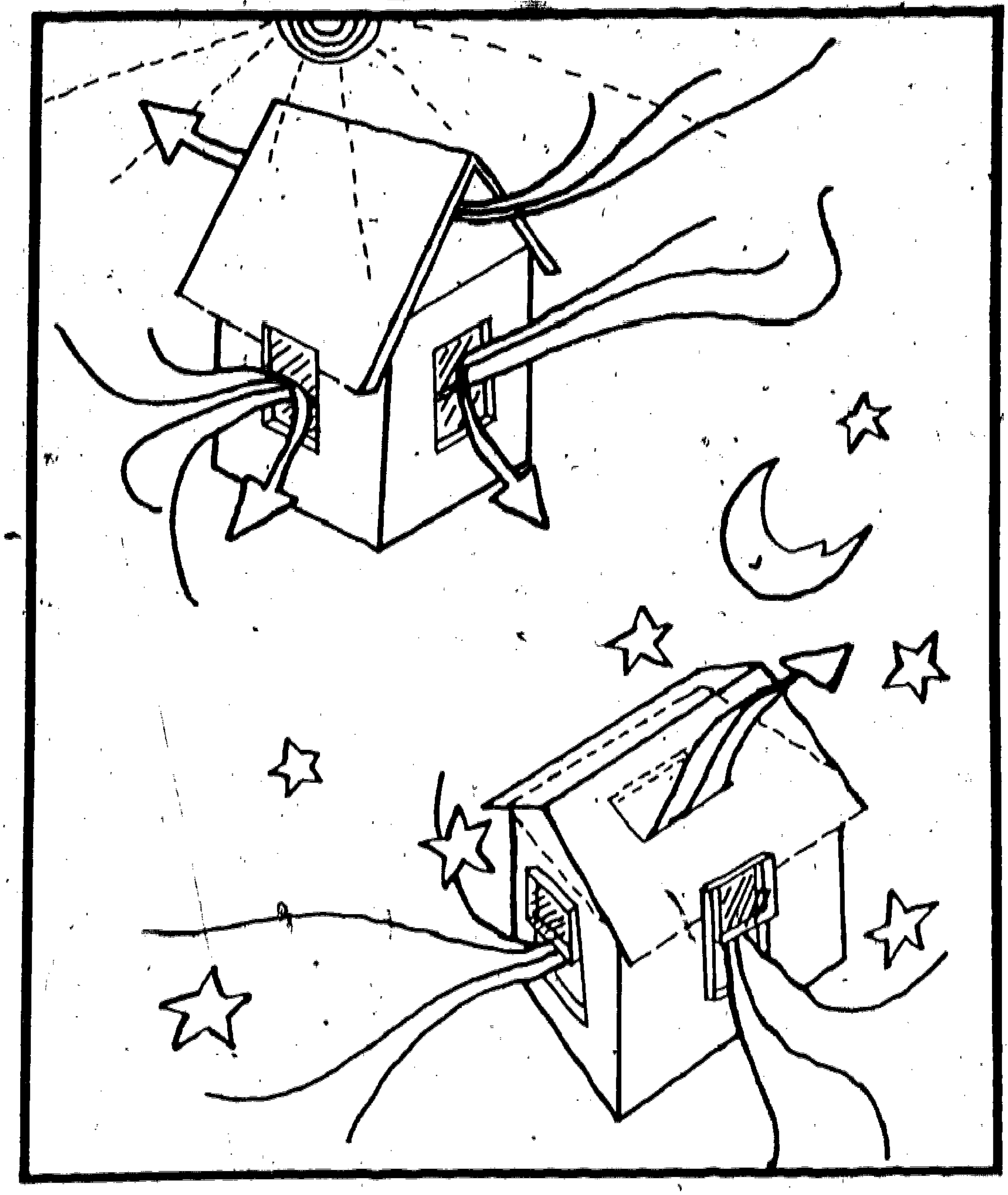
During the cooling season, the relative humidity is generally too high for comfort (except in arid regions). At a relative humidity of 85 percent, a temperature below 70°F is required for comfort; however, at 30 percent relative humidity, a temperature of 82°F will be within the comfort zone. Under extreme conditions, interior furnishings will mold or rust, and occupants will experience great discomfort. A mechanical air conditioner reduces relative humidity; however, a dehumidifier may be needed in excessively humid climates or for specific areas such as basements, laundry rooms, baths, or kitchens. A dehumidifier may be installed in the central air conditioning system or a portable dehumidifier may be used for a specific area. Kitchen ventilating fans may also be controlled by a humidistat to control excess water vapor. The advantage of the built-in system is that it evenly dehumidifies air in the home. However, a portable unit is less expensive and can be placed near the source of the excess water vapor.

Natural Ventilation

In many parts of the country, it is possible to maintain indoor comfort during much of the year without mechanical heating or cooling. It is practical in many areas to take advantage of the daily temperature cycle. The outside air may be as much as 35 degrees cooler at night than during the day.[16] In warmer seasons, open the windows and attic vents to permit night air to enter the house and close up the house in early morning. Do the reverse in the cooler seasons, but remember in both cases to make sure the air conditioner or furnace is not running when windows are open! (See Figure 47.)

Many older homes were designed with features for promoting natural ventilation and some new houses are again incorporating these ideas. Other than through the addition of attic fans, it is difficult to convert an existing house to take advantage of natural ventilation. Houses which foster natural comfort control take advantage of solar orientation, have properly sized and located openings, and minimize internal and external heat gain.

When ventilating a house in warm weather, air should be drawn in low from the coolest side of the house. Warm air should be expelled through the attic or high windows. A ventilator fan can be installed to increase the movement of air through the house. Slight air movement also aids in providing comfort through evaporation.



During Warmer Seasons.

Figure 47. Natural Ventilation Cycle.

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO BE AWARE OF THE ROUTINE MAINTENANCE REQUIREMENTS OF TYPICAL ENVIRONMENTAL CONTROL SYSTEMS AND THEIR EFFECTS ON EFFICIENCY.

Improper maintenance can significantly reduce the efficiency of heating and cooling equipment and may even damage it. The housing occupant should become familiar with the equipment to the degree that routine maintenance, safety checks, and cleaning can be done. The occupant should obtain operating manuals for all environmental control equipment or consult a dealer or contractor to determine the routine maintenance required. The local utility company can also provide information.

In general, the major areas of concern are the filters, heat exchangers, and burner adjustments. In forced air systems, filtration is accomplished by disposable or cleanable air filters. These filters should be examined regularly and replaced or cleaned when necessary. The air circulation through the furnace or air conditioning unit can be reduced or even blocked by clogged filters. When this happens, the heat transfer is reduced and can seriously reduce the efficiency of the unit. In some cases the furnace may overheat and cause damage; or the air conditioning unit may ice over. In a clean house (with no long-haired animals or shedding rugs), the filters should be checked seasonally. In homes where there is material to clog filters, checks should be made every 30 to 60 days.

If filters are not properly maintained, dust and lint will not only cause loss of energy and performance but will also reach the heat exchanger, or cooling coils. This creates a more serious problem since the build-up actually acts as insulation and prevents the efficient transfer of heat between the unit and the air. As a result, the unit will be less efficient. It is also difficult to clean or reach the heat exchanger. If it becomes soiled, a serviceman may have to be called to clean it. Grass, dirt, and soil may be brushed or hosed off outdoor condensing coolers or air conditioners. However, one should remember that the heat exchange surfaces are fragile and can be bent and damaged easily. To aid in maintaining a clean efficient unit, all grass, dirt, and dust should be kept away from both indoor and outdoor units.

Oil filters (filters in the oil line) must be changed or cleaned periodically and the burner adjusted and examined at least once a year. There are very few maintenance requirements for oil or gas furnaces other than filters. However, a professional serviceman should be called at any sign of trouble.

In addition to the steps already mentioned, several tips for improved maintenance are given below:

1. Dust radiators and wall or baseboard units frequently.
2. Don't store a'lot of junk around furnaces or air-conditioners.
3. Keep draperies and furniture away from vents, thermostats, and equipment.
4. Don't allow vegetation to surround or impinge on outdoor equipment.
5. Do not abuse the equipment--call a serviceman.

UNIT 4.3 THERMOSTAT

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE WAYS TO CONSERVE ENERGY THROUGH THE PROPER USE AND PLACEMENT OF THERMOSTATS.

A significant savings in heating and cooling costs can be achieved through proper use and placement of thermostats. In a study sponsored by the National Science Foundation and the Energy Research and Development Administration, it was shown that very minor reductions in thermostat settings (from [illegible] to 68 degrees) in all U.S. homes during the heating season could result in a savings of [illegible] percent of the nation's total energy consumption. Additional nighttime setbacks to 55 degrees could bring the total savings to [illegible] percent of the nation's total energy consumption.[illegible]

Nighttime setbacks can be made manually or a clock actuated device can be added to central systems. The clock actuated thermostat automatically changes the thermostat between two settings at predetermined times, permitting the temperature to be automatically reduced at night. The device costs approximately $[illegible] and is easily installed on existing systems.[illegible] An electric blanket may add comfort when practicing nighttime setback, but don't let it remain on when not in use. (See Figure 4[illegible].)

The Federal Energy Administration predicts that setting thermostats no lower than [illegible] degrees could result in reductions in home cooling costs up to [illegible] percent.[illegible] The National Bureau of Standards [illegible] increasing the thermostat setting during peak cooling [illegible] periods which may reduce costs [illegible] percent or more.

Although the savings vary from area to area, in general a reduction in the thermostat setting for heating results in a savings of approximately three percent for each degree. Each degree of increase in the thermostat setting for cooling results in a savings of approximately five percent per degree.[illegible] The [illegible] setting for the heating season is [illegible] degrees. (See Figure [illegible].)

In addition to thermostat settings, the proper location of thermostats affects energy consumption. The [illegible] location should allow the instrument to sense temperature [illegible] representative of the entire area to be heated or cooled. In general, thermostats should be located on an interior wall away from drafts, [illegible] sunlight, and fireplaces. [illegible] should not [illegible] the thermostat.

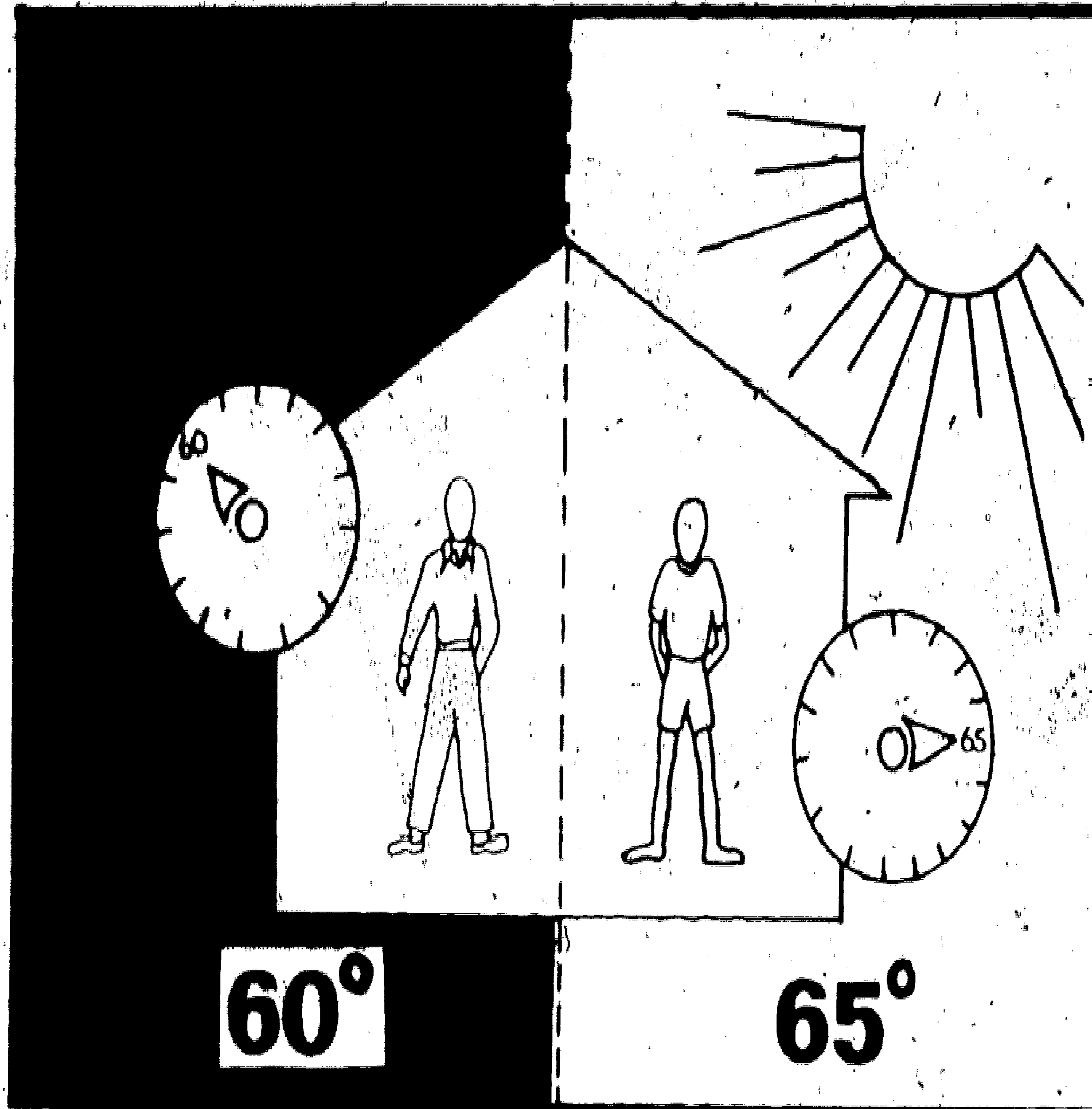


Figure 48. Nighttime Thermostat Setback.

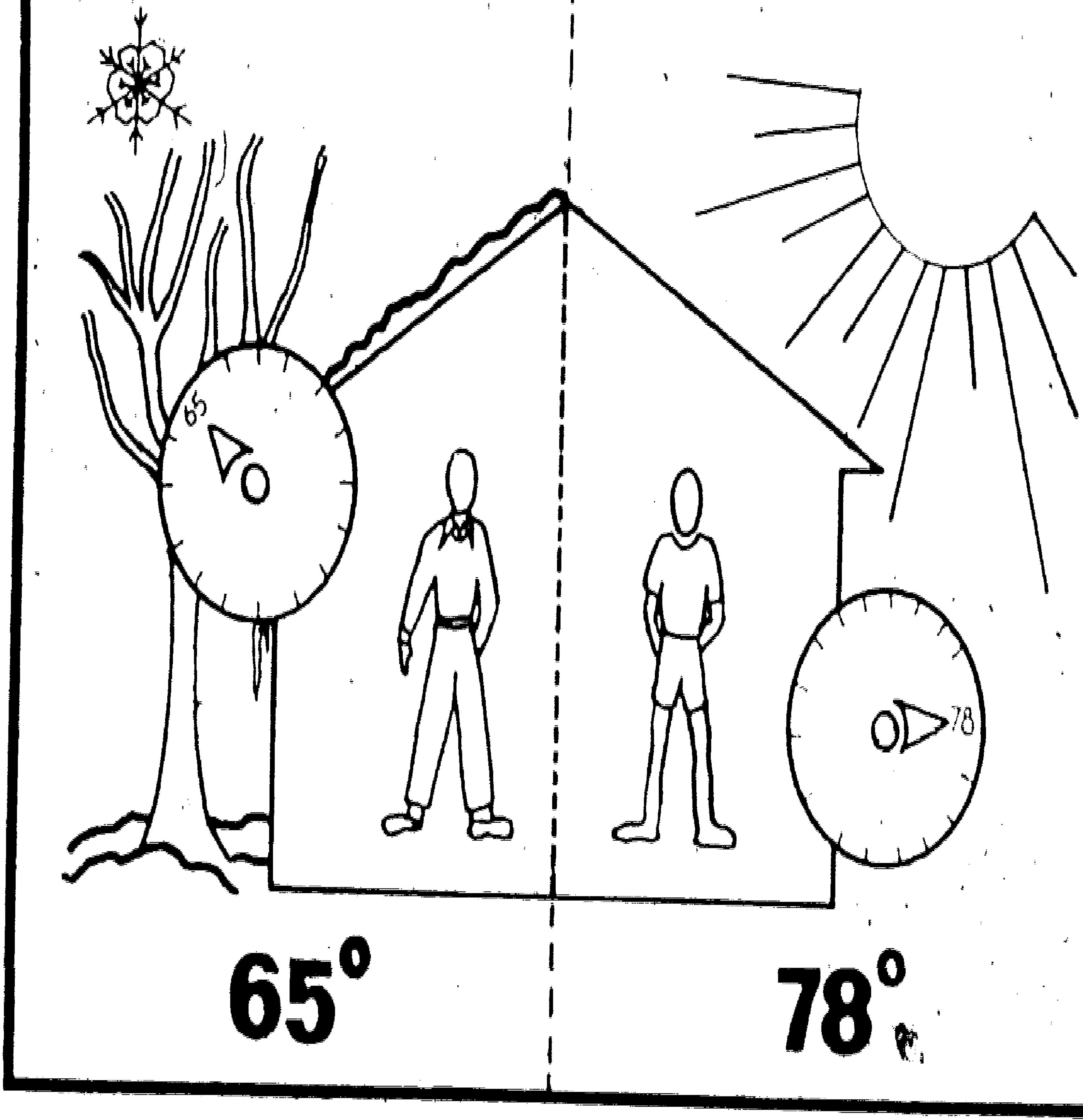


Figure 49. Seasonal Thermostat Settings.

In many cases a single thermostat is not sufficient. Zone control--independent temperature control for each area to be heated and cooled with appropriate distribution control (components to direct water or dampers to direct air)--has several advantages. First, fuel can be saved since only those areas occupied are heated or cooled. Second, quicker response to temperature change is possible. And finally, comfort in sleeping and living areas can be individually controlled for desired temperatures. Tests have shown that zoning can achieve energy savings of at least 20 percent.[22]

[SEE ACTIVITIES G and H.]

OBJECTIVE: TO ENABLE TEACHERS AND STUDENTS TO RECOGNIZE HOW ENERGY COULD BE CONSERVED THROUGH MORE EFFECTIVE DESIGN AND USE OF RESIDENTIAL WATER HEATERS.

After space heating and cooling, water heating is the largest consumer of energy in the home. As much as 15 percent of residential energy is used for water heating and this accounts for three percent of all the energy used in the United States.[23] A substantial energy savings is possible through the improvement of water heating equipment, efficient operation, and conservative consumption practices.

Approximately 25 percent of the energy consumed for residential water heating could be saved by the replacement over a period of years of existing water heaters with more efficient, better insulated heaters.[24] (The average life of a water heater is 10 years.)

In 1970, natural gas water heaters accounted for 55 percent of residential water heaters; electric for 25 percent; and oil for about 10 percent.[25] There has been a shift toward electric water heaters since 1970. Electric water heaters are considerably more efficient in terms of energy used in the home (at point of use) as can be seen from the table below:*

Water Heater	% Total Heat Input	% Heat Lost Through Tank Surface	% Heat Lost Up Flue: Burner Firing	% Heat Lost Up Flue: Pilot Light[a]	% Net Usable Heat
50-gallon electric	100.0	21.2	--	--	78.8
40-gallon gas/LPG	100.0	35.0	12.0	7.6	45.5
40-gallon fuel oil	100.0	35.0	13.5	8.0	43.5

[a]Assuming a 750 Btu/hr pilot and efficiency of heat transfer to the water of 70 percent for gas/LPG units and 67 percent for oil units.

Source: *Residential Water Heating: Fuel Conservation, Economics, and Public Policy*. Prepared for the National Science Foundation by James J. Mutch, R-1498-NSF, Rand Corporation, Santa Monica, CA. May 1974.

*The overall fuel system efficiency of electricity is less than gas and oil due to losses in generating and transmitting electricity.

The table also indicates possible areas for conservation measures. For electric water heaters, tank insulation is indicated. For gas and oil water heaters, not only is insulation indicated, but also some method for reducing flue losses.

The most effective way to increase water heater efficiency is through the addition of insulation. If insulation (3 inches of thermal insulation) were added to water heaters now in homes, the use of electricity for heating water could be reduced by as much as eight percent (one percent of total residential electricity consumption).[26] Tank insulation becomes more cost-effective as fuel prices rise. At a cost of four cents per kilowatt hour for electricity, six inches of insulation (owner-installed) would save $4.90 per year. It would be impractical to install even two inches of insulation if electric prices were one or two cents per kilowatt hour. At 40 cents per therm for natural gas, four inches of insulation would save $10.70 per year; at 40 cents per gallon for fuel oil, four inches of insulation would save $6.60 per year.[27] Although the addition of insulation to existing water heaters is beneficial, the cost effectiveness of factory installed insulation is much greater.[28]

Hot flue gas losses are the major cause of inefficiency in gas or oil water heaters. There seems to be no practical way to reduce this loss appreciably in existing water heaters; however, factory installed automatic dampers and increased heat exchange surfaces within the heater may provide for increased efficiency.[29]

The drop in efficiency as the result of pilot lights in oil and gas water heaters may be alleviated by improved technology of an electric ignition system (similar to the one utilized by gas clothes dryers). However, the heat produced by the pilot light is not lost; it actually helps maintain the water temperature so that the main burner does not have to operate as frequently.

Another factor which greatly affects the energy consumption of water heaters is the thermostat setting. The higher the setting, the more difficult it is to maintain the water temperature due to the relatively lower surrounding air temperature.

Water heater thermostats are preset at the factory often as high as 150°F.[30] Normal household heated water use requires 140°F; however, if the water heater services only baths, a temperature of only 110°F is sufficient.[31] Check to determine if the thermostat is set properly. Most residential water heaters allow a temperature selection between 110°F and 160°F. The Rand Corporation has predicted as much as a nine percent savings for electric water heaters and 15 percent for gas or oil if thermostats were reduced from 140°F to 110°F.[32]

Hot water pipes are another source of heat loss. This loss can be reduced by the following measures: (1) reducing pipe size; (2) adding insulation; (3) making pipe runs as short as possible; (4) reducing water temperature; or (5) providing two systems (one at 110°F for washbasins, baths, and showers and another at 140°F for dishwashing and laundry).

The practicality of these measures would depend on fuel costs, consumption practices and structure of the home. Piping runs can be reduced by installing the water heater as close as possible to areas of greatest use such as washers and baths.

It is especially important to insulate hot water pipes which run through cold areas such as basements and garages. Also, insulated pipes reduce "warm up" time.

Other practices may also reduce the energy consumed for water heating. When not required for extended periods (such as during vacations away from home), water heaters should be turned off. Timing mechanisms may be installed to automatically shut down the water heater during periods of little or no use.

Water heaters should be properly sized. An oversized unit wastes energy heating unneeded water. It is commonly assumed that a typical family consumes 50 gallons of hot water a day or 75 gallons if an automatic washer is used.[33] However, additional research is needed to verify these estimates. Quick recovery units tend to encourage greater use of hot water since an unlimited supply is available. Consequently more energy is consumed. It should also be noted that quick recovery units require more energy per unit of water heated.[34] Remember, a leaky hot water faucet or pipe wastes energy as well as water. A leak of one drop per second will amount to 650 gallons in a year's time![35]

If solar water heaters were widely adopted, the energy savings potential for water heating would rise dramatically. Solar energy can be utilized to heat water in homes. Electrically boosted solar water heaters are available today and are practical where fuel costs are high and solar conditions favorable. In the solar-electric water heaters, which use electricity to provide hot water during extended cloud cover periods, the collector surface may be sized and designed to provide any amount of hot water.[36]

The table on the next page summarizes the effectiveness of several measures to reduce thermal losses from water heaters and reduce their energy consumption.

[SEE ACTIVITY I.]

Alternative Measure	Extent of Measure	Type of Water Heater	Fuel Price Necessary to Justify	Percent Reduction In Annual Fuel Use
Increased tank insulation	4 inches to 7 inches	electric	1¢ to 4¢/kwh	8.2 to 11.0
	3 inches to 5 inches	fossil fuel	10¢ to 40¢/therm	21.6 to 25.0
Lower hot water temperature	per 10°F reduction	electric	(a)	4.5
		fossil fuel	(a)	5.8
Hot water plumbing insulation	per 25 ft. of exposed tubing	electric	3.5¢/kwh	1.6
		fossil fuel	70¢/therm	1.6
Automatic water shut down	during periods of non-use	electric	15¢/kwh	0.2
		fossil fuel	90¢/therm	0.6

NOTE: Percentage reductions in fuel use are not directly additive.

[a] Lower hot water temperature is economically justified at any fuel price since it requires no additional investment.

Source: *Residential Water Heating: Fuel Conservation, Economics, and Public Policy.* Prepared for the National Science Foundation by James J. Mutch, R- 1498-NSF, Rand Corporation, Santa Monica, CA., May 1974.

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THE NEED FOR DUCT AND HOT WATER PIPE INSULATION.

In many central environmental control systems, the conditioned air is circulated to rooms through attics, under floors, or through other non-insulated spaces. Since ducts lose heat in winter and gain heat in summer, they should be insulated with an installed thickness of at least one inch of board type or 1.5 inches of wrap-on, good fibrous insulation or the equivalent.[37] (See Figure 50.) As much as 40 percent of the heating value of fuel may be lost through the ducts of a forced hot air system if the ducts are uninsulated or leak.[38] Some of the duct loss is regained by the house, but a significant amount is not.

Air-conditioning ducts located in attics are subject to temperatures ranging from 120 to 140 degrees on hot sunny days.[39] It is customary to insulate inside the duct (approximately one inch thick), but additional insulation is needed on the outside. In a very hot sunny area, as much as two additional inches would be a worthwhile investment. Remember that adequate natural ventilation can keep attic temperatures below 120 degrees.

It is also wise to insulate hot water pipes, particularly if they run through non-insulated areas. The heat loss from hot water pipes reduces the available water temperature, thus extending "warm-up" time and increasing consumption. During warmer seasons, the heat loss from hot water pipes creates an additional load on space cooling equipment. In cooler weather, non-insulated pipes are more likely to freeze. It is cost-effective to insulate hot water pipes with one to two inches of fibrous insulation.

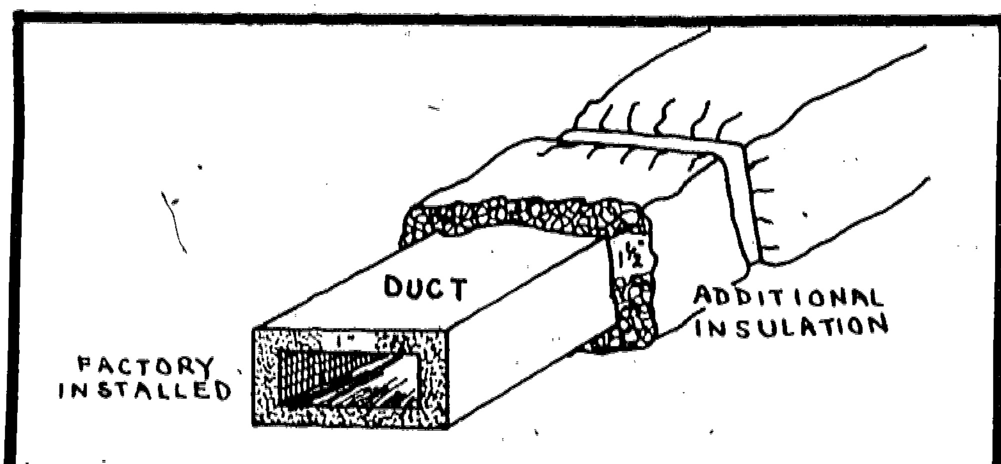


Figure 50 Duct Insulation.

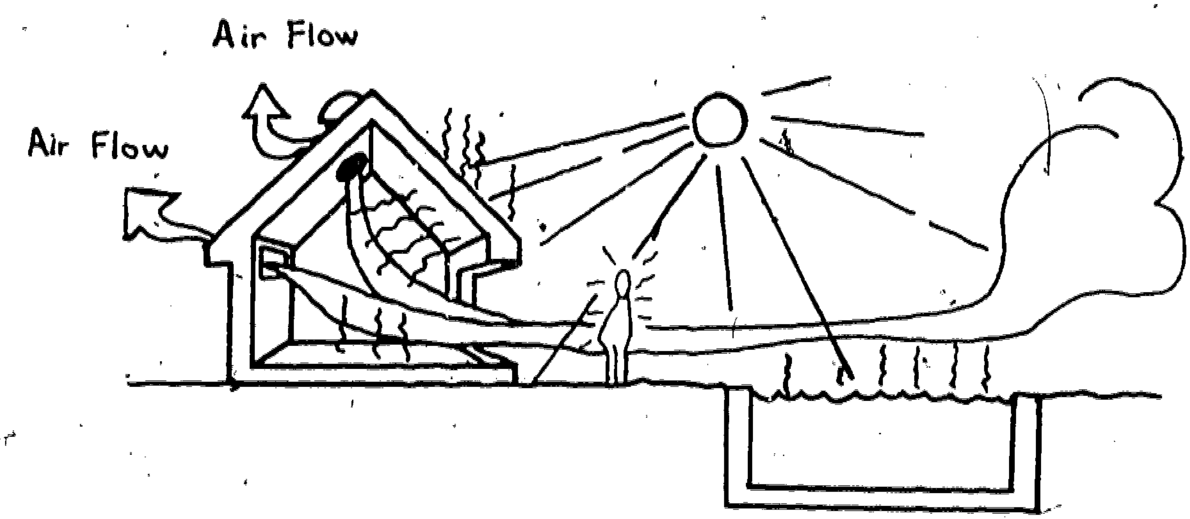
OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THAT SOLAR TECHNOLOGY CAN BE USED FOR RESIDENTIAL HEATING, COOLING, AND WATER HEATING.

The objective of solar technology is to use the energy of the sun to reduce the need for the use of other, more scarce, fuels. Solar energy may be used to heat space, cool space, heat water, and generate electricity. However, at this time, it is not economically feasible to use solar energy for all of these tasks in homes throughout the United States. Solar energy is most economical in areas which have high energy costs, scarce fuel supplies, severe climatic conditions, and generous quantities of sunlight.

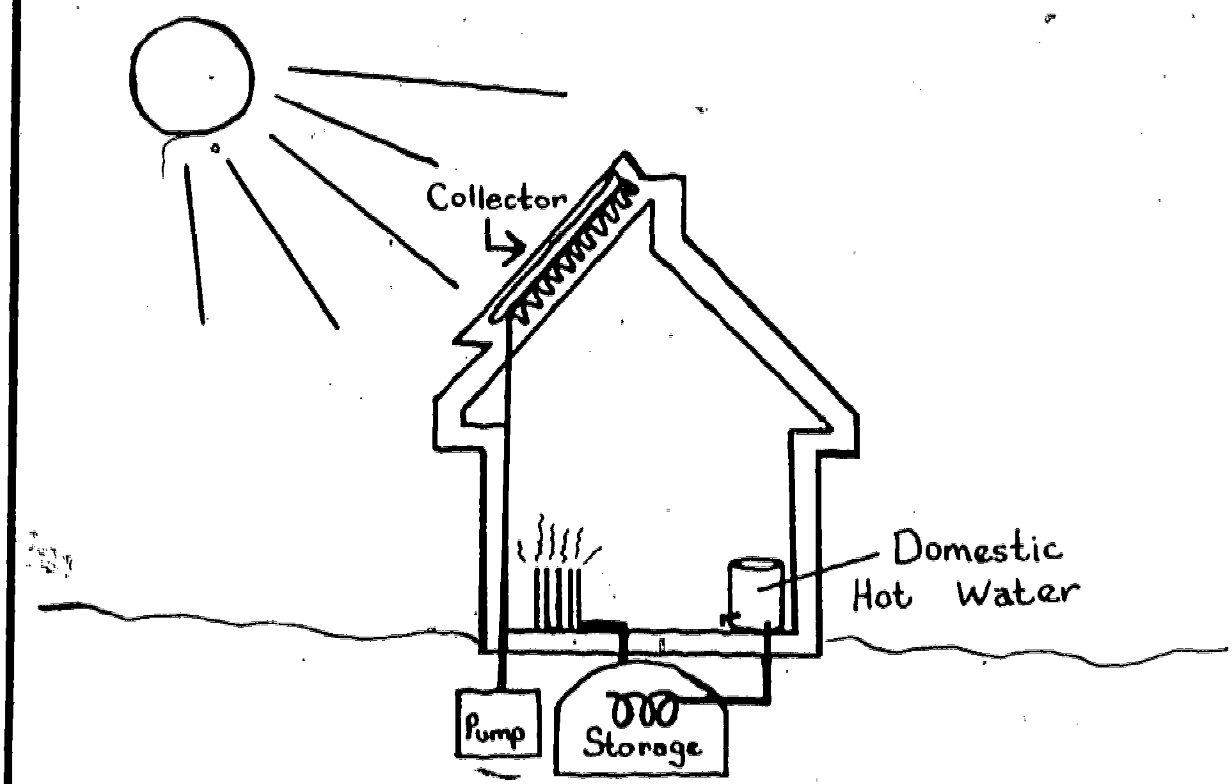
The sun's energy may be used by *passive means*, with no additional energy, or *active means*, where additional energy such as electric fans or water pumps or electric heat pumps are used to transfer the sun's thermal energy.[40] In the previous units, a number of passive means were presented for collecting solar energy; for example, placing the majority of a home's windows on the south side to trap the winter sun. However, passive means are most valuable in sunny regions, since the sun's energy cannot be collected when or where the sun doesn't shine. (See Figure 51.) The sun's heat can also be used passively to create ventilation through the house. This was described in UNIT 4.1. Or the sun's thermal energy can be used to directly heat water for domestic use. The trouble with passive is that you may not be able to get the energy when you need it or where you need it, and it is very difficult to store for long periods.

In an active solar house, many of these problems can be overcome by using collector, transport, and storage systems. The collector absorbs the sun's energy; then a fluid or air is used to transport the thermal energy to where it is needed, or to storage. Additional energy may be needed to move the thermal energy to where it is needed. A heat pump may be used to draw the thermal energy from storage and to provide supplemental heat when the sun's energy is not adequate. (See Figure 51.) A variety of collectors are now on the market which may be built into new houses or added to existing houses.

Before selecting, purchasing, or installing a solar system, you need to investigate it thoroughly. The Federal Energy Administration and Office of Consumer Affairs have developed a buyers guide, *Buying Solar*. Also, you may obtain additional information from The National Solar Heating and Cooling Information Center by writing to Solar Heating, P.O. Box 1607, Rockville, Md. 20850, or by calling (toll free) 800/523-2929 or in Pennsylvania 800/462-4983.



PASSIVE



ACTIVE

Figure 51. Passive and Active Solar Systems.

FOOTNOTES

[1]"The ABC's of Air Conditioning" (Syracuse, New York: Carrier Corporation, 1975), p. 2.

[2]Federal Energy Administration, "Speaking of Energy" (Washington, D.C.: Government Printing Office, 1975), p. 2.

[3]*The Builder's Guide to Energy Conservation* (Washington, D.C.: National Association of Home Builders, 1974), p. 25.

[4]Ibid., p. 40

[5]Ibid., p. 26.

[6]Henry R. Spies and others, *350 Ways to Save Energy in Your Home and Car* (New York: Crown Publishers, 1974), p. 89.

[7]*Directory of Certified Unitary Air-Conditioners, Unitary Heat Pumps, Sound-Rated Outdoor Unitary Equipment, and Central System Humidifiers* (Arlington, Virginia: Air Conditioning and Refrigeration Institute, 1975), pp. 10-79 and 85-95.

[8]"Energy Conservation with Heat Pumps" (Washington: Government Printing Office, 1975), p. 2.

[9]*The Builder's Guide to Energy Conservation*, p. 41.

[10]"Energy Conservation with Heat Pumps," p. 2.

[11]Spies and others, p. 76.

[12]E.C. Hise and A.S. Holman, *Heat Balance and Efficiency Measurements of Central, Forced-Air, Residential Gas Furnaces*, ORNL-NSF-EP-88 (NTIS, 1975), pp. 4, 14.

[13]Spies and others, p. 66.

[14]Eugene Eccli and Sandra Fulton Eccli, "Save Energy: Save Money!" (Washington, D.C.: Office of Economic Opportunity, 1974), p. 25.

[15]Kurt Vragel, *How to Save Energy in Your Home* (Denver, Colorado: Kurt Vragel Associates, 1975), p. 19.

[16]U.S. Department of Commerce, "11 Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling" (Washington: Government Printing Office, 1971), p. 19.

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[18]Ibid., p. 10.

19 Federal Energy Administration, "Tips for Energy Savers" (Pueblo, Colorado: Public Document Center, 1975), p. 13.

20 "11 Ways to Reduce Energy Consumption," p. 15.

21 [illegible] (Knoxville, Tennessee, 1975), p. 1.

22 [illegible], p. 29.

23 FEA, "Tips for Energy Savers," p. 16.

24 John George Muller, [illegible] (Washington, D.C.: Federal Energy Administration, 1975), p. i.

25 Ibid., p. 5.

26 John Tansil, [illegible], ORNL-NSF-EP-51 (NTIS, 1973), p. 16.

27 James J. Mutch, [illegible] (Santa Monica, California: RAND Corporation, 1974), p. 20.

28 R. S. Quinn and J. C. Meyers, [illegible], ORNL-NSF-EP-40 (Oak Ridge, Tennessee, 1972), pp. 28-29.

29 Muller, p. 10.

30 Ibid., p. 2.

31 Ibid., p. 6.

32 Ibid., p. 12.

33 Ibid., p. 2.

34 Tansil, pp. 16-17.

35 "101 Ways to Conserve Electricity at Home," (New York: Con Ed, [n.d.]), p. 11.

36 Muller, pp. ii, vii, viii.

37 "11 Ways to Reduce Energy Consumption," p. 9.

38 Hise and Holman, pp. 19-24.

39 Spies and others, p. 91.

40 [illegible] (Vienna, Virginia: Sheet Metal and Air Conditioning Contractors' National Association, Inc., 1977), pp. 21-1 and 21-5.

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OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO IDENTIFY AND APPLY ENERGY CONSERVATION CRITERIA AND INFORMATION WHEN SELECTING A HOME.

[illegible]

[illegible] mobile home, several general criteria should be considered [illegible] insulation, orientation, windows and type of heating and cooling systems, and water heater.

Regardless of the type of home, it should be well insulated. Check [illegible] in the attic and basement. [illegible] completed structure, but the [illegible]

[illegible] the orientation [illegible] of the windows [illegible] south [illegible]

[illegible] ventilation [illegible] not more than [illegible] percent of the floor area [illegible] with double or triple pane glass.

[illegible] the heating and cooling system [illegible] Are the [illegible] adequately insulated [illegible] do not have the expertise to [illegible] heating or air conditioning contractor. The contractor can determine the age and condition of the equipment and estimate cost of repairs if needed.

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THE ENERGY CONSERVATION CRITERIA TO BE CONSIDERED WHEN SELECTING AN APARTMENT OR CONDOMINIUM.

Some energy conservation criteria are unique to apartments and condominiums. Unlike single-family residences, apartments and condominiums are [illegible] rows or blocks, with several units in a building. This situation affords a good opportunity to save energy, since an apartment or condominium which is adjacent to another apartment or condominium will not be exposed to unheated space on that side; for example, an interior apartment has fewer surfaces exposed than an exterior or end apartment, so it will require less heating or cooling. It can be seen from Figure 52 that Rowhouse 2 has less exposed surface than Rowhouse 1 or 3 because it is bounded on two sides. Apartment B in Figure 52 has even less surface exposed since it is bounded on two sides as well as above and below.

Another aspect of an apartment or condominium which affects the heating and cooling load is the level or floor on which it is located. Due to the fact that heat rises, apartments on upper floors tend to be warmer in the winter than those on lower floors; apartments on the lower level tend to be cooler in the summer. However, if natural ventilation is a major concern, a bottom floor or basement level may have little or no breeze.

Windows and doors in apartments and condominiums are seldom protected with storm panels. This makes the number, size, and orientation of the windows and doors important. For example, an apartment in a cold climate with all its windows facing north will be much more difficult and expensive to heat than one in which the windows face south. Care must also be taken to determine if the apartment will be shaded by other buildings or by vegetation.

Very little can be done to improve the shell of a condominium or apartment, so great care should be taken in its selection. If the apartment or condominium was previously occupied, it would be wise to ask the cost of heating and cooling in previous years. Unusually high consumption (in kwh) could indicate a poorly constructed shell.

Advocate energy conservation to the building owner, manager and other tenants. Recommend added insulation or storm windows and doors if they are needed. Ask for weatherstripping and caulking. Report unnecessary energy waste such as open lobby doors, improperly vented laundry facilities, or heated unused spaces.

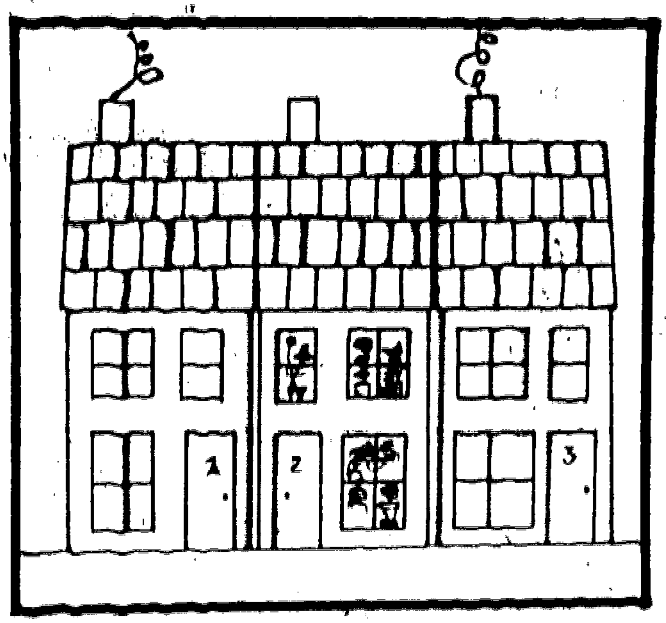
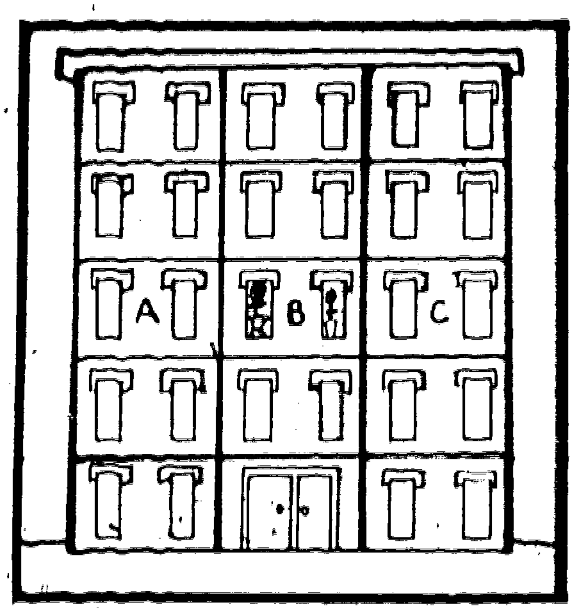


Figure 52

Row Houses (above) and
Apartments (below).



OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THE ENERGY CONSERVATION CRITERIA WHICH MUST BE CONSIDERED WHEN SELECTING A MOBILE HOME.

When you buy a mobile home, check to see if it meets the Mobile Home Construction and Safety Standards established by the U.S. Department of Housing and Urban Development (HUD). If a new mobile home meets the basic HUD requirements for insulation, infiltration, and condensation control, a permanently affixed label of certification should be found on an interior wall. The certification label will give the climate conditions the mobile home is suited for and the capacity of the heating and cooling equipment. Mobile home buyers may also consult the local Mobile Home Association for guidelines in purchasing a mobile home, site selection, and maintenance. Of course, it is wise to seek out the most reputable dealers in an area.

Mobile homes have several common problems related to energy efficiency: thin walls, ceilings, and floors; detachment from the ground; metal exteriors; and elongated, compartmentalized interiors. One of the most cost-effective energy conservation measures for mobile homes is the addition of a skirt or foundation, which encloses the area under the mobile home. Properly installed skirting acts as added insulation. Vents should be provided in the skirting to allow for air circulation to prevent moisture buildup and to provide air for the heating system. Also, storm windows and doors may be added, or the installation of 4-to-6-mil plastic sheeting will reduce heat loss and gain. Although it is very difficult to add insulation, rigid foam insulation boards applied to the interior of the home and on the ceiling may be particularly beneficial. [Caution: Some rigid foam is very flammable and should not be used; check the insulation manufacturer's specifications.] Also, urethane can be sprayed on the roof for insulation; however, it should be coated with a sealer. Batt insulation can be installed under the floor. The compartmentalized interiors of some mobile homes impede the flow of air and make heating and cooling difficult. On the other hand, the space in most mobile homes is carefully engineered to give maximum usable space within the outside dimensions.

Proper siting of the mobile home on its lot can also reduce energy consumption. In cold climates the long sides should face north and south to take advantage of the winter sun. However, a carport, fence or plantings should be provided on the north side for wind protection. In the warmer climates, the long sides should face east and west to catch the cooling breezes. Storm winds should be avoided. (See Figure 53.)

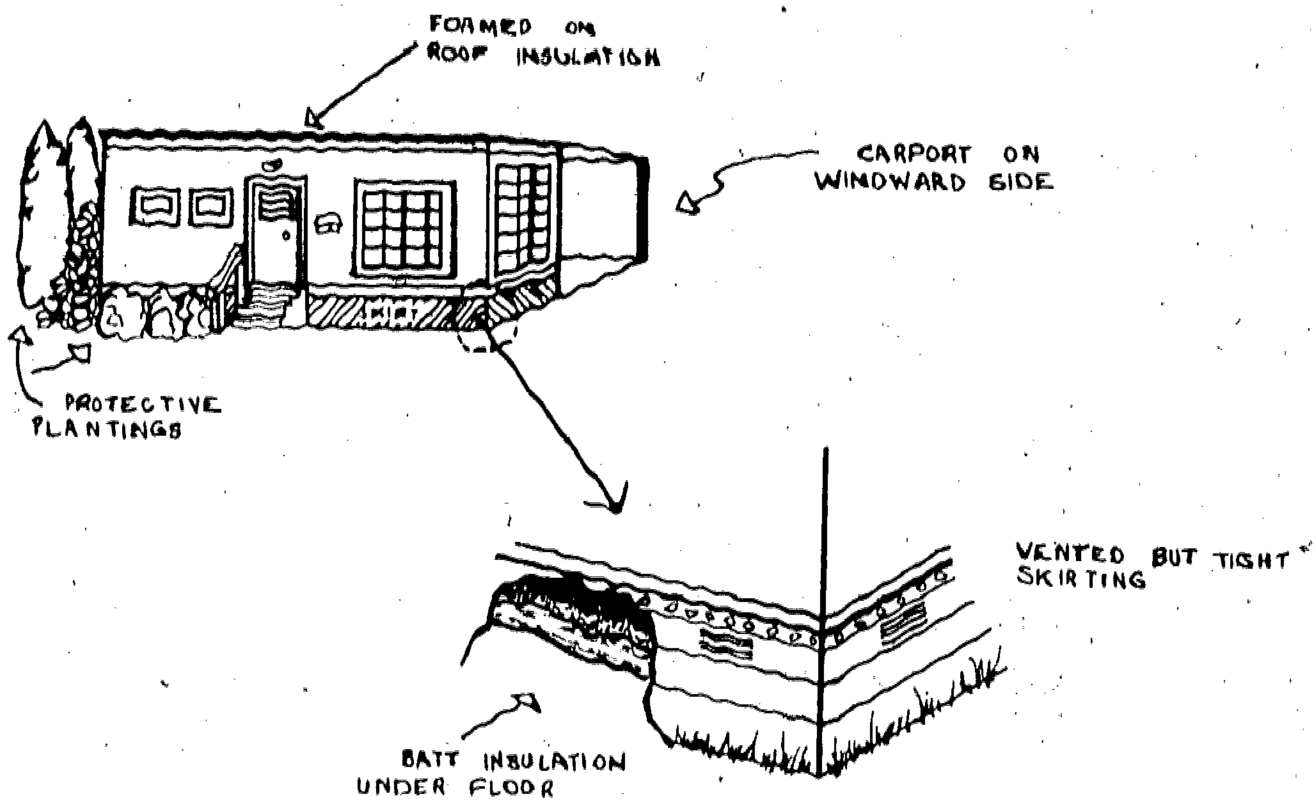


Figure 53. Energy Conserving Mobile Home Features.

UNIT 5.3

OLDER HOMES

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THE ENERGY CONSERVATION CRITERIA WHICH MUST BE CONSIDERED WHEN SELECTING AN OLDER HOME.

Older homes have advantages and disadvantages in relation to energy conservation. First, an older home has a history for heating and cooling which should be obtained from the previous owner or the utility company. These data can tell the potential buyer the heating and cooling cost in previous years (remember to adjust to current rates) and indicate the relative energy efficiency of the home. If the heating or cooling bill is high for the size of the home, one should ask why and how it might be improved. If additional insulation and equipment is needed, an adjustment in purchase price may be warranted. If the ceiling is uninsulated, a small investment in insulation by the new owner can make a large difference in utility costs.

Certain features of older homes may make them energy-inefficient. Very old homes may not have any insulation and inadequate infiltration barriers (e.g., building paper, foil, caulking). The table below shows the R-value for the surfaces of houses as they used to be built and how they can be improved for even a cold climate.

Typical Old House Surface	R-Value	Retrofitted Old House
Roof	3	insulate with 12" fiberglass, R = 43
Wall	4	insulate with 3½" blown insulation, R = 18
Basement	10	insulate walls with 3½" fiberglass or 2" styrofoam, R = 20
Ground floor	5	insulate with 6" fiberglass, R = 25
Door	2	add storm door, R = 3, substitute insulated door, R = 10
Window	1	add storm window, R = 2, add insulating shutters, R = 10

Source: Maine Audubon Society, *Energy Education Project*, Falmouth, Maine.

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THE ENERGY CONSERVATION CRITERIA WHICH MUST BE CONSIDERED WHEN SELECTING A NEW HOME.

New homes are restricted by local building codes and frequently by the FHA-MPS (Federal Housing Authority, Minimum Property Standards). Although these codes require certain construction materials and techniques, the standards are minimal and usually do not afford optimal energy savings, where "optimal" means the minimum cost of buying *plus* operating the house over its lifetime. A prospective home owner or person planning to build a new home should obtain the regional code restrictions. FHA provides checklists and guidelines for builders and homeowners. Of course, it is easier and less expensive to build in energy conservation measures than to add them later. All of the features and practices discussed in Units 3 and 4 should be considered when buying or building a home. Although energy saving features usually tend to increase the purchase cost, the increased mortgage payment will often be more than offset through lower utility bills.

FOOTNOTES

[1]FEA, "Tips for Energy Savers" (Washington, D.C.: GPO), p. 19.

[2]John Tansil, *Residential Consumption of Electricity 1950-1970*, Report No. ORNL-NSF-EP-51 (Oak Ridge, Tennessee: Oak Ridge National Laboratory, 1973), p. 7.

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SECTION 6 FOOD

OBJECTIVE: TO ENABLE THE TEACHER AND STUDENT TO RECOGNIZE CHOICES AND PRACTICES OF ENERGY CONSERVATION, WASTE, AND EFFICIENCY DURING FOOD PURCHASE, STORAGE, PREPARATION, AND CLEAN-UP ACTIVITIES.

The high productivity of the American food industry depends on large quantities of energy to produce, process, transport, store, and prepare a large variety of foods.[1] As a result, advanced agricultural systems are running up an energy deficit. As the geographic distance from producer to consumer lengthens, the degree of processing increases, and energy is substituted for labor and natural soil fertility, the energy deficit increases.

In 1910, the energy content of food produced in the U.S. was slightly greater than the energy used to grow, process, and transport the food. In 1970, however, nine times as much energy was consumed by the food system than was contained in the food produced.[2] In other words, by the time the food reaches the consumer's plate, the total energy expended is many times that contained in the food being eaten. It is the processing, transportation, and distribution of the food that absorbs most of the energy. Therefore, it is wise to select food items carefully, as well as to store and prepare them efficiently.

The home preparation of food accounts for almost four percent of the total U.S. energy consumption. The major in-home energy consumption for food occurs in storage (refrigeration and freezing) and preparation (ranges, ovens, and small appliances).[3]

The storage and preparation of food includes energy use by appliances both directly and indirectly. There is direct use of energy for refrigeration, cooking, and dishwashing. The indirect use of energy is for hot water, to maintain a comfortable room temperature where appliances are operating, and for manufacturing the appliances. Appliances and equipment account for 33 percent of the energy consumed in the home. The water heater, refrigerator, and range are the top energy users.[4] Included in the Appendix of this Guide is a listing of appliances and equipment found in American households indicating their average yearly energy consumption.

OBJECTIVE: TO ENABLE THE TEACHER AND STUDENT TO MAKE ENLIGHTENED FOOD SELECTIONS AND TO PRACTICE JUDICIOUS PLANNING, SHOPPING, AND BUYING TECHNIQUES.

Few people realize the extent of the indirect use of energy to produce food--energy consumed in the manufacture of food-related equipment, manufacture and transportation of fertilizer, pesticides, and herbicides; manufacture, maintenance, and operation of farm equipment. The higher up the food chain, the more energy is consumed by the product. For example, beef cattle are more energy-intensive than vegetables, and man is more energy-intensive than cattle. (See Figure 54.) In an energy conserving society, a conscious effort would be made to shift from animals raised on feed lots to animals raised on the range, from animal protein to vegetable protein; from meat, fish, poultry, eggs, milk, and cheese to soy products, wheat germ, dry beans, peas, and lentils. (Figure 55) [SEE ACTIVITY L.]

The more direct energy costs of preserving, packaging, and transporting food are the most obvious. Drying food to preserve it can require little energy, particularly if done by solar energy. Canning uses more energy than drying. Freezing requires even more energy, and energy must be continuously used during storage. To conserve energy, reduce the use of extensively processed foods. Of course, fresh foods eliminate the energy and cost for preservation.

A major source of energy waste is in packaging: often more energy is embodied in the container than the food itself. One way to reduce this inefficiency is to cut down on disposable containers. Another is to purchase food in bulk. The most energy-intensive food items are in throw-away aluminum cans, plastic bottles, ready-to-heat frozen packages, and aerosol cans. The packaging makes a great deal of difference; for example, twice as much energy is required to produce a 6-ounce aerosol spray can of cooking oil as an equal amount of bottled cooking oil.[5] The reuse of containers could yield a dramatic energy savings. The Environmental Protection Agency estimates that if 90 percent of the market used returnable beverage containers, the equivalent to 92,000 barrels of oil per day would be saved.[6]

The greatest single inefficiency in the food system is in transportation of food from the market to the home.[7] The use of a two-ton vehicle--the family car--to transport 30 pounds of food several miles once a week is grossly inefficient. To conserve energy, shopping trips should be carefully planned. It is helpful to write menus for a few days or a week and then make a shopping list. Consult newspapers, radio, and television for bargains. Since freeway driving is nearly twice as economical as driving in

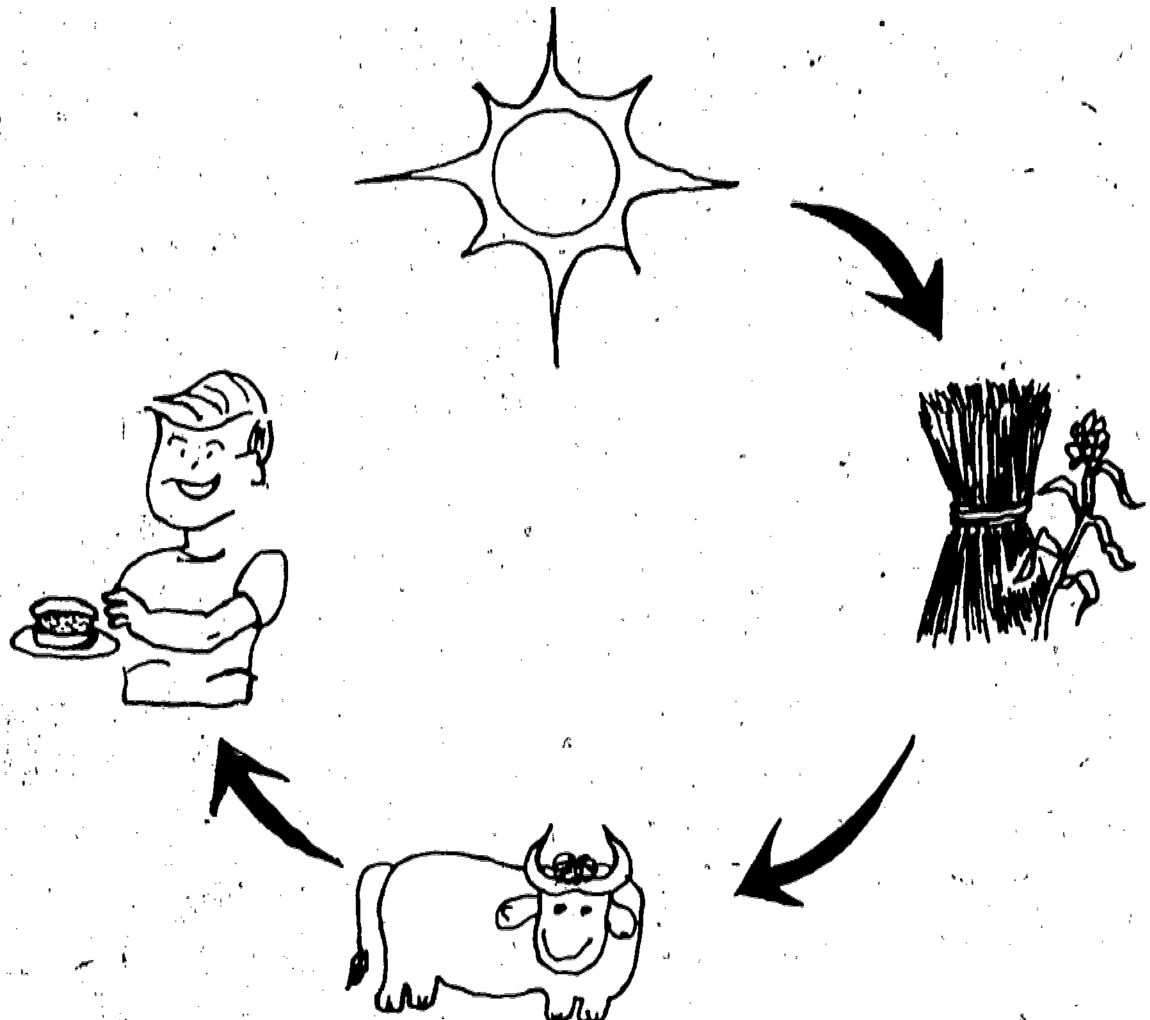


Figure 54. The Food Chain.

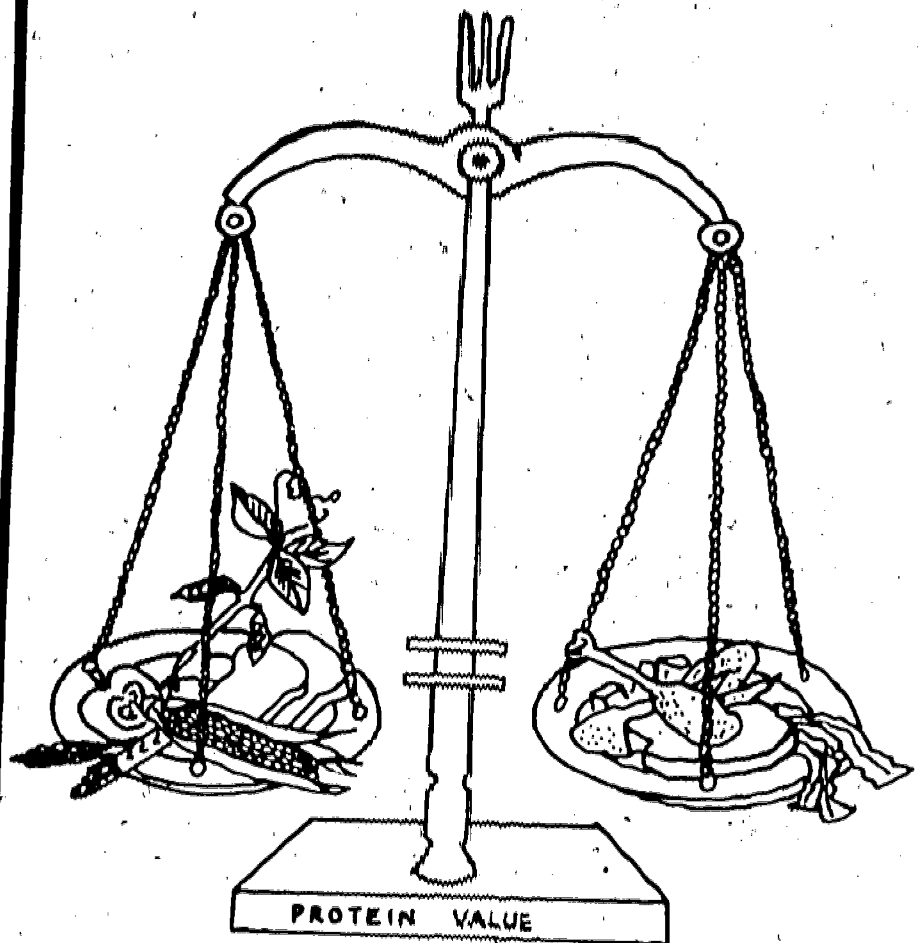


Figure 55. Vegetable Protein vs. Animal Protein.

heavy city traffic, shopping trips should be carefully combined with commuting trips.[8] Better yet, bike or walk to a store in your immediate area. [SEE ACTIVITY M.]

OBJECTIVE: TO ENABLE TEACHERS AND STUDENTS TO IDENTIFY THE ENERGY USES RELATED TO FOOD STORAGE AND HOW, THROUGH PROPER SELECTION AND USE OF APPLIANCES, ENERGY CAN BE CONSERVED.

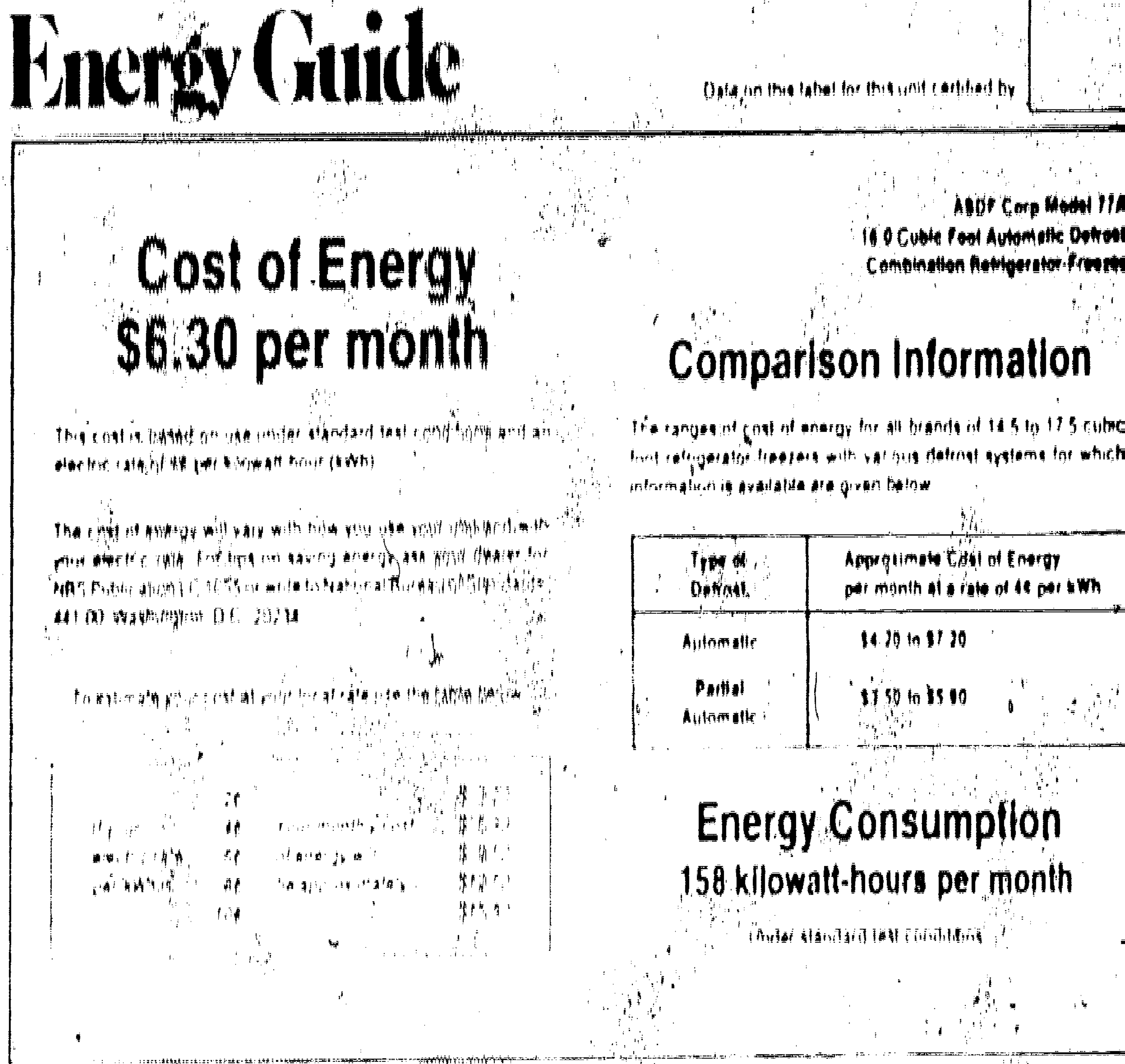
The storage conditions for each kind of food must be correct so that the original quality is maintained. Some foods require freezer storage, some refrigerator storage, and others dry room temperature storage. If there is any spoilage, food, money, and energy are wasted.

Ample space must be provided for each storage condition. Pantry storage requires little energy; however, refrigerator and freezer storage are energy intensive. Refrigerators and food freezers run 24 hours a day. The energy required to preserve foods follows third in line for home energy consumption behind (1) space cooling and heating and (2) water heaters.[8] Refrigerators and freezers give the third greatest opportunity to conserve energy in the home. Fortunately, refrigerators and freezers are available that use as little as half the energy that others do for little extra cost. Savings in smaller utility bills can make up the difference in purchas cost in the first year or two.

In 1973, the President directed that a voluntary energy labeling program be developed for energy-intensive household appliances and equipment.[7] The goal of the program was to provide the consumer with information at the point of sale on the energy consumption and energy efficiency of household appliances and equipment. The appliances now covered are room and central air conditioning systems, refrigerators and freezers, clothes washers and dryers, dishwashers, ranges and ovens, water heaters, comfort heating equipment, and televisions. Appliances of participating manufacturers bear the U.S. Department of Commerce mark illustrated below.

An example of an Energy Consumption Label is shown in Figure 56.

The energy consumption is given in kilowatt-hours per month which can be converted to actual cost by multiplying the kwh/month by the electric rate. For example, a 158 kilowatt-hour per month refrigerator will cost approximately $4.74 a month to operate where the electric rate is 3¢ per kwh (158 kwh/mo × 3¢/kwh = $4.74/mo). Thus, over a 10 year period, the electric



Energy Guide

Data on this label for this unit certified by

ABDF Corp Model 77A
16.0 Cubic Foot Automatic Defrost
Combination Refrigerator-Freezer

Cost of Energy
$6.30 per month

This cost is based on use under standard test conditions and an electric rate of 4¢ per kilowatt hour (kWh).

The cost of energy will vary with how you use your appliance and with your electric rate. For tips on saving energy, ask your dealer for NBS Publication LC 1055 or write to National Bureau of Standards, 441.00 Washington D.C. 20234

To estimate your cost at your local rate use the table below

	2¢		[illegible]
If your	4¢	your monthly cost	[illegible]
electric rate	6¢	of energy would	[illegible]
is	8¢	be approximately	[illegible]
	10¢		[illegible]

Comparison Information

The ranges of cost of energy for all brands of 14.5 to 17.5 cubic foot refrigerator-freezers with various defrost systems for which information is available are given below.

Type of Defrost	Approximate Cost of Energy per month at a rate of 4¢ per kWh
Automatic	$4.20 to $7.20
Partial Automatic	$1.50 to $5.90

Energy Consumption
158 kilowatt-hours per month

(Under standard test conditions)

Figure 56 - Energy Consumption Label

bill for this refrigerator would be about $564.00, with no adjustments for inflation or increased cost of electricity.

The Association of Home Appliance Manufacturers (AHAM) provides a *Directory of Certified Refrigerators and Freezers* which gives energy consumption, volume, and total shelf area of AHAM certified models.[11] The AHAM certification seal (below) will be found on models included in the directory.

(AHAM Directories may be ordered through The Association of Home Appliances Manufacturers, 20 Northwacker Drive, Chicago, Illinois 60606, at a cost of 50¢ each up to 25 copies and 25¢ each for over 25 copies.)

In addition to the Energy Labeling Program, the Department of Commerce is involved in an "Energy Efficiency Program." The goal of this program is to reduce the energy usage of new appliances an average of 20 percent by 1980.[12] Although this program is voluntary, mandatory action is being requested in the Congress. Specific energy reduction goals are listed below:

Energy Reduction Goals Appliance Category	Energy Use Reduction Percent
Water heaters, electric	9
Water heaters, gas	25
Refrigerator-freezers	30
Freezers	25
Ranges, electric	10
Ranges, gas	30
Television receivers, monochrome	48
Television receivers, color	42
Room air conditioners	22
Clothes dryers, electric	6
Clothes dryers, gas	12
Clothes washers	10*
Dishwashers	18*

*Includes energy used to heat water

More recently, the Energy Policy and Conservation Act (1975) required that the Federal Energy Administration (FEA) direct the National Bureau of Standards (NBS) to develop "energy efficiency improvement targets" for appliances. These targets will be designed to attain maximum energy efficiency by 1980. The Act also required the development of test procedures and labeling rules. The new labeling information is to include "estimated annual operating cost." The appliances covered by the Act are refrigerators, refrigerator-freezers, freezers, dishwashers, clothes dryers, water heaters, room air conditioners, home heating equipment, furnaces, televisions, kitchen ranges and ovens, clothes washers, dehumidifiers, humidifiers, and central air conditioners.[13] These labels should appear on new appliances soon, so watch for them along with improved appliance efficiencies.

Before buying a new appliance, find out how much energy it uses compared to other models. Look for the Energy Consumption Label. Make certain the capacity suits the need--that it has the features suited for your lifestyle. For example, a frost-free refrigerator requires more energy than a standard model, but if the owner of a standard model is unable to maintain it, the energy costs could be great. Consider initial cost, energy consumption, capacity, and timesaver features before buying an appliance. Energy saving devices should also be considered. A new refrigerator with a "power-saver switch" is available which gives consumers living in air-conditioned or nonhumid rooms the option of saving up to 15 percent of the appliance's energy use by switching off the mullion heaters, which are small resistance wires used to heat around the door openings to prevent sweating when it is humid.[14]

The use of refrigerators and freezers greatly affects their energy consumption. Cooling appliances should be located away from heating equipment and direct sunlight. The temperature controls should be properly set. Turn the control to the warmest setting which will keep food properly preserved. Use a thermometer to check the temperature; 0°F for the freezer and 35-45°F for the refrigerator are recommended.[15] (Caution: It is dangerous to store perishable foods at temperatures above 45°F.[16]) Set the control dials a couple of settings warmer when away from home a weekend or more. Since the door will not be opened while you are gone, a warmer setting will keep the food properly chilled. If a second refrigerator is used only during one season, unplug it for the balance of the year.

Freezers and refrigerators operate most efficiently when filled to the correct capacity. However, do not overload the refrigerator as this will keep the compressor running more than it should. Food should be placed slightly apart on refrigerator shelves for correct circulation. The freezer should be kept as full as possible to prevent heavy icing. Cover all liquids stored in the refrigerator (especially frost-free models). Moisture is drawn into the air from uncovered liquids, making the refrigerator work harder. Finally, unless a recipe requires quick chilling or freezing, let hot food cool before placing it in the refrigerator or freezer. (Caution: Food may not be safe to eat if held for more than three or four hours at temperatures between 60° F and 120° F.[17])

Open and close the refrigerator and freezer doors only when necessary. Several items can be removed at once to reduce loss of cold air. By keeping a list of the location of foods in the freezer, the freezer door can be kept open a minimum amount of time.

Maintenance of refrigerators and freezers also affects their efficiency. The gaskets around the doors should be kept in good condition. To check the gasket, close the door on a piece of paper. If it pulls out with no drag, the seal is bad and the gasket should be replaced. On self-defrosting refrigerators, keep the condensate drains cleaned. On all models keep condensor coils clean for maximum efficiency and conservation of energy. The dust attachment on the vacuum cleaner can be used to clean the condensor (located at either the bottom or rear of the unit). Dust on the condensor and coils causes the appliance to run longer. The freezer should be defrosted before frost becomes ¼-inch thick to avoid wasting energy by overworking the compressor. [SEE ACTIVITY N.]

Care should be taken to assure proper air circulation around refrigerator and freezer coils and compressor. As the unit's heat exchangers operate, the surrounding air is heated. Without proper circulation the air temperature around the exchanger becomes overheated and the efficiency of the unit is diminished. Under extreme conditions the compressor may "burn out." Refrigerators and freezers should not be placed in closets or small rooms with poor circulation. It is helpful to avoid placing the equipment in corners.

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO SELECT, USE, AND MAINTAIN COOKING APPLIANCES AND TO PRACTICE FOOD PREPARATION TECHNIQUES WHICH FOSTER ENERGY CONSERVATION.

The preparation of food includes energy use for appliances to combat additional internal heat load and to heat water. Energy can be saved by the proper selection, use, and maintenance of appliances and judicious preparation practices.

The major energy consumer for food preparation is the range, which ranks fourth after the heating/cooling system, water heater, and refrigerator in home energy consumption. As can be seen from Appendix C, the other appliances used for food preparation (blenders, broilers, toasters, coffeemakers) use very little energy compared to the range. Therefore, the range offers the greatest opportunity to conserve.

The first consideration is the selection of a range. Ranges are relatively efficient appliances. Surface units on electric ranges are about 75 percent efficient and approximately 55 percent of all food preparation is done on surface units.[18] Cooking inside the oven is generally a more efficient use of energy; since the heating is intermittent, much heat is retained within the oven walls and there is less convection loss.[19] Due to the necessity for oven ventilation for good baking results, oven efficiency could be increased only minimally. However, self-cleaning ovens, because of their additional insulation, require less energy to operate than standard ovens. Also, microwave ovens are quite efficient for cooking certain types of foods. Although ranges do not now have energy consumption fact tags, they will be labeled in the near future just as air conditioners and refrigerators are. For the time being, the consumer must rely on reputable manufacturers and dealers when selecting cooking

In addition to efficiency and quality of the unit, the consumer should consider its appropriateness for the family's lifestyle. The use of oversized units is very inefficient. Microwave ovens, toasters, coffeemakers, and other small appliances should be used when appropriate. There has been some question as to how much energy a microwave oven could save and tests of efficiency are being done now. Consumers Institute has found that microwaves offer the greatest energy savings in cooking small to medium quantities of concentrated foods such as meats, potatoes, desserts, and TV dinners,[20] but their studies indicate some foods actually require more energy in a microwave oven than cooked conventionally. Some of the test results are given on the following page:

Food Cooked in Microwave Oven	Energy Consumption
4 Baked Potatoes	60.7% less than ccm*
1 Frozen TV Dinner (11½ oz.)	79.3% less than ccm
Casserole (4½ cups)	58.4% less than ccm
Summer Squash (16 oz.)	58.4% more than ccm
Peas and Celery (3½ cups)	46.1% more than ccm
Frozen Broccoli (10 oz.)	30.2% more than ccm

*ccm - conventional cooking method

[SEE ACTIVITY O.]

Gas range pilot lights have come under recent attack due to their energy consumption (1/3 to 1/2 of the total gas used by the range.)[21] However, in addition to providing a starter flame, pilot lights provide the safety shut-off system for the gas supply and a small amount of space heating in winter. Thus the issue isn't as simple as it might seem at first glance. For instance, if the gas were used to generate electricity, about two-thirds of its energy would be lost at the power plant alone. Appliance manufacturers are seeking to reduce the energy waste of pilot lights by using smaller flames. Also, electric ignition is currently available on at least some models produced by the majority of gas range manufacturers.

The key to the cost of operating cooking appliances is the way in which they are used. The consumer has the opportunity to exert a great deal of control over the energy consumption of the range, cooktop, or oven. First, cooking appliances should be used as they were intended:

1. Don't use the range for heating the kitchen. This wastes a lot of energy since the range is not an efficient space heater. It is also dangerous!

2. Don't use the oven as a dryer. It is not economical and it can start a fire.

3. When cooking only small quantities, it is usually more economical to use small appliances rather than the range top or large oven. Toasters, waffle irons, skillets, grills, popcorn poppers, fondue pots, bean pots, and coffeemakers use less energy for their specialized jobs than does the range. If you have both a small and large oven, use the small one whenever possible.

4. Preheating the oven is often unnecessary and may be a waste of energy. When preheating is required, or when baking time is only a few minutes, avoid preheating for longer than 10 minutes.[22] Use a timer as a reminder that the oven is heated. Surface units should not be preheated.

Put pots and pans on the range top before the heat is turned on to avoid wasting heat.

5. Don't be an oven peeker. Every time the oven door is opened during operation, the oven temperature drops 25 to 50 degrees.[23] A range with an oven door window might be a good investment for the "peek-a-boo" cook.

6. If food must be kept warm for extended periods, store it in an oven set no higher than 140°F to 200°F. (Caution: Food may become contaminated if kept warm at temperatures below 140°F.[24]) A food warmer built into the range usually requires less energy than the oven or surface unit when used for keeping food heated. Foods, plates, and platters can be warmed with the stored heat remaining in an oven after baking with no additional energy use. A ceramic tile warmed while baking can be used to keep rolls hot during the meal instead of keeping the oven on or using an electric bun warmer.

7. Brown foods on medium high heat and then reduce to medium or low to finish cooking. This will reduce shrinkage and spattering and will consume less energy.

8. Use a timer with a loud bell to avoid overcooking and wasting energy.

9. Take advantage of the heat-sensing elements on gas and electric ranges to control the surface unit. It allows the unit to cut off the energy supply and coast occasionally while still cooking. Electric surface units can be shut off a short period (5 minutes or so) before the food is done. The food will continue to cook from stored energy.

10. Remember to turn off all units immediately after use. A warning light or buzzer is helpful as a reminder. Establish the habit of turning off the range before removing the utensil.

11. When cooking on top of the range, a vent fan can exhaust heated air directly to the outside and ease the burden on the home's cooling system. But don't let it run needlessly.

The proper selection and use of cooking utensils can afford additional energy savings. The following considerations should be made:

1. Pots and pans should fit the surface unit. The bottom should cover the heating element but not extend more than an inch over the edge. This will help minimize the amount of heat loss to the air. If the pot or pan is too large for the surface unit, it will heat unevenly and heat will reflect down to the range top around the unit and eventually craze it.

2. To ensure minimal heat loss from the pot or pan, it should have a flat bottom, straight sides and a tightly fitting cover. Good utensils allow less heat to escape and lower heat settings to be used. A pressure cooker can cut time and energy even more.

3. Ceramic, glass, and stainless steel utensils retain heat better than other materials. When baking with these materials, the oven setting can be lowered 25 degrees.

4. Slightly lower temperatures can be selected when using teflon-lined utensils for frying or pan broiling on top of the range.

5. Use a tea kettle instead of a pan for heating or boiling water to avoid heat loss through steam.

6. Cover saucepans whenever possible. Food will cook faster and a lower temperature setting can be used. Be sure the lid fits tightly.

Care should be taken not to use energy for cooking appliances unnecessarily. Heating water and thawing foods are the most common causes for waste. The following tips can help avoid unnecessary energy use:

1. When heating or boiling large quantities of water, start with hot tap water where a major part of the heating has already been done more efficiently by the water heater.

2. Large amounts of water use more energy and lessen the nutritional value of foods. Use only enough water to make steam and avoid sticking when cooking vegetables. The water will heat faster and conserve energy. Remember to reduce the temperature to simmer as soon as the steaming point is reached and use a pan with a tight lid. Vegetables will retain more vitamins and minerals and taste better.

3. Frozen foods require more energy than completely thawed foods whether cooked in the oven, under the broiler, or on top of the range. For example, a roast that has been defrosted requires 33 percent less cooking time than one that is still frozen.[25] However, exercise caution to avoid bacterial growth.

4. Broiling meat is faster and more efficient than other methods.

Energy-conscious cooks schedule and plan for the most efficient use of their appliances. Cooking several items at the same time and choosing cooking times carefully can conserve energy. Following are suggested ways in which cooking might be better planned and scheduled:

1. Sometimes it is more practical to cook several dishes at once instead of reheating the oven several times during the day. Two or three dishes can be baked with little more energy than one. For example, if three dishes are to be cooked at similar temperatures (325, 350, and 375) pick the average temperature (350) and cook all three, making a small allowance in cooking time. The oven (which is more efficient than the range top) can be used in this manner to prepare the entire meal.

2. Preparing multiple recipes for meals like spaghetti sauce, soups, and stews that take a long time to cook can save energy. Then refrigerate

or freeze for future use.

3. By dividing a skillet with foil inserts, several dishes can be prepared simultaneously.

4. When baking or cooking foods with extended cooking times try to avoid "peak hours" (8-11 a.m. and 4-8 p.m. are usually the peak hours).[26] During peak hours, utility companies often use less efficient means to provide for the higher demand for electricity.

Proper maintenance of cooking appliances is also important, not only to conserve energy but also for safety. Clean appliances work more efficiently, more safely, and certainly more hygienically. Proper inspection of equipment will help insure efficient operation. The following steps should be taken to maintain the efficiency of cooking appliances:

1. Keep heat reflection surfaces clean, especially the reflectors below the heating element on top of the range and the entire oven.

2. For the most efficient use of fuel, gas burners should have a steady blue flame. A yellow flame means it needs attention.

3. Make sure the pilot on a gas range is properly adjusted. It may be using more fuel than necessary.

4. Have faulty switches, burners, and thermostats fixed promptly and professionally. Check the oven thermostat every six months with a thermometer.

5. Make sure oven door seals are tight and not leaking heated air.

6. Air filters on exhaust fans must be cleaned periodically to work effectively and efficiently.

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO IDENTIFY ENERGY CONSUMPTION FOR FOOD CLEAN-UP ACTIVITIES AND TO PRACTICE FOOD CLEAN-UP TECHNIQUES WHICH FOSTER ENERGY CONSERVATION.

The clean-up activities for food include disposal of food material, cleaning of appliances, and washing of dishes and utensils. These activities involve the use of energy directly and indirectly. The use of appliances such as dishwashers, food disposals, and trash compactors involves the direct use of electricity. However, the use of hot water involves the indirect use of energy to heat the water.

There has been a great deal of controversy as to which cleaning technique requires more energy--hand-washing or dishwasher. There is no simple answer. The energy involved in hand-washing is for hot water, generally 15 gallons per day, and to combat the increase on the house's cooling system created by the heat from the hot water.

Dishwashers use energy in four ways: circulate the water; heat the water and dry the dishes; consume hot water; and combat the increased internal heat load on hot days. Dishwashers vary in efficiency and the quantity of hot water required. At present, manufacturers are not required to label dishwashers as to their energy efficiency but may in the near future. Their hot water consumption varies from 5 to 15 gallons per load.[27] Check the manufacturer's label for voluntary energy and hot water consumption information before buying a dishwasher. Consumer practices also have a great effect on the energy consumption for dishwashing. When using an automatic dishwasher, the following practices will help conserve energy:

1. Accumulate dishes until the dishwasher is full before washing to avoid fuel, hot water, and detergent waste.[28] Be careful not to overload the unit or block the circulation of water. Consult the operation manual.

2. Scrape dishes but do not rinse them before loading the dishwasher. If rinsing is necessary, use cold water.

3. Use only dishwasher detergents. Other cleaning agents can block the washing action, causing overflow and requiring a second wash cycle. Also, use the proper quantity of detergent.

4. Partial load cycles, rinse-only cycles, mid-cycle turnoff, and other special features are designed for energy conservation as well as convenience. One modification, a dishwasher power-saver switch, can cut off approximately 8 percent of the total energy consumption (both hot water and operational energy).[29]

5. Dishwasher drains and filters must be kept clear of debris so as not to reduce efficiency or cause overflow.

6. Dishwasher energy consumption can be reduced by about one-third by turning off the dishwasher after the final rinse and before the drying cycle.[30] Let the dishes air dry. After the final rinse, turn off the control knob of the dishwasher and open the door.

7. Don't use the dishwasher as a plate warmer.

8. On hot days use the dishwasher at night or in the very early morning to avoid extra heat in the house during the day. Automatic timers may be attached to the dishwasher to avoid "peak load" operation (usually 4-8 p.m.) and thus to help the electric utility in its problem of meeting peak demand.

When washing dishes by hand, the following practices will help conserve energy:

1. Use two containers, one for washing and another for rinsing, to avoid an excessive use of hot water.

2. Avoid washing dishes after each meal. Rinse dishes off with cold water and collect them until a sufficient number to warrant a full load is gathered.

3. Allow dishes to drain dry rather than drying with a towel (air-dried dishes are more germ-free than those dried with a towel) and avoid adding dish towels to the laundry (and energy) load.

The use of compactors and food disposers requires little electrical energy and conserve energy over other methods of waste disposal. Compactors save municipal collection costs and the energy required for waste handling; food disposals also save energy over other methods of waste disposal.[31]

FOOTNOTES

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[20]Butel, p. 22.

[21]"The Energy Challenge," p. 17.

[22]Ibid.

[23]Ibid., p. 18.

[24]Horner.

[25]Ibid., p. 17.

[26]FEA "Speaking of Energy," p. 4.

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[28]Henry R. Spies and others, *350 Ways to Save Energy and Money in Your Home and Car* (New York: Crown Publishers, 1974), p. 116.

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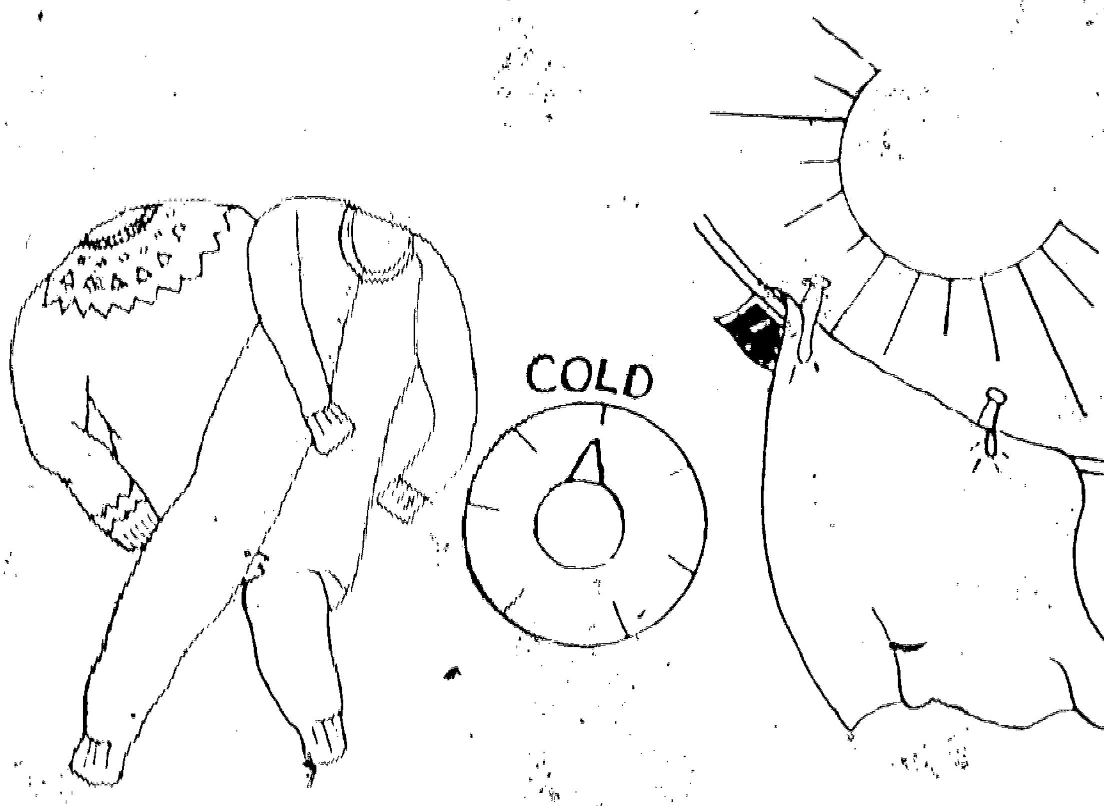
SECTION 7 — CLOTHING

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO MAKE WISE CLOTHING SELECTIONS AND TO RECOGNIZE ENERGY WASTING AND ENERGY CONSERVING CLOTHING CARE CHOICES AND PRACTICES.

Proper clothing selection can reduce the need for artificial heating and cooling and reduce energy consumption for clothing care as well. The judicious selection of clothing care appliances--washers, dryers, irons--can result in significant savings also. The clothes dryer is one of the major energy consuming appliances in the home. But the greatest energy savings can be achieved through conscientious laundry practices which conserve both electricity and hot water. Hot water is one of the largest, yet least apparent, uses of energy in the home; approximately 15 percent of the energy used in the home and 3 percent of energy used in the United States is for heating water.[1]



OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO MAKE ENLIGHTENED CLOTHING SELECTIONS WHICH WILL FOSTER ENERGY CONSERVATION.

Proper clothing selection can contribute to energy conservation in two ways: (1) by making the wearer comfortable and thereby reducing the need for air conditioning or heating; and (2) by reducing the need for hot water, hot air, and ironing when caring for clothing.

Clothing can act as insulation for the body by keeping a layer of warmth around it or as an air conditioner, allowing the body to cool itself by the evaporation of perspiration. During cool periods, clothing should be selected for its insulative value. Bulky fabrics, such as knit fabrics, hairy fabrics, or napped fabrics, have a great deal of air trapped within their structures which acts as insulation to keep body heat in and cool air out. Fibers such as wool and kinked synthetics are better for cold weather than smooth filament fibers, such as filament nylon or polyester, because they don't pack down and lie flat, eliminating air. The moisture content of wool also aids the feeling of warmth. Wool absorbs more moisture than synthetics or other natural fibers, and in doing so releases heat and feels warmer.

Check the garment tag for fiber content. Since the heat loss from the arms and legs is the controlling factor in body heat loss, the use of long-sleeved garments and those that cover the legs will help prevent chills. When feeling cool, one should put on a sweater rather than turn up the thermostat.

During warm periods, clothing that permits air to circulate and perspiration to evaporate is desired. Lightweight, loosely woven fabrics and clothing that fits loosely and has a minimum of layers provide for the best circulation of air. Cotton is an excellent fiber for warm weather clothing since it can be loosely woven in thin layers and has the ability to absorb perspiration from the body and pass it to the surrounding air. Most synthetics are poor moisture absorbers. Light-colored clothing also contributes to warm weather comfort by reflecting heat and solar radiation.

Today, a wide variety of fiber blends and fabric finishes are available which make clothing easier and less costly to care for. Many fabrics are permanent press and soil repellent. Permanent press items (clothing and linens) can be cold or warm water washed, require lower dryer temperatures and less drying time than regular fabrics, and need no ironing. Thus, they allow a savings of electricity and hot water. Washable woolens may also be washed in cold water, and all synthetics require lower ironing temperatures than natural fibers. Soil repellent fabrics not only require less frequent laundering than regular fabrics, but are easier to clean. Read the garment tag carefully to determine the proper care procedures. Remember, "dry clean only" fabrics are more costly to clean, both in money and energy, transport to the dry cleaner, use of dry cleaning chemicals, mechanical equipment, and plastic bags for protection. [See Figure 57.]

Before buying, always try on ready-made clothing to check for fit, appropriateness of style and color, and defects in manufacture. This will help avoid a trip back to the store to return unsuitable merchandise. When selecting patterns, fabrics, and notions to do home sewing, select everything on the same shopping trip to save fuel for transportation. Your time and energy will also be saved.

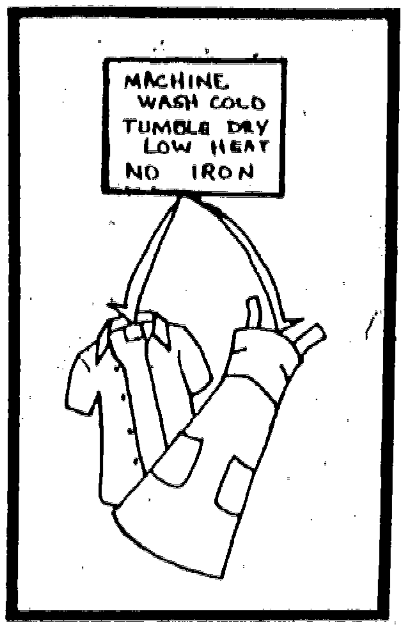


Figure 57 - Clothing Labels

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE PRACTICES FOR CLOTHING CONSTRUCTION WHICH WILL HELP CONSERVE ENERGY.

The uses of energy for clothing construction include electricity for electric scissors, sewing machine, hand iron and lighting. The major energy user is not the sewing machine but the iron. (See Appendix A.) Therefore, thought should be given to ways to reduce pressing time, the number of pressing sessions and the temperature setting of the iron.

It is beneficial to stitch as much as possible before pressing. If the same color thread can be used, two or more garments can be worked on at the same time. Several seams should be stitched at the same sitting before pressing. Do as much pressing as possible at one time and turn the iron off between pressing sessions. If the pressing session will require a lot of time, turn off the sewing machine light. Always select the proper temperature on the iron for the fabric you are sewing to reduce the need for repeated pressings and the danger of scorching.

By utilizing natural light, the need for artificial lighting may be avoided. Place the sewing machine near a window and sew during daylight. Natural light may be used for cutting and pressing as well.

Electric scissors use very little energy and provide the advantage of cutting several layers of cloth at the same time. However, use them frugally. They are not appropriate for all cutting jobs.

To operate efficiently, electric equipment must be properly maintained. Consult the manual for the sewing machine to determine its maintenance requirements. Keep all equipment clean and free of lint.

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO SELECT APPLIANCES AND RECOGNIZE PRACTICES THAT WILL FOSTER ENERGY CONSERVATION IN THE CARE OF CLOTHING.

Home care of clothing involves the use of appliances which consume electricity and hot water. The largest portion of the energy used for home laundering is used to heat water. The largest contribution to energy conservation in the home could be realized by switching from hot to cold water washing cycles; this could amount to an annual savings of about nine dollars[3] per household or about 10 percent of the energy used to heat water. A savings equivalent of 100,000 barrels per day (BPD) of oil could be achieved by the nation if cold water washing were adopted.[4] In the U.S., the average hot water temperature is 130°F; warm water temperature is 105°F; and cold water temperature is around 60°F. Water temperatures currently used in home laundering in the U.S. are: hot water, 30 percent; warm water, 50 percent; and cold water, 20 percent.[5]

There are a number of energy conserving features to look for when purchasing appliances such as washers, dryers, and irons:

1. Look for certification seals, such as Underwriters' Laboratories (UL), Association of Home Appliance Manufacturers (AHAM), and American Gas Association Laboratories (AGAL):

2. Inquire about the amount of hot water and electricity required to complete a normal cycle; there are differences in these respects among the washers on the market.

3. A "soak cycle" feature on a clothes washer is an energy saver. It can be used to loosen stubborn stains so heavily soiled clothes need to be washed just once.

4. Design of the washer should permit a partial filling of the tub when less than a full load of wash is to be done.

5. Select a washer with adjustable water controls which allow the user to select the water level to match the size of the load.

6. Many washers have adjustable wash-time controls. By matching wash-time to load and soil levels, washing longer than necessary can be avoided.

7. The automatic controls on the washer should permit rinsing to be performed in cold water regardless of the temperature selected for the wash.

8. Suds-saver features allow for the reuse of hot and warm water for several loads. These features permit the use of the warm water from the first load for the washing of the second load, and so on. This saves not only energy to heat water, but water and detergent. You can save up to 27% on water and 33% on detergent for laundering.[6]

9. Permanent press cycles on both the washer and dryer use lower temperatures than regular cycles and are especially designed to avoid wrinkling so no ironing is necessary.

10. Look for the proper capacity washer and dryer for your specific needs. Large capacity washers and dryers can handle in one load what small ones must do in two and so save energy. However, an underloaded large washer or dryer will waste energy. Capacity is indicated in terms of pounds of clothes. Portable washers are available which will wash and rinse a load (approximately 1/2 the size of the normal load in an automatic washer) in just 22 gallons. However, both the wash and rinse water can be reused twice. This can save as much as 63% on water used for laundering.

11. Dryers should be equipped with a buzzer to indicate when clothes are dry so they can be removed before wrinkles are set.

12. The most accurate type of control for dryers is a moisture sensor. It automatically shuts off when clothes are properly dry.

13. An "air fluff" cycle dries without heat. This can be a big advantage in drying delicate fabrics or feather pillows.

14. A "damp dry" setting on the dryer saves energy by reducing drying time and allowing clothes to be removed when ready for ironing.

15. Look for an iron with fabric settings to insure the proper temperatures to avoid wasting energy and scorching.

The use and maintenance practices for washers, dryers, and irons should be directed toward the conservation of electricity and hot water. This involves an attempt to reduce operation times and temperature settings to a minimum without sacrificing effectiveness. The units must be properly maintained to avoid operation inefficiencies which will require more energy to do an effective job. The following operation, maintenance, and practice tips will help reduce the energy demand when laundering:

1. Read the operation manuals for your washer, dryer, and iron and take advantage of energy saving instructions. Read maintenance instructions and follow them carefully.

2. The major cost in washing clothes is the hot water used. The more wash that can be done with cold or warm water, the more energy that can be saved. *Always* rinse with cold water. Sort clothes according to fabric and degree of soil since permanent press and washable woolens and lightly soiled clothing can be washed in cold water. There are a number of cold water detergents on the market, many with germicides which take the place of hot water for killing bacteria. [See Figure 58.]

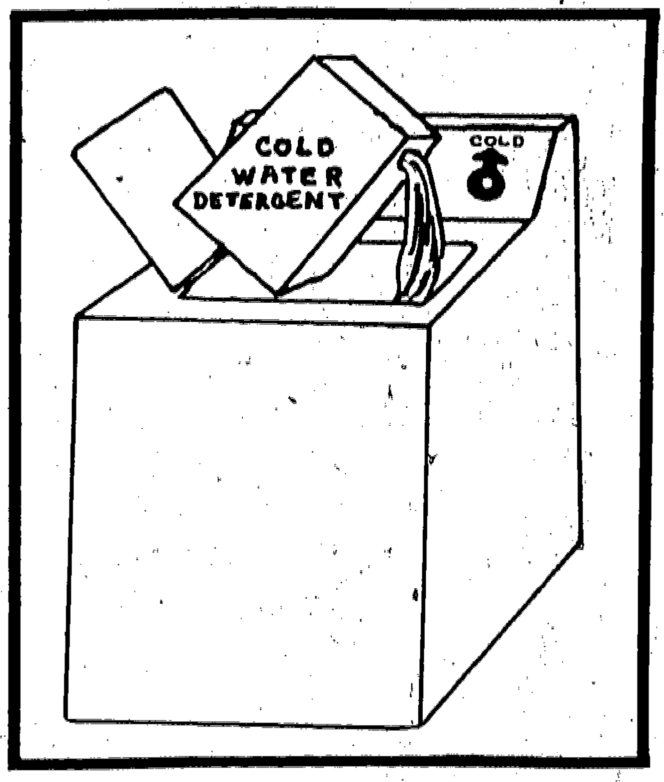


Figure 58 - Cold Water Washing

3. It is a good idea to locate the washer near the water heater to minimize heat loss in pipes. And be certain there are no leaks between water heater and washer.

4. Both the washer and dryer must be properly loaded. Collect laundry until there is a full load. Automatic washers and dryers go through the same cycle for a full load or a single item, unless they are equipped with a small load of mini-load cycle. Be careful not to overload. Overloading reduces the cleaning action of the washer and the drying action of the dryer as well as resulting in more abrasion, lint, and wrinkling. Varying the size of the garments in a full load allows for freer circulation in washer and dryer.

5. Use the special features on appliances to conserve energy; i.e., short cycles, mini-load cycles, cold water rinse, suds-savers, soak cycles, timers, moisture sensors, selection controls.

6. Use the appropriate water level, water temperature, washing time, drying temperature, and drying time for the type and size laundry load. Separate drying loads into heavy and lightweight items. Since the lighter ones take less time to dry, the dryer doesn't have to be on as long.

7. Dryers should be installed in a warm place to reduce the amount of heat needed; i.e., avoid placing dryers in unheated areas such as garages and utility rooms.

8. Keep the lint screen clean in the dryer, remove lint after each load. If the washer does not clean its lint filter automatically, you must clean it after each load. Check and clean the dryer exhaust on the outside of the house occasionally.

9. Dry clothes in consecutive loads to take advantage of the heat from previous loads. Small items may be dried on the stored heat from a previous load.

10. With the use of an old-fashioned clothes line (a practical solar energy device!), the energy consumption required for drying can be eliminated. Sun-drying also has a germicidal effect, adds needed humidity in the winter or in arid climates, and makes linens smell fresher.

11. Damp drying saves energy and prepares clothes for ironing without sprinkling. Natural fibers such as cotton, wool, or linen need a small amount of moisture to avoid feeling harsh and becoming wrinkled. Over-dried clothes are difficult to iron.

12. By removing clothing and linens promptly from the dryer and folding or hanging them carefully, many items will require little or no ironing. Some dryers are equipped for several minutes of "fluff only" with intermittent signals as a reminder to remove permanent press items before wrinkles set.

13. Hand irons consume as much energy as ten 100-watt light bulbs. Time can be reduced by ironing large batches of clothes at one time, avoiding heating up the iron several times, ironing fabrics which require low temperatures during warm-up and cool-down periods, and turning off the iron when interrupted for any length of time and when finished.

14. Use the lowest iron temperature required for each fabric. For example, synthetics require the lowest temperature; silk and wool require medium temperature; and cotton and linen require high temperature. Matching the temperature setting to the fabric prevents scorching or underpressing.

FOOTNOTES

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[2]Henry R. Spies and others, *350 Ways to Save Energy and Money in Your Home and Car* (New York: Crown Publishers, 1974), p. 50.

[3]"The Energy Challenge: What Can We Do?" (Malvern, PA: Energy Conservation Research, 1974), p. 21.

[4]John George Muller, *The Potential for Energy Savings Through Reductions in Hot Water Consumption* (Washington, D.C.: FEA, 1975), p. 1.

[5]Ibid., p. 22.

[6]"Suds Saver Washers," *Maytag Technical Bulletin, Number 11.*

[7]"Water Conservation," *Maytag Technical Bulletin, Number 10.*

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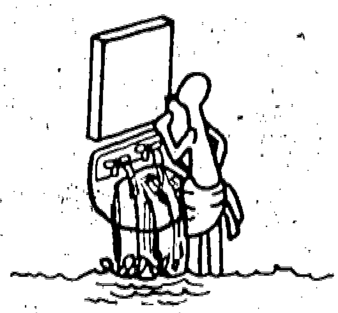
OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE WAYS IN WHICH ENERGY IS CONSUMED AND MAY BE CONSERVED FOR BATHING AND GROOMING.

Bathing and grooming activities consume energy for hot water and electrical equipment operation. The major consumption is for heating water, offering a significant potential for savings in an area over which the consumer may exercise a great deal of control. Also, the current popularity of a wide variety of grooming and beauty aids which require electricity or hot water increases the demand for energy. Savings can be achieved through energy-conserving fixtures, equipment, purchase practices, and uses.



UNIT 8.1 BATHING

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THE WAYS IN WHICH ENERGY IS CONSUMED AND MAY BE CONSERVED FOR BATHING.

The National Bureau of Standards (NBS) reports that bathing accounts for 42 percent of the daily use of hot water in the home.[1] Approximately 88 gallons of water per day are consumed by the average family in the United States for bathing (see Appendix B) and the average point-of-use temperature is 105°F.[2] The energy consumed for hot water used when bathing may be reduced through technology and frugal consumer practices. Some suggestions are given in this unit.

The average shower uses eight gallons of water per minute. There are showerhead flow control devices which can cut the flow to three gallons of water per minute. The reduced flow rate is compensated by increased pressure to insure effectiveness. By installing a flow restrictor or a new showerhead with a smaller flow rate and holding the duration of two showers to 5 minutes each, a reduction of 30 gallons per day of hot water could be realized. At present energy rates, this would result in a savings per year of $10.25 for gas-fired water heaters, $20.00 for oil-fired water heaters, and $36.00 for electric water heaters.[3]

Many devices are available to limit the flow of water from showerheads. A simple washer is the least expensive, but more elaborate flow restrictors are available which maintain a constant flow. (If line pressure drops, the device opens wider to maintain a constant flow.)[4]

It is somewhat impractical to expect people to reduce the number or temperature of th[illegible]s or showers significantly, but they should be encouraged to redu[illegible] amount of water they use. A significant savings could be achieved i[illegible]sumers would take short showers as opposed to lengthy showers or tub baths. A short shower uses less hot water, thus less energy.[5] (SEE ACTIVITY Q.)

A full bathtub requires about 36 gallons of water. The minimum water level for a bath (to allow for proper rinsing) is about 10 to 20 gallons. Taking a shower with the water running constantly requires eight gallons per minute without a flow control device. That means 40 gallons for a five minute shower up to 160 gallons for a twenty minute shower. A flow restrictor can reduce the water for showering to 15 gallons for a five minute shower. By turning the water off while soaping up and using water only for wetting down and rinsing off, only about 4 gallons will be needed.

The use of hot water at the bathroom lavatory is another source of energy consumption. The typical lavatory faucet permits a flow of five gallons per minute when wide open. With the use of an aerator or spray tap, the flow is reduced (mixing air with water makes the flow seem larger than it is). Aerators can reduce water consumption at bathroom lavatories by 25 percent. Flow restrictors may also be used on lavatory faucets, giving a savings of about 25 percent. It is estimated that a spray tap can save 50 percent over standard faucets.[6] Spray taps are more commonly found on kitchen sink faucets than bathroom lavatory faucets; however, because of their energy savings potential, they may become more popular. (A maximum temperature control device at the point of use may also reduce energy consumption by limiting the flow of hot water. Its main purpose, however, is as a safety device to avoid scalds.) Aerators, spray taps, and flow restrictors, though they vary widely in price and type, are all quite cost-effective.

Of course, every effort should be made to avoid leaks, particularly from hot water faucets. A hot water leak not only wastes water, but also the energy required to heat it.

If consumers demand other methods and improved technology in regard to hot water consumption, several possibilities exist for development. One of these is the improved design of tubs, shower stalls, and lavatories. These fixtures could be insulated, made of a material which feels warm and will not absorb or transmit heat, and shaped to fit the body more closely.

Another way to reduce hot water is by mixing hot and cold water at the water heater instead of adjusting the faucet. This can be accomplished by adjusting the valves on the water heater which are set to determine flow rate and temperature.[7]

Research is now underway in the area of waste water reclamation. It may be possible to reclaim the heat from the waste water from tubs, showers, and lavatories, as well as to reclaim the water for flushing toilets.

Following is a list of several tips for saving energy and hot water when bathing:

1. Take short showers instead of baths.

2. Reduce the duration of showers.

3. Fill the lavatory with warm water, rather than allowing it to run when washing or shaving.

4. During winter, allow the water for baths to cool (releasing heat to the bathroom) before draining.

5. Encourage members of your family to bathe one after the other (or together) to take advantage of the warmth of the fixture (and room) from previous use.

6. Avoid drafts near the tub or shower which would encourage the use of a higher water temperature.

7. Check for leaks around fixtures.

UNIT 8.2 GROOMING

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE WAYS IN WHICH ENERGY IS CONSUMED AND MAY BE CONSERVED FOR GROOMING.

Grooming involves the consumption of hot water, electricity, and petroleum products. Although the quantity of energy consumed for one grooming process or beauty product may be small (see Appendix A), when many pieces of equipment are involved, or when energy is wasted the costs mount up. The following beauty aids and equipment are commonly used for grooming: electric shavers, electric hair dryers, electric hair curlers and irons, electric toothbrushes, electric water pump tooth-and-gum cleaners, contact lens autoclaves, electric make-up mirrors, electric manicure sets, electric facial misters, and electric shoe buffers/polishers. This does not include the bathroom or dressing area equipment which may be in operation; lights, heaters, ventilators, sun lamps, heat lamps, air conditioners, and dehumidifiers. The popular use of these items, as well as the extravagant use of beauty products (which are petroleum products for the most part) is an indication of the lack of energy conservation awareness which currently prevails in the United States.

The simplest, most direct way to reduce the energy used for grooming is to limit the use of equipment which requires electricity. Another way to reduce energy consumption is to restrict the use of hot water. Also, a reduction in the quantity of petroleum products will indirectly save energy. The following are tips to aid in saving energy while grooming:

1. When no longer in use, equipment should be turned off, disconnected, and stored (out of reach of young children).

2. Electric equipment should be properly maintained. Check for faulty wiring, dials, thermostats, and seals. Keep equipment clean.

3. Use equipment only when necessary. For example, air dry hair when possible, brush your teeth "by hand," and polish your shoes "by hand."

4. Keep light fixtures clean.

5. Keep exhaust fans and ventilators clean.

6. Avoid overheating the bathroom. An exhaust fan may be used to remove excess heat and moisture from a bathroom more efficiently than by air-conditioning.

7. An electric shaver may be more energy conserving than shaving with a blade if a great deal of hot water is used, not to mention shaving cream.

FOOTNOTES

[1]John Muller, "The Potential for Energy Savings Through Reduction in Hot Water Consumption" (Washington, D.C.: Federal Energy Administration, 1975), p. 16.

[2]Ibid., p. 5.

[3]Ibid., p. 17.

[4]Ibid., p. 19.

[5]FEA, "Tips for Energy Savers" (Pueblo, Colorado: Public Document Center, 1974), p. 18.

[6]Muller, p. 20.

[7]Ibid., p. 19.

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SECTION 9 ENTERTAINMENT

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO REALIZE HOW ENERGY IS CONSUMED BY ENTERTAINMENT DEVICES AND HOW ENERGY COULD BE SAVED THROUGH IMPROVED ENTERTAINMENT PRACTICES.

Home entertainment for the most part means watching television, listening to a radio, or playing tapes, cassettes, or records. In 1970, the percent of U.S. households having televisions was 94.7.[1] The large number of these devices multiplied by the amount of time they are being operated alarms conservationists. Energy could be saved if more Americans would entertain themselves. A return to reading, card games, table games, or even good conversation would reduce the amount of energy used for entertainment.

In addition to a reduction in the use of entertainment devices, it is important to carefully select these devices. Color television sets use about twice as much energy as comparable black and white sets.[2] Also, "tube type" sets require about twice as much energy as comparable solid state sets.[3] Extra features such as "instant on" and wireless remote control require more energy. The extra energy is not consumed in turning the set on or changing the channel, but in keeping parts of the set on *all the time*--even when the set is turned "off."[4] (See Appendix A.)

Energy consumption information for tape decks, record players, and radios varies greatly, depending on life style; however, when selecting these devices it is wise to choose a reputable dealer, look for the Underwriters Laboratory (UL) tag (not only on the cord but also on the unit), and consider paying more initial cost to save money in operating costs.

The way in which entertainment devices are used and maintained also affects the amount of energy consumed. One of the major problems is leaving equipment on unnecessarily. Never let the television, radio, tape or record player entertain an empty room! Often the TV is only being listened to, not watched. The program may be broadcast on radio which requires only one-sixth the energy of television. However, be careful not to continually turn off and on a "tube type" unit; heating and cooling the tubes repeatedly wears them out. Also, don't allow several devices to operate at the same time. It might help if small children are not encouraged to operate these pieces of equipment.

All entertainment devices should be kept clean and free of dust. Dust on tubes causes them to overheat and reduces their lifetime. Dust on television screens greatly reduces the quality of the picture, while dust on record and tape players not only reduces the sound quality but may also damage the records and tapes. Records and tapes are petroleum products, so great care should be taken in their use and selection. Teenagers and young adults are the major market group for tapes and records and tend to purchase the "current hits" which are soon discarded. Possibly tapes and records will be recycled in the future.

"Tube-type" devices must have good air circulation to cool. Therefore, they should be placed where air will be free to circulate around them (particularly in the back). Don't place "tube-type" devices on shelves or in cabinets where there is little or no air circulation. If you have an "instant on" television, unplug the set when no one will be using it for an extended time (e.g., vacations).

FOOTNOTES

[1]Tonsil, John. *Residential Consumption of Electricity*, Report No. ORNL-NSF-EP-51 (Oak Ridge, 1973), p. 6.

[2]Spies, Henry and others, *350 Ways to Conserve Energy and Money in Your Home and Car*, (New York, 1974), p. 118.

[3]"Watts Going On Where You Live?" (Louisville, Ky: General Electric [n.d.]), p. 14.

[4]Spies, p. 118.

ADDITIONAL REFERENCE

"101 Ways to Conserve Electricity at Home." New York: Commonwealth Edison, [n.d.].

SECTION 10 IMPROVING ENERGY EFFICIENCY IN THE HOME

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE HOW TO IMPROVE ENERGY EFFICIENCY IN THE HOME.

There are many ways to save energy in the home; some cost money, but many are absolutely free. They all save the occupants fuel and money as well as keep them comfortable. HUD estimates that each year American homes waste the equivalent of about 223 million barrels of oil which could be saved without sacrificing comfort.[1] Energy can be saved by adding insulation to homes, by proper upkeep of homes and appliances, and by minor interior alterations.

[SEE ACTIVITY S.]

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO DETERMINE IF ADDITIONAL INSULATION IS NEEDED IN A HOME.

Probably the single most important way to improve energy efficiency in the home is by adding insulation.[2] Most homes are underinsulated; some are not insulated at all! As shown in Figure 59, walls, floors, and ceilings should be insulated. Insulation can be easily added by the occupant in most cases. It is usually easiest and most effective to install insulation above the ceiling. Next easiest is under the floor. The most difficult place to add insulation is in walls. Furthermore, the addition of insulation is cost-effective; that is, it will more than pay for itself in energy savings. The following steps should be followed when insulating your home.

1. Determine how much insulation is desirable for the particular climatic region in which the home is located. This is most easily accomplished by asking the local utility company or the State Energy Office. Examples of *currently* recommended minimum R-values are listed below:

	FHA Minimum Standards for Gas Heat	National Mineral Wool Assoc. for Oil Heating	TVA Electric Heating	Studies Based on Minimum Life Cost	Owens Corning
Ceilings	R-19	R-19 or R-22*	R-19	R-30	R-38
Walls	R-11	R-11 or R-13*	R-11	R-20	R-19
Floors over unheated space	---	R-11	R-11	R-20	R-22

*special situations

2. Translate the R-value into insulation thickness. As mentioned, insulating materials have differing abilities to reduce the transfer of heat. This is illustrated in the table on the following page:

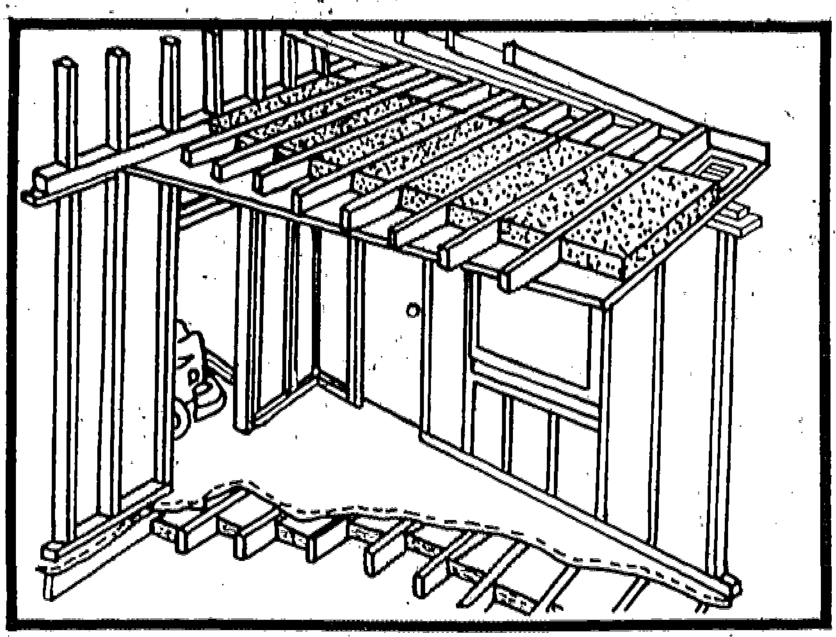

Figure 57. Wall, Floor, and Ceiling Insulation.

	Insulation				
	Batts or Blankets		Loose Fill (Poured-in)		
Material Thickness	Glass Fiber	Rock Wool	Glass Fiber	Rock Wool	Cellulose Fiber
1 inch	R-3.38	R-3.66	R-2.20	R-2.75	R-3.66
2 inches	R-6.76	R-7.32	R-4.40	R-5.50	R-7.32
3 inches	R-10.14	R-10.98	R-6.60	R-8.25	R-10.98
4 inches	R-13.52	R-14.64	R-8.80	R-11.0	R-14.64
5 inches	R-16.90	R-18.30	R-11.0	R-13.75	R-18.30
6 inches	R-20.28	R-21.96	R-13.20	R-16.50	R-21.96
7 inches	R-23.66	R-25.62	R-15.40	R-19.25	R-25.62
8 inches	R-27.04	R-29.28	R-17.60	R-22.0	R-29.28

Note: R-value is marked on insulation.

3. Determine the level and type of *existing* insulation, and translate into R-values. As an example, the following information has been determined for a home in Knoxville, Tennessee:

Location	Type of Existing Insulation	R-value of Existing Insulation	R-Value Recommended for Location	Additional R-value needed
Ceiling	4" loose rock wool	11	30	19
Walls	2½" fiberglass batt	8.45	20	11.55
Floor	none	--	20	20

4. Determine what additional insulation is needed using the format of the table above. In the previous example, the ceiling would require seven additional inches of loose rock wool; the floor would require six inches of fiberglass batt; and the walls could not be further insulated due to a lack of space. The additional insulation may be installed by the occupant or by a contractor.

[See Activity T.]

UNIT 10.2 UPKEEP ON HOME

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THE UPKEEP PRACTICES REQUIRED TO MAINTAIN AN ENERGY EFFICIENT HOME.

It is not enough to start with an energy efficient home and sit back and relax. As the home ages, cracks and crevices form and infiltration increases; insulation tends to settle and degrade. Since the soiling process is a never-ending problem, filters must be changed, windows cleaned, and heating and cooling elements cleaned periodically. In addition, heating, ventilation, and air-conditioning (HVAC) systems, plumbing, and lighting must be maintained.

Every year or two the following steps should be taken to maintain a home's energy efficiency:

1. Check the interior and exterior of the home for cracks and crevices; fill or seal them.

2. Check the weatherstripping and caulking around windows, doors, and chimneys; repair if necessary.

3. Have the heating, ventilation, and cooling systems checked; adjust oil furnace burners at least once a year to avoid wasting fuel.

4. Paint interior and exterior if needed to seal small cracks.

5. Examine the chimney for cracks and deterioration; repair if necessary.

Each fall and spring:

1. Make sure furnace and air conditioning filters are clean. Dirty filters waste fuel and money and will shorten the life of the equipment. Filters should be checked every month if possible.

2. Clean windows to take advantage of solar radiation.

3. Dust radiators and baseboard units thoroughly; dust reduces the efficiency of a unit.

4. Check for water leaks or drips; hot water loss results in both an energy loss and a water loss.

[SEE ACTIVITY U.]

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE THE UPKEEP PRACTICES REQUIRED TO MAINTAIN APPLIANCE EFFICIENCY.

Most people do not worry about the maintenance of appliances until they malfunction, yet great quantities of energy are being wasted each year by poorly maintained equipment. Several maintenance tips are listed below:

1. Each year open the hot water tank valves to draw off bottom water and sediment which has accumulated. (Sediment interferes with transfer of heat to the water.)

2. Defrost refrigerators and freezers regularly and check the gaskets for wear. (Close the door on a piece of paper. If it can be easily pulled out, it's time to adjust or replace the gasket.) Clean the condensing coils--dust acts as a insulator that reduces efficiency.

3. Clean the clothes dryer lint filter after each load.

4. Clean the dishwasher screen often.

5. Clean the kitchen and bathroom exhaust fan filters often

6. Keep appliances clean, dust, food, and cleanser build-up interfere with efficiency.

7. Check oven door gaskets for wear.

[SEE ACTIVITY V]

UNIT 10.4 INTERIOR ALTERATIONS

OBJECTIVE: TO ENABLE THE TEACHER OR STUDENT TO RECOGNIZE INTERIOR TREATMENTS WHICH INTERFERE WITH THE HEATING AND COOLING OF THE HOME, AND HOW THEY MIGHT BE AVOIDED OR ALLEVIATED.

Interior furnishings and structure should not interfere with or reduce the efficiency of the heating and cooling equipment or the shell of the home as an insulator. In fact, the interior treatments should enhance the energy efficiency of the home.

To avoid reduced efficiency, the following items should be considered in the home:

1. Heating and cooling registers should not be blocked by furnishings.

2. Window coverings should permit opening and closing to utilize solar radiation.

3. Thermostats should not be covered, blocked, or exposed to direct sunlight.

4. Avoid dark interiors which require more artificial lighting.

5. Caulk and seal cracks and crevices at wall, floor, ceiling, tile, and cabinet joints to reduce infiltration.

6. Avoid interior partitioning; walls, furniture, hangings, or cabinets interfere with air circulation. This creates uneven heating and cooling and places a strain on the equipment.

7. Avoid placing refrigerators and freezers in areas where there may be inadequate circulation of air (corners, closets, cul-de-sacs). These units need good air circulation around their heat exchangers in order to operate efficiently.

To enhance the energy efficiency of a home, the following suggestions are given for alterations:

1. Insulate with drapery or window treatments.

2. Apply vinyl wallcovering to exterior walls to reduce infiltration.

3. Remove obstructions to air circulation.

4. Install wall-to-wall carpeting for added insulation.

5. Place storage units against exterior walls.

6. When remodeling, place cabinetry, closets, and seldom-used spaces on exterior walls.

7. Replace incandescent lighting with fluorescent lighting where possible.

8. Use light-colored furnishings and finishes where practical.

FOOTNOTES

[1]Abt Associates, Inc., *In the Bank. . . Or Up the Chimney?. A Dollars and Cents Guide to Energy-Saving Home Improvements* (Washington: Government Printing Office, April 1975), p. i.

[2]Henry R. Spies and others, "350 Ways to Save Energy and Money in Your Home and Car", (New York: Crown Publishers, Inc., 1974), p. 13.

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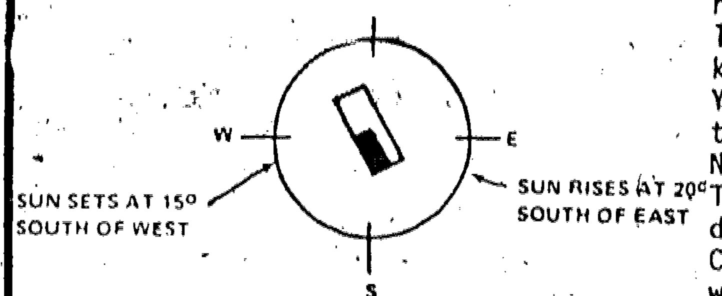
ACTIVITY A — SUN ORIENTATION/WIND ORIENTATION

OBJECTIVE: TO DETERMINE WHERE THE SUN RISES AND SETS IN RELATION TO YOUR HOME AND TO DETERMINE LOCAL WIND PATTERNS.

The way in which your home is oriented to the sun and wind affects the impact of the climate and the energy needed to maintain comfort. To understand this concept, it is helpful to determine the compass orientation of your home. First, think of your home as a box (usually a rectangular box) and view it from a bird's perspective. Given the directions of the compass on the circle below, locate your house in the center facing the appropriate direction. Use a compass to determine which direction each side of your home faces. It may not be directly N, S, E or W, but using the face of the compass and this circular representation you should be able to make a good estimation of the direction. Once the house is sketched on the circle, use your compass to locate the point at which the sun rises and sets.

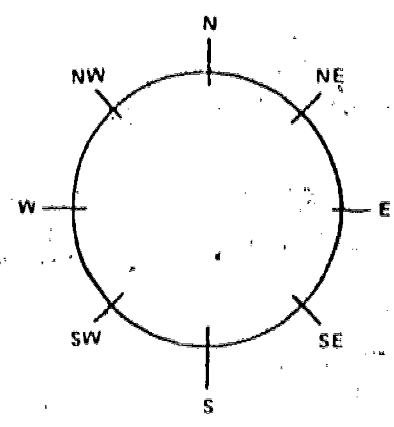


In the example on the left, the house is rectangular and the living area (the family room/kitchen) is represented in black. You can see that the long axis of the house runs slightly W of North by slightly E of South. The points indicating the sunrise direction and sunset are marked. Conclusion: The family room area will receive the afternoon sun and be a "sun warmed" area. This could be beneficial or bad depending on the climate.

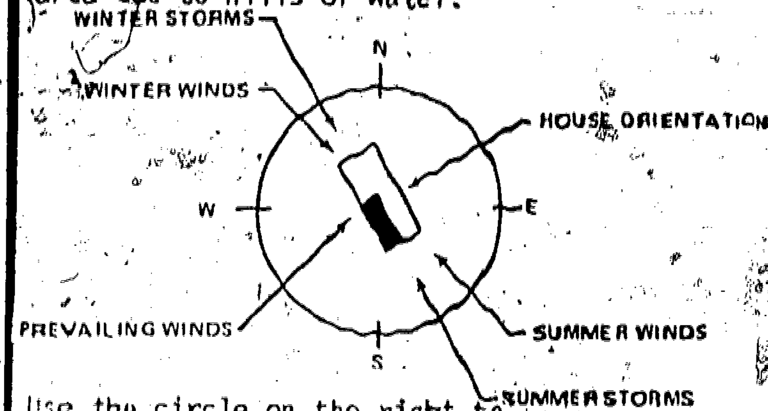
Use the circle on the right to locate your house.

Instructions:

1. Draw in your house's orientation to the compass.
2. Draw in where the sun rises and sets.
3. Where are the living areas (den, family room, kitchen) of your house in relation to the compass?
4. Are the living areas exposed to morning or afternoon sun?



In addition to the sun, the winds also can be located on a similar drawing. Using the same example, we can illustrate the direction from which the winds affect the house. Information about winds can be found through observation or by inquiring at your local weather bureau, agricultural extension service, or news agencies. There may be slight differences within a local area due to hills or water.

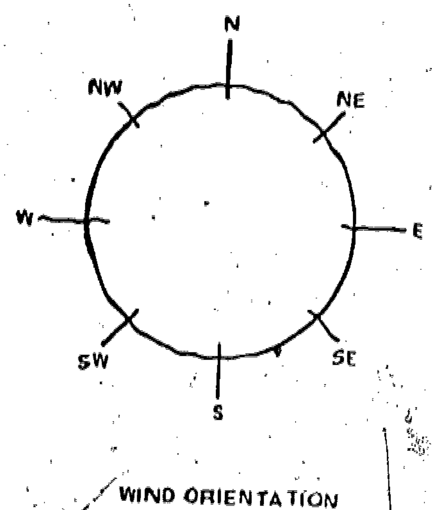


In the example, the living area is only exposed to prevailing winds and slightly to summer storm winds. The winter winds are from the NW, so the example house should not have large window areas on the NW side if it is located in a temperate or cool climate zone.

Use the circle on the right to locate your house.

Instructions:

1. Locate house orientation.
2. Locate prevailing winds.
3. Locate summer winds and summer storms.
4. Locate winter winds and winter storms.
5. Which areas of your house are exposed to storm winds? To winter winds?



Question: Do you feel your house has a good or poor orientation to the sun and wind? Why?

Suggestion: The teacher may need to demonstrate how to use a compass. Locate the classroom on a circular grid.

OBJECTIVE: TO DETERMINE THE EFFECT VEGETATION HAS ON ENERGY CONSUMPTION AND COMFORT.

Trees and plantings are often leveled in an area prior to residential development with little regard for their economic and esthetic values. The trees, shrubs, ground covers, vines, and flowers temper the impact of sun and wind on the home. Vegetation can shield a home from unwanted sun and wind, but still admit desirable sun and breezes. Because of the angle of the sun and the effects of seasonal changes, most homes need protection from the sun during summer on the south, west, and east sides, and protection from wind during winter on the north side. Of course, there are regional variations. Investigate the N, S, E, and W sides of your home and determine if the vegetation is beneficial and where additional vegetation is needed. Make your comments in the space provided.

North Side:

Trees ______________________________

Shrubs ______________________________

Does the vegetation make a good wind shield?

South:

Trees ______________________________

Shrubs ______________________________

Groundcover ______________________________

Vines ______________________________

Does the vegetation make a good sun shade? Are most of the trees deciduous?

West:

Trees ______________________________

Shrubs ______________________________

Groundcover ______________________________

Vines ______________________________

East:

Trees ______________________________

Shrubs ______________________________

Groundcover ______________________________

Vines ______________________________

Suggestions:

1. Have a landscape architect or nurseryman visit the class to discuss different types of vegetation and their effects on homes' heating and cooling needs.

2. Investigate the vegetation around the school and make recommendations to the school administration for additional plantings if they would be beneficial.

ACTIVITY C — ROOM ORIENTATION

OBJECTIVE: TO DETERMINE YOUR HOME'S LIVING AREAS IN RELATION TO THE SUN AND WIND.

As an expansion of Activity A, let's not only look at the orientation of your house's exterior faces, but at the rooms on the interior. It is important to determine which directions the rooms face (that is, outwardly facing, not toward the interior of the house). A room may face more than one direction depending on how many sides are exterior sides. On the grid below are indicated the orientations of the rooms of a sample house. As you can see, most rooms have more than one orientation. Notice most of the daytime areas face southerly or westerly directions which will be lighter and warmer in the afternoon.

Space (EXAMPLE)	N	NE	E	SE	S	SW	W	NW
Sleeping		X	X	X				
Family				X	X	X		
Living			X	X	X			
Food Prep/Kitchen		X	X					
Dining						X	X	X
Play Space					X	X	X	
Storage	X	X						
Bathrooms					X	X	X	

On the grid below indicate the room orientation of your home. Use a compass to determine yours. Stand inside facing directly the wall whose orientation you are trying to determine. The direction indicated on the compass is the one you mark on the grid. Check all the outside facing walls of a room. (Interior rooms having no exterior walls will have *no* X's on the grid.)

Space	Orientation							
	N	NE	E	SE	S	SW	W	NW
Sleeping								
Family								
Living								
Food Prep/Kitchen								
Dining								
Play Space								
Storage								
Bathrooms								
Other Spaces								

Considering your climate, do the rooms in your house have advantageous orientations? Why or why not?

If the orientations are poor, what measures can be taken to overcome or reduce the problem? (Awnings, plantings, paint color, insulation, room use changes, etc.)

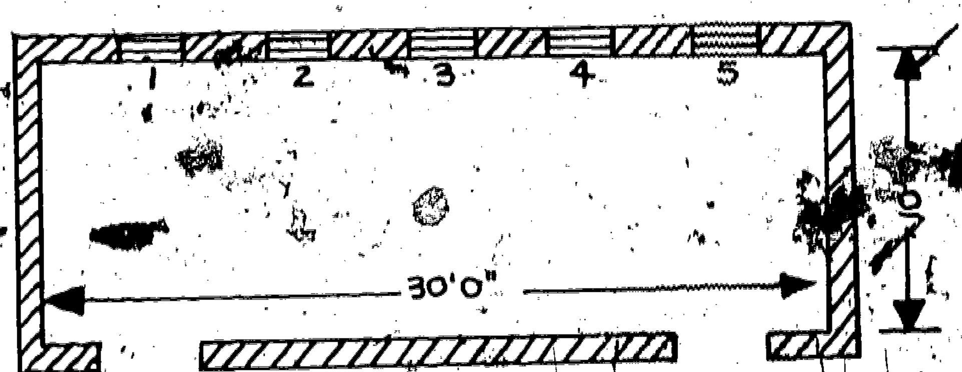
Suggestion: The teacher may need to demonstrate how to use a compass to determine room orientation. Use the classroom as an example.

ACTIVITY D — WINDOW AREA INVESTIGATION

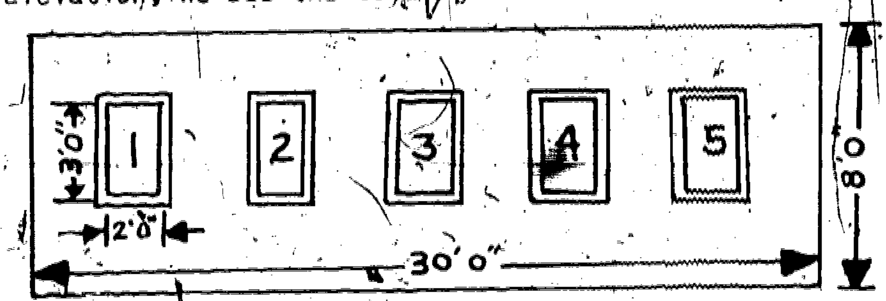
OBJECTIVE: TO DETERMINE THE PERCENTAGE OF SQUARE FOOTAGE OF WINDOW AREA TO TOTAL WALL AREA AND TOTAL FLOOR AREA.

Since glass has much less insulative value than a wall, it is wise to use as little glassed area (windows) as possible to conserve energy for cooling and heating. There are building code restrictions and guidelines for the amount of glassed area: 10 percent of the total square footage of floor-space for the home and less than 20 percent of the total square footage of the exterior wall are generally accepted standards for residences.

It is a simple arithmetic procedure to determine if your home or classroom meets these guidelines. First try the 10-percent-of-the-floor method. In the example below, we see the square footage of the room is 300 square feet.



From the elevation, we see the total *glassed* area is 30 square feet.



To determine the percentage of glassed area you simply divide:

$$\frac{30 \text{ glassed area}}{300 \text{ floor area}} = .10 \text{ or } 10\%$$

Now try the 20-percent-of-total-wall-area method. In the example, the total wall area is 240 sq. ft. since 8' x 30' = 240 sq. ft. The glassed area is 30 sq. ft. Therefore, the percentage of glassed area is:

$$\frac{30}{240} = .125 \text{ or } 12.5\%$$

Using either method, the glassed area is within the guidelines.

Now determine if your classroom or home meets the guidelines.

Method I: 10% of floor area

Total Floor Area ________ sq. ft.
Total Glassed Area ________ sq. ft.

________ $\frac{\text{glassed area}}{\text{floor area}}$ = ____ = ____ %

Method II: 20% of wall area

Total Wall Area ________ sq. ft.
Total Glassed Area ________ sq. ft.

________ $\frac{\text{glassed area}}{\text{walled area}}$ = ____ = ____ %

Suggestions:

1. Try both methods in the classroom before trying to tackle your home.
2. This makes a good group activity.
3. This Activity may be used in conjunction with reading floorplans and measuring interior spaces.
4. Remember to measure only the *glassed* area of windows--not the frames, too.
5. Note that weather changes will also affect heating and cooling energy uses.

ACTIVITY E FLUORESCENT VS. INCANDESCENT LIGHTING

OBJECTIVE: TO DEMONSTRATE THE RELATIVE ENERGY EFFICIENCY OF FLUORESCENT AND INCANDESCENT LIGHTING.

Wattage is not a measure of the amount of light given off by a light bulb, but how much energy is required to operate it. The amount of light it provides is indicated in lumens. Bulb packages should give not only the wattage required, but also the lumens produced by the bulb. Using bulb packages, compare several incandescent and fluorescent bulbs for efficiency (lumens per watt).

For example: A 100-watt incandescent bulb may yield 1750 lumens which gives the bulb an efficiency of 17.5 lumens per watt:

$$\frac{1750 \text{ lumens}}{100 \text{ watts}} = 17.5 \text{ lumens per watt}$$

Determine the efficiency of the following bulbs, plus any others you may have.

A. 100 watt fluorescent bulb: $\frac{\_\_\_\_ \text{ lumens}}{100 \text{ watts}}$ = ____ lumens per watt

B. 40 watt fluorescent bulb: $\frac{\_\_\_\_ \text{ lumens}}{40 \text{ watts}}$ = ____ lumens per watt

C. 100 watt incandescent bulb: $\frac{\_\_\_\_ \text{ lumens}}{100 \text{ watts}}$ = ____ lumens per watt

D. 25 watt incandescent bulb: $\frac{\_\_\_\_ \text{ lumens}}{25 \text{ watts}}$ = ____ lumens per watt

1. Which type of lighting is more efficient--incandescent or fluorescent?

____

2. Is it more efficient to buy four 25-watt or one 100 watt incandescent bulb? ____________________

Suggestions:

1. Ask the school maintenance supervisor for empty fluorescent light bulb boxes. The information you need is on the *box*, not the bulb.

2. Have students bring in bulb *boxes* from home.

3. Check at home for the use of multiple low wattage bulbs where a larger wattage bulb might be used to save energy. But remember, a larger wattage bulb gets hotter during operation and some fixtures are not designed for the larger wattage bulbs.

4. Discuss the comparative lifetimes of fluorescent and incandescent bulbs. (Refer to Section 3.2, "lighting.")

5. Discuss the turning off and on of incandescent and fluorescent bulbs. (Refer to Section 3.2, "lighting.")

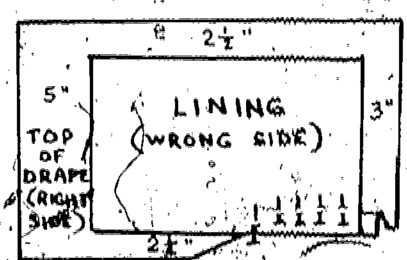
ACTIVITY F — DESIGN AND FABRICATE A WINDOW TREATMENT

OBJECTIVE: TO DESIGN AND FABRICATE AN ENERGY CONSERVING WINDOW TREATMENT.

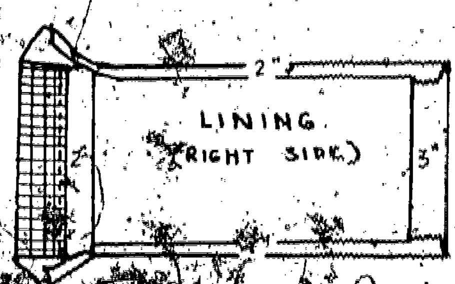
One of the least expensive and most effective window treatments for the conservation of energy is an insulated drapery. The major differences between a standard drapery and an energy-conserving drapery are a tight fit and insulative lining. Standard drapery construction guides should be followed in making energy-conserving draperies, but make certain that they include returns to the wall, a 4-inch overlap, and full length from ceiling to floor if possible. A cornice or valance may be used to reduce convection air flow over the top of the drapery. Then substitute *insulative* lining for the standard lining. Insulative lining is available in several types: (1) plastic or vinyl which may be either clear or opaque and serves mainly as a barrier to air and moisture; (2) fabric coated with vinyl; (3) silver backed fabric which is particularly valuable in reflecting the sun's rays as well as serving as a barrier to air and moisture; and (4) a foam backed fabric which has the added benefit of increased R-value, and as acoustical insulation.

Included for your convenience is a step-by-step illustration for making lined drapery.

Step 1

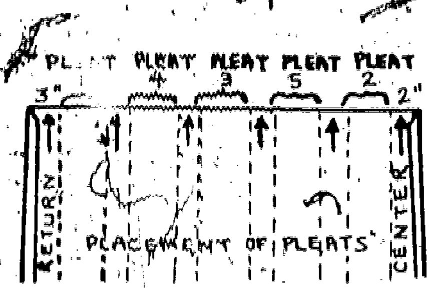


Step 2

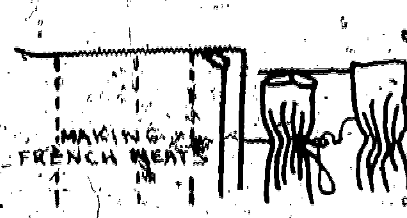


Step 3

Step 4



Step 5



Suggestions:

1. Make drapery for a window in the Home Economics Laboratory. If funds are available, identical draperies with different or no lining could be made to compare their insulative value.

2. If possible, have students fabricate drapery for their own rooms at home.

3. Demonstrate measuring for drapery prior to this activity.

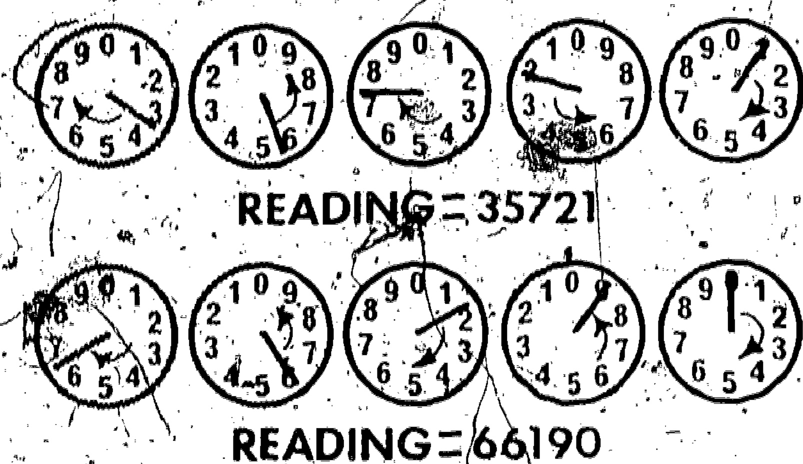
4. As an alternative to constructing an insulated drapery, an insulated window shade might be made. Plans for construction, as well as hardware kits, are available from:

   Rainbow Energy Works
   2325 Moraine Circle
   Rancho Cordova, Ca. 95670

OBJECTIVE: TO DEMONSTRATE HOW TO READ ELECTRIC AND GAS METERS, AND HOW TO DETERMINE CONSUMPTION OVER A PERIOD OF TIME.

In order to determine the effectiveness of your energy-conservation efforts you must be able to tell how much energy is being consumed at your house. The easiest way to do this is by taking meter readings. Electric and gas meters give the total, or cumulative, energy consumption. They operate much like the odometer on a car. You must compare beginning and end readings to find out how much energy your family used over a given period of time (one day, one week, one month). For example, if your meter read 35721 kilowatt-hours on Monday morning and 35731 on Tuesday morning, it means your home consumed 10 kilowatt-hours of electricity for that day or 24-hour period.

Most electric meters have five dials organized from right to left: the rightmost indicates kilowatt-hours; the next dial, tens of kilowatt-hours; then hundreds; and so on. But the dials alternately rotate clockwise and counterclockwise. You should record the digit the indicator has just passed. Study the illustrations and readings below.



The dials of a gas meter are much like that of an electric meter except that there are usually only four dials with markings representing 100 cubic feet on the rightmost dial. In the illustration on the next page, the reading of 4846 represents 484,600 cubic feet of gas.

READING=4846

If, after one day, the reading were 4876, then the consumption that 24-hour period would have been 3,000 cubic feet of gas.

487600
-484600
3000 cubic feet of gas

Now check your meter and record your findings:

Initial Reading________________________
Final Reading________________________

Consumption for designated
time period________________________

Now institute one or several energy-conserving practices (reset thermostat; clean filters; cut down on use of lights, appliances, TV; take short showers) and record your findings: (Use the same time period as before)

Initial Reading________________________
Energy Conservation Measures Instituted

____

____

____

Final Reading________________________
Consumption for designated
time period________________________

Was there a reduction in consumption when conservation was practiced?

Suggestions:

1. Use a time period of at least a week.
2. Ask your local Utilities for information or demonstrations.

ACTIVITY H THERMOSTAT SETBACK

OBJECTIVE: TO DEMONSTRATE THE EFFECT THERMOSTAT SETBACK HAS ON ENERGY CONSUMPTION.

Now that you can read your meter (Activity G), you can investigate the effects of thermostat setback on the energy consumption at your residence. During the cooling season, thermostats should be set up to 78°F to reduce the use of mechanical air conditioning and during the heating season, set down to 65°F. For additional savings, the thermostat can be set back to 60°F during the night. The effect of these thermostat setbacks will vary from residence to residence, but should be significant.

To test the impact of thermostat setback at your home, first determine the weekly consumption of energy prior to the setback. Read your gas, oil, or electric meter one week before the setback and read it a second time exactly seven days (to the hour) later.

For example:

First Reading	Second Reading
Meter Reading: 14276 kwh	Meter Reading: 15101 kwh
Date: 9/8/77	Date: 9/15/77
Time: 8:00 a.m.	Time: 8:00 a.m.

The energy consumed by the example home for the week was 925 kwh (15101 kwh - 14276 kwh = 925 kwh)

Immediately after the second reading set back the thermostat 5°F lower if heating and 5°F higher if cooling. Then take a third meter reading exactly seven days later.

For example:

Third Reading
Meter Reading: 15897 kwh
Date: 9/22/77
Time: 8:00 a.m.

The energy consumed by the example home for the week with the set back is 796 kwh. To determine the possible savings, find the difference between the first week's consumption and the setback week's consumption.

Using the example home:
925 kwh - 796 kwh = 129 kwh

Now try the test at your residence.

First Reading	Second Reading	Third Reading
Meter Reading: ______	Meter Reading: ______	Meter Reading: ______
Date: ______	Date: ______	Date: ______
Time: ______	Time: ______	Time: ______

First week's consumption:

______ - ______ = ______
meter reading 2 - meter reading 1 = consumption

Setback week's consumption:

______ - ______ = ______
meter reading 3 - meter reading 2 = consumption

Savings

______ - ______ = ______
First week's consumption - Setback week's consumption = savings

Questions:

1. Why is it better to use a week's consumption for comparison rather than a day or an hour?

2. What could be possible reasons for finding no savings or possibly an increase in consumption during the week with the setback?

3. How much money could be saved in a year if you could realize the savings you found (if you found one) during the setback week?

Suggestions:

1. Do this investigation when mechanical heating or cooling is certain to be needed.

2. Refer to Activity G for a more detailed description of meter reading for electricity, oil, or gas.

3. Make certain no one adjusts the thermostat during the two weeks of the investigation.

ACTIVITY I — HOT WATER AUDIT

OBJECTIVE: TO DEMONSTRATE A FAMILY'S HOT WATER CONSUMPTION AND POSSIBLE CONSERVATION MEASURES.

The major uses of hot water in the home are for bathing and laundry. Use the data sheet provided to estimate your family's hot water consumption for a week.

Task	Number of times/week	Multiplier (in gallons)	Quantity of Hot Water (in gallons)
laundry loads			
tub baths		15	
showers		25	
dishwasher loads		20	
washing dishes		10	
by hand		5	

Total-

Tally the number of times per week the task using hot water occurs. Then multiply the number of times by the multiplier provided. The multiplier is the average amount of hot water required for the task. The resulting value is the quantity of hot water consumed for the task. Then add the quantities for each task to arrive at an estimate of the hot water your family uses in one week. (The average household uses about 350 gallons of hot water per week.)

You can now approximate the energy required to supply this quantity of hot water.

_____________ gallons x 2.45 watt-hours/gal. = _______ watt-hour
quantity of water

If you use ________ gallons per week, you use approximately 52 times that per year or ______ gallons.

Calculate the energy cost for a year's consumption:

_____________ gallons x 2.45 watt-hours/gal. = _____ watt-hours
quantity of water

This is __________ kwh for one year (just move the decimal 3 places to the left). Find out the rate in your area for electricity per kwh and determine the cost of one year's hot water consumption.

_______________ kwh x ____ cents = $ _______________
yearly energy consumption for hot water   rate kwh

How could you save money and energy for hot water at your house?

Some things to look for if your hot water consumption is high:

1. Check your water heater's thermostat--it should be set at 140°F or less.

2. Check for leaks.

3. Are the hot water pipes insulated?

Suggestions:

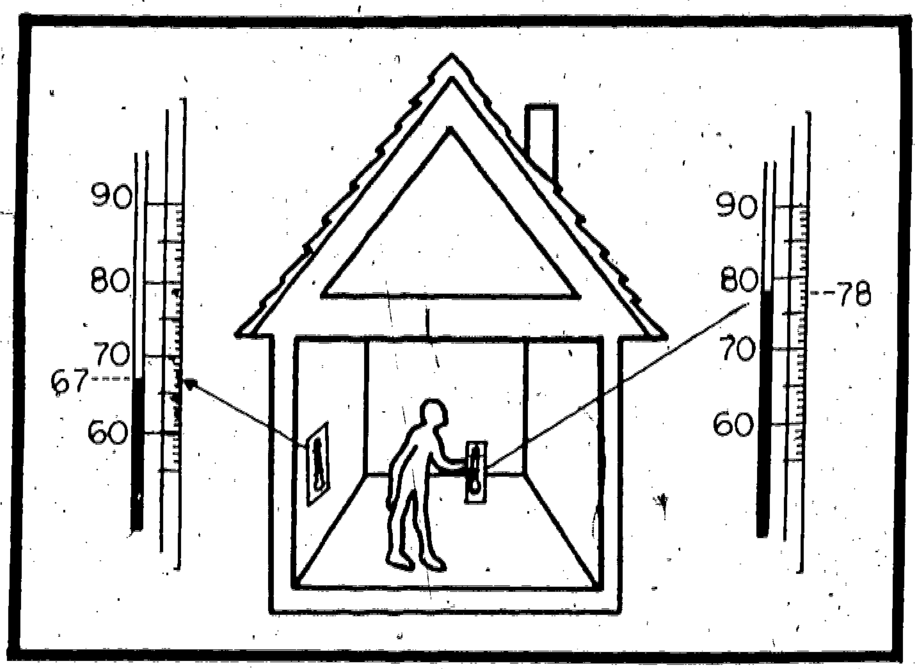
1. Students should bring in their tallies of frequencies from home and do the calculations as a class.

2. All of the figures and calculations in this activity are based on averages and estimates and do not indicate actual hot water use. However, by checking appliance manuals and timing showers (approximately 8 gallons of water is used per minute), a more accurate consumption figure could be obtained.

ACTIVITY J — CHECKING WALL INSULATION

OBJECTIVE: TO DETERMINE THE ADEQUACY OF WALL INSULATION IN A COMPLETED STRUCTURE.

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



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

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

Room ______________________

Outside wall thermometer reading ______________________
Center of the room thermometer reading ______________________

The difference between the readings:

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

Is the difference greater than 5°F?

Conclusions:

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

Suggestion:

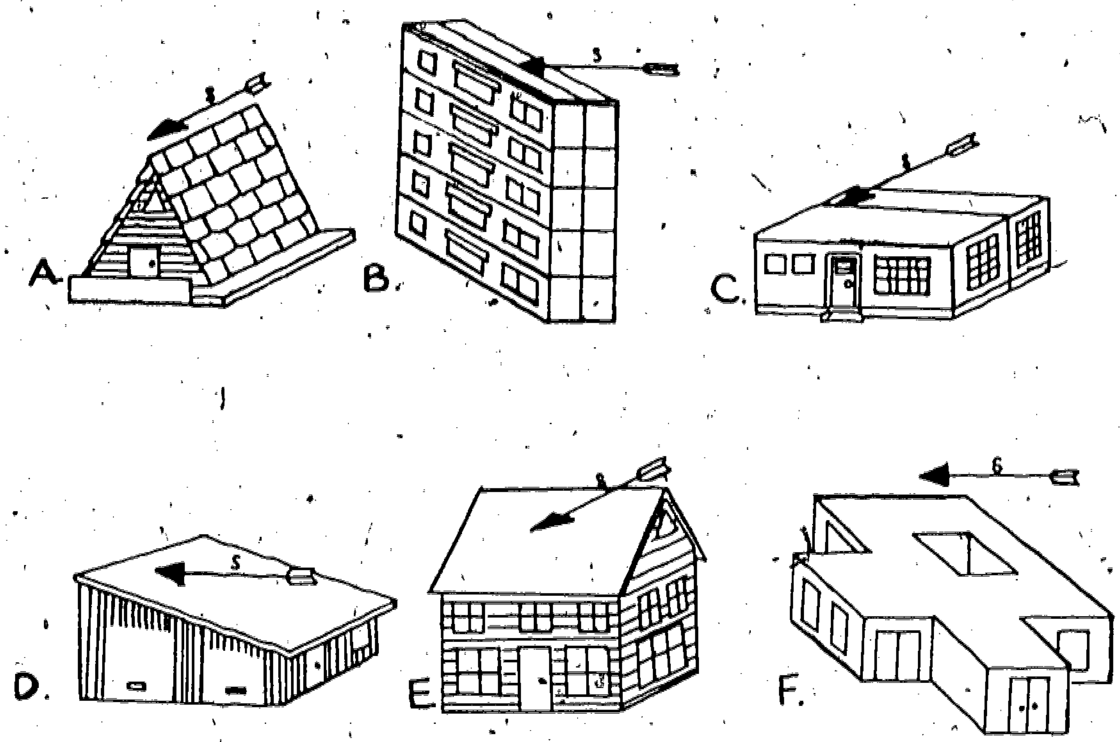
Try this exercise in the classroom.

ACTIVITY K HOME SIZE, SHAPE, AND EXPOSURE

OBJECTIVE: TO ILLUSTRATE HOW SIZE, SHAPE, AND EXPOSURE OF A HOUSE AFFECTS ITS ENERGY REQUIREMENTS FOR HEATING AND COOLING.

In addition to insulation and the amount of floor space a house has, the shape of the space, the height of ceilings, and the exposure to the weather all affect the quantity of energy required to cool or heat the house. For the climate in which you live, discuss the heating or cooling efficiency of each of the homes illustrated below. All the homes have 1800 square feet of floor space and are well insulated.

For example; if you lived in a cold climate, Home A would be a good selection since there is a great deal of space with little exposure to the weather. Also, the south-facing wall will absorb heat from the sun in winter.



Questions:

1. Which home would be most efficient if *none* have *any* insulation?
2. How does your home compare with these?
3. Try to determine the *least* efficient home and the *most* efficient home for your area. Then take a survey around your neighborhood. Do you see more of the efficient or inefficient homes?

Suggestion:

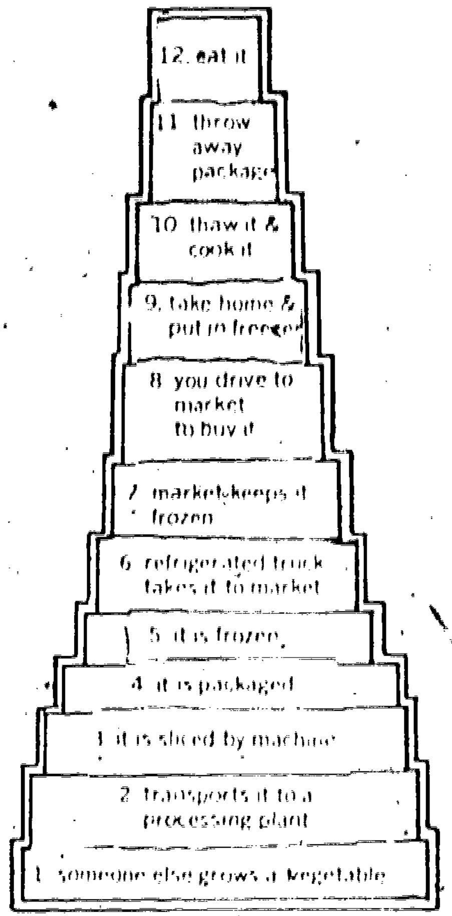
Have students compare homes in their neighborhoods.

ACTIVITY L

FOOD CYCLE ENERGY STEPS

OBJECTIVE: TO ENABLE STUDENTS TO ISOLATE ENERGY CONSUMING STEPS IN THE FOOD SYSTEM AND TO SPECULATE AS TO THE DIFFERENT WAYS IN WHICH ENERGY COULD BE SAVED.

Twelve areas in a food system are listed below for a frozen vegetable. Which steps could be eliminated to save energy?

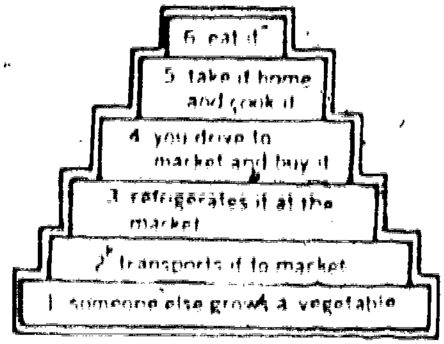


Construct the food chain steps for a canned soft drink and then make suggestions for steps which might be eliminated to save energy.

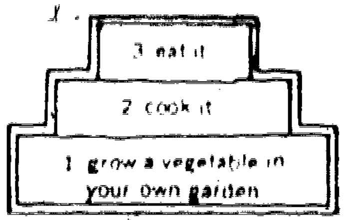
Suggestions: This type of visual representation makes a nice bulletin board display.

Possible Answers:

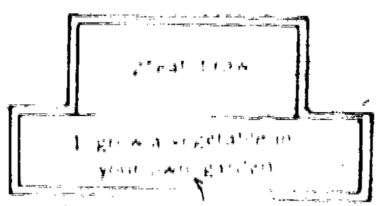
(a)



(b)



(c)



ACTIVITY M — MARKETING TRIP EVALUATION

OBJECTIVE: TO DEMONSTRATE THE ENERGY CONSUMED FOR MARKETING TRIPS AND WAYS ENERGY COULD BE SAVED.

The major factors involved in energy consumption for marketing are the number of trips, distance to the market, and mode of transportation. To obtain a better perspective of your family's marketing practices, take a survey of the trips your family members make to market in a week, recording the distance and mode of travel. Use the data form provided below.

Date	Time	Destination	Mode of Travel	Distance

Distances can be obtained from a city or county map, the car odometer, or by estimation (one city block is about one-eighth of a mile).

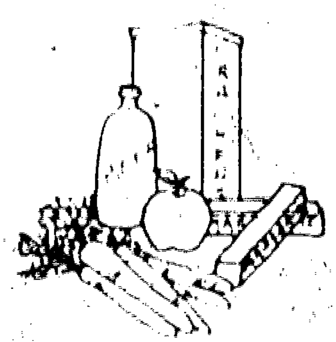
1. Using the completed data form, do you see possibilities for energy savings?
2. Are there trips by car of less than half a mile in distance?
3. Could several trips have been combined into one?
4. Could shopping be done on the way to or from work or school?
5. Could marketing have been done closer to home?
6. Would carpooling for shopping with neighbors be a possibility?
7. What recommendations would you make to your family for ways to conserve energy when marketing?

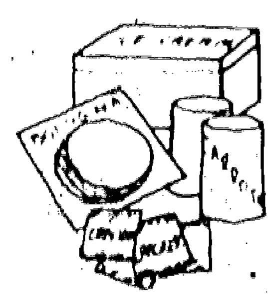
Suggestions: Survey the students at large to determine how they travel from home to school and back. Discuss findings and recommendations in class.

ACTIVITY N — AN ENERGY MENU

OBJECTIVE: TO INDICATE THE EQUIVALENT ENERGY COSTS OF DIFFERENT FOODS AND HOW WISE FOOD CHOICES CAN SAVE ENERGY.

Review the items offered in the Menu on the following page and select your "first preferences" based strictly on likes and dislikes. Place checks beside those items in Column 1. Next, make selections from the menu on the basis of least energy consumption. Remember, the energy cost of a food includes: fertilizers and insecticides; equipment; transportation; processing, packaging, and preparation. Place a check by each "low energy" item selected in Column 2. Then refer to the Energy Price List for each item's Energy Cost. Indicate the "price" of each item you chose and determine your total bill. To discover how you might have saved energy, find the differences between the individual items in the two columns and enter those figures in Column 3. The differences will be losses or gains in costs. Add the total "pluses and minuses" in this column to find total energy savings. If you were to select items for Column 1 (preferences) again, would your choices be any different?





ENERGY MENU

	1 FIRST PREFERENCE $	2 LEAST ENERGY $	3 DIFFERENCES (+ or -) $
APPETIZERS (CHOOSE ONE FROM EACH PAIR)			
Frozen Juice			
Fresh Juice			
Crackers A (unwrapped, available to the cafeteria in bulk)			
Crackers B (wrapped individually, packed in small cartons)			
Butter			
Margarine			
MAIN DISH (PLEASE MAKE A FIRST AND SECOND CHOICE AS WE DO NOT ALWAYS CARRY EACH ENTREE)			
Luncheon Meat			
Chicken			
Turkey			
Rice with Vegetables			
Beef (grass-fed)			
Beef (grain-fed)			
VEGETABLE (SORRY, TODAY WE HAVE ONLY CARROTS, BUT YOU MAY CHOOSE YOUR PREFERRED TYPE)			
Fresh Carrots			
Dehydrated Carrots			
Frozen Carrots			
Canned Carrots			
DRINKS (PLEASE CHOOSE A FIRST AND SECOND CHOICE AS WE SOMETIMES RUN SHORT OF ONE KIND OF DRINK AT LUNCH)			
Soft Drink (in aluminum can)			
Soft Drink (in returnable glass bottle)			
Milk			
Beer (in aluminum can)			
Beer (in returnable glass bottle)			
DESSERT: CHOOSE ONE			
Apples (homegrown in our cafeteria's own garden)			
Apples (store-bought)			
Walnuts (shelled)			
Walnuts (unshelled)			
Ice Cream			
TOTAL BILL			

ENERGY PRICES

(Prices are proportional to actual energy expenditure)

APPETIZERS:

- Fresh Juice: 12¢
- Frozen Juice: 4¢

(Freezing and processing use a great deal of energy, both initially and for storage)

- Cracker A: 10¢
- Cracker B: 15¢

(Food excessively packaged or only available in small packages is more energy-intensive than unwrapped foods or foods available in bulk)

- Butter: [illegible]
- Margarine: 6¢

[illegible]:

- Luncheon Meat: [illegible]
- Chicken: [illegible]
- Turkey: 1.06
- Rice with Vegetables: [illegible]
- Beef (grass fed) [illegible]
- Beef (grain-fed) [illegible]

(Animals are inefficient converters of protein. A pound of meat requires about four times the energy to produce and market as a pound of vegetable protein. Some animals are more efficient converters of protein than others.)

VEGETABLE:

- Fresh Carrots: [illegible]
- Dehydrated Carrots: [illegible]
- Frozen Carrots: 31¢
- Canned Carrots: 23¢

(Processed vegetables require more energy than fresh vegetables; freezing and dehydration especially require large amounts of energy.)

[illegible]:

- Soft Drink (aluminum can): 45¢
- Soft Drink (returnable bottle): [illegible]
- Milk: [illegible]
- Beer (aluminum can): 50¢
- Beer (returnable bottle): [illegible]

[illegible]:

- Homegrown apple: [illegible]
- Store-bought apple: 11¢

(Homegrown apple by commercial methods saves commerce and transport; organic methods would save more.)

- Walnuts, shelled. $1.04
- Walnuts, unshelled. [illegible]
- Ice cream: [illegible]

(Large quantities of milk are used; freezing is necessary.)

Source: (adapted from) Energy Menu. [illegible] by Deborah Katz and Mary T. Goodwin

ACTIVITY O CONVENTIONAL OVEN VS. MICROWAVE OVEN

OBJECTIVE: TO DEMONSTRATE THE ENERGY CONSUMPTION DIFFERENCES OF CONVENTIONAL AND MICROWAVE OVENS.

A microwave oven has the capability of saving energy as a result of the short cooking time needed for some foods. However, many foods may still be more efficiently cooked in a conventional oven.

In the home economics laboratory, compare the energy required to cook the following food items: cake; tuna casserole; frozen TV dinner; frozen broccoli; and baked potatoes. To determine the energy used to cook each item, calculate the energy used in kilowatt-hours. This can be done by first determining the wattage of the cooking unit (listed on the appliance):

watts for microwave oven (usually around 1,450 watts)

watts for conventional oven (usually around 12,200 watts)

Then determine the amount of time the unit operates to cook the food item. The operation time of the microwave oven will be easy to determine since it operates continuously and is usually equipped with a timer. The operation time of the conventional oven will be more difficult to determine since pre-heat time must be included and a conventional oven does not operate continuously. A stop-watch will be needed to determine the operation time. You must time each interval that the oven is operating (most ovens are equipped with a light which indicates when the oven is operating) and add them to arrive at the total time of operation required to cook the food item.

Once the wattage and cooking times are determined, the energy use can be calculated. For example: if a cup of squash requires 30 minutes to cook in a 12,000-watt oven, it requires 6 kilowatt-hours of energy:

$$12{,}000 \text{ watts} \times 30 \text{ minutes} \times \frac{1^*}{60{,}000} = 6 \text{ kilowatt hr}$$

* (The conversion factor is $\frac{1}{60{,}000}$ since there are 1000 watts to a kilowatt and 60 minutes to an hour.)

CAKE (use the same recipe in each oven)
Conventional Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

Microwave Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

TUNA CASSEROLE
Conventional Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

Microwave Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

FROZEN TV DINNER:
Conventional Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

Microwave Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

FROZEN BROCCOLI
Conventional Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

Microwave Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

FOUR BAKED POTATOES
Conventional Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

Microwave Oven:

_______ watts x _______ minutes x $\frac{1}{60,000}$ = _______ kilowatt-hr.

Tabulate your Results.

Food Item	Energy Used By Conventional Oven	Energy Used By Microwave Oven
CAKE	____kilowatt-hr.	____kilowatt-hr.
TUNA CASSEROLE	____kilowatt-hr.	____kilowatt-hr.
TV DINNER	____kilowatt-hr.	____kilowatt-hr.
FROZEN BROCCOLI	____kilowatt-hr.	____kilowatt-hr.
BAKED POTATOES	____kilowatt-hr.	____kilowatt-hr.

Suggestions:

1. Remember that the quantities and types of foods cooked in the ovens must be the same to provide valid comparisons.

2. What would have been the effect on energy consumption if more than one food was cooked in the oven at once? Would this method of conserving energy be more effective for conventional or microwave ovens?

3. You may wish to choose different foods to test. If so, try to select a range of items from "dense" (such as meat) to "much less dense" (such as squash) to provide dramatic results.

4. A dramatic demonstration of the misuse of the microwave is to compare the time it takes to boil a quart of water, as opposed to boiling a quart of water on top of the range.

ACTIVITY P — ENERGY CONSUMPTION OF APPLIANCES

OBJECTIVE: TO DETERMINE THE ENERGY CONSUMPTION OF HOME APPLIANCES AND EQUIPMENT

If you were to list all the energy-using appliances and equipment in your home, you would see why it is estimated that a well-equipped home consumes as much as 35,000,000 BTU's of energy each year to operate appliances and equipment. Much of this energy is wasted and offers a great opportunity for energy conservation.

The first step toward conservation is to gain a better perspective and understanding of the energy consumption of each appliance or piece of equipment. This is very easy to do. Just find the electrical "ratings" information on the back or bottom of the appliance or piece of equipment. You will see several numbers much like those shown below (from the base of a blender):

For Service
Specify No.
850-14A

Watts 960

Model 850
Series
Volts 120
Freq. 25-60 cycle
A.C. only

UL

JX

The key number is the wattage rating, 960 watts in the example above. The wattage is an indicator of the kilowatt-hours of energy used per hour of operation of the appliance. It requires 1 kilowatt-hour per hour of operation for 1000 watts. In the example above:

Appliance: blender

960 watts ÷ 1000 $\frac{\text{watts}}{\text{kilowatt-hr per hr of operation}}$ = 0.96 kilowatt-hour

(Note: You can divide by 1000 by moving the decimal 3 digits to the left.)
Now you try it.

Appliance: ________

________ watts ÷ 1000 $\frac{\text{watts}}{\text{kwt-hr per hr of operation}}$ = _____ kilowatt-hr.

Appliance: ____________________

________watts ÷ 1000 watts / kwt-hr per hr of operation = ________kilowatt-hr.

Appliance: ____________________

________watts ÷ 1000 watts / kwt-hr per hr of operation = ________kilowatt-hr.

Using the table below you can see what the appliances you checked consume in equivalents of oil or coal.

Electrical Appliance Energy Table

Appliance Wattage Rating	Kilowatt-Hours of Energy Used per Hour	Ounces of oil Burned per Hour	Ounces of coal Burned per Hour
10	0.01	0.1	0.13
25	0.025	0.25	0.33
40	0.04	0.4	0.5
60	0.06	0.6	0.8
100	0.1	1	1.33
150	0.15	1.5	2
200	0.2	2	2.66
300	0.3	3	4
500	0.5	5	6.66
750	0.75	7.5	10
1000	1	10	13.33
1500	1.5	15	20
2000	2	20	26.66
5000	5	50	66.66
10000	10	100	133.33

Suggestions:

1. Do not try to move large appliances by yourself to obtain wattage ratings.
2. Seek permission and aid from parents to locate wattage rating information.
3. The teacher may use appliances in the home economics laboratory as examples.
4. Students may be assigned different equipment to insure a wide range and thorough investigation of household appliances.
5. Answers in terms of kilowatt-hours of energy required may be expanded to annual use by determining daily or weekly use and multiplying.

ACTIVITY Q — SHOWER VS. BATH

OBJECTIVE: TO DEMONSTRATE THAT A SHORT SHOWER IS MORE ENERGY CONSERVING THAN A BATH, AND THAT LENGTHY SHOWERS WASTE HOT WATER AND ENERGY.

If people took short showers instead of baths or lengthy showers, a lot of energy could be saved. It takes about an ounce of oil (or a cubic foot of gas, or ¼ kilowatt-hour of electricity) to heat a gallon of water.

Compare the water used for a bath and a shower. Fill your bathtub (at the temperature and depth you like best) and measure the depth with a yardstick (when you are out of the water). Record the depth:________ inches. At your next bathing time, take a shower (in the same tub). Keep the drain closed during your shower, but be careful not to overflow the tub. (Do not rush your shower; take your time!) This time record your bathing time as well as the water depth.

Beginning Time________________ Ending Time________________
Duration of Shower______________ Water Depth________________

If you took a short shower, it should have required only about half as much water as your bath.

Questions

1. Which bathing practice is more conservative for you?

2. What would be the energy impact of taking a 20-minute shower?

3. What are some other ways to conserve energy while bathing?

4. What effect would a flow restriction device have?

Suggestions:

1. If your shower was lengthy, you may need to measure the depth, empty the tub and then finish your shower and measure again. Add the two depths.

2. Investigate the bathing practices of other members of your family. Who is the most conservative?

ACTIVITY R — ENTERTAINMENT PRACTICES

OBJECTIVE: TO DEMONSTRATE THE EXTENT OF USE OF ENTERTAINMENT DEVICES.

Teenagers and young adults are often abusers of entertainment devices. In one household as many as four or five devices may be operating at the same time. Take a survey of the students at your school to determine the extent of their use of entertainment devices. Use the following form:

Device	Hours of use per day	OR Hours of use per week
Black and white TV		
Color TV		
Radio		
Tape player		
Stereo		
Electric Instrument		
Model Trains or cars (electric)		
Electric games		
Slide projector		
Movie projector		

From your survey calculate the average hours of operation for a year for *one* student.

To do this, take the total hours a week of all those surveyed and divide by the number of students surveyed. This yields the average hours of operation for *one* week. Then multiply by 52 (52 weeks in a year).

$\frac{\text{Total hours per week}}{\text{Number of students surveyed}}$ = ______ average/week

______ average/week x 52 = ______ average/year

Now use the total number of students in your school to estimate the total hours of operation of entertainment devices for one year.

________ average/year x ________ number of students in your school =

________ operation per year of entertainment devices by your school's students

It might also be enlightening to determine the quantity of records and tapes the students at your school purchase in a year. Remember; tapes and records are petroleum products.

Suggestions:

1. Randomly survey at least 25 students.
2. The hours of use per day should be recorded for very frequent use and then converted to hours per week.
3. Publicize your results and offer suggestions for reducing this energy use.
4. Survey entire families.
5. This activity makes a good class project. Do calculations on the board.

ACTIVITY S | RESIDENTIAL ENERGY CHECKLIST

OBJECTIVE: TO PROVIDE AN EASY AND QUICK SCAN OF THE HOME TO REVEAL POSSIBLE SOURCES OF ENERGY WASTE AND POTENTIALS FOR ENERGY CONSERVATION.

The following energy checklist can be used by you (the student), your parents, and relatives as a handy guide to systematically search for residential energy waste and potentials for conservation. The checklist does not attempt to quantify the energy loss, nor estimate the cost to aleviate the problems. In some cases, it might not be practical to try to eliminate the waste, but rather to reduce it or its impact. You should refer to the specific areas in the text for further information. For example, if you find several problems under home construction, you should refer to Section 3 of the text. If you see a lot of waste in the area of Food Preparation, you should refer to Section 4.

RESIDENTIAL ENERGY CHECKLIST

House: The Shell	yes	no
1. Are plants properly located around the house to provide a break against wind and shade against unwanted sun?		
2. Are drapes and furniture located so they do not obstruct heating, air-conditioning or ventilation?		
3. Are draperies insulated?		
4. Do draperies fit snugly around the window?		
5. Are exterior house doors closed quickly after use?		
6. Are lights and appliances turned off after use?		
7. Do you have storm windows and doors?		
8. Are all doors and windows properly caulked and weatherstripped?		
9. Are draperies and shades closed at night and on cloudy, windy days during the heating season?		
10. Are draperies opened to admit sunlight on sunny days in the heating season?		
11. Are draperies and shades closed on sunny days during the cooling season?		
12. Is the attic ventilated?		
13. Is the attic insulated to 6-8"?		
14. Are the walls insulated?		
15. Do floors exposed to unheated or cooled air have from 2-3½" of insulation?		
16. Is the fireplace damper closed when not in use?		
17. Is the den, gameroom or family room oriented to the south?		
18. Is the house shaded from the western sun?		

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	yes	no
19. Does your home have window area equivalent to 10% or less of its square footage?		
20. Is your home sealed from drafts? Is it free from cracks and holes?		
21. Does your home have fluorescent lighting where appropriate?		
22. Does your home have wall-to-wall carpeting?		
23. Do all windows have drapes, shades, blinds, shutters or other covering?		
Environmental Control		
24. Are ducts, radiators or air conditioners closed off in unused rooms or closets?		
25. Are hot water pipes insulated in unheated and uncooled spaces?		
26. Are air ducts insulated in unheated and uncooled spaces?		
27. Is the thermostat set at 68°F or below during the heating season?		
28. Is the thermostat set at 78°F or above during the cooling season?		
29. Are heating and cooling filters clean?		
30. Is the thermostat turned back at night?		
31. Are windows and doors tightly closed while mechanically heating or cooling?		
32. Is an attic fan used in the summer?		
33. Do thermostats indicate correct temperature settings?		
34. Is an outside air conditioning unit located on the shady (north) side of the house?		
35. Is the water heater insulated?		
36. Is the water heater temperature setting at 140°F or less?		

	yes	no
37. Is the air-conditioning unit properly sized for your needs?		
38. Do you have a heat pump?		
39. Do you use natural ventilation as much as possible?		
40. Are radiators and other heating or cooling equipment clean and dust free?		
41. Is the water heater located in a heated space?		
Housing Selection		
42. If you live in an apartment, is it an "inside" apartment?		
43. If you live in a mobile home, does it have a "skirt"?		
44. If you live in an older home, have its plumbing, wiring, insulation and chimneys been checked by "experts"?		
Food		
45. Is the frost on the refrigerator and freezer less than ¼ inch thick?		
46. Is the refrigerator set at $40^{\circ}F$?		
47. Is the freezer set a $0^{\circ}F$?		
48. Are gaskets around refrigerators and freezers tight?		
49. Is the oven used to bake more than one food at a time?		
50. Is the gasket around ovens tight?		
51. Are frozen foods thawed completely before cooking?		
52. Is the cooking range turned off immediately after use?		

	yes	no
53. Are dishes washed only when there is a full load?		
54. Are dishes allowed to air dry?		
55. Are appliances clean and dust free (particularly cooling coils)?		
56. Is the oven never used as a dryer or heater?		
57. Are flat bottom pots and pans used?		
58. Is a timer used to avoid over-cooking?		
59. Are pots covered during cooking?		
60. Is as little water as possible used during cooking?		
61. Is the heated dry cycle on the dishwasher not used?		
Clothing		
62. Does your family dress warmer in cool weather to avoid mechanical heating?		
63. Does your family dress cooler in warm weather to avoid mechanical cooling?		
64. Are clothes washed only when there is a full load?		
65. When washing, is cold or warm water used when possible?		
66. Are clothes line dried when possible?		
67. Are most of your family's clothes wash-and-wear, permanent press, to avoid dry cleaning and ironing?		
68. Are clothes always rinsed with cold water?		
69. Is the washer located near the water heater?		
70. Is the dryer lint screen cleaned after each load?		

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Personal Care | yes | no

71. Do the members of your family take short showers or use only small amounts of water for tub baths?

72. Are all water faucets repaired and not leaking?

73. For washing, shaving or make-up is the lavatory filled rather than allowing water to run?

Entertainment

74. Are entertainment devices turned off when not in use?

75. Do members of your family try to entertain themselves rather than rely on devices?

--If you answered with 65 or more yes's, you are truly an energy conserver and will make a good conservation advocate.

--If you answered with 55 to 65 yes's, you are energy conscious but lack will-power or drive.

--If you answered with 45 to 54 yes's, you are wasting energy but with minor changes could make a conserver.

--If you answered with 36 to 44 yes's, you are an energy waster and should make an all-out effort to reform!

--If you answered with less than 35 yes's, you are making an effort to waste energy and should consider the long range and immediate effects!!

Suggestions:

1. Distribute these checklists school-wide.

2. Try a before and after approach to using the checklist. Check before your conserving effort and after.

3. Survey students to see if their families are generally conservative or not.

ACTIVITY T | INSULATION INVESTIGATION

OBJECTIVE: TO FAMILIARIZE STUDENTS WITH AVAILABLE TYPES OF INSULATION AND THEIR LABELING.

There is a wide variety of insulation available today. They have different uses, R-values, and forms. As a class, try to collect five to ten different types and develop an information display indicating the R-values and uses. Try to obtain the following types: (1) loose-fill mineral wool; (2) loose-fill polystyrene beads; (3) batt mineral wool without vapor barrier; (4) batt mineral wool with vapor barrier; (5) rigid foam board; (6) cellulose fiber; (7) vermiculite or perlite. Look on the label for the R-value and use. See the *Sample Label* below:

NAME OF MANUFACTURER

Loose Insulation

Weight of insulation per bag: 30 lbs. The manufacturer recommends these maximum coverages at these minimum thicknesses to provide the levels of installed insulation resistance (R) values shown:

R Value	Minimum Thickness	Maximum net Coverage
To obtain an insulation resistance R of:	Installed insulation should be not less than:	Contents of this bag should not cover more than:
R-24	8 1/4 inches thick	28 square feet
R-19	6 1/2 inches thick	35 square feet
R-13	4 1/2 inches thick	50 square feet
R-9	3 1/4 inches thick	75 square feet

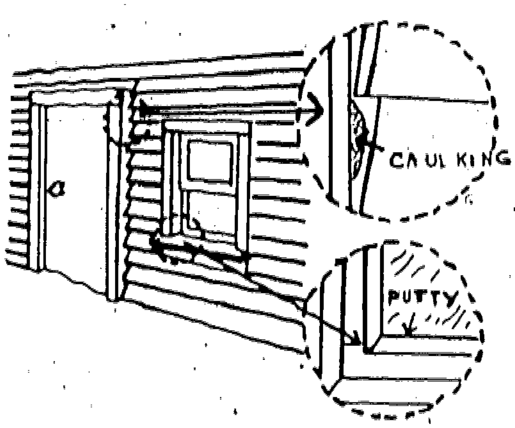
Suggestions:

1. Seek insulation from building supply stores, building contractors, and insulation suppliers.
2. Your local utility company may have an insulation display and demonstration which they would present at your school.
3. Be careful with fiberglass insulation--it is glass and can penetrate the skin causing a great deal of irritation.

ACTIVITY U — WEATHERPROFING INVESTIGATION

OBJECTIVE: TO DETERMINE HOW MUCH, IF ANY, ADDITIONAL WEATHERPROOFING NEEDS TO BE ADDED TO YOUR HOME.

To reduce the heating and cooling costs in a home, it is important to reduce air movement in or out of the home. The cheapest, most effective way to reduce infiltration is with weatherproofing: caulking, putty, or weatherstrips. Below you will see illustrations of several locations where infiltration is likely to occur. Refer to the illustrations and use the checklist to determine the condition or existence of weatherproofing at your house.



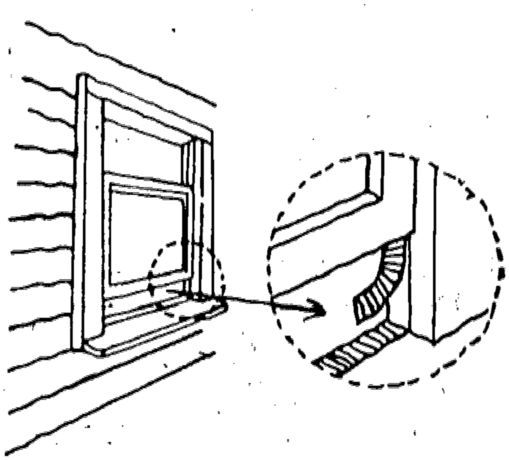
1. WINDOWS

Check the circled areas of your windows.

☐ OKAY - Good, unbroken weatherstripping in all places with no drafts.

☐ FAIR - Weatherstripping damaged or missing in some places and minor drafts.

☐ POOR - No weatherstripping at all and very drafty.



2. DOORS

Check the circled parts of the door.

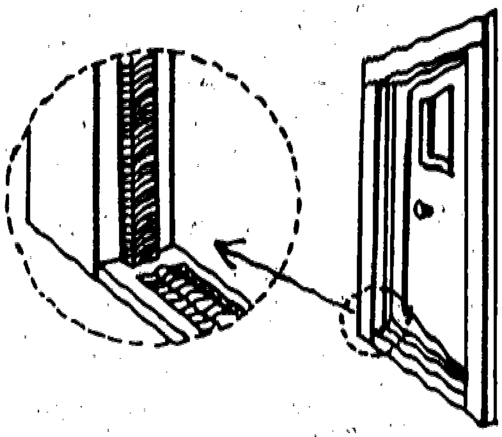
☐ OKAY - Good, unbroken weatherstripping with no drafts.

☐ FAIR - Weatherstripping is missing or damaged in places with minor drafts.

☐ POOR - No weatherstripping and very drafty.

Conclusions:

2. AREA AROUND THE DOORS AND WINDOWS



Look at a typical door and window area and check the circled areas carefully.

- ☐ OKAY - Caulking fills all cracks around the door frame and the putty around the window is unbroken and solid; no drafts.
- ☐ FAIR - Putty and caulking are cracked or missing, causing minor drafts.
- ☐ POOR - No caulking at all and the putty is in very poor condition causing very bad drafts.

Conclusions:

If you checked fair or poor for any of the three areas, then the weatherstripping, caulking, or putty needs to be replaced. If all areas are okay, then you don't need caulking, weatherstripping, or putty.

ACTIVITY V	APPLIANCE AUDIT

OBJECTIVE: TO DEMONSTRATE THE NUMBER OF APPLIANCES IN THE HOME, AND INDICATE THEIR APPROXIMATE ENERGY CONSUMPTION AND COST OF OPERATION.

Few people realize how many appliances they have, and certainly don't realize how much energy they consume. Below you will find an audit form you can use to record information on the appliances in your home. The audit provides a listing of the most common items as well as their annual energy consumption; it also provides a check for maintenance or condition of the item. Record all the items in your home, check their condition and then tally the annual consumption rates. Use the cost per kilowatt-hour in your area to determine the annual cost of the appliances in your home. Make recommendations for the maintenance of items from your checklist.

APPLIANCE AUDIT FORM

ITEM	EST. KWH CONSUMED ANNUALLY	QUANTITY	TOTAL EST. KWH CONSUMED ANNUALLY	GOOD CONDITION	DIRTY	BAD FILTER	BAD GASKET	THERMOSTAT PROBLEM	NEEDS DE-FROSTING	NEEDS REPAIR	OTHER
Example Hair Dryer	14	2	28					✓		✓	
Air Cleaner	216										
Air Conditioner (room)	860										
Bed Covering	147										
Blender	15										
Broiler	100										
Carving Knife	8										
Clothes Dryer	993										
Coffee Maker	106										
Deep Fryer	83										
Dehumidifier	377										
Dishwasher	363										
Egg Cooker	14										
Fan (Attic)	291										
Fan (circulating)	43										
Fan (rollaway)	138										
Fan (window)	170										
Freezer, 15cu. ft	1195										

APPLIANCE AUDIT FORM (CONT.)

ITEM	EST. KWH CONSUMED ANNUALLY	QUANTITY	TOTAL EST. KWH CONSUMED ANNUALLY	GOOD CONDITION	DIRTY	BAD FILTER	BAD GASKET	THERMOSTAT PROBLEM	NEEDS DE-FROSTING	NEEDS REPAIR	OTHER
Freezer, 15 cu. ft. frostless	1,761										
Frying Pan	186										
Germicidal Lamp	141										
Hair Dryer	14										
Heater (portable)	176										
Heating Pad	10										
Heat Lamp	13										
Hot Plate	90										
Humidifier	163										
Iron (hand)	144										
Mixer	13										
Oven, Microwave	190										
Radio	86										
Radio/Record Player	109										
Range with oven	1,175										
with self-cleaning oven	1,205										
Refrigerator 12 cu. ft.	728										
Refrigerator 12 cu.ft. frostless	1,217										
Ref./Freezer 14 cu. ft.	1,136										
Ref./Freezer 14 cu.ft. frostless	1,829										
Roaster	205										
Sandwich grill	33										
Shaver	1.8										
Sun Lamp	16										
Television black & white tube type	350										
black & white solid state	120										
color tube type	660										
color solid state	440										

APPLIANCE AUDIT FORM (CONT.)

ITEM	EST. KWH CONSUMED ANNUALLY	QUANTITY	TOTAL EST. KWH CONSUMED ANNUALLY	GOOD CONDITION	DIRTY	BAD FILTER	BAD GASKET	THERMOSTAT PROBLEM	NEEDS DE-FROSTING	NEEDS REPAIR	OTHER
Toaster	39										
Tooth Brush	0.5										
Trash Compactor	50										
Vibrator	2										
Waffle Iron	22										
Washing Machine automatic	103										
Washing Machine non-automatic	76										
Waste Disposer	30										
Water Heater 2475 watt	4219										
Water Heater 4474 watt	4811										

TOTAL CONSUMPTION

________ x $________ = $________

total no. kwh consumed   cost per kwh

How could your family conserve on their appliance energy cost?

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ACTIVITY W	AN ENERGY ETHIC

OBJECTIVE: TO ENCOURAGE AN ENERGY CONSERVING ETHIC FOR STUDENTS

Below you will see a list of items and activities which require energy for their manufacture, use, and disposal. Number (rank) these items in order of importance and necessity to you. Mark your responses in column A--number 1 being most important on down to number 20 for least important.

A		B	C
___	watching television	___	___
___	hot water for bathing	___	___
___	electric toothbrush	___	___
___	waffle iron	___	___
___	synthetic clothing	___	___
___	reading a book	___	___
___	eating a raw apple	___	___
___	TV dinners	___	___
___	car ride to the store	___	___
___	drive-in movie	___	___
___	making homemade ice cream	___	___
___	lipstick or cologne	___	___
___	aerosol deodorant	___	___
___	electric hairdryer	___	___
___	bike riding	___	___
___	a walk in the sun	___	___
___	candy	___	___
___	nighttime football games	___	___
___	hot lunches	___	___
___	school buses	___	___

Now that you have ranked these items according to their importance to you, go back and rank the ones you feel are *most energy intensive* in Column B (from "1 to "10".) Discuss your answers in class.

Now mark in Column C the items you could do without which would help you and our nation conserve energy. Discuss your answers in class.

Suggestions:

1. Develop an Energy Alternatives bulletin board for the school.

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ACTIVITY X — LIFESTYLE INDEX

OBJECTIVE: TO AID THE STUDENTS IN UNDERSTANDING THEIR LIFESTYLES IN TERMS OF ENERGY REQUIREMENTS AND TO PLACE THEIR LIFESTYLES IN WORLD PERSPECTIVE.

The Lifestyle Index is designed to demonstrate how much energy an individual uses each year and how his standard of living compared with that of an average individual in other countries of the world.

The basic unit employed is the Energy Unit which is equivalent to about 10 kilowatt hours or exactly 34,300 British thermal units.

Part I-A. HOUSEHOLD ENERGY EXPENDITURES
(Precise Method)

The most precise method of calculating household energy expenditures is to convert quantities of electricity and fuel used to Energy Units by applying the following conversion factors. If you have not retained bills for the past year, go directly to Part I-B and use the approximate method. If you do use this precise method, omit Part I-B (except for the section on Residential Buildings Materials) and omit the section on Preparing and Preserving in Part III (Foods and Beverages) and the section on Electronic Appliances in Part IV (Leisure Activities).

ELECTRICITY

Multiply total kilowatt hours used in the last 12 months by the conversion factor 0.368. ___

NATURAL GAS

Multiply total cubic feet used in the last 12 months by 0.038.

FUEL OIL

Multiply number of gallons used in the last 12 months by 4.5.

Divide total energy units by number of users in the household and enter total here and on page 244.

Part I-B. HOUSEHOLD ENERGY EXPENDITURES
(Approximate Method)*

HOME APPLIANCES

Values listed in brackets are average Energy Units used per item annually. Multiply by the number of items in the home. Appliances used in preparation and preserving of food will be figured in Part III (Foods and Beverages)

*Note: Use the "approximate method" to verify your utility bills. If your actual bills are much lower than the approximation, be conservative in the rest of this activity. If your bills are higher, compensate raising your estimations for Parts II through VI

ELECTRIC APPLIANCES

clock	[6]	
floor polisher	[6]	
sewing machine	[4]	
vacuum cleaner	[17]	
air conditioner	[80]	
bed covering	[54]	
dehumidifier	[128]	
heating pad	[4]	
humidifier	[60]	
germicidal lamp	[52]	
hair dryer	[5]	
heat lamp (infrared)	[5]	___
shaver	[0.7]	___
toothbrush	[0.2]	___

vibrator [0.7] ___
clothes dryer [365] ___
iron (hand) [53] ___
washing machine (automatic) [38] ___
washing machine (nonAutomatic) [28] ___
water heater (standard) [1555] ___
water heater (quick recovery) [1770] ___

GAS APPLIANCES
clothes dryer [277] ___
water heater [1170] ___
Subtotal

HOME LIGHTING
Figures are for average annual use. If your household uses more or less, increase or decrease accordingly.

Electric lighting [268] ___
Ornamental gas lights [668]
Subtotal

COOLING AND VENTILATION
CENTRAL AIR CONDITIONING (electric)
New England [755]
Mid-Atlantic [957]
East North Central [905] ___
West North Central [905]
South Atlantic [1510]
East South Central [1560]
West South Central [1710]
Mountain [1058]
Pacific [1210]

CENTRAL AIR CONDITIONING (gas) [1046]

COOLING AND VENTILATION (noncentral)
fan (attic) [107]
fan (circulating [16]
fan (roll-away) [51]
fan (window) [58]
electric room air conditioner [316]
Subtotal

SPACE HEATING
ELECTRICITY, NATURAL GAS, OIL, AND SOLAR HEATING
If you have not used the precise method of Part I-A, the following table will provide an estimate of space heating energy expenditure, depending on location and type of heating.

	Elec-tric	Nat. Gas	Oil	Oil/Solar
Northeast	6480	5360	6380	---
Mid-Alantic	5800	4800	5720	2210
East North Central	6030	4900	5940	2290
West North Central	5350	4440	5280	2040
South Atlantic	4460	3700	4400	1700
East South Central	4040	3330	3960	790
West South Central	2900	2400	2860	570
Mountain	4910	4060	4840	1870
Pacific	3800	3140	3740	1440

COAL
Multiply tons of coal used in the last 12 month by 775.

WOOD
Multiply cords used in last 12 months by 620.

RESIDENTIAL BUILDING MATERIALS AND GROUNDS
Total home construction energy (including mining, processing, fabrication, transportation, and sales) has been allotted over the average lifetime of the home before major alterations are required. A 25-year span has been chosen for amortization. If your residence was build in the last 25 years, add the following for building materials.

single dwelling [844]
2-to-4 unit
apartment [642]
5-units or more
apartment [668]
public housing [700]

ADDITIONS AND ALTERATIONS
Multiply dollars expended for this purpose during the past year by 1.1
Subtotal

LAWN AND GARDEN GASOLINE ENGINES [50]
Subtotal

Add all subtotals in Part I-B and divide by number of users in household. Enter total here and on page 244.
Total

Part II. HOUSEHOLD MATERIALS AND PERSONAL ITEMS

It requires energy to produce all consumer products from house furnishing to cigarettes. Consumer items such as rugs and soap require energy at every step of processing. In calculating Energy Units, it is necessary to include raw materials, processing, freight, and merchandizing. Handcrafting such household materials as drapes does not result in energy savings, since an electric sewing machine probably uses more energy than if mass production methods were used.

HOUSEHOLD MATERIALS

The following Energy Units represent annual expenditures for manufacturing and merchandising household items. Operating energy will be calculated in Part IV for radios, phonographs, and similar items. Energy units are calculated for the individual user. Make allowances if you are a heavy or light user.

furniture [35]
electric appliances [46]
electronic equipment (radio, phonographs, etc.) [17]
pottery, earthenware, china [5]
other household wares (cutlery, glassware, etc.) [10]
rugs and floor coverings [29]
other textile furnishings [73]
tissues, paper towels, and other household paper products [25]
cleaners and soaps [38]
Subtotal

PERSONAL ITEMS
Adjust, according to whether the individual is a light, normal, or heavy user.

WEARING APPAREL
The large expenditure in the case of women's apparel is due to larger dollar sales and larger energy expenditures of establishments selling such apparel.

men and boys [156]
women and girls [204]

MISCELLANEOUS
toiletries and beauty aids [23]
health and medical supplies [58]
tobacco products (1.6 packs per day for average cigarette smokers) [86]
shoes, footwear [27]
other leather products (luggage, handbags, gloves) [6]
photographic supplies [6]
jewelry [12]
costume jewelry [9]

Subtotal

Add all subtotals in Part II and enter here and on page
Total

Part III. FOODS AND BEVERAGES

About 12 percent of America's energy is used to produce, transport, sell, and prepare foods. A large proportion of this is concentrated in meat products. If you do not eat meat, omit the meat category and add extra for vegetables. If you produce your own vegetables by hand and without fertilizer, do not include the 19 Energy Units for vegetables. Energy Units are calculated by apportioning food agricultural energy expenditures according to the dollar basis of the food categories in Reference 12 and making adjustments for imports and exports. Average yearly consumption per capita is given in parentheses.

PRODUCTION

meat:
- beef (114.8 lb/yr) ___
- veal (2.2 lb/yr) ___
- lamb and mutton (3.4 lb/yr) ___
- pork (73.0 lb/yr) ___
- chicken (42.9 lb/yr
- turkey (8.9 lb/yr) [163] ___

dairy products (356.1 lb/yr) [41] ___

eggs (318 eggs/yr) [11] ___

vegetables and melons (excluding home gardens; 312 lb/yr) [20] ___

fruits and nuts (132 lb/yr) [14] ___

food grain (141 lb/yr) [7] ___

sugar:
- refined (103 lb/yr)
- corn syrup (22 lb/yr) [9] ___

beverages (coffee, tea, cocoa; 18 lb/yr) [8] ___

edible vegetable oils and animal fats and oils (53 lb/yr) [17] ___

fish (11 lb/yr) [11] ___

Subtotal ___

TRANSPORTATION OF FOOD TO PROCESSING PLANT AND STORE

Omit if you grow your own produce or buy most of your food at a farm. [16] ___

Subtotal ___

PROCESSING
- meat [28] ___
- dairy products [24] ___
- canned and frozen foods [28] ___
- grain products [16] ___
- bakery products [13] ___
- sugar [21] ___
- confectionery [4] ___
- miscellaneous foods [32] ___
- beverages [24] ___

Subtotal ___

CONTAINERS

The following Energy Units are for one 12-ounce container used per day throughout the year. Adjust accordingly.

BEVERAGE CONTAINERS
- refillable glass bottles [24] ___
- one-way glass bottles [71] ___
- bimetallic cans (steel and aluminum) [57] ___
- aluminum cans [96] ___
- distilled beverages or wine [3] ___

Subtotal ___

OTHER FOOD CONTAINERS
- paper [4] ___
- steel (cans) [17] ___
- glass [9] ___
- aluminum [6] ___
- plastic [7] ___

Subtotal ___

RETAILING AND WHOLESALING ENERGY EXPENDITURES

Calculated on the basis of grocery sales for various food items.
- meat [46] ___
- dairy products [18] ___

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fish [7] ___
produce [26] ___
canned and frozen foods [30] ___
grains and bakery products [77] ___
sugar and confectionary products [9] ___
beverages (nonalcoholic) [13] ___
miscellaneous foods [18] ___
alcoholic beverages [31] ___

Subtotal ___

PET FOODS

Multiply the pounds of meat products consumed each week by 50 and the pounds of pet food cereal products by 12 to get the total Energy Units. Then divide this figure by the number of persons in the household who regard the pet as theirs.

Subtotal ___

FOOD PREPARATION AND PRESERVING

If you calculated home fuels by the precise method in Part I-A, or if all your meals are eaten out, this section should be skipped.

ELECTRIC APPLIANCES

blender [6] ___
broiler [37] ___
carving knife [3] ___
coffeemaker [39] ___
deep fryer [30] ___
dishwasher [133] ___
egg cooker [5] ___
freezer (15 cubic ft) [-140] ___
freezer (frostless, 15 cubic ft) [648] ___
frying pan [68] ___
hot plate [33] ___
mixer [4] ___
oven (microwave only) [70] ___
range (self-cleaning) [443] ___
range (regular) [432] ___
refrigerator (12 cu. ft) [268] ___
refrigerator (frostless, 12 cu. ft.) [648] ___
refrig-frzr, 14 cu. ft. [418] ___
refrigerator-freezer, (frostless, 14 cu. ft.) [673] ___
roaster [75] ___
sandwich grill [12] ___
toaster [14] ___
trash compactor [18] ___
waffle iron [8] ___
waste disposer [11] ___

GAS APPLIANCES

outdoor gas grill [100] ___
range (apartment) [350] ___
range (single unit) [389] ___
refrigerator [509] ___

Add Energy Units for electric and gas appliances and divide by number of users in household to get subtotal

Subtotal ___

Add all subtotals in Part III and enter total here and on page 244.

Total ___

Part IV. LEISURE ACTIVITIES

Estimates for leisure activities outside the home vary considerably with distance traveled, means of transportation, equipment used, and frequency of use.

ELECTRONIC APPLIANCES

Omit if you estimated electricity used by the precise method in Part I-A. Energy expenditures for materials have already been calculated under Household Materials in Part III. Figures are for operation only, computed on the basis of average electric use per item per year (4 hours daily for television, 6 hours weekly for stereo). Adjust accordingly.

radio [31] ___
radio/record player [40] ___
stereo [15] ___
television
black & white (tube) [129] ___
Black & wh. (solid state) [44] ___

color (tube) [243]
color (solid state) [162]
Subtotal ___

CULTURAL AND LITERARY RECREATION

LITERARY ACTIVITIES
newspapers [95]
books [76]
periodicals [15]
use of type-writer (materials and operation) [1]
Subtotal ___

CRAFTS
Activities such as designing, floral arranging, knitting, and sewing require less than 1 Energy Unit and have been omitted. For other activities, add Energy Units according to the following scales, adjusting figures for more intensive, normal, and less intensive use.

[1 to 10 Energy Units]
Painting, drawing, leatherwork, woodcarving, sculpturing, stamp collecting, coin collecting, collecting articles such as bottles.

[10 to 100 Energy Units]
Woodworking (with electric lathe), pottery work (with kiln), metal-working (with forge or oven), recording

MISCELLANEOUS ACTIVITIES
visits to amusement parks [20]
motion pictures (8-9 movies per year) [9]
toys [14]
musical instruments [8]
Subtotal ___

SPORTS
Outdoor spectator sports require very small amounts of energy (except for night baseball games and the like) and may be omitted. Some participative sports (jogging, hiking, and most field events) require only human energy. Others, such as baseball football, other ball games, swimming (in unheated pools), surfing, canoeing, skating (on natural ice), fishing (without a motor boat), biking, sledding, and indoor gymnastics (yoga, karate, judo, acrobatics) require less than 1 Energy Unit and may also be omitted. For other participative sports, add Energy Units according to the following scales, adjusting figures for more intensive and less intensive use. Let your conscience be your guide.

[1 to 10 Energy Units]
Indoor basketball, volleyball, wrestling, boxing, squash, handball, outdoor tennis, go-carting, camping, small boat sailing.

[10 to 100 Energy Units]
Tennis (on clay court), skiing, horseback riding, mountain climbing, caving, scuba diving.

[More than 100 Energy Units]
Bowling with automatic pins, indoor swimming (private), motor boating, water skiing, snowmobiling, fox hunting, field polo, deep-sea fishing, yachting, airplane flying, dune buggy riding Subtotal ___

Add all subtotals in Part IV and enter total here and on page 244.
Total ___

BICYCLE

Multiply miles per year by 0.016 ______

PUBLIC TRANSPORTATION

Multiply miles traveled per year by the following number.

urban mass transit	0.14	______
intercity train	0.094	______
highway bus	0.042	______
	Subtotal	______

Add all subtotals in Part V and enter here and on page 244.

Total ______

Part VI. SOCIAL AND COLLECTIVE SERVICES

PRIVATE SERVICES

In addition to the personal uses of energy considered so far, certain social and collective uses must be charged to the ultimate consumer on a per capita basis. We may not attend schools or use hospitals ourselves, but it is necessary to expend energy to keep them available. If you are sure that certain services do not apply to you (for instance, beauty parlors), they may be omitted. Multiply by 2 for heavy use; divide by 2 for light use.

LEGAL	[43]	
NONPROFIT (INCLUDING RELIGIOUS)	[56]	
PERSONAL		
laundries	[18]	______
beauty parlors	[8]	
barber shops	[3]	
photographic services	[2]	
shoe repair	[1]	
funeral services	[5]	______
REPAIRS (NONAUTO)	[13]	
HOTELS AND LODGINGS	[26]	

BUSINESS SERVICES

advertising, sign painting	[32]	______
services to buildings	[5]	______
business and consulting	[12]	______
credit	[3]	______
duplicating, mailing, steno	[3]	______
commercial research and testing	[5]	
detective services	[2]	______
equipment rental	[5]	______
trading stamps	[3]	______
Subtotal		______

PUBLIC SERVICES

All citizens have access to the following services and facilities. If all of them apply, your subtotal should be 631. The Energy Units listed apply to both construction and operation.

hospitals (public and private)	[211]	______
education (public and private)	[80]	______
telephone service (3 calls per day)	[21]	______
other public utilities	[46]	______
highway construction and maintenance	[186]	
conservation and development of resources	[11]	
sewer systems	[17]	
water systems	[47]	
trash collection	[12]	
Subtotal		

GOVERNMENT SERVICES

Government services are major users of energy. Since all are benefited (or harmed) by these services, the total energy expended must be divided among all citizens. Reliable statistics are available for federal energy expenditures. That is not the case for state and local government services. They are

Part V. TRANSPORTATION

All forms of transportation considered below include a factor for associated costs (fuel refining and retailing, vehicle manufacture and maintenance. insurance, etc.) except for highway construction, which is included in Part VI under Public Services. Energy consumed in freighting is included in the consumer product or service and is thus not counted separately here.

NONBUSINESS TRAVEL

PRIVATE CAR

This is a major part of your lifestyle energy use and should be calculated as closely as possible. First, determine the number of non business miles traveled each year by subtracting miles of business travel from annual car mileage. Divide by the average number of passengers. Then multiply this figure by the following number, depending on your car's miles per gallon (mpg).

8 mpg.	Multiply by	0.50
14 mpg.	" "	0.29
20 mpg.	" "	0.20
25 mpg.	" "	0.16

______

MOTORCYCLE

Divide number of nonbusiness miles each year by average number of riders (if any) and multiply by the following number, depending on miles per gallon.

50 mpg.	Multiply by	0.08
100 mpg.	Multiply by	0.04
160 mpg.	Multiply by	0.025

GAS, OIL, TIRES, MAINTENANCE, INSURANCE, PARKING

For private car or motorcycle, multiply Energy Units calculated directly above by 0.395. ______

VEHICLE CONSTRUCTION AND RETAILING

This assumes the life of your vehicle is average (about 8 years). Divide the weight of the vehicle by the number of users and multiply this figure by 0.154. ______

OTHER NONBUSINESS TRANSPORTATION

Multiply the number of miles traveled per year by the figures indicated.

train	0.094	______
highway bus	0.042	______
urban mass transit	0.14	______
commercial aircraft	0.30	______
modern cruise liner	0.48	______
yacht	1.4	______
bicycle	0.016	______
	Subtotal	______

RIDING TO WORK

The multiplying factors here are larger than in the preceding section because they include associated costs, such as vehicle maintenance and construction.

PRIVATE CAR

First determine annual mileage by multiplying round trip in miles by workdays per year. Divide by the number of passengers and then multiply this figure by the following number, depending on the car's miles per gallon (mpg).

7 mpg.	Multiply by	0.80
10 mpg.	" "	0.56
14 mpg.	" "	0.40
21 mpg.	" "	0.27
28 mpg.	" "	0.20

______

MOTORCYCLE

Divide miles per year by average number of riders (if any) and multiply by the following number, depending on miles per gallon.

50 mpg.	Multiply by	0.11
100 mpg.	" "	0.056
160 mpg.	" "	0.036

______

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estimated here to be equivalent to the federal government's non-military energy expenditures in comparable areas.

FEDERAL GOVERNMENT

The major user of energy in the federal government is the military, with 603 Energy Units per capita annually. Total federal expenditure, printed as your subtotal, is 709 Energy Units.

Subtotal 709

STATE AND LOCAL GOVERNMENTS

Construction not previously included amounts to 27 Energy Units. Maintenance of fire and police departments, etc., accounts for another 100.

Subtotal 127

POSTAL SERVICES

Per capita energy expenditure for the average person (824 pieces sent or received each year--or about 16 per week) is 31 Energy Units. Adjust accordingly.

Subtotal ______

Add all subtotals in Part VI and enter total here and in the space below.

Total ______

Enter below the Energy Unit totals for each of the six parts of the Lifestyle Index as each is completed. Then find your grand total.

Part		Energy Units
I.	Household Energy Expenditures (A. Precise Method; B. Approximate Method)	______
II.	Household Materials and Personal Items	______
III.	Foods and Beverages	______
IV.	Leisure Activities	______
V.	Transportation	______
VI.	Social and Collective Services	______
	GRAND TOTAL	______

You should now compare your total annual expenditure of energy with that of the average U.S. citizen (10,000 Energy Units) and with those of citizens of other countries given below:

ANNUAL ENERGY UNITS PER CAPITA IN SELECTED COUNTRIES

Afghanistan	23	Brazil	435	Congo	212
Albania	624	Burma	57	Costa Rica	378
Angola	130	Burundi	9	Cuba	949
Argentina	1490	Cameroon	82	Czechoslovakia	5590
Australia	4600	Canada	7870	Dahomey	30
Austria	2890	Chad	23	Denmark	4495
Bahamas	4285	Chile	1255	Ecuador	263
Barbados	975	China	473	Egypt	241
Bolivia	175	Colombia	559	El Salvador	171

Ethiopia	34	Kenya	145	Puerto Rico	3230
Finland	3655	Khmer Republic	20	Saudi Arabia	813
France	3314	Kuwait	8610	Singapore	1320
Gabon	874	Laos	71	Spain	1406
Germany	4412	Lebanon	709	Sweden	5140
Ghana	157	Liberia	313	Switzerland	3015
Greece	1240	Malagasy Republic	62	Tanzania	59
Greenland	3750	Mali	21	Turkey	436
Guatemala	196	Mexico	1072	Uganda	61
Guinea	85	Mozambique	148	U.S.S.R.	3825
Haiti	24	Morocco	171	United Kingdom	4650
Honduras	183	Nepal	8	United States	9500*
Hong Kong	862	Netherlands	4325	Uruguay	775
Iceland	3640	Nicaragua	324	Venezuela	2107
India	157	Niger	21	Yemen	11
Indonesia	106	Nigeria	50	Yugoslavia	1360
Iran	865	Norway	4400		
Ireland	2830	Pakistan	68		
Israel	2245	Panama	662		
Italy	2245	Paraguay	119		
Ivory Coast	238	Peru	519		
Jamaica	1068	Philippines	246		
Japan	2755	Poland	3690		
Jordan	260	Portugal	685		

WORLD AVERAGES

With United States	1630
Without United States	1167

*This represents the per capita U.S. energy expenditure for 1971. The figure for 1972 (latest year on which computations could be based) is 10,000 Energy Units.
Source: *World Energy Supplies*, Statistical Papers. Series J. No. 16, United Nations, New York, 1973 (converted into Energy Unit values by the author).

Source: (Adapted from)
Lifestyle Index
Contrasumers by Alfred J. Fritsch

ACTIVITY Y

ENERGY ATTITUDE SURVEY

OBJECTIVE: TO DETERMINE THE ATTITUDES OF STUDENTS IN RELATION TO ENERGY.

Often we are not aware of the attitudes and opinions of those around us. It may be that there are a large number of students in your school who are interested in energy conservation and would make good conservation advocates.

Take a survey of the students in your class or school to determine their attitudes about conserving energy, their role, the government's role, their recommendations and so on. Included in this activity is a survey form and a tally sheet. You may wish to distribute the survey form or place it in your school paper. Feel free to add your own questions.

You might like to administer before-and-after attitude surveys. Take a survey before your class becomes active in learning and providing energy conservation information. Then after your energy conservation campaign, take a second survey. See if attitudes have changed.

ENERGY ATTITUDE SURVEY

1. Do you believe there is an energy shortage? ___yes ___no ___don't know

2. Do you believe you have been given a realistic picture of the energy situation facing the United States? ___yes ___no ___don't know

3. Do you believe most Americans are energy "wasters"? ___yes ___no ___don't know

4. Do you believe most Americans are energy "conservers"? ___yes ___no ___don't know

5. Do you believe Americans are "spoiled", self-indulgent and reluctant to take responsibility for the future? ___yes ___no ___don't know

6. Do you believe it is the responsibility of every U.S. citizen to conserve energy voluntarily? ___yes ___no ___don't know

7. Do you believe Americans will conserve energy only when government controls are imposed? ___yes ___no ___don't know

8. Would you be willing to reduce your standard of living to conserve energy? ___yes ___no ___don't know

9. Do you believe you as an individual can make an impact on energy consumption? ___yes ___no ___don't know

10. Would you conserve energy to save money? ___yes ___no ___don't know

11. Do you think the money saved is worth the inconvenience of conserving energy? ___yes ___no ___don't know

12. Do you think the energy saved is worth the inconvenience of conserving energy? ___yes ___no ___don't know

13. Do you feel technology will "bail us out" of the energy shortage? ___yes ___no ___don't know

14. Do you feel you have any input or participation in the energy usage decisions made by your family? ___yes ___no ___don't know

15. Are you going to do something to save energy? ___yes ___no ___don't know

ENERGY ATTITUDE TALLY

Question	Yes	Percent	No	Per-cent	Don't Know	Percent
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
Additional questions						

Find the percentages for each response. For example: if on question 1 200 students respond; 100 say yes, 60 no and 40 don't know then the percent saying yes is $\frac{100}{200}$ or 50%; saying no is $\frac{60}{200}$ or 30%; saying don't know is $\frac{40}{200}$ or 20%. (You may choose to use a claculator, especially if large numbers of students respond).

Suggestions:

1. Survey your class separately to see if the study of Home Economics has an effect.
2. You might print your results in the school newspaper.
3. Survey the teachers and administrators. Do their opinions differ much from the students?

ACTIVITY Z

ENERGY CONSERVATION TASK FORCE

OBJECTIVE: TO EXTEND THE FINDINGS IN THIS COURSE OF STUDY BEYOND THE CLASSROOM AND TO INITIATE A CONSERVATION ADVOCACY PROGRAM.

The impact of energy conservation is only as great as the number of people involved and actively seeking and practicing conservation. The more people you can convince, enlighten, or involve in energy conservation efforts, the more energy can be saved.

Set up an Energy Conservation Task Force to plan and execute a continuing effort to collect and provide energy conservation information. The information you have gathered and applied should be shared with others in the form of bulletin boards, displays, class discussions, PTA meetings, school newspaper articles, printed fliers, recycling drives, demonstrations, and sponsored speakers and films.

Suggestions:

1. Have students write short papers on energy conservation which could be used in the school or local newspaper.
2. Develop a series of bulletin boards dealing with the everyday practical aspects of energy conservation. Depict, for example, Bath vs. Shower, Use of a Microwave Oven, Food-Chain, Riding in a car vs. Walking, etc.
3. Investigate the school's consumption patterns and make recommendations to the administration. Investigate food service, surrounding vegetation, insulation, shades or draperies, thermostat settings, busing, and athletics.
4. Give demonstrations on conserving energy when cooking, sewing, or ironing and how to select and check appliances for energy conservation.
5. The Energy Conservation Task Force could be organized into a regular school club.
6. Sponsor field trips to power plants, energy conservation activities such as an energy fair, 4-H and FHA activities dealing with energy and the planning office or chamber of commerce in your area.
7. Design, print and sell "Energy Conservation T-Shirts."

APPENDIX-A

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

SECTOR and END USE	BPD**	PERCENT OF 1974 TOTAL
RESIDENTIAL		
Space Heating	3,800,000	10.6
Water Heating	1,100,000	3.0
Cooking	320,000	0.9
Clothes Drying	160,000	0.4
Refrigeration	490,000	1.4
Air Conditioning	420,000	1.2
Lighting and Other	770,000	2.1
Residential TOTAL	7,100,000	20.0%
COMMERCIAL		
Space Heating	2,400,000	6.5
Water Heating	240,000	1.0
Cooking	80,000	0.2
Refrigeration	370,000	1.0
Air Conditioning	800,000	2.3
Feedstock	560,000	1.6
Lighting and Other	830,000	2.3
Commercial TOTAL	5,300,000	15.0%
INDUSTRIAL		
Process Steam	5,800,000	16.1
Electric Drive	2,900,000	8.1
Electrolytic Processes	390,000	1.1
Direct Heat	3,800,000	10.6
Feedstock	1,100,000	4.7
Other	130,000	0.4
Industrial TOTAL	14,000,000	41.0%
TRANSPORTATION		
Automobiles	4,300,000	12.1
Trucks	1,700,000	4.6
Aircraft	1,700,000	4.7
Railroads	250,000	0.8
Buses	42,000	0.1
Waterways	84,000	0.2
Pipelines	84,000	0.2
Other	640,000	1.8
Transportation TOTAL	8,800,000	24.0%
NATIONAL TOTAL	35,000,000	100.0%

*Totals do not add due to rounding. **BPD equivalent barrels of oil per day
Source: Muller, John George. "The Potential for Energy Savings Through Reductions in Hot Water Consumption." Washington, DC: FEA, 1975 (FEA-D75-152).

APPENDIX B

HOW WATER IS USED BY A TYPICAL AMERICAN FAMILY OF FOUR

USE	Gallons Used Per Day
Dishwashing	15
Cooking, Drinking	10
Utility sink (washing hands, etc.)	5
Laundry	35
Bathing	80
Bathroom sink	8
Toilet	100
TOTAL	225

Source: Water Conservation and Wasteflow Reduction in the Home. Special Circular 184. The Pennsylvania State University, College of Agriculture, Extension Service and the Institute for Research on Land and Water Resources, University Park, Pa.

APPENDIX C

ANNUAL ENERGY REQUIREMENTS OF ELECTRIC HOUSEHOLD APPLIANCES UNDER NORMAL USE

When using these figures for projections, such factors as the size of the specific appliance, the geographic area of use and individual usage should be taken into consideration. Note that wattages are not additive since all units are normally not in operation at the same time.

Appliance	Average Wattage	Est. kWh Consumed Annually
FOOD PREPARATION		
Blender	386	15
Broiler	1,436	100
Carving Knife	92	8
Coffee Maker	894	106
Deep Fryer	1,448	83
Dishwasher	1,201	363
Egg Cooker	516	14
Frying Pan	1,196	186
Hot Plate	1,257	90
Mixer	127	13
Oven, Microwave (only)	1,450	190
Range		
with oven	12,200	1,175
with self-cleaning oven	12,200	1,205
Roaster	1,333	205
Sandwich Grill	1,161	33
Toaster	1,146	39
Trash Compactor	400	50
Waffle Iron	1,116	22
Waste Disposer	445	30
FOOD PRESERVATION		
Freezer (15 cu. ft.)	341	1,195
Freezer (Frostless 15 cu. ft.)	440	1,761
Refrigerator (12 cu. ft.)	241	728
Refrigerator (frostless 12 cu. ft.)	321	1,217
Refrigerator/Freezer (14 cu. ft.)	326	1,137
(Frostless 14 cu. ft.)	615	1,829

APPENDIX C (Continued)

Appliance	Average Wattage	Est. kwh Consumed Annually
LAUNDRY		
Clothes Dryer	4,856	993
Iron (hand)	1,008	144
Washing Machine (automatic)	512	103
Washing Machine (non-automatic)	286	76
Water Heater	2,475	4,219
Water Heater (quick recovery)	4,474	4,811
COMFORT CONDITIONING		
Air Cleaner	50	216
Air Conditioner (room)	860	860*
Bed Covering	177	147
Dehumidifier	257	377
Fan (attic)	370	291
Fan (circulating)	88	43
Fan (rollaway)	171	138
Fan (window)	200	170
Heater (portable)	1,322	176
Heating Pad	65	10
Humidifier	177	163
HEALTH & BEAUTY		
Germicidal Lamp	20	141
Hair Dryer	381	14
Heat Lamp (infrared)	250	13
Shaver	14	1.8
Sun Lamp	279	16
Tooth Brush	7	0.5
Vibrator	40	2
HOME ENTERTAINMENT		
Radio	71	86
Radio Record Player	109	109
Television		
black & white tube type	160	350
black & white solid state	55	120
color tube type	300	660
color solid state	200	440

*Based on 1000 hours of operation per year. This figure will vary widely depending on area and specific size of unit.

APPENDIX C (Continued)

Appliance	Average Wattage	Est. kwh Consumed Annually
HOUSEWARES		
Clock	2	17
Floor Polisher	305	15
Sewing Machine	75	11
Vacuum Cleaner	630	46

SOURCE: Electric Energy Association

ENERGY BASICS

OBJECTIVE: TO PROVIDE THE HOME ECONOMICS TEACHER WITH A FIRM GRASP OF THE BASIC ENERGY CONCEPTS, WITH A KNOWLEDGE AS TO HOW ENERGY IS TRANSPORTED AND STORED, AND WITH AN UNDERSTANDING OF THE FUTURE AVAILABILITY OF THE BASIC ENERGY RESOURCES

WHAT IS ENERGY?

Energy, though not easily defined, is not easily ignored. Man's senses respond to a variety of energy forms. The eyes respond to light energy. The ears detect sound energy. Other nerves indicate contact with thermal and electrical energy. These energy forms are interconnected and exchangeable; different forms of energy can be used for the same purpose; energy can be stored or transformed. But probably the most common and important characteristic of energy is its capacity for doing work.

Definition of Work

Students often say such things as, "My work load is too heavy" or "I'm doing yard work this summer" or "I have to help my mother with the housework." Suppose, in the last comment, that you must push a refrigerator from one side of the kitchen to the other. You must work against the frictional force which exists between the refrigerator and the floor, which means overcoming an opposing force. The amount of work done depends upon the force exerted on the refrigerator and on how far the refrigerator is moved. That is,

$$\text{Work} = \text{force} \times \text{distance}$$

$$\text{or } w = fd,$$

where d is the distance of movement (in meters) and f is the applied force, measured according to Newton's law of dynamics (that is, $f = Ma$). This unit of force is called the newton (n). Thus, the amount of work done is measured in newton-meters. When applied to work, newton-meters are called *Joules*, for the English physicist James Prescott Joule. One joule equals one newton-meter.

Suppose that, instead of moving a refrigerator, you must lift a television. In this case, work is done against the gravitational force. Again, $W = fd$, but the magnitude of the force is the weight of the object, of $F = Ma$ where a is the acceleration due to gravity, and M is Mass. Gravitational acceleration is usually indicated by the letter g. The weight or the gravitational force acting on the object is:

$$W = F_{grav} = Mg$$

On or near the surface of the earth, g has a value of 9.8 m/s^2 (meters per square second). Work required to lift the television to a height h can be written as:

$$W = Mgh.$$

If the television has a mass M of $8kg$ and it is raised one meter ($1m$), the work done is:

$$W = Mgh = (8kg)\ (9.8m/s)\ (1m) = 78.4\ joules$$

Definition of Power

A definition of the term *power* is also necessary for a full understanding of energy. Power, like work, has a scientific meaning that differs from that used in ordinary conversation. When we say that a person has great power, we mean either great physical strength or great authority. But in physics, power means the *time rate of doing work* (using energy).

$$P = \text{Power} = \frac{\text{Work done (or energy used)}}{\text{time}}$$

When work is measured in joules and time is measured in seconds, power is expressed in watts; one joule per second equals one watt (J/s = W). (The watt is named after James Watt who designed the first practical steam engine. The watt may be used to express quantities of mechanical as well as electrical power). The average human being can produce, at most, 100 watts.

Suppose that you must move an 8kg television a vertical height of one meter in two seconds. How much power (average) will be required?

$$P = \frac{W}{t} = \frac{Mgh}{t} = \frac{8(kg)\ (9.8m/s)\ (1m)}{2\ sec} = \frac{78.4j}{2\ sec} = 39.2\ \text{watts}$$

Discussions of electrical generating plants and consumption figures (including your electric bill) use the terms Kilowatt (Kw or 1,000 watts) and megawatt (Mw or 1,000,000 watts). Also, the horsepower, defined in terms of the watt, is often used as a unit of measuring power: one horsepower (hp) equals 746 watts or almost 3/4 kw.

Units of Measuring Energy

Other units besides the joule are commonly used to measure energy; for example, the *kilowatt-hour* is often used to measure electrical energy. One kilowatt-hour (kwh) is the amount of energy used to run a 1,000-watt (one kilowatt) appliance for one hour. The kilowatt is a measure of power; therefore, the kilowatt-hour is a unit of energy that describes the work accomplished through the use of power over time:

$$Power = \frac{Work\ done\ or\ energy\ used}{time}$$

or

$$Energy\ used = Power \times Time$$

One kwh can be expressed in joules:

$$kwh = P \cdot T = (100w) \times (1hr) \times (3600s/1\ hr)$$

$$= (3.6)\ (10^6)\ w/s$$

$$= (3.6)\ (10^6)\ joules$$

Remember, kilowatts refer to power--the rate at which energy is used--and kilowatt-hours refer to the amount of energy used. The cost of one kilowatt-hour is from 1.5¢ to 9¢ these days. You might be surprised to learn how much work a kilowatt-hour will do. For instance, the work equivalent of one kilowatt -hour would lift 10 cubic feet of water about 40 feet!

The *calorie* is the unit of energy used in heat problems. One calorie is the amount of heat necessary to raise one gram of water at 15° Celsius one degree Celsius; one calorie is mechanically equivalent to 4.186 joules. One thousand calories is a *kilocalorie* or *k-calorie*--the familiar unit of food energy. (The average American consumes 3,150 Calories each day).

The *British thermal unit (Btu)* is the amount of heat energy required to raise the temperature of one pound of water one degree Fahrenheit. The Btu is commonly used by engineers to specify the total amount of energy used for some specific purpose; for example, an air conditioner may have a cooling capacity of 8,000 Btu's per hour. The Btu is also used to specify the energy content of primary fuels or energy resources; for example:

> Each gallon of gasoline has a heating value of about 136,000 Btu. (Heating value is the maximum amount of energy released when fuel combines with oxygen in a combustion process). If an automobile gets ten miles per gallon of gasoline, then it takes about 13,600 Btu to drive the car each mile. [Weast, p. 81]

The following table relates the four basic units of energy:

Energy Conversion Factors	Value in joules	Value in kilowatt-hours	Value in Btu's
1 joule	1	$(2.78)(10^{-7})$	$(0.95)(10^{-3})$
1 kilowatt-hour	$(3.6)(10^{6})$	1	$(3.41)(10^{3})$
1 Calorie	4186	$(1.16)(10^{-3})$	3.97
1 Btu	1055	$(2.93)(10^{-4})$	1

Source: Marion, p. 29.

MAJOR FORMS OF ENERGY

Besides energy contained in light, in molecules (like gas, oil, coal), and in atomic nuclei (like uranium), there are two major forms of energy: energy of position or configuration (potential energy) and energy of motion (kinetic energy). Potential energy is always due to the presence of one of the three basic types of forces in nature: gravitational, electrical, and nuclear. Chemical energy, though also a form of potential energy, is more conveniently discussed as a separate form, even though all forms of chemical energy are basically electrical in character. Kinetic energy is the thermal energy associated with the interior motion of a material's particles. Two manifestations of kinetic energy are mechanical energy and sound energy. Material in this section presents an examination of the ways in which each form of energy can be converted into types of energy.

Potential Energy

Stored energy in a substance is called *potential energy*. For example, suppose a television is knocked off its stand and, upon falling, hits your foot. Energy was transferred from the television to your foot. Clearly, energy must have been contained in the television while it was resting on its stand. The television acquired the energy it had before it fell when someone lifted it to its stand.

Because potential energy can be converted into work, work units are used to measure and describe potential energy; that is, potential energy can be measured in joules. The potential energy (PE) of a mass (M) raised through a distance (h), where the acceleration due to gravity is (g), is:

$$PE = Mgh$$

Suppose you want to find the potential energy of an 8-kg television that has been raised one meter from the floor to its stand. You would conduct the following computation:

$$PE = (8kg)\ (9.8m/s)\ (1m) = 78.4\ joules$$

Thus, the amount of potential energy the television possesses relative to its potential energy while sitting on the floor is equal to the amount of work it took to raise the television to its stand. This kind of potential energy is associated with the force of gravity. There are other kinds, associated with other forces. For example, a stretched rubber band has potential energy. So does an electric battery.

Gravitational Energy. A television resting on its stand has gravitational potential energy. The weight of the television, the distance it rests above the floor, and the earth's gravitational force all combine to give the television the potential to do work.

Two natural energy resources can be harnessed for their gravitational potential energy: tides and rivers. When high tides go out, their gravitational potential energy is converted into kinetic energy which can be harnessed to create electrical energy. The tidal-powered electrical generating plant on the Rance River in France takes advantage of the power of the English Channel tide which rises as high as 44 feet. As the tide rises, gates are opened in the dam and water flows behind to form a nine-square-mile pool. At high tide, the gates are closed. As the tide lowers, the trapped water is allowed to flow out, driving electricity-generating turbines. In other locations, the flowing water of rivers is stored behind hydroelectric facilities in dammed reservoirs. The stored water can be released at will to turn the plant turbines which generate electricity.

Electrical Energy. All matter is composed of atoms, and each atom consists of protons, electrons, and neutrons. An electron is a negative particle of electricity; a proton is a positive particle of electricity. These two kinds of particles are attracted to each other through an electrical field (analogous to the television set being attracted to the earth through the gravitational field). Electricity is a manifestation of either the separation of electrons from portons (static electricity) of the motion of electrons.

You can produce static electricity by rubbing a balloon on your hair. The balloon gains electrons and becomes negatively charged while your hair loses electrons and becomes positively charged. The energy used to create the work (done by your hand) is stored in the atomic systems of both balloon and hair. Thus, after the rubbing, both balloon and hair may be said to have potential energy just as a television has potential energy after it has been placed on its stand.

In order for a substance to conduct electricity, its atoms must have electrons that are free to move from atom to atom. Metals have free electrons, and liquids and gases have ions that can produce an electric current. Such substances are known as conductors of electricity. Electrons or ions in any conductor travel through a conductor from a negative source to a positive source of electricity.

There are two main kinds of current: *direct* and *alternating*. Work must be done to create either a direct or an alternating current in a circuit. In both cases, the energy expended comes from outside the system. Direct current often uses chemical energy to move electrons, while alternating current uses the force of a rotating magnetic field to induce current. In both cases, the current can be used to perform work.

Direct current (dc) flows continuously in the same direction until the circuit is broken or the power fails. Dc generators are used in automobiles to supply the electrical energy needed to keep the storage battery fully charged.

A current which flows in one direction during part of a generating cycle and the opposite during the remainder of the cycle is called an *alternating current (ac)*. Alternating current is more widely used than direct current for two reasons: (1) simpler generating machines and electric motors are possible with alternating current; and (2) alternating current can be readily transformed into high voltages while direct current cannot. Household appliances use alternating current.

Although electricity is a form of energy, it is not a source of energy; rather, it serves as an energy transport system. Electricity is usually generated from the following sources: petroleum, natural gas, coal, hydro power, or nuclear power.

Chemical Energy. Substances store chemical energy in the sense that when they enter into a chemical reaction with oxygen (oxidation) to form a new chemical compound, they release heat or cause electricity to flow. For example, when wood burns, it combines with oxygen and gives off heat; when gasoline burns, the potential chemical energy in the gasoline is released as heat energy. Other sources of chemical energy besides natural gas and wood are coal and petroleum (fossil fuels) and storage batteries.

Natural gas is primarily composed of methane. When methane burns, its reaction with oxygen produces carbon dioxide, water, and energy. Specifically, 55,000 joules of energy are released by one gram of methane when it is burned. For the reaction to occur, several atomic bonds must be broken and new ones formed. Since methane and oxygen together have more electrical potential energy than carbon dioxide and water, the oxidation of methane releases energy.

Nuclear Energy. The release of chemical energy involves the rearrangement of molecules. Similarly, the release of nuclear energy involves the rearrangement of neutrons and protons to form different nuclei (the core) within individual atoms. There are two types of nuclear energy: fission and fusion. *Fission* occurs when the nucleus of an atom is split into two parts. When a neutron hits an atom of a fissionable element, it may be captured by the atom's nucleus. If it is, the atom may split into two smaller atoms, each having approximately half the mass of the original atom. The original atom releases two or three neutrons which may then hit other atoms and cause them to split. Thus, a chain reaction may occur. Radiant (light) energy is also released during the fission process.

Fusion occurs when two lightweight atomic nuclei (neutrons and protons) unite to form a heavier nucleus. A fusion reaction is also called a thermonuclear reaction because it takes place only at extremely high temperatures. At the present time, man does not know how to make hydrogen atoms fuse in a useful way (other than in an explosion) because a method to contain the extremely high temperatures needed has not been found. Hydrogen fusion could be a useful energy alternative because its fuel comes from water (deuterium). Unlike fission, hydrogen fusion would produce much less radioactive waste.

Kinetic Energy

Every moving object has *kinetic energy*. The earth is considered stationary, and an object resting on the surface of the earth is said to have zero kinetic energy. Kinetic energy depends on the mass as well as the speed of the moving object; the expression of kinetic energy (*KE*) of an object or mass (*M*) moving with a velocity (*v*) is:

$$KE = \tfrac{1}{2}Mv^2$$

Note that kinetic energy depends on the square of the object's velocity. As with potential energy and work, the unit for measuring kinetic energy is the joule. Kinetic energy interrelates energy of heat with energy of motion.

Suppose that you wish to determine the kinetic energy of an 8-Kg television between the time it is knocked off its stand and the time it strikes the floor. The television falls at a rate of about five meters per second:

$$KE = \tfrac{1}{2}Mv^2 = \tfrac{1}{2}(8mg)\ (5m/s)\ (5m/s) = 100\ joules$$

In falling to the floor, the television loses potential energy, but gains kinetic energy. By the time the television strikes the floor, all of the potential energy has been converted into kinetic energy which is then converted into work and heat. Energy is transferred from the television to the floor (and damages the set!).

There are three major types of kinetic energy: mechanical, sound, and radiant.

Mechanical energy is found in machines. In ordinary language, the term *machine* refers to any mechanical device that is used to accomplish a chore faster or more conveniently than would be possible without a machine. A machine can perform one of five basic functions: (1) transform; (2) transfer; (3) multiply force; (4) change direction; or (5) multiply speed.

One type of machine is used to *transform* energy; for example, a generator transforms mechanical energy into electrical energy, while a windmill transforms wind energy into mechanical energy. Other machines *transfer* energy from one place to another; for example, energy is transferred from the combustion cylinders of an automobile to the rear wheels by the connecting rods, crankshaft, drive shaft, and rear axle. A third type *multiplies force;* for example, the pulleys on venetial blinds enable easy lifting of shades. A related type of machine allows one to *change the direction* of a force;

for example, the pulley mechanism inside public bathroom towel machines exerts an upward force on the used portion of the towel as a downward force is exerted on the clean portion of the towel. A fifth type of machine can be used to *multiply speed;* for example, the sprocket wheel of a bicycle (the wheel to which the pedals are attached) turns the rear wheel of the bicycle at a faster rate than that of the sprocket wheel itself.

One must keep in mind that although machines are generally associated with kinetic energy, machines are constantly involved in an interplay of kinetic and potential energy. A falling object exhibits only kinetic energy during the single split-second before it strikes the earth. During all the other seconds of its fall, it has both kinetic and potential energy.

The interplay of kinetic and potential energy in machines is known in physics as the *law of conservation of mechanical energy.* This law states that the sum of the potential and kinetic energy of an ideal energy system (an ideal machine) remains constant. Of course, there are no ideal machines. All machines are hindered by dissipative forces such as friction (which produces heat rather than mechanical energy). But this heat energy is not "lost" in the real sense; the laws of thermodynamics say that there is a constant amount of energy in the universe--energy may be converted into another form, but it is never lost.

Because of the presence of dissipative forces, no machine is 100 percent efficient. The ratio of the useful or conservative work output of a machine to the total work input is called its efficiency:

$$\text{Efficiency} = \frac{\text{Work Output (Conservative)}}{\text{Work Input (Total)}}$$

Sound Energy. Like heat energy and electric energy, sound energy is a method of energy transfer. Sound may be generally defined as the result of a series of wave disturbances traveling from a source through a medium (usually the atmosphere) to the human ear. Wave disturbances also occur at levels above and below the wave frequencies to which the human ear is sensitive. The range of audible frequencies compose the *audio spectrum,* while those above and below this range compose the *ultrasonic* and *infrasonic spectrums.* The three spectrums together are known as the *sonic spectrum.*

A wave's frequency in the sonic spectrum is the number of waves (cycles) passing a given point in a unit of time. Thus, frequency is the number of cycles per unit of time. Frequency is measured in hertz; for example, if 30 wave disturbances (cycles) pass a given point in one second, the frequency of the wave is 30 hertz (30/sec.). The audio spectrum extends from approximately 20 to 20,000 hertz.

The speed of sound in air is about 331.5 meters/second at 0°C. Keep in mind that the speed of light in free space is $2.997925(10^8)$ meters/second. This difference in speed accounts for our seeing a distant flash of lightning before hearing the accompanying thunder. In water, the speed of sound is four times greater than in air; sound travels through water at about 1500 meters/second.

Suppose that you are swimming under water in a pool and a friend hits two rocks together under water. The collision of the rocks sets into motion the water molecules in the immediate vicinity; the nearby water molecules acquire energy from the collision. These molecules then collide with other molecules and further molecular collisions occur; in other words, the collision initiates a series of waves. Sound is carried by the waves to your ear. Thus, sound is due to waves--regular molecular motions--and therefore is a form of kinetic energy.

Radiant energy is the result of electromagnetic disturbances or waves. The electromagnetic theory says that the various phenomena of radiation are caused by electromagnetic waves whose energy is divided between an electric field and a magnetic field--both of which are perpendicular to each other and to the direction in which the waves move. Unlike sound energy, radiant energy does not require a medium to be carried through space; radiant energy can travel through free space.

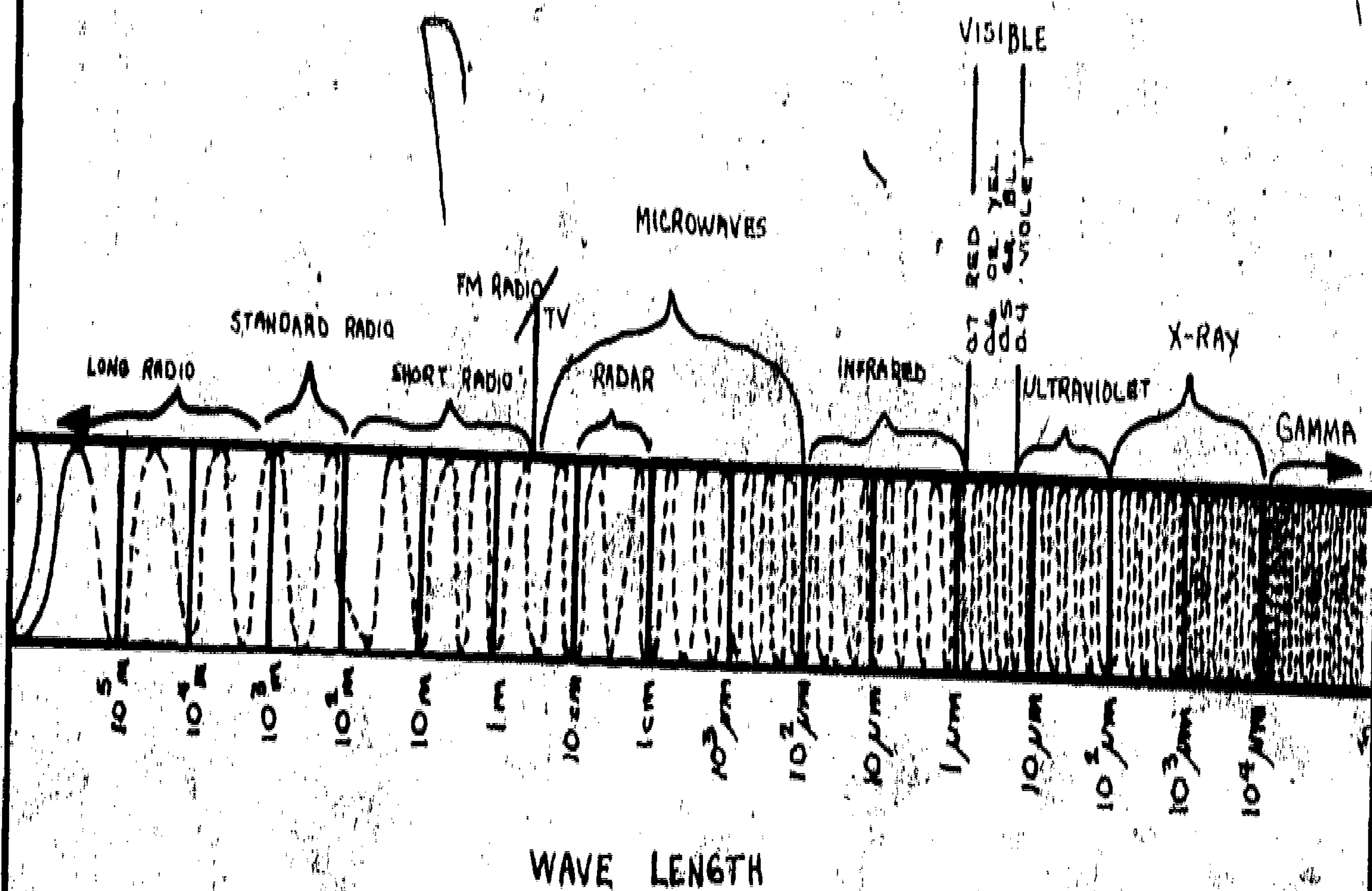
The *radiant* or *electromagnetic spectrum* consists of a large range of radiation frequencies, from 10 hertz to more than 10^{25} hertz. While all electromagnetic radiations travel at $3(10^8)$ meters/second, the radiations vary in wavelength from $3(10^7)$ meters to less than $3(10^{-17})$ meters. The longer the wavelength, the lower it is in frequency and energy. The angstrom (A) is commonly used to express the wavelengths of electrimagnetic radiations; one angstrom is a linear measure equivalent to 10^{-10} meters. For example, a wavelength of $2(10^3)$ meters/second is equivalent to $2(10^{13})$ angstroms.

The radiant or electromagnetic spectrum can be divided into eight major regions. In order of lowest frequency to highest frequency, they are: (1) electrical; (2) radio; (3) infrared; (4) optical; (5) ultraviolet; (6) X-ray; (7) gamma; and (8) hard gamma. The figure on the following page gives a brief description of each.

Light may be defined as the electromagnetic energy that a human body can detect. The *optical spectrum* consists of light energy--a small part of all radiant energy. The wavelength of visible radiant energy ranges from 7600A to 4000A.

Thermal Energy: The Bridge Between Potential and Kinetic Energy

Thermal energy is the total potential and kinetic energy associated with the random motion of a substance's particles. The quantity of thermal energy possessed by a body determines its temperature. But the same quantity of thermal energy possessed by different bodies does not give both the same temperature. The relation between thermal energy and temperature depends on the particular substance. If the average kinetic energy (a part of the total thermal energy) of a substance's particles is increased, the temperature of the substance is increased. If the average kinetic energy is decreased, the temperature goes down. If we were able to cool a body to the point where all thermal motion ceased, the temperature would be called "absolute zero".


VISIBLE
RED
OR.
YEL.
BL.
VIOLET
MICROWAVES
FM RADIO
TV
STANDARD RADIO
LONG RADIO
SHORT RADIO
RADAR
INFRARED
ULTRAVIOLET
X-RAY
GAMMA
WAVE LENGTH

Most substances have three phases or states: solid, liquid, and gas. The change of phase from a liquid to a solid is called *fusion*. (Do not confuse this term with *nuclear fusion*.) Energy must be supplied to a body undergoing fusion in order to increase the potential energy of the solid's particles or appears as work done on the particles in changing from a solid structure to a liquid "structure". Fusion is a constant temperature process: as the solid melts, the potential (not kinetic) energy of the substance increases. For example, when the appropriate amount of energy is supplied to a piece of ice without a change in average kinetic energy, the particles of the ice increase in potential energy without a change in temperature and the ice melts to form water; the energy enables the particles in the water molecules to overcome the forces that hold them in fixed positions. The energy added to any substance to make it melt increases the thermal energy of its molecules.

Similarly, when an appropriate amount of energy is supplied to a liquid without a change in kinetic energy, the liquid increases in thermal energy and becomes a vapor without a change in temperature; that is, liquid particles become particles in the vapor phase. When a substance undergoes vaporization, the energy supplied gives the particles of the liquid sufficient thermal energy to overcome the forces binding them to the liquid, and enables them to separate from each other and move among the molecules of the gases above the liquid. The energy required to vaporize a unit mass of liquid at its boiling point is called its heat of vaporization.

The terms *temperature* and *heat* are often confused. *Temperature* is the measurement of a quantity proportional to the average kinetic energy of the molecules in a substance. *Heat* involves the transfer of thermal energy from one body to another of lower temperature. Boiling water always has approximately the same temperature, but the amount of heat in boiling water depends on the amount of boiling water; a small pot of boiling water contains less heat than a large pan of boiling water, though their temperatures are the same. Heat is a term for thermal energy that is applied to a substance of lower thermal energy. The energy supplied to a substance that causes it to melt or vaporize is thermal energy (more specifically, heat energy). All substances have thermal energy, but all substances are not sources of heat energy. The amount of heat energy in a substance depends upon the total amount of thermal energy it has in relation to other substances. It is possible for a substance to have a low temperature, yet produce a lot of heat; for example, a radiator gives off more heat than a burning match even though the water in the radiator has a lower temperature than the flame of the match.

All substances have thermal energy, but all cannot be called thermal energy sources; that is, not all are good sources of heat energy. The sun, for example, is an excellent source of a base amount of heat energy. Some of the sun's heat energy can be harvested with solar collectors. Also, scientists know how to harness some of the heat within the earth (geothermal energy) and turn it into electrical energy. Geothermal heat originates from magma (molten rock) which finds its way to the surface of the earth in the form of steam.

ENERGY CONVERSION

Energy conversion means changing one form of energy into another. For example, when we switch on a vacuum cleaner, electrical energy is converted into mechanical energy. The conversion of nuclear energy from the sun to electrical energy is a more complex example. Nuclear fusion reactions in the sun produce radiant energy which causes water on the earth to evaporate and winds carry the vapor over land. The evaporated water eventually condenses to form clouds which may then condense further to form rain. The rain may fall into a river which flows past a hydroelectric plant, where the gravitational potential energy of the river is turned into electricity. The electricity may then be used to produce mechanical energy (e.g., to power a saw) or it may be stored as chemical energy (e.g., in batteries used to operate the electrical starters in automobiles).

There are a vast number of energy conversion examples. In the following matrix, some typical machines or processes that convert energy are summarized.

Conversion	From Mechanical:	From Heat:	From Sound:	From Chemical:	From Electrical:
To Mechanical:	windmill bicycle propeller	steam engine	voice activated recorder	human muscle gas engine plant cell	electric motor
To Heat:	friction brake	gas flame refrigerator	sound absorber	food fossil fuel match	resistors toasters spark-plug
To Sound:	bell violin piano	flame tube	megaphone	firecracker	telephone loud speaker thunder
To Chemical:				food feed	electrolysis
To Electrical:	generator	thermopile	induction microphone	battery fuel cell	transformer

Source: Tombari, p. 5.

The series of energy conversions in a steam generating plant are shown in simplified form in the following diagram:

Fossil Fuel--------->Boiler--------->Turbine--------->Generator
Chemical Energy----->Heat Energy----->Mechanical Energy----->Electric Energy

Coal, more often than oil and natural gas, is used in most steam electric generating plants. The coal is loaded into a furnace. While it burns, it releases heat energy which sets water boiling and subsequently changes it into steam. The steam then flows through large pipes to the steam turbine where it turns the blades of the turbine to produce mechanical energy in the form of a rotating shaft. Recall that some mechanical energy is always dissipated by friction. The rotating shaft drives an electric generator which produces electricity. Nuclear energy can also be used to generate steam and now accounts for almost ten percent of all U.S. electricity generation.

Basic Laws of Energy

According to Einstein's equation, $E = mc^2$, energy and mass are interrelated. Mass may be converted into energy and energy may be converted into mass. Both types of conversion are occurring continually in the universe, but the total amount of energy and mass remains constant at all times. This fact is expressed in the *law of conservation of matter and energy*: the total amount of matter and energy in the universe remains constant. The conservation law has been repeatedly proved in laboratory experiments and by observations.

When Watt developed his steam engine 200 years ago, he had little scientific and quantitative knowledge as to how the engine actually worked. During the first half of the nineteenth century, Joule, Carnot, and Clausius formulated the relationships among energy, heat, and work known as the *laws of thermodynamics:*

1. Energy and matter can be neither created nor destroyed.

2. The energy of the universe is constant, but the entropy of the universe increases toward a maximum, where *entropy* is a measure of the unavailable energy in a thermodynamic system.

The first law (energy cannot be created or destroyed) says that "there is no such thing as a free lunch" or "you can't get something for nothing." The second law says that "it's impossible to do something with the same energy that was used to do it in the first place." Once an act is accomplished, the energy required to accomplish it has degraded to a lower level, and less is available to do work.

The Entropy Law says that whenever energy is used, it loses some of its quality. Highest quality sources should be used for highest quality needs; for example, high quality natural gas should be used whenever its high flame temperature and cleanliness are needed (bakeries need such a fuel). Likewise, it makes sense to heat residential water with solar heat rather than with natural gas.

Consider the following as an example of the Entropy Law. Natural gas is being used to heat a pan of water. The temperature of the gas flame is very high--several thousand degrees Fahrenheit. Some of the heat warms the water to 120°F from 60°F, and the rest of the heat is lost to the air; therefore, making the air a little warmer. No energy is really *lost* in the process; it is simply dispersed from a state of high quality or available to a state of low quality or availability.

The importance of the laws of thermodynamics cannot be overemphasized. Their formulation meant that energy could be understood theoretically for the first time in history, that engines could be built to maximize energy through increased efficiency, that the relationships of energy to a technological society could be understood.

RENEWABLE AND NONRENEWAVLE ENERGY RESOURCES: THEIR PRESENT AND FUTURE AVAILABILITY

All energy resources belong to one of two groups--renewable or nonrenewable resources. Nondepletable energy resources are *renewable;* for example, the sun is a renewable resource, as is water. Depletable energy resources are *nonrenewable*. Fossil fuels--coal, oil, and gas--are nonrenewable because they were produced over millions of years by vegetation under pressure in the earth's crust and heated by the sun. Uranium, another important energy resource, is also nonrenewable.

Renewable Energy Resources

Solar. By the year 2000, solar heating and cooling could satisfy perhaps half the needs of all new residential and commercial buildings. Presently there are some very promising approaches to using solar energy for low temperature needs such as space and water heating, but the cost is still relatively high ($10 to $12 per square foot for solar panels) and functional storage systems must be developed to operate in conjunction with the solar devices. If solar equipment can be made cheaply enough, we could produce electricity either by a thermal cycle (making steam and driving a turbine) or by direct conversion using solar cells. The thermal cycle alternative is much closer to practical implementation, but is still several times as expensive as present methods of energy generation.

Geothermal. Large amounts of geothermal energy (heat in the form of steam, such as that found in geysers) is present in the earth's crust, but it is possible to tap these resources only in limited locations. Thus far, development and exploration in the U.S. has been conducted mainly in the West (California) because the most promising sites are found there. Experts estimate, however, that over the next 25 years as much as 25,000-MW will be provided by geothermal plants, where steam from the earth is used to drive turbines which generate electricity. There are, however, a number of disadvantages to using geothermal energy in this manner. Equipment used in the plants tends to corrode quickly because of minerals which dissolve in the hot water. These same minerals can create some environmental problems in the form of ground water contamination, waste salts, and air pollution (including escaping hydrogen sulfide which smells like rotten eggs). Finally, geothermal steam is not very hot, and so is an inefficient means of producing electricity (it also produces a lot of "waste heat").

Wind. Like geothermal energy, practical wind energy is found only in certain locations, mostly in the Midwest, Northeast, Southwest. Even there, it is variable and must be accompanied by storage devices or used only for special purposes, such as pumping water for stock ponds. At present, however, wind power generators are being tested in Northern Europe, Russia, and the U.S. A 100-KW wind turbine generator is in operation at NASA's Plumb Brook Station at Sundusky, Ohio, sponsored by ERDA. Research designers are investigating such possibilities as "power towers" which combine "eggbeater" wind machines with solar collectors to generate electricity.

Tides. Although suggestions have been made to harness the energy in tides, the total amount of tidal energy potential ($2x10^6$MW) would make a negligible impact on the world's energy supply. Furthermore, suitable locations are not where the demand is and severe environmental problems could be caused by massive movements of water in and out of coastal areas. Other disadvantages are visual pollution if the generating facilities were in a resort area, corrosion of equipment by salt water, and high capital costs.

Wood. Wood is still an important energy source in "third world" nations and can provide a great deal of power for short periods. Wood could continue to be used as a renewable fuel if it were grown on "planations" and then burned to produce electricity. The obvious disadvantage, however, is the competition for land use by the agricultural sector.

Hydro (Water). Most hydroelectric potential in the United States is already being used and environmental problems will probably prevent the development of additional sites. At the end of 1970, the installed hydroelectric capacity (both conventional and pumped) was 56,000 MW. By the year 2000, it is estimated that it will provide 125,000MW of power, but only 10 percent of the nation's electricity demand. Much of the capacity in 2000 will be used or pumped storage systems which will use the spare capacity of "base load" electric plants (for example, in the middle of the night) to provide power during periods of peak demand the next day. Water will be pumped uphill for storage, and power will be produced later when it is released downhill.

Fusion. Although the key concepts and technologies which will unlock the intricacies of fusion are not yet known, fusion remains a major hope for significant quantities of power. Once developed, fusion could provide a long-range solution to the world's energy shortages because a nearly inexhaustible supply of deuterium (the fuel necessary to produce fusion power) is found in water.

Refuse. Using our solid wastes to supply part of our electrical demand is an idea which appeals to many people and, indeed, some small plants are already in operation or under construction which can produce electricity from solid wastes. One such plant in St. Louis burns approximately 300 tons of municipal waste per day to generate 12.5 MW of electricity. If we took full advantage of the energy contained in *all* refuse, about 10 percent of our energy needs would be met.

Nonrenewable Energy Resources

Coal. Coal is the only nonrenewable energy resource which still exists in any abundance. Proved U.S. reserves are estimated to be 400 billion tons; possible resources are estimated as high as 3200 billion tons. This adds up to as much as 300 years' supply of coal at the current energy use rate. Coal is presently used to convert water to electricity or to make steam for industry. In the future, it may be converted directly to gas or oil. Coal creates many environmental problems, however. Because it is a "dirty" fuel, it causes air pollution (the higher the sulphur content, the more pollution; western coal has less sulphur, but more ash, than eastern coal). Strip-mining--the easiest and least dangerous method of coal mining--causes erosion and leaches wastes into streams and watersheds. Companies which strip-mine for coal (about half of all U.S. coal is strip-mined) are being required to reclaim stripped land at high cost.

Natural Gas. The proved reserves of natural gas are close to 200 trillion cubic feet. At current energy use rates, this supply would last only nine more years. Estimates of possible additional resources range from 450 to 2,000 trillion cubic feet--a current use rate range of 20 to 100 years. At the present time, natural gas is our least expensive fossil fuel because of price controls that make it artifically cheap. In the future, however, the price of natural gas will become much higher, necessitating many current users to switch to some other fuel. There will undoubtedly be opposition to such a switch since natural gas is the cleanest of the three fossil fuels and is in great demand for space heating.

Oil. The amount of oil which remains in the U.S. and offshore is unknown, though proved reserves (including Alaska) are estimated to be 45 billion barrels (BBL) and estimates of possible reserves are in the neighborhood of 89 BBL. Like that of natural gas, the price of extracting petroleum from U.S. oil fields may become so high that we will change our present use patterns (7,736 thousands of barrels of oil BBL from FEA Monthly Energy Report [May 1977]). Costs will increase because most of the easy-to-get has been used and new, harder-to-get sources requiring more complicated technologies will have to be tapped. Exploration for additional oil reserves centers on sites under as much as 800 feet of ocean or as far as 25,000 feet underground. Other large reserves of oil are trapped in fine-grained rock called shale. Useful fuel can be extracted from oil shale, but the net energy produced may be small, the process expensive (perhaps twice the present cost), and the environmental problems significant (large amounts of water are needed for extracting processes).

Uranium. Uranium, as a fuel for nuclear reactors, is a controversial energy source. It is highly favored by some groups because the potential energy of a given quantity of uranium is several million times greater than the energy available from an equal quantity of any one of the three fossil fuels. Mining uranium is a great deal more difficult than fossil fuels, however.

Even the richest uranium ore may contain only a fraction of one percent of uranium. Because uranium ore is not pure and the costs of extraction vary, the amount ofcurrent reserves are hard to estimate. It has been suggested, though, that we only have 30 years worth left of U^{235}--the uranium necessary to produce fission reactions in conventional nuclear power plants. The drawbacks to fission as it is presently used to produce electricity are the radioactive wastes and safety concerns. These objections may be overcome with the possible future development of the breeder reactor. At the present time, breeder technology is not well-established: costs of development will be high, and it is known that the waste product--plutonium--is extremely toxic. If breeders can be successfully developed and these obstacles overcome, the effective amount of fissionable material (the plentiful U^{238} after being converted to Pu^{239}) is tremendously increased, making our current energy reserves of uranium large enough to fulfill our energy needs for thousands of years.

ENERGY TRANSPORTATION AND STORAGE

Energy Resource Transportation Options

There are five basic ways to transport energy: water, rail, highway, pipeline, and powerline. The method used depends upon the particular energy resource and the location of the resource; for example, if water is nearby, coal may be shipped by barge rather than by train. This decision may be influenced further by the *energy intensiveness* of each mode; that is, the method used depends upon how much energy is used in each mode of transportation. The following table shows the energy intensiveness of each mode of energy resource transport (except powerlines--electricity cannot be effectively measured in tons) in 1970:

Energy Transport Mode	Energy intensiveness, expressed in BTUs of energy needed to move 1 ton of freight 1 mile
Truck	2,800
Waterway	680
Railroad	670
Pipeline	450

Source: Hirst, page 18.

Clearly, truck transport is less energy-efficient than pipeline transport. Thus, if you had a choice between shipping petroleum by truck or by pipeline and your only criterion for choice was minimum energy consumed, you would transport it by pipeline--fewer Btu's of energy consumed during transport usually means a lower transportation cost. Electricity (secondary energy) is very costly to transmit, even at high voltages. Furthermore, on the average, 10 percent of all electric energy may be lost through transmission and distribution inefficiencies. It also takes energy to move oil and gas through pipelines, but much less than electricity. On the other hand, electricity is relatively cheap to generate; the transmission and generation costs are about equal.

The cost of each mode of transportation is important; for example, the transport cost may determine whether you heat your home by natural gas, oil, or electricity. This section presents a discussion of each mode of transportation and its relative cost.

Water. Coal, oil, and sometimes natural gas (liquefied) can be moved on water. Domestic coal is sometimes transported by barge; in 1973, 11.6 percent of all coal was moved by barge. A tow of up to 20 barges can carry 20,000-30,000 tons of coal. Efficient tow boats can move coal cargo along inland waterways at low cost. Supertankers can carry up to 300,000 tons of crude oil. There are now over 200 of these large tankers in use in the world. While supertankers save a substantial amount in freight cost, they require 2.5 miles to come to a full stop. Clearly, the possibility of collision is substantial. Currently no U.S. harbor is capable of accommodating supertankers, although three sites are being considered: Texas, Maine, and South Carolina.

Like crude oil, refined oil is often moved by water carriers. Refineries, often located on principal waterways, deliver approximately 30 percent of their products by water. During very cold weather, such as the winter of 1976-77, frozen waterways can restrict flows of energy just when it is needed most. Desperately needed coal was stranded not only in snow drifts along the railroads, but in the jams on the Mississippi and Ohio Rivers.

Natural gas can be liquefied and transported from foreign fields to the U.S. by water. LNG (liquid natural gas) tankers require special low temperature "thermos bottle" containers for the gas. Few tankers are equipped for LNG service, but the few that are can carry out a billion cubic feet of gas. Newer models will have almost three times that capacity. By 1985, it is estimated that 100 to 150 such tankers will be needed to accommodate LNG imports to the U.S. At the present time, natural gas liquefaction and regasification increases the price of natural gas three to four times its wellhead price, whereas the transporting of oil from the Persian Gulf to New York by tanker increases the well head price of oil only by 25 percent.

Rail. Other than piplines, the most efficient form of land transport today is the railroad. Diesel trains have very efficient engines and normally carry large loads which are optimized to the engine's requirements and design. As indicated earlier, trains require less than one-fourth the amount of energy than trucks to move the same amount of freight. Furthermore, trains in 1970 used one-fifth the energy they did in 1950, mostly because of conversion from coal-fired steam locomotives to the more efficient diesel-fired locomotives.

Only a small amount of oil moves by rail--approximately 0.2 percent of crude oil and 2.6 percent of refined oil products in 1968. Oil may be shipped by tanker for less than .5¢ per million Btu for every 100 miles transported; oil transportation by rail costs three times as much. On the other hand, in 1973, 67 percent of all coal left the mine by rail. Since the early 1960's the "unit" train or shuttle has enhanced coal's economic attractiveness. The unit train, which carries coal non-stop from mine to power plant, has reduced transport rates from 3.5¢ per million Btu per 100 miles to 1.75¢. In the future, these specially designed trains may reduce the cost of coal transport even further.

Coal is relatively "dirty". From mining to burning, it is difficult to handle without major environmental and health impacts. But due to improvements in transport techniques and coal's general availability (the coal supply in the U.S. has not dwindled as rapidly as the oil and natural gas supply), coal's competitive position in the future will improve.

Highway. As indicated earlier, truck transport is the most energy intensive (least energy-efficient) mode of energy resource transport; it is also the most expensive method of energy transport. Unlike trains, trucks require more fuel today than they did in 1950 to move the same load. Increased energy use in trucking has been largely due to better highways which allow for higher speeds. Coal and oil are often transported by motor carriers (trucks). Approximately 10 percent of all coal moves from the mine to the power plant by truck, and approximately 11 percent is moved by conveyor belt or truck to mine-mouth generating plants. Approximately 7 percent of crude oil (in 1968) and 41 percent of refined oil products (in 1973) were moved by truck.

Pipeline. Natural gas, oil, and coal can travel by pipeline. Domestic natural gas transport is largely dependent on pipelines. Large-diameter pipelines carry gas from well-heads to processing installations. From there, the gas moves to pumping stations, then to distribution centers, and finally to local gas companies and consumers. As indicated earlier, pipelines need very little energy to move energy resources: 450 Btu per 100 miles. In 1975 there were 980,044 miles of gas main (pipeline) in use to transmit and distribute natural gas in the U.S.; these utility mains represent 99.1 percent of all mains in service. The cost of transporting gas is between that of pipelining oil and railing coal--between 1.5¢ and 1.75¢ per million Btu's per 100 miles. In 1968, approximately 75 percent of all crude petroleum and 30 percent of all petroleum products were shipped by pipeline.

It is also possible to transport coal by pipeline. From 1957 until 1963 a coal pipeline was successfully operated in northern Ohio, but railroad companies, threatened by the prospect of pipelines moving millions of tons of coal, lowered their rates and forced the Ohio pipeline to shut down. In 1962 the Federal Administration introduced a bill which would have granted the right of eminent domain to coal pipelines. The bill died in committee. But subsequent legislation and changes in the views of the Interstate Commerce Commission have enabled construction of a 275-mile coal pipeline which delivers coal from northeastern Arizona to a power plant in southern Nevada. It has been in use since 1971. In 1974, legislation granting five pipelines the power of eminent domain was approved by the Senate Interior Committee.

Powerlines. Electricity, in itself an energy transport system is transmitted by powerlines from power plants. Electric transportation costs are not cheap. Part of the cost is due to the cost of the transmission wire.

Also, the cost depends on the voltage of the electricity transmitted. National Power Survey statistics show that in 1964 it cost between 11¢ and 12¢ per billion Btu (of A/C electric energy) when transmitting at 550 kilovolts over 200 miles; between 12¢ and 15¢ at 345 kv; and between 15¢ and 19¢ at 220 kv. Thus, the higher the voltage, the less it costs to transmit the electricity. Unlike pipeline transmission, electrical transmission and distribution systems allow the energy to be drawn upon for use along the way. While powerlines are unsightly, they do not pollute as pipelines do when they break, and although powerlines lose about 10 percent of the electrical energy they carry through transmission and distribution inefficiencies, powerlines are the fastest growing energy transport method.

Energy Resource Storage

Whenever possible, energy is stored for future use. The type of energy storage used depends upon the particular energy resource. This section discusses the ways in which fossil fuels, water, electrical energy (in the form of chemical energy), and mechanical energy are stored.

Fossil Fuels. After *coal* is removed from the mine, it is transported to a power plant, coke-oven, or some other type of coal-processing operation. It is then stockpiled in the open air. Unfortunately, this is not an efficient storage method since oxygen causes coal to deteriorate. But coal is so bulky and heavy that it cannot be stored otherwise. Since the early 1960's, unit trains have lessened the need for huge stockpiles, so a large amount of coal can now quickly reach power plants in periods of peak energy demand.

During the winter, residential consumers use approximately five times as much *natural gas* as in the summer. The distribution utilities, therefore, contact natural gas companies for sufficient gas to meet peak demand days and dispose of excess "summer gas" to industrial consumers, unless this excess can be stored underground. In 1970 there were 325 underground storage pools with a total estimated capacity of approximately 5.2 trillion cubic feet. Most of these storage areas are former gas-producing pools. The rest were converted from combination oil and gas pools, oil pools, coal mines, salt storages, and aquifer reservoirs (water-bearing beds). At the end of 1970, natural gas stored in reservoirs amounted to 4.0 trillion cubic feet. On some days during that year more than 75.0 percent of peak demand sendouts came directly from storage.

Crude *oil* is stored either in pipelines or in large storage areas, usually tanks. The huge floating concrete storage tank at the Ekofisk production center in the North Sea holds one million barrels of oil. Outer Continental Shelf (OCS) oil is stored on the ocean floor by some countries. It is anticipated that the U.S. will develop this type of storage as OCS drilling moves greater distances from the U.S. shores.

Crude oil is stored until it is needed for refining. Domestic supplies are refined and then once again are stored in tanks--on the shore or miles inland --or in underground pipeline systems. In the case of the Ekofisk production center, the stored crude oil is transported to England by pipeline and then refined. Foreign supplies of crude oil are transported to the U.S. by supertanker. An undersea or underground pipeline takes the oil to storage tanks on the mainland where it is refined and stored again.

Refined petroleum products are stored until they are needed in the consumer sectors; for example, heating oil is stored in tanks until it is needed for winter heating. Residences that burn oil are generally equipped with 265-gallon oil tanks. In the future, these tanks may have a capacity as large as 1000 gallons. Though unsightly unless buried below ground level, these tanks will lessen the oil companies' storage and transportation costs. Gasoline, another refined petroleum product, is transported to service stations where it is stored in underground tanks until it is dispensed to motor vehicles.

Water. Two types of water storage are used to create hydroelectric energy: gravity water storage and pumped water storage. Rivers are natural energy resources that can be harnessed for their gravitational potential energy. The potential energy in the water was supplied by solar power, which earlier evaporated the water and transported it to the higher elevation. Gravity water storage is used to collect and hold a river at high elevations so that the potential energy available from the river can be converted to electrical energy during peak electrical demand periods.

If rivers flowed continuously at a constant rate, a gravity water storage system would not be necessary. But rivers tend to dry up in the summer and flow at such powerful rates in the spring that most of the energy available would be lost without gravity water storage, which compensates for the minimum water energy available during summer. Thus, storage areas or reservoirs allow hydroelectric plants to operate at the highest and most efficient level possible.

The flow of a river into a reservoir depends upon the geography and climate of the area; in other words, the actual flow of a river at a given time cannot be predicted. But the annual flow can be predicted accurately enough to determine the optimum power plant size, reservoir volume, and operating schedule for the most efficient use of the river's gravitational potential energy.

Water storage which involves pumping water rather than river flow is called *pumped water storage.* The simplest pumped water storage system uses energy from a thermal plant to pump water from one reservoir to a higher one. At a later time, gravity causes the water to flow back to the lower reservoir, and electricity is generated. Pumped water storage systems are usually used in conjunction with gravity water storage systems. Many pumped water systems make use of some natural river flow; that is, river water flows into the higher reservoir and water is pumped to the higher reservoir from the lower reservoir. Less water is pumped than is used for generating purposes.

The advantage of the pumped water system is that during periods of low electricity demand the thermal plant can consistently use the power it generates to pump water to the higher storage area. Then, during periods of peak demand, energy from the thermal plant and the pumped storage plant can be utilized to meet peak demand. Thus, the thermal plants can be efficiently operated continuously at full load and, consequently, energy for peak demand periods is obtained at low cost. However, energy is lost in using pumped storage because the electric motors used to pump the water and the turbine-generators used to reconvert to electricity are not 100 percent efficient. Typically, 30 percent or more of the energy is lost in this process. Unlike the gravity storage system, the pumped water storage system, due to the thermal plant, presents air pollution and heat waste problems.

At the end of 1970, pumped water storage accounted for 4,000MW as compared to 52,000MW for conventional hydroelectric systems. In the future, the number of pumped water storage systems is expected to increase significantly; by the end of 1990, it is projected that pumped storage capacity will be 71,000MW (conventional hydroelectric capacity is expected to be 82,000MW by that year). (Since conventional hydroelectric development requires damming a river and flooding a valley, it is likely that much more of this kind of development will meet fierce opposition.) At the present time, pumped water storage is of almost no value in the Pacific Northwest because conventional water storage systems can be provided with the additional peak energy they need more cheaply by extra turbine-generator systems than by a pumped water storage system. But in the future, the number of acceptable sites for conventional hydroelectric plants in other parts of the country will dwindle more rapidly and additional pumped storage systems will be needed.

Electrical Energy. Batteries are used to store small quantites of direct current electrical energy in the form of chemical energy. The high capital cost of batteries and AC/DC/AC conversion equipment make battery energy storage impractical where large amounts of energy are concerned.

Four types of batteries are common: lead-acid, nickel-cadmium, zinc-silver, and nickel-iron. The type of battery used depends upon the particular application; for example, when high discharge rates are needed to power an external load, zinc-silver batteries are used. On the other hand, moderate discharge rates are provided by low-cost lead-acid batteries; they are the most commonly used type. Minimum gas generation is provided by nickel-cadmium batteries, and ruggedness is provided by nickel-iron batteries.

The 1976 Energy Research and Development Administration's Conservation Program includes use of energy storage systems. One system under investigation is a lithium-sulphur (Li/S) battery, which has the potential to solve the combined requirements of: (1) helping a utility meet its peak load; (2) leveling solar and wind load; and (3) propelling electric vehicles. The technical feasibility of this storage system has been demonstrated, although certain problems such as basic cost and material corrosion have not as yet been solved. It is anticipated that by 1985 Li/S batteries could capture 15 percent of the market for all load leveling applications, including the electric vehicle market. If successful, this battery could save the equivalent of millions of barrels of petroleum daily.

Mechanical Energy. As indicated above, pumped water storage systems can generate electricity during low demand periods, and provide energy during peak demand periods. Unfortunately, pumped storage is relatively inefficient (67 percent), takes up a lot of land, and costs approximately $400 million for a single plant. A compact, cheap, and highly efficient energy-storage system is needed that would be environmentally equitable for any location, even densely populated areas. A flywheel system of storage might answer all these requirements.

The principle of a *flywheel* is that a spinning wheel stores mechanical energy; that is, just as water can be put into and taken out of a reservoir, energy can be put into and taken out a revolving wheel (flywheel). The earliest known flywheel was the potter's wheel of 6500 years ago. During the Industrial Revolution, flywheels were used to oppose and moderate any fluctuations of speed in the steam engines that powered mills and factories. Today, flywheels carry the rotation of pulses of mechanical energy delivered by the pistons of internal-combustion engines.

At the present time, experiments are using flywheels to power buses in the Soviet Union and the United States. They also are used to provide a variety of electric power supplies; for example, in Australia, a 20,000-hp electric-powered dragline/earth-moving machine maintains its peak power demands with a flywheel.

Flywheels have already proved their high-performance value in a large range of applications. But improvements must be made in general performance and safety before they can be used as power peaking storage units. These improvements can be made if flywheels are constructed of "super" materials--materials which exhibit different properties when tested along axes in different directions. To be successful, such materials must exhibit extremely high strength to resist centrifugal forces (outward spinning forces which could break the wheel apart) yet must be of low density. In the past, flywheels have been made of heavy, high-density materials which have been unable to store much energy per unit mass. If successful, the light, low-density flywheel will require only 10 percent as much mass to store the same amount of energy as the heavy, high-density flywheel. Low-density flywheels can be built of fiber composites developed originally for aerospace needs. These light flywheels are called superflywheels. Unlike the pumped storage system, superflywheel systems have not as yet been built or demonstrated.

Once superflywheels are developed, they will be able to store energy from an electric power plant during low electrical energy demand periods and will be able to provide energy during peak periods, It is estimated that such a system will have an efficiency of approximately 95 percent and a lifetime of 30-40 years or more. It will also be approximately 1,000 times smaller than a pumped storage system. It is estimated that a superflywheel system storing 10,000 kilowatt-hours of mechanical energy and having a power rating of 3,000 kilowatts will be much less costly than a pumped storage system. The superflywheel should be applicable to energy storage suitable for generating plants but also in a size suitable for use in automobile.Also, the superflywheel could provide the means to store solar and wind power.

FOOTNOTES

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GLOSSARY

ACCELERATION. The time rate of change of velocity in either speed or direction. (13)*

ACCELERATION DUE TO GRAVITY. The acceleration of a body freely falling in a vacuum. The International Committee on Weights and Measures has adopted as a standard or accepted value, 980.665 cm/sec^2 or 32.174 ft/sec^2. (13)

ALTERNATING CURRENT (AC). An electric current whose direction of flow is changed at periodic intervals (many times per second). (7)

ANGSTROM. A unit of linear measure equal to 10^{-10} micron or 1×10^{-8} cm. (13, 15)

AQUIFER. An underground bed or stratum of earth, gravel, or porous stone that contains water. (6)

ATOM. The smallest particle of an element which can enter into a chemical combination. All chemical compounds are formed of atoms, the difference between compounds being attributable to the nature, number, and arrangement of their constituent atoms. (13)

ATOMIC BOMB. An explosive that derives its energy from the fission or fusion of atomic nuclei. (13)

ATOMIC ENERGY. (1) The constitutive internal energy of the atom which was absorbed when it was formed; (2) Energy derived from the mass converted into energy in nuclear transformations. (13)

ATOMIC PILE. A nuclear reactor.

AUDIO SPECTRUM. The audible range of sound frequencies, extending from approximately 20 to 20,000 hertz. (15)

BARREL. Although seldom stored in actual "barrels," crude oil is measured in a unit called the barrel, equal to 42 U.S. gallons. One barrel of crude oil has the same energy as 350 pounds of coal. (9)

BATT. See *Blanket Insulation.*

BLACKOUT. (1) A total power failure caused unintentionally by storm damage, equipment failure, or overloaded utility equipment. (2) An exceptional situation in which all power is deliberately cut off by electrical generating facilities.

BLANKET INSULATION. Cotton fiber mineral wool or wool fiber made into varying thicknesses in a length.

*Numbers in parentheses refer to the GLOSSARY REFERENCES.

CLOCK-ACTUATED THERMOSTAT. Automatically changes the thermostat between two settings at predetermined times, permitting the temperature to be automatically reduced in the evening.

COAL. Solid, combustible, organic hydrocarbon formed by the decomposition of vegetable material without free access to air. (6)

COAL GASIFICATION. The conversion of coal to a gas suitable for use as a fuel. (6)

COLUMN EFFECT. As the volume of a cube increases, the volume-to-surface ratio decreases.

COMBUSTION. Burning; technically, a rapid oxidation accompanied by the release of energy in the form of heat and light. It is one of the three basic contributing factors causing air pollution. The others are attrition and vaporization. (6)

COMFORT AIR CONDITIONING. The process of treating air so as to control simultaneously its temperature, humidity, cleanliness, and distribution.

COMFORT ZONE. The proper temperature, humidity, and air movement to create a feeling of comfort.

COMPOUNDS. Substances containing more than one constituent element and having properties, on the whole, different from those which their constituents had as elementary substances. The composition of a given pure compound is perfectly definite, and is always the same, no matter how that compound may have been formed. (13)

CONDUCTOR (ELECTRICAL). A material capable of carrying an electrical current. (6)

CONSERVATION. The care or preservation of natural resources. (6)

CONSERVATION OF MATTER AND ENERGY (LAW OF). The sum of the potential and kinetic energy of an ideal energy system remains constant. (13)

CONSERVE. To manage or use wisely. (6)

CONVECTION. The transfer of energy by moving masses of matter, such as the circulation of a liquid or gas. (3)

CONVENTIONAL HYDROELECTRIC PLANT. A hydroelectric power plant that utilizes streamflow only once as the water passes downstream, as opposed to a pumped-storage plant which recirculates all or a portion of the streamflow in the production of power. (6)

COOLING LOAD. The amount of heat gain per unit time imposed on the cooling (refrigerating or air-conditioning) equipment. (1, 12)

COOLING TOWER. A device used to cool power plant condensor water before it is returned to lake, river, or ocean. The cooling tower is intended to prevent thermal pollution. (6)

COULOMB. The quantity of electricity equal to the charge of 6.25×10^{18} electrons. (15)

CRUDE OIL. Liquid fuel formed from the fossils of animals and plants at the bottom of ancient seas; petroleum as it comes from the ground. (9)

CURRENT (ELECTRIC). The rate of transfer of electricity. (13)

CURTAILMENT. Cutting back the use of energy resources as opposed to conserving or wisely using energy resources. (4)

DECIDUOUS. Trees and shrubbery that lose their leaves during the fall season of each year and regain them in the spring.

DENSITY. Concentration of matter, measured by the mass per volume. ([illegible])

DIFFRACTION. That phenomenon produced by the spreading of waves aro[illegible] and past obstacles which are comparable in size to their wavelen[illegible] (13)

DIRECT CURRENT (DC). An electric current that flows in only one direction through a circuit. (6)

DIRECT ENERGY CONVERSION. The process of changing any other form of energy into electricity without machinery that has moving parts. For example, a battery changes chemical energy into electricity by direct energy conversion. (9)

DOUBLE GLAZED WINDOW. Two panes of glass factory-sealed together with a small air space between them. Double glazing has about twice the R-value of single glazing.

EER (ENERGY EFFICIENCY RATIO). An indication of how efficiently an appliance uses energy.

$$\text{EER} = \frac{\text{Number of BTU's Used by the Appliance}}{\text{Appliance's Unit Wattage}}$$

Since 1973 manufacturers of window air-conditioning units have been required to label each unit with its EER. (2)

EFFICIENCY. The ratio of the useful work performed to the amount of energy used in the process. (15)

ELECTRICAL ENERGY. The energy associated with electric charges and their movements. Measured in watt hours and kilowatt hours. One watt-hour equals 860 calories. (6)

ELECTRIC FIELD. The region in which a force acts on an electric charge brought into the region. (15)

ELECTROCHEMICAL CELL. A cell in which chemical energy is converted to electric energy by a spontaneous oxidation-reduction reaction. (15)

ELECTRODE. A conducting element in an electric cell, electronic tube, or semiconductor device. (15)

ELECTROLYSIS. The conduction of electricity through a solution of an electrolyte or through a fused ionic compound, together with the resulting chemical changes. (15)

ELECTROLYTE. A substance whose solution conducts an electric current. (15)

ELECTROMAGNETIC WAVES. Transverse waves having an electric component and a magnetic component, each being perpendicular to the other and both perpendicular to the direction of propagation. (15)

ELECTRON. The electron is a small particle having a unit of negative electrical charge, a small mass, and a small diameter. Every atom consists of one nucleus and one or more electrons. (13)

ELEMENTS. Elements are substances which cannot be decomposed by the ordinary types of chemical change, or made by chemical union. (13)

ENERGY. The capability of doing work. Potential energy is energy due to position of one body with respect to another or relative parts of the same body. Kinetic energy is due to motion. (13)

ENTROPY. Entropy is the capacity factor for isothermally unavailable energy. Every spontaneous process in nature is characterized by an increase in the total entropy of the bodies concerned in the process. (13)

ENVIRONMENT. The sum of all external conditions and influences affecting the life, development, and ultimately the survival of an organism. (6)

EVAPORATION. The change from liquid to gas in which molecules escape from the surface of the liquid. (6)

FEEDSTOCK. Energy resources used as raw materials in the production of such products as wax and asphalt rather than as fuels for burning. (3)

FIRST LAW OF THERMODYNAMICS (Also called the *Law of Conservation of Energy*). Energy can be neither created nor destroyed. (3)

FISSION. A nuclear reaction from which the atoms produced are each approximately half the mass of the parent nucleus. In other words, the atom is split into two approximately equal masses. There is also the emission of extremely great quantities of energy since the sum of the masses of the two new atoms is less than the mass of the parent heavy atom. The energy released is expressed by Einstein's equation, $E = Mc^2$. (13)

FLYWHEEL. A method of energy storage working on the principle of a spinning wheel. By its inertia, a spinning wheel stores mechanical energy. (11)

FOAM INSULATION. (1) Styrofoam; (2) Rigid foam boards; or (3) Liquid foam insulation.

FORCE. That which changes the state of rest or motion in matter, measured by the rate of change in momentum. The force F required to produce an acceleration a in a mass m is given by $F = ma$. (13)

FOSSIL FUELS. Coal, [illegible] natural gas, and other fuels originating from geologic deposits of ancient plant and animal life depending on oxidation for release of energy. (6)

FREEZING POINT. The temperature at which a liquid changes into a solid. (15)

FREQUENCY. Number of vibrations or cycles per unit of time. (15)

FRICTIONAL FORCE. Force required to move one surface across another. (13)

FUEL. A substance used to produce heat energy, chemical energy by combustion, or nuclear energy by nuclear fission. (6)

FUEL CELL. A device in which fuel and oxygen are combined to produce chemical energy that is converted directly into electricity. (6)

FUSION (ATOMIC). A nuclear reaction involving the combination of smaller atomic nuclei or particles into larger ones with the release of energy from mass transformation. This is also called a thermonuclear reaction by reason of the extremely high temperature required to initiate it. (13)

FUSION. 1. The change of state from a solid to a liquid; 2. A reaction in which light nuclei combine to form an atom with greater mass. (15)

GAMMA RAYS (NUCLEAR X-RAYS). Emitted from radioactive substances, they are quanta of electromagnetic wave energy similar to, but of much higher energy than, ordinary X-rays. (13)

GAS. A state of matter in which the molecules are practically unrestricted by cohesive forces. A gas has neither definite shape nor volume. (13)

GASOLINE. Mixture of hydrocarbons obtained from petroleum. (6)

GENERATOR. A device that converts heat or mechanical energy into electrical energy. (6)

GEOTHERMAL. As applied to power generation, the use of heat energy obtained through the medium [illegible] water or steam coming from beneath the earth's surface.

GEOTHERMAL ENERGY. The heat energy available in the earth's subsurface believed to have been produced by natural radioactivity. The thermal gradient of the earth's crust is such that the temperature in a deep well or mine increases by about 1° F for each 100 ft. of depth. (6)

GRAM. A unit of mass in the metric system; 10^{-3} standard kilogram. (15)

GRAVITATION. The universal attraction existing between all material bodies. (13)

GREENHOUSE EFFECT. A method of using solar radiation to warm underheated areas (window treatments are opened to allow the window to admit and trap the sun's heat).

GROSS NATIONAL PRODUCT (GNP). A measure of economic activity which is the total market value of all goods and services produced in a country. Depreciation and other allowances for capital consumption are not deducted. (3)

GROUNDWATER. The supply of water under the earth's surface in an aquifer or soil that forms a natural reservoir. (6)

GROUNDWATER RUNOFF. Groundwater that is discharged into a stream channel as spring or seepage water. (6)

HEAT. Energy possessed by a substance in the form of kinetic energy, usually measured in calories or, in space heating, by the British thermal unit. Heat is transmitted by conduction, convection, or radiation. (6)

HEAT CAPACITY. That quantity of heat required to increase the temperature of a system or substance one degree of temperature. It is usually expressed in calories per degree Celsius. (13)

HEAT ENERGY. Energy that causes an increase in the temperature of an object. It may change the object from solid to liquid or from liquid to gas. (6)

HEAT PUMP. A device that absorbs heat from the outside air and pumps it into the house. It works in reverse as a standard air conditioner for cooling.

HEATING LOAD. The amount of heat loss per unit time imposed on the heating equipment (Btu/hr./sq. ft.). (1, 12)

HEAVY HYDROGEN. A kind of hydrogen that has one proton and one neutron in the nucleus of each atom and one electron in orbit around the nucleus. (6)

HERTZ. The MKS unit of frequency, one hz being equivalent to the expression "one cycle per second." (15)

HIGH-SULPHUR COAL. Generally, coal that contains more than one percent of sulphur by weight. (6)

HORSEPOWER. A unit that measures the rate at which energy is produced or used. A man doing heavy manual labor produces energy at the rate of about .08 horsepower. (9)

HYDROELECTRIC PLANT. An electric power plant in which the turbine-generators are driven by falling water.

HYDROELECTRICITY. Electricity production by water-powered turbine generator. (6)

HYDROLOGY. The science dealing with the properties, distribution, and circulation of water and snow.

HYDROPOWER. Power produced by falling water. (3)

INFILTRATION. The movement of air from the exterior of the house, or colder portions of the environment, to the interior of the house or warmer areas of the environment. Winter winds blow cold outdoor air into indoor spaces through cracks around windows and doors on the windward side of the house.

INFRASONIC SPECTRUM. The range of compression waves at frequencies below the audio range (below 20 hertz). (15)

INSULATION. A substance that insulates is one that can slow down the flow of heat or sound. (6)

INTERIOR FINISHING MATERIALS. The permanent finishes or furnishings, such as paint, wallcoverings, paneling, flooring, tile, acoustic tile, and carpeting, which are applied to the inside of a home.

INTERNAL COMBUSTION ENGINE. Energy is supplied by a burning fuel which is directly transformed into mechanical energy by controlled combustion. (6)

ION. An atom or group of atoms that is not electrically neutral but instead carries a positive or negative electric charge. Positive ions are formed when neutral atoms or molecules lose valence electrons; negative ions are those which have gained electrons. (13)

ISOTOPE. A variation of an element having the same atomic number as the element itself, but having a different atomic weight because of a different number of neutrons. Different isotopes of the same element have different radioactive behavior. (6)

JOULE. A metric unit of work or energy; the energy produced by a force of one newton operating through a distance of one meter.

KILOCALORIE. Heat energy equal to 4.19×10^3 joules. (15)

KILOVOLT (KV). 1,000 volts. (6)

KILOWATT (KW). The unit of power equal to 1,000 watts, 3.413 Btu's, or 1,341 horsepower. Roughly, the power of one KW is capable of raising the temperature of a pound (pint) of water 1°F in one second. (6)

KILOWATT-HOUR (KWH). The amount of work or energy delivered during the steady consumption of one kilowatt of power for a period of one hour; equivalent to 3.413 Btu's. (6)

LIGHT. Radiant energy which an observer can see. (15)

LIQUIFIED NATURAL GAS (LNG). Natural gas that has been changed into a liquid by cooling to about -260°F (-160°C) at which point it occupies about 1/600 of its gaseous volume at normal atmospheric pressure; thus, the cost of shipping and storage is reduced. (6)

LIQUID. A state of matter in which the molecules are relatively free to change their positions with respect to each other but restricted by cohesive forces so as to maintain a relatively fixed volume. (13)

LOOSE INSULATION. Small pieces of insulation which are blown into place.

LOW SULPHUR COAL AND OIL. Generally, coal or oil that contains one percent or less of sulphur by weight. (6)

MAGMA. Molten rock within the earth's interior. (3)

MAGNETIC FIELD. A region in which a magnetic force can be detected. (15)

MASS. A measure of the weight of matter in an object. The weight of an object depends on its mass. The United States standard mass is the avoirdupois pound as defined by 1/2.20462 kilogram. (7, 13)

MATTER. Anything which is solid, liquid, or gaseous. (15)

MECHANICAL ENERGY. The kind of energy that is released to make objects move. (6)

MEDIUM. Any material--solid, liquid, gas--in which waves travel. (15)

MEGAWATT (MW). A unit of power equal to 1,000 kilowatts or one million watts. (6)

METHANE. Colorless, nonpoisonous, and flammable gaseous hydrocarbon; emitted by marshes and by dumps undergoing decomposition. (6).

MOBILE HOME SKIRT. A foundation piece added to enclose the area under a mobile home.

MOLECULE. The smallest unit quantity of matter which can exist by itself and retain all the properties of the original substance. (13)

MOMENTUM. Quantity of motion measured by the produce of mass and velocity. (13)

MOTION. Continuous change of location or position of a body. (15)

NATURAL GAS. Naturally-occurring mixtures of hydrocarbon gases and vapors occurring naturally in certain geologic formations; usually found associated with oil. (6)

NEUTRON. A neutral elementary particle of mass number 1. It is believed to be a constituent particle of all nuclei of mass number greater than 1. (13)

NEWTON. The force necessary to give acceleration of one meter per second to one kilogram of mass. (13)

NONRENEWABLE RESOURCES. Depletable energy resources such as the fossil fuels--coal, gas, and oil. (5)

NUCLEAR ELECTRIC POWER PLANT. One in which heat for raising steam is provided by fission rather than combustion of fossil fuel. (6)

NUCLEAR (ATOMIC) FUEL. Material containing fissionable uranium of such composition and enrichment that, when placed in a nuclear reactor, will support a self-sustaining fission chain reaction and produce heat in a controlled manner for process use. (6)

NUCLEAR POWER. Electric power produced from a power plant by converting the energy obtained from nuclear reaction. (6)

NUCLEAR POWER PLANT. Any device, machine, or assembly that converts nuclear energy into some form of useful power, such as mechanical or electrical power. In a nuclear electric power plant, heat produced by a reactor is generally used to make steam to drive a turbine that, in turn, drives an electric generator. (6)

NUCLEAR REACTION. A reaction involving a change in an atomic nucleus, such as fission, fusion, neutron capture, or radioactive decay, as distinct from a chemical reaction, which is limited to changes in electron structure surrounding the nucleus. (6)

NUCLEUS. The dense central core of the atom in which most of the mass and all of the positive charge is concentrated. (13)

OFF-PEAK. Energy supplied during periods of relatively low system demands. (6)

OIL SHALE. Sedimentary rock containing solid organic matter (kerogen) that yields substantial amounts of oil when heated to high temperatures. (6)

OIL SPILL. The accidental discharge of oil into oceans, bays, or inland waterways. Methods of oil spill control include chemical dispersion, combustion, mechanical containment, and absorption. (6)

OPEC (Organization of Petroleum Exporting Countries). An organization of countries in the Middle East, North Africa, and South America which aims at developing common oil-marketing policies. (3)

OPTICAL SPECTRUM. Includes those radiations, commonly called light, that can be detected visually. They range from 7600Å to 4000Å and are a type of electromagnetic radiation. (15)

ORIENTATION. Position with relation to the compass.

OXIDATION. A chemical reaction in which oxygen unites or combines with other elements. Organic matter is oxidized by the action of aerobic bacteria; oxidation is used in waste water treatment to break down organic wastes. ([illegible])

PEAKING. Power plant operation to meet the highest portion of the daily load. (6)

PEAKING CAPABILITY. The maximum peak load that can be supplied by a generating unit, station, or system in a stated period of time. For a hydroproject, the peaking capability would be equal to the maximum plant capability only under favorable pool and flow conditions. Often the peaking capability may be less due to reservoir drawdown or tailwater encroachment. (6)

PHASE. (1) A condition of matter. (2) The position and motion of a particle of a wave. (15)

PHOTOSYNTHESIS. The process by which some plants make food with the help of sunlight energy (the food is a sugar called glucose; oxygen gas is also produced during photosynthesis); the process in which sunlight falling on green plants causes carbon dioxide and water to be converted into more complex organic materials such as glucose. ([illegible])

PLUTONIUM. A fissile element, artificially produced by a neutron captured by U^{238}. (13)

POTENTIAL (ELECTRIC). Difference of potential between two points is measured by the work necessary to carry unit positive charge from one to the other. (13)

POWER. The time rate at which work is done. If an amount of work W is done in time t the power or rate of doing work is $P = W/t$. Power will be obtained in watts if W is expressed in joules and t in seconds. (13)

PRESSURE. The force applied to a unit area. (15)

PROTON. An elementary particle having a positive charge equivalent to the negative charge of the electron but possessing a mass approximately 1,837 times as great. The proton is, in effect, the positive nucleus of the hydrogen atom. (13)

PUMPED HYDROELECTRIC STORAGE. The only means now available for the large-scale storage of electrical energy. Excess electricity produced during periods of low demand is used to pump water up to a reservoir. When demand is high, the water is released to operate a hydroelectric generator. Pumped energy storage only returns about 66 percent of the electrical energy put into it, but costs less than an equivalent generating capacity. (6)

PUMPED STORAGE PLANT. A hydroelectric power plant which generates electric energy for peak load use by utilizing water pumped into an elevated storage reservoir during off-peak periods. (6)

R-VALUE. Thermal resistance; computed by the conductivity divided into one. The measure of resistance to heat flow. (1, 2)

RADIATION. The emission and propagation of energy through space or through a medium in the form of waves. (13)

RECLAMATION. Act or process of reclaiming; for example, strip-mined land should be reclaimed--replanted and leveled. (14)

REFLECTION. The turning back of a wave from the boundary of a medium. (15)

REFUSE. See *solid waste*.

RENEWABLE RESOURCES. Nondepletable resources; for example, the sun. (5)

RESERVES. The amount of a natural resource known to exist and expected to be recovered by present-day techniques.

RESERVOIR. A pond, lake, tank, or basin--natural or manmade--used for the storage, regulation, and control of water. (6)

RESOURCES. The estimated total quantity of a natural resource such as [illegible] ground; includes undiscovered mineral reserves. (6)

SECOND LAW OF THERMODYNAMICS. One of the two "limit" laws which govern the conversion of energy. Referred to here as the "heat tax," it can be stated in several equivalent forms, all of which describe the inevitable passage of some energy from a useful to a less useful form in any energy conversion. (3)

SHELL. The roof or cover of a home, the foundation or part that sits on the ground, and the sides which join the two.

SIMPLE MACHINE. A contrivance for the transfer of energy and for increased convenience in the performance of work. (13)

SOLAR CELL. A photovoltaic cell which converts radiant energy from the sun into electrical energy. (6)

SOLAR ENERGY. Radiation energy from the sun falling upon the earth's surface. (6)

SOLID. A state of matter in which the relative motion of the molecules is restricted and they tend to retain a definite fixed position relative to each other, giving rise to crystal structure. A solid may be said to have a definite shape and volume. (13)

SOLID WASTE. Useless, unwanted, or discarded material with insufficient liquid content to be free flowing. (6)

SONIC SPECTRUM. The region of sound range which includes audio range frequencies, ultrasonic range frequencies, and infrasonic range frequencies. (15)

SOUND ENERGY. A kind of energy carried by molecules that vibrate back and forth, so that waves are formed. (6)

SPECIFIC HEAT. The heat capacity of a material per unit mass. (15)

SPEED. Time rate of motion measured by the distance moved over in unit time. (13)

STATIC ELECTRICITY. Electricity at rest. (15)

STEAM-ELECTRIC PLANT. A plant in which the prime movers (turbines) connected to the generators are driven by steam. (6)

STOCKPILE. A storage pile or reserve supply of an essential raw material; for example, coal is stockpiled in the open air for storage purposes. (14)

STORAGE CELL. An electrochemical cell in which the reacting materials are renewed by the use of a reverse current from an external source. (15)

STORED ENERGY. See *Energy (potential).*

STORM DOOR. Additional door with an air space between it and the existing door.

STORM WINDOW. Additional window with an air space between it and the existing window. Storm windows will cut in half the heat that passes through windows in your house.

STRIP-MINING. A process in which rock and topsoil strata overlying ore or fuel deposits are scraped away by mechanical shovels. Also known as surface mining. (6)

SUBLIMINATION. The change of phase from a solid directly to a vapor or gas. (15)

SUPERFLYWHEEL. A flywheel of the future that will be constructed of materials which have special properties along each axis. See also *flywheel.*

SUPERTANKERS. Extremely large oil tankers that can hold up to four million barrels (170 million gallons) of oil. The largest ones will require deepwater ports.

TECHNOLOGY. Applied science.

TEMPERATURE. The condition of a body which determines the transfer of heat to or from other bodies; particularly, it is a manifestation of the average translational kinetic energy of the molecules of a substance due to heat agitation. (13)

TENSILE STRENGTH. The greatest longitudinal stress a substance can bear without tearing apart. (14)

THERMAL EFFICIENCY. The ratio of the electric power produced by a power plant to the amount of heat produced by the fuel; a measure of the efficiency with which the plant converts thermal to electrical energy. (6)

THERMAL ENERGY. The total potential and kinetic energy associated with the random motions of the particles of a material. (15)

THERMAL PLANT. A generating plant which converts heat energy to electrical energy. Such plants may burn coal, gas, oil, or use nuclear energy to produce thermal energy. (6)

THERMAL POLLUTION. Degradation of water quality by the introduction of a heated effluent. Primarily a result of the discharge of cooling waters from industrial processes, particularly from electrical power generation. (6)

THERMODYNAMICS. The science and study of the relationship between heat and mechanical work. (4)

TRANSFORMER. A machine which can increase or decrease the voltage of an alternating current. (6)

TRANSMISSION. The act or process of transporting electric energy in bulk from a source or sources of supply to other utility systems. (6)

TRANSMISSION LINES. Wires or cables through which high voltage electric power is moved from point to point. (6)

TURBINE. A motor, the shaft of which is rotated by a stream of water, steam, air, or fluid from a nozzle and forced against the blades of a wheel. (6)

ULTRASONIC SPECTRUM. The range of sound compression waves at frequencies above the audio range (above 20,000 hertz). (10)

UNIT TRAIN. An ore shuttle that carries coal non-stop from mine to power plant. (10)

VALENCE ELECTRONS OF THE ATOM. Electrons which are gained, lost, or shared in chemical reactions. (13)

VAPOR. The words *vapor* and *gas* are often used interchangeably. *Vapor* is more frequently used for a substance which, though present in the gaseous phase, generally exists as a solid or liquid at room temperature. *Gas* is more frequently used for a substance that generally exists in the gaseous phase at room temperature. (13)

VAPORIZATION. The change of a substance from a liquid or solid state to the gaseous state. One of three contributing factors to air pollution; the others are attrition and combustion. (6)

VELOCITY. Time rate of motion in a fixed direction. (13)

VOLT. The unit of electromotive force. It is the difference in potential required to make a current flow through a resistance. (13)

VOLTAGE. The amount of force employed to move a quantity of electricity; measured in volts. (6)

WATER VAPOR. Water in the form of a gas. (6)

WATT (W). A unit of measure for electric power equal to the transfer of one joule of energy per second. The watt is the unit of power most often associated with electricity (1 horsepower = 746 watts) determined by multiplying required volts by required amperes (volts x amps = watts).

WAVE MOTION. A progressive disturbance propagated in a medium by the periodic vibration of the particles of the medium. Transverse wave motion is that in which the vibration of the particles is perpendicular to the direction of propagation. Longitudinal wave motion is that in which the vibration of the particles is parallel to the direction of propagation. (13)

WEATHERSTRIPPING. Reduces the rate of air infiltration by making sure that all doors and windows fit their frames snugly.

WEIGHT. The measure of the gravitational force acting on a substance. (15)

WINDOW TREATMENTS. Applications to the interior side of windows--(blinds, shades, shutters, draperies).

WORK. A force acting against resistance to produce motion in a body; measured by the product of the force acting and the distance moved through against the resistance. (13)

X-RAYS. A type of radiation of higher frequency than visible light but lower than gamma rays. Usually produced by high energy electrons impinging upon a metal target. (13)

ZONE CONTROL. Independent temperature control for each area to be heated and cooled with appropriate distribution control.

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