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1. Energy Overview

by
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Preface

This 12-part energy resource series is designed for adults and students with a serious interest in the energy situation.

This first publication provides an overview of the energy picture to make you aware of the wide ranging ramifications and interrelated factors concerning the present and future energy situation. Other publications in the series each examine a different energy source and consider the advantages and disadvantages associated with its use.

When necessary, diagrams and/or tables are used to clarify or elaborate upon information found in the text. Questions with answers are included at the end of each publication so that you can test what you have learned.

The author wishes to thank Larry Piercy and Linda Bach of the Department of Agricultural Engineering, University of Kentucky, for reviewing this text.

The Energy Resource Series for Youth and Adult Energy Programs includes the following publications:

AEES-21 Energy Overview
AEES-22 Definitions
AEES-23 Oil and Gas
AEES-24 Coal
AEES-25 Solar
AEES-26 Wind
AEES-27 Nuclear Fission
AEES-28 Nuclear Fusion
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1. Energy Overview

The History of Energy in the United States

Since the development of the internal combustion engine and its rapid adoption as a power source, the people of the United States and several other developed countries have enjoyed the benefits of relatively cheap energy. This has had a direct bearing on the standard of living we have today.

The availability of the internal combustion engine in various sizes, followed closely by the development of the steam turbine-generator and economical fuel to energize them, has reduced greatly the number of people engaged in the production of our basic needs—food, clothing and shelter. Engines and motors have been substituted for human labor on the farm. Those leaving the basic production areas became engaged in the production of luxury items, some of which further reduced human labor requirements and released still more human effort into luxury item production.

Today it is difficult for a young person to differentiate between essentials and luxuries and between needs and wants. This generation cannot be blamed because it grew up with abundant energy at hand. Today in the United States, 99 percent of all dwellings have electricity, 95 percent have running water and 90 percent have inside toilets. This standard of living is based primarily on cheap, easily obtained fuel.

Undoubtedly, the cost of fuel will continue to increase in the near future as energy supplies become limited and the search for additional fossil fuels goes deeper into the ground, out into the edge of the oceans and into severe climates. However, these are short-term solutions. People must learn to sort out real needs from wants. Habits will have to change, if we are to live within our energy means. Just 100 years ago, wood was used to heat homes and to do the cooking. The horse was the power source. But within the last 75 years, the marvels of the gas engine and steam turbine have consumed a large percentage of the fossil fuel supply that took several million years to develop.

Total Energy Consumption Today

It is difficult to say whether the development of engines to use the fuel came first, or the discovery of the fuel (oil and gas). It is probably safe to say that they came along together, since an engine is certainly of no use with no fuel and vice versa. At any rate, the development and adoption of the gas engine were no more spectacular than the search for and production of fuel. The important thing about energy today is knowing where it comes from, how much we use, what we do with it and how much fuel is left.

Figure 1 shows the amount of energy consumed in the United States each year in British thermal units (Btu), while Figure 2 illustrates the equivalent amount of energy in barrels of crude oil.
crude oil could be stacked up in a neat cube, it would be about 3,800 feet on each edge, or nearly three-quarters of a mile on each edge!

Remember this is energy equivalent. This is the total amount of energy used, and if it had all been from oil this would be the size of it. But natural gas, coal, water and nuclear power also were used. If one were to add up the total energy used from each of these sources in any given year (Figures 3, 4 and 5), it would equal the amount in Figure 1.

Oil and Gas Consumption

Starting about 1956 we used more oil and natural gas than we produced in this country. Figures 3 and 4 show the amount of these fuels used and the amounts produced along with new discoveries. The new discoveries became part of our known reserves. It is important to examine these figures carefully because the difference between the amount used and that produced is made up of imports from other countries.

Fig. 3.—Amount of oil used, discovered and produced from known reserves in the United States.

From Figure 3, you can see our oil production and new discoveries have fallen way behind the oil consumed, while imports have increased to make up the difference. The natural gas situation has not been quite as bad (Figure 4). Up until 1967, new discoveries were much greater than our natural gas use. But since 1956, we have consistently used a little more than we produced out of these known reserves. The difference has been made up largely by importing Canadian natural gas via pipeline and by importing some gas by ship from other countries.

Fig. 4.—Amount of natural gas used, discovered and produced from known reserves in the United States.

Since 1967, new discoveries of natural gas have decreased sharply, while consumption has steadily climbed. This means that unless new sources are discovered, the United States will rapidly use up the known reserves or have to import still greater amounts. When any country must import essentials, international economics and political involvement continually cloud the picture. A nation that has something essential, such as oil, will hold the high cards and can successfully bargain.

Coal Consumption

In Kentucky, many families derive their living from some phase of coal production. The May 1976 U.S. Bureau of Mines report shows Kentucky as the leading state in production of coal, with West Virginia a close second. Figure 5 indicates the production and use of coal in the United States. In contrast to oil and natural gas, coal is the only fossil fuel with known reserves that have produced more than was consumed. Most of this difference has

Fig. 5.—Annual use and production of coal in the United States.
gone into exports. A small amount has gone into stock piling at power plants and at factories that use coal. From this it can be seen how coal, much of which is from Kentucky, can affect the international energy picture.

Projections of Future Consumption

The data pictured in Figures 1 to 5 are already several years old. Current data are difficult to obtain since there is often a lag of a year or two between gathering data and publishing results. One way to avoid this lag and give a rather complete look at where we have been, where we are and what lies ahead is to make predictions based on the best available information. Assuming that new reserves will be discovered, Figure 6 paints a theoretical picture for us.

Fig. 6.—Projected total energy use to the year 2000 in the United States. The area between each of the curves, read from the curve immediately below to the given curve, forecasts the amount of a particular fuel that will be used at a given time.

Note the vertical scale in Figure 6. The top value is 240 quadrillion Btu, while Figure 1 had a top value of 80 quadrillion Btu. This represents a three-fold increase from 1972 to the year 2000. Imports play a major part in this production. Note also that the imports in the year 2000 are equal to the total that was used in 1972. In reality, this probably will never take place. By that time, the lush oil fields of the Mideast will run out. As production declines, the cost will rise unbearably.

Individual Consumption

Consider now how individuals in the United States affect the energy picture. In the following discussion, the amount of energy that each individual consumes is figured in equivalents of gallons of gasoline. One gallon can be visualized as a container about 8 inches high and 6 inches in diameter, or as a cube about 6 inches on each edge.

Table 1 gives a breakdown on the approximate daily energy consumption during 1973. Note that the energy (gasoline equivalent) used in food production, processing, distribution and home storage, that is, energy used to store foods in refrigerators and freezers amounts to about one gallon out of the total of 8.5, or 13 percent. Personal transportation and the transportation of consumer goods by trucks and trains uses 23.5 percent. The related industrial factories, which process these goods, use a major part of the total at about 47 percent. The remaining 16 percent is used in homes and apartments for space and water heating and does not include the energy used in cooking and storing food.

Table 1.—Average U.S. per Capita Daily Energy Consumption in Various Categories.

<table>
<thead>
<tr>
<th>Category</th>
<th>Consumption (Gallons/Day)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food Use:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm production</td>
<td>0.2</td>
<td>2.4</td>
</tr>
<tr>
<td>Processing, distribution, home storage and preparation</td>
<td>0.9</td>
<td>10.6</td>
</tr>
<tr>
<td><strong>Nonfood Use:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td>2.0</td>
<td>23.5</td>
</tr>
<tr>
<td>Industry</td>
<td>3.0</td>
<td>35.3</td>
</tr>
<tr>
<td>Commercial</td>
<td>1.0</td>
<td>11.7</td>
</tr>
<tr>
<td>Residential</td>
<td>1.4</td>
<td>16.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8.5</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Proper insulation and thermostat settings are two ways to help economize. An analysis of Table 1 indicates clearly that transportation (personal and luxury freight) and its related industry can be looked at as other possible ways to economize. More ways will be discussed later.

To further explain the food-related energy consumption, look at Table 2. The big items are the processing, most of which is done in highly automated factories, and home preparation. Emphasis must be placed on the importance of energy conservation in home preparation of food. With certain techniques, this 30 percent value may be cut in half.
Table 2.—Energy Consumption for Various Aspects of Food Use.

<table>
<thead>
<tr>
<th>Category</th>
<th>Consumption Gasoline Equivalent (Gallons/Day)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>.198</td>
<td>18</td>
</tr>
<tr>
<td>Processing</td>
<td>.363</td>
<td>33</td>
</tr>
<tr>
<td>Transportation</td>
<td>.033</td>
<td>3</td>
</tr>
<tr>
<td>Wholesale and retail</td>
<td>.176</td>
<td>16</td>
</tr>
<tr>
<td>Home preparation</td>
<td>.336</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.106</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Agricultural engineers, food scientists and food technicians work in the very broad area of food processing to achieve ways of economizing on the energy needed. Agricultural engineers and agronomists work on the production phase to devise methods of economizing. It may be that more human energy needs to be put back into this phase, since there are more humans and less energy than desired. Good working conditions and discreetly applied mechanization can make this possible.

Another way of getting an overall view of the energy consumption picture is to examine Figure 7. Figure 7 shows the U.S. population from 1920 to 1980 and the energy consumed per person. It clearly can be seen that our individual consumption has grown greatly. When the annual population growth curve and per capita consumption growth curve interact, they rapidly multiply the total energy consumption shown in Figure 1.

**The Need for Conservation**

Even with maximum emphasis on conservation of present fossil fuels by car pools, mass transit, insulation and thermostat adjustment, there will be an end to this finite supply. Attention must be turned to several alternate sources, such as direct solar, wind, nuclear, methane digesters, water, wood and alcohol. These alternate sources are areas of energy use that today's youth can explore as career possibilities. Conservation of our present fossil fuel resources is necessary to move us successfully from the present to some future time when many new kinds of energy sources will be available.

In this interim period of time, the use of each existing fuel resource must be carefully examined. We must slow down our energy consumption by driving smaller cars or organizing car pools. Day-light saving time has been instituted and is purported to conserve fuel. Nonetheless, look at the newspaper advertisements for air travel to distant places. Energy must be conserved across the board if we are to stretch this interim period from a fossil fuel base to a multiple source base.

In the 30s, the development of the automobile, roads and motels started a trend of family vacation travel. From that time to the early 70s, it was the fashion for families to travel for a week or two of vacation time. Car fuel usage, coupled with the associated energy expenditures for constructing vacation resorts and highways gradually became a major consumer of petroleum. In addition, conventions and business meetings have become common practice in the United States. Thousands of meet-
ings, large and small, entail long distance travel by plane and auto each year.

The bar graph in Figure 8 shows the comparison of oil consumption of several leisure activities carried out in the United States. By studying this graph closely, you can find many ways to conserve energy.

![Bar graph showing leisure time energy use.](image)

**Fig. 8.**—Comparison of energy consumption in 1973 for some leisure time activities in the United States.

In addition to the energy we consume, in heating our homes, cooking, transportation, etc., the manufacturing process uses large quantities of energy. A tremendous amount of energy is needed to manufacture aluminum, steel, copper, insulation, cement and asphalt.

Any attempt to design new ways of producing energy, such as wind mills, additional hydro electric plants, solar collectors or nuclear power plants would require the use of materials that consume large quantities of fossil fuels in their manufacturing process. Thus, present fossil fuels are a necessary ingredient for the development of new energy sources; therefore, sensible management of present sources is a necessity. Designers of new energy sources must view and examine the entire system. They must be certain that the new source will supply more energy in the long run than was needed to develop and manufacture the materials.

Learning how to conserve our energy resources requires thinking in terms of units of an energy economy, such as miles per gallon, instead of a dollar economy. The dollar is artificial and the value of it can change with the whims of people; but, the quantity of a unit of energy (Btu per gallon) used or traded will remain stable. The quantity of energy contained in several fuels is shown in Table 3.

**Table 3.**—Energy Values of Various Fuels.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Btu/lb</th>
<th>Btu/gal</th>
<th>Btu/cu. ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>13,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>20,000</td>
<td>124,000</td>
<td></td>
</tr>
<tr>
<td>Natural gas</td>
<td>21,000</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>6,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry forage (corn stalks, leaves, grass, hay)</td>
<td>8,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal fat (bacon grease)</td>
<td>13,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Minerals Deserve Conservation Also**

Before studying some specific energy sources in this series of resource publications, one more important fact should be considered. Fossil fuels are not the only materials being used at an accelerated rate. Minerals, such as iron ore, copper and aluminum (bauxite) are being mined in enormous quantities each year; these are non-renewable materials. The energy needed to do these mining jobs is enormous, and the minerals themselves are of finite quantity. Searching for ways to remove these minerals is going to require great amounts of energy.

Nuclear energy is also in this category. Uranium is the fuel source, and this element is extremely scarce. The fission process, which obtains heat from splitting uranium atoms, uses uranium up rapidly. The fusion process, which forces fast-moving hydrogen atoms together to form helium, does not require uranium once the process is started, but the extremely high temperature needed to start or trigger the fusion of hydrogen atoms to helium atoms can, at the present time, be done only with the high temperature developed by the fission of uranium (see AEES-27, _Nuclear Fission_ and AEES-28, _Nuclear Fusion_).

Conservation and common sense must be exercised with all these non-renewable materials. Even if some new energy sources were developed within the next quarter century that would give us a nearly unlimited energy supply again (as during the past 50 years), how would we utilize the source if there were no essential minerals?
A Picture Of Our Present High Energy Consumption

One way to view the total energy situation is shown in Figure 9. The information is not exact, but it does present an overall view that dramatizes the many millions of years it took to form all the fossil fuels in the crust of the earth, and the minute amount of time it is taking to use them up. The strong probability that we will run out of fossil fuels before the end of the present generation’s lifetime is a sobering fact.

Fig. 9.—This graph is not intended to depict exact data but to dramatize the fossil energy consumption age in which you live. It is probable that this age will end as quickly as it began unless we develop acceptable new sources that will allow us to follow the dotted lines 4b and 5 at the right.

In Figure 9, the short vertical lines depict divisions between similar eras of time. Their number and length probably varied quite a lot. In general, each of them could be considered as a global era of agriculture. The beginning stages of global agriculture required the earth’s surface and atmosphere to support green plant life, by photosynthesis. It is theorized that each series of such eras ended by some sudden, violent change in the earth’s surface, such as major earthquakes and volcanic eruptions. The side effects were giant tidal waves and lava flows that buried large quantities of lush green plant growth, some of it probably hundreds of feet tall. This occurred in just a few days or weeks.

For aeons these materials lay buried in fossil form, preserving the sun’s energy. Repeated layers of plant material were buried by events similar to this that happened time and time again at various places on the surface of the earth. This explains why coal and gas are found at different levels in the earth and more or less in layers covering large areas. Enthusiastic prospecting, mining and drilling began when humans discovered that these fossilized materials would burn like wood but would produce a lot more heat.

In Figure 9, the word fillet appears at the base of the tall curve. A fillet is a curve that leads smoothly from one line into another. In this case, the fillet on the left, or the first one, represents an extremely short time at the beginning of the Industrial Revolution, about 1700, until people were in the full swing of drilling, pumping and mining the fossil fuels at a tremendous rate in 1960. The years from 1960 to 1970 represent the peak of the consumption curve.

Here is where reality confronts us. The right hand side of the curve will probably descend faster or steeper than it went up. It is the same rule that causes a baseball to come down a similar path it took going up, unless it is helped by external energy input like the wind. The reason is that the area under the tall, slim curve equals the area under all the dashed lines labeled “D”. This simply represents the quantity of fossilized material available from previous aeons. There is no way to change the area under the tall, thin curve.

Fillet number 1 is now history and nothing can be done about its shape. The top of the consumption curve has been reached, and the downward turn started. Nothing can be done about how we got there; that is history, but we can, if we plan and work a program, change our descent to another shape as shown with the dotted lines. Here is how it can be done.

There is no need to try to stretch our present quantities of fossil fuel into the distant future. To put it another way, “It’s just not in the cards.” We can change the future path or fillet shape by starting now to develop new sources of energy. If we don’t start now, there will simply be no energy, and the effect will be the same as an automobile running out of gas; it stops.

Fossil fuel conservation plays its part by lengthening for a few short years, fillet number 2, the time the fossil fuels can be depended upon and then gradually replaced by other new energy sources. If we want to maintain our present standard of living by using energy near today’s levels, it will be necessary to be on a program that makes a curve like fillet number 5. It would be a disaster of catastrophic proportions to start a program of possibilities too late and not have enough fossil fuel to bridge the gap, and thus follow fillet number 3.
If there is further delay in making decisions for future generations but a realistic energy program is developed, the path of filament number 4 can be followed. Energy use would be cut in half. However, if the right decisions on new sources are made the recovery would take path 4b. But if the new sources floundered we would at some future time start downward again as shown in 4a.

**Conclusion**

To develop new energy sources will require as much energy as it took to succeed in our moon landing program. But if we should fail, the consequences will be much more serious. There is an immediate need for well-trained minds to work on energy-related problems. These problems can be viewed as opportunities, since the energy field offers a wide range of future career possibilities. As you read this series of energy resource publications, consider the impact that you personally can have in the field of wise management of our energy resources.

**Questions**

To stimulate thought and greater understanding, answer these questions with the best word(s) to make a true statement. Refer to the material when necessary.

1. At what time in history did the total energy consumption in the United States begin to exceed the amount produced and cause the United States to import fuels?  
2. What category of energy use by individuals is the smallest?  
3. In the category of food-related energy use in the United States, what area uses the most energy?  
4. Personal transportation and transportation needed to freight luxury items amounts to what percent of the total energy used by individuals in the United States?  
5. The total amount of energy consumed by individuals in the United States each day is what, in gasoline equivalents?  
6. Of the three fossil fuels—oil, gas and coal—which one shows greater supply than production in this country?  
7. If the United States had free access to the oil and gas fields of the Mideast would this guarantee relief of an energy crunch forever? (Yes or No)  
8. Name one easy thing that can be done in the home to help reduce heating energy consumption.  
9. What event in comparatively recent history has contributed to the freeing of human labor for development of luxury items?  
10. Will conservation practices ultimately solve the energy shortage? Why?  
11. After some study of Figure 8, why do you think we, in the United States, ran into the energy shortage in 1973?  
12. What one fact supports the necessity of developing new kinds of energy?  
13. Give the primary reason why fossil fuel conservation is important today.  
14. Which of the following decisions would save the most energy? (a or b)  
   (a) forego a traveling vacation  
   (b) drive 55 mph on a vacation
Answers

1. 1956 (Figure 1)
2. Farm Production (Table 1)
3. Processing (Table 2)
4. 23.5 (Table 1)
5. 8.5 (Table 1)
6. Coal (Figure 5)
7. No
8. Lower thermostat setting
9. Engines and motors substituting for human labor on farms
10. No. We must switch to renewable energy sources.
11. The extremely rapid rise of personal energy use from 1950 to 1973, the year imports were cut. At that time we wanted more oil than was available.
12. Fossil fuels are finite
13. To bridge the gap from fossil fuels to alternate sources
14. (a)