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The Energy Situation

By: Ronald N. Salzman
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THE ROCHESTER COMMITTEE FOR SCIENTIFIC INFORMATION
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by

Ronald N. Salzman, Ph. D.

Introductory Note, by Vice President for Scientific Activity, RCSI:

Although the "crisis" may have ceased to exist for most people, when gasoline scarcity ended, the RCSI feels that the need for understanding by the public is even more important when the issue has vanished from the popular media. The situation is real, it will not solve itself, and there is little evidence that national policy is adjusting to the reality.

As this bulletin was being prepared for distribution, news appeared in the press indicating that the recent shortages had left memories behind. According to stories in the Rochester Times-Union, the United States consumption was down 5% and the rest of the world was saving 12%. There is evidence of a surplus of gasoline in some places, with prices being cut and distributors threatening retailers with franchise revocation if they did not sell to the limit of their allotment.

-Herman S. Forest

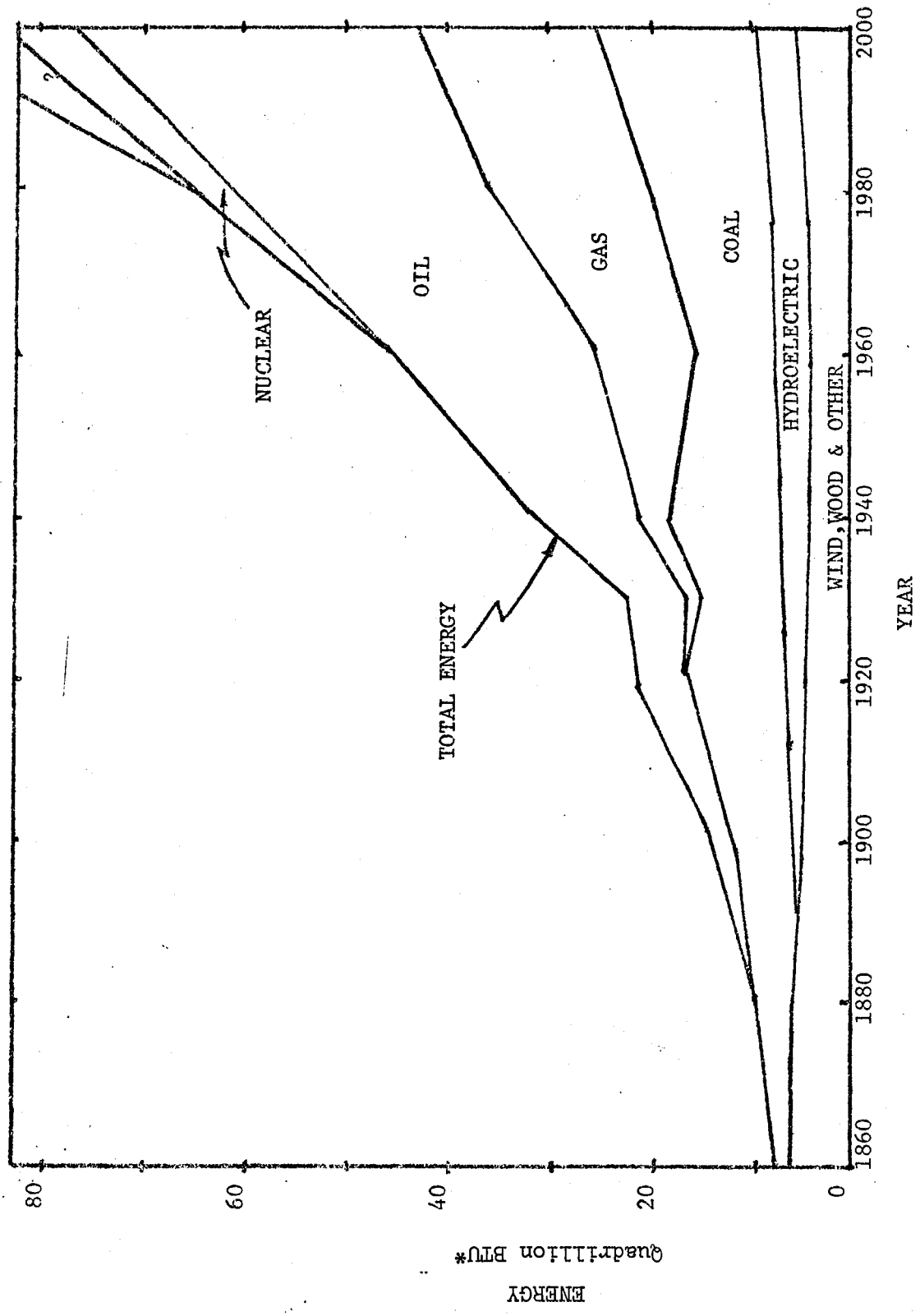
Is There a Real Shortage?

The energy shortage is genuine, even though the immediate extent is yet to be determined. Newspaper and television coverage tends to imply that this has developed in a relatively short time and may be the result of complex oil company plots. Both of these implications are false. The oil companies are probably guilty of small manipulations and maneuvering for profit but this crisis situation has taken many years to develop and is not their brain child. This problem is the predictable result of a demand for energy growing faster than the capacity of industry to supply the resources (petroleum, natural gas, and coal). The impending shortage had been forecast by numerous scientific and technical writers during the last seven to ten years.

Energy is an essential ingredient in the production and transportation of all goods. A shortage of energy resources therefore has an immediate impact on all segments of our society. We have been operating as though the earth and its resources were infinite. Our energy and environmental problems are indications that the old assumptions are no longer satisfactory.

The immediate problem is not that we are running out of fuels, but that the rate at which consumption is increasing is outstripping our ability to increase the supply. Our fossil fuels will be depleted eventually, but even for petroleum and natural gas, that is still several decades away. The immediate problem is to equitably control consumption within the limits of the projected supply. Based upon the recent history of energy requirements, energy demand is projected to increase at a rate of 5% per annum, with electrical consumption increasing 7% per annum (Figure 1). This growth cannot be sustained with current technology and energy resources.

Figure 1. United States Energy Consumption (1)



* BTU = British Thermal Unit - Heat required to raise 1 lb. water one (1) degree Fahrenheit

Science and technology cannot offer any quick, painless solutions. It is unlikely that there will be any technical breakthrough which will eliminate this problem during the next decade. Advanced power systems which can supply vast quantities of energy with fewer environmental problems will not be available in significant numbers for twenty years, if then. It is therefore probable that energy supplies will be limited for the next two decades and so the use of energy must be restricted. Voluntary reductions have been helpful but stringent governmental controls are likely for the long term.

Where Do We Get Energy?

Today, useful energy is commercially obtained in three ways. The most common method involves burning of fossil fuels; coal, natural gas and petroleum products. The other sources of energy are water power and nuclear fission. The relative importance of each is shown in Figure 2.

For the near future natural gas, petroleum, and coal will continue to be the mainstays of our energy needs. Expansion of hydroelectric power is limited, while nuclear energy (1% of the total) has not become as significant as predicted. Problems of thermal pollution, radioactive waste and emotional reaction have slowed the production of nuclear electric generating plants. Petroleum meets 43% of our total energy requirements. Approximately 30% of our petroleum is imported. The Middle East supplies nearly 10% of our petroleum and hence 4.3% of our total energy.

How is Energy Used?

It is difficult to obtain accurate information on energy usage (Figure 3). In some references usage is attributed to the location where the resource is consumed. Hence, electric generating plants are a major energy consumer. In other references energy utilization is considered to be the point of application. Electric generation is then included with the residential, commercial and industrial. In Figure 3, electric generation is included as a separate entity. About one quarter of the total U. S. consumption of energy is used to generate electricity. Of this, two-thirds is applied to commercial and residential applications and one-third to industry.

Most electric generation is controlled by public utilities, which also control the final distribution of natural gas. Hence, public utilities exert a direct control on better than 50% of the energy consumed in this country. The public utilities are second only to the oil companies in their impact toward solving energy related problems.

Approximately 27% of our energy resources are consumed by industry while 24% is used for transportation. About 8% (coal and petro-chemicals) is exported. The remaining energy resources are consumed in commercial and residential applications (17%).

By applying electrical production to its applications, a more accurate picture may be made of where we use energy. Transportation and export expenditure are not affected by this view. Industrial consumption is 35% of the total; commercial, 14%; and residential 19%.

Figure 2. United States Energy Sources (1, 2, 3)

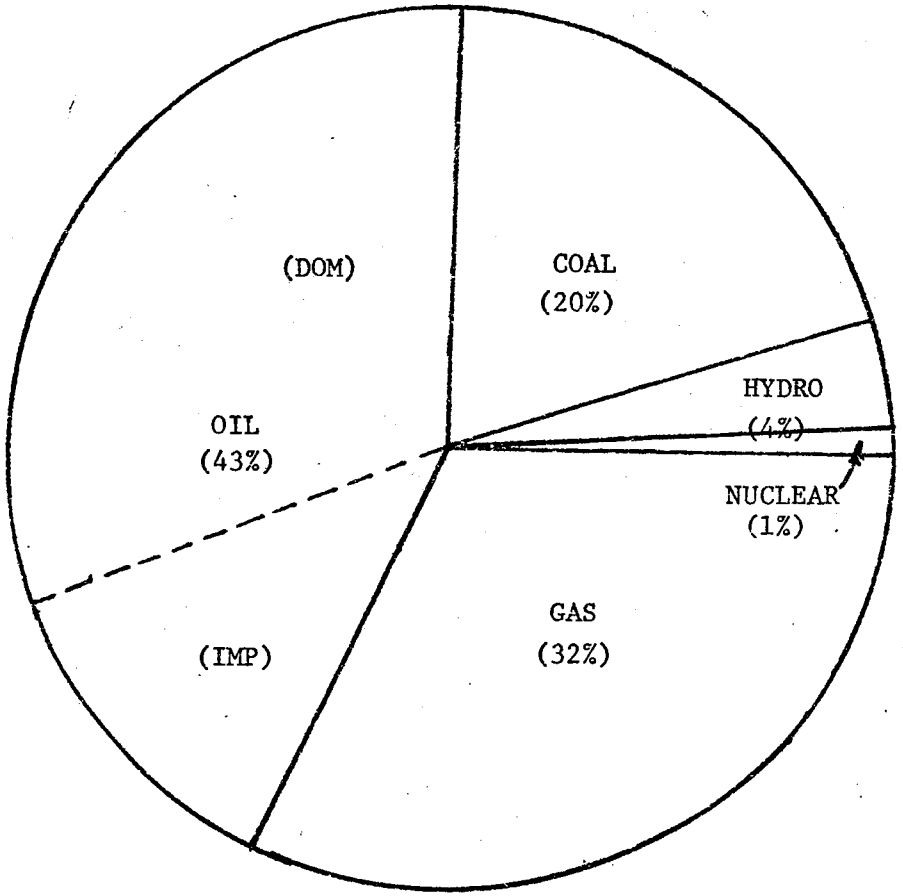
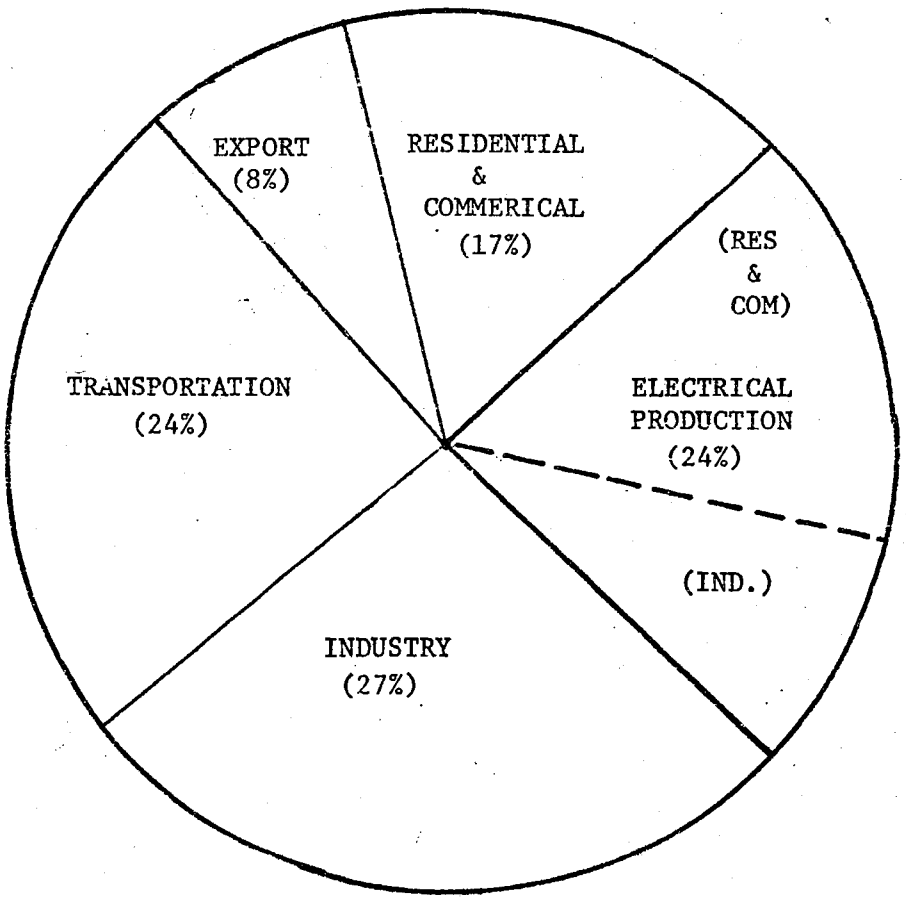


Figure 3. United States Energy Expenditures (1,2,3,4)



Can Energy Be Conserved?

A contributing cause of our crisis is our inefficient and wasteful practices. A conscientious national program to conserve energy is required. Many estimates indicate that savings of 15-20% are available with a minimum impact on our economy. This is equivalent to uncovering new reserves capable of sustaining modest industrial growth for more than four years. Basic information on efficiency is presented in Figure 4.

The information on this chart points out how present governmental controls are encouraging less efficient operation. Today many new installations are being designed with electric resistance heat because of restrictions on the use of natural gas and fuel oil. The process of burning fuel to generate electricity for heating is only about 35% efficient. By comparison, an on-site natural gas or fuel oil heating system is better than 60% efficient over the heating season. Therefore, it is ineffective to control natural gas and fuel oil without similar controls on electricity. If governmental controls are required, they must be applied to all aspects of energy consumption.

Is Transportation Efficient?

Since transportation accounts for 24% of our total energy usage, a further breakdown of this element is instructive (Figure 5). The total energy consumed by ships, trains, farm and construction equipment is only about 3% of the total energy consumed in the United States. Considering the essential services performed, this does not appear to be unreasonable. On the opposite end is the automobile. It is far the most significant and wasteful element of this group. 13% of all the energy consumed in the United States, is used to power our cars. This amounts to 53% of all the transportation energy. Because of the low average number of passengers per automobile, it is an inefficient means of transportation of people. Only when a small car is used to transport three or four passengers is it reasonably efficient.

One comment frequently heard is that the emission control devices should be removed to improve gas mileage. This action would achieve a saving of approximately one-half of one percent of the total U.S. energy requirements. With the current demand for energy, this would delay the development of energy problems by only five weeks. Weighing this short-term gain against environmental effects, such a move should not be seriously considered. The best way to increase gas mileage is to eliminate air conditioning (12-20% loss of efficiency) and reduce the weight of the vehicle (roughly 0.40 mi./gallon/100 lbs). According to a recent Environmental Protection Agency report, a Toyota Corolla gets three times the mileage of a Buick Regal. Both meet the same emission standards.

Can Much Energy Be Saved At Home?

Residential electrical utilization is indicated in Figure 6. Because of the range of variables from household to household, this can only be considered a guide. Note that the largest users are the air conditioner, range, oven, and hot water heater. The first is a luxury item and the others would operate more efficiently with natural gas. The many small electrical convenience items do not operate often enough to be a significant factor. Even a sparing use of air conditioners and selective use of electrical appliances can have a significant impact on a nation-wide basis. A 15% saving, if applied in each home, would amount to a national energy saving of 3%.

Figure 4. Efficiency of Energy Devices (5)

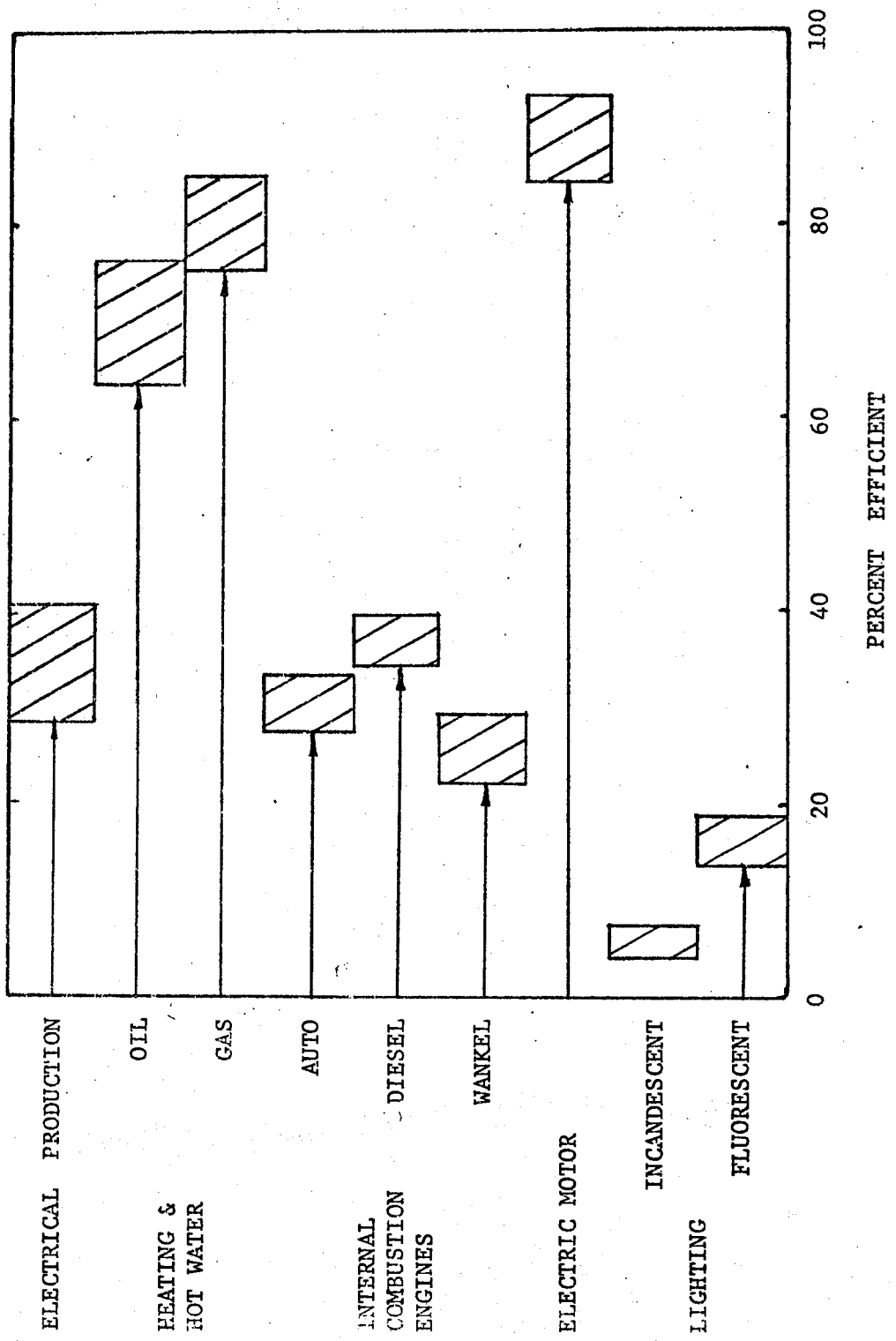


Figure 5. Breakdown of Transportation Energy (4)

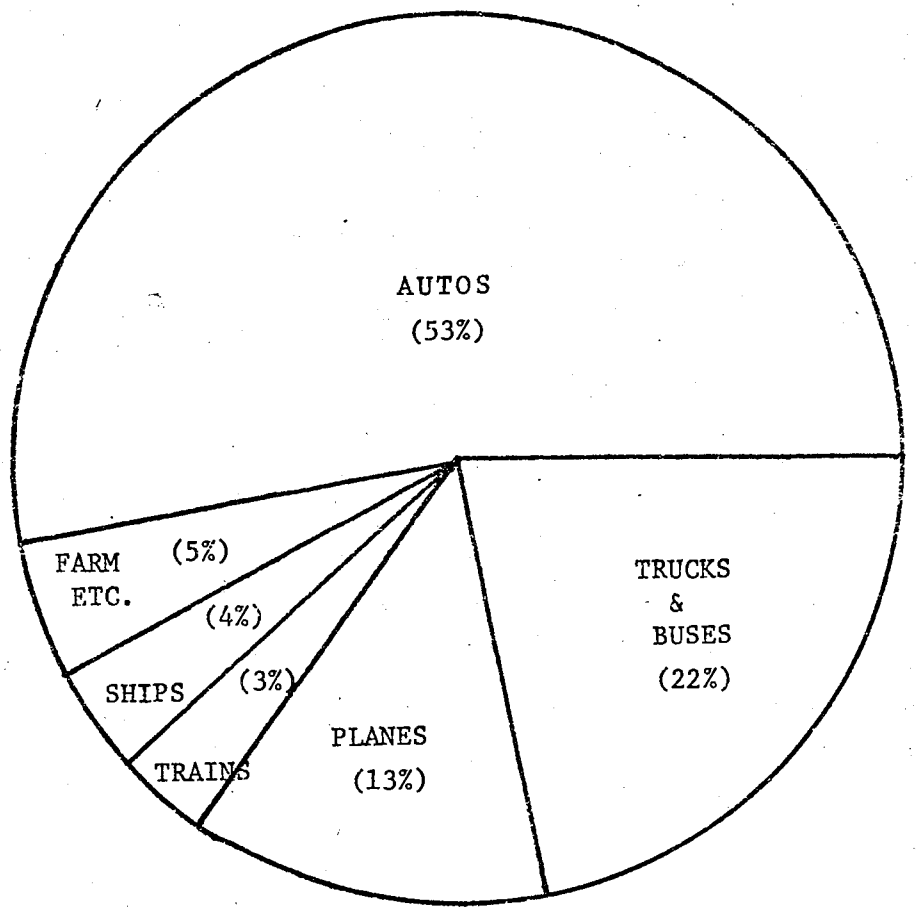
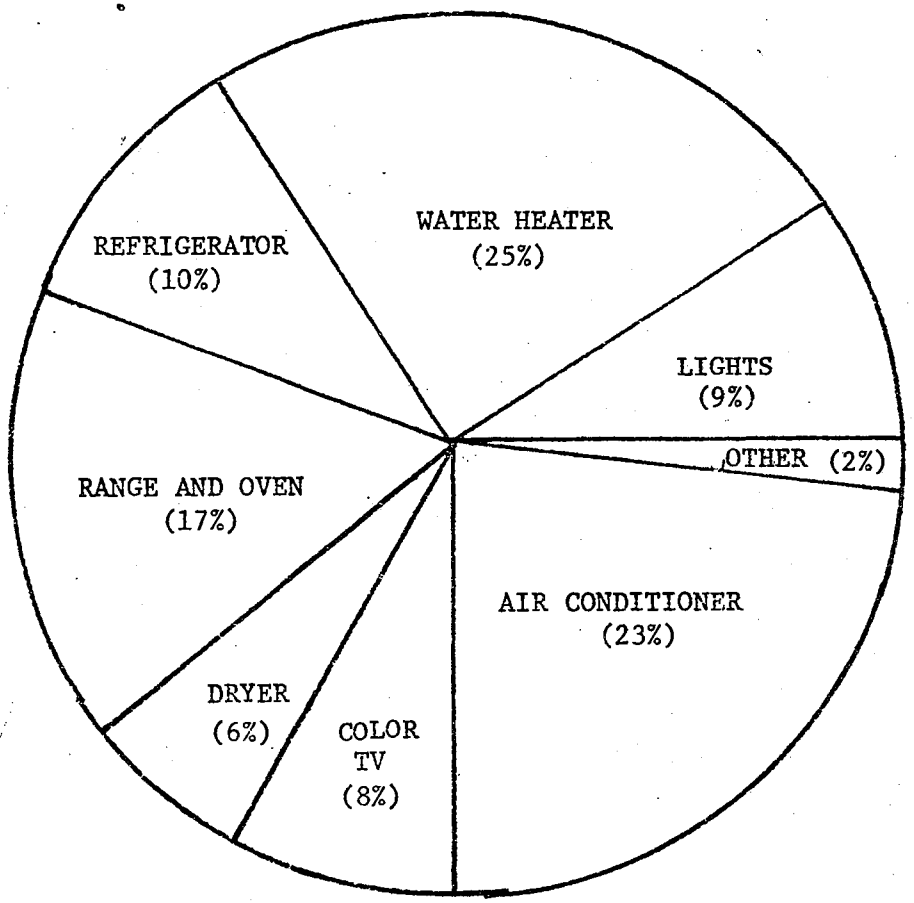


Figure 6. Residential Electrical Use (Summer) (5, 6)



Can Industry And Commerce Save Without High Cost?

The diverse nature of industry and commerce makes it difficult to obtain a meaningful breakdown of energy usage. Based upon the author's first-hand knowledge, there is considerable energy waste in industry. At present production levels, a 10% reduction in energy consumption would be quite reasonable. To obtain 15-20% savings, capitol investment would be required. In most commercial and office applications, 10% savings could be achieved by just adjusting light levels and thermostat settings. Capital expenditures for insulation, awnings, storm windows, etc. could save another 10%. These are very broad statements and intended only as an order of magnitude estimate. Each industry, office building, and store must be considered individually to maximize the savings available.

Will Technology Improve The Energy Supply?

The efficiency of present electric generating plants can not be significantly improved. Major improvements can only be made by applying advanced technology to develop new types of generating plants. The advanced systems outlined in Table 1 will generate electricity with even higher thermodynamic efficiencies and therefore produce less thermal pollution.

To demonstrate the relationship between efficiency and thermal pollution, compare a modern fossil fuel plant and a nuclear plant. Modern fossil fueled power plants reach efficiencies of 40% compared with 30% for nuclear plants. As a result, nuclear plants produce 55% more waste heat.*

In the near future, solar energy could be utilized extensively in new construction. Solar collectors on the roof of homes or office buildings could supply most winter heating and domestic hot water requirements. This is presently feasible and should be commercially available within the next two years. New air conditioning systems are being developed and will be available to operate, using the same solar collector. Implementation of these systems would reduce the demands on fossil fuels (and electricity). In addition these solar energy systems have no known deleterious effects on the environment.

Until the next generation of technology is available, we must use our present resources wisely and efficiently. Some general suggestions for improved utilization of energy are presented in Table 2. The fact that we waste huge amounts of energy makes it possible to realize immediate relief through economy measures. The rigorous application of technology to these wastes could result in reduction of 20% in our present consumption.

To realize these savings all of us will be required to sacrifice. Individuals will either have to use mass transit or car pooling for commuting; reduce pleasure driving, accept lower indoor temperatures in winter, and higher temperatures in summer. The long-term offers a more positive picture. Less waste and more efficient utilization means fewer environmental problems. Hence, the energy crisis re-emphasizes that the earth and its resources are finite and must be used accordingly.

* Explanation:

Plant 40% efficient -

1 BTU useful work--- 2.5 BTU primary energy; hence 1.5 BTU waste heat

Plant 30% efficient -

1 BTU useful work---3.33 BTU primary energy; hence 2.33 BTU waste heat

$$2.33/1.5 = 1.555$$

Therefore a 10% decrease is efficiency results in 55% increase of thermal pollution.

Table 1. Energy Sources for the Future.

Nuclear Fast Breeder Reactor -

- Enriches more fuel than is used
- 40 times the energy can be extracted from the fuel than with present nuclear reactors
- 1 lb. uranium has the same energy as 4,000,000 lbs coal (or 450,000 gallons of gasoline)
- 35-40% efficient

Solar Energy -

- 80% of winter heating for private homes in this latitude possible with present technology.
- Solar air conditioning will be available within 2 years
- Solar radiation falling on 0.5% of United States land area could supply all the energy needed in the year 2000
- Space satellites with an area equal to 0.05% of the United States land area could supply all the energy needed in the year 2000

Geothermal -

- Energy from the earth's molten core

MHD (Magnetohydrodynamics) -

- Burns conventional fuel (natural gas, oil, or coal)
- Produces electricity by passing hot ionized gases through a magnetic field. (In an electric generator a wire is passed through a magnetic field.)
- High combustion temperatures result in low levels of atmospheric pollution
- 55-60% efficient

Fusion (Energy of the Stars) -

- Fuel is heavy hydrogen (deuterium and tritium)
- In a volume of seawater 8 feet to a side there is 1 lb. of heavy hydrogen
- 1 lb. heavy hydrogen has the same energy as 9,500,000 lbs. coal or 1,100,000 gallons of gasoline
- 55-60% efficient

Table 2. Recommendations for Efficient Energy Utilization

1. New residential and commercial buildings:
   - A Effective insulation
   - B Windows and doors with low infiltration rates
   - C Efficient heating and air conditioning systems
   - D Reduction of air change requirements
   - E In-situ combustion systems for heating and hot water

2. Older residential and commercial buildings:
   - A Retrofit effective insulation
   - B Reduce infiltration (storm sashes and doors)
   - C Reduction of air change requirements

Table 2, continued

3. Industry:
   - A Recirculation, whenever health is not endangered, of filtered factory air
   - B Encourage the use of recycled materials
   - C Increases in energy allocations based upon efficient operation

4. Transportation:
   - A Public mass transit
   - B Efficient private transportation (smaller, lighter cars)
   - C Encourage transportation by most efficient mode
     1. From plane to bus or rail (short-intermediate distances)
     2. From truck to rail (intermediate-long distances)

5. Commerce:
   - A Efficient packaging
   - B Lower store light levels
   - C Reduced outdoor lighting

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