TECHNOLOGY, ENERGY, AND SOCIETY: A STUDY OF THE SOCIOLOGICAL IMPACT OF THERMONUCLEAR FUSION REACTORS

by

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CHAPTER I

INTRODUCTION

Throughout history, man constantly has had to adjust to his environment. When his life was endangered or uncomfortable, man has tried to find relief through social and technical innovations. An example of this is the invention of the hoe. Previous to its invention, man had been dependent upon hunting animals and gathering food from his environment. The invention of the hoe combined with a knowledge of planting enabled man to have a stable food supply and a permanent residence.

The purpose of this thesis is to investigate the relationship between technology and social change. Technical innovations both influence and are influenced by social change.[1] However, the writer will deal more specifically with how technology alters society through the process of social change.[2] In this investigation, the writer will focus on the kinds of social change which might be produced by one specific technological innovation, the possible innovation and diffusion of thermonuclear fusion reactors.

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[1]W. F. Ogburn, Social Change (New York: The Viking Press, 1928), pp. 114-17.

[2]Francis R. Allen, et al., Technology and Social Change (New York: Appleton-Century-Crofts, Inc., 1957), pp. 7-25.

This thesis is meant to serve as both a guideline and a stimulus for further investigation concerning the degree and type of social change which may be stimulated by fusion reactors.

Among the areas to be examined are population, the rural community, transportation, and manufacturing. A separate chapter is devoted to each of these. The concluding chapter will consider some of the consequences and implications which the development of fusion reactors might have for society.

Theoretical Framework

Before doing this, it is necessary to explore the general relationship between technology and social change. For a theoretical framework, technology refers to the sources of energy, the tools, and the knowledge connected with the use of both tools and sources of energy for the production of goods and services.[3] Thus, technology is the knowledge and use of inventions and of material culture as well as the application of science.[4]

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[3]Gideon Sjoberg, The Preindustrial City (New York: Free Press, 1960), pp. 7-8.

[4]William F. Ogburn, "Why the Family Is Changing," Perspectives On the Social Order, ed. by H. Laurence Ross (New York: McGraw-Hill Book Company, 1963), p. 301.

As previously mentioned, social change is often related to technology. When man is confronted with danger or discomfort, a technical solution is often sought and the need or desire for change stimulates innovation. When the hoe was invented, for example, man was able to settle in villages and raise the food he needed instead of relying on hunting and gathering techniques. The hoe was a necessary condition for settlement. This same principle which is involved in any technical innovation produces the ability to have social change. Whether or not the invention actually stimulates social change depends upon the adoption and diffusion of the invention.[5] To produce a social change, a large number of people have to adopt and use the innovation.

When studying the relationship between technology and social change, a major difficulty is the numerous indirect ways in which technology can influence social change. The hoe was an example of a direct influence on change. However, technology most often influences change through indirect channels. The relationship between the airplane and world politics is a good illustration. The airplane has a direct effect on war and, consequently, upon differential world power. This, in turn, influences world politics.[6]

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[5] Everett M. Rogers, Diffusion of Innovations (New York: Free Press of Glencoe, 1962), pp. 303-307.

[6] William F. Ogburn, and Meyer F. Nimkoff, Sociology (Boston: Houghton Mifflin Company, 1964), p. 702.

William F. Ogburn, who has described the impact which technology has on social change, called this type of indirect influence "the derivative effect."[7]

Other major processes include discovery, invention, adoption, diffusion, convergence, and dispersion. Discovery is the perception of relations between elements not previously recognized or understood.[8] This discovery may be found accidently or it may be a result of planning. An example of a planned discovery would be Einstein's formulation of the relationship $E = mc^2$. Invention differs from discovery because it is a combination of known elements or devices into some new form.[9] An example of an invention is the automobile. It is a combination of the internal combustion engine and the buggy. Diffusion is the process by which a new idea or invention spreads through a society.[10] Diffusion depends upon human interaction in which one person communicates a new idea to another person. Adoption is the mental process through

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[7] Ibid.

[8] Raymond W. Mack and Kimball Young, Sociology and Social Life (New York: American Book Company, 1968), pp. 436-437.

[9] Ibid.

[10] Everett M. Rogers, Diffusion of Innovations (New York: The Free Press, 1962), p. 13.

which an individual decides to make full use of an innovation.[11] Convergence refers to the process by which several innovations combine to produce a single social change.[12] One classical example of this process is the liberation of the American women from the home. This is at least partly due to the manufacturing of canned and frozen goods, the invention of the automobile, the invention of the refrigerator, freezer, automatic range, typewriter, telephone, and numerous other items which have freed the housewife from time consuming tasks and/or provided her with job opportunities. Another process known as the dispersion of inventions refers to the ability of one invention to affect many institutions and members of society.[13] Television is a good example. It is used in entertainment, education, and business.

Actually, the various methods by which technological innovations can affect man often combine to produce social change. This makes a difficult relationship even more complex to analyze. In many instances it is almost impossible to isolate a single technical invention and show that it is solely responsible for creating a given change.

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[11] Ibid., p. 17.

[12] W. F. Ogburn and Meyer F. Nimkoff, Sociology (Boston: Houghton Mifflin Company, 1964), p. 703.

[13] Ibid., p. 698.

However, some of the more important technological innovations and the social changes which they stimulated will be noted in each chapter.

In order to determine what alternate routes a particular innovation might take, it is necessary to examine history in order to determine which areas of society have most often been affected by technology. The basic areas modified significantly by technological change seem to be agriculture, transportation, manufacturing, and population.[14] In each of these areas, problems related to energy sources still exist today. Each of the following chapters will be devoted to an investigation of fundamental problems in each of these areas to determine if cheap abundant energy, particularly fusion energy, possesses the capacity to alleviate or reduce the severity of the problems.

Fusion Reactors: A Research Note

Today, a great deal of scientific effort is being devoted to the development of a new energy source, called thermonuclear fusion reactors which has the potential for a revolutionary impact upon society.[15] This reactor would

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[14] Sjoberg, pp. 27-31; 80-107; 196-214.

[15] For a detailed discussion of fusion energy see Wm. C. Gough and Bernard J. Eastlund, "Prospects of Fusion Power," Man and the Ecosphere (San Francisco: W. H. Freeman and Company, 1971), pp. 252-266.

develop its power from the fusion of ions very similar to the reaction which occurs in the sun. Fusion energy is not new since the first hydrogen bomb utilized the principle of the fusion reaction. Scientists now feel that this reaction can be slowed down sufficiently so that its power can be used to heat water to drive conventional steam turbines and generate electricity. Depending on the level of effort and the difficulties ahead, a prototype of the fusion reactor could come into operation within a period of ten to fifty years.[16]

This reactor could produce an extremely large volume of energy. Furthermore, it has several advantages over present power sources. The cost of the energy produced by fusion could be relatively low. In addition the reactor would be free from radiological hazards and atomic explosions. Although the reactor uses radioactive material, it does not produce any additional dangerous products. The fusion reactors cannot cause an atomic explosion because they do not contain a critical mass of explosive material as do the atomic fission reactors which are already in use.[17] Fission reactors utilize some radioactive fuel such

[16] Ibid., p. 266.

[17] Gough and Eastlund, Prospects of Fusion Power, p. 264.

as uranium. These reactors get their energy as a result of the fission of uranium isotopes into more stable atoms. This reaction occurs constantly in nature but the energy released is spread over the entire earth. In the fission reactor, enough of the radioactive fuel is brought together that a critical mass is formed. The critical mass is a concentrated amount of fuel which is capable of substaining the fission reaction until an atomic explosion is possible. The fusion reactor utilizes a different principle.[18] The fuel consists of elements such as hydrogen isotopes which can fuse into more stable atoms. This fusion reaction releases heat which can be used to generate electricity. Thus, this is a process in which no critical mass is present and no radioactive products are released.[19] In addition, the fusion reactors would not pollute the environment as do the fossil burning power plants currently in operation.[20] Another undesirable effect of nuclear fission reactors and fossil burning power plants is the thermal pollution of lakes and rivers. However, knowledgeable scientists have reason to believe that fusion reactors

[18] Ibid., p. 356.

[19] Wm. C. Gough, "Why Fusion?" Proceedings of the Symposium on Thermonuclear Fusion Reactor Design (Lubbock, Texas: Texas Tech University, June 2-5, 1970).

[20] Gough and Eastlund, Prospects of Fusion Power, p. 263.

will utilize more of the heat produced i.e., be more efficient, and thus produce less thermal pollution.[21]

Another advantage of fusion reactors can be seen in the fusion torch concept.[22] The fusion torch would use the high temperatures of the gases released from the reactor to convert waste material back into its basic elements in such a fashion that the elements could be reused. A new method of producing electricity directly from high temperature plasmas produced in the reactor might also be available.[23] This process would eliminate the conventional principle in which steam is used to drive turbine generators. In light of present pollution and energy shortages, eventual development of fusion power seems essential.

In addition to the previously mentioned advantages, the fusion reactor uses a fuel which is very inexpensive and plentiful. Scientists estimate that sea water, which contains the primary source for fuel, can supply more than 8 billion times the amount of energy required for the

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[21] Gough, p. 301.

[22] U.S. Atomic Energy Commission; The Fusion Torch: Closing the Cycle From Use to Reuse, by W. C. Gough and Bernard J. Eastlund (Washington, D.C.: Government Printing Office, May 15, 1969).

[23] A. S. Roberts, Jr., "On the Concept of Pulsed Thermonuclear MHD Energy Conversion," Proceedings of the Symposium on Thermonuclear Fusion Reactor Design (Lubbock, Texas: Texas Tech University, June 2-5, 1970).

world in the year 2000.[24] Another possible advantage of fusion reactors is that they may be very efficient, i.e. capable of utilizing a high percentage of the heat produced in the reaction. If this proves to be the case, great flexibility can be exercised when locating the facility. If very little unused heat is released at the facility, it will not be necessary to place the plant on a large body of water which can be used to cool the reactor. In fact, because of the expected greater efficiency and the freedom from nuclear explosion it could possibly be located right in the center of cities.[25] The wasted heat could be used to heat buildings or in the distillation of sewage.[26]

As previously stated, the reactor itself produces no weapons grade material, but there is some which is recycled in the reactor itself. Yet, as the reactor itself would have to be modified before this material could be used, there would be little motivation to steal the materials to make atomic weapons. Security would not be endangered and plants could be located in underdeveloped countries to aid in their development.

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[24] Gough and Eastlund, p. 4.

[25] Gough, p. 301.

[26] Ibid.

However, there are also problems in the development of fusion energy.[27] Many of the problems are purely technological or economic, and can be overcome if the U.S. would devote more manpower and money to developing the reactor.[28] One of the major disadvantages of fusion reactors is the high capital cost of building such a facility. The capital expense might be so high that it would be economically infeasible for many private companies to construct them. According to most estimates, fusion reactors will operate most efficiently when they are very large.[29] However, a new method has recently been proposed which might provide the means by which cities with as little as 100,000 population could construct and operate a plant efficiently.[30] Another disadvantage of the fusion reactor is that great caution must be exercised when supplying power for industries in which a power failure would be disastrous or extremely costly. This problem, however, is not limited to fusion reactors alone as was demonstrated by the power failure which paralyzed the East Coast in November 9, 1965.[31]

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[27] Gough, p. 313.

[28] Gough, pp. 317-22.

[29] Gough and Eastlund, Prospects of Fusion Power, p. 260.

[30] Kristiansen, Magne, personal communication, Texas Tech University, Lubbock, Texas, May 28, 1971.

[31] New York Times, November 10, 1965, pp. 1-3.

Transportation problems were particularly acute. Eight hundred thousand people were stranded in subways and many others were tied up in traffic jams and in airports.[32] The reason why care must be exercised in supplying transportation and certain industries with power from fusion reactors is because of the large magnitude of power produced. If the fusion reactor failed, the loss of a large amount of electricity could cause other power plants to fail. Therefore, surplus capacity would have to be built into all plants to take care of any emergency created by the failure of a large fusion plant. Perhaps the whole problem can be resolved by the development of better automated equipment to prevent the spread of blackouts.[33] Nevertheless, a power failure from a large fusion reactor as well as large fission reactors could be damaging.

At the present time, the fission reactor has an advantage over fusion simply because the fission reactors are further developed. Fairly efficient and satisfactory fission plants are already in operation and their performance is likely to improve in the future. However, fusion reactors will be possible only after many more years of research

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[32] Ibid., p. 2.

[33] U.S. World and News Reports, December 13, 1965, p. 98.

and development. By the time this is accomplished, atomic fission reactors will be highly sophisticated. Thus, it will add to the difficulty of adoption and diffusion of thermonuclear fusion reactors.

For purposes of this thesis, two assumptions will be made. The first and major assumption is that fusion reactors are technically and economically feasible. Secondly, we shall also assume that they are capable of producing a large volume of energy at relatively lost cost. Having made these assumptions, it is possible to proceed with the analysis of the sociological impact of fusion reactors.

CHAPTER II

POPULATION AND ENERGY

Introduction

Technological developments have had a tremendous impact on population. One of the most obvious changes has been the increase in the number of people. It is estimated that in 1650, there were only 470 million people in the world.[1] In 1969, the United Nations estimated the world population at 3,552 million and much of that growth occurred after 1930.[2] The population increase has been produced mainly by such technological advances as vaccination and innoculation against communicable diseases, the development of the sulfa drugs and antibiotics, and the control of diseases such as malaria through the use of DDT and other insecticides.[3] Many of the underdeveloped countries of the world have only recently started to experience the improvements in medical technology. Consequently, their death rates are being reduced rapidly, but their fertility

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[1]Walter F. Willcox, Studies in American Demography (Ithaca, New York: Cornell University Press, 1940), p. 45.

[2]United Nations, Demographic Yearbook (New York: United Nations, 1969), p. 115.

[3]Warren S. Thompson and David Lewis, Population Problems (New York: McGraw-Hill, 1965), p. 433.

rates are still high. These countries are going through a stage of development often called demographic transition.[4]

Population has changed not only in numbers but in age composition. For example, the median age of the United States in 1960 was about 30 compared to 17 in 1820.[5] The population of the United States has grown older over the last several centuries, with the short term exception of the decade following World War II when fertility was so high.[6]

The primary goal of this chapter is to examine the possible effects which fusion power could have on population change. To make such an analysis, each component of population needs to be examined. The most basic variables affecting population growth are migration, mortality, and fertility, but there are numerous other factors which affect each of these variables.

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[4]William Petersen, Population (New York: Macmillan Company, 1961), pp. 12ff.

[5]United States Department of Commerce, Bureau of the Census, United States Census of Population: 1960, Vol. I, Characteristics of the Population, pt. 1, United States Summary, pp. 1-173.

[6]Ralph Thomlinson, Population Dynamics (New York: Random House, 1965), pp. 436-7.

Demographic Variables

Migration

Migration is the permanent movement of persons over a significant distance.[7] The dominant variable contributing to migration has probably been economic differences between communities.[8] If an area has better economic opportunities, it is likely to attract people. There are, however, non-economic motives which also affect migration. These include such things as political pressures, a desire for a new environment, religious preferences, and family considerations.[9] In the United States, the economic motive and family considerations are probably the most important factors affecting people's decisions to migrate or not.

It appears that fusion reactors would have the greatest impact on the economic motive for migrating. If a cheap new power source becomes available, there could well be a relocation of some industries and the establishment of others. It is important that certain industries, such as steel mills, locate themselves as near as possible to a major source of energy. By doing this they can acquire cheaper power and reduce their production costs. It

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[7] Petersen, p. 51.

[8] Thompson, 1953, p. 309.

[9] Thompson and Lewis, p. 479ff.

normally is expensive to transport large amounts of energy over great distances. This is why steel mills are usually located near large coal deposits. If industries were free to locate independently of power sources, they might move to areas which supply their raw materials or to areas that would buy their products, or where labor is cheap. In addition to the relocation of some industries, there would probably be some development of new industries in the vicinity of the new power plants. If new industries were built in these areas, they would require manpower, which might be available locally, or might have to be imported from other areas. In the latter case, the migration of workers could produce drastic population shifts. If the industries are merely relocating rather than establishing new branches, original employees might also be part of this migration.

The present pattern of migration is to move away from rural areas and cities of less than 50,000 people. Fusion reactors can be an important variable in determining future migration. It is very possible that the construction of a fusion reactor will encourage a migration to the area in which it is located. Therefore, if fusion reactors could be built in rural areas and be easily dispersed, as via REA, industries would develop around them, thus encouraging a migration back to rural areas and small towns. A discussion of this reverse migration and the conditions favorable for it is included in chapter three. Since the establishment of a fusion reactor will encourage migration into an area, locating fusion reactors in urban areas would strengthen the present pattern of migration. If fusion reactors replace the current sources of urban power, the new industries as well as the ones already established will be located in large metropolitan areas. Thus, the pattern of migration which involves movement away from the rural areas and into the large metropolitan areas would continue.

The amount and the direction of any migration produced by fusion depends mostly upon whether or not the fusion reactor is efficient. In particular, the reactor is not "efficient" if it produces more heat than can be utilized in the generation of electricity. Then large quantities of water would be required to keep the reactor cooled. Consequently, there would be a limited number of acceptable sites upon which the reactor could be constructed. In this event, migration to areas on rivers and oceans might be necessary. However, if the reactor is efficient enough that it does not have to be located near watèr, then freedom of choice can be exercised in selecting its location. In the event that fusion reactors are inefficient, a second limitation is placed on the selection of locations for the reactor. This is that the heat released may be unbearable for an urban population. In this case, the reactor would have to be located some distance from any major cluster of population. Under these conditions very little migration would be expected.

The two other variables which influence migration are the desire for a new environment and family considerations. The first of these, a desire for a new environment, involves the type of migration which occurs when a site is selected because of its climatic or geographic location. An example is the migration of retired people into the warm regions of Florida and Arizona. Another example is the desire to move to the mountainous states of Colorado, Oregon, and Washington. Large numbers of these people are primarily interested in a change in scenery and recreational opportunities. The possible effects which future technology and particularly fusion reactors could have on this type of migration remains unknown. Perhaps urban communities will prove more environmentally acceptable if fusion reactors reduce smog and air pollution. Presently, people are escaping from the urban environment and into parks and recreational areas, as demonstrated by the growth of the camper industry. If fusion reactors were located in these states and they were accompanied by industrial development, people seeking wide open spaces might be less motivated to migrate into them. For all practical purposes, however, it seems that advancing technology per se will not have a significant effect on the type of migration which is stimulated by a desire for recreational opportunities or climatic changes.

Another type of migration is that which results from a desire to have better facilities for the family. For example, one might move so that his children can have a better education or more room. Again, fusion reactors will probably have little direct influence on these personal motives.

Mortality

The second major component of population change is mortality. The variables which determine rates of mortality are medical technology, its availability to all members of the society, the availability of food, the development of sanitary procedures, the degree of safety present in the occupations of the labor force, and the control of pollution and health hazards.[10] In this analysis, we are primarily interested in those variables which affect population growth.

There are two ways in which reduced mortality rates can result in population growth. One way is to reduce the

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[10]Thompson and Lewis, p. 334ff and Petersen, p. 248ff.

death rate of infants or people who have not completed their reproductive period. Drastic drops in infant mortality have occurred since 1900.[11] The infant mortality rate dropped from 152 per 1,000 live births in 1898-1902 to 23 per 1,000 in 1956-1960 for the countries of England and Wales.[12] If more people survive through their reproductive period, more children will be born who then marry and have children of their own. This is similar to the economic concept of compound interest. At the end of the month, the interest which has been earned becomes part of the principal thereby drawing interest itself during the next month. The extra children who survive are like the interest which then breeds more interest. Therefore, the factors which enable a baby to live through his reproductive period contribute significantly to population growth. There is also a second way in which reduced mortality results in population growth. By bringing the factors which cause high mortality under control, people live longer. As people survive longer, the elderly part of the population increases thereby, contributing to total population growth. Since the infant mortality rates have already been reduced to less than 30 per 1,000 live births for most industrialized

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[11]Thompson and Lewis, p. 357.

[12]<u>Ibid</u>.

countries, the future drop will be much smaller. In the United States, Warren Thompson thinks the infant mortality rate will drop about 8 to 10 points from the 1960 level of 26 per 1,000 live births.[13] He says that 50 to 60 per cent of all infant deaths are due to causes which are not yet controllable, such as asphyxia, birth defects, and injuries. Therefore, most of the reduction in the infant mortality rate will come from the reduction of infant deaths in the non-white population.[14] The present infant mortality rates could drop even further if medical care is extended to lower class families, particularly during the prenatal period and for a period of time after birth. Since the first year after birth is the most critical, a significant number of people could be added to the reproductively active population. For the underdeveloped countries, a reduction of the infant death rate is to be expected. Thus many of these countries will experience a very rapid population growth.

The role of fusion energy in helping to reduce mortality rates is unclear. Any assumption concerning the future development of medical technology would be purely speculative, but the particular effects of fusion appear especially remote. If a medical breakthrough did occur,

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[13]Thompson and Lewis, p. 357.

[14]<u>Ibid</u>.

it is not logical to assume the change would be due to fusion reactors.

Another variable affecting human mortality is the available food supply and its distribution. Presently, it is estimated that between 16 and 32 per cent of the total number of deaths occurring throughout the world are a result of starvation or malnutrition.[15] If the food supply is inadequate or if it is not properly distributed over the entire world, then a significant number of people die because of weakened physical strength and lack of endurance, particularly during periods of illness.[16] Today two-thirds of the world population is ill-nourished.[17] If these people were properly fed, then there would be more people surviving through their reproductive period. When more people survive through the reproductive period, there are more people who become parents and population growth results. This is very evident in many of the underdeveloped countries in South America, Africa, and Southeast Asia. The countries such as Kenya, India, and Mexico who are in a stage of

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[15]Paul R. Ehrlich and Anne H. Ehrlich, Population, Resources, Environment (San Francisco: W. H. Freeman and Company, 1970), p. 72.

[16]Thompson and Lewis, p. 388.

[17]Charlton Ogburn, Jr., "Population and Resources: The Coming Collision," Population Bulletin, XXVI (June, 1970), p. 9.

demographic transition, whereby they recently have experienced a rapid decrease in the mortality rate but they still have high fertility. Consequently, they are having a population explosion. Therefore, if an adequate diet were available to the entire world, a decrease in fertility rates would be necessary to prevent a dangerous population growth. Distribution of food is therefore an important variable affecting rates of mortality.

The bulk of the world's food supplies is presently concentrated in Western Europe and North America.[18] By Western standards, many of the underdeveloped countries of Asia, Africa, and South America have inadequate calorie, protein, and vitamin intakes.[19] The gap in food consumption between the Western World and the underdeveloped countries has grown larger in the recent years.[20] Therefore, the distribution of food as well as the available food supply is a severe problem. It is estimated that if all the tillable land in the world could, with the aid of irrigation and fertilizers, produce yields which are comparable to

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[18] Charlton Ogburn, Jr., pp. 10, 11.

[19] Joseph Fisher and Neal Potter, "Natural Resource Adequacy for the United States and the World," The Population Dilemma, ed. by Philip Hauser (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1969), pp. 116-7.

[20] Ogburn, Jr., p. 1ff.

those attained in the European countries, the food produced would feed only about 3.7 billion people at United States consumption levels.[21] Thus it is unlikely that we can have a large increase in world population and a significant rise in the standard of living within undeveloped countries as well as industrialized countries. The standard of living cannot rise for all countries with continued population growth.[22]

The role of fusion power in the production of food could be very important. One of the major uses of fusion power could be the desalination of sea water. If fusion reactors produced water for irrigation, additional land would be tillable at higher yields. The increased supply of food could be used to feed people in underdeveloped countries. If problems of distribution could then be overcome, the level of food consumption for the Third World would rise. Or if population continues to grow in these countries, increased food production would mean the same diet for a larger number of people.

Thus, fusion reactors could be used to stimulate the production of additional food. However, depending upon world fertility and distribution of the food, increased

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[21] Ibid., p. 8.

[22] Ibid., p. 9.

production could either improve the diet of people in the underdeveloped countries that have controlled fertility, or it could feed the increased population resulting from high fertility at their current standards. Therefore, if the world population is to experience a rise in the standard of living, the control of fertility is essential. A later section of this chapter will discuss the momentum of population growth and its implications in terms of the demand for resources.

Another factor affecting the food supply should be considered. In the United States, an abundance of food is being produced by highly mechanized agriculture powered by internal combustion engines. These internal combustion engines depend upon energy derived from petroleum. But the consumption of petroleum will probably peak shortly after the year 2000 and decrease after that.[23] When the shortage of hydrocarbon fuels arrives, another energy source will have to provide the power needed by agriculture. Although it would be quite expensive in today's terms, electrically powered agricultural machinery may of necessity someday be developed. If this happens, there would be a need for electrical power sources such as fusion reactors.

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[23] Harrison Brown, James Bonner, and John Weir, <u>The Next Hundred Years</u> (New York: Viking, 1957), p. 99.

Another variable affecting mortality is sanitation. In contrast to the 19th century, we now have relatively clean water and sewage systems which keep epidemics to a minimum. On the other hand, the pollution of our waters, air and land is growing at an alarming rate. Most of the pollution can be prevented, but society must be willing to pay the price. If the concept of the fusion torch becomes a reality, then fusion reactors might reconvert much of our waste into usable materials. But if the fusion torch is not feasible, these reactors can still reduce pollution.

When we look for a power source which is pollution free, fusion reactors may come closest to meeting the requirements. As previously noted, fusion reactors may create a problem in thermal pollution if they are not efficient. Contrary to fission reactors, the fusion reactors will produce only minute amounts of radioactive material over twenty years of operation. As mentioned before, another advantage of fusion reactors often noted is that they are free from the danger of nuclear explosion. Of course, this is an asset when one considers immediate injury, pollution, and health hazards. Fusion reactors also produce no weapons grade materials. There would therefore be less political resistance to locating the fusion reactors in foreign countries. Since these reactors produce no weapons grade material, they would also contribute nothing to an arms race. Consequently, it seems that fusion reactors could be used more easily to aid the economic growth of underdeveloped countries than could fossil fuels or fission reactors.

One other variable affecting mortality is the relative safety of occupational endeavors. Occupations in the U.S. which have previously been regarded as dangerous are decreasing in number. Many of these jobs are now being performed by machines or becoming obsolete. The trend today is toward greater automation and perhaps the trend may accelerate in the future. Although automation is not being limited by the lack of energy, industries using electrical energy are most easily automated. In all probability, automation will reduce the death rate in most industries. However, any reduction in occupational death rates will be small and have only a minimal effect on population growth.

The trend toward automation may be reinforced through the introduction of either fission or fusion reactors. In both cases, the primary power output will probably be electricity which is more easily utilized in automation than any other type of power. Therefore, reactors and automation may be complementary forces in changing the labor forces.

Fertility

The third major factor affecting population growth is fertility. Not only is fertility the most complex demographic variable, but it is also the most important variable affecting population growth in the U.S. Some of the most commonly agreed upon causes for differencies in fertility are age at marriage, knowledge of contraceptive techniques, the stress of competition and social status, the place of children in life goals, childlessness, a decline in the death rate, and different patterns of sexual behavior.[24]

Fusion reactors will probably have little direct effect on fertility. But the reactors may influence fertility indirectly through encouraging economic growth. Cheap and clean energy could be a stimulus to economic growth, particularly if energy is in short supply. So reactors, whether they are fusion or fission, might have some influence on fertility indirectly through economic channels.

If the present trend toward automation continues, there will probably be increased leisure time. Whether this increased leisure time will affect patterns of sexual behavior or the place of children in the life goals of couples is an important issue. Increased leisure time and money could

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[24] Thompson and Lewis, pp. 272-333.

act as a stimulus to have additional children because the couple could afford it financially, and they would have sufficient time to devote to the children. So fertility rates could go up with increased leisure time, but they could also go down. This is because increased leisure time may cause people to view children as a liability. For example, the couples may view children as a burden which restricts travel and the pursuit of other essentially personal goals, and consequently may decide to restrict family size.

Thus, the proper conclusion would appear to be that it is impossible to form definite conclusions concerning fertility and fusion reactors. The causes of changes in fertility are difficult to measure and impossible to predict. Fertility rates vary with economic and social conditions. While fusion reactors might have some influence on these, the diffusion of nuclear reactors would be only one of many variables affecting fertility.

Population and the Demand for Energy

It is often desirable to have some knowledge concerning future population growth in order to make administrative decisions about the present. Now that the variables which determine population growth have been discussed, it is possible to make some predictions about future population growth. First of all, it is meaningful to distinguish between population forecasts and population projections. A forecast is a prediction of a population which uses independent social and/or economic variables as the basis for extrapolation.[25] However, population projections are estimates of population growth based upon past trends and they do not include social and economic variables.[26] Projections are extensions of present trends combined with some assumptions regarding birth rates, death rates and immigration. Projections are therefore useful in determining agricultural, industrial, and transportation needs. The writer will attempt to stay in the ream of projections and leave out predictions concerning possible changes in social and economic conditions.

The method used by the U.S. Bureau of the Census makes four projections each of which varies on different assumptions about fertility rates.[27] Rates of mortality and migration are held constant. In general, each of these projections assumes that the number of children per woman will remain constant with successive cohorts and that the

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[25] Petersen, p. 298.

[26] *Ibid.*

[27] U.S. Department of Commerce, Bureau of the Census, *Population Estimates and Projections* (Washington, D.C.: Government Printing Office, August 6, 1970), p. 1.

age distribution of women having children will remain constant. Hence, the projections differ only in assumptions of completed fertility rates and the median ages of the mothers.

Since the original projections were published in 1966, the Bureau has found it necessary to drop series A which assumed the highest fertility and add a new series E which assumed lower fertility rates than any of the other series. The cohort fertility rates per 1000 women and the median ages used by the U.S. Census Bureau in its calculations are shown in Table 1.

TABLE 1

FERTILITY ASSUMPTIONS USED BY U.S. BUREAU OF THE CENSUS[a]

Completed Fertility Rate		Median Age of Mother
Series A	3350	25.3
Series B	3100	25.8
Series C	2775	26.4
Series D	2450	27.2
Series E	2110	27.2

[a]U.S. Department of Commerce, Bureau of the Census, Population Estimates and Projections (Washington, D.C.: Government Printing Office, August 6, 1970), p. 1.

The age specific birth rates are listed in Table 10 of the Appendix. Based on recent trends, an assumption of 400,000 net immigrants per year is made for all four series. The resulting population for each series is shown in Table 11 and Figure 9 of the Appendix.

Another method of population projection is based upon the expected family size of future mothers. Two of these studies, Growth of American Families I and II, are well known.[28] The initial study conducted in 1955 concerned the number of children expected by wives during the next five years. The second study indicated that the responses were accurate when compared with the total number of children who were actually born. A later study was made in 1967 by the Office of Economic Opportunity.[29] This study shows that the expected family size for white wives increases with an increase in age. This reveals a desire on the part of younger white wives to have smaller families. The study also revealed that expectations of additional children varies inversely with age of wife, years married, and socio-economic status. Studies such as these should give some indication of population trends in the near future. This type of study might be even more useful if unmarried men and women were included in the sample.

Another dimension of population growth which needs to be recognized is population momentum.[30] To understand

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[28] Maria Davidson, "Expectations of Additional Children by Race, Parity, and Selected Socio-economic Characteristics," Demography, VIII, No. 1, Feb., 1971, p. 27.

[29] Ibid., p. 28.

[30] Population Association of America, "On the Momentum of Population Growth," Demography, VIII, No. 1, Feb., 1971, p. 72.

population momentum, it is essential that one understands a few basic concepts. Replacement level fertility refers to the birth rates which will only replace the existing population. For every woman in a given cohort, each should have approximately two children, one to replace herself and one to replace her husband. This type of population would be stable. However, in 1960, an average of 2.63 children were born to each woman age 35-44 who was ever married.[31] Thus to have a stable population and replacement level fertility, the number of children to each set of parents should be about 2.38[32] to compensate for those who do not have many children or for those who are not fecund. Perhaps a better way to look at it is the number of children ever born to all women aged 35-44. In 1960, this figure was 2.47 compared to 2.0 children which would be needed to replace the existing population. Population momentum is, therefore, the population growth which will occur if fertility is reduced to replacement level. One might wonder how a population can grow if fertility is at replacement level. The growth is due to the age composition of the population. For example, the United States has 31 per cent of its

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[31] U.S. Department of Commerce, Census of Population: 1960, p. 212.

[32] Thompson and Lewis, p. 271.

population under 15 years of age.[33] These people will enter the reproductive period and have children before the number of people necessary to cancel population growth have died. Population momentum is, therefore, the product of a large percentage of the population which is young and has long life expectancies. Other countries such as Ceylon have approximately 40 per cent of their populations under age 15.[34] Therefore, they have a greater capacity to grow after fertility reaches replacement level.

The Population Association of America has derived a formula for estimating population momentum.[35] This equation gives the ratio of the ultimate population to the present population. This ratio is then an estimation of the population growth which could be expected after replacement level fertility has been reached. Several factors in the equation can only be estimated for populations in underdeveloped countries. However, the factors in the industrialized countries are known to be reliable.

Based on this formula, if replacement level fertility was achieved the ultimate population of the United States would be 1.25 times the 1966 population. This is assuming

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[33] *Ibid.*, p. 101.

[34] *Ibid.*, p. 109.

[35] Population Association of America, p. 75.

that fertility drops instantly to match death rates which is impossible because it is contradictory to our social values. Based upon 1967 figures the ratio had dropped to 1.18. For underdeveloped countries, the rates are in the neighborhood of 1.5. This means that for countries such as Mexico, Brazil, India, and Kenya, the ultimate population would be about 1.5 times greater than the present population.[36] However, no countries, and particularly not the underdeveloped countries, are likely to reduce their fertility to replacement level in the near future. And it is important to know that if the drop to replacement level fertility occurs after a 15 year period, the ultimate population will be about 2.5 to 3.0 times greater than the present population.[37]

This indicates how much greater population pressure will be even after replacement level fertility has been reached. In the event that people see a shortage in energy and cut back on their reproduction, the population will still continue to increase for many years and make demands on the country's resources.

More important than population size is the consumption level of that population. In 1968, North America and the

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[36] Ibid., p. 76.

[37] Ibid., p. 77.

European countries consumed 64 per cent of the energy consumed in the world.[38] Figure 1 shows the 1968 distribution of energy and steel for industrialized and underdeveloped countries. It is evident that the industrialized countries consume far more energy and steel per capita than the underdeveloped countries.

However, the underdeveloped countries are not likely to remain content with their standard of living. They are becoming aware of the standards of living in industrialized countries, and feel deprived of some of the observed pleasures and comforts of life. This realization of being deprived is often referred to as relative population pressure.[39] Figure 2 shows the per capita energy consumption and the standards of living. As the underdeveloped countries begin to demand a better standard of living, the consumption of materials and energy will rise rapidly.

Figure 2 shows that the United States consumes roughly 10 times more energy than do countries such as Mexico, Turkey, Brazil, Pakistan, and India. The industrialized countries also expect a rise in their per capita consumption of materials and energy. Therefore, if the

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[38]United Nations, Statistical Yearbook: 1969 (New York: United Nations Publishing Service, 1969), pp. 40-43.

[39]Thompson and Lewis, p. 502.

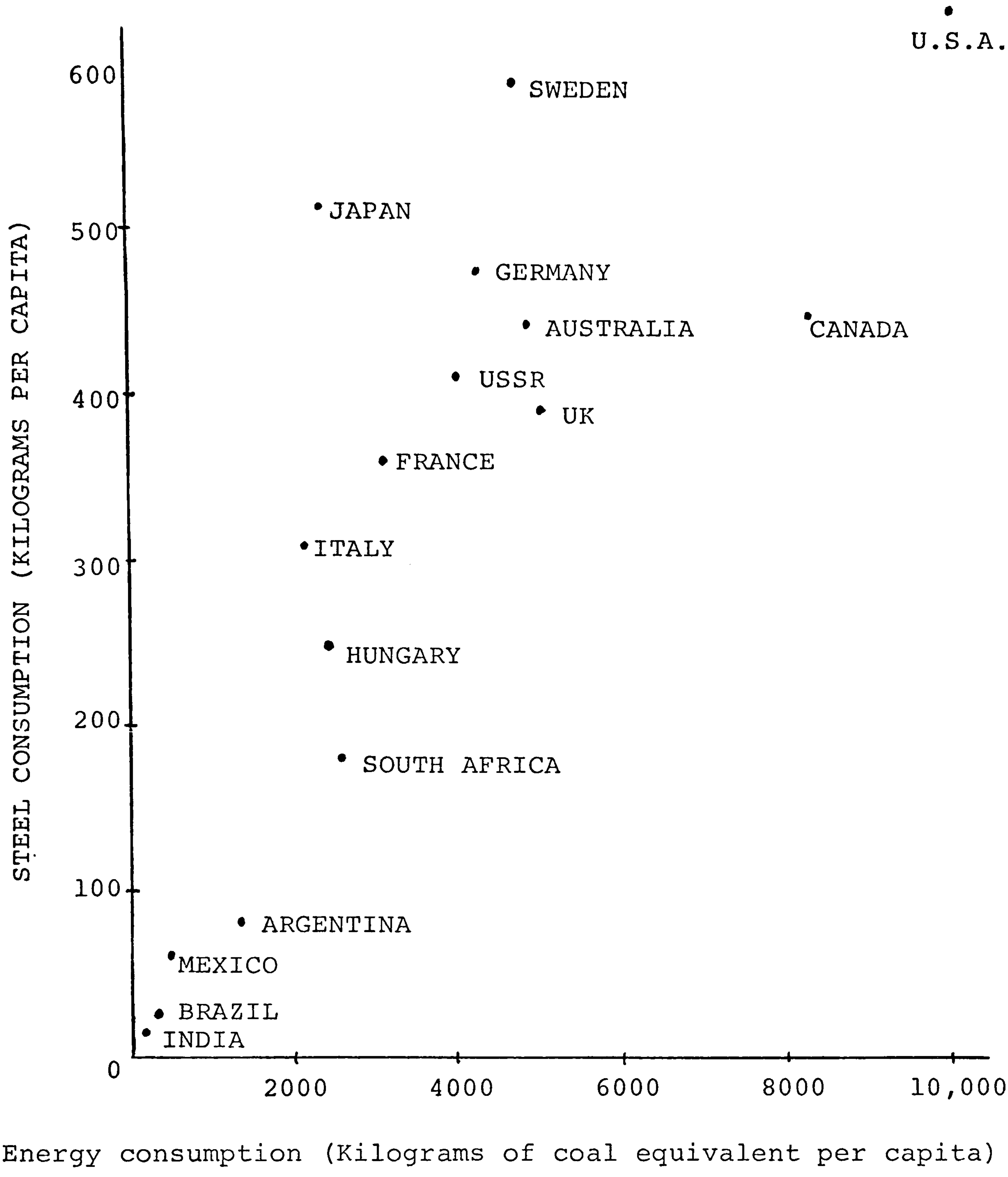

Fig. 1.--Energy and materials

Source: William C. Gough, "Why Fusion?" Proceedings of the Symposium on Thermonuclear Fusion Reactor Design (Lubbock, Texas: Texas Tech University, June 2-5, 1970), p. 260.

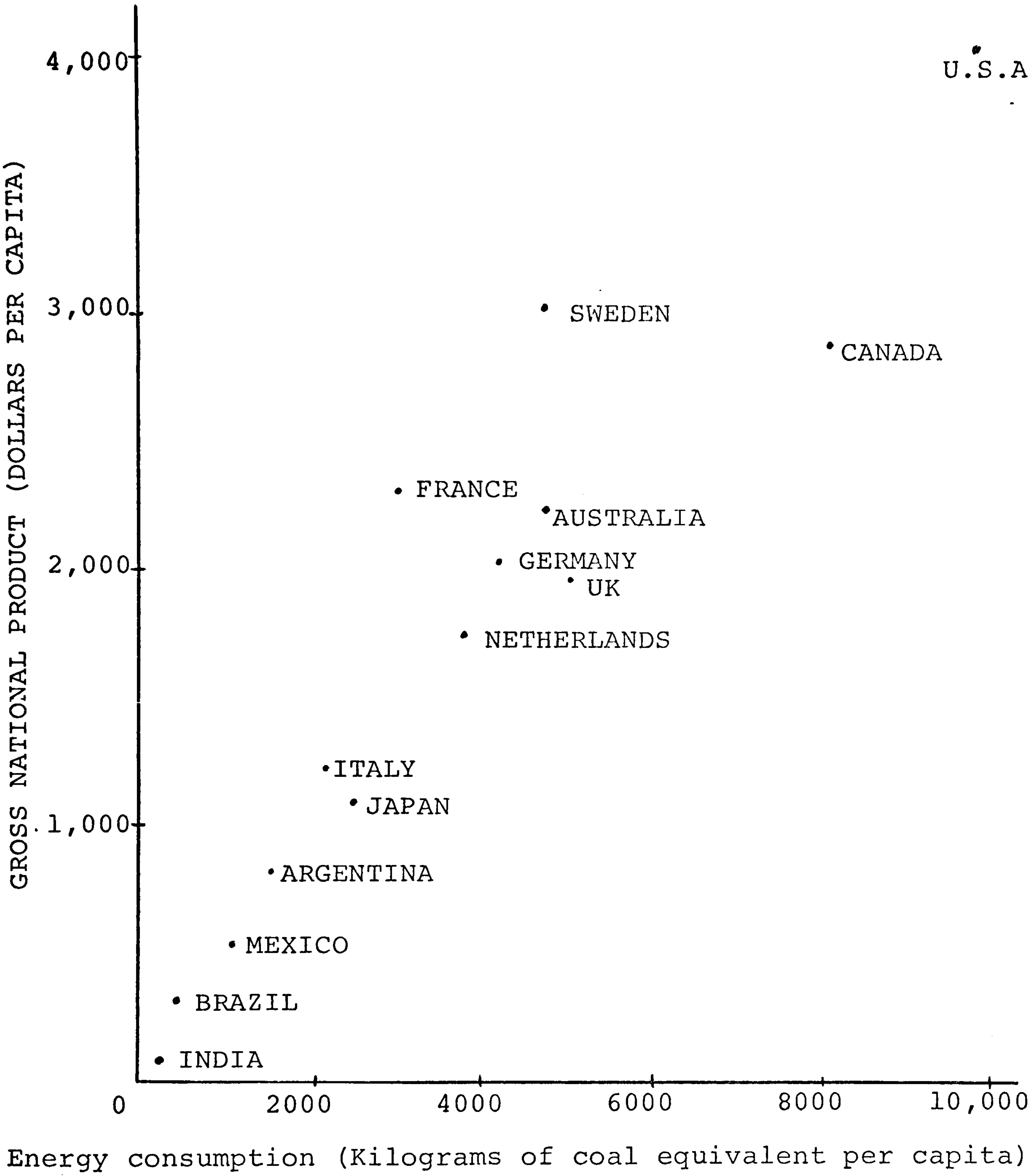

Fig. 2.--Energy and standards of living

Source: William C. Gough, "Why Fusion?" Proceedings of the Symposium on Thermonuclear Fusion Reactor Design (Lubbock, Texas: Texas Tech University, June 2-5, 1970), p. 259.

underdeveloped countries are going to have an increased standard of living, much more energy will have to be available. Yet, the United States and other industrialized countries are already net importers of many energy resources, particularly petroleum.[40] If the standard of living is to rise in the underdeveloped countries, resources must be recycled, and perhaps new sources of energy must be made available.

We have already seen how population will continue to grow even after replacement level fertility has been reached. The problem is compounded even further by the increased consumption of nations as they become industrialized. Thus, the combination of population growth and relative population pressure are certain to make large demands on the production of ever increasing amounts of clean energy such as nuclear fusion hopefully can provide.

[40]United Nations, Department of Economic and Social Affairs, Statistical Yearbook: 1969 (New York: United Nations Publishing Service, 1970), p. 325.

CHAPTER III

ENERGY AND THE RURAL COMMUNITY

Rural society and agriculture have been profoundly affected by technological change. Numerous problems have arisen in agriculture and many of them have been solved by technological means. One of the classic examples of how technology has influenced rural society is the domestication of grains.[1] Grain is a concentrated food that can be stored for long periods of time. The domestication of grains made possible a year-around food supply for urban populations which was required before cities could emerge. Later came the tractor made possible by the internal combustion engine and pneumatic tires. Consequently, large numbers of people were freed to migrate to the cities. Other mechanical innovations in agriculture have led to similar changes in rural communities. The purpose of this chapter is to describe the basic social conditions, trends, and problems of rural communities and to explore how the invention of fusion reactors might affect rural society.

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[1]Sjoberg, p. 29.

Migration Created by Mechanization of Agriculture and Industrialization

The mechanization of agriculture and the process of industrialization have created a large migration of the rural farm population into the urban manufacturing centers. This migration has played a predominant role in changing rural society. What, then, started this migration and why has it continued? Originally it was made possible by an increase in production per worker due to technological developments.[2] Equally important were the occupational opportunities which became available in urban areas. The labor surplus in rural areas moved to the rapidly industrializing urban areas. The technology which produced this initial increase in production centered mainly on innovations in land preparation and improvement.[3] This technology resulted in an increased production per worker while later developments in biological and chemical technology have increased the productivity of agricultural resources. Recent developments have emphasized harvesting,

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[2] Everett M. Rogers, Social Change in Rural Society (New York: Appleton-Century-Crofts Incorporated, 1960), p. 5ff.

[3] C. E. Bishop, "Implications of Community Resource Development for Agriculture," ed. by Luther T. Wallace, Daryl Hobbs, and Raymond D. Vlasin, Selected Perspectives for Community Resource Development (Raleigh, North Carolina: Agricultural Policy Institute, 1969), p. 10.

transportation, processing and related activities.[4] It is possible that fusion reactors will increase both production per worker and the productivity of agricultural resources, but this will be discussed later. According to C. E. Bishop, improvements in technology usually reduce the amount of capital needed to replace a unit of manpower or a unit of land at a given level of output. The cost of additional production is likely to decrease with improvements in technology.[5] Therefore, improvements in agricultural technology provide incentives to substitute capital for labor. Technical improvements are then diffused and adopted quickly. Job opportunities in the rural areas become few in number so people, and particularly the young, migrate to urban areas.[6]

The resulting migration greatly affects rural society. The first and probably most noticeable change is in the age composition of the population. Because of greater education and fewer job opportunities in the rural area, the younger people are more prone to migrate to the city. Consequently, there is a significant decrease in the percentage of the rural population which is economically active.

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[4] Ibid.

[5] Ibid., p. 12.

[6] Ibid., p. 45.

The ratio of persons not in the labor force to those in the labor force for 1960 is 1.79 for the rural farm population compared to 1.46 for the urban population.[7] The youth dependency ratio, i.e., the number of persons under 19 to the number of people 20-59, is 86.2 for the rural farm population as compared to 68.9 for the urban population.[8] In brief, the rural farm population contains a higher percentage of persons who are not in the labor force. This greatly affects taxation which is based upon those who are economically active. Therefore, workers are heavily taxed in order to provide even the present meager support for social institutions.[9]

Rural to urban migration is the result of increased mechanization of agriculture. Farmers have adopted newer technology which requires less labor. This new technology is often expensive, but it can be justified since the farmer can utilize large tracts of land. New technology has also increased the per acre yields for the farmer. As a result, the per capita production of farm goods has risen rapidly. This increase has led to an excess production and the prices which the farmer receives for his produce have

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[7]Thompson and Lewis, p. 160.

[8]*Ibid.*, p. 97.

[9]Rogers, *Social Change in Rural Society*, p. 212ff.

not risen as fast as the prices of other products. The farmer is therefore forced to farm larger acreage which the new technology has allowed him to do. Consequently, fewer farmers are needed so there is an excess of farm labor. The younger members of the labor market then leave the rural areas to seek employment in urban areas. This flow of young workers from the farm to the city has produced problems for both the rural community and the urban community. Some of these problems could possibly be reduced by the development of a new source of mass energy. For example, one of the factors contributing to slum conditions in urban areas has been the constant flow of unskilled rural-farm workers into the city. The urban areas have been unable to train and utilize these people whereas the rural areas have decreased in population and suffered from insufficient funds to operate their schools, governments, and churches. If the migration could be stopped or slowed, rural and urban problems might be reduced. However, this migration is encouraged by the lack of continued economic growth in rural areas. But a new source of energy might stimulate the growth of industry in rural communities. Presently, many people who stay in rural areas face unemployment, poor health, poor housing, and poor educational facilities. If fusion reactors could be located in rural areas, they might create jobs and encourage economic growth for the community.

Social Problems in the Rural Community

By encouraging economic growth, fusion energy could reduce the number of rural social problems. In order to understand the impact which fusion reactors could have on rural communities, it is essential to understand rural social problems.

The social problems faced by rural communities are not too different from those faced by urban communities. For example, both types of communities share problems in education, medical care, and unemployment. The causes of the problems are also similar. The cause of unemployment in both the rural and the urban communities is an excess of manpower above that which can presently be utilized and the changes in production technology which make skills obsolete. Housing problems in rural and urban communities are also comparable. Both types of communities have a shortage of low cost housing which the lower socioeconomic group can afford. As a result, old deteriorated buildings are used for dwellings and large numbers of individuals are forced to live in close quarters. One reason for poor educational and medical care in these communities is the lack of sufficient funds to operate the needed facilities.

The rural area and the urban slum both depend entirely upon people who are economically active and who have money beyond what is needed for minimal living expenses. Hospitals and schools both receive inadequate funds to meet the needs of the people they serve.

One problem, however, is unique to the rural community. This is the fading influence it can exert upon governmental policy. With more recent court decisions, a movement toward a one man, one vote concept has led to the reapportionment of congressional districts. As higher percentages of people live and work in the urban areas, the rural population has lost voting power. In addition, the rural population is poorly organized and cannot compete with pressure groups supported by labor or industry. Consequently, the rural areas are becoming less powerful in bringing rehabilitation programs, training programs, medical facilities and housing programs into their area.

Poverty is one of the major social problems found in rural communities. Associated with this poverty are all the problems of crime, education, housing, medical care, and unemployment. In 1966, rural America had 20.8 per cent of families living in poverty compared to 17.6 per cent of the urban families.[10] These rates were based upon the

[10]Council of Economic Advisors, "The Demography of Poverty," Poverty in Affluence, ed. by Robert E. Will and

Social Security Administration Poverty-income Standard. Of some 30 million people who live in poverty, nearly one-half of about 14 million live in the rural areas whereas only about 25 per cent of the total population of the United States lives in rural areas.[11]

The problems of minority groups are even more severe in the rural community. The difference between educational levels of the white and black is twice as great in rural areas as it is in urban areas.[12] Migratory workers, who number about one million, are exploited and have very poor living conditions. Rural slums are not unusual. Although they are not crowded or the basis of the spatial arrangement of houses, the rural slums are equally crowded on a person per room basis.

Rural health facilities are also very poor. While farming has the third highest accident rate of all occupations, health care in rural areas is below average.[13] An indication of the need for better medical care facilities found in rural areas is the high infant mortality rate.

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[10]Harold G. Vatter (New York: Harcourt, Brace and World, 1970), p. 53.

[11]President's Advisory Commission on Rural Poverty, "The People Left Behind," Poverty in Affluence, ed. by Robert E. Will and Harold G. Vatter (New York: Harcourt, Brace, and World, 1970), p. 69.

[12]Rogers, Social Change in Rural Society, p. 374.

[13]Ibid., p. 387.

The rural areas need good health facilities because of the high accident rate in farming, and the growing proportion of elderly people, yet, the rural areas usually have the older and less specialized doctors and an inadequate number of dentists and hospital facilities.

Rural communities also have their problems with institutions such as government and the schools. For example, many local governments fail to consolidate, yet their tax base is so small that they cannot support well trained individuals in the public services. The schools are in the same situation. Failure to consolidate means that funds are very limited and students are too few to merit offering the variety of courses needed.

Rogers explains that rural poverty in the South is a result of a lack of migration out of an area to find employment, the excess of labor in the low-income areas, small, inadequate farms, and a high proportion of the aged.[14]

Although many rural people are unable to find work, they hesitate to migrate to the urban areas. Sometimes they lack information on the types and locations of jobs that are available. At other times they are poorly trained for any type of urban employment. Thus it is evident that vocational training and job placement services are needed.

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[14] *Ibid.*, p. 378.

Efforts must be made to shift some of the rural population into non-farm activities.

The mechanization of agriculture decreased the number of people who can still earn a living from their farm.[15] In fact, the average gross income of agricultural labor in 1965 was only 35 per cent of that for those involved in manufacturing.[16] Mechanization and other developments in agricultural technology have created a need for larger farms. In 1965, it was estimated that between one and two million families were living on units too small to operate efficiently.[17] In addition, surplus production has complicated the situation even more.

In summary, social problems in rural areas are due to an excess of labor brought about by the mechanization of agriculture. This mechanization has created the need for rural people to learn a skill and migrate to the urban areas. If they do not, they are faced with increasing rural poverty. However, it is not intended that the reader view this migration of rural people into urban areas as totally

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[15] G. S. Tolley and B. N. Farmer, "Farm Labor Adjustments to Changing Technology," Farm Labor in the United States, ed. by C. E. Bishop (New York: Columbia University Press, 1967), pp. 41-52.

[16] Theodore W. Schultz, "National Employment, Skills, and Earning of Farm Labor," Farm Labor in the United States, ed. by C. E. Bishop (New York: Columbia University Press, 1967), p. 55.

beneficial. As previously noted, the influx of rural people into urban areas has been one of the main causes of urban poverty, slums, and unemployment. A better solution to rural problems in the U.S. is possible. With a basic knowledge of the rural community and its social problems, the writer will now turn his attention to the focal point of this chapter: What role can fusion energy take in solving problems in agriculture and the rural community?

Effect of Fusion Energy Upon the Rural Community

The innovation and diffusion of thermonuclear fusion energy per se will not solve the problems of the rural community. However, it is possible that fusion power might be utilized in a more comprehensive government initiated plan to solve these problems.

The role of fusion energy in solving rural problems could be twofold. First, the energy could be used in powering new industries which could be located in the rural areas. Secondly, the fusion power could desalinate sea water which would then be used for irrigation purposes. Ideally, a combination of the two should be used. If new industry were induced into the rural community, it could provide the necessary ingredients for reviving the rural area. This new industry could revive the rural community by providing jobs for those who are unemployed or underemployed. The personnel who operate the fusion reactor itself must be highly skilled. Therefore, the jobs for the rural community would have to be provided by the secondary industries which utilize the cheap energy produced by the fusion reactor. However, new industries must use the manpower available in the rural community. If the industries import their own labor, then no problems would be solved and the industrial complex would add a few problems itself. Industries can use the available manpower only if it is properly trained. Therefore, the government may have to provide the necessary training facilities and rehabilitation centers before the workers can be used in the industries. Nevertheless, industries might still have to import certain specialists which the rural community is unable to provide.

The industries that locate in the rural community should meet several requirements.[18] They should either be new ones that manufacture previously unknown products or represent an expansion of current industry. The industry cannot close down in the urban area and move to the rural area. Few if any problems would be solved if the

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[18]Raymond D. Vlasin, "Some Important Considerations in Regional Development," Selected Perspectives for Community Resource Development, ed. by Luther T. Wallace, Daryl Hobbs, and Raymond D. Vlasin (Raleigh, North Carolina: Agricultural Policy Institute, 1969), p. 28.

industries just relocated. Another requirement is that the industries must not have negative effects upon the environment. The fusion reactor itself seems to be ideal because it produces almost no pollution. Therefore, industries which located around the reactor would then have the benefit of clean and inexpensive power.

There are also several other factors which should be considered when proposing economic development. These include the stability of the economic venture over time, the income distribution effects of the venture, and the complementary, supplementary and competitive relationship between the new industry and other economic and social factors.[19] The long run stability of any economic venture is difficult to predict, yet the community certainly needs to avoid any industry which is only short ranged. It is desirable that the industries be free of pollutants, and that they manufacture articles which will be needed in the future as well as now.

Secondly, the income distribution of the economic venture must not be one sided. The higher socioeconomic groups should not be the only ones in the community to benefit from the construction of new industry. The rural workers currently receive low wages for their work, and

[19] Ibid.

consequently their standard of living is also low. If they are to improve their standard of living, a redistribution of income is essential. Therefore, the new industry should pay fair wages to the rural workers. The final factor proposed by Vlasin was the complementary, supplementary, and competitive relationships between the new industry and previously established business and social norms. The new industry should not undermine any industry already in existence. The new industry would ideally aid previously established industry. In addition, the industry would have to manufacture articles which were acceptable according to the social norms of the rural community. For example, a brewery could not be established in a community which advocated abstinence from alcoholic beverages. The new industries must be fitted to the location.

If new industry is brought into rural communities, it can have several desirable effects. The new industry could revitalize the community by doing basically four things. First, it could strengthen the tax base by providing the people with jobs so that they could share a greater proportion of the tax burden. Secondly, the industry itself can be taxed. Thirdly, new secondary industries could provide part-time employment for many persons underemployed or those who live on farms too small to operate. Finally, the new industry could provide jobs for some of the younger people who will be entering the labor force. In this way more of the economically active members of the population could be retained.

Some alternatives are also available to the rural community such as increasing the service sector of the labor force and employing more people in the creative or artistic occupations. However, these alternatives are usually present only in a community which has already started industrialization. Therefore, these occupations are primarily found in abundance only in industrialized urban centers.

In conclusion, a source of cheap energy that does not pollute the environment could be very important in stimulating the economic development of rural communities. The cheap energy provided by a source such as fusion reactors could attract secondary industries thereby providing jobs for the unemployed. With a tax base supported by industries and more economically active people, many rural social problems would be reduced.

CHAPTER IV

ENERGY AND TRANSPORTATION

The preceding chapters have investigated how technology and energy have affected social change, population, and the rural community. This chapter will focus on the changes which new energy sources could produce in transportation. The first section of this chapter is devoted to an investigation of how energy affected transportation in preindustrial cities. The effects of new energy on the city, as seen in the shift from preindustrial to industrial, are instructive. This knowledge will be beneficial in the later sections which are concerned with the impact of energy upon transportation in the industrial and post industrial societies.

Energy Uses in Preindustrial Cities

Technological development in the area of transportation has greatly contributed to the development of the urban community. The previous chapter demonstrated how developments in early agricultural technology enabled man to settle in small villages, then with additional innovations, particularly the domestication of grains, man could produce a surplus of staple products. As fewer men were required to grow the necessary food, large numbers of people were freed to engage in commercial activities. Thus preindustrial cities were formed.[1] The primary characteristic of the feudal or preindustrial city, according to Sjoberg, is in dependence upon animate sources of energy, i.e., energy provided by the muscles of men and animals, whereas, the modern or industrial city emerged when inanimate energy such as coal, petroleum, and ultimately nuclear energy came into use.[2] Indeed, one primary variable in the development of the urban industrial complex was the type of energy available and its application to transportation.

In the development of the urban community, the ability to transport heavy goods played an important limiting role.[3] The surplus of agricultural products which was produced by domestication of grain could not be transported great distances overland because there were serious limits on what could be carried on the backs of animals or in a cart. Even the loads carried in carts were small because of a lack of good harness and brakes.[4] River transportation was

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[1] For a detailed discussion of energy and urban development see Gideon Sjoberg, Preindustrial City (New York: Free Press, 1960).

[2] Sjoberg, pp. 10-12.

[3] For a detailed discussion of urban development and transportation see Harlan W. Gilmore, Transportation and the Growth of Cities (Glencoe: The Free Press, 1953).

[4] Gilmore, p. 4.

almost entirely downstream because the only methods of population were by oars and/or sails. Although wind is an inanimate source of energy, its use was very limited because sailing ships could not tack.[5] The development of inanimate energy was essential to shipping goods upstream. Ocean and sea transportation was also poorly developed. They, too, were limited to oars or sailing ships which could not tack. Navigational equipment and knowledge were also lacking.[6] Hence, ocean and sea transport ships had to follow the coast line in sight of land. Since these ships were unable to travel upstream, cities were formed at the mouths of rivers where an exchange of goods floated down the river could be made with goods brought in by the seagoing vessels. The mouths of rivers became primary focal points for the development of cities, and they would become even more important when ships were able to cross large bodies of water.

Further urban growth did not occur until the 14th century when new inventions made animate power more efficient in terms of transportation. Land transportation was improved through the use of collars, better harness, brakes,

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[5] Ibid., p. 7.

[6] Ibid., p. 8.

and the pivoting axle.[7] Prior to the invention of the pivoting front axle, wagons were dragged around corners. With improved harnesses, brakes, and the pivoting axle, however, heavier loads could be transported overland. There was also a significant improvement in navigation with the addition of tacking. However, upstream navigation was still difficult so not many cities were established inland. Ocean vessels were also improved with the addition of more and better sails, instruments such as the compass and astrolabe, and rudders. Ships could now sail directly across large bodies of water instead of around the edge in sight of land. Therefore, communities located on the boundary of large bodies of water became important trading centers. However, in spite of all the improvements in transportation, the size of cities was still limited because the carriers still depended upon animate energy.

The pattern of settlement within the city was also influenced greatly by the means of transportation. Since travel was by either foot or animal, there was a need for public buildings to be located close together.[8] Communication was conducted principally by word of mouth except for the small elite who was literate. The elite also had

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[7] Gilmore, p. 25.

[8] Sjoberg, p. 99.

the ability to purchase land near the public buildings. Therefore, the status of the people declined as distance from the central buildings increased. The lowest class and those workers engaged in the most undesirable occupations lived on the edge of the city. Transportation and communication, therefore, played an important role in establishing the ecological structure of the city.

Thus, as late as the 19th century, transportation overland and across seas was still propelled by animate power. Consequently, inland cities were few and restricted in size. The urbanization process had to await the Industrial Revolution which would provide the improved technology and inanimate sources of energy which would encourage the growth of inland cities.

Energy Uses in the Industrial City

According to Sjoberg, the primary characteristic of the industrial city is the utilization of inanimate sources of power. When inanimate sources of power such as the steam engine and the internal combustion engine were invented, transportation was greatly improved. Transportation powered by inanimate sources played a vital role in the Industrial Revolution and the urbanization process. The technological developments which made the industrial city possible were the sources of inanimate energy, improved agricultural methods which produced more surplus food, more sophisticated tools of manufacture which either multiplied power or improved its transmission, and better transportation which could move food into the city.[9] However, our investigation at this point centers around only one of these forces: improved transportation.

The steam engine was the first inanimate source of power to affect transportation. Of course, the first steam engines worked on low pressures and were very inefficient. These engines could not be used on river boats or ocean vessels because of the large amounts of fuel which they required.[10] Later the quality of steel was improved and utilized in boilers. Higher pressures were then possible so a new type of steam engine was introduced.

With the resulting increase in the efficiency of the steam engine, river and ocean transportation became possible. Furthermore, urban communities were formed upstream from the river mouths. The screw-driven steamer, which was a great improvement over the paddle wheel, followed. Nevertheless, the development of the steamship was limited until a more efficient engine, particularly the steam turbine,

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[9]Ogburn, On Culture and Social Change, p. 85.

[10]Gilmore, p. 55.

was invented.[11] Innovations in water travel, however, were not the only improvements in transportation which influenced urban growth.

There were also major advancements being made in land transportation which utilized inanimate energy. Two of these were of particularly importance: the railroad and the automobile. The railroad became one of the most important factors in the establishment of inland urban centers. The railroad could haul very large and heavy loads practially anywhere in the interior of the country. It was not limited to level ground as were canals and it could travel twenty times faster than the canal barges.[12] Thus cities began to grow inland away from bodies of water. Numerous cities grew up along the railroad lines. Later the diesel engine was applied to many of the railroads. Since the steam engine had to stop often for water, long distance diesel powered trains altered or eliminated many of these towns which grew up around water stops.[13] The railroad also provided means for transporting finished raw materials. As a result, cities were located near coal

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[11] R. A. Buchanan, Technology and Social Progress (Oxford, England: Pergamon Press, 1965), p. 63.

[12] Gilmore, p. 59.

[13] William F. Cottrell, Energy and Society (New York: McGraw-Hill Book Company, Inc., 1955).

veins and ore deposits. The factory system was also produced to accommodate power-driven machinery. This was partially due to the fact that steam could be produced cheaply only in large quantities and it had to be utilized close to its source.[14] Thus steam encouraged the growth of a highly concentrated population.[15] Consequently, inanimate power utilized by railroads was a major stimulus to the development of inland cities.

A second inanimate power source was developed which improved land transportation. The internal combustion engine was developed and applied to wagons and carriages. The resulting invention was, of course, the truck and the automobile. Later these inventions would have many implications on the use of resources and pollution.

Both the truck and the automobile were free from tracks or canals so they were very flexible. This flexibility proved very valuable in terms of urban transportation. The diesel engine became a primary source of power for transporting people and products. The development of the internal combustion engine led to a demand for more and better roads.[16] Travel became extremely easy because

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[14] S. McKee Rosen and Laura Rosen, Technology and Society (New York: Macmillan Company, 1941), p. 245.

[15] Ibid., p. 247.

[16] Buchanan, p. 66.

of the automobile. Consequently, the first effect of the car was to increase the centralization of business and commerce.[17] After traffic congestion proved to be a severe problem, however, businesses began to decentralize. Workers were no longer restricted to living near their place of work. Thus, improved transportation made possible by inanimate energy was one of the forces which led to suburban migration and which eventually resulted in metropolitan districts rather than individual cities.[18] Dormitory suburbs and satellite cities grew up surrounding the central city.[19] Improved transportation and communication provided mobility which encouraged urban sprawl.

Actually, the emergence of modern transportation and communication systems were complementary forces in creating urban sprawl. Because the telephone was a means for instant verbal communication, families were less reluctant to move away from friends or relatives. Furthermore, the telephone was a cheap and quick avenue for conducting business. The telephone seems to be an indispensable aid for many of the retail stores in suburban areas. Mass

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[17]Gilmore, p. 115.

[18]Rosen and Rosen, p. 28.

[19]For a detailed discussion of these see Leo F. Schnore's "Satellites and Suburbs," <u>Social Forces</u>, Vol. 36, Dec., 1957, pp. 121-7.

communication via television, radio, and newspapers have stimulated the demand for consumer goods.[20] Therefore, it encouraged the growth of retail stores in dormitory suburbs and satellite cities. The flexible modes of transportation could then deliver requested merchandise quickly and efficiently. In general, communication and transportation improvements have helped alter the nature of the city by making metropolitanization possible. Without sources of inanimate energy, metropolitanization could not have occurred.

Urban Transportation: The Present Picture

We have now seen how transportation propelled by inanimate energy has contributed to the growth of urban industrial centers. However, society has not used inanimate sources of energy as efficiently as it could have. Problems in transportation still exist in most large urban centers. Among the most pressing problems is a lack of adequate facilities for moving large populations. The basic problems of present transportation can be divided into two classes: those encountered by mass transit and those confronted by private vehicles. Both of these types of problems were created by a cultural lag. The independent

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[20]Buchanan, p. 92.

variables in this cultural lag are the technological changes and population growth which have occurred at an accelerating rate over the last century. The dependent variable which has been too slow in responding is municipal planning.[21] Automobile transportation, for example, has suffered from problems of too much success too quickly. Thus facilities have not kept pace with demand. The reasons behind this rapid success and resulting congestion are complex, but the primary factor contributing to the problem is the American's devotion to his car.[22]

Private Transportation

Although it is not strange that Americans depend primarily on private automobiles for transportation, the results are certainly not totally beneficial. The automobile provides comfort, flexibility, and economy. For example, the car owner has the convenience of leaving directly from his own home independently of scheduled time-tables. The car owner can also ride in air conditioned comfort with the aid of power steering and power brakes. In addition to the comfort and flexibility of the private car, the owner is able to travel at costs close to those charged by

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[21] Paul M. Danforth, Transportation: Managing Man on the Move (Garden City, New York: Doubleday and Company, Inc., 1970), p. 173.

[22] Diana Reische, ed., Problems of Mass Transportation, The Reference Shelf, Vol. XLII (New York: H. W. Wilson Company, 1970), p. 3.

mass transit systems.[23] However, the owner can drive only if there are adequate facilities for all people who own a car and wish to drive. In the last few decades, highways, streets, and parking lots have become crowded and jammed in the major central cities. Thus, the cost of operating an automobile has risen considerably for the owner. The United States Census of 1960 indicates that 64 per cent of all workers traveled to and from work in private cars. The number of cars has been increasing by some eight million per year until now there are 22 cars for every mile of road.[24]

The traffic congestion is caused by commuters who live in suburbs and drive to and from work. Traffic, which reaches a peak during these hours, is intensified by the limited number of people riding in each car. The average automobile in the United States carries only 1.5 passengers.[25] This results in a tremendous volume of automobiles on the highways during peak hours. Also contributing to the problems of traffic congestion in urban areas are the vast number of intersections.[26] Yet, roadways constructed to avoid intersections are extremely costly and several

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[23] Ibid., p. 43.

[24] Ibid., p. 59.

[25] Danforth, p. 51.

[26] Ibid., p. 29.

acres of land are required for only one intersection. Parking is also a major problem. Although many underground and multistory parking lots have been built, a shortage of space still exists so cars are permitted to park on the street which creates additional traffic congestion.

Another problem involving private automobiles is more directly of concern in this study. This is the pollution which they cause. During 1966, 86 of 142 million tons or some 60 per cent of air contaminants came from motor vehicles.[27] Such companies as Standard Oil Company believe automobiles which do not pollute will be built at economical costs in the near future.[28] Nevertheless, automobiles presently contribute heavily to air pollution.

The status of problems caused by the private automobile have been summarized very well by R. H. Haase:

> Certainly the "cost" of transportation when measured in terms of energy, land, time, manpower, and material could be reduced if every automobile were filled to capacity or if very small single-passenger automobiles were used for the single-passenger trip instead of the larger six-passenger cars. But these innovations require radical changes, in the habits and desires of people; to date, we as a society prefer to pay the additional "cost" rather than change.[29]

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[27]Danforth, p. 55.

[28]R. C. Mallatt, Bulletin of the Atomic Scientists, May 1970, p. 44.

[29]R. H. Haase, Analysis of Some Land Transportation Vehicles - Today and Tomorrow (Santa Monica, Calif.: Rand Corporation, 1962), p. 22.

Mass Transportation

The second class of problems confronting transportation today lies in the deterioration of mass transit systems. The very nature of mass transportation contributes to this deterioration. For example, the system must be able to accommodate all passengers at peak loads with comfort and at moderate prices. However, during the other twenty hours per day, they must operate on a regular schedule without a sufficient number of passengers to make it profitable.[30] Another obstacle to intelligent urban transportation planning is the complex and uncoordinated administrative arrangements for such planning.[31] In many metropolitan areas, there is competition and conflict between city governments which hinders the development of an integrated system of trains. These cities have grown together due to urban sprawl, but they still maintain separate local governments.

Yet another problem area lies in the regulations imposed by the federal government.[32] Although they were originally devised to prevent monopolies, regulations now are forcing railroads and other mass transportation systems

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[30]Reische, p. 15.

[31]Danforth, p. 182.

[32]For a detailed discussion of Federal Regulation see Business Week, "Transportation Needs a Drastic Overhaul" (Nov. 14, 1970).

to carry goods and people at a loss and to operate spur lines which are unprofitable.[33] The principle on which the railroads have tried to operate when encountering uneconomical but socially necessary services is cross-subsidization.[34] This means that they depend upon high profit operations to equalize the nonprofitable lines. But companies now say they cannot cross-subsidize and still provide good service, attract capital to pay equipment replacement costs, develop new technology, and hire the best employees.[35] The companies maintain that ultimately uneconomic transportation will be paid by the consumer.

Another criticism of the federal government's policy is aimed at the advantages given to private transport systems that are not given the railroad system. To demonstrate this, the trucking industry does not have to raise the capital necessary to buy right of ways and build the highways on which they operate.[36] Thus the truckers can operate with a low level of capital. The taxes placed on fuel and the purchase of permits and licenses are the only

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[33] Ibid.

[34] Ibid., p. 68.

[35] Ibid., p. 73.

[36] Paul Cherington, "Transportation," Forbes, CVII, No. 1 (January 1, 1971), p. 172.

expenses which the trucker has to pay toward construction and maintenance of highways. Therefore, the government is providing the necessary capital. Other transport systems are supported in the same manner.

> While the United States is the only major nation in the world that relies primarily on privately owned and operated transportation, it has been made possible only through the use of publicly granted authority and investment of public resources in construction of locks, dams, channels, highway networks, airports and harbors.[37]

In addition, mass transportation systems lack sufficient capital to develop and test new technologies. Therefore, the transportation industry feels that government sponsored research is essential for the development of a modern and efficient mass transit system.[38]

In spite of the difficulties being experienced by the mass transit systems, rapid transit systems will continue to be essential for the larger cities.[39] The role which the mass transit system will take depends on several things. If pollution and congestion do not force the automobile from its dominant position in American transportation, the private automobile may be incorporated into some mass transit system. For example, cars may be driven from the

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[37] Reische, p. 32.

[38] *Ibid.*, p. 56.

[39] *Ibid.*, p. 183.

home onto an automatically controlled lane which guides the car along a predesignated route. However, the car may experience significant changes, especially in its method of propulsion. Most of the proposals along this line assume that the car will be powered by electricity. Of course, any prediction concerning the fate of the automobile would be merely speculation. But it would be useful in this investigation to distinguish some possible methods of future transportation. By identifying some alternative transportation systems, one might know the type of energy required and therefore make an analysis of the impact of fusion reactors more meaningful.

The Future of Electrical Energy and Urban Transportation

There is presently, a debate as to how long our known reserves of oil, gas, and coal will last. Some experts predict that they will last for several thousand years and others predict that the reserves will be depleted by the end of the century. These differences in predictions are partially due to contrasting assumptions as to what resources are economically feasible to recover.[40] Some people prefer to make estimates of fuel resources in terms

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[40] Sheldon Novick, The Careless Atom (Boston: Houghton Mifflin Company, 1969), p. 177.

of what can be feasibly recovered at present costs by present methods. For example, if a method is discovered for tapping the world's supply of oil shale, energy derived from that oil could supply the earth for several centuries.[41] But Sheldon Novick thinks that fossil fuels will become more valuable as raw materials for manufacturing synthetic chemicals than as fuel per se.[42] Therefore, petroleum will probably be used eventually as raw materials for manufacturing rather than as sources of energy. This fact combined with the pollution created by the burning of hydrocarbons necessitates the adoption of a new source of clean energy.

The demand for clean energy has already led to the development of fission reactors. For example, England presently produces one-half of its electrical power with fission reactors.[43] Because of the danger of explosion and radiation, other power sources such as fusion reactors are being sought. Ultimately, it seems certain that man will have to depend on breeder reactors, controlled fusion

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[41]Ibid., p. 179.

[42]Ibid.

[43]H. A. D. Bodin, Nuclear Scientist at Culham Laboratories, England, lecture given at Texas Tech University, Lubbock, Texas, Nov. 11, 1970.

energy, and solar energy.[44] Since the energy produced by these sources in all probability will be electrical, an analysis of the impact of electrical energy on transportation would seem to be desirable. In 1965, transportation consumed 28 per cent of the total energy consumed in the United States as shown in Figure 3.

In this analysis, the author assumes that electrical power produced by fusion will be economically competitive with electrical power produced by other sources. In addition, no predictions will be made as to what type of transportation will exist in the future. Given the present technology and means of transportation, the author will investigate how electrical energy produced by fusion reactors could be utilized in the movement of persons and products.

Transportation systems can roughly be divided into two types: private vehicles and mass transit systems. We shall examine each in turn.

Private Vehicles

As pointed out earlier, the 1960 Census of the United States showed that 64 per cent of its workers traveled to work in private cars. Consequently, congestion caused by

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[44]Gough, *Fusion Torch*, p. 5.

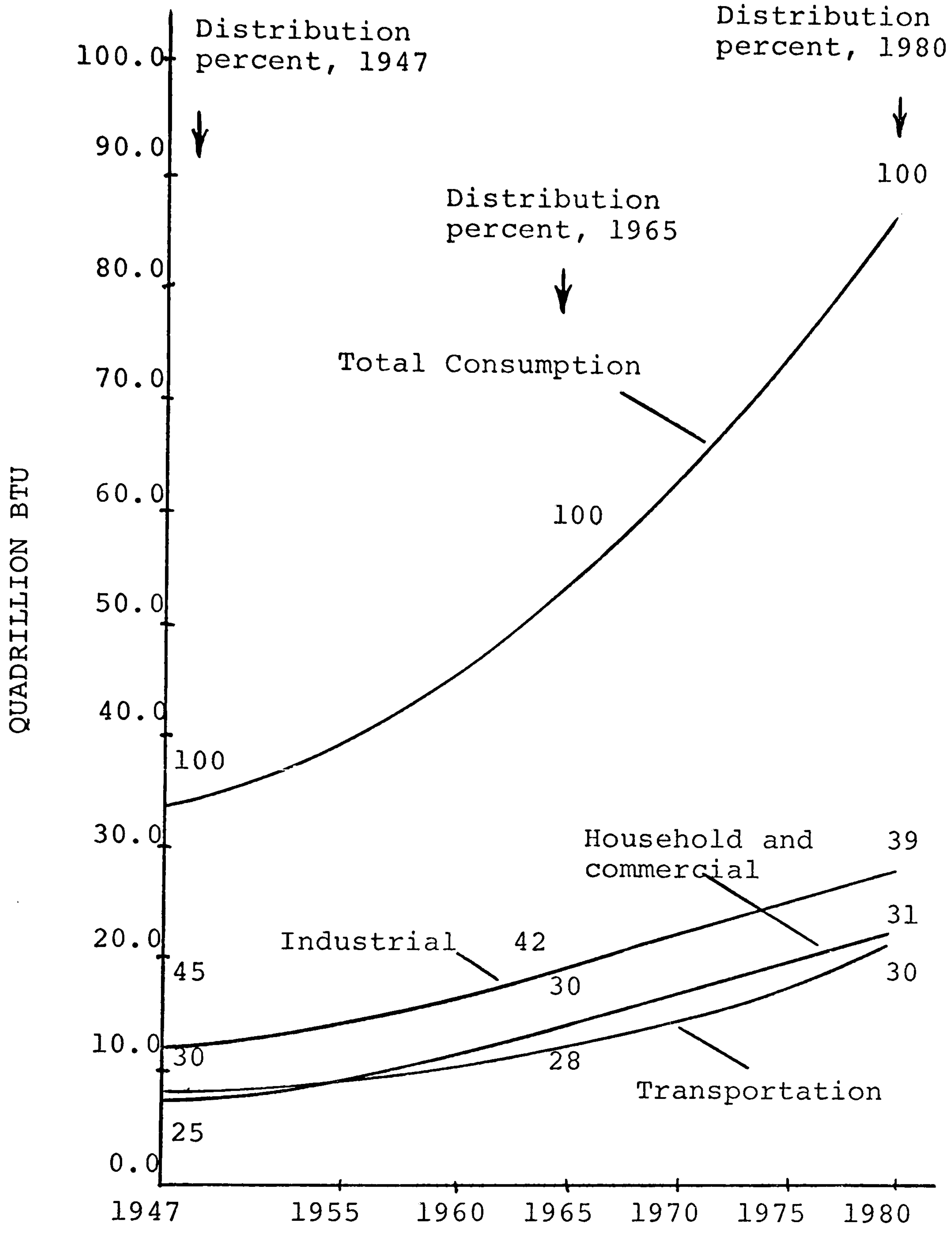

Fig. 3.--Consumption of energy by major consuming sectors

Source: U.S. Department of the Interior. Bureau of Mines, An Energy Model for the United States Featuring Energy Balances for the years 1980 and 2000, by Warren E. Morrison and Charles L. Reading Washington, D.C.: U.S. Government Printing Office, 1968), p. 97.

private cars during peak hours is becoming a severe problem. Numerous proposals have been made which might reduce this congestion. For example, if small cars are used in city operation, the road capacity for city traffic would be increased by more than 50 per cent.[45] Other proposals include the transfer of on street parking to underground or multistory parking lots.[46] Still another attempt was made in London to reduce traffic congestion. The city officials encouraged companies to relocate in less congested areas.[47] Assuming that these or other methods of reducing traffic congestion are successful, the problem of pollution still exist. As previously mentioned, some 60 per cent of the air contaminants come from motor vehicles. But major oil companies and car manufacturers insist that they can build a car and fuel which is pollution free.[48] Indeed, many improvements are being made by these industries. Hence, private vehicles may continue to be a major mode of transportation. However, if pollution is not drastically reduced, internal combustion engines may be replaced by other forms of propulsion. In addition, the shortage of gasoline

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[45]Danforth, p. 40.

[46]<u>Ibid.</u>, p. 47.

[47]<u>Ibid.</u>, p. 50.

[48]Mallatt, p. 44.

and oil may demand that these internal combustion engines be phased out.

If private automobiles are forced to abandon the gasoline engine, electrical power produced by fusion reactors might become the primary form of propulsion. This means that cars would have electrical motors rather than the internal combustion engine. In fact, the Federal Power Commission projects sales of electric cars to be 1.5 to 2 million by 1980.[49] These projections assume that the electric car will be the family's second or third car.[50] The cars could operate on batteries while traveling in urban fringe areas and they could run on lanes which provides electric power when traveling in densely populated areas.[51] The batteries could be recharged while traveling on such a lane, while parking in the central business district, or during the night at the owner's residence.[52] If ground transportation were converted to use electrical power, the demand for electricity would increase by about 50 per cent.[53] Large fusion reactors in urban centers

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[49]Reische, p. 194.

[50]Bruce C. Netschert, "The Economic impact of electric Vehicles: A Scenario," Bulletin of the Atomic Scientists, XXVI, No. 5 (May, 1970), p. 29ff.

[51]Danforth, p. 147.

[52]*Ibid.*, p. 33.

[53]*Ibid.*, pp. 30-31.

could easily provide this additional power. Industries other than the utility industry would also be affected by a mass switch to electrically powered vehicles. Some of these industries include the oil companies as well as the automotive industry and its suppliers of specialized parts. This is not to mention the service station industry. All of these industries would have to undergo significant change.[54] A discussion of the electrification of industries will be included in the following chapter. Even though the electrification of land transportation will produce a great amount of social change, private electric vehicles may become a major means of transportation. Of course, this change process would occur over a period of many years and a system utilizing present automobiles would persist for a while. Nevertheless, electric power supplied by fusion reactors may well play a key role in changing patterns of land transportation.

Mass Transit

The second type of transportation is mass transit systems. Many experts think that elimination of the private automobile within the central business districts of large cities is inevitable.[55] Therefore, new systems of mass

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[54] Netschert, p. 32.

[55] "When Traffic Jams Stall the Nation," Business Week (December 6, 1969), p. 186ff.

transit must be developed.[56] Many new systems as well as improvements on old systems have been proposed. Prototypes already exist for many of these new systems while others are still in the design stage.

There are several new systems of mass transit for people and products which for purposes of our analysis are of little concern. These systems include mostly air and water vehicles. Shuttle systems utilizing vertical takeoff and short landing aircraft have been proposed to reduce the congestion in urban areas and to facilitate travel to and from airports. The mass movement of containerized products via specialized ships is also in limited use. But because of the size and flexibility required in these systems, the utilization of fusion reactors as the power source is unfeasible. It is possible that the technology to transmit energy through the air will be developed, but this seems unlikely in the foreseeable future. If a flexible means of transmission of electrical power is discovered, batteries could be eliminated and electric power could be used in these systems.

However, the focal point of this analysis is mass land transit systems. People such as Walter Rainville think

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[56]United States Department of Housing and Urban Development, Office of Metropolitan Development, Tomorrow's Transportation: New Systems for the Urban Future (Washington, D.C.: Government Printing Office, 1968), pp. 27-8.

that there simply is not enough space in the central business districts to handle the traffic created by all those who want to drive into it.[57] According to Rainville, it is generally acknowledged that mass transit systems are more efficient and require no downtown space for parking.[58] Even buses, which are not the most efficient means of mass transit are six times more efficient than the average auto.[59]

Presently, most large cities have some type of mass transit system. Cities such as Chicago and New York have systems which carry almost 90 per cent of the traffic into the central business section.[60] Lisco says that where mass transportation is a good alternative to driving, i.e., if it is comfortable and economical, people use the mass transit systems.[61] Therefore, it seems reasonable to assume that these systems will continue and perhaps even spread in the future.

Almost all of the mass transit systems either in existence today or proposed can utilize electrical energy.

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[57] Reische, p. 14.

[58] *Ibid.*

[59] Danforth, p. 51.

[60] Reische, p. 41.

[61] *Ibid.*

Some of the most promising methods of transportation are dependent solely upon electrical power. One example is the vehicles powered by linear induction motors. This system uses two electromagnets which hang on opposite sides of a large central rail. When a current is passed through the magnets, they are either attracted or repelled from the rail.[62] Many of these LIM systems also ride on an air cushion making it possible for them to travel at speeds in excess of 300 mph.

Another major proposal for mass land transit lies in the greatly increased use of buses. Buses presently serve about 75 per cent of those who use mass transportation.[63] These buses can also be powered by electricity and some cities such as El Paso have such vehicles in operation. Therefore, a fusion reactor located in the center of a metropolis could supply the energy needed. The bus transit system could grow if lanes designed exclusively for buses become more widespread.

Still another mode of transportation which had been proposed is the Lockheed type cylindrical cars which travel

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[62]For a discussion of LIM systems see Reische, p. 182; Business Week, Nov. 14, 1970, p. 42; "High-Speed Ground Transit at a Profit," The American City, January, 1971, p. 74; and Danforth, p. 175.

[63]Reische, p. 81.

on rails inside a tube.[64] Figure 4 illustrates how these gravity-vacuum transit systems would work. The journey could be made in 8.5 minutes.[65] Electrical energy could again be used. The suggested means of propulsion is gravity which accelerates the car while traveling downward and a vacuum which pulls the car back to the surface. Because electrical energy does not pollute the air, it could be used in a closed system.

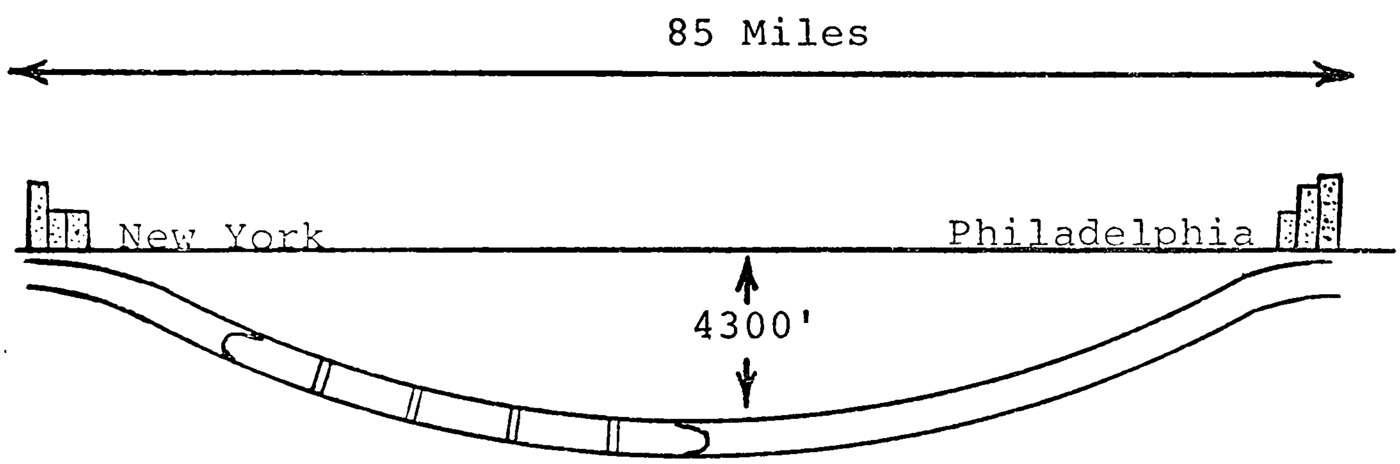

Fig. 4--Pneumatic Tube Trains

Source: Paul M. Danforth, Transportation: _Managing Man on the Move_ (Garden City, New York: Doubleday & Company, Inc., 1970), p. 169.

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[64]For discussions of this system see Reische, p. 192; Danforth, p. 167; and Haase, p. 27.

[65]Danforth, p. 169.

Still another form of urban transportation is being designed for extremely high density areas. This system, known as the Bouladon Continuous Integrated Transporter, employs the same principle as a conveyor belt.[66] The passenger steps onto an escalator which is accelerated and moved onto a transporter belt moving at 20 mph. Electrical energy could again provide the necessary power, particularly if fusion reactors can be located in centers with a high population concentration.

A final system which needs to be examined involves the integration of the taxi into a mass transit system. This system, known as DART (Demand-Actuated Road Transit) provides a mini-bus in which passengers are picked up at their residences and carried to work for one-fourth the cost of a taxi.[67] This system is made possible by an automated vehicle locator which can handle one million vehicles simultaneously.[68] This system seems desirable since it combines the benefits of private automobiles with the benefits of mass transit. If electrical cars become a major vehicle of the future, then a DART system utilizing fusion produced electrical power would be feasible.

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[66] Reische, p. 148.

[67] _Ibid._, p. 178.

[68] _Ibid._

In summary, many different forms of mass transportation are being proposed. Not all of these are dependent solely upon electrical energy. Nevertheless, electrical energy could be used in all the systems. Whether any of these systems will be developed depends on advances made in technology. However, regardless of the types of systems which are developed, they could use electrical energy supplied by fusion reactors.

CHAPTER V

ENERGY AND MANUFACTURING

We have already mentioned the fact that energy has been a major variable in the development of transportation and manufacturing. For example, the guilds of the pre-industrial period depended on animate energy, but the manufacturing companies of the industrial era have utilized inanimate sources of power.[1] Steam was the first major form of inanimate energy to be used. Because of the necessity to generate steam in large volumes and utilize it near its source, the guild system of production was eliminated. The factory system proved to be more efficient. With the development of the factory system, the nature of workers changed. Instead of being highly skilled craftsmen, the workers became semi-skilled machine operators. Given this transition plus that which is being brought about by automation, the following question arises: what impacts could fusion energy be expected to have upon manufacturing and labor? To answer this question, an analysis of what industries would be affected most by the availability of cheap and abundant energy is required.

As was revealed by Figure 3 in chapter IV, industry consumes 42 per cent of all the energy utilized in the

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[1] Sjoberg, p. 10.

United States.[2] It is, therefore, important to know where this energy is being used in order to understand what effects might result if fusion energy is adopted and widely diffused. The industries which would be affected most would be those which use a large amount of energy or those industries in which a high percentage of the total cost of production is for energy. By knowing which industries will be affected most, one gains some knowledge of the impact on workers. If cheap energy from fusion reduces the cost of industrial products, the greatest gain will be made by those industries which are the major users of energy, assuming that there is an adequate demand for those products.

A second way in which fusion energy might alter industries is by reducing the number of workers involved in the conventional energy producing industries such as the coal, gas, and petroleum industry. If fusion power is widely adopted, the demand for conventional energy might decrease. In that case, there could be unemployment in some coal, gas, and/or petroleum industries. Therefore, an investigation of future energy demands and the available energy sources would indicate if the adoption of fusion power might

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[2]U.S. Department of the Interior, Bureau of Mines, <u>An Energy Model for the United States, Featuring Energy Balances for the Years 1947 to 1965 and Projections and Forecasts to the Years 1980 and 2000</u>, by Warren E. Morrison and Charles L. Reading, IC8384 (Washington, D.C.: Government Printing Office, 1968), p. 97.

reduce the demand for conventional energy and thereby produce a dislocation of workers.

The first part of this chapter will consist of an analysis of which industries would be most affected by cheap, abundant energy produced from fusion. The following table is a condensed list of the types of industries in the United States which have the highest energy costs.

TABLE 2

COST OF ENERGY CONSUMED BY MAJOR U.S. INDUSTRIES: 1967[a]
(In millions of dollars)

Primary metal industries	1635.7
Chemical and allied products	1188.3
Food and kindred products	661.6
Stone, glass, and clay	637.8
Paper and allied products	576.8

[a]Calculated from: U.S. Department of Commerce, Bureau of the Census, Census of Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, pp. 45-7.

A complete list of all types of industries and their energy costs is given in Table 12 of the Appendix. This table reveals that the primary metal industries and the chemical industries are the industries which spend the most money on energy. Another table based upon the actual amount of energy consumed by major industries indicated that the chemical industry actually uses more energy than the primary metal industry.

TABLE 3

ENERGY CONSUMPTION OF MAJOR INDUSTRIES[b]
(In million kilowatts of electricity of equivalent)

Chemicals and allied products	726,385.5
Primary metal industries	567,103.3
Stone, glass, and clay products	358,002.6
Paper and allied products	320,855.5
Food and kindred products	246,205.1

[b]Calculated from: U.S. Department of Commerce, Bureau of the Census, Census of the Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, pp. 197-244.

One possible reason for the shift in ranking of the two industries in Tables 2 and 3 is a difference in the cost of energy for various industries.

Table 4 provides a list of the industries in which the cost of energy constitutes a high proportion of the total manufacturing costs. It is a partial reproduction of Table 13 in the Appendix. The category "Food and kindred

TABLE 4

INDUSTRIES WHICH HAVE HIGH PROPORTIONS OF ENERGY COSTS[c]

Stone, clay and glass	5.88%
Chemical and allied products	4.21%
Primary metal industries	4.06%
Paper and allied products	3.32%
Petroleum and coal products	2.41%
Lumber and wood products	2.15%
Food and kindred products	.95%

[c]Calculated from: U.S. Department of Commerce, Bureau of the Census, Census of the Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, pp. 197-244.

products" was included because of its presence on the other two tables. Several industries ranked higher than it did in the percentage of total manufacturing cost which went into energy.

The facts revealed in these tables correspond closely to the information contained in Figure 5. This graph shows that in 1962, 87 per cent of the energy utilized by the industrial sector of the United States was attributed to the manufacturing industries. The energy inputs of those industries which were included in the previous tables are also shown on the graph. The only addition was that of the mineral industries which consumes 13 per cent of the total energy used in the industrial sector. According to the graph the industries which use the most energy are as follows:

TABLE 5

PER CENT OF ENERGY USED BY THE INDUSTRIAL SECTOR[d]

Primary metal industries	31%
Total mineral industries	13%
Petroleum and coal products	13%
Stone, clay, and glass	6%
Food and kindred products	6%
Paper and allied products	6%
All other	14%

[d]Calculated from: U.S. Department of Commerce, Bureau of the Census, Census of Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, pp. 197-244.

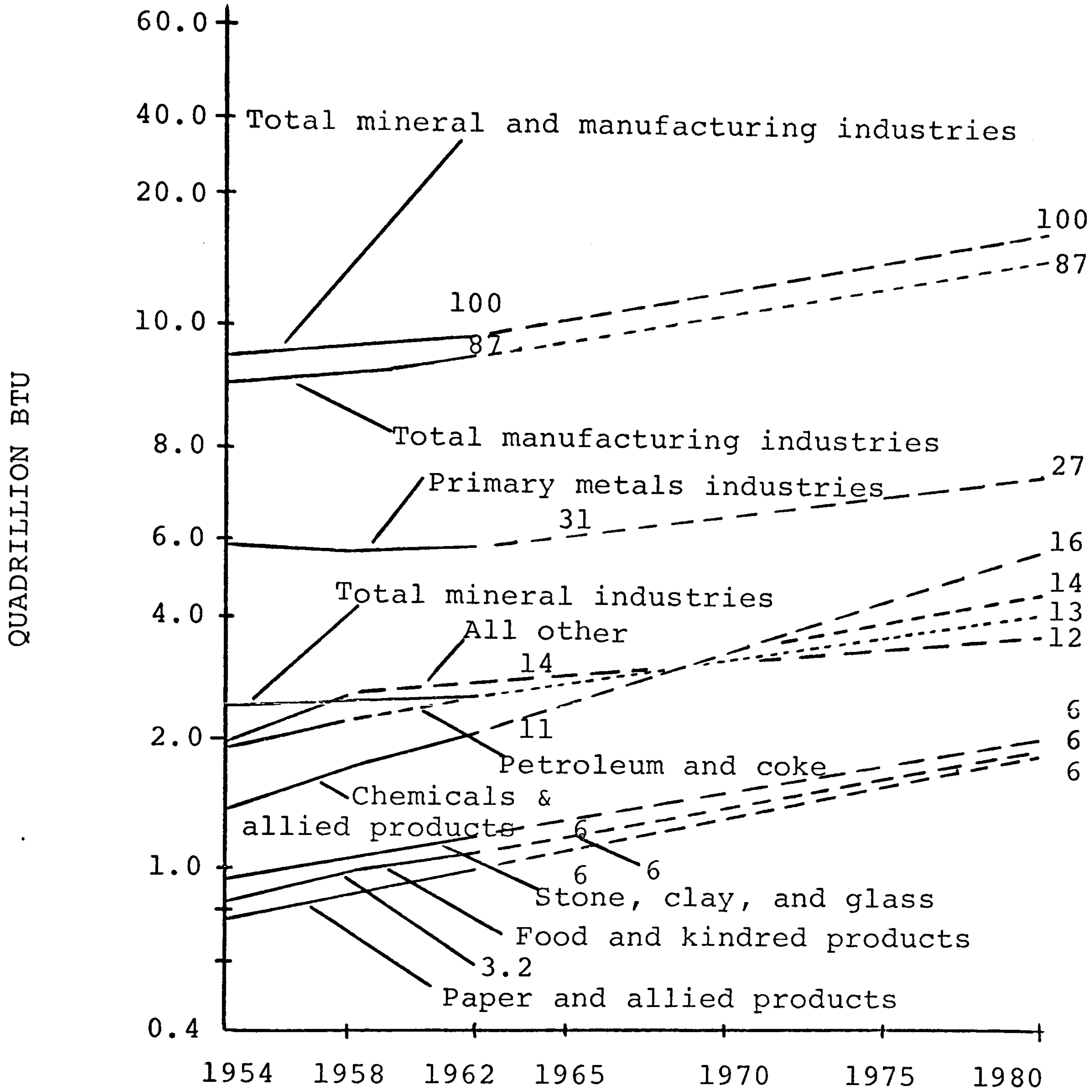

Fig. 5.--Industrial sector-energy inputs to major mineral and manufacturing industries

Source: U.S. Department of the Interior, Bureau of Mines <u>An Energy Model for the United States Featuring Energy Balances for the Years 1947 to 1965 and Projections and Forecasts to the Years 1980 and 2000</u>, by Warren E. Morrison and Charles L. Reading (Washington, D.C.: Government Printing Office, 1968), p. 94.

The differences between the values shown on the graph and in the tables is probably due to the changes which occurred in the energy consumption patterns of the industries during the five year period. Nevertheless, the same industries are present on both the graph and the tables. These will probably be the industries which will be affected most by the adoption and diffusion of fusion power.

From the previous tables and graph, it is evident which major industries would be affected most by the introduction of fusion power. However, there is considerable variation in the amount of energy used by various manufactures within each industry grouping. Table 14 in the Appendix shows the amount of energy consumed by various manufactures within the major energy consuming industries. From that table, the following summary table is given.

TABLE 6

THE DIVISIONS OF INDIVIDUAL INDUSTRIES WHICH CONSUME THE MOST ENERGY[e]
(In million kwhr.)

Chemicals and allied products	Energy Consumed
Industrial organic chemical	247,468.2
Industrial inorganic chemicals	177,257.1
Alkalies and chlorine	58,280.6
Plastics materials and resins	34,682.8
Cellulosic manmade fibers	30,667.9
Cyclic intermediates and crudes	30,206.0
Organic fibers	26,722.7
Industrial gases	17,821.3
Synthetic rubber	15,832.0
Fertilizers	13,277.1
Inorganic pigments	13,019.9
Chemical preparations	13,425.6

TABLE 6--Continued

Primary Metal Industries	Energy Consumed
Blast furnaces and steel mills	272,171.
Primary aluminum	108,348.8
Gray iron foundries	27,921.5
Electro-metallurgical	20,474.6
Copper rolling and drawing	19,609.7
Primary zinc	17,334.2
Iron and steel forgings	15,527.6
Primary copper	13,119.8
Steel foundries	11,388.9
Stone, Glass, and Clay Products	
Cement hydraulic	137,521.1
Glass containers	34,595.0
Brick and structural tile	30,051.9
Lime	23,062.4
Ready mixed concrete	20,083.0
Pressed and blown glass	18,824.0
Flat glass	15,647.3
Mineral wool	10,654.5
Paper and Allied Products	
Papermills, except building	148,941.6
Paperboard mills	125,938.3
Pulpmills	22,336.7
Building paper and board mills	11,101.0
Food and Allied Products	
Meat packing plants	23,128
Beet sugar	21,217
Fluid milk	18,789.4
Wet corn milling	17,711
Bread, cake, and related products	13,882.1
Prepared feeds for animal & fowls	13,742
Canned fruits & vegetables	10,700
Soybean oil mills	10,277.3

[e]Calculated from: U.S. Department of Commerce, Bureau of the Census, Census of Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, pp. 197-244.

From this table it is evident that the specific manufactures which would be most affected by the development of fusion energy would be those listed in the following table.

TABLE 7

SPECIFIC MANUFACTURES USING THE MOST ENERGY[f]

Manufactures	Kwhr. of Energy Consumed
Blast furnaces and steel mills	272,171.1
Industrial organic chemicals	247,468.1
Industrial inorganic chemicals	177,257.1
Papermills, except building	148,941.6
Cement, hydraulic	125,938.3
Primary aluminum	108,348.8
Alkalies and chlorine	58,280.6

[f]Calculated from: U.S. Department of Commerce, Bureau of the Census, Census of Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, pp. 197-244.

Now that we have established which manufactures would possibly be affected most by the introduction of fusion power, an investigation of the possible effects on employment is appropriate. The price of manufactured articles depends upon production and distribution costs. Since energy costs are part of the production cost, the price of the manufactured articles should decrease as the cost of energy decreases. Then, assuming that cheaper prices for the articles will stimulate a demand for them, the manufactures will expand until the public market has been saturated with the article. Therefore, the growth of all these industries would provide employment for large numbers of people.

Fusion power could also alter the employment situation by providing energy which was previously produced by conventional sources such as the coal, gas, and petroleum industries. By doing so, the conventional energy suppliers would suffer from a lack of demand thereby necessitating a cutback in employment. However, Figure 6 reveals that

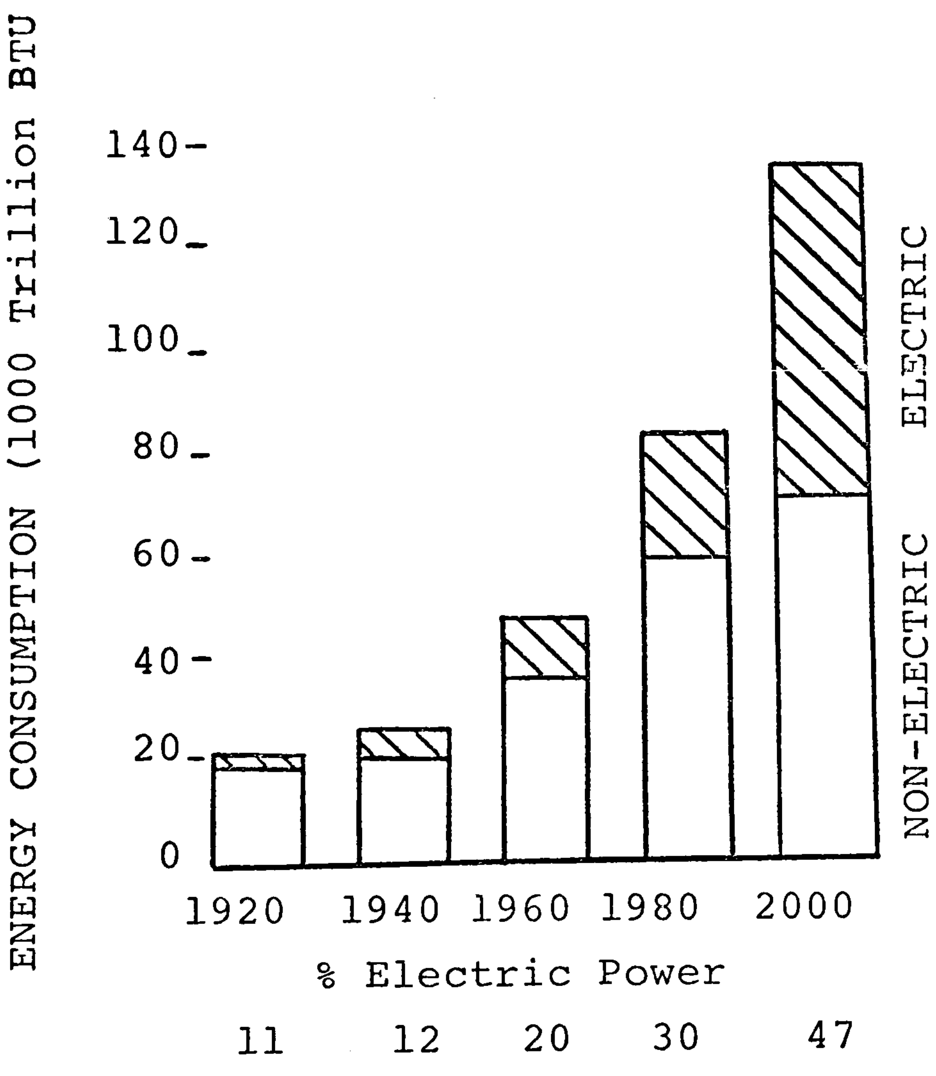

Fig. 6.-- U.S. Energy consumption 1920-2000

Source: U.S. Atomic Energy Commission; The Fusion Torch: Closing the Cycle From Use to Reuse, by W. C. Gough and Bernard J. Eastlund (Washington, D.C.: Government Printing Office, May 15, 1969), p. 3.

conventional power sources will not experience a decrease in demand providing there is no major breakthrough in electrical power. The figure shows that although electric power will continue to make up a growing proportion of our total energy, the non-electrical energy sources will actually increase their production. By the year 2000, electrical power is expected to supply about 47 per cent of the total energy consumed in our society. Yet the non-electric sources will continue to grow and produce an estimated 70 thousand trillion BTU of energy in 2000. Figure 6 shows that the demand for energy will increase during the foreseeable future. Fuel burning plants as well as nuclear plants are expected to be needed to supply the necessary energy. However, pollution and depletion of fossil fuels may cause a rapid growth in nuclear energy.

Figure 7 also reveals the same information. The fuel burning plants produced 82 per cent of the total electricity generated in 1965 and they are expected to generate 71 per cent in 1980. Therefore, fuel burning plants will generate a lower percentage of the total electricity consumed. However, fuel burning plants are expected to generate 5.6 per cent more kilowatt hours of electricity in 1980 than they produced in 1965. Consequently, the conventional fuel burning power plants will actually expand their present production. Therefore, no large scale unemployment will result in the conventional power sources due to the adoption of fusion power plants.

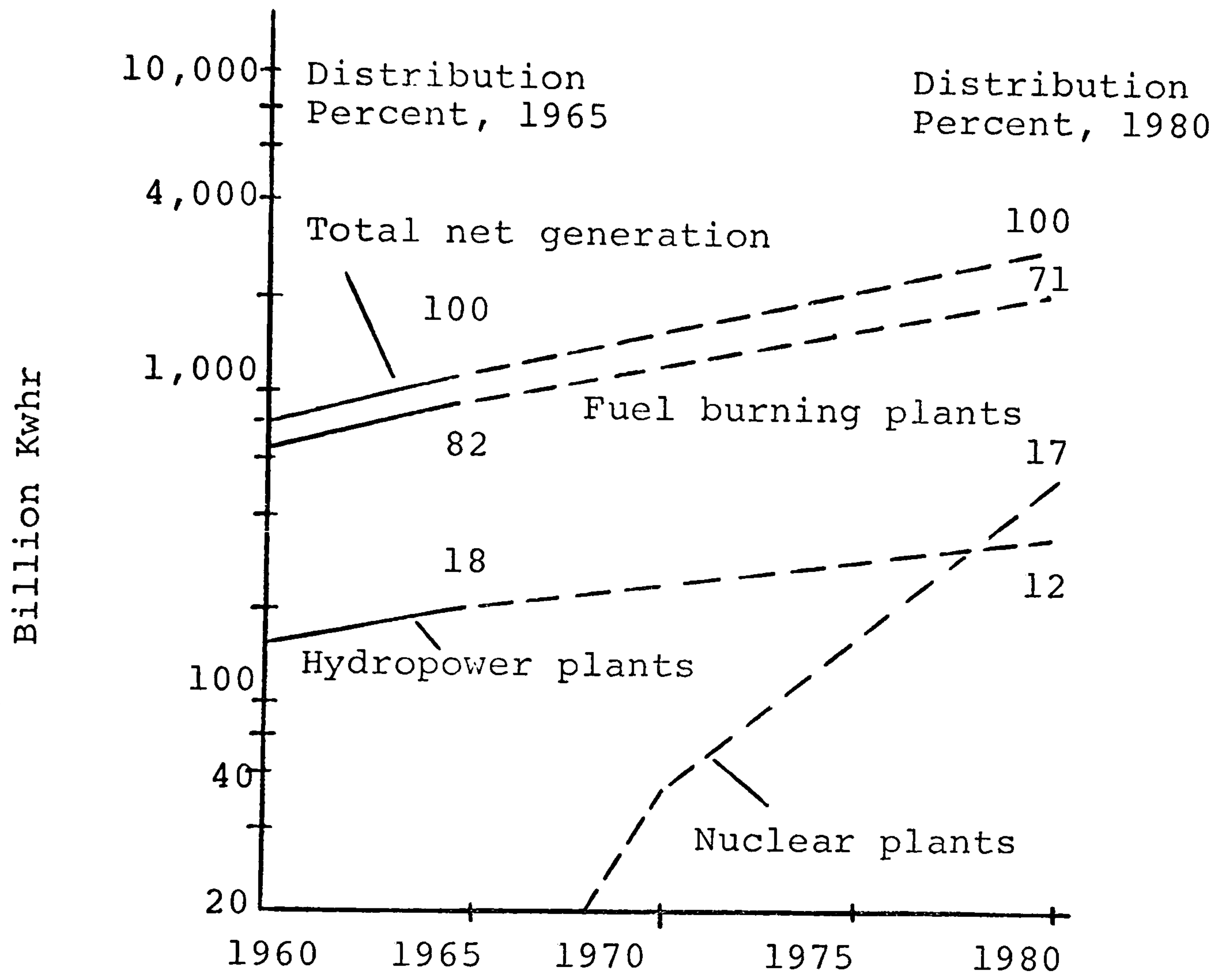

Fig. 7.--Generation of electrical power by source.

Source: U.S. Department of the Interior, Bureau of Mines, <u>An Energy Model for the United States Featuring Energy Balances for the Years 1947 to 1965 and Projections and Forecasts to the Years 1980 and 2000</u>, by Warren E. Morrison and Charles L. Reading (Washington, D.C.: Government Printing Office, 1968), p. 86.

Figure 8 shows that the world's use of petroleum will peak around the turn of the century while coal consumption continues to rise slowly.

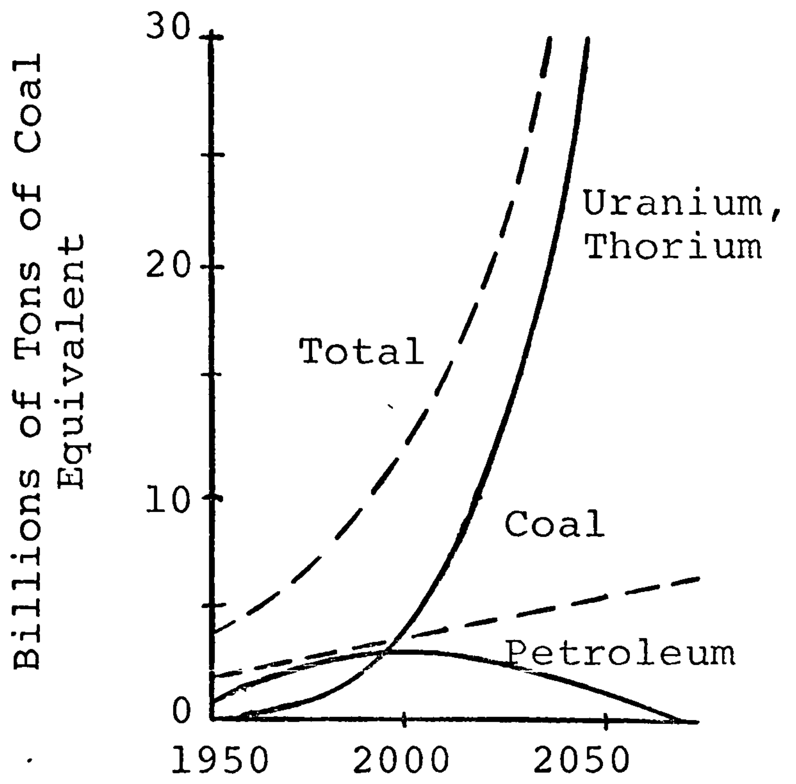

Fig. 8.--Projected sources of energy

Source: Charlton Ogburn, Jr., "Population and Resources: The Coming Collision," Population Bulletin, XXVI (June, 1970), p. 19.

The graph shows that the U.S. will consume less petroleum as energy shortly after 2000. Indeed, the limited supply of petroleum may prove to be more valuable as a raw material for lubricants, plastics, and chemicals than as a source of energy. The petroleum industry, therefore, will probably not suffer. But in the unlikely event that the petroleum industry did suffer from the introduction of fusion power, the changes in the nature of the petroleum industry would be sufficiently slow to allow the industry to shift dislocated workers into other jobs within the industry. If a cutback in employment was necessary, the decline could easily be attained by failing to hire additional workers instead of firing any existing ones. Therefore, there should not be any widespread areas of unemployment in the petroleum industries. However, it is more probable that the technology necessary to extract shale oil and other technical developments will allow the petroleum industry to flourish. At the same time, the nature of the petroleum industry may change by manufacturing lubricants, chemicals, and plastics rather than producing energy.

One other conclusion regarding the affect of fusion energy on manufacturing can also be drawn. Earlier figures revealed that the energy costs for various manufacturers ranged from less than one per cent to over five per cent of the total manufacturing costs. From the figures in Table 8, we see the average cost of energy of all the U.S. manufacturers was 1.72 per cent of the total manufacturing costs in 1967.

TABLE 8

MANUFACTURING COSTS FOR U.S. INDUSTRIES[g]

Total payroll	$123,480.6 (million)
Materials less energy	290,822.0
Capital expenditure	22,469.9
Fuel and electricity	7,691.7
Total	$444,464.2

[g]Calculated from: U.S. Department of Commerce, Bureau of the Census, Census of Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, p. 45.

Table 9 shows that energy cost accounts for 2.02 per cent of the total costs of production, i.e., the cost of wages of production workers plus the cost of materials used.

TABLE 9

THE COSTS OF ACTUAL PRODUCTION[h]

Wages of production workers	$ 81,393.6 (million)
Materials less energy	290,822.0
Fuel and electricity	7,691.7

[h]Calculated from: U.S. Department of Commerce, Bureau of the Census, Census of Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, p. 45.

Disregarding capital expense and the wages of nonproduction workers, energy accounts for only 2.02 per cent of the total cost of manufacturing goods in the United States. Therefore, the costs of completed products will not drop significantly if fusion energy is utilized.

Furthermore, the standard of living would probably not rise because members of the lower classes would still be unable to afford most products. A problem of income distribution would still exist. While a lack of energy would definitely lower the standard of living, excess energy per se will not make the standard of living rise. Fusion reactors may well be necessary to insure that enough energy is available to prevent a drop in the standard of living, but it is not the dominant variable. The lack of resources or pollution may actually prevent a rise in the standard of living before the severe shortage of energy occurs.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The conclusions that can be made from an exploratory study of this type can only be suggestive and general in nature. Our guesses as to the social implications of fusion energy can only be approximations based upon our understanding of present technology, and our estimations of population growth, resource reserves, and energy demands. Because energy is only one of many variables affecting society, exact predictions are impossible. Nevertheless, the conclusions reached show a need for further research on how technology and energy affect society.

One of the principle variables producing social change has been various sources of energy. Before the invention of inanimate sources of energy, industrialization and urbanization were impossible. Now, yet another source of energy may have implications for the post-industrial society. Indeed, the following conclusions seem to be warranted:

Population

Population will probably be affected most through economic changes produced by the fusion reactor. The abundance of energy does not insure a rise in the standard of living. However, a shortage of energy would lower the affluence of a society. Fusion reactors may well be necessary to prevent such a shortage of energy.

Similarly fusion reactors can provide the means of producing additional food by providing desalinated sea water for irrigation. The additional food could either support additional people at current standards, or providing fertility is controlled, it could be used to improve the diets of the present population.

For all practical purposes, however, population growth cannot be stopped instantaneously (See supra, pp. 36). Population growth is maintained by its own momentum which will continue to exert pressure on resources, energy, and the environment even after an optimum population has been reached.

The distribution of the population may, however, change because of the industrial development which would accompany the construction of a fusion reactor. Therefore, a migration of people toward the location of the reactor is likely.

The Rural Community

Fusion reactors could stimulate economic development in rural areas. By encouraging industry to locate in these rural areas, employment would be provided for rural workers. The economic development of rural areas should, among other things, provide jobs for the young adults thereby increasing the proportion of people in rural areas who are economically active. Problems created by the rural to urban migration might be reduced if young adults are provided jobs in rural areas. In addition, revenue provided by taxation on the new industries could help support rural institutions.

Transportation

Pollution and the shortage of fossil fuels for use as energy will demand that alternate systems of transportation be developed. The new sources of energy used in these systems will probably be electrical which would therefore encourage the development of electrical mass transit systems such as the LIM or Lockheed Cylinderical cars. It is also probable that the introduction of fusion reactors would encourage the development of the private electric car. Therefore, fusion reactors would probably aid the adoption of various types of electrical vehicles.

Manufacturing

The industries which would most likely be affected by fusion reactors would be the manufacturers of chemical products, primary metal products, stone, glass, and clay products, paper products, and food products. This is because a decrease in the cost of energy could increase the demand for these products thereby stimulating growth in these industries and thereby increasing employment.

The development of fusion reactors will not significantly affect the conventional sources of power because of the increased demand for energy. Likewise, cost of energy is only a small proportion of the total cost of manufacturing. Therefore, if the cost of energy is reduced significantly, there will only be a minimal effect on the total price of products. Consequently, if the lower socioeconomic groups cannot afford to buy products before the diffusion of fusion power, they will still be unable to do so after its adoption. Because of these factors, a rise in the standard of living for the lower socioeconomic class seems unlikely.

There would be no large scale pockets of unemployment in the economy due to fusion reactors per se. However, fusion reactors would tend to encourage several trends already in progress such as increased consumption of electrical energy, increased automation, and possibly the widespread use of electric cars. All of these trends could alter the petroleum and automotive industries and the nature of employment.

Energy and Society

In conclusion, it appears that although energy itself is a vital resource for the development and prosperity of society, other factors such as depletion of high grade mineral ores, population growth, and pollution may limit the quality of life before a shortage of energy occurs. However, this study is totally exploratory and additional investigation is required for each of the major areas described in this study.

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APPENDIX A

Tables and Figure of Population Growth

TABLE 10

ULTIMATE AGE SPECIFIC BIRTH RATES ASSUMED FOR VARIOUS SERIES PROJECTIONS[a]

(Rates represent births per 1,000 females at specified age)

Age of mother	Series B	Series C	Series D	Series E
Total fertility rate	3,100.0	2,775.00	2,450.0	2,110.0
14 years	4.1	3.5	2.9	2.8
15 years	12.0	10.0	7.9	8.2
16 years	33.5	28.1	22.7	22.8
17 years	67.3	56.7	46.1	45.8
18 years	111.6	91.8	77.9	76.0
19 years	156.5	129.2	101.5	106.5
20 years	184.4	150.2	115.4	125.5
21 years	202.7	164.6	126.0	138.0
22 years	211.2	173.4	135.0	143.7
23 years	213.7	177.4	140.6	145.4
24 years	206.1	174.3	142.2	140.3
25 years	193.5	166.8	140.0	131.7
26 years	181.0	159.4	137.7	123.2
27 years	168.1	151.8	135.5	114.4
28 years	155.2	142.8	130.5	105.7
29 years	141.6	133.4	125.3	96.4
30 years	128.0	122.6	117.5	87.1
31 years	113.2	110.7	108.4	77.0
32 years	103.0	101.3	99.9	70.1
33 years	91.0	91.5	92.4	61.9
34 years	80.2	81.8	83.7	51.6
35 years	71.6	72.9	74.4	48.7
36 years	61.4	62.9	64.6	41.8
37 years	51.8	53.2	54.8	35.2
38 years	44.8	46.3	48.0	30.5
39 years	35.3	36.3	37.5	24.0
40 years	27.3	28.0	28.9	18.6

TABLE 10--*Continued*

Age of mother	Series B	Series C	Series D	Series E
41 years	18.9	19.2	19.6	12.9
42 years	13.9	14.2	14.5	9.4
43 years	8.5	8.7	9.0	5.8
44 years	4.6	4.8	4.9	3.1
45 years	2.5	2.6	2.6	1.7
46 years	1.1	1.2	1.2	0.8
47 years	0.4	0.5	0.5	0.3
48 years	0.1	0.1	0.1	0.1
49 years	0.1	0.1	0.1	0.1

[a]U.S. Department of Commerce, Bureau of the Census, *Population Estimates and Projections* (Washington, D.C.: Government Printing Office, 1970), p. 48.

TABLE 11

POPULATION PROJECTION[b]

Year	Series B Population	Series C Population	Series D Population	Series E Population
1970	205,456	205,357	205,167	205,070
1975	219,101	217,557	215,588	214,735
1980	236,797	232,412	227,510	225,510
1985	256,980	249,248	240,925	236,918
1990	277,286	266,319	254,720	247,726
1995	297,884	283,180	267,951	257,345
2000	320,780	300,789	280,740	266,181
2005	347,073	320,055	293,751	275,066
2010	376,249	341,033	307,436	283,711
2015	407,379	363,191	321,683	291,893
2020	440,253	385,959	335,869	299,171

[b]Calculated from: U.S. Department of Commerce, Bureau of the Census, Population Estimates and Projections (Washington, D.C.: Government Printing Office, 1970), p. 48.

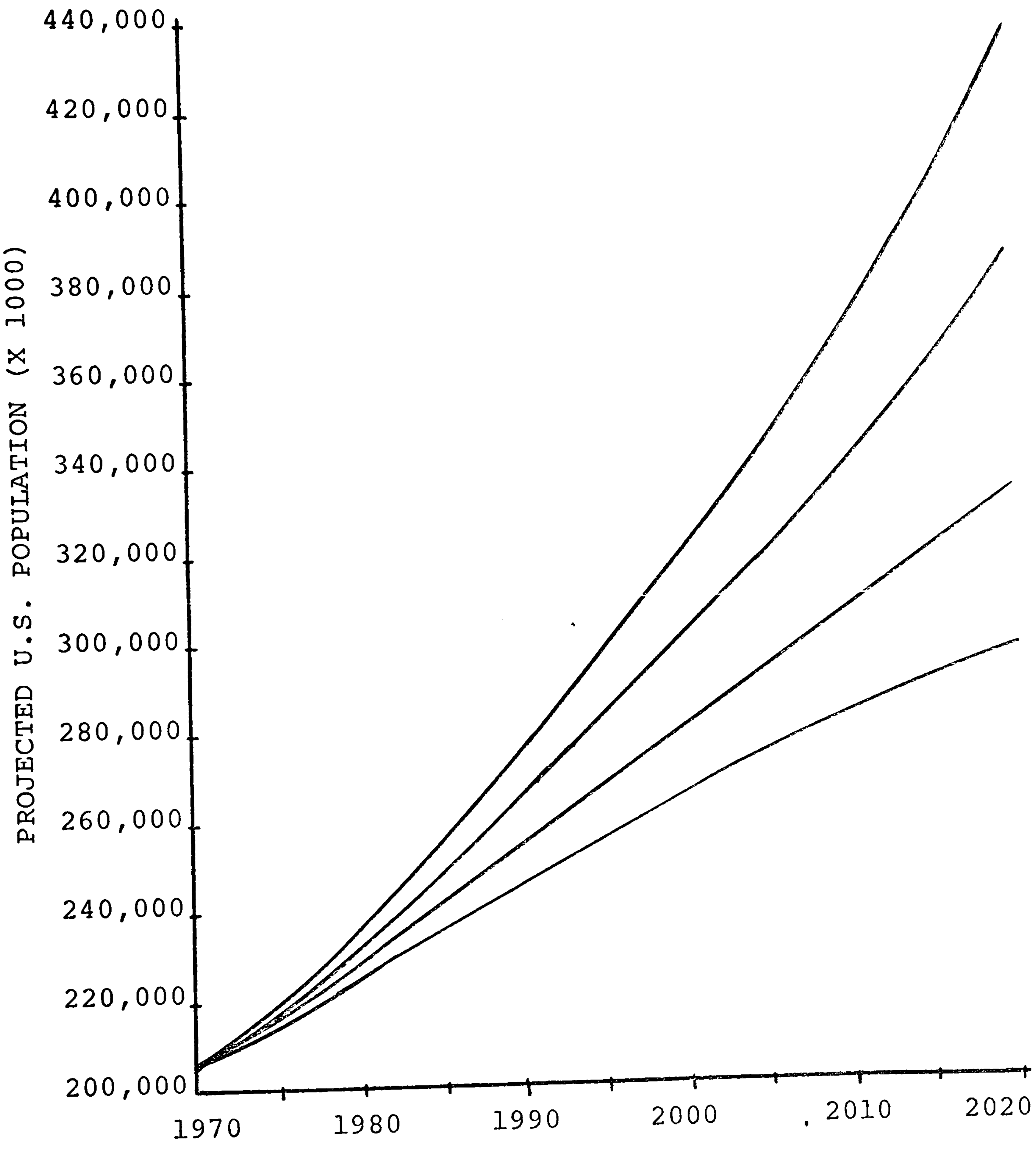

Fig. 9.--Population projections for 1970 to 2020

APPENDIX B

Tables of Energy Consumed by Manufacturing

TABLE 12

ANNUAL COST OF ENERGY CONSUMED BY INDUSTRY GROUP[c]

Manufactures	Millions of Dollars
Total U.S.	$7,691.7
Primary metal industries	1,637.7
Chemical and allied products	1,188.3
Food and kindred products	661.6
Stone, clay, and glass	637.8
Paper and allied products	576.8
Petroleum and coal products	456.9
Machinery except electrical	356.0
Textile mill products	284.5
Lumber and wood products	204.3
Rubber and plastics	175.1
Printing and publishing	120.2
Apparel and other textile products	94.2
Furniture and fixtures	58.2
Instruments and related products	55.8
Leather	34.1
Tobacco manufacturers	15.0
Miscellaneous manufacturing industries	58.5
Fabricated metal products	D[d]
Electrical equipment and supplies	D
Transportation equipment	D
Ordance and accessories	D

[c]U.S. Department of Commerce, Bureau of the Census, Census of Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, pp. 197-244.

[d]Complete figures are not provided by the Census.

TABLE 13

PERCENTAGE OF MANUFACTURING COST ATTRIBUTED TO ENERGY[e]

Manufactures	% of Total Cost for Energy
Total U.S.	1.73
Stone, clay, and glass	5.88
Chemical and allied products	4.21
Primary metal industries	4.06
Paper and allied products	3.32
Petroleum and coal products	2.41
Lumber and wood products	2.15
Rubber and plastic products (n.e.c.)[f]	1.76
Instruments and related products	1.75
Textile mills	1.68
Furniture and fixtures	.96
Food and kindred products	.95
Machinery except electrical	.95
Leather and leather products	.84
Printing and publishing	.78
Apparel and other textile products	.55
Tobacco manufacturers	.45
Miscellaneous manufacturing	.73
Fabricated metal products	D[g]
Electrical equipment and supplies	D
Transportation equipment	D
Ordnance and accessories	D

[e]Calculated from: U.S. Department of Commerce, Bureau of the Census, Census of Manufactures: 1967 (Washington, D.C.: Government Printing Office, 1968), Vol. I, Summary and Subject Statistics, pp. 197-244.

[f]not elsewhere classified.

[g]Complete figures are not provided by the Census.

TABLE 14

ENERGY CONSUMPTION BY VARIOUS INDUSTRIES[h]

Primary Metal Industries	Million Kwhr.
Blast furnaces and steel mills	272,171.1
Primary aluminum	108,348.8
Gray iron foundries	27,921.5
Electro-metallurgical	20,474.6
Copper rolling and drawing	19,609.7
Primary zinc	17,334.2
Iron and steel forgings	15,527.6
Primary copper	13,119.8
Steel foundries	11,388.9
Primary metal products (n.e.c.)	8,147.6
Nonferrous wire drawing	7,127.0
Aluminum castings	6,590.9
Malleable iron foundries	6,459.3
Primary nonferrous metal (n.e.c.)	5,267.0
Secondary nonferrous metals	5,107.2
Rolling and drawing (n.e.c.)	4,478.6
Nonferrous forgings	3,150.8
Primary Lead	3,868.8
Cold finishing of steel shapes	2,802.6
Steel wire and related products	2,545.9
Nonferrous castings (n.e.c.)	2,459.7
Steel pipe and tubes	2,106.4
Chemical and Allied Products	
Industrial organic chemicals	249,468.2
Industrial inorganic chemicals	177,257.1
Alkalies and chlorine	58,280.6
Plastic materials and resins	34,682.8
Cellulosic fillers	30,667.9
Cyclic intermediates and crudes	30,206.0

TABLE 14--Continued

Chemical and Allied Products	Million Kwhr.
Organic fibers, noncellulosic	26,722.7
Industrial gases	17,821.0
Synthetic rubber	15,832.0
Fertilizers	13,277.1
Inorganic pigments	13,019.9
Chemical preparations	12,425.6
Explosives	9,580.1
Pharmaceutical preparations	9,126.0
Soap and other detergents	5,884.5
Paints and allied products	5,645.0
Carbon black	5,109.6
Medicinals and botanicals	4,204.4
Adhesives and gelatin	3,641.9
Gum and wood chemicals	2,964.0
Fertilizers mixing only	2,063.6
Biological products	505.2
Paper and Allied Products	
Papermills, except building	148,941.6
Paperboard mills	125,938.3
Pulpmills	22,336.7
Building paper and board mills	11,101.0
Corrugated and solid fiber boxes	8,272.4
Paper coating and glazing	4,265.5
Stone, Glass, and Clay Products	
Cement hydralic	137,521.1
Glass containers	34,595.0
Brick and structural tile	30,051.1

TABLE 14--Continued

Stone, Glass, and Clay Products	Million Kwhr.
Lime	23,062.4
Ready mix concrete	20,083.0
Pressed & blown glass	18,824.0
Flat glass	15,647.3
Mineral wool	10,654.5
Gypsum	9,079.3
Clay refractories	9,017.0
Instructural clay products	8,713.3
Other concrete	6,711.1
Concrete block and brick	5,871.7
Minerals, ground or treated	6,764.0
Nonclay refractories	5,704.9
Asbestos	3,678.1
Products of purchased glass	3,384.2
Vitreous plumbing fixtures	3,028.7
Abrasive products	2,922.4
Ceramic wall and floor tile	2,175.4
Cut stone and stone products	1,513.3
Food and Kindred Products	
Meat packing plants	23,128
Beet sugar	21,217
Fluid milk	18,789
Wet corn milling	17,711
Bread, cake, and related products	13,882
Prepared feeds for animals and fowls	13,742
Malt liquors	11,911
Canned fruits and vegetables	10,700
Soybean oil mills	10,272

TABLE 14--*Continued*

Food and Kindred Products	Million Kwhr.
Cane sugar refining	9,158
Shortening and cooking oils	8,293
Animal and marine fats and oils	8,108
Bottled and canned soft drinks	7,997
Condensed and evaporated milk	7,904
Distilled liquor except brandy	7,752
Food preparations (n.e.c.)	7,035
Frozen fruits and vegetables	6,253
Poultry dressing plants	4,820
Creamery butter	4,725
Sausages and other prepared meats	4,718
Flour and other grain mill products	4,581
Canned specialties	4,564
Raw cane sugar	3,149
Cheese natural and processed	2,963
Cookies and crackers	2,926
Confectionery products	2,683
Malt	2,517
Roasted coffee	2,511
Chocolate and cocoa products	1,868
Chewing gum	323

[h]Calculated from: U.S. Department of Commerce, Bureau of the Census, *Census of Manifactures: 1967* (Washington, D.C.: Government Printing Office, 1968), Vol. I, *Summary and Subject Statistics*, pp. 197-244.