ENERGY REQUIREMENTS AND IMPACT OF OIL SHORTAGE

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The energy shortage in the United States presents a major problem to economic growth and the welfare of the American people. Quantative estimates of the magnitude of the shortage can help in adopting an effective energy policy. If energy requirements are not met, inflation and rationing are likely to cause economic recession, increased unemployment, and a lower standard of living.

The purposes of this paper are (a) to examine consumption and production of energy, (b) to estimate the effect of population and income growth on energy requirements, and (c) to discuss some of the economic problems resulting from the oil shortage.

CONSUMPTION AND PRODUCTION OF ENERGY

There are five major energy consumer markets, households and commercial, industrial, transportation, and electric generator utilities, which in 1970 used 20%, 31%, 24%, and 25%, respectively, of total energy consumed in the United States (Table 1). Population growth, rising per capita income, and improved standards of living have increased energy consumption by more than 50% in the last ten years (Table 2). Predictably, rising income and growth of consumer markets will continue to increase the demand for energy (1).

Oil, natural gas, coal, and electricity, provided 31%, 39%, 25%, and 5%, respectively, of the total energy production in the United States during 1970. (Table 3). The demand for oil is increasing while its domestic production is declining (2). Oil provided 43% of the total energy consumed and domestic production provided only 31.4% in 1970.

EFFECT OF POPULATION AND INCOME GROWTH

An equation can be derived to determine the effects of population and income growth on energy requirements. The nature of energy consumption suggests that no substitute commodities need be incorporated into the analysis. Accordingly, the following model is hypothesized:

$$E = f(P, I, U) \qquad \text{Eq. 1}$$

where

E is energy consumed per year,
P is population,
I is per capita disposable income, and
U is error component.

A multiple linear regression equation using population (P) and per capita disposable income (I) as independent variables and energy consumed per year (E) as

TABLE 1. *Energy consumption by major consumer markets.*

Consumer Market	British Thermal Units × 10^{12}				Percentage			
	1965	1968	1969	1970	1965	1968	1969	1970
Total	53,969	62,448	65,773	68,810	100.0	100.0	100.0	100.0
Households and commercial	11,687	13,148	13,628	14,098	22.1	21.1	20.7	20.4
Industrial	17,734	19,712	20,570	21,129	32.6	31.6	31.3	30.7
Transportation[a]	12,715	15,302	15,950	26,546	23.6	24.6	24.2	23.9
Electric generation, utilities	11,104	14,043	15,433	16,967	20.6	22.4	23.5	24.7
Miscellaneous	549	243	192	180	1.0	0.4	0.3	0.3
Utilities electricity purchased[b]	3,600	4,529	4,920	5,197	c	c	c	c

[a] Includes bunkers and military transportation.
[b] Electricity generated and imported.
[c] Not applicable.

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TABLE 2. *Energy consumption in the United States.*

	British Thermal Units, × 10^{12}						Percentage				
Year	Total	Anthra-cite	Bitu-minous and lignite	Crude petro-leum	Natural Gas	Elec-tricity	Anthra-cite	Bitu-minous and lignite	Crude petro-leum	Natural Gas	Elec-tricity
1960	44,816	447	9,967	18,608	14,163	1,631	1.0	22.2	41.6	31.6	3.6
1961	45,573	404	9,809	18,989	14,726	1,645	0.9	21.5	41.6	32.3	3.7
1962	47,620	363	10,160	19,662	15,632	1,803	0.8	21.3	41.2	32.9	3.8
1963	49,598	361	10,722	20,231	16,511	1,773	0.7	21.7	40.8	33.2	3.6
1964	51,676	365	11,295	20,707	17,417	1,892	0.7	21.8	40.3	33.5	3.7
1965	53,969	328	12,030	21,566	17,950	2,095	0.6	22.3	40.0	33.2	3.9
1966	57,130	290	12,740	22,703	19,284	2,113	0.5	22.3	39.8	33.7	3.7
1967	59,156	274	12,587	23,484	20,414	2,397	0.5	21.3	39.7	34.5	4.0
1968	62,448	260	13,069	27,052	19,580	2,487	0.4	20.9	43.3	31.4	4.0
1969	65,773	245	13,293	28,419	21,040	2,776	0.4	20.2	43.2	32.0	4.2
1970	68,810	194	13,598	29,617	22,546	2,855	0.3	19.8	43.0	32.8	4.1

TABLE 3. *Energy production in the United States.*

	British Thermal Units, × 10^{12}						Percentage				
Year	Total	Antra-cite	Bitu-minous and lignite	Crude petro-leum	Natural gas	Elec-tricity	Antra-cite	Bitu-minous and lignite	Crude petro-leum	Natural gas	Elec-tricity
1960	41,704	478	11,886	14,935	13,822	1,583	1.1	26.1	35.8	33.2	3.8
1961	42,165	443	10,558	15,206	14,336	1,622	1.1	25.0	35.9	33.9	4.1
1962	43,786	429	11,034	15,522	15,004	1,797	1.0	25.2	35.4	34.3	4.1
1963	46,169	464	12,024	15,966	15,941	1,774	1.0	26.0	34.6	34.5	3.9
1964	48,038	436	12,759	16,164	16,792	1,887	0.9	26.6	33.6	34.9	4.0
1965	50,015	378	13,417	16,521	17,628	2,071	0.8	26.8	33.0	35.2	4.2
1966	52,861	329	13,986	17,561	18,885	2,100	0.6	26.5	33.2	35.7	4.0
1967	55,813	312	14,479	18,651	19,971	2,400	0.6	25.9	33.4	35.8	4.3
1968	57,716	291	14,285	19,308	21,372	2,460	0.5	24.8	33.5	37.0	4.2
1969	59,587	266	14,685	18,922	22,858	2,856	0.4	24.6	31.8	38.4	4.8
1970	62,423	236	15,458	18,579	24,295	2,855	0.3	24.8	31.4	38.9	4.6

dependent variable was constructed as follows:

$$E = A + B_1P + B_2I + U \qquad \text{Eq. 2}$$

A stepwise least-squares multiple-regression procedure was used to estimate the parameters of the regression equation (3). Analysis of the data yielded satisfactory results in terms of the conventional measures of statistical reliability. The dependent variable E is measured in trillions of British Thermal Units (BTU) consumed per year. The estimated multiple regression equation is:

$$E = -8.08987 + \underset{(.0014)}{0.10731P} + \underset{(.1053)}{13.560831I}$$

$$R^2 = 0.99$$

The regression coefficient (B_1) is 0.107, i.e., total energy consumption increases by 0.107 trillion BTU per 1000 population growth. The regression coefficient (B_2) is 13.56, i.e., each one-dollar increase in per capita disposable income increases total energy consumption by 13.56 trillion BTU a year. The coefficient of determination (R^2) indicates that 99% of the increase in energy consumption depends upon an increase in per capita income and population.

Income elasticity for energy measures the sensitivity of the amount of energy consumed to changes in per capita disposable income and can be computed by:

$$I_e = \frac{dE}{dI} \cdot \frac{\bar{I}}{\bar{E}} \qquad \text{Eq. 4}$$

where

$\frac{dE}{dI}$ is the first derivative of the amount of energy E consumed with respect to per capita disposable income I.

$\bar{I}$ is the average per capita disposable income in the period of study.

$\bar{E}$ is the average amount of energy consumed in the period of the study.

Thus, income elasticity for energy is:

$$I_e = 13.56 \frac{2604}{56171} = 0.6 \quad \text{Eq. 5}$$

This indicates that a 1% increase in per capita disposable income increases energy consumption by 0.6% a year.

ENERGY REQUIREMENTS

The current population growth rate of 1.5% a year alone will increase energy requirements by as much as 1.5% per year. In addition to the population growth rate, income growth affects energy requirements. The United States has experienced rates of growth in per capita income of about 5% per year. The rate of growth in total energy requirements is the product of growth in per capita disposable income and the income elasticity of demand for energy, plus the population growth rate. Therefore, the rate of growth in total energy requirements under present conditions is 4.5% per year, (i. e., $0.6 \times 5 = 3.0 + 1.5 = 4.5$).

OIL SHORTAGE AND ECONOMIC PROBLEMS

In 1973, the United States expected an increase in oil requirements of about 450,000 barrels a day. These requirements could not be met because of the October, 1973, Middle East war. The Arab oil embargo increased the domestic shortage to about 3 million barrels per day. By the end of 1973, the oil shortage was expected to average 25% of the daily requirements. The Bureau of Mines estimated that the United States was importing 3.4 million barrels of oil per day, or about 25% of its daily needs, most of it from the Middle East. In 1974, the oil shortage will be about 4.7 million barrels a day or 31% of the daily requirements.

An oil shortage was expected to exert inflationary pressures on the prices of fuel and gasoline. Inflation may reach 8% in 1974, and will directly affect the cost of living.

It was predictable that an oil shortage would cause a transportation problem and force power plants, refineries, and industries to reduce production or shut down, with consequent rise in unemployment. The National Petroleum Council's study indicated that an oil shortage could cause an annual loss of 48 billion dollars in the gross national product and could push unemployment up to 8%.

ENERGY POLICY

The government has proposed an energy conservation plan which allocated fuel oil, reduced automobile speed limits, declared industries exempt from environmental controls, and returned the United States to year-round daylight savings time. The government also called for voluntary controls by the American people, e.g., lowering thermostat settings.

The energy conservation policy is aimed at reducing the consumption of energy rather than increasing production of energy. If the United States is to continue its economic growth and well-being, however, oil supplies must be increased. Lifting of the Arab oil embargo will help meet current energy requirements, but there is urgent need to develop technology which will supply the energy needs of the United States with solid fuels, e.g., coal, oil shale, and uranium.

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