THE ENERGY SITUATION AND OUTLOOK: DECEMBER 1973

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Introduction

The Middle Eastern crisis has increased the public's awareness of our energy problems. What is less well understood is the fact that even without an Arab-Israeli war and a 100 percent shutoff of Arab crude oil and products to the U. S., we would have had major energy problems in a number of sectors. Heating oil shortages this winter and a curtailment of gasoline consumption next summer were both expected by the experts. The degree of shortage would have depended on winter conditions and factors such as environmental regulations. The Mid-East situation has greatly aggravated the situation and this has been compounded by recent actions taken by Canada and other countries supplying our import needs (through export restrictions and higher prices).

It is not too simplistic to begin this discussion with the statement that our energy problem stems largely from a shortage of supply at prevailing prices. What I hope to do is review the historical factors that have led up to the current situation and then explore in depth the reasons for our present resource scarcity. As you will see, there are numerous institutional and governmentally created reasons for our current dilemma. After this review, I will attempt to provide an appraisal of both the short and long run outlook in the energy area.

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Historical Background

Economic Indicators: Let us begin with a historical review of the energy situation. Referring first to the Table 1 (Appendix A), one can get a macro impression of the manner in which we have utilized energy resources in the past. Gross energy consumption in the United States has increased from 33 quadtrillion BTU's in 1947 to over 72 quadtrillion BTU's in 1972. This represents a 3.1 percent annual rate of growth in energy demand. During the same period, net energy inputs increased at an average annual growth rate of 2.8 percent. Gross energy is merely the total inputs to the economy of primary fuels. Net energy usage consists of the use by each input sector after appropriate conversions in energy form have taken place. Largely as a result of increased electrical energy usage relative to total energy usage, the conversion efficiency has decreased over the same time period from 88.5 percent in 1947 to 82.5 percent in 1972. I look for a continuation of all these trends in 1973 despite the energy problems that have developed late in the year. The 1974 situation of course could see a sharp break in use (depends on the extent of the oil boycott) but not in the efficiency decline.

These average annual rates of increase can be contrasted with a population increase over the same time period which has averaged only 1.4 percent per year. Another way of looking at these statistics is to indicate that gross energy inputs will double every 23 years if the average growth rate continues. On the other hand, population would double every 50 years. In general, these values indicate that both gross and net energy consumption per capita have continued to increase rather rapidly in the time period shown. On the other hand, the use of energy per dollar of gross national product is undergoing a moderate decline. While gross national product has increased at an average

annual rate of 3.7 percent, the gross energy consumption per dollar of GNP has declined at the rate of .6 of 1 percent per year.

Consumption: These indicators are somewhat indicative of the increasingly energy intensive nature of our society. However, as the data in Table 2 indicate the distribution of total gross consumption of energy resources among the major sources has continued to shift dramatically. Anthracite coal continues to decline in importance as an energy source due to its relative scarcity within the continental United States. On the other hand, although we are blessed with abundant resources of bituminous coal and lignite, production over the past 26 years has seen severe fluctuations and is currently at a lower level than occured in 1947. The reasons for this shift are numerous. To a large extent, changes in technology have been a driving force in shifting preferences among fuel sources. This has had a substantial effect on the coal use situation. More recent developments, largely of an environmental nature, have increased coal's problems.

Natural gas and petroleum products, on the other hand, have experienced soaring consumption. Natural gas has experienced over a 6.5 percent annual growth rate while petroleum, beginning from a larger base, shows a 4.2 percent annual increase over the past 26 years. Nuclear power is also experiencing a spectacular growth rate but still supplies only a small percentage of total U. S. energy demands (less than 1 percent). This is true despite massive R+D support by the government to the exclusion of other potential supply sources. Hydropower, another relatively small contributor to total energy resources, is slowing its rate of growth as potential sites are exploited. Seemingly large fluctuations in the annual production of hydro-

power can be traced directly to the weather conditions affecting reservoir utilization. A good example of this phenomenon is the recent experience in the Northwest where drought, rather than the Middle East crisis, has precipitated major efforts at energy conservation. In general, it can be seen that the United States economy is largely dependent for energy on fossil fuel sources although some rather interesting and spectacular shifts in demand among these sources has occured historically and continues to change our total supply picture. Year to year percentage changes in these various consumption patterns can be seen by referring to Table 3. The future picture is extremely uncertain, but increased emphasis on utilization of coal seems certain.

The values in Table 2 do not imply that all fossil fuels are used directly by final consuming sectors. In 1972, almost 21 percent of the total consumption of fossil fuels was used for electricity generation. This usage varied from 63 percent of total coal consumption to 7 percent for the petroleum sector and 18 percent of natural gas usage. In contrast, only 9 percent of total fossil fuel consumption was utilized for electrical production in 1947, with the bulk of this being supplied by coal.

Production: U. S. production of energy resources over the past 26 years is shown in Table 4. Production differs from consumption largely by imports and exports. As can be seen, natural gas has assumed the number one position (in terms of BTU's) among domestically produced energy resources, surpassing petroleum in 1963. Natural gas reserves continue to be produced annually at more than twice the rate of new discoveries. It should be noted that only coal, among our sources of fossil energy, results in product exports. We are net importers of oil and natural gas. Although natural gas production exceeds consumption (Table 4 versus Table 2) most of this excess is used for well rein-

jection and other domestic, nonconsumptive purposes. Table 4 also shows the beginning of a decline in domestic production of petroleum. This decline appears to have continued at an increasing rate into 1973 and will further decline in 1974. It reflects the fact that all domestic wells are currently producing at their maximum efficient rate and that domestic exploration has not kept pace with domestic demand. Table 5 shows the year by year percentage changes in the production of the various energy resources.

Prices: Table 6 provides further insight into why our economy has become increasingly energy intensive. In addition to rising incomes and increases in population, the cost of energy resources has exhibited either relative stability or an actual decline in real prices over the past 13 year period. The average wellhead price for natural gas is virtually identical to what is was 13 years ago, but will rise some during 1973-1974. On the other hand, domestic crude oil prices have actually dropped by an average of 1.5 percent annually over that time period. Of course, 1973 and 1974 will show substantial jumps in this value. Until this year, foreign crude oil prices have exhibited only a moderate annual increase and, contrary to good free market economics, have been maintained below the domestic market price by virtue of our oil import quota program. The average cost per kilowatt-hour of electricity has also declined by an average rate of 2.4 percent. Obviously, as labor costs have increased, it has been wise economics on the part of our industrial, commercial and transportation systems to replace manpower with the use of energy to drive mechanical devices. Only the price of domestically produced coal has increased to some extent and then, only in recent times due to environmental and safety regulations.

Although historical price data, along with our knowledge of other demand influencing factors, leads to a rational explanation for our increasing per capita consumption of energy resources, the data often seems counter-intuitive with respect to the supply or production of energy resources. As indicated in Table 4, natural gas and petroleum production have increased annually from domestic sources, with petroleum only falling off in the last year. This does not seem to correspond with the economist's notion of upward sloping supply function. However, the appropriate values to compare are not price and annual production but price and annual reserve discoveries and additions. All fossil fuel production takes place from known reserves and it is the annual rate of reserve finds which is the crucial factor in formulating future production schedules and contractual commitments for production. Annual reserve finds for crude oil have been less than annual production in 8 of the past 13 years. For natural gas, reserve finds have been less than annual production in 4 of the last 5 years. These results indicate a declining reserve to production ratio which means an increasingly critical problem with domestic production from these sources in the intermediate future. We have been living off our past success. Only coal has sufficient known reserves to make its annual production directly dependent on market price.

Sectorial Demand: Tables 7, 8 and 9 provide a breakout of net energy inputs to the various final demand sectors. Energy statistics have traditionally classified these sectors as industrial, transportation, and household and commercial. No further breakout, on a comprehensive basis, is available for specific sectors such as agriculture.

Note that of the net energy consumption in the U. S. economy, almost 39 percent is attributable to the industrial sector, while the transportation and

household and commercial sectors utilize just over 30 percent each. Unfortunately, these definitions are somewhat misleading. For example, the transportation component of each sector is included under the transportation sector and not as part of final household or industrial demand. For each individual sector of final demand, it is interesting to note the source of energy consumed. For the industrial component, over 46 percent of its net energy intake is derived from natural gas, with almost 24 percent from petroleum and only 19 percent from coal and 11 percent from electricity. For the transportation component, over 95 percent of net energy intake is from the petroleum sector. The household sector derives 42 percent of its net energy intake from natural gas and almost 37 percent from petroleum with 19 percent from electricity and the remainder from coal. The electrical energy sector, although not shown in table form, derives over 41 percent of its basic energy needs from coal with 22.5 percent from natural gas and 17.5 percent from petroleum.

Viewed from the standpoint of each individual source, the transportation sector accounts for almost 53 percent of total petroleum use whereas 20.5 percent is used by the household sector, 17 percent by the industrial sector and 10 percent by the electrical generating sector. Almost 46 percent of natural gas consumption takes place in the industrial sector with 33 percent in the household sector, 18 percent in the electrical sector. Almost 63 percent of coal is used to generate electricity and the remainder is largely used for industrial purposes. From these values, it is obvious that if petroleum is in a critical supply situation, cuts in transportation usage are pre-ordained.

Reserves: Given some background in our historical and current rates of consumption and production, it will be instructive to briefly review the

state of energy reserves both domestically and worldwide. Are we running out of energy resources and does the future hold conditions of increasing energy scarcity? Unfortunately, data on our energy reserves are far from perfect. For most of the basic sources of energy only the discovered or proven resources which are recoverable at historical prices are tabulated. Known reserves available at higher prices are not usually estimated. Estimates of undiscovered reserves, of all types, are largely educated guesses. Estimates of these "speculative" and "probable" reserves vary over a wide range for the United States and are almost unknown for the world at large.

Table 10 provides estimates of United States recoverable energy reserves as of December 31, 1971. Note that for coal, we have well over a hundred years supply at current rates of production without major price increases. On the other hand, the reserve to production ratio for both natural gas and crude oil has fallen to between 10-1 and 12-1 in recent years. For natural gas this has been a continuous drop from 37.5-1 in 1945. The ratio for crude oil has remained fairly constant over time due to periodic reserve additions from large discoveries such as Prudhoe Bay in Alaska.

On the other hand, American Petroleum Association estimates indicate that over 136 billion barrels of oil remain to be recovered domestically. Similarly, the Potential Gas Supply Committee has estimated that over 1,146 trillion cubic feet of natural gas reserves remain to be discovered. Of course, the probability of achieving all such speculative reserve estimates is unknown. However, it is certain that the cost required would mean market prices in excess of those currently prevailing. Drilling deeper wells and in deeper waters offshore will be required. As such prices increase, alternative energy sources such as shale and tar sands will also become economical. Some estimates of the reserves in this area are also shown in Table 10.

All estimates discussed above refer to the United States and its offshore waters. For the rest of the world, such estimates are highly speculative. However, it has been estimated by the U. S. Bureau of Mines that over 3.5 trillion short tons of coal, 857 trillion cubic feet of natural gas and almost 500 billion barrels of oil can be classified as proven reserves. Of the petroleum supply so indicated, over 350 billion barrels exist in the Middle East. In addition, a potential exists for over 8 trillion barrels of shale oil. In summary, most observers do not foresee shortages of energy resources on a worldwide scale for the foreseeable future. Reserves are available if the economic and institutional factors can be solved. Even with respect to the domestic situation, adequate resources appear to be available for the foreseeable future, although substantial price increases may be required to tap known and potential reserves.

Current Situation

Coal: The current problems with coal can be summarized quickly. They include:

1. Environmental restrictions, including air pollution standard requirements and potential requirements with respect to strip mining.
2. The ramifications of the Mine, Health and Safety Act.
3. The location of reserves and the type of coal deposits prevalent in those reserves.

The single largest drawback to greater coal consumption in the United States has obviously been the regulations associated with our air quality standards.

Since most coal found in the eastern United States has a high sulfur content and cannot be used as mined in populated areas, the consumption of coal for electrical generation and industrial processes has been eroded over the past ten years. Current state, and proposed federal, strip mine regulations are also having a major effect on eastern United States production since much of the terrain for strip mining requires stringent reclamation procedures. These regulations and economic factors of production have spawned a major move toward strip mining coal in the western United States where reclamation processes are easier and current regulations not nearly as strict. However, western coal is at a locational disadvantage for use in the eastern United States. Moreover, although western coal is often of low sulfur content, it is also of lower heat content. Therefore, many experts feel that per unit of energy derived little difference in sulfur emmission will result from its use. Eastern coal needs assurance of continued demand if necessary investments to increase production are to be forthcoming.

The Mine, Health and Safety Act has increased deep mine production costs by approximately 10 percent. However, because coal prices on a BTU basis are currently far below those of oil, these safety requirements and reclamation requirements should not be a long run inhibition to increases in coal production. In the long run if desulfurization technology can be developed or if air pollution standards are relaxed, I would look toward a major increase in the production and consumption of coal (perhaps as much as doubling of current production by 1985). In the short run, the uncertainties associated with environmental regulations, the competition from petroleum products (due to locked in technology) and the large capital and equipment requirements necessary to substantially increase production will severely limit the amount

of increased production which we can expect from coal. Moreover, the shortage of railroad cars in much of the United States is inhibiting increased coal production from mines currently able to substantially increase output.

On the horizon, given higher prices for alternative fuel sources, is the use of coal for the production of synthetic natural gas and for use in liquefaction processes to produce synthetic oil. Already, synthetic natural gas plants using coal as the primary energy source are being constructed. The future expansion of such plants depends largely on our energy policies and market conditions with respect to other fuel sources. In any case, it is unlikely that synthetic natural gas or liquefaction processes will provide a substantial portion of our energy requirements before 1990.

Oil: For both the short and long run, petroleum is a much more critical area of concern for United States energy policy. Because of the dependence of our entire transportation sector on petroleum products, oil becomes a critical factor in the economic outlook of the nation. Even without the Middle Eastern war, petroleum products would have been in short supply this winter and for a number of years thereafter. This is due to several major factors. First, due to our oil import quota program, which was terminated last March by Presidential order, oil companies have not increased refinery capacity within the United States over the past 5 to 7 years. Because they could not be guaranteed of an assured source of oil supply from foreign sources (due to the quota program), no refinery construction was undertaken. At the same time, much of the international oil company expenditure for exploration and resource development was channeled overseas because easily found reserves in the United States had been exhausted and the cost of overseas exploration per production unit was substantially lower. Therefore, maximization of

company profits called for foreign investments. United States tax laws have encouraged this trend. Reduced drilling and reserve finds in the United States resulted even though the quota program maintained domestic oil prices at a premium to foreign prices for landed oil. The differential involved was insufficient to maintain adequate domestic exploration.

These twin factors largely accounted for the failure of the oil import quota program and its replacement last spring with a tariff. That tariff was purposely created with a differential between crude oil and the petroleum product imports. Product imports were to be taxed at a higher rate so as to encourage domestic refinery construction. Prior to the Middle Eastern situation, the change in governmental policy seemed to be having the desired effect. Numerous refinery construction starts were announced by oil companies. However, at the present time all of these announcements are in some doubt since the world situation again makes it difficult to assure a company a guaranteed long term source of crude oil supplies. Moreover, since refinery construction takes a minimum of 3 to 4 years, the major oil producing countries seem to have gained the upper hand in forcing crude oil supplies furnished by them to be refined on their own soil. I look for an increased emphasis on this point in the future by OPEC countries. This will make it more difficult for us to obtain self-sufficiency in refinery capacity unless we are able to maintain self-sufficiency in our production of crude oil itself.

Although policy changes made last spring would have beneficial, they are a good example of governmental policy which was at least 2 or 3 years too late. Moreover, the benefits of those announced changes were severely mitigated by the use of price controls over domestic production. For the first time in history, the price of foreign crude oil landed in the United States

exceeds (and sometimes by a substantial amount) that of domestic production. Again, this has encouraged foreign exploration (for example, the North Sea) rather than domestic. Although this policy problem has been recently alleviated to some extent by decontrolling the price of crude oil produced from new wells and from the so-called "stripper" wells, it is still having a dampening effect upon increased U. S. energy production. Equipment and supplies used in oil production are also in short supply due largely to price controls over certain items.

A third area of governmental policy causing problems in the oil sector is our use of the outer continental shelf areas. Although we have been actively leasing outer continental shelf lands for over 19 years, less than 2 million barrels per day of our domestic production stems from these areas. The dominant governmental policy has been to maximize revenue to the government from the leasing of these lands rather than to maximize production. In addition to increasing our dependency on foreign sources, this policy has resulted in a major capital drain that could have been used for exploration by the oil companies. U. S. Policy can be contrasted with that of Great Britain and the North Sea area. Here, exploration has been underway for less than 5 years and production is expected to reach more than 2 million barrels a day by 1978.

A fourth item contributing to the lack of domestic petroleum supply has been the failure to construct the Trans-Alaska pipeline. Although this pipeline will have little or no effect upon the supply-demand situation east of the Rockies, it would make the west coast of the United States substantially independent from foreign oil sources.

Fifth, most U. S. refineries are structured to process domestic crude which is of low sulfur content. Since foreign crude, on the other hand, is

largely high in sulfur content our refineries are not well suited to its processing. This has caused a further problem with our refinery capacity. Currently, although we are consuming 17.6 milllion barrels of oil per day, our refinery capacity is only 13.3 million barrels per day. The remainder must be satisfied by the import of petroleum products. Table 11 provides detail on our net trade with respect to petroleum (including both crude and product). As can be seen, our imports of petroleum products exceed those of foreign crude oil. However, the recent drop in oil quotas has not provided enough time to develop long term contracts for product imports.

Although the national security and national independence arguments for self-sufficiency now seem more persuasive than they did during the late fifties and early sixties, it is difficult to see how the United States with its requirements for imports of also one third of total petroleum usage can become self-sufficient in petroleum anywhere in the near future. Capital and equipment requirements for exploration and reserve development, alone, make this task nearly impossible. In addition, the current status of our offshore leasing policy (even though the acreage of annual lease sales was tripled recently) is still inadequate to make a substantial early reduction in import requirements.

Natural Gas: Contrary to popular opinion, most natural gas found in the United States is not associated with the production of oil. Over 70 percent of our natural gas production comes from wells unassociated with oil finds. Depending upon your viewpoint, the natural gas scarcity problem boils down to one of three factors. First, the lack of additional reserves available for discovery. Second, the monopolistic behavior of natural gas producers who are inhibiting production in order to maintain high profits in intrastate

(unregulated) markets. Third, the regulatory policies of the Federal Power Commission with respect to interstate wellhead gas prices. A fourth and possible contributing problem is the slow pace of leasing our outer continental shelf lands.

Most observers discount the first issue as being unsubstantiated by geological data. A great deal has been written concerning the competition question. I am not convinced, however, that monopoly power exists among natural gas producers. The predominant weight of economic opinion agrees with this conclusion. Rather, the artificially low wellhead prices established by the Federal Power Commission for interstate natural gas rates appear to be the major cause of our developing shortage. Rather than a highly elastic supply function for natural gas, which was thought to exist by many economists in the early sixties, it is now clear that the supply function is more inelastic and that artificially low prices have both restricted exploration and encouraged massive shifts in demand to natural gas. These shifts have been encouraged by our air pollution law requirements and by the convenience features of this energy source. As a result, natural gas has become the major energy source for the industrial and household sectors. Use of this pure energy form as a boiler fuel would never have developed to its current extent unless prices had been artificially low. On a BTU basis at the burner tip, the price of natural gas is currently less than one half that for petroleum products. Only in the transportation sector, where technology has locked us into petroleum, has a massive shift to the use of natural gas been avoided.

The Outlook

Environmental restrictions on the use of coal, faulty governmental policies with respect to oil, and low regulated prices for natural gas have exasperated our fuel situation by causing massive shifts in demand growth and reduced exploration domestically. Governmental policy toward refineries and superports has further aggravated the situation. Technology aimed at reducing pollution emmission from the burning of petroleum products has increased our demand for oil products. Natural gas scarcities, which began to show up in 1970, resulted in further demand shifts toward a low sulfur petroleum and petroleum products. Finally, the monopoly power of the cartel known as OPEC resulted in worldwide disruptions of the energy market for economic and political reasons. What then is the short range and long range outlook for domestic energy.

First, I view the new Federal Energy Administration and the appointment of William Simon as its director as an extremely encouraging development. Centralization of most energy policy under one aggressive administrator should begin to provide direction and substance to what has previously been an aimlessly drifting ship. Mr. Simon is an able and aggressive administrator who can quickly analyze and evaluate problem areas and act with dispatch.

Second, we are currently experiencing a shortfall of petroleum of between 3 and 3.5 million barrels per day. Even if OPEC decides to modify their current boycott, it will be at least 90 days before new oil can arrive in the United States and be processed for use. Due to this and the fact that refinery output has been switched to encourage fuel oil production, we are guaranteed a shortage of gasoline, at current prices, during the summer months.

Third, with respect to this winter, some localized shortages of heating oil will occur but it would appear that a major shortfall may be avoided if

weather conditions stay mild. An increased severity in weather, failure to conserve at least 10 to 15 percent of last year's fuel oil consumption or a further worsening of the international situation could, however, result in severe fuel oil problems.

Fourth, the petroleum product now in critical supply appears to be the residual oil utilized by many east coast electrical utilities. Since much of this product is imported and requires a low sulfur content, brown outs and reduced voltage may be the rule along the east coast by the middle of January.

Fifth, as a result of the shortfall, higher prices for all petroleum products are guaranteed. These will probably result from a combination of market forces and increased federal taxes. Uncertainties surrounding the political negotiations make it very difficult to forecast but $.75 to $.80 per gallon of gasoline appears to be well within reality by late next spring. Prices of $.35 per gallon of fuel oil are also considered attainable. The result will be a substantial increase in inflationary pressures but the final impact on the consumer price index will depend upon whether other components of the index offset the petroleum increases. Energy currently makes up approximately 6 percent of the value of the index.

Sixth, little difficulty should be experienced by residential consumers in obtaining adequate supplies of natural gas but interruptable service consumers may have difficulty if winter conditions become severe.

Seventh, conservation measures will have a relatively small effect on total oil demand in the short run (less than 7 percent of petroleum usage) but could be potentially valuable in the long run. Estimates of savings as high as 3.5 million barrels per day of crude oil by 1980 have been made if

a conserted effort is made to modify our transportation system and improve the efficiency of energy use for space heating and lighting purposes.

Eighth, although current users of natural gas and coal will have little trouble in obtaining needed supplies, the possibilities for substitution of these fuel sources for petroleum, when technology permits, will be severely curtailed and limited.

Finally, the pervasive dependence of our economy on readily available energy makes it likely that if a solution to the Middle East problem is not found within the next month, a severe recession will develop in the first and second quarters of 1974. Forecasts of a 10 percent unemployment rate do not appear to me to overstate the severity of the problem. This could well be accompanied by a zero or negative rate of real growth in gross national product and a 6-8 percent rate of inflation.

What of the longer term? First, given our seeming political resolve to become independent of a single petroleum supply source, prices will need to increase substantially in order to encourage domestic exploration, development of technology to utilize our abundant energy resource (coal), and to substantially reduce the rate of growth in domestic consumption. The alternative to such a course of action is a perpetual system of import dependence. Long run implementation of this policy will, however, maintain a continued upward pressure on the inflation indices. Some balance will need to be struck over the long term.

On the other hand, the OPEC countries are perfectly capable of doing an about face in their present export policies if they see a long term threat to their largest markets. It would not be surprising to see some reductions in foreign prices after several years. These reductions would probably be just sufficient to force the United States to reconsider development of substitute sources of energy.

Second, President Nixon's announced program - "Project Independence" - to make this country self-sufficient in energy production by 1980 is considered by most exports to be infeasible and unworkable. This is particularly true in the petroleum sector. Even with sharp price increases curtailing the rate of growth in petroleum consumption and encouraging domestic exploration, most forecasting models do not foresee any drop in our need for imports on an absolute basis. Even with massive shifts in demand away from petroleum to natural gas and/or coal resources and a substantial increase in federal leasing policy for offshore areas, it is difficult to forecast a U. S. production of more than 14.5 million barrels per day of crude oil by 1985. At best, we will only be able to hold domestic consumption in 1985 to around 21 to 22 million barrels per day. Thus, at least modest annual increases in our rate of imports must be accomodated. Forecasts like this generally assume long term prices in the area of $9 to $10 per barrel at the wellhead which is approximately 2.5-3.0 times last year's domestic price.

Third, without legislation to deregulate the wellhead price of natural gas or substantially higher regulated prices, our supply of natural gas will continue to dwindle with resultant curtailments in usage and economic dislocations. Free market pricing in the natural gas market could alleviate shortage situations within a period of 5 years.

Finally, it is now much more evident that our energy problems will be deeper and longer lasting than most Americans perceive. This will result in substantial changes in energy markets with the resultant effect that Americans will slowly be forced to realize that substitution in terms of their life styles may be economically beneficial. Thus, I look for slowly changing but ultimately rather pervasive switches in how America conducts its business over the next 10 years.

APPENDIX A

Historical Energy Statistics

TABLE 1

SELECTED UNITED STATES ECONOMIC AND ENERGY INDICATORS, 1947-1972

Year	Gross energy input[1] (Quadrillion BTU)	Net energy input[2] (Quadrillion BTU)	Population (Millions)	Gross National Product (Billion of $ 1958)	Gross energy/ GNP (1000's of BTU)	Gross energy/capita (Millions of BTU)	Net energy/capita (Millions of BTU)	Conversion Efficiency[3] (Percent)
1947	33.0	29.2	144.1	309.9	106.4	229.0	202.8	88.5
1950	34.0	29.7	152.3	355.3	95.7	223.2	194.8	87.3
1955	39.7	34.3	165.9	438.0	90.6	239.3	206.7	86.4
1960	44.6	38.2	180.7	487.7	91.4	246.8	211.5	85.7
1961	45.3	38.7	183.8	497.2	91.1	246.5	210.6	85.8
1962	47.4	40.5	186.5	529.8	89.5	254.1	217.2	85.5
1963	49.3	42.0	189.2	551.0	89.5	260.5	222.0	85.2
1964	51.2	43.6	191.8	581.1	88.1	266.9	227.3	85.5
1965	53.3	45.3	194.2	617.8	86.3	274.4	232.1	85.0
1966	56.4	47.6	196.5	658.1	85.7	287.0	242.2	83.8
1967	58.3	50.4	198.6	675.2	86.3	293.5	253.8	86.4
1968	61.7	51.7	200.6	706.6	87.3	307.5	257.7	83.7
1969	65.0	54.4	202.6	724.7	89.7	320.8	268.5	83.7
1970	67.4	56.0	204.8	720.0	93.6	329.1	273.6	83.1
1971	68.7	56.8	207.0	741.7	92.6	331.9	274.4	82.6
1972[p]	72.1	59.5	208.8	789.7	91.3	345.3	285.0	82.5

Source: U. S. Bureau of Mines

[p]Preliminary

[1]Gross energy is the total of inputs into the economy of the primary fuels (petroleum, natural gas, and coal, including imports) or their derivatives, plus the generation of hydro and nuclear power converted to equivalent energy inputs.

[2]Net energy is the sector inputs (household and commercial, transportation, and industrial), and consists of direct fuels and purchased electricity.

[3]The conversion efficiency factor is the percent of total gross energy going into the sectors.

TABLE 2

UNITED STATES TOTAL GROSS CONSUMPTION OF ENERGY RESOURCES BY MAJOR SOURCES,[1] 1947-72
(Trillion BTU)

Year	Anthracite	Bituminous coal and lignite	Natural gas, dry[2]	Petroleum[3]	Total fossil fuels	Hydropower	Nuclear power	Total gross energy inputs	Percentage change from prior year
1947....	1,224	14,600	4,518	11,367	31,709	1,326	--	33,035	--
1950....	1,013	11,900	6,150	13,489	32,552	1,440	--	33,992	+8.0
1955....	599	10,941	9,232	17,524	38,296	1,407	--	39,703	+9.5
1960....	447	9,693	12,699	20,067	42,906	1,657	6	44,569	+3.3
1961....	404	9,502	13,228	20,487	43,621	1,680	18	45,319	+1.7
1962....	363	9,826	14,121	21,267	45,577	1,821	24	47,422	+4.6
1963....	361	10,353	14,843	21,950	47,507	1,767	34	49,308	+4.0
1964....	365	10,899	15,648	22,386	49,298	1,907	35	51,240	+3.9
1965....	328	11,580	16,098	23,241	51,247	2,058	38	53,343	+4.1
1966....	290	12,205	17,393	24,394	54,282	2,073	57	56,412	+5.8
1967....	274	11,982	18,250	25,335	55,841	2,344	80	58,265	+3.3
1968....	258	12,401	19,580	27,052	59,291	2,342	130	61,763	+6.0
1969....	224	12,509	21,020	28,421	62,174	2,659	146	64,979	+5.2
1970....	210	12,712	22,029	29,614	64,565	2,650	229	67,444	+3.8
1971....	186	11,887	22,819	30,570	65,462	2,862	404	68,728	+1.9
1972....	149	12,279	23,308	32,812	68,548	2,937	606	72,091	+4.9

Source: U. S. Bureau of Mines

[1]Gross energy is that contained in all types of commercial energy at the time it is incorporated in the economy, whether the energy is produced domestically or imported. Gross energy comprises inputs of primary fuels (or their derivatives), and outputs of hydropower and nuclear power converted to theoretical energy inputs. Gross energy includes the energy used for the production, processing, and transportation of energy proper.

[2]Excludes natural gas liguids.

[3]Petroleum products including still gas, liquefied refinery gas, and natural gas liquids.

TABLE 3

PERCENTAGE CHANGE FROM PRIOR YEAR IN UNITED STATES
TOTAL GROSS CONSUMPTION OF ENERGY RESOURCES BY MAJOR SOURCES, 1950-72

Year	Anthracite	Bituminous coal and lignite	Natural gas, dry	Petroleum	Total fossil fuels	Hydropower	Nuclear power	Total gross energy inputs
1950	-24.9	+1.9	+16.3	+11.3	+8.4	-0.6	-	+8.0
1955	-12.3	+15.0	+8.0	+8.6	+9.8	+1.4	-	+9.5
1960	-6.5	+3.9	+5.9	+1.6	+3.3	+4.1	+200.0	+3.3
1961	-9.6	-2.0	+4.2	+2.1	+1.7	+1.4	+200.0	+1.7
1962	-10.2	+3.4	+6.8	+3.8	+4.5	+4.8	+33.3	+4.6
1963	-0.6	+5.4	+5.1	+3.2	+4.2	-3.0	+41.7	+4.0
1964	+1.1	+5.3	+5.4	+2.0	+3.8	+7.9	+2.9	+3.9
1965	-10.1	+6.2	+2.9	+3.8	+4.0	+7.9	+8.6	+4.1
1966	-11.6	+5.4	+8.0	+5.0	+5.9	+0.7	+50.0	+5.8
1967	-5.5	-1.8	+4.9	+3.9	+2.9	+13.1	+40.4	+3.3
1968	-5.8	+3.5	+7.3	+6.8	+6.2	-0.1	+62.5	+6.0
1969	-13.2	+0.9	+7.4	+5.1	+4.9	+13.5	+12.3	+5.2
1970	-6.3	+1.6	+4.8	+4.2	+3.8	-0.3	+56.8	+3.8
1971	-11.4	-6.5	+3.6	+3.2	+1.4	+8.0	+76.4	+1.9
1972[p]	-19.9	+3.3	+2.1	+7.3	+4.7	+2.6	+50.0	+4.9

[p] Preliminary

TABLE 4

UNITED STATES TOTAL PRODUCTION OF ENERGY RESOURCES BY MAJOR SOURCES, 1947-72
(in Trillions of Btu)

Year	Anthracite	Bituminous coal and lignite	Natural gas, dry	Petroleum	Total fossil fuels	Hydropower	Nuclear power	Total gross energy inputs	Percentage change from prior year
1947....	1,453	16,522	5,012	10,771	33,758	1,296	---	35,054	-
1950....	1,120	13,527	6,841	11,449	32,937	1,415	---	34,352	+12.3
1955....	665	12,080	[1]10,532	[1]14,445	[1]37,722	[1]1,360	---	39,082	+10.8
1960....	478	10,662	[1]14,135	[1]14,664	[1]39,939	[1]1,608	6	41,553	+2.1
1961....	443	10,308	14,691	15,185	40,627	1,656	18	42,301	+1.8
1962....	429	10,782	15,365	15,495	42,071	1,816	24	43,911	+3.8
1963....	464	11,712	16,271	15,741	44,188	1,768	34	45,990	+4.7
1964....	436	12,418	17,138	15,691	45,683	1,886	35	47,604	+3.5
1965....	378	13,017	17,652	15,930	46,977	2,059	38	49,074	+3.1
1966....	329	13,507	18,984	16,925	49,745	2,062	57	51,864	+5.7
1967....	311	13,904	20,087	18,100	52,402	2,347	80	54,829	+5.7
1968....	291	13,664	21,548	18,593	54,096	2,349	130	56,575	+3.2
1969....	266	13,957	22,838	18,886	55,947	2,648	146	58,741	+3.8
1970....	247	15,001	24,154	19,772	59,174	2,630	229	62,033	+5.6
1971....	222	13,451	24,805	19,322	57,800	2,862	404	61,066	-1.6
1972[p]....	180	14,372	25,284	19,432	59,268	2,937	606	62,811	+2.9

[p] Preliminary

[1] Denotes first year for which figures include Alaska and Hawaii

TABLE 5

PERCENTAGE CHANGE FROM PRIOR YEAR IN UNITED STATES TOTAL PRODUCTION OF ENERGY RESOURCES BY MAJOR SOURCES, 1950-72

Year	Anthracite	Bituminous coal and lignite	Natural gas, dry	Petroleum	Total fossil fuels	Hydropower	Nuclear power	Total gross energy inputs
1950	+3.2	+17.9	+15.7	+7.2	+13.0	-0.7	----	+12.3
1955	-10.0	+17.7	+11.0	+7.6	+11.2	---	----	+10.8
1960	-8.8	+0.8	+5.8	----	+2.1	-3.7	+200.0	+2.1
1961	-7.3	-3.3	+3.9	+3.6	+1.7	+3.0	+200.0	+1.8
1962	-3.2	+4.6	+4.6	+2.0	+3.6	+9.7	+33.3	+3.8
1963	+8.2	+8.6	+5.9	+1.6	+5.0	-2.7	+41.7	+4.7
1964	-6.0	+6.0	+5.3	-0.3	+3.4	+6.7	+2.9	+3.5
1965	-13.3	+4.8	+3.0	+1.5	+2.8	+9.2	+8.6	+3.1
1966	-13.0	+3.8	+7.5	+6.2	+5.9	+0.1	+50.0	+5.7
1967	-5.5	+2.9	+5.8	+6.9	+5.3	+13.8	+40.4	+5.7
1968	-6.4	-1.7	+7.3	+2.7	+3.2	+0.1	+62.5	+3.2
1969	-8.6	+2.1	+6.0	+1.6	+3.4	+12.7	+12.3	+3.8
1970	-7.2	+7.5	+5.8	+4.7	+5.8	-0.7	+56.8	+5.6
1971	-10.1	-10.3	+2.7	-2.3	-2.3	+8.8	+76.4	-1.5
1972[p]	-18.9	+6.9	+1.9	+0.6	+2.5	+2.6	+50.0	+2.9

Source: U. S. Bureau of Mines

[p]Preliminary

TABLE 6

FOSSIL FUEL PRICES: 1960-1972
(1972 dollars)*

Year	Domestic Natural Gas: Average Wellhead Price/MCF	Domestic Natural Gas: New Gas Interstate Price/MCF	Domestic Crude Oil: Average Well-head Price/Barrel	Foreign Crude Oil: Weighted Average Cost (Landed)	Petroleum Products: Gasoline	Petroleum Products: Residual	Domestic Coal Average F.O.B. Mine Price/Ton	Electricity Ave. Cents/ KWH
1960	$.198	NA	$4.07	$--	$--	$.0652/gal	$6.62	$.0239
1961	.211	NA	4.03	2.48	--	.0641	6.39	.0236
1962	.214	NA	4.00	2.69	--	.0626	6.18	.0232
1963	.215	NA	3.93	2.78	.1971/gal	.0597	5.98	.0225
1964	.206	NA	3.86	2.67	.1898	.0576	5.96	.0217
1965	.205	NA	3.76	2.66	.1942	.0607	5.84	.0209
1966	.201	.236	3.69	2.68	.1951	.0583	5.81	.0200
1967	.199	.237	3.61	2.89	.1959	.0544	5.73	.0194
1968	.196	.229	3.51	2.92	.1916	.0499	5.57	.0185
1969	.190	.225	3.52	2.94	.1905	.0467	5.68	.0175
1970	.185	.225	3.43	3.01	.1877	.0645	6.75	.0172
1971	.188	.232 (approx.)	3.49	3.17	.1854	.0750	7.28	.0174
1972	.196	Probably exceeds .300	3.39	3.03	.1722	.0585	7.46	NA

Source: Office of the Secretary, U. S. Department of the Interior

* Implicit price deflator for total gross national product used for columns 1,2,3,7 and 8; for imports for column 4, and for total personal consumption expenditures for columns 5 and 6.

TABLE 7

DEMAND FOR ENERGY INPUTS TO INDUSTRIAL SECTOR, 1947-72

Year	Natural Gas		Petroleum		Coal		Electricity Purchased		Total Sector Inputs
	Million cubic feet	Trillion BTU	Million barrels	Trillion BTU	Thousand short tons	Trillion BTU	Billion Kilowatt-hours	Trillion BTU	Trillion BTU
1947..	2,905,571	3,007	423.0	2,517	273,403	7,298	135	459	13,281
1950..	3,601,757	3,727	446.8	2,666	223,507	5,957	164	559	12,909
1955..	4,768,562	4,935	579.8	3,406	214,946	5,726	295	1,008	15,075
1960..	6,074,114	6,287	643.9	3,682	175,225	4,673	383	1,306	15,948
1961..	6,221,668	6,471	642.6	3,682	168,090	4,478	383	1,306	15,937
1962..	6,579,008	6,842	678.8	3,880	169,995	4,527	411	1,402	16,651
1963..	6,917,738	7,160	702.0	3,994	178,201	4,754	429	1,464	17,372
1964..	7,198,706	7,451	744.6	4,184	189,561	5,063	453	1,544	18,242
1965..	7,433,200	7,671	740.4	4,139	200,688	5,366	479	1,634	18,810
1966..	7,948,486	8,203	781.0	4,353	204,945	5,472	524	1,788	19,816
1967..	8,332,614	8,599	798.4	4,432	194,595	5,199	547	1,868	20,098
1968..	8,987,095	9,274	897.2	4,965	191,602	5,124	599	2,044	21,407
1969..	9,587,670	9,885	943.6	5,171	188,586	5,051	632	2,155	22,262
1970..	9,856,844	10,162	961.4	5,267	186,637	5,004	648	2,210	22,643
1971..	10,252,000	10,570	927.3	5,094	159,320	4,330	672	2,293	22,287
1972[p]..	10,400,457	10,723	1009.3	5,544	163,993	4,457	722	2,465	23,189

Source: Division of Fossil Fuels, Bureau of Mines, U.S. Department of the Interior.

[p]Preliminary

TABLE 8

DEMAND FOR ENERGY INPUTS IN TRANSPORTATION SECTOR 1947-1972

Year	Coal[1]		Petroleum[2]		Natural Gas		Utility Electricity Purchased		Total Energy Input
	Thousand short tons	Trillion BTU	Million barrels	Trillion BTU	Million cubic feet	Trillion BTU	Billion Kilowatt-hours	Trillion BTU	Trillion BTU
1947...	113,324	3,030	1,050.3	5,761	Neg	--	8	29	8,820
1950...	63,783	1,701	1,248.8	6,785	125,546	130	7	24	8,640
1955...	17,429	464	1,691.4	9,109	245,246	253	6	19	9,845
1960...	3,294	87	1,934.1	10,372	347,075	359	5	18	10,836
1961...	770	21	1,971.9	10,575	377,607	390	6	19	11,005
1962...	687	18	2,051.3	11,001	382,496	396	5	18	11,433
1963...	670	18	2,146.7	11,506	423,783	438	6	19	11,981
1964...	711	19	2,198.9	11,791	435,570	451	6	20	12,281
1965...	655	18	2,271.9	12,179	500,524	517	5	18	12,732
1966...	609	16	2,382.6	12,777	535,353	552	5	16	13,361
1967...	467	13	2,497.1	13,408	575,752	594	5	17	14,032
1968...	417	11	2,703.8	14,535	590,965	610	5	18	15,174
1969...	313	8	2,815.8	15,125	630,962	651	5	17	15,801
1970...	298	8	2,902.8	15,592	722,166	745	5	16	16,361
1971...	214	6	3,032.3	16,286	742,788	766	5	17	17,075
1972[p]...	214	6	3,208.2	17,231	774,788	799	5	18	18,054

Source: Division of Fossil Fuels, Bureau of Mines, U. S. Department of the Interior

[p]Preliminary

[1]Includes anthracite, bituminous, and lignite coals.

[2]Includes bunkers and military transportation.

TABLE 9

DEMAND FOR ENERGY INPUTS IN HOUSEHOLD AND COMMERCIAL SECTORS, 1947-1972

Year	Natural Gas		Petroleum		Coal		Electricity Purchased		Total Energy Inputs
	Million cubic feet	Trillion BTU	Million barrels	Trillion BTU	Thousand short tons	Trillion BTU	Billion Kilowatt-hours	Trillion BTU	Trillion BTU
1947...	1,087,000	1,125	385.3	2,251	128,657	3,399	115	391	7,148
1950...	1,586,207	1,642	526.2	3,038	110,422	2,913	160	546	8,139
1955...	2,753,171	2,849	691.7	4,001	66,039	1,745	250	854	9,449
1960...	4,123,389	4,268	853.3	4,923	37,180	983	370	1,262	11,436
1961...	4,325,427	4,477	871.9	5,028	32,805	868	406	1,385	11,758
1962...	4,685,231	4,849	907.7	5,227	32,955	872	437	1,490	12,438
1963...	4,856,804	5,027	915.0	5,258	27,603	731	482	1,645	12,661
1964...	5,162,009	5,343	903.7	5,191	22,949	609	525	1,792	12,935
1965...	5,346,450	5,517	978.0	5,635	25,676	678	571	1,948	13,778
1966...	5,760,999	5,945	1,000.1	5,766	25,587	677	616	2,101	14,489
1967...	6,029,855	6,223	1,078.9	6,206	22,134	585	661	2,257	15,271
1968...	6,250,997	6,451	1,069.5	6,129	19,983	529	723	2,467	15,576
1969...	6,682,804	6,890	1,099.6	6,269	16,875	447	807	2,752	16,358
1970...	6,894,007	7,108	1,128.4	6,453	16,114	427	879	3,000	16,988
1971[p]...	7,144,398	7,366	1,131.2	6,440	15,253	408	941	3,209	17,423
1972[p]...	7,399,486	7,629	1,174.9	6,689	14,356	384	1,011	3,449	18,151

Source: Division of Fossil Fuels, Bureau of Mines, U.S. Department of the Interior.

[p]Preliminary

TABLE 10

ESTIMATES OF UNITED STATES RECOVERABLE ENERGY RESERVES - Dec. 31, 1971[1]

Energy Source	Units	Quantity	Trillion BTU
1. Anthracite Coal	,000 short tons	8,035,300	204,097
2. Bituminous Coal and Lignite	,000 short tons	578,397,000	14,089,751
3. Crude Oil	,000 barrels	38,062,957	220,765
4. Natural Gas Liquids	,000 barrels	7,304,227	33,746
5. Natural Gas	,000,000 cu. ft.	278,805,618	287,449
6. Uranium	,000 pounds recoverable U_3O_8	546,424	------
7. Shale Oil	,000 barrels	600,000,000	3,480,000
8. Tar Sands	,000 barrels	17.7-27,600,000	------

[1]Coal reserves based upon economically recoverable resource at current prices. Uranium reserves based upon $8.00 per pound U_3O_8. Oil and gas reserves based upon API and AGA power reserve estimates. Shale oil reserves include only Green River Formation reserves which average 25 gallons of oil per ton.

Source: U. S. Bureau of Mines

TABLE 11

UNITED STATES NET TRADE, CRUDE OIL- 1947-72
(In Million BBLS)

Year	Exports		Imports		Net trade	
	Crude oil	Product	Crude oil	Product	Crude oil	Product
1947...	-46	-118	98	62	52	-56
1950...	-35	-77	178	133	143	+56
1955...	-12	-123	285	170	273	+47
1960...	-3	-71	372	293	369	+222
1965...	-1	-67	452	449	451	+382
1970...	-5	-90	483	765	478	+675
1971...	-1	-81	613	820	612	+739
1972[p]...	-0.2	-80	798	917	798	+837

Source: U. S. Bureau of Mines

[p]Preliminary