ALTERNATIVE ENERGY FUTURES?

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Introduction

The United States, indeed the entire western world, is in serious trouble - economically and strategically. One fundamental problem is the root cause. That problem is the failure to secure a certain energy supply for the 1980's. How we handle this issue will effectively determine if this country, as we know it today, exists in 1990. Our rate of economic growth, the course of inflation, life styles, employment patterns, and virtually all the comforts of life we now take for granted are intimately tied to the question of energy supply.

But why, in a country as endowed with energy resources as the United States, is there an energy supply problem? There are two interrelated answers. One is the rapid depletion of our domestic oil resource and the other is the lack of time. The energy crisis is primarily one of liquid fuels refined from domestic crude oil. But we are rapidly running out of the time needed, if that has not already occurred, to find adequate new supplies, develop crude oil substitutes, allow conversion of existing petroleum uses to alternative fuels and develop adequate conservation programs. Since the United States, and the world, are petroleum based economies, the result can only be a substantial period of unwanted change, economic upheaval, and eventual accomodation.

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Literally thousands of factors, however, affect which of the many possible alternative energy futures will become reality. As a result, both the outlook for next year and the longer term prospects are highly uncertain. I will review these prospects, discuss the historical factors that have led to our current situation and attempt to provide an evaluation of the policy prescriptions being proposed by our nation's decision makers.

The Outlook

The world can no longer count on increases in oil production to meet the energy requirements needed to fuel economic growth. Current oil consumption is exceeding new discoveries by a substantial degree. This has led to falling U.S. production and will shortly result in production declines in the Soviet Union. Countries with large reserves vis-a-vis production are increasing capacity slowly or not at all. Although some excess capacity exists in certain Persian Gulf nations, production there is unlikely to increase substantially from its current level. Political, economic, geological and social factors all mitigate against such an increase. Production from OPEC countries outside the Persian Gulf is limited by capacity and major changes are unlikely in the next several years. Outside of OPEC, increases in North Sea and Mexican production will be largely offset by declines in production from the U.S. and the USSR. By 1983, North Sea production will also peak.

On the supply side, therefore, one can expect little better than the status quo. Demand for petroleum, however, continues to rise. In the United States, for example, consumption during the first six months of 1979 averaged over 19 million barrels per day. This is almost 10 percent more than the 17.3 million barrels per day consumed in 1973 (the year of the Arab oil embargo) and includes a period of slack consumption due to the spring Iranian situation. Demand in 1980 will be dependent on the severity of any recession and the degree of future price increases. Recent experience, however, indicates that even a recession as deep as the one of 1974-75 will reduce petroleum consumption by less than half a million barrels per day. Furthermore, the relative increase in oil prices during the last year has been less than after the 1973 Arab oil embargo; thus, the conservation impacts may not be as great.

The near term outlook is, thus, not optimistic. Worldwide, the consumption and production of petroleum is within a half a million barrels per day of precise balance. In the near future, this situation will probably continue as a result of the production ceilings imposed by OPEC producers and the difficulties in Iran. Within several years, however, even moderate rates of economic growth will result in severe shortages of production capacity. In either case, the outlook is for ever increasing tightness in oil supplies and substantially higher prices.

Long term contracts could easily reach $30.00 per barrel before mid-1980 and as high as $40.00 per barrel by the end of the year (compared with a current world price that averages over $21.00, an average price in 1978 of $14.57, and the average landed price of $3.03 per barrel in 1972). If OPEC raises their base price to $26.50 per barrel at the December meeting, there will have been an 82 percent price increase over the past year alone. Because of the worldwide uncertainty over future oil supplies, spot market prices are likely to lead the price rises -- trending steeply upward and with a great deal of short term volatility. Of equal importance, is the fact that spot market sales now account for over 20 percent of all the oil traded in the world market, up from just 3 to 5 percent a year ago. With the recent U.S. action regarding Iranian supplies, the proportion of sales on the spot market will escalate even further. This movement away from contract sales by the oil exporting countries permits a market psychology that leads to rapid price increases.

As petroleum prices increase, a roller coaster effect is established in the developed countries. The higher prices from each round of price revisions are first absorbed and economic activity begins to rebound. Increased economic activity then runs up against shortages in oil supply, leading to yet another round of energy price increases, attendant inflation and incipient recession. On the side of the oil producing countries, as prices rise, pressure mounts to reduce production because of large financial surpluses. This pressure is abetted during times of rapid inflation because oil becomes more valuable in the ground (economists will recognize this as a classic case of the backward bending supply curve).

Yet our present rate of inflation is substantially dependent on energy prices. (Ten percent of the consumer price index and 15 percent of the producer price index are directly dependent on energy prices and virtually the entire index is indirectly affected. As a result, almost half of the 1979 inflation rate can be accounted for by higher energy prices.)

The more important future impact, however, will be the lack of available energy to run our economic system. For this winter, we are almost assurred of adequate heating oil supplies (due to the stockpiling program, warmer than normal weather during the first part of the heating season and the impact of conservation). Later next year, however, some shortages will develop unless the Iranian problem is resolved or gasoline consumption drops by 2 to 3 percent. Even without the additional complication of Iran, only recession and the maintenance of a high production ceiling by Saudi Arabia would insure the absence of supply shortfalls in 1980. Since supply and demand are so close to balance, on a worldwide basis, only a slight perturbation in production and delivery capability need to occur for pervasive shortages to reappear at any time. Consider the following:

1. The strong possibility that political and/or policy factors will further reduce oil shipments to the rest of the world from Iran;
2. The substantial risk that production cutbacks could occur in Saudi Arabia, Nigeria, Libia, Kuwait, Iraq, Venezuela, Canada and/or Algeria (all threatened or possible for political reasons),
3. Sabotage resulting in the disruption of vital oil pipelines in the Middle East or of shipping lanes in the Straits of Hormuz;
4. Slower production increases than anticipated from Mexico;
5. An extraordinarily harsh winter in the United States;
6. More rapid U.S production declines then anticipated due to field depletions (Texaco, for example, just revised their reserves estimates substantially downward);
7. Logistical or mechanical problems resulting in delivery disruptions from the Trans-Alaska Pipeline; or
8. An acceleration in the recent pace of worldwide stockpiling.

A shortage caused by any one or a combination of these factors would leave the U.S. highly vulnerable. As a result of declining petroleum production and rising demand, the United States is currently importing almost fifty percent of the oil it consumes, either as raw crude or refined product. Even with severe conservation measures, these import levels will continue to rise due to an increasely rapid decline in domestic U.S. production.

The only immediate offset available to a supply disruption is the Strategic Petroleum Reserve (SPR) program which currently has 90 million barrels of oil stored and is able to supply up to a million barrels a day to domestic refiners. Thus, should we choose to use it, this stockpile could insulate the country from a shortfall of as much as a million barrels per day for up to 90 days. However, no additions have been made to the reserve for some time because of tightness in the world market and once the reserve is depleted the outlook is not bright for its replenishment.

Nor do we have other choices. All large scale solutions to our supply problem will take many years, billions of dollars of investment and substantially higher costs in terms of product prices. Synthetic fuel facilities, new domestic crude oil finds, solar power, an operational electric car, fusion power or other exotic sources will not be feasible solutions during the 1980's. Only increased conservation or short turn around production facilities for oil substitutes such as gasohol are now available. But, for the next decade, solutions based on conservation would require unprecedented reductions in the rate of petroleum consumption. And a massive conservation program will take a substantial period of time to implement. The most optimistic observers do not foresee conservation, alone, as an adequate answer to supply shortfalls. And ethanol production, while capable of rapid implementation, does not afford a sufficient supply base to provide more than marginal additions to liquid fuels in the near future.

Thus, for the next decade, adequate solutions to diminishing oil supplies are not in sight. Although there is a slim chance that the U.S. may make it through 1980 without widespread shortages of oil, it is unlikely to do so in 1981. In fact, until an effective energy policy reduces dependence on foreign oil supplies or contains price increases, low economic growth rates, high rates of inflation and increasingly severe shortages of liquid fuels will be a way of life.

Historical Prospective

What has led to the current situation and how close is the United States to extraditing itself from supply uncertainty? An historical prospective drawn from our energy and economic statistics can provide some clues to these questions.

Economic Indicators: Referring first to Table 1 (Appendix A), let's review the manner in which energy use has changed in the past. Gross energy consumption (which is the total input of primary fuels to the economy) in the United States has increased from 33 quadtrillion BTU's in 1947 to over 78 quadtrillion BTU's in 1978. This represents more than a 2.7 percent annual rate of growth in energy demand. Up to 1972 this growth rate was 3.1 percent annually, but after the Arab oil embargo the rate lowered to less than 0.8 percent on an average annual basis. However, the bulk of that decline occurred because of the 1974-75 recession. Thus, while up to 1972, our use of gross energy was doubling every 23 years, it would double every 88 years if the average growth rate since 1972 were to continue. However, if that growth rate is primarily due to the 1974-75 recession, more recent increases averaging 2.4 percent per year would mean a doubling of use every 29 years.

As a comparison, gross national product increased at an average annual rate of 3.7 percent from 1947 to 1972, allowing gross energy consumption per dollar of GNP to decline at the rate of .6 of 1 percent per year. After 1972, GNP increased at an annual rate of 1.9 percent while gross energy use per dollar of GNP declined at the annual rate of 1.1 percent. Likewise, the rate of increase in gross energy use per capita has slowed considerably (from 1.4 to 0.6 percent), while the use of net energy per capita has shown considerable sidewise oscillation since 1972.

Net energy consists of energy use by each input sector after appropriate conversions in form have taken place. During the 1947-78 period, net energy inputs increased at average annual growth rate of 2.3 percent (dropping to 0.2 percent after 1972). Largely as a result of increased electrical energy usage relative to total energy usage, conversion efficiency decreased over the same time period from 88.5 percent in 1947 to 78.4 percent in 1978. This downward trend of 0.4 percent per year will continue as we become more dependent on electrical power.

In general, these values may indicate that a fundamental structural shift has begun to take place in both our energy consumption and our rate of economic growth since the 1973 Arab oil embargo. The impact of energy inflation on GNP is becoming evident and the effect of increased conservation is clearly shown by the accelerating decline in energy use per dollar of GNP. However, the rate of that decline has not been adequate to maintain both stable oil import levels and rising GNP, nor have the American people yet learned to live with less energy use per capita.

Consumption: As the data in Table 2 indicate, shifts in the use of energy resources continue to take place. Anthracite coal, which for years has declined in importance as an energy source, has stablized its production. Moreover, it may be poised for a turnaround due to the demand for low sulfur coal and recent regulations that permit utility plants using anthracite to avoid the installation of stack scrubbers. However, due to its relative scarcity within the continental United States, anthracite will never be a major energy source. On the other hand, although we are blessed with abundant resources of bituminous coal and lignite, production over the past 32 years has seen severe fluctuations and is still at a lower level than occurred in 1947. The reasons for this shift are numerous. To a large extent, changes in techology 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. But coal again seems poised for a renewed role in our energy picture as political barriers are lowered and the alternatives diminish.

Natural gas and petroleum products, on the other hand, have experienced soaring consumption in the past. Natural gas use increased at a 6.5 percent annual growth rate up until 1972. Since that time, our limited reserves have forced a 2.1 percent annual decline. Petroleum use, beginning from a larger base, grew at a 4.2 percent annual rate up to 1972. This increase has since slowed to an annual rate of 1.4 percent as higher prices and recession have limited demand (but a rate of growth which still exceeds that for overall energy consumption). Nuclear power is also experiencing a spectacular growth rate but still supplies only a small percentage of total

U.S. energy demands (less than 4 percent). This is now likely to stablize and could decline through the end of the century if nuclear power is phased out. Hydropower, another relatively small contributor to total energy resources, is slowing its rate of growth as potential sites for large installations are exhausted. Seemingly large fluctuations in the annual production of hydropower can be traced directly to weather conditions affecting reservoir utilization. Energy from other sources is almost irrelevant at this time.

Year to year percentage changes in these various consumption patterns can be seen by referring to Table 3. In general, the U.S. economy is largely dependent for energy on fossil fuel sources although some rather interesting shifts in demand among these sources have occured historically and continue to change our total supply picture. Note especially that, with the exception of the 1974-75 recession, total energy consumption and use of petroleum, in particular, have continued their rapid rates of annual growth.

Sectorial Demand: Tables 4, 5 and 6 provide a breakout of energy inputs to the various final demand sectors. In 1978, of the net energy consumption in the U.S. economy, over 36 percent is attributable to the industrial sector, 34 percent to the transportation sector and 30 percent to the household and commercial sectors. Agriculture accounts for 2 percent of U.S. energy consumption and approximately 8 percent of total distillate consumption. Note that the transportation component of of final household and industrial demand is included under the transportation sector. Likewise, electrical usage is divided among the various sectors. Over time, the transportation and household sectors have increased their consumption at the expense of the industrial sector.

For each individual sector of final demand, it is interesting to note the sources of energy consumed. For the industrial component, over 37 percent of its net energy intake is derived from natural gas, with 34 percent from petroleum, 16 percent directly from coal and 12 percent from electricity. For the transportation component, over 97 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 35 percent from petroleum with 22 percent from electricity and the remainder from coal. Although not shown in table form, the electrical production required for the other three sectors is over 44 percent derived from coal, almost 14 percent from natural gas and 17 percent from petroleum (the remainder is from nuclear, hydro and other sources).

Viewed from the standpoint of each individual source, almost 42 percent of natural gas consumption takes place in the industrial sector with 39 percent in the household sector, and 19 percent in the electrical sector. Almost 76 percent of U.S. coal consumption is used to generate electricity and the remainder is used mainly for industrial purposes. The transportation sector accounts for almost 53 percent of total petroleum use whereas 17 percent is used by the household sector, 20 percent by the industrial sector and 10 percent by the electrical generating sector. From these values, it is obvious that if petroleum is in critical supply, cuts in transportation provide the most flexible and immediate means of conservation.

Table 7 shows both lack of progress made over the past ten years in increasing passenger car efficiency and the opportunity available for a substantial conservation program in this area. On the average our passenger car fleet achieved less than 14 miles per gallon of fuel in 1977 (less than 51 percent of the 27.5 mile per gallon mandatory standard established for 1985 and equal only to the milage achieved by the 1967 fleet).

Production: U.S. production of energy resources over the past 32 years is shown in Table 8. 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, like oil, continue to be reduced 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. Table 8 also shows the decline in domestic production of petroleum. This decline was slightly reversed in 1978 (due to continuing increases in our Alaskan production) but will continue to decline in 1980 (by as much as 3 to 3.5 percent). This 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. As a result, U.S dependence on petroleum imports will resume its upward movement (as shown in Table 9). Table 10 shows the year by year percentage changes in the production of the various energy sources.

Prices: Table 11 provides further insight into why our economy has become so energy intensive. Historically, 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. For example, the average wellhead price for natural gas in 1973 was virtually identical to the price in 1947. On the other hand, domestic crude oil prices actually dropped in real terms between 1947 and 1973. Until 1973, foreign crude oil prices exhibited only a moderate annual increase and were maintained below the domestic market price by virtue of our oil import quote program. Similar price patterns occurred with other energy sources. Up until 1973, only the price of domestically produced coal increased to some extent and, then, only in recent times due to environmental and safety regulations. Obviously, as labor costs increased, it was wise economics on the part of our industrial, commercial and transportation sytems to replace manpower with the use of energy to drive mechanical devices.

Since 1972, price patterns have been substantially different. The price of domestic crude oil has risen at the rate of 7.9 percent per year in real terms while the real prices of imported crude will be rising at the rate of almost 25 percent per year if OPEC increases their December price to $26.50 per barrel. Other fossil fuel prices are also rising with natural gas increasing at more than a 15 percent annual rate and coal rising at over 8 percent. Note that these increases are in real terms; that is, over and above the general rate of inflation.

As we have seen in the earlier tables, increases of this magnitude are beginning to impact, more importantly than in the past, our energy demand. Although the short run price elasticity for energy is low, increasingly adjustments to demand will be made as our capital stock is replaced and as price increases continue. The degree of conservation that will ultimately result is unknown and probably not subject to forecasting because we have had no past experience with a similar situation. It is, however, clear that a long period of time is necessary for price increases to exhibit their full impact. It is also increasing clear that conservation induced by higher prices, while a critical part of our policy solutions, will not alone be adequate to reduce our import dependence. Regardless of the exact magnitude, the long run price elasticity for energy is probably insufficient for this to take place.

Although public debate continues over this question, it is increasingly obvious that the U.S. must work both sides of the energy equation. While conservation actions (either government mandated or due to market forces) can reduce growth rates in energy consumption, the gap between demand and domestic supply will continue to widen in the foreseeable future. Conservation requires literally millions of individual decisions which will, by nature, be spread though time. Even if these actions were to result in a zero energy consumption growth rate (highly unlikely over the long term), foreign oil imports would continue to grow. U.S. production of conventional oil and natural gas continues to decline because the depletion of our known reserves has exceeded new finds since the early 1970's. Few expect new discoveries of conventional fields to increase sufficiently in the future to maintain the present level of domestic supply. Thus, without alternative energy sources and/or major shifts in energy consumption to plentiful fuel sources like coal, imports will increase.

Politically the result has been increased interest in policies designed to augment domestic supply by developing alternative energy sources. The current interest in solar energy, biomass fuels, oil shale and coal synthetics are examples of this movement. Recent Presidential initiatives have considered all of these alternative energy sources, as well as an expansion of federal leasing of public domain lands to encourage additional exploration and development of conventional hydrocarbons. But do we have adequate domestic resources to become more self sufficient?

Reserves: Estimates of undiscovered resources are always speculative. However, even with higher prices, additions to domestic reserves of conventional fossil fuels have not been promising. 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 since the early 1960's with the exception of our Alaskan discovery in the early 1970's. For natural gas, reserve finds have been less than annual production since the mid-1960's. As a result, the reserve to production ratio continues to decline and we face an increasingly critical problem with domestic production from these sources in the immediate future. We have been living off our past success. That has now come to an abrupt halt. Only coal and oil shale have sufficient known reserves to make production directly dependent on market price.

The Policy Alternatives

What then of our policy options? If the U.S. is now, and will be for the next decade, on the ragged edge of supply, policies must be a blend which will see us through the immediate supply gap and provide for our long run energy requirements. Yet, the focus of concentration in Washington is on what, at best, are long run solutions. Listen to the list:

1. An Energy Mobilization Board to cut government red tape involved in building long-run energy projects;
2. An Energy Security Corporation designed to encourage development of synthetic fuel plants outside of normal bureaucratic procedures (in order to reduce time lags);
3. Private development of synthetic fuels from coal and oil shale;
4. Conversion of oil fired electrical utility plants to coal;
5. Expanded domestic exploration activity (especially on Federal lands); and
6. Expanded use of nuclear power.

All of these options have supporters, but none can impact energy supply quickly. The Energy Mobilization Board and the Energy Security Corporation are both monuments to our failure to come to grips with energy shortages. Both are aimed at cutting red tape and avoiding political/bureaucratic delay. Both are concerned with projects that have long run impacts. Both are untested institutions that will, by their very creation, result in an unsettled period where new institutional linkages must be formed, issues litigated, and little forward progress made (witness our experience with the Department of Energy). Synthetic fuel development, by its very newness and technical difficulty, can have no perceptible impact until the end of the 1980's. Coal gasification or liquefaction plants and oil shale production facilities will require no less than 7 years of lead time from conception to production. And the economic and environmental costs of this option are little understood. Attempts at conversion of utilities to coal have been underway since the first Arab oil embargo. Almost no oil savings have resulted as laws and regulations have been tied up in court and environmental concerns have raised questions about the wisdom of such a policy. Expanded domestic exploration may be able to stem our already precipitous production decline from old fields. Sizeable new finds will, however, take eight to ten years to get into the pipeline. The federal leasing process can add 3 to 5 years to this timetable in new frontier areas. And large, potentially valuable, areas, such as the Artic Wildlife Refuge, have been declared off limits for environmental reasons. Expanded use of nuclear power does not appear to be a realistic possibility for both technical and political reasons. The dangers and costs of nuclear plant operation are now more clearly understood and the difficulties involved in nuclear waste storage are beyond the solution of society as we know it. In any case, nuclear power plant construction has the longest lead time of any type of electrical facility and cannot be an immediate answer to our liquid fuels crisis. Extensive production from inexhaustible resources such as solar energy, fusion or geothermal power face similar time difficulties.

During this time, prices of energy will increase faster than the general rate of inflation, shortages will become a fact of life and economic, as well as national security, uncertainty will increase sharply. None of the proposed long term solutions will alter these facts. Yet, up to now, the only major response from Washington has been the Presidential initiative to impose oil import quota at the level of 8.5 million barrels per day. The Senate rightfully saw the folly of such a course of action in voting to require a veto over its application. It would lead to accelerated inflation in world oil prices, a huge new bureaucracy, lower economic growth and would replace impartial market forces with the special favors common to political solutions.

If these policies are inadequate for the short run, can anything be done short of military intervention in the Middle East? No policy or combination of policies will have the instant effect that is now needed to avoid problems with liquid fuels over the decade of the 1980's. However, some policy options should be enacted at once to cushion the economic impacts of high import levels and physical shortages.

First, oil prices should be immediately decontrolled. One way to hold down imports is to let prices rise. Neither controls nor conservation based on government programs can compensate for market forces. The fact is, conservation doesn't work until prices rise. For example, fuel efficient cars only make it cheaper to drive when prices are stable. The only time gasoline consumption drops in this country is after rapid increases in real price - as in 1974 and 1979.

Second, coupled with price decontrol, an additional gas tax of at least $1.00 per gallon should be imposed immediately. This tax should then be escalated upward over time at a more rapid rate than inflation. The effect of such a tax would be similar to that of rationing but implementation would be more efficient and equitable. A large bureaucracy would not be required to administer the program, the even hand of the market would be more equitable than an administrative hand responding to political pressure, the need for a white market in rationing coupons (with its windfall profits for citizens who drive less than the imposed quote) would be avoided, and, conversely, the government would have substantially increased tax revenues that could be used to offset other taxes such as those imposed on a majority of citizens for social security purposes.

The only potential disadvantage of a gas tax relates to its short run effectiveness in reducing gasoline consumption. Whether it would be sufficient without also imposing rationing depends on the extent of conservation desired and the magnitude of the tax one is willing to impose. Experience would appear to indicate that a tax in the area of a $1.00 per gallon would have the necessary short run effectiveness (if coupled with the other measures suggested here). More importantly, such a tax would provide the needed incentive for major long run conservation efforts, wider use of mass transportation, increased purchases of fuel efficient transportation, and an accelerated search for more fuel efficient transportation technology.

It is these latter issues that is especially troublesome with respect to our current situation. For we have seen that the most flexible, and yet substantial, use of petroleum is the transportation sector. But the response of the American automobile industry is a national scandal and disgrace. Today's more fuel efficient cars now cost more in the dealers showroom than a heavier gas gussler; if they can be bought at all. For the waiting time on Detroit's new front wheel drive small cars has stretched to months and, then, the customer must order expensive options to obtain a car. Technically, cars achieving 40 to 80 miles per gallon are feasible, yet Detroit has wasted over six years in moving toward fuel efficient vehicles. And they continue to drag their collective feet in this endeavor. At least in part, the American public's attention has been directed toward the wrong corporate villain. For the oil industry has little control over the long run trend in energy prices but the automotive sector has a great deal of control over gasoline consumption per mile driven. We need to direct our attention to the auto industry; a true oligopoly. Manufacturers must be pushed toward more rapid innovation leading to dramatic increases in fuel efficiency. In Washington, this is a silent option.

Third, a crash program should be started which would utilize biomass for conversion to ethanol. The technology is known, needed equipment can be obtained off the shelf, and construction time is minimal. In addition to feed grains, waste by-products, such as cheese whey, should be considered for this type of conversion. New distillation facilities should use coal or other nonpetroleum based fuels; and active attempts should be made to locate such facilities near power plants and other facilities where cogeneration technology could be used. Although ethanol from biomass may never supply more than 5 percent of our gasoline needs, even a relatively small contribution would be of substantial assistance over the next several years. However, because of the close relationship between energy and agricultural policy in this matter, active participation by all interested segments will be required to make such a program operational.

Fourth, environmental rules should be set aside until a more suitable time, allowing conversion of oil fired utility plants to coal. Rapid conversion could save more than a half a million barrels of oil per day under existing demand conditions.

Finally, massive conservation programs should be initiated to provide assistance for home and factory insulation projects, efforts at reducing lighting needs, reduced automobile travel, improved building design, and expanded installation of alternate energy sources. Federal, state and local funds should be used for this effort, but the primary responsibility for execution should be at the local level. Organizations like Cooperative Extension should become leaders in this effort.

Summary

The energy crisis is here, the solutions are not. For many of the reasons cited above, they are not likely to come from Washington. Rather, greater reliance on market forces and the resulting incentives at the grass roots will be the only feasible route through the energy poor 1980's. Recognition of this fact is slowly taking place. Consequently, I look for actions from Washington which will ultimately reduce regulatory interference and permit innovative solutions to form from the broader public. If we are able to resist the pressures of special interests, the interests of the country and all its citizens may be enhanced by the disruptive events that are about to take place.

APPENDIX A

Historical Energy Statistics

TABLE 1

SELECTED UNITED STATES ECONOMIC AND ENERGY INDICATORS, 1947-1978

Year	Gross Energy Input[1] (Quadrillion BTU)	Net Energy Input[2] (Quadrillion BTU)	Population (Millions)	Gross National Product (Billion of $ 1972)	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	468.3	70.5	229.0	202.8	88.5
1950	34.0	29.7	152.3	533.5	63.7	223.2	194.8	87.3
1955	39.7	34.3	165.9	654.8	60.6	239.3	206.7	86.4
1960	44.6	38.2	180.7	736.8	60.5	246.8	211.5	85.7
1965	53.3	45.3	194.3	925.9	57.6	274.3	233.1	85.0
1970	67.4	56.0	204.9	1075.3	62.7	328.9	273.3	83.1
1971	68.7	56.8	207.1	1107.5	62.0	331.7	274.3	82.7
1972	71.6	59.5	208.9	1171.1	61.2	342.9	284.8	83.1
1973	74.6	60.7	210.4	1235.0	60.4	354.6	288.6	81.4
1974	72.8	58.6	211.9	1217.8	59.7	343.4	276.7	80.6
1975	70.7	56.3	213.6	1202.3	58.8	331.0	263.7	79.7
1976	74.5	59.3	215.2	1271.0	58.6	346.3	275.4	79.5
1977	76.5	60.5	216.9	1332.7	57.4	352.9	278.8	79.0
1978	78.2	61.3	218.6	1385.1[P]	56.4	357.5	279.7	78.4

Source: U. S. Bureau of Mines
U. S. Department of Energy

[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] 1947-78
[Quadrillion (10^{15}) BTU]

Year	Anthracite	Bituminous Coal and Lignite	Natural Gas, Dry[2]	Petroleum[3]	Total Fossil Fuels	Hydropower	Nuclear Power	Other[4]	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	0.599	10.941	9.232	17.524	38.296	1.407	—	—	39.703	+9.5
1960	0.447	9.693	12.699	20.067	42.906	1.657	0.006	—	44.569	+3.3
1965	0.328	11.580	16.098	23.241	51.247	2.058	0.038	—	53.343	+4.1
1970	0.210	12.712	22.029	29.614	64.565	2.650	0.229	—	67.444	+3.8
1971	0.186	11.887	22.819	30.570	65.462	2.862	0.404	—	68.728	+1.9
1972	0.136	12.311	22.699	32.947	68.093	2.941	0.584	.008	71.625	+4.2
1973	0.129	13.171	22.512	34.837	70.649	3.008	0.910	.046	74.605	+4.2
1974	0.120	12.757	21.732	33.454	68.063	3.307	1.272	.115	72.756	-2.5
1975	0.111	12.712	19.948	32.732	65.503	3.217	1.900	.086	70.706	-2.8
1976	0.112	13.622	20.345	35.178	69.257	3.065	2.111	.081	74.513	+5.4
1977	0.115	14.004	19.931	37.176	71.226	2.519	2.702	.097	76.536	+2.7
1978	0.120	13.949	19.797	37.964	71.830	3.145	2.977	.199	78.151	+2.1

Source: U. S. Bureau of Mines
U. S. Department of Energy

[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 liquids.

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

[4]Includes geothermal power, electricity produced from wood and waste and net coke imports.

Note: Totals may not equal sum of components due to independent rounding.

TABLE 3

PERCENTAGE CHANGE FROM PRIOR YEAR IN UNITED STATES
TOTAL GROSS CONSUMPTION OF ENERGY RESOURCES BY MAJOR SOURCES, 1950-78

Year	Anthracite	Bituminous Coal and Lignite	Natural Gas, Dry	Petroleum	Total Fossil Fuels	Hydropower	Nuclear Power	Other	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
1965	-10.1	+6.2	+2.9	+3.8	+4.0	+7.9	+8.6	--	+4.1
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	-26.9	+3.6	-0.5	+7.8	+4.0	+2.8	+44.6	--	+4.2
1973	-5.1	+7.0	-0.8	+5.7	+3.8	+2.3	+55.8	+475.0	+4.2
1974	-7.0	-3.1	-3.5	-4.0	-3.7	+9.9	+39.8	+202.6	-2.5
1975	-7.5	-0.4	-8.2	-2.2	-3.8	-2.7	+49.4	-25.2	-2.8
1976	+0.9	+7.2	+2.0	+7.5	+4.2	-4.7	+11.1	-5.8	+5.4
1977	+2.7	+2.8	-2.0	+5.7	+2.8	-17.8	+28.0	+19.8	+2.7
1978	+4.3	-0.4	-0.7	+2.1	+0.9	+24.9	+10.2	+105.2	+2.1

TABLE 4

DEMAND FOR ENERGY INPUTS TO INDUSTRIAL SECTOR, 1947-78

Year	Natural Gas Million Cubic Feet	Natural Gas 10^{15} BTU	Petroleum Million Barrels	Petroleum 10^{15} BTU	Coal[1] Thousand Short Tons	Coal[1] 10^{15} BTU	Net Coke Import Thousand Short Tons	Net Coke Import 10^{15} BTU	Electricity Purchased Quadrillion BTU	Net Sector Inputs Quadrillion BTU	Electrical Energy Loss Distribution Quadrillion BTU	Total Energy Use Quadrillion BTU
1947	2,905,571	3.007	423.0	2.517	273,403	7.298	—	—	.459	13.281	NA	NA
1950	3,601,757	3.727	446.8	2.666	223,507	5.957	—	—	.559	12.909	NA	NA
1955	4,768,562	4.935	579.8	3.406	214,946	5.726	—	—	1.008	15.075	NA	NA
1960	6,074,114	6.287	643.9	3.682	175,225	4.673	—	—	1.306	15.948	NA	NA
1965	7,433,200	7.671	740.4	4.139	200,688	5.366	—	—	1.634	18.810	NA	NA
1970	9,856,844	10.162	961.4	5.267	186,637	5.004	—	—	2.210	22.643	NA	NA
1971	10,252,000	10.570	927.3	5.094	159,320	4.330	—	—	2.293	22.287	NA	NA
1972	10,400,457	10.723	1,009.3	5.544	163,993	4.457	—	—	2.465	23.189	NA	NA
1973	10,183,154	10.397	1,168.0	6.441	185,074	4.377	-308	-.008	2.374	23.580	5.564	29.144
1974	9,777,344	10.012	1,154.6	6.277	175,423	4.047	2,269	.059	2.368	22.762	5.668	28.430
1975	8,356,513	8.532	1,079.1	5.929	166,053	3.786	538	.014	2.334	20.594	5.613	26.207
1976	8,596,078	8.768	1,213.9	6.682	165,846	3.773	—	.000	2.558	21.780	6.144	27.924
1977	8,463,271	8.641	1,366.6	7.552	160,035	3.612	576	.015	2.672	22.492	6.431	28.923
1978	8,113,614	8.284	1,382.4	7.639	152,105	3.433	5,038	.131	2.763	22.249	6.759	29.008

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

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

NA - Not available.

TABLE 5

DEMAND FOR ENERGY INPUTS IN TRANSPORTATION SECTOR, 1947-78

Year	Natural Gas		Petroleum[1]		Coal[2]		Utility Electricity Purchased	Net Sector Inputs	Electrical Energy Loss Distribution	Total Energy Use
	Million Cubic Feet	Quadrillion BTU	Million Barrels	Quadrillion BTU	Thousand Short Tons	Quadrillion BTU	Quadrillion BTU	Quadrillion BTU	Quadrillion BTU	Quadrillion BTU
1947	Negl.	--	1,050.3	5.761	113,324	3.030	.029	8.820	NA	NA
1950	125,546	.130	1,248.8	6.785	63,783	1.701	.024	8.640	NA	NA
1955	245,246	.253	1,691.4	9.109	17,429	.464	.019	9.845	NA	NA
1960	347,075	.359	1,934.1	10.372	3,294	.087	.018	10.836	NA	NA
1965	500,524	.517	2,271.9	12.179	655	.018	.018	12.732	NA	NA
1970	722,166	.745	2,902.8	15.592	298	.008	.016	16.361	NA	NA
1971	742,788	.766	3,032.3	16.286	214	.006	.017	17.075	NA	NA
1972	774,788	.799	3,208.2	17.231	214	.006	.018	18.054	NA	NA
1973	727,718	.743	3,287.9	18.132	127	.003	.014	18.893	0.034	18.927
1974	668,945	.685	3,251.4	17.677	87	.002	.015	18.379	0.035	18.414
1975	582,762	.595	3,252.8	17.872	44	.001	.015	18.483	0.036	19.408
1976	548,039	.559	3,415.2	18.799	--	Negl.	.015	19.372	0.035	20.068
1977	531,832	.543	3,524.4	19.476	--	Negl.	.014	20.033	0.037	20.606
1978	526,934	.538	3,622.3	20.017	--	Negl.	.015	20.569	0.022	20.591

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

[1] Includes bunkers and military transportation.

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

NA - Not available.

TABLE 6

DEMAND FOR ENERGY INPUTS IN HOUSEHOLD AND COMMERCIAL SECTORS, 1947-78

Year	Natural Gas		Petroleum		Coal[1]		Electricity Purchased	Net Sector Inputs	Electrical Energy Loss Distribution	Total Energy Use
	Million Cubic Feet	Quadrillion BTU	Million Barrels	Quadrillion BTU	Thousand Short Tons	Quadrillion BTU	Quadrillion BTU	Quadrillion BTU	Quadrillion BTU	Quadrillion BTU
1947	1,087,000	1.125	385.3	2.251	128,657	3.399	.391	7.148	NA	NA
1950	1,586,207	1.642	526.2	3.038	110,422	2.913	.546	8.139	NA	NA
1955	2,753,171	2.849	691.7	4.001	66,039	1.745	.854	9.449	NA	NA
1960	4,123,389	4.268	853.3	4.923	37,180	.983	1.262	11.436	NA	NA
1965	5,346,450	5.517	978.0	5.635	25,676	.678	1.948	13.778	NA	NA
1970	6,894,007	7.108	1,128.4	6.453	16,114	.427	3.000	16.988	NA	NA
1971	7,144,398	7.366	1,131.2	6.440	15,253	.408	3.209	17.423	NA	NA
1972	7,399,486	7.629	1,174.9	6.689	14,356	.384	3.449	18.151	NA	NA
1973	7,469,148	7.626	1,238.7	6.831	12,389	.293	3.489	18.239	8.295	26.534
1974	7,341,797	7.518	1,143.0	6.214	12,657	.292	3.469	17.493	8.419	25.912
1975	7,425,073	7.581	1,062.7	5.839	10,877	.248	3.584	17.252	8.729	25.981
1976	7,711,765	7.866	1,142.7	6.290	10,505	.239	3.725	18.120	9.060	27.180
1977	7,308,521	7.462	1,144.9	6.327	10,368	.234	3.934	17.956	9.589	27.545
1978	7,520,078	7.678	1,158.2	6.400	11,741	.265	4.083	18.427	10.110	28.537

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

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

NA - Not available.

TABLE 7

UNITED STATES PASSENGER CAR EFFICIENCY

	Ave. Fuel Consumed Per Car		Ave. Miles Traveled Per Car		Ave. Miles Traveled Per Gallon of Fuel Consumed	
Year	Gallons	Index	Miles	Index	Miles	Index
1967	684	100.0	9,531	100.0	13.93	100.0
1968	698	102.0	9,627	101.0	13.79	99.0
1969	718	105.0	9,782	102.6	13.63	97.8
1970	735	107.5	9,978	104.7	13.57	97.4
1971	746	109.1	10,121	106.2	13.57	97.4
1972	755	110.4	10,184	106.9	13.49	96.8
1973	763	111.5	9,992	104.8	13.10	94.0
1974	704	102.9	9,448	99.1	13.43	96.4
1975	712	104.1	9,634	101.1	13.53	97.1
1976	711	103.9	9,763	102.4	13.72	98.5
1977	706	103.2	9,839	103.2	13.94	100.1

Source: U. S. Department of Transportation

TABLE 8

UNITED STATES TOTAL PRODUCTION OF ENERGY RESOURCES BY MAJOR SOURCES, 1947-78
[Quadrillion (10^{15}) BTU]

Year	Coal	Natural Gas, Dry	Petroleum[1]	NGPL[2]	Total Fossil Fuels	Hydropower[3]	Nuclear Power	Other[4]	Total Gross Energy Inputs	Percentage Change From Prior Year
1947	18.005	5.012	10.771		33.788	1.296	—	—	35.084	—
1950	14.647	6.841	11.449		32.937	1.415	—	—	34.352	+12.3
1955	12.745	10.532	14.445		37.722	1.360	—	—	39.082	+10.8
1960	11.140	14.135	14.664		39.939	1.608	0.006	—	41.553	+2.1
1965	13.395	17.652	15.930		46.977	2.059	0.038	—	49.074	+3.1
1970	15.248	24.154	19.772		59.174	2.630	0.229	—	62.033	+5.6
1971	13.673	24.805	19.322		57.800	2.862	0.404	—	61.066	-1.6
1972	14.485	22.208	19.987	2.597	59.277	2.830	0.584	0.035	62.812	+2.9
1973	14.366	22.187	19.493	2.569	58.615	2.859	0.910	0.046	62.431	-0.6
1974	14.468	21.211	18.575	2.471	56.725	3.175	1.272	0.056	61.228	-1.9
1975	15.189	19.641	17.729	2.374	54.933	3.152	1.900	0.072	60.057	-1.9
1976	15.853	19.480	17.262	2.327	54.922	2.976	2.111	0.081	60.091	+0.1
1977	15.964	19.565	17.454	2.327	55.310	2.337	2.702	0.082	60.431	+0.6
1978	15.117	19.222	18.420	2.255	55.014	2.964	2.977	0.068	61.023	+1.0

Source: U. S. Bureau of Mines
Energy Information Administration

[1]Includes lease condensate.

[2]Natural gas plant liquids; series began in 1972 (formerly included under petroleum).

[3]Includes industrial and utility production of hydropower.

[4]Includes geothermal power and electricity produced from wood and waste (series began in 1972).

Note: Totals may not equal sum of components due to independent rounding.

TABLE 9

UNITED STATES DEPENDENCE ON PETROLEUM IMPORTS
(Million Barrels Per Day)

Year	Direct Imports From Arab/OPEC Countries	Direct Imports From OPEC Countries	Direct Imports Total All Countries	Domestic Petroleum Products Supplied	Percent Imports
1973	0.91	2.99	6.26	17.31	36
1974	0.75	3.28	6.11	16.65	37
1975	1.38	3.60	6.06	16.32	37
1976	2.42	5.07	7.31	17.46	42
1977	3.18	6.19	8.81	18.43	48
1978	2.92	5.64	8.23	18.82	44
1979 (1st half)	3.14	5.51	8.20	19.02	43

Source: U. S. Department of Energy

TABLE 10

PERCENTAGE CHANGE FROM PRIOR YEAR IN UNITED STATES TOTAL PRODUCTION OF ENERGY RESOURCES BY MAJOR SOURCES, 1950-78

Year	Coal	Natural Gas, Dry	Petroleum[1]	NGPL[2]	Total Fossil Fuels	Hydropower[3]	Nuclear Power	Other[4]	Total Gross Energy Inputs
1950	+16.8	+15.7	+7.2	--	+13.0	-0.7	--	--	+12.3
1955	+16.3	+11.0	+7.6	--	+11.2	--	--	--	+10.8
1960	+0.4	+5.8	--	--	+2.1	-3.7	+200.0	--	+2.1
1965	+4.3	+3.0	+1.5	--	+2.8	+9.2	+8.6	--	+3.1
1970	+7.3	+5.8	+4.7	--	+5.8	-0.7	+56.8	--	+5.6
1971	-10.3	+2.7	-2.3	--	-2.3	+8.8	+76.4	--	-1.6
1972	+5.9	-10.5	+3.4	--	+2.6	-1.1	+44.6	--	+2.9
1973	-0.8	-0.1	-2.5	-1.1	-1.1	+1.0	+55.8	+31.4	-0.6
1974	+0.7	-4.4	-4.7	-3.8	-5.4	+11.1	+39.8	+21.7	-1.9
1975	+5.0	-7.4	-4.6	-3.9	-3.2	-0.7	+49.4	+28.6	-1.9
1976	+4.4	-0.8	-2.6	-2.0	--	-5.6	+11.1	+7.2	+0.1
1977	+0.7	+0.4	+1.1	--	+0.7	-21.5	-21.8	+1.2	+0.6
1978	-5.3	-1.8	+5.5	-3.1	-0.5	+26.8	+10.2	-17.1	+1.0

Source: U. S. Bureau of Mines
U. S. Energy Information Administration

[1]Includes lease condensate.

[2]Natural gas plant liquids; series began in 1972 (formerly included under petroleum).

[3]Includes industrial and utility production of hydropower.

[4]Includes geothermal power and electricity produced from wood and waste (series began in 1972).

TABLE 11

FOSSIL FUEL PRICES: 1960-79

Year	Domestic Natural Gas: Average Wellhead Price/MCF	Domestic Crude Oil: Average Wellhead Price/Barrel	Foreign Crude Oil: Weighted Average Cost (Landed)	Petroleum Products: Gasoline	Petroleum Products: Residual	Domestic Coal Average F.O.B. Mine Price/Ton (Contract Sales)	Average Retail Electricity Price/KWH
			Actual				
1960	$.136	$2.80	NA	NA	$.046	$4.55	$.017
1965	.152	2.79	$2.07	$.146	.046	4.34	.016
1970	.169	3.13	2.69	.174	.060	6.17	.016
1971	.181	3.35	2.98	.179	.073	6.99	.017
1972	.196	3.39	3.03	.172	.059	7.46	.019
1973	.216	4.57	6.21	.390	NA	8.60	.020
1974	.304	6.87	12.52	.528	NA	11.90	.025
1975	.445	7.67	13.93	.562	.266	16.25	.029
1976	.580	8.19	13.48	.587	.274	17.90	.031
1977	.790	8.57	14.53	.590	.315	19.25	.034
1978	.919	9.00	14.57	.655	.304	21.41	.037
1979^P	.997	10.29	18.45	.797	.392	25.19	.038
			1972 Dollars*				
1960	.198	4.07	NA	NA	.067	6.62	.024
1965	.205	3.76	2.79	.196	.062	5.84	.021
1970	.185	3.43	3.01	.190	.066	6.75	.017
1971	.188	3.49	3.17	.186	.076	7.28	.018
1972	.196	3.39	3.03	.172	.059	7.46	.019
1973	.204	3.42	5.87	.369	NA	8.13	.019
1974	.262	5.92	10.79	.455	NA	10.26	.022
1975	.350	6.03	10.96	.442	.209	12.78	.023
1976	.434	6.12	10.08	.439	.205	13.38	.023
1977	.558	6.05	10.26	.417	.222	13.59	.024
1978	.604	5.91	9.58	.431	.200	14.08	.024
1979^P	.604	6.23	11.18	.483	.237	15.26	.023

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

*Implicit price deflator for gross national product used.

^P Preliminary

NA - Not available.

TABLE 12

UNITED STATES OIL AND GAS EXPLORATION AND DEVELOPMENT

Year	Rotary Rigs In Operation	Exploratory and Development Wells Drilled				Total Footage Drilled
		Oil	Gas	Dry	Total	
1973	1,194	9,902	6,385	10,305	25,592	136,391
1974	1,475	12,784	7,240	11,674	31,698	150,551
1975	1,660	16,408	7,508	13,247	37,235	174,434
1976	1,656	17,059	9,085	13,621	39,765	181,780
1977	2,001	18,912	11,378	14,692	44,982	210,848
1978	2,259	17,775	13,064	16,218	47,057	227,110
1979[a]	2,056	11,534	9,095	9,509	30,138	145,881

Source: U. S. Dept. of Energy

[a]Figures through August.